Corporate Social Responsibility, Production, and Environment: Evidence from Mandatory CSR in Indonesia

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Abstract

Corporate social responsibility (CSR) integrates social, environmental, and ethical values into business practices. This paper studies its effects on firms' production, profits, and environmental outcomes. To address endogeneity in CSR adoption, I exploit Indonesia's mandate requiring CSR implementation among limited-liability firms in natural-resource-related industries. Treated firms expanded CSR and environmental information disclosure, consistent with the policy's environmental preservation aim. A triple-difference design shows that treated firms improved environmental performance ratings and reduced carbon emissions by decreasing coal use and substituting toward LPG. The fuel shift involved expenditure reallocation but did not affect profits, output, revenue, or total expenses. Effects are larger for firms with stronger community-based relational incentives, particularly middle-aged firms sourcing capital domestically and privately. Village-firm matched data corroborate declining pollution incidents around treated firms. Legal CSR requirements can act as environmental regulation when firms are embedded in local networks that provide additional CSR incentives.

Keywords: Corporate Social Responsibility, CSR, Indonesia, Green transition, Carbon emissions

JEL classification: L2, Q5, O2, H4

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I. Introduction

Corporate Social Responsibility (CSR) — the integration of social, environmental, and ethical values into business practices — has increasingly become the mainstream of corporate strategy. According to KPMG (2015), 73% of the N100 sample (the top 100 firms by revenue in 49 countries; 4,900 firms in total) publish annual CSR reports. Reporting rates are especially high in emerging Asian economies, led by India, Indonesia, and Malaysia, suggesting that it is becoming a global norm observed beyond developed countries.

This prevalence, however, challenges the traditional economic view that profit-maximizing firms should leave public goods provision and externality correction to governments (Friedman, 1970). Two hypotheses could explain widespread CSR adoption: CSR genuinely enhances profitability, or firms engage in purely symbolic activities, generating little real social impact. Distinguishing between these explanations has proven difficult because CSR adoption is endogenous—larger and better-performing firms disproportionately self-select into CSR programs (Hong et al., 2012; Colonnelli et al., 2023).

This paper exploits a unique regulatory reform to identify the causal effects of CSR. In 2007, Indonesia became the first country to mandate CSR *implementation*—not merely disclosure—for specified firms (Waagstein, 2011). Because the mandate applied to firms with similar pre-reform characteristics and trends, it provides plausibly exogenous variation in CSR engagement. I use this setting to address two questions: How does mandated CSR affect production and profitability? And does it generate measurable benefits for local communities?

Exploring the feasibility and real-world implications of embedding CSR in a competitive economy through policy efforts is particularly pertinent to the country. First, large Indonesian firms report CSR activities at rates ranking among the world's second highest (2015). Second, the country's limited state capacity (Olken, 2007) makes private-sector engagement in the provision of public goods and the control of externalities under CSR particularly appealing. Indonesia introduced mandatory CSR in 2007 explicitly to address environmental externalities from large corporations. Given that environmental regulation in developing countries often suffers from weak monitoring and enforcement, examining whether mandatory CSR induces firms to internalize environmental costs offers important policy insights.

I exploit the 2007 Indonesian Corporate Law No.40, which requires CSR implementation for limited liability (LL) firms operating in natural resource-related businesses (NRB). The law prescribes administrative sanctions for noncompliance and authorizes business permit revocation for certain industries, including mining. Relevant ministries have partnered with local authorities to enforce the mandate in some regions. Business groups fiercely challenged the mandate as discriminatory, but the Constitutional Court later upheld it based on environmental risks from corporate activities. The law's dual eligibility criteria—legal status and industry—motivate a triple-difference (DDD) design. I compare LL-NRB firms before and after 2007 with three control groups: (i) LL but non-NRB firms, (ii) NRB but non-LL firms, and (iii) other firms. This specification flexibly controls for LL-specific and NRB-specific trends while isolating the causal effect of the mandate on treated firms.

I first document that the CSR mandate promoted firms' CSR reporting. To measure CSR disclosure, I hand-collected 871 annual reports from every Indonesian publicly listed company listed before 2015 and applied text analysis. CSR-related content expanded in annual reports among firms under CSR obligations, particularly following the introduction of sanctions for noncompliance. Consistent with the policy's environmental conservation objectives, environmental and CO_2-related contents increased, as did social contents following the mandate's enforcement with sanctions.

I then examine whether the mandate improved firms' environmental performance. Using triple-difference estimation, I analyze firm-level environmental ratings from the Ministry of Environment and Forestry for 2002–2018, which I digitized from ministerial documents. These ratings provide a standardized performance measure and mitigate selection concerns through mandatory participation for regulated firms. The DDD estimates show that treated LL-NRB firms improved environmental ratings by 0.48 standard deviations relative to control firms.

To understand the mechanisms behind this improvement and assess impacts on profitability and production, I next turn to detailed Indonesian manufacturing survey data. The results reveal that treated firms reduced CO_2 emissions and energy use by switching from coal, the most carbon-intensive input, to LPG, the cleanest available fuel. Crucially, despite this fuel switching, CSR-mandated firms experienced no significant changes in output, profits, expenditures, or revenue.

Finally, I test whether firm-level environmental gains benefited local communities using village census data linked to manufacturing-firm locations. Village-level DDD estimates indicate that greater exposure to treated firms reduced reported pollution incidents, with no effects on other public goods. These findings demonstrate that mandatory CSR induced cleaner production through fuel substitution, reduced local pollution, and imposed no profit penalty on regulated firms.

These findings raise three questions that guide the discussion: Why was the mandate effective despite weak enforcement? Why was fuel substitution inexpensive? And how does mandatory CSR compare to traditional environmental regulation? To begin, a battery of subgroup analyses addressing which firm types were affected most reveals a distinctive heterogeneity by age. Relatively young firms in the range of the 25th–50th age percentile improved environmental performance significantly more than older or younger counterparts, with no detectable heterogeneity in other dimensions, such as by size, capital, public image, or R&D.

The middle-young firms' prominent upgrading suggests relational contracts as a key mechanism underlying the mandate's effectiveness. While firms typically view CSR as an operational burden, established relationships with local communities create incentives to channel resources to stakeholders. The age pattern aligns with theory on relational contracting (Macchiavello and Morjaria, 2015; McMillan and Woodruff, 1999): older firms have stronger community ties that incentivize local contributions, but CSR's signaling value for building long-term relationships diminishes with relationship maturity, generating peak responsiveness among middle-aged firms. Consistent with this mechanism, event study estimates show that CSR adoption concentrated among firms with strong local ties—those sourcing capital domestically and privately rather than from government or foreign investors. By contrast, formal enforcement appears irrelevant: variation in sanction exposure across firms explains no treatment heterogeneity.

Turning to the apparent low-cost nature of the fuel adjustment, a budget allocation analysis documents that treated firms increased the *share* of production-related fuel expenditures in total costs rather than absolute spending levels, implying that cost adjustments operated through composition rather than scale. Firms offset higher fuel expense shares by reducing miscellaneous expenditures, primarily storage costs. This slack budget spared for miscellaneous expenses appears to play an important role as a buffer to absorb increased fuel costs without profitability losses. However, not all firms successfully adjusted: heterogeneity analysis shows increased exit rates uniquely among young and middle-aged firms—the same cohorts exhibiting the strongest environmental improvements. Thus, while mandatory CSR did not hurt profits or output, it imposed relative fuel cost increase, required budget reallocation, and forced exit among some firms inable to adjust.

In addition, Indonesia's energy subsidy regime likely facilitated low-cost fuel switching. Although subsidy levels declined during the sample period, subsidies for non-coal fuels stabilized LPG prices despite rising demand. Nonetheless, subsidies do not explain the observed reallocation patterns. DDD estimates show no differential fuel price trends for treated firms, indicating they had no differential access to subsidized fuels. Moreover, results remain robust to controlling for sector-specific fuel price trends. The subsidy regime thus provided favorable background conditions—price rigidity for cleaner fuels—but did not drive the fuel substitution itself.

Lastly, compared to traditional environmental regulation, mandatory CSR generated comparable aggregate effects but targeted different firms. An event study shows that policy primarily affected firms with greater environmental burdens (no prior pollution-abatement expenditures), operating on the extensive margin by inducing previously noncompliant firms to internalize costs rather than intensifying efforts among already-green producers. However, the earlier age-heterogeneous effects distinguish mandatory CSR from uniform carbon taxation. While highly effective at reducing CO_2 emissions among middle-aged firms, this effectiveness dissipates with firm age, functioning as a temporary rather than permanent carbon price. To formalize this distinction, I extend Golosov et al. (2014)'s optimal carbon tax model by incorporating an inverse-U-shaped social cost of emissions.

I also briefly discuss how the exit patterns among middle-aged firms further differentiate mandatory CSR from traditional carbon tax. By promoting exit of polluting firms during intermediate growth stages, mandatory CSR may generate long-run compositional improvements—selective survival of cleaner firms—at the cost of short-run economic losses from exit (e.g., unemployment, output decline). In contrast, traditional carbon taxes primarily target large, full-fledged firms with the highest absolute emissions. These firms face lower exit risk, limiting the policy's compositional effects while also avoiding exit-related costs.

This paper contributes to the literature on firms' profit-maximization motive in two respects. On the one hand, it adds to evidence on firm behavior deviating from profit maximization, which is often documented in developing countries (Kremer et al., 2019).[1] I show that weakly enforced CSR mandates with no profit effects nonetheless induced behavioral change, suggesting firms operated below the profit frontier. On the other hand, some responses nonetheless align with profit maximization under relational contracts (Macchiavello, 2022). CSR activities emerged only among firms with domestic private stakeholders who supply capital, and the age-heterogeneity pattern is consistent with theories of relational contracting.

This study also contributes to debates on public goods provision in weak state-capacity settings (Finan et al., 2017). CSR mandates offer an alternative mechanism for mobilizing private provision of goods and mitigation of externalities traditionally handled by governments (Kotchen, 2006; Besley and Ghatak, 2007; Samwick and Wang, 2023; Cramer et al., 2025). In Indonesia, private engagement materialized when firms faced exit risk during the mid-young phase and were embedded in local communities rather than relying on formal

[1] Examples include poor managerial practices (Bloom and Van Reenen, 2007, 2013), profit-reducing tax behavior (Almunia et al., 2024; Tourek, 2022), and low training take-up (Hjort and de Rochambeau, 2025. Firms in developed countries also exhibit suboptimal entry (Goldfarb and Xiao, 2011), bidding (Hortaçsu and Puller, 2008), wage-setting (Dube et al., 2025), and pricing (DellaVigna and Gentzkow, 2019; Cho and Rust, 2010).

state enforcement. Crucially, the mandate induced polluting firms—not already-compliant producers—to internalize environmental costs, suggesting CSR mandates can complement traditional regulation (Chen et al., 2023) while circumventing limitations of weak enforcement and monitoring (Duflo et al., 2013; 2018; Zou, 2021) and adverse behavioral responses (Davis, 2008; He et al., 2020). However, the effects may be short-lived and local if the response is concentrated among specific firm-age cohorts and depends on domestic private capital providers.

More specifically, this paper belongs to the growing literature on CSR (Herkenhoff et al., 2024; Besley and Ghatak, 2007; Samwick and Wang, 2023; Cramer et al., 2025; Bénabou and Tirole, 2010; Servaes and Tamayo, 2013; Flammer, 2015; Hoang et al., 2023; List and Momeni, 2021; Hedblom et al., 2019; Bertrand et al., 2020) and related domains, where firms actively integrate seemingly non-profitable values in production.[2] I provide causal evidence on CSR impacts using quasi-experimental variation, addressing concerns about endogenous adoption (Hoang et al., 2023). While most studies examine mandatory CSR *reporting* (Christensen et al., 2021; Chen et al., 2018; Darendeli et al., 2022; Fiechter et al., 2022), fewer analyze mandatory *implementation*, such as India's 2013 regulation (Manchiraju and Rajgopal, 2017; Cramer et al., 2025). I study Indonesia's 2007 mandate and evaluate effects on production and community outcomes using linked firm-village data.

This paper is structured as follows. Section II outlines institutional background and the scope and motivation of Indonesia's CSR laws. Section III and IV describe the data and empirical framework. Section V presents the main results on the effects of CSR on production and village-level outcomes. Section VI explores underlying mechanisms and policy implications, and Section VII concludes.

II. Institutional Backgrounds

A. Indonesia's Major CSR Law—Law No.40/2007 Article 74

Before the enactment of formal CSR legislation, Indonesia relied largely on customary norms and fragmented regulations in areas such as labor rights, environmental protection, and consumer welfare (Pargal and Wheeler, 1996; Waagstein, 2011).These frameworks, however, were weakened by limited enforcement capacity and frequent conflicts with economic interests. Mounting concerns over the environmental and human rights impacts of corporate activity spurred a legislative initiative among a few members of the Indonesian parliament,

[2]Examples include ESG (Colonnelli et al., 2023, 2025; Allcott et al., 2023; Baker et al., 2022; Starks, 2023), environmental standards (Kotchen, 2006; Eichholtz et al., 2010), labor rights (Tanaka, 2020; Alfaro-Ureña et al., 2025; Boudreau, 2024) and fair trade (Dragusanu et al., 2014; Hainmueller et al., 2015).

advocating mandatory CSR implementation as a preventive approach to offset the detrimental effects of corporate activities on society.

The legislative process culminated in August 2007 with the passage of *Indonesia's Corporate Law No.40/2007*. Although mandatory CSR was absent from the government's initial draft, it was introduced by parliamentarians during negotiations and retained in the final bill. Debate centered on which types of firms should be subject to the obligation, and the mandate was ultimately limited to companies with significant involvement in natural resources. The law was enacted after six parliamentary hearings with representatives from 23 societal institutions, while business entities and academia were absent from the process.

Article 74 establishes the CSR obligation, applying to limited liability (LL; *Perseroan Terbatas*) companies companies engaged in natural-resource-related businesses (NRB). It defined CSR explicitly as "sustainable economic development aimed at enhancing the quality of life and environment, benefiting the company itself, local communities, or the general public.[3]" Non-compliance with the mandated CSR provisions was subject to sanctions under relevant legislative regulations, although specific details were left deliberately ambiguous, with further clarity delegated to subsequent government regulations. See Appendix A for the original article and definition of limited liability companies.

The enactment of Law No.40/2007, which introduced mandatory CSR through Article 74, immediately faced opposition from business groups concerned about a potential increase in operational costs. These concerns escalated into a formal legal case in 2009 (Judicial Review of 2008 Laws No.40, Judgment, Case No.53/PUU-VI/2008), brought by the Indonesian Chamber of Commerce and several major corporations, which alleged the article was unconstitutional. A central claim was that the provision was discriminatory and violated Article 33 (4) of the Indonesian Constitution. The Constitutional Court, however, rejected these arguments in its April 2009 ruling, upholding the constitutionality of Article 74. The Court reasoned that the CSR mandate was justified by the environmental risks inherent in corporate activity and did not constitute discrimination against specific firms.

The motivation and background of the Indonesian CSR law underscore its focus on environmental concerns while simultaneously envisioning a broad set of beneficiaries, as reflected in its definition of CSR as benefiting "the company itself, local communities, or the general public." Uniquely, it mandates CSR *implementation*, going beyond the more common requirement of CSR reporting. This effort to institutionalize CSR practice represented the first of its kind globally (Waagstein, 2011).

[3]Original clause I-1-3: "Tanggung Jawab Sosial dan Lingkungan adalah komitmen Perseroan untuk berperan serta dalam pembangunan ekonomi berkelanjutan guna meningkatkan kualitas kehidupan dan lingkungan yang bermanfaat, baik bagi Perseroan sendiri, komunitas setempat, maupun masyarakat pada umumnya."

Yet scholars have emphasized persistent ambiguities in the law's practical implementation and enforcement (Waagstein, 2011; Butt and Lindsey, 2018a). The legislation does not clearly define which activities qualify as "natural-resource-related businesses," what sanctions should apply to non-compliant firms, or which institution bears responsibility for monitoring and enforcement.

Over time, CSR legislation was consolidated through supplementary government and ministerial regulations that addressed gaps in implementation. A 2012 regulation clarified the NRB industries subject to Law No.40/2007, while a 2010 law introduced additional sanctions for mining companies that failed to comply with CSR obligations. The next subsection discusses these regulations in greater detail.

B. Indonesia's Surrounding CSR Regulations

While Law No.40/2007 left implementation ambiguous, subsequent regulations helped consolidate the legal framework and institutionalize CSR practices.

In February 2010, *Government Regulation No.23/2010* introduced sanctions for non-compliance with CSR obligations, focusing on the mining sector.[4] Sanctions included written warnings, temporary suspension of operations, and revocation of Mining Permits (*Izin Usaha Pertambangan, or IUP*) or Special Mining Permits (*Izin Usaha Pertambangan Khusus, or IUPK*). This regulation marked an important step toward strengthening accountability in resource-extractive industries.

In December 2010, *Government Regulation No.93/2010* provided tax incentives for CSR activities.[5] It allowed corporations to deduct up to 5% of the previous year's net revenue from gross revenue for eligible CSR expenditures, including disaster relief, joint R&D with accredited institutes, and investments in education, sports, and social infrastructure.

In April 2012, *Government Regulation No.47/2012* established a clearer framework for enforcing the CSR mandate under Law No.40/2007.[6] It defined the industries subject to the law—forestry, oil and gas, geothermal resources, mineral and coal mining, electricity generation, and environmental protection and management—and required corporate boards in these sectors to incorporate CSR into their annual work plans, thereby embedding CSR at the managerial level.

In August 2012, *Ministry of Finance Regulation KEP-431/BL/2012* mandated that all publicly listed companies disclose CSR activities in their annual reports (see Appendix A for the defi-

[4]https://peraturan.bpk.go.id/Details/5031
[5]https://peraturan.bpk.go.id/Details/5118
[6]https://peraturan.bpk.go.id/Details/5260

nition of publicly listed companies). Disclosure was required in areas such as environmental protection, labor practices, community development, and product responsibility. This measure further incentivized larger firms to integrate CSR into their operations.

Finally, two earlier legal initiatives sought to institutionalize CSR prior to Law No.40/2007. The first was *Ministry of State-Owned Enterprises Regulation KEP-236/MBU/2003*, which required state-owned enterprises to engage in CSR activities. The second was *Investment Law No.25/2007*, introduced almost simultaneously with Law No.40/2007, which obligated firms with "investment" status to undertake CSR under the threat of sanctions (see Appendix A for the definition of investment companies). These frameworks are outside the scope of this paper, due to low public awareness of them (Butt and Lindsey, 2018b) and the lack of suitable control groups for empirical analysis.

C. Monitoring, Sanctions, and Enforcement

It is worth noting that no company has ever been criminally prosecuted solely for failing to implement CSR. Instead, enforcement has gradually emerged at the local level through administrative sanctions, though it remains limited and uneven. This reflects the decision of national authorities to leave practical implementation unresolved in Law No.40/2007. During the Constitutional Court hearings, the government's plan envisioned that local governments would determine the allocation of CSR funds, applicable penalties, and the intended objectives and beneficiaries, tailored to regional needs (Waagstein, 2011).

Consistent with this decentralized approach, several provinces and districts enacted their own CSR regulations in the form of governor regulations, decrees, or local ordinances. For example, the Special Region of Yogyakarta created CSR forums through Governor's Decree No.397/KEP/2012. West Java adopted Governor Regulation No.30/2011 to facilitate CSR activities, while East Java issued Local Regulation No.4/2011 to establish a similar framework (Nd, 2023).

Several local governments have applied administrative sanctions to firms that fail to meet CSR obligations. In 2017, for instance, the West Pasaman Regency government in West Sumatra identified palm oil companies that had failed to disburse the CSR funds previously agreed upon with local communities, and issued formal written warnings threatening further penalties under regional law.[7] More recently, in 2023, the Mining Investigation Unit of the East Kalimantan Provincial Parliament (*Dewan Perwakilan Rakyat Daerah*) launched a monitoring initiative to assess whether extractive industry firms were meeting their CSR commitments.[8] These subnational initiatives signal an emerging practice of regional moni-

[7] https://www.antaranews.com/berita/799740/puluhan-perusahaan-sawit-diduga-tidak-realisasikan-csr
[8] https://www.antaranews.com/berita/3340125/pansus-ip-kawal-reklamasi-dan-csr-perusahaan-tambang-

toring and enforcement, even in the absence of direct national-level prosecutions.

Sanctions initiated by local governments can also be reinforced through national administrative procedures. In 2023, for example, the Jambi provincial government, in coordination with the Ministry of Energy and Mineral Resources, suspended the operations of seven coal mining companies for failing to deposit the agreed CSR funds on time.[9] The suspension order, issued on March 13, 2023, halted operations by blocking coal transportation and freezing coal sales accounts. This type of sanction is consistent with Government Regulation No.23/2010 and entails strong disciplining functions. These cases highlight how CSR enforcement is becoming embedded within broader regulatory practices, particularly in the natural resource sector.

Nevertheless, enforcement remains decentralized and largely confined to the local level. This underscores the need for empirical evidence on its actual effects. The following sections on data and empirical strategy set out the approach to addressing this question.

D. Rising Trend in CSR Disclosure

Before assessing mandatory CSR's effects on production, profits, and environmental outcomes, I document CSR trends and the role of CSR regulations using text data from publicly listed firms' annual reports. I hand-collected 871 annual reports by visiting the websites of all firms listed before or in 2015, excluding service sectors unlikely targeted by Law No.40/2007 (Appendix B lists included and excluded sectors). This analysis examines firms' reporting behavior following the introduction of CSR regulations, focusing on the energy sector, which according to Indonesian Stock Exchange classification captures mining firms—those facing the strongest CSR pressures under Law No.40/2007 and GR No.23/2010.[10] Two limitations constrain causal inference: frequent missing years (particularly in earlier periods) and no variation in limited liability status among publicly listed companies (uniformly with limited liability status), which only leaves the sectoral requirement to pin down Law No.40/2007's target and fails to completely isolate the law's effect from sectoral trends. These results therefore provide suggestive rather than definitive evidence.

I measure CSR disclosure using hit ratios—the share of sentences in each annual report semantically similar to pre-determined keyword sets for each of the six classifications (CSR, Environment, Social, Governance, CO_2, and financial performance). The analysis employs

di-kaltim

[9]https://www.antaranews.com/berita/3444654/tujuh-perusahaan-batu-bara-tidak-setor-csr

[10]The energy sector (sector A Energy) includes A11 Oil & Gas, A12 Coal, A13 Oil, Gas & Coal Supports, A21 Alternative Energy Equipment, and A22 Alternative Fuels.

BERT (Bidirectional Encoder Representations from Transformers), a deep learning model for natural language processing (Devlin et al., 2019). BERT maps text into high-dimensional vector representations, capturing context-dependent semantics that simple keyword counts miss, including implicit or paraphrased CSR references. Appendix B provides CSR-related keywords and implementation details.

<Figure 1>

Figure 1 plots annual report content trends from 2005 to 2020 across the six categories. Panel (1) shows that the energy sector subject to Law No.40/2007's CSR obligations exhibits sharply increasing CSR disclosure relative to other sectors, with divergence beginning around 2010, coinciding with GR No.23/2010's introduction of sanctions for noncompliance. Subsequent panels document similar increases not only in social content but also in environmental and CO_2-related disclosures, consistent with the policy's environmental conservation objectives. By contrast, governance and finance-related content show no comparable trends, serving as a placebo test since these dimensions fall outside CSR mandates.

III. Data

This paper draws on three primary datasets. The first, used to overview environmental impacts of CSR, is the firm-level environmental performance assessment administered by Indonesia's Ministry of Environment, known as the *Program for Pollution Control, Evaluation, and Rating* (PROPER). I digitized annual firm lists released by the Ministry for the years 2002, 2003, 2004, 2006, 2008–2010, 2013–2015, and 2017–2018, creating a panel of 2,844 firm-year observations covering 237 firms across 12 survey years.

Participation in PROPER is compulsory for firms selected by the Ministry of Environment (García et al., 2007), reducing concerns about sample selection based on baseline environmental performance. The ministry targets firms with substantial environmental impacts, export-oriented operations, or publicly listed firms whose products directly affect the public (Ministry-of-Environment, 2009). Although some firms may participate voluntarily to signal environmental practices, the sample is overwhelmingly composed of large limited liability companies: 224 of 237 firms in this study.

Second, to analyze the effects of mandatory CSR on production and profits, I draw on firm-level data from Statistics Indonesia's *Annual Survey of Manufacturing Industry*, spanning 2000–2015. The survey covers the universe of manufacturing firms with 20 or more employees and provides detailed information on inputs, outputs, technologies, and financial indicators. The resulting panel comprises 141,712 firm-year observations from 8,857 firms over 16 years. Crucially, the data report both industry classification (natural-resource-related or not) and corporate legal status (limited liability or otherwise), allowing precise identification of CSR-mandated firms and reducing the risk that estimates simply capture industry-specific trends.

Third, to assess the local impacts of CSR, I use the *Village Potential Statistics* (*Statistik Potensi Desa, or PODES*), a near-universal census of Indonesian villages collected by Statistics Indonesia in 2000, 2003, 2005, 2008, 2011, 2014, 2018, 2019, 2020, and 2021. These data allow me to examine CSR effects on environmental quality and the provision of local public goods. Villages receiving CSR benefits—those hosting firms subject to the CSR law—are identified by linking village data with manufacturing firm locations from the *Manufacturing Industry Directory* compiled by Statistics Indonesia.

Constructing this panel dataset at the village level over two decades is a contribution to the literature that uses the *PODES* data (Martinez-Bravo, 2014; Martinez-Bravo, 2017; Banerjee et al., 2023, among others), which has relied almost exclusively on cross-sectional data. The main challenge arises from the hundreds of district (*kabupaten*) and subdistricts (*kecematan*) splits since the early 2000s, which complicate consistent village identification, especially for villages reassigned to new districts or subdistricts. To resolve this, I compiled information on all administrative reforms since 2000 and matched every province, district and subdistrict, and aggregate villages on the subdistrict level. The resulting panel contains 39,990 observations from 3,990 subdistricts across 10 survey years. Appendix C reports descriptive statistics.

IV. Model

Environmental Performance Score Analysis — To assess the impact of mandatory CSR on firms' environmental performance, I estimate an event-study specification within a triple-difference framework:

$$Score_{it} = \sum_{j \in J}^{2021} \beta_{DDD}^{t=j}(NRBLL_i \times \delta_{t=j}) + \sum_{j \in J}^{2021} \beta_{DD1}^{t=j}(NRB_i \times \delta_{t=j}) + \sum_{j \in J}^{2021} \beta_{DD2}^{t=j}(LL_i \times \delta_{t=j}) + \alpha_i + \delta_{t=j} + \epsilon_{it} \quad (1)$$

where $Score_{it}$ is the PROPER environmental rating of firm i in year t. The estimation sample covers $J = \{2002, 2003, 2004, 2006, 2008, 2009, 2010, 2013, 2014, 2015, 2017, 2018\}$, the years for which ratings are available. I omit 2006 as the reference year, since it immediately precedes the onset of treatment. NRB_i indicates whether the firm operates in a natural-resource-related sector (energy or mining; 78 out of 237 firms) and LL_i indicates limited liability (formally, Indonesia's *Perseroan Terbatas*; 219 out of 237 firms). The $\beta_{DDD}^{t=j}$ coefficients capture dynamic treatment effects for NRB–LL firms relative to the baseline, which constitutes 25.32% (60 out of 237 firms), while $\beta_{DD1}^{t=j}$ and $\beta_{DD2}^{t=j}$ absorb the time-varying effects of NRB or LL status alone. Importantly, $\beta_{DD1}^{t=j}$ and $\beta_{DD2}^{t=j}$ do not the effect of the mandatory CSR at all, as only meeting both criteria and having a value of one for $NRBLL_i$ after 2007 lead to the legal obligation. Firm fixed effects α_i absorb time-invariant firm characteristics, while year fixed effects $\delta_{t=j}$ capture common shocks.

It is worth acknowledging that the sample contains no non-limited-liability, non-natural-resource-business companies. The absence of this pure control group implies that $\sum_{j\in J}^{2021} \beta_{DD2}^{t=j}(LL_i \times \delta_{t=j})$ is omitted in practice. Accordingly, I also report results from a Difference-in-Differences (DD) specification, including the estimates based on Callaway and Sant'Anna (2021):

$$Score_{it} = \sum_{j\in J}^{2021} \beta_{DD}^{t=j}(NRBLL_i \times \delta_{t=j}) + \gamma X_{it} + \alpha_i + \delta_{t=j} + \epsilon_{it} \tag{2}$$

Manufacturing Firm Analysis — To estimate the effects of the CSR mandate, I implement an event-study design within a triple-difference framework:

$$\begin{aligned} Y_{it} = &\sum_{j=2000}^{2015} \beta_{DDD}^{t=j}(NRB_i \times LL_i \times \delta_{t=j}) + \sum_{j=2000}^{2015} \beta_{DD1}^{t=j}(NRB_i \times \delta_{t=j}) + \sum_{j=2000}^{2015} \beta_{DD2}^{t=j}(LL_i \times \delta_{t=j}) \\ &+ \gamma X_{it} + \alpha_i + \delta_{t=j} + \epsilon_{it} \end{aligned} \tag{3}$$

where Y_{it} is the outcome for firm i in year t. The sample spans 2000–2015, with 2006 omitted as the baseline year. As before, NRB_i equals one if the firm operates in a natural-resource-related sector (29.78% of the sample), and LL_i equals one if the firm holds limited-liability status (52.95% of the sample). Table 1 lists the NRB sectors within manufacturing, as defined by Government Regulation No. 47/2012. The $\beta_{DDD}^{t=j}$ coefficients capture dynamic treatment effects for NRB–LL firms (17.26%) relative to the baseline, while $\beta_{DD1}^{t=j}$ and $\beta_{DD2}^{t=j}$ absorb the time-varying effects of NRB or LL status individually. Firm fixed effects α_i account for time-invariant firm traits, and year fixed effects $\delta_{t=j}$ absorb aggregate shocks. The control vector X_{it} includes sector-year fixed effects corresponding to the 23 industry classifications listed in Table 1.

<Table 1>

Village-level Analysis — To evaluate the wider community impacts of CSR obligations, I implement a similar event-study design that leverages variation in firm presence across villages:

$$\begin{aligned} Y_{st} = &\sum_{j\in J} \beta_{DDD}^{t=j}(NRBLL_s \times \delta_{t=j}) + \sum_{j\in J} \beta_{DD1}^{t=j}(NRB_s \times \delta_{t=j}) + \sum_{j\in J} \beta_{DD2}^{t=j}(LL_s \times \delta_{t=j}) \\ &+ \gamma X_{st} + \alpha_s + \delta_{t=j} + \epsilon_{st} \end{aligned} \tag{4}$$

where Y_{st} denotes the outcome for subdistrict s in year t. The estimation sample consists of survey years $J = \{2000, 2003, 2005, 2008, 2011, 2014, 2018, 2019, 2020, 2021\}$, with 2005 omitted as the baseline since it is the last pre-treatment observation. NRB_s and LL_s measure the number of natural-resource businesses (NRB) and limited liability (PT) firms in subdistrict s, respectively (means: 1.87 and 2.99; ≥ 1 for 29.3% and 37.6% of subdistricts), while $NRBLL_s$ counts firms that are both NRB and LL (mean: 0.96; ≥ 1 for 18.8%). The coefficients $\beta_{DDD}^{t=j}$ capture the relative effect of exposure to NRB–LL firms in each year j, compared with the baseline, whereas $\beta_{DD1}^{t=j}$ and $\beta_{DD2}^{t=j}$ capture the separate, time-varying effects associated with NRB-only and LL-only firm presence. Subdistrict fixed effects α_s absorb time-invariant subdistrict characteristics, and year fixed effects $\delta_{t=j}$ account for aggregate shocks. The control vector X_{it} includes province-year fixed effects for each of the 30 provinces.

V. Results

A. Environmental Performance Score Analysis

The empirical analysis begins by testing whether the 2007 CSR mandate achieved its underlying goal of disciplining the environmental conduct of large corporations. I use ministerial environmental assessment data (*PROPER*), which track aggregate trends in large firms' environmental performance. The triple-difference (DDD) specification in equation (1) relies on the standard parallel-trends assumption, while the simpler difference-in-differences (DD) specification in equation (2) applies the same assumption without controlling for NRB- and LL-specific trends. These assumptions are evaluated using both trend plots and event-study estimates. Figure D1 (1) displays standardized environmental performance scores for NRB–LL firms (treatment group) and other firms (control group) within a DD framework, with dotted vertical lines marking the introduction of the CSR law in 2007. The figure shows that the two groups followed nearly parallel trends prior to 2007 but diverged sharply thereafter.

<Figure 2>

<Table 2>

Figure 2 and Figure D1 (2) show that event-study estimates from both the DDD and DD specifications are statistically indistinguishable from zero before 2007, providing implicit support to the parallel trends assumption, but turn positive thereafter. The baseline DDD and DD estimates imply that the CSR mandate raised environmental scores by 0.484 and 0.371 standard deviations, respectively (Table 2). The DD estimate adjusted for multiple hypotheses (Callaway and Sant'Anna, 2021) yields a smaller effect, 0.275 standard deviations, but still indicates a significant improvement. Overall, these results demonstrate that the 2007 CSR law enhanced environmental performance among firms in natural-resource-intensive sectors, particularly those in energy and mining. Yet key questions remain. How did these environmental improvements affect firm profitability and production? And through what channels did they arise? The next section turns to detailed manufacturing firm data to explore these mechanisms.

B. Manufacturing Firm Analysis

This section turns to firm-level outcomes on production and profitability to shed light on the mechanisms behind, and the consequences of, improved environmental performance. I estimate the triple-difference model in equation (3), where the treated group consists of limited liability (LL) firms operating in natural-resource-based industries (NRB). The preferred specification includes sector-by-year fixed effects, allowing 23 manufacturing subsectors to follow their own trends. All event-study figures are based on this specification, while the tables report both a parsimonious model without sector-specific trends (odd-numbered columns) and the preferred specification (even-numbered columns). Acknowledging that some firms self-generate electricity, I report separate results for electricity generation in Appendix E.[11] As shown later, the results are qualitatively unchanged whether we analyze total firm activity (including power generation) or restrict attention to manufacturing production.

Production — I begin by asking whether the observed improvements stem from how firms produce (through technology adoption or input substitution) or from how much they produce (scale effects). Distinguishing between these mechanisms is critical for interpreting the law's broader economic impact. Table 3 reports DDD estimates for output, productivity, and a range of inputs, and Figure D2 plots the corresponding event-study estimates. Table 3 (a) shows that production or productivity (measured by the ratio of active to total production units) did not change following the CSR mandate. The DDD estimates in columns (2) and (4) are indistinguishable from zero. Consistent with this, Figure D2 (a-1) and (a-2) show event-study coefficients centered around zero. Likewise, electricity generation and generator efficiency were unaffected (Appendix E). Taken together, improvements in environmental performance were not driven by reductions in production.

I find no effects on major production inputs. As shown in Table 3 (b) and (c)—particularly columns (2), (4), (6), and (8)—and Figure D2 (b-1) to (c-4) show null DDD estimates and flat event-study coefficients for fuels, lubricants, raw materials, labor, capital, and land. Figure

[11] As of 2006, 17.5% of manufacturing firms generated their own electricity to ensure stable access during outages and to sell excess supply to other users (Brucal et al., 2019).

D3 and Table D1 similarly offer no evidence of any change in capital and land transactions.[12] There is suggestive evidence of a shift in capital sources from government to domestic private providers (Figure D4; Table D2), though pre-treatment instability in Figure D4 suggests potential overestimation in Table D2. I discuss this capital source switching in Section VI-A. Overall, the mandate did not affect major input quantities.

<Table 3>

Although aggregate input use did not change with the CSR mandate, disaggregated fuel measures reveal meaningful shifts. Figure 3 and Table 4 show that coal use declined while LPG use rose following the policy: Expenditure on coal declines by 24%, while expenditure on LPG rises by 25%; both estimates are statistically different from zero at the 5% level. These results hold when measured in physical quantities as well as in expenditures (Figure D5; Table D3), indicating that the shift reflects changes in input mix rather than input prices. To assess the environmental implications, Table D4 reports CO_2 emissions per mmBTU by fuel type. Coal, the reduced input, is the most carbon-intensive fuel, while LPG, the increased input, is the second cleanest. This substitution therefore should lead to a substantial reduction in emissions.

<Table 4>

<Figure 3>

Table 5 and Figure 4 confirm that treated firms reduced both CO_2 emissions and energy use.[13] Results are robust to including or excluding power generation, which is examined separately in Appendix E. One limitation is that these results omit natural gas and LPG, which appear in questionnaires only for 2000 and 2006-2015. Table D5 and Figure D6 re-estimate emissions including them while dropping 2001-2005 observations. The CO_2 coefficient estimate falls to 33% (now reflecting increased LPG use), gets less precise due to fewer observations, yet remains statistically significant at the 10% level. Overall, treated firms reduced emissions and energy use by substituting LPG for coal.

<Table 5>

<Figure 4>

[12]Two caveats, however, merit discussion. First, capital and land values rise in one post-treatment year (Figure D2 (c-3) and (c-4)), though DDD estimates remain insignificant (Table 3 (c), columns (6) and (8)). Second, event-study coefficients show pre-treatment fluctuations in land and capital transactions (Figure D3), undermining the parallel trends assumption. While the limitation should be acknowledged, corresponding DDD estimates are not statistically different from zero.

[13]Fuel inputs are converted into energy (mmBTU) and CO_2 emissions using the USEPA's Emission Factors for Greenhouse Gas Inventories (2025). Brucal et al. (2019) employs the same source for Indonesia's manufacturing survey. Appendix F provides conversion details.

Profit, revenue, expenditure, and exit — Improved environmental performance could increase profits by attracting customers and investors (Kotchen, 2006) or reduce profits through adjustment costs deviating from conventional modes of production (Chen et al., 2018). Table 6 and Figure D7 indicate no significant effects on profits, revenues, expenses or exit rates.[14][15] Donation expenses, often viewed as a salient form of CSR spending, also remained unchanged. The mandate thus induced environmental improvements without reducing profitability.

<Table 6>

C. Village-level Analysis

This section examines whether mandatory CSR generated local benefits, focusing on environmental conditions and public goods provision.

Pollution — I test whether villages reported fewer pollution incidents to local administrations, which is measured as indicators, not counts. Figure 5 (1) shows declining pollution reports in villages with treated firms. Panels (2)–(4) reveal concentrated reductions in water pollution. DDD estimates in Table 7 show that each additional NRB–LL firm per subdistrict reduced any-pollution incidence by 0.672 percentage points (3.2% relative to the mean) and water pollution by 0.932 percentage points (7.2% relative to the mean). Reduced coal use likely drove water pollution declines, consistent with evidence on coal's water quality impacts (Chai et al., 2018; Kondash et al., 2019; Wang et al., 2022). Air and soil pollution show no significant changes.

Alternative mechanisms do not explain these patterns. Figure D8 (1) and Table D6 (2) show no change in waste disposal into rivers, ruling out household waste as a channel. Figure D8 (2)–(3) and Table D6 (4) and (6) show no decline in industrial river use or mining activity, ruling out reduced industrial activities as an explanation.

<Table 7>

<Figure 5>

Public goods provision — Beyond pollution reduction, I examine whether mandatory CSR induced public goods provision by firms as in Cramer et al. (2025). Figure D9 and Table 8 check education, health, and crime outcomes. Despite some pre-treatment fluctuations

[14] Markup equals (total output value - total production expenses) / total production expenses.

[15] Exit is defined as consecutive absence from the manufacturing survey post-2007. This approach uses the balanced pre-2007 sample, mechanically generating zero pre-treatment coefficients in Figure D7. An alternative approach allowing pre-treatment exit is infeasible because legal status (the treatment criterion) is unavailable or inconsistently defined outside 2006.

in panels (1) and (4), DDD estimates are consistently zero. Overall, the mandate does not appear to affect local public goods provision. This also suggests that the observed pollution reductions are unlikely to reflect correlated infrastructure upgrading.

<Table 8>

VI. Discussions

The empirical evidence demonstrates that firms improved their environmental performance by shifting from coal to LPG, with positive spillovers to village-level environmental conditions, as reflected in fewer pollution incidents. These findings raise three questions: Why was the mandate effective despite weak enforcement? Why was fuel substitution relatively inexpensive? And how does mandatory CSR compare to traditional environmental regulation? This section explores these mechanisms and policy implications

A. Why Was the CSR Law Effective?

Heterogeneity analysis reveals which firm types drove environmental improvements. Table 9 Panel (a) shows a distinctive age pattern: firms in the 25th–50th age percentile (Q2) reduced CO_2 emissions significantly more than older or younger counterparts. By contrast, columns (3)–(6) detect no significant heterogeneity by size (labor or capital), and Panel (b) shows no differential effects by R&D intensity, advertising expenditure, or prior environmental awareness. Therefore, this distinctive age heterogeneity is unlikely to be explained by correlations with these characteristics, such as young firms average tendency of being plausibly small, more active in R&D, sensitive to public images, or pro-environmental.

<Table 9>

Relational contracts — The age-heterogeneous response pattern resonates with relational contracts as the enforcement mechanism. While firms typically view CSR as an operational burden—opposition from the business sector even culminated in a constitutional court challenge—established relationships with local communities create incentives to channel resources to stakeholders. Figure 5 Panel (a) documents an inverse-U-shaped relationship between CSR responsiveness and firm age, with peak environmental improvements among middle-aged firms. Panel (b) confirms this pattern through event study estimates.

This age pattern aligns with theory on relational contracting (Macchiavello and Morjaria, 2015; McMillan and Woodruff, 1999). The inverse-U shape emerges from two countervailing forces. First, older firms with deeper community ties have stronger incentives to contribute locally through CSR. Second, CSR's signaling value for building long-term relationships diminishes as relationships mature. Young firms gain substantial reputational benefits from demonstrating commitment to stakeholders, but these signaling returns decline for established firms whose reliability is already known. The result is peak CSR responsiveness among middle-aged firms—old enough to have developed meaningful stakeholder relationships, yet young enough that signaling future reliability remains valuable.

<figure 5>

To test whether local stakeholder relationships drive compliance, I examine heterogeneity by capital source using manufacturing survey data reporting capital shares from four origins: central government, local governments, national private enterprises or Indonesian citizens, and foreign investors. Three stylized facts characterize the data. First, 86.15% of firms derive at least 50% of capital from national private sources, compared to only 2.31%, 1.92%, and 10.11% for central government, local governments, and foreign investors respectively.[16] Second, firms typically rely on a single capital source: 84.01% finance exclusively through national private enterprises, with only 2.16%, 1.83%, and 5.00% financing exclusively through central government, local governments, and foreign investors respectively. Third, Table D2 and Figure D4 show that capital source distributions shifted from local governments to national private providers, while overestimation is likely due to pre-treatment trends, following the mandate.[17]

Figure 5 Panel (c) shows that environmental improvements appear only among firms with majority capital from national private sources (dark blue line), while firms relying on government or foreign capital show no particular response. Although Table 9 Panel (b) column (1) yields an insignificant DDD coefficient interacted with domestic private capital (potentially due to limited benchmark observations, given 86% of firms source capital domestically), the event study pattern strongly suggests that local capital relationships drive compliance. This finding is intuitive: Law No. 40/2007 defines CSR as benefiting "the company itself, [and] local communities," explicitly designating local stakeholders as targets. When capital originates locally, firms have stronger incentives to deliver tangible benefits to communities on which their financing depends. Moreover, the shift in capital sources toward domestic private providers (Table D2; Figure D4) underscores their increasingly dominant role and firms' limited outside options at the time. In this climate, firms embedded in local capital networks face stronger incentives to protect communal environmental assets.

[16] Capital sourced from central government refers to the state budget (Anggaran Pendapatan dan Belanja Negara), from local governments to regional budgets (Anggaran Pendapatan dan Belanja Daerah), from national private to national private enterprises and/or Indonesian citizens, and from foreign investors to foreign governments, citizens, and/or parties (2006 Annual Manufacturing Survey).

[17] Gehrke et al. (2025) study Indonesia's protectionist policies discouraging foreign capital inflows in the 2000s. Table D2 and Figure D4 show no differential foreign capital loss among NRB-LL firms.

Surrounding CSR regulations — Supplementary regulations introduced tax incentives and sanctions beyond Law No. 40/2007 Article 74, but these do not explain the observed environmental improvements. Government Regulation No.93/2010 (December 2010) added tax incentives for specific CSR activities, including education provision. However, Table 8 and Figure D9 show no change in private education infrastructure, indicating tax incentives played no role in compliance.

Similarly, Government Regulation No. 23/2010 and Indonesian Investment Law No. 25/2007 imposed stricter sanctions on mining-sector firms and investment companies (see Appendix A). This cross-sectional variation in sanction stringency provides a test of formal enforcement mechanisms. Table 9 (b) columns (4) and (5) show no differential emission reductions for firms facing stricter sanctions—neither mining-related manufacturers nor investment firms (41.53% of the sample) exhibit larger treatment effects.[18] These null results rule out formal sanctions as a compliance mechanism in the manufacturing industry.[19]

In summary, mandatory CSR achieved compliance not through formal enforcement but through relational contracts with local stakeholders. The inverse-U-shaped age response reflects the evolution of relationship value: middle-aged firms balance established community ties with high marginal returns to signaling commitment. Compliance concentrated among firms with domestic private capital confirms that local stakeholder relationships—not government sanctions or foreign investor pressure—drove environmental improvements.

B. How Did Firms Finance the Shift to Cleaner Fuel?

Budget reallocation — Earlier results show that profits, revenues, expenditures, and exit rates were unchanged despite fuel substitution and improvements in environmental performance. The remaining question is how firms financed the adjustment. I first examine shifts in expenditure shares. Figure 5 (1) and Table 10 column (2) documents a significant rise in the *share* of production-related fuel costs, while Figure D2 (b-2) and Table 3 (b) column (2) show no significant change in the *level* of production-related fuel spending. This pattern indicates that the adjustment cost operated through composition rather than scale.

<Table 10>

[18]Mining-related firms include manufacturers in sectors 23, 26, 27, or 28 (Table 1; 13.73% of sample) and coal-consuming firms as of 2006 (3.59% of sample).

[19]Earlier, Figure 1 shows that listed energy firms exhibit sharply steeper CSR disclosure trends beginning around 2010, when GR No.23/2010 imposed stricter sanctions, providing suggestive evidence of sanction effectiveness within the highly regulated energy sector. The null sanction effects documented in Table 9 (b) columns (4) and (5) should therefore be interpreted as specific to the manufacturing context, where formal enforcement appears less binding than in the energy sector.

<Figure 5>

I next examine how the higher relative fuel cost was accommodated. Figure 5 (6) and Table 10 column (12) show a decline in the share of miscellaneous expenses.[20] The 1.115-percentage-point reduction in the miscellaneous share roughly offsets the 1.017-point increase in the production-related fuel share. Together, these results indicate that firms financed the relative rise in fuel costs by cutting miscellaneous spending, enabling flexible reallocation and cushioning the cost shock.

To further identify which expense category was tightened within the miscellaneous budget, I check storage management outcomes, while other outcomes such as R&D and pollution prevention data are not available across years. Table D7 document declines in raw material stock. Corresponding event study (Figure D11) confirms declining trends emerging upon the onset of mandatory CSR not only in raw material stock but also in finished output stock. This decline in stock could be seen as suggestive evidence of less space usage for storage, which likely enables firms to yield spare budget that can readily be allocated to increasing fuel costs.

Exit increases — The preceding analysis documents that firms adapted to increased relative fuel costs by reallocating budgets from miscellaneous expenses. However, the aggregate coping pattern or the earlier null average effect on firm performance does not inform whether all firms managed to absorb the fuel cost increase. Table 11 and Figure 8 examine exit rates—defined as consecutive absence from the manufacturing survey post-2007. Panel (a) column (2) shows that Q2 firms (25th–50th age percentile) experienced significantly elevated exit rates by 0.821 percentage points at the 10% level, with column (1) indicating even stronger effects for the young group below the median firm age (1.370 points, significant at the 1% level). Corresponding event study in Figure 8 confirms this pattern: Q1 and Q2 firms exhibit rising post-treatment exit probabilities, while Q3 and Q4 firms show little to no change.

The concentration of exits among young and middle-aged firms—precisely the cohorts exhibiting the strongest environmental improvements—reveals that adaptation imposed real costs. While the mandate did not reduce average profitability, it required budget reallocation that some firms could not manage. Those unable to absorb the relative fuel cost increase faced exit. This pattern suggests mandatory CSR imposes compositional effects: it selectively eliminates polluting firms during intermediate growth stages.

<Table 11>

[20] Miscellaneous expenses include management fees, promotion/advertising, water, post, telephone, facsimile, travel expenses, environmental pollution prevention, R&D, and human resource development.

<Figure 8>

Fuel subsidization — In principle, higher LPG demand and lower coal demand could induce general-equilibrium price movements, raising LPG prices and lowering coal prices and thus making a switch to cleaner fuels more costly and less likely. In Indonesia, however, this concern appears limited: triple-difference estimates in Table 10 indicate no statistically significant changes in fuel prices for NRB–LL firms after the CSR mandate.

<Table 12>

Limited price responses are likely explained by government subsidization of coal alternatives. During the period surrounding the CSR mandate, LPG, kerosene, gasoline, and diesel were subsidized, although the size of subsidies was on a declining trend (Savatic, 2016; Ihsan et al., 2024). Crucially, subsidy regimes did not change around 2007 nor differentially target NRB–LL firms, rendering subsidies an unlikely confounder for the observed improvements in environmental performance. Consistent with this interpretation, no distinctive fuel price trends for NRB–LL firms are observed in the corresponding event study (Figure D12). Moreover, Table D8 shows that key results are robust to the inclusion of controls for fuel prices interacted with sector to capture sector-specific price effects. These results reinforce the conclusion that subsidization played a limited role in triggering the fuel adjustment, but only sustained fuel prices and facilitated long-run fuel switching.

C. Comparing the CSR Law with Traditional Environmental Regulation

Internalization of environmental costs — I examine whether the post-mandate improvement in environmental performance arose because previously less environmentally aware firms began to internalize environmental costs, or because already green firms intensified their efforts. If the former, the CSR law operates analogously to traditional environmental regulation, which typically targets poorer environmental performers.

To investigate this mechanism, I analyze heterogeneity using the subset of firms (12.72% of the sample) that reported positive pollution-prevention expenditures in 2006, the final pre-mandate year and the only year with this measure. While the motive for these expenditures is unobserved, I treat these firms as more environmentally aware at baseline and compare the magnitude of their subsequent improvements in environmental performance.

Figure 9 shows that the post-mandate downward trend appears only among firms that had not undertaken pollution-prevention spending in 2006, or those previously less environmentally aware. By contrast, firms with prior environmental efforts exhibit no distinctive post-treatment declines. Their negative, non-parallel pre-trends may suggest limited room for additional improvement and explain the insignificant triple-difference estimate in Table

9 (b) column (8). Taken together, this evidence indicates that the observed enhancement reflects extensive-margin internalization, with previously inactive firms beginning to bear environmental costs. In this respect, the CSR law resembles traditional environmental regulation in the profile of firms affected by their prior environmental performance.

<Figure 9>

Theoretical framework (in progress) — The evidence demonstrates that mandatory CSR induced extensive-margin internalization: previously noncompliant firms began bearing environmental costs. In this respect, the policy resembles traditional environmental regulation that typically target polluting firms.

However, the age-heterogeneous response differentiates mandatory CSR from traditional regulation in economically meaningful ways. Traditional carbon taxes impose permanent, age-invariant emission prices. Mandatory CSR instead generates concentrated CO_2 reductions among middle-aged firms that dissipate with firm age—functioning as a temporary carbon price targeted at specific cohorts. To formalize this distinction, I extend Golosov et al. (2014)'s optimal carbon tax model. Their framework characterizes the optimal uniform carbon tax balancing current consumption against future climate damages in a dynamic general equilibrium setting. I modify their model to incorporate an inverse-U-shaped social cost of emissions that varies with firm age, where representative firms age over time. This modification generates temporary policy effectiveness peaking for the middle-aged phase, replicating the observed treatment effects. Appendix G derives the extended model in detail.

Moreover, mandatory CSR can be different from traditional regulation due to its exit patterns in Table 11 and Figure 8, which can lead to compositional effects through selective survival. Mandatory CSR promotes exit of polluting firms during intermediate growth stages, potentially generating long-run improvements in surviving firms' environmental profiles. This compositional benefit entails short-run costs—output losses and unemployment from exits. Traditional regulation, targeting large established firms with lower exit risk and higher environmental burden, generates limited compositional effects while avoiding exit-related costs. The welfare implications depend on the trade-off between long-run compositional gains and short-run adjustment costs. Quantifying this trade-off through a model incorporating both firm aging and endogenous exit remains ongoing work.[21]

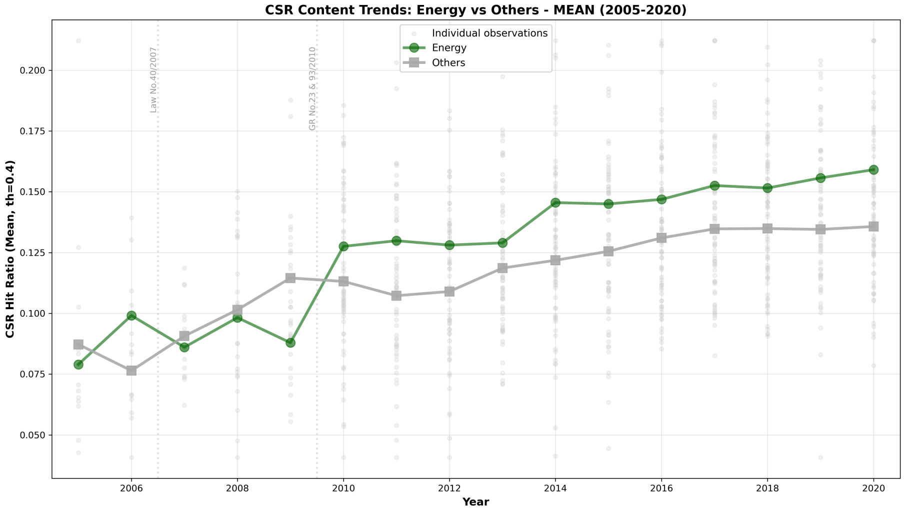
[21] Another point is that the government does not collect tax revenue through CSR unlike carbon tax. However, CSR circumvents deadweight loss due to inefficiency in running carbon tax, such as monitoring and reporting costs and bureaucratic burden. Without detailed dataset on these aspects, the priority for modeling would be age-specific effectiveness and exit patterns.

VII. Conclusion

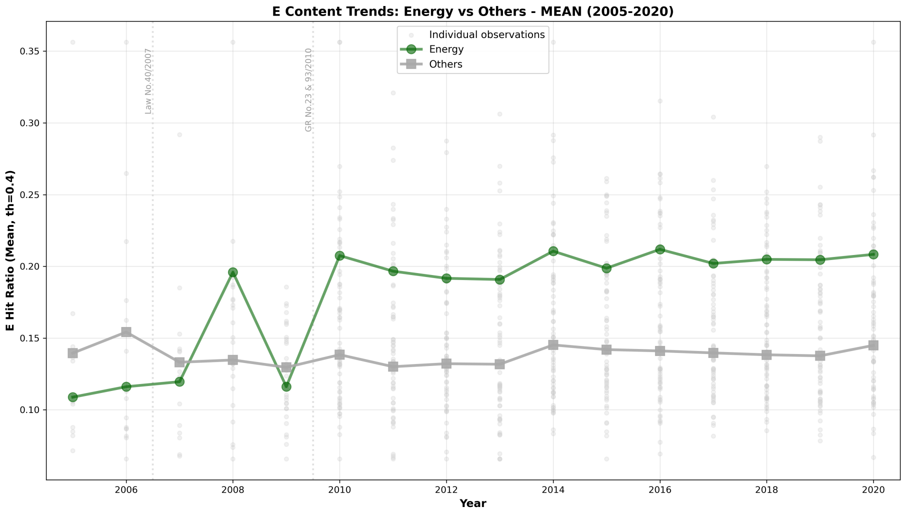
This paper examines how Corporate Social Responsibility (CSR)—the integration of social, environmental, and ethical values into business practices—affects firms' profits, production, and environmental outcomes in Indonesia. To address endogenous CSR adoption, I exploit the 2007 mandate requiring CSR among limited-liability firms in natural-resource–related activities. I first document rising CSR disclosure trends among publicly listed treated firms, particularly in social, environmental, and CO_2-related content in annual reports. Triple-difference analyses show that the mandate improved environmental performance ratings and reduced carbon emissions by inducing firms to shift from coal, the most carbon-intensive fuel, to LPG, a cleaner alternative. Firms accomplished this transition through expenditure reallocation, leaving profits, output, revenue, and total expenses unchanged. Despite limited formal monitoring and enforcement, relational motives, particularly ties with local capital providers, strengthened CSR incentives. Consistent with this, mid-young firms that likely have the strongest relation-building incentives exhibited greater environmental upgrading, while uniquely incurring firm exits. Reflecting these firm-level results, village-level evidence shows fewer reported pollution incidents where CSR-obligated firms operate. By facilitating extensive-margin internalization of environmental costs, legal CSR mandates can have comparable effects to traditional environmental regulation. Yet, its age heterogeneity makes its effectiveness short-lived and exit risk for mid-young firms shapes firm composition and welfare differently.

Figure 1: Trends of Annual Report Contents

(1) Ratio of CSR-related sentences



(2) Ratio of Environment-related sentences



(3) Ratio of Society-related sentences

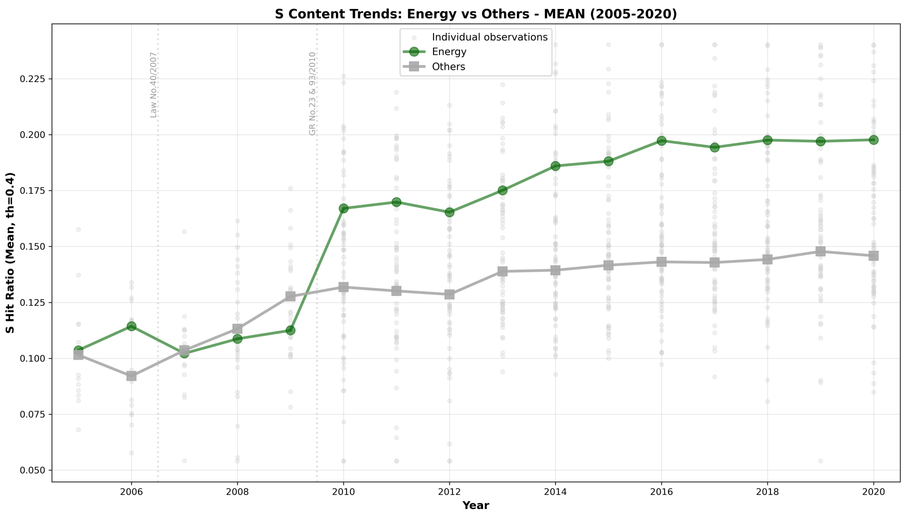
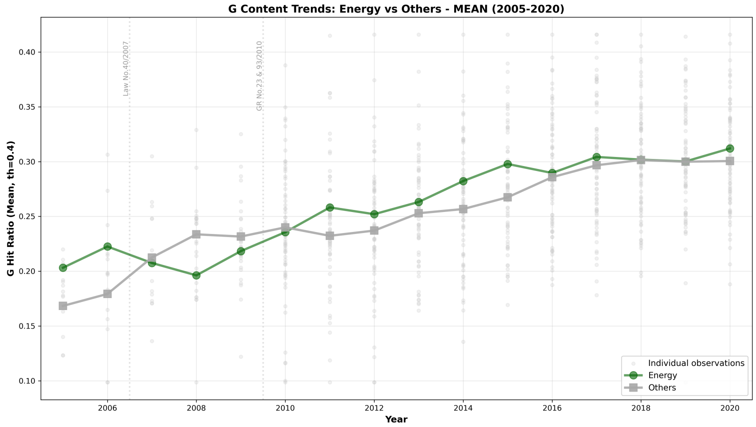
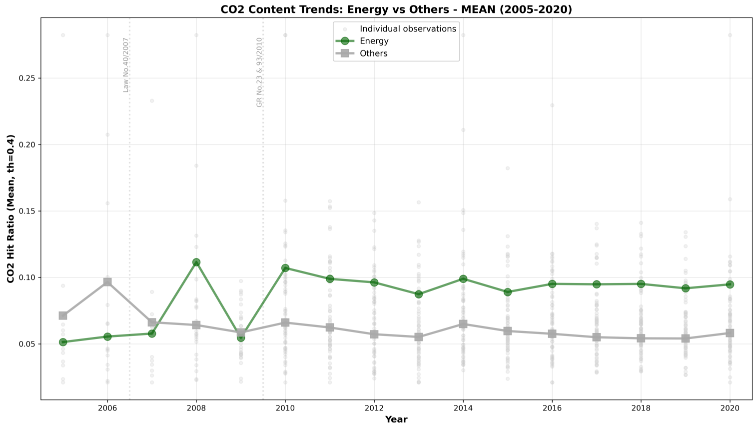


Figure 1: Trends of Annual Report Contents (Continued)

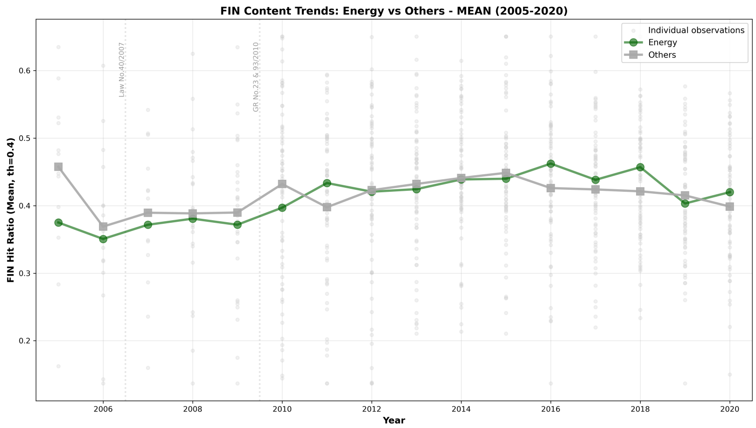
(4) Ratio of Governance-related sentences



(5) Ratio of CO_2-related sentences



(6) Ratio of Finance-related sentences

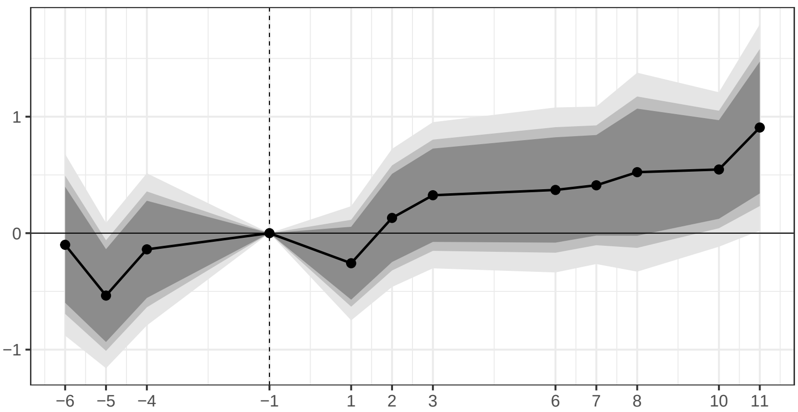


Notes: This figure plots annual report content trends using all available reports from publicly listed firms listed before 2015. The green line shows yearly average hit ratios—the share of sentences semantically similar to category-specific keywords (CSR, Environment, Society, Governance, CO_2, and Finance)—for the energy sector, which contains mining companies under Indonesian Stock Exchange classification and faces the strongest CSR regulatory pressure. The gray line shows yearly average hit ratios for non-energy sectors. Because this analysis uses only publicly listed firms and does not exploit limited liability status variation, it does not fully separate out the causal effect of Law No.40/2007 from sectoral trends. The patterns provide suggestive evidence that CSR-related regulations contributed to increasing disclosure of CSR, environmental, social, and CO_2 content. See Appendix B for details.

Table 1: Definition of Natural Resource Businesses for Firm- and Village-level Analyses

KBLI 2-digit	Freq.	Percent	NRB	
15	1,993	22.5		15 - Manufacture of food products and beverages
16	242	2.73		16 - Manufacture of tobacco products
17	895	10.11		17 - Manufacture of textiles
18	655	7.4		18 - Manufacture of wearing apparel; dressing and dyeing of fur
19	237	2.68		19 - Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwea
20	342	3.86	o	20 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21	218	2.46	o	21 - Manufacture of paper and paper products
22	209	2.36		22 - Publishing, printing and reproduction of recorded media
23	29	0.33	o	23 - Manufacture of coke/coal, refined petroleum products and nuclear fuel
24	624	7.05		24 - Manufacture of chemicals and chemical products
25	862	9.73	o	25 - Manufacture of rubber and plastics products
26	639	7.21	o	26 - Manufacture of other non-metallic mineral products
27	135	1.52	o	27 - Manufacture of basic metals
28	413	4.66	o	28 - Manufacture of fabricated metal products, except machinery and equipment
29	241	2.72		29 - Manufacture of machinery and equipment n.e.c.
30	1	0.01		30 - Manufacture of office, accounting and computing machinery
31	149	1.68		31 - Manufacture of electrical machinery and apparatus n.e.c.
32	46	0.52		32 - Manufacture of radio, television and communication equipment and apparatus
33	29	0.33		33 - Manufacture of medical, precision and optical instruments, watches and clocks
34	166	1.87		34 - Manufacture of motor vehicles, trailers and semi-trailers
35	130	1.47		35 - Manufacture of other transport equipment
36	585	6.6		36 - Manufacture of furniture; manufacturing n.e.c.
37	17	0.19		37 - Recycling
Total	8,857	100		

Figure 2: Event Study of Standardized Environment Performance



Notes: This figure presents event study estimates of standardized environmental performance scores using equation (1), a triple-difference specification. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

Table 2: DDD/DD Analysis of Standardized Environment Performance

	(1)	(2)	(3)
	DDD specification	DD specification	
		Basic DD	CS (2021)
VARIABLES	Standardized environmental performance score		
DD(D) (NRB x LL)	0.48423***	0.37127***	0.27490*
	(0.14064)	(0.11695)	(0.13513)
DD (NRB)	-0.12627		
	(0.11721)		
Observations	2,032	2,032	2,032
R-squared	0.45581	0.45586	-
Establishment FE	Y	Y	Y
Year FE	Y	Y	Y

Notes: This table presents triple-difference and difference-in-differences estimates of the CSR mandate's effect on standardized environmental performance scores. Column (1) uses equation (1) with the full DDD specification. Column (2) uses equation (2) with the DD specification. Column (3) employs the Callaway and Sant'Anna (2021) DD estimator. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 3: Triple-Difference Analysis of Output, Productivity, and Input

(a) Output and Productivity

	(1)	(2)	(3)	(4)
VARIABLES	log (output value)		log (active production unit ratio)	
DDD (NRB x LL)	-0.00478	-0.03981	1.23284	-0.32457
	(0.10545)	(0.11391)	(1.14532)	(1.18540)
DD (NRB)	-0.11745*	-0.10460	3.37982***	3.39607***
	(0.06972)	(0.07404)	(0.62896)	(0.65867)
DD (LL)	0.00941	-0.37392	-3.85737***	-0.33479
	(0.07179)	(0.23247)	(0.78410)	(2.53648)
Observations	141,712	141,712	139,134	139,134
R-squared	0.72257	0.72516	0.41112	0.41694
Establishment FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y

(b) Fuel, Material and Lubricant Inputs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	log (total fuel expense)		log (production-related fuel expense)		log (total material expense)		log (total lubricant expense)	
DDD (NRB x LL)	-0.02441	0.00084	-0.05185	-0.02112	-0.00671	0.02854	-0.28361*	-0.11539
	(0.10798)	(0.11634)	(0.12247)	(0.13297)	(0.09501)	(0.10340)	(0.15650)	(0.16595)
DD (NRB)	-0.22137***	-0.23428***	-0.11637*	-0.11870	-0.14147**	-0.14811**	-0.31608***	-0.36509***
	(0.06234)	(0.06525)	(0.06941)	(0.07358)	(0.06162)	(0.06568)	(0.08752)	(0.09191)
DD (LL)	-0.03945	0.02463	-0.06656	0.12400	0.08809	-0.03306	0.29270***	0.88085***
	(0.06901)	(0.21476)	(0.07777)	(0.23938)	(0.06665)	(0.19981)	(0.10252)	(0.33109)
Observations	141,711	141,711	141,685	141,685	141,712	141,712	141,712	141,712
R-squared	0.61832	0.62087	0.55538	0.55786	0.69941	0.70225	0.53664	0.53901
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y	N	Y	N	Y

(c) Other Inputs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	log (total number of workers)		log (total wage expense)		log (estimated total capital value)		log (estimated total land value)	
DDD (NRB x LL)	-0.01665	-0.00319	-0.05450*	-0.01434	0.24065	0.21396	0.14209	0.06799
	(0.02407)	(0.02590)	(0.03301)	(0.03577)	(0.29561)	(0.31562)	(0.27344)	(0.29231)
DD (NRB)	-0.01041	-0.02528*	-0.04751**	-0.06872***	-0.99872***	-0.94828***	-0.76360***	-0.65690***
	(0.01340)	(0.01436)	(0.01852)	(0.01963)	(0.16736)	(0.17660)	(0.15236)	(0.16027)
DD (LL)	0.02715	0.01186	0.06931***	0.02803	-0.40665**	0.27912	-0.32177*	0.22770
	(0.01674)	(0.05412)	(0.02344)	(0.07680)	(0.18706)	(0.53016)	(0.17890)	(0.49190)
Observations	141,712	141,712	132,855	132,855	132,850	132,850	132,849	132,849
R-squared	0.87919	0.88040	0.79061	0.79562	0.48315	0.48643	0.49695	0.49994
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y	N	Y	N	Y

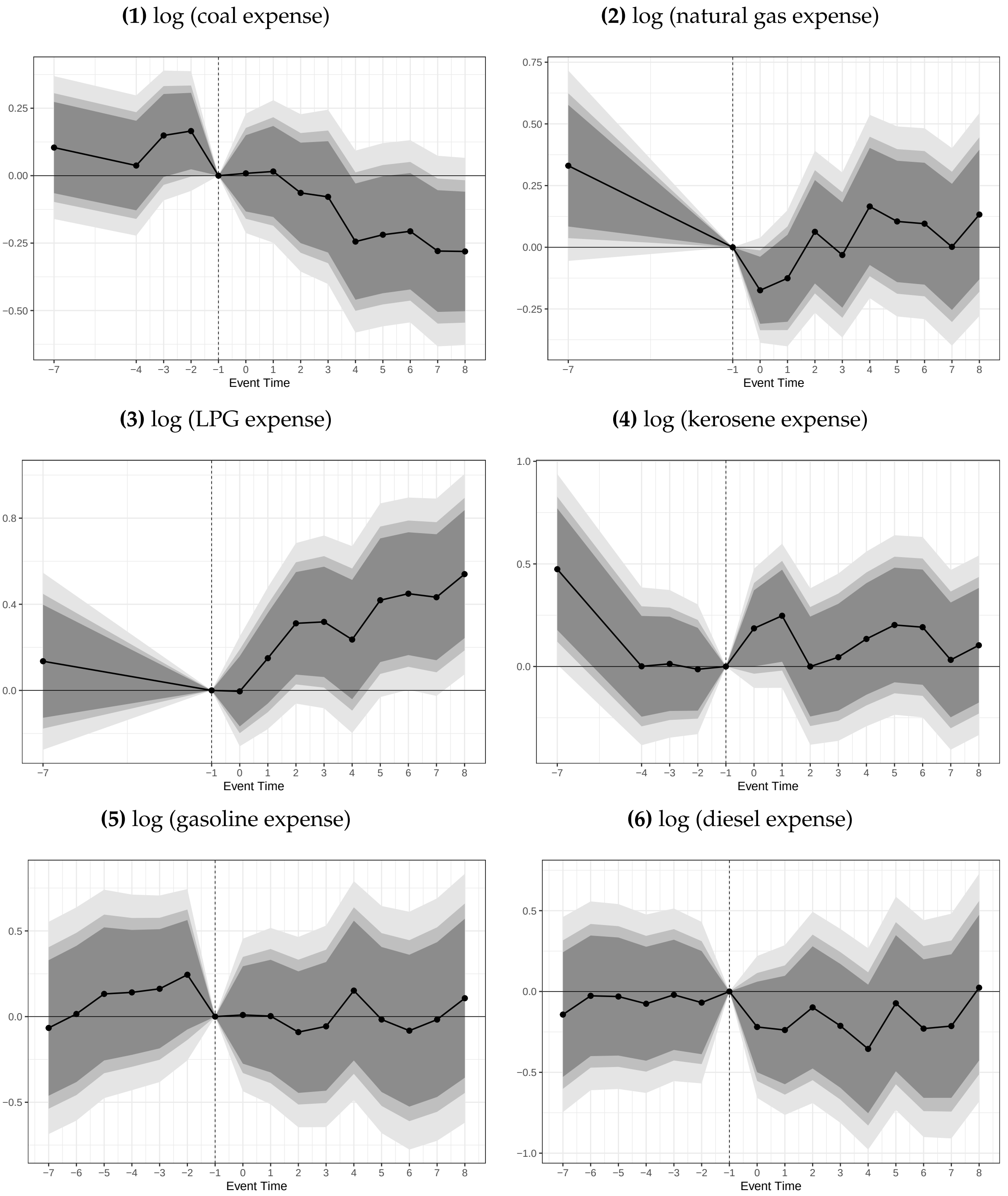
Notes: This table presents triple-difference estimates of the CSR mandate's effects on manufacturing firm outcomes using equation (3). Panel (a) examines output and productivity measures, panel (b) examines fuel, material, and lubricant inputs, and panel (c) examines other input factors. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4: Triple-Difference Analysis of Fuel Inputs (Expenditure)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
					Fuel input expense							
VARIABLES	log (coal expense)		log (natural gas expense)		log (LPG expense)		log (kerosene expense)		log (gasoline expense)		log (diesel expense)	
DDD (NRB x LL)	-0.04364	-0.24103**	-0.06144	-0.13957	0.47691***	0.24915**	-0.05642	0.03202	-0.02935	-0.08908	-0.36597**	-0.12735
	(0.10031)	(0.10921)	(0.10024)	(0.10956)	(0.11637)	(0.12469)	(0.11247)	(0.11316)	(0.17480)	(0.18626)	(0.17112)	(0.18117)
DD (NRB)	0.47815***	0.62145***	0.43401***	0.45577***	-0.55391***	-0.42901***	0.57894***	0.40054***	-0.22345**	-0.21292**	-0.41699***	-0.48181***
	(0.06785)	(0.07291)	(0.05265)	(0.05775)	(0.07340)	(0.07541)	(0.06694)	(0.06742)	(0.09566)	(0.10005)	(0.09584)	(0.10067)
DD (LL)	-0.36810***	-0.88058***	0.01022	0.50290**	-0.63176***	-0.45118	0.18439**	0.67305**	0.07598	0.26310	0.57253***	-0.38125
	(0.05227)	(0.14523)	(0.04784)	(0.24871)	(0.07495)	(0.30149)	(0.08982)	(0.26432)	(0.12334)	(0.35018)	(0.11700)	(0.35723)
Observations	123,998	123,998	97,427	97,427	97,427	97,427	123,998	123,998	141,712	141,712	141,712	141,712
R-squared	0.58351	0.59808	0.65874	0.66139	0.58014	0.58387	0.52013	0.52778	0.56859	0.57069	0.63180	0.63549
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y

Notes: This table presents triple-difference estimates of the CSR mandate's effects on fuel input expenditures by fuel type using equation (3). The analysis examines coal, natural gas, LPG, kerosene, gasoline, and diesel expenses. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure 3: Event Study of Fuel Inputs (Expenditure)



Notes: This figure presents event study estimates of fuel input expenditures by fuel type using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

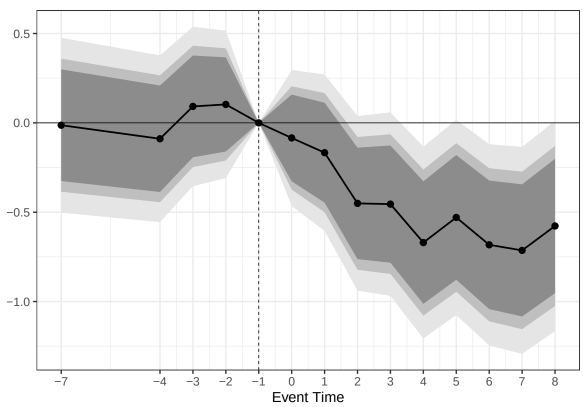
Table 5: Triple-Difference Analysis of Energy Use and CO_2 Emission

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	log (total energy use)		log (production-related energy use)		log (total CO_2 emission)		log (production-related CO_2 emission)	
DDD (NRB x LL)	-0.45788***	-0.49964***	-0.52339***	-0.58669***	-0.62437***	-0.62411***	-0.70207***	-0.72581***
	(0.14846)	(0.15880)	(0.15839)	(0.17084)	(0.18260)	(0.19354)	(0.19935)	(0.21369)
DD (NRB)	0.25241***	0.31764***	0.42365***	0.49330***	0.25259**	0.31074***	0.48620***	0.54894***
	(0.09125)	(0.09677)	(0.09649)	(0.10271)	(0.10979)	(0.11543)	(0.11840)	(0.12532)
DD (LL)	0.05444	-0.58845**	0.09268	-0.17410	0.21727*	-0.52501	0.24607*	-0.02854
	(0.09278)	(0.28355)	(0.10038)	(0.28749)	(0.11904)	(0.35279)	(0.13109)	(0.36813)
Observations	123,998	123,998	115,130	115,130	123,998	123,998	115,130	115,130
R-squared	0.62593	0.62992	0.60690	0.61045	0.59874	0.60225	0.57596	0.57908
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y	N	Y	N	Y

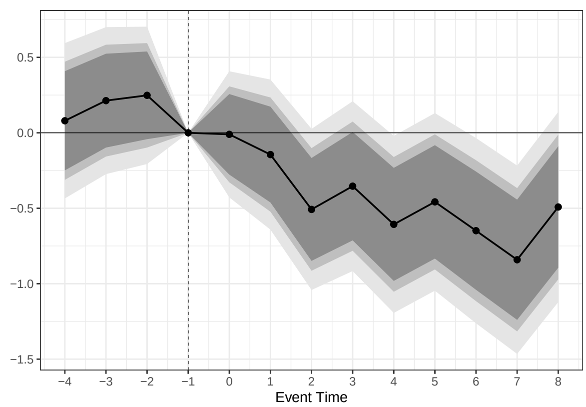
Notes: This table presents triple-difference estimates of the CSR mandate's effects on energy use and CO2 emissions using equation (3). The analysis examines both total and production-related measures. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure 4: Event Study of Energy Use and CO_2 Emission

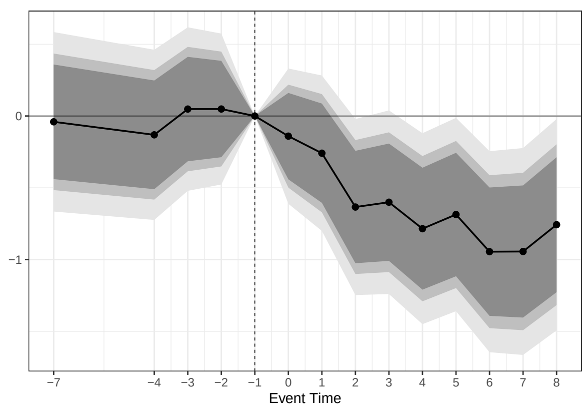
(1) log (total energy use)



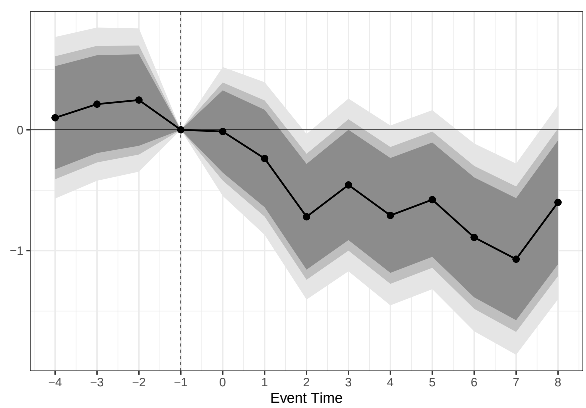
(2) log (production-related energy use)



(3) log (total CO_2 emission)



(4) log (production-related CO_2 emission)



Notes: This figure presents event study estimates of energy use and CO2 emissions using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

Table 6: Triple-Difference Analysis of Profit, Revenue, Expenditure, and Exit

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Profit			Revenue						Expense			Operation	
VARIABLES	log (profit)		log (total income)		og (manufacturing income		Markup		log (total expense)		log (donation expense)		Exit	
DDD (NRB x LL)	-0.12208	-0.06183	-0.08883	0.04265	-0.18800	-0.11451	0.16598	-0.03202	-0.01514	0.00454	-0.18998	-0.09242	0.00208	0.00130
	(0.24480)	(0.24751)	(0.21756)	(0.23094)	(0.17621)	(0.18853)	(0.41315)	(0.22814)	(0.04759)	(0.05177)	(0.14869)	(0.16123)	(0.00204)	(0.00209)
DD (NRB)	-0.01105	-0.09728	-0.02285	-0.13287	0.06790	0.02473	0.26780	0.18807	-0.09260***	-0.10045***	0.14577*	0.07739	-0.01216***	-0.00968***
	(0.10167)	(0.10148)	(0.12191)	(0.13072)	(0.10074)	(0.10794)	(0.18459)	(0.12272)	(0.02842)	(0.03068)	(0.08562)	(0.09198)	(0.00110)	(0.00115)
DD (LL)	0.28154	0.54359	0.19841	0.62568	0.21732*	0.41030	-0.03305	0.38294	0.04013	-0.03139	0.14193	0.68039**	-0.00211	0.00370
	(0.18294)	(0.66623)	(0.14435)	(0.45218)	(0.11645)	(0.37079)	(0.05755)	(0.23714)	(0.03333)	(0.10610)	(0.09405)	(0.30679)	(0.00153)	(0.00442)
Observations	11,868	11,868	141,673	141,673	141,712	141,712	132,854	132,854	141,712	141,712	141,708	141,708	210,592	210,592
R-squared	0.80592	0.81705	0.51975	0.52200	0.55365	0.55585	0.08211	0.10672	0.78937	0.79383	0.50333	0.50499	0.07478	0.08367
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y

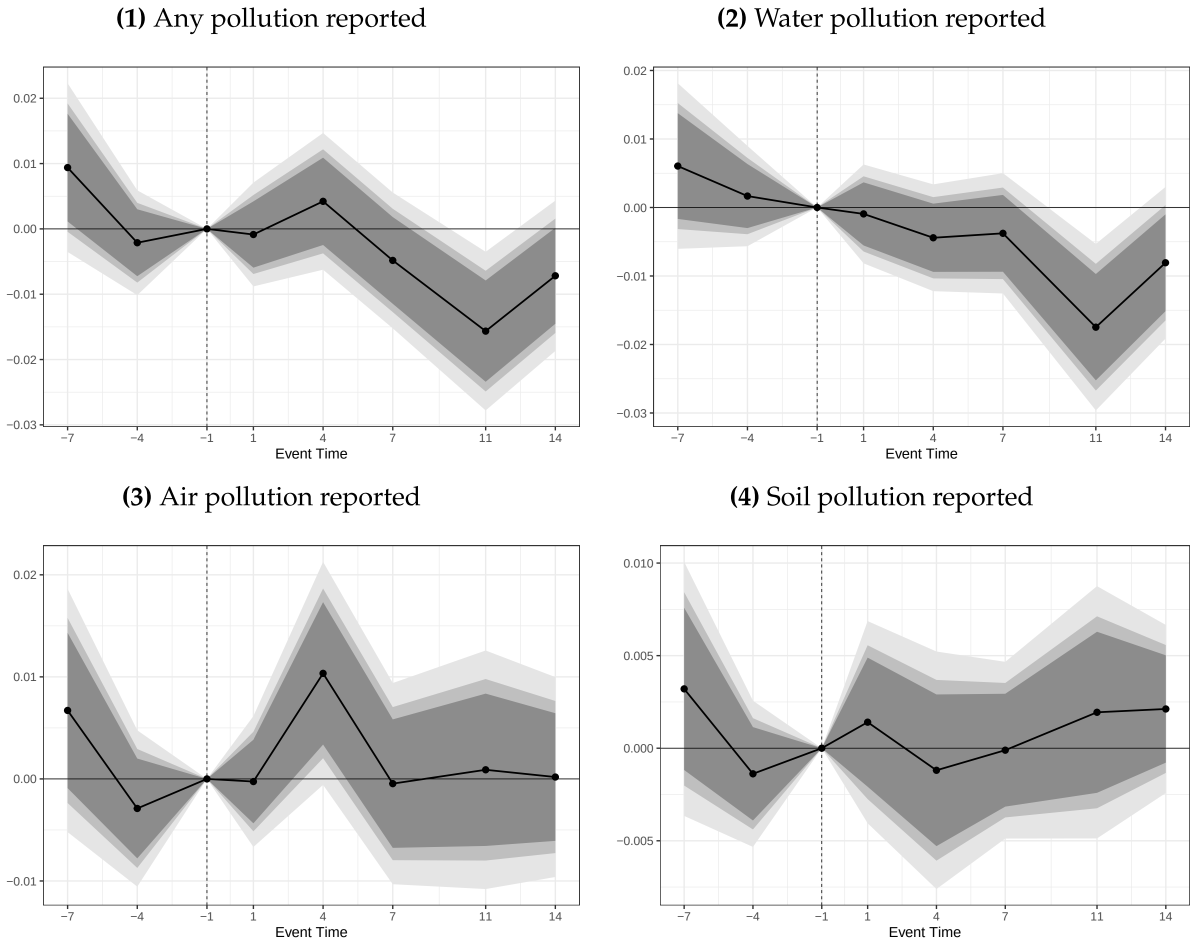
Notes: This table presents triple-difference estimates of the CSR mandate's effects on profit, revenue, expenditure, and firm exit using equation (3). The analysis examines various financial performance measures and operational outcomes. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 7: Triple-Difference Analysis of Reported Pollution Incidence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
		Any pollution			Water pollution			Air pollution			Soil pollution	
VARIABLES	Acknowledged		Reported	Acknowledged		Reported	Acknowledged		Reported	Acknowledged		Reported
DDD (NRB x LL)	-0.00771***	-0.00672**	-0.00445**	-0.01134***	-0.00932***	-0.00941***	0.00228	0.00134	-0.00104	0.00044	0.00043	-0.00053
	(0.00275)	(0.00285)	(0.00216)	(0.00237)	(0.00233)	(0.00225)	(0.00260)	(0.00272)	(0.00250)	(0.00148)	(0.00147)	(0.00082)
DD (NRB)	-0.00049	-0.00077	-0.00018	0.00142*	0.00105	0.00113*	-0.00196	-0.00198	-0.00123	0.00038	0.00030	0.00026
	(0.00122)	(0.00129)	(0.00082)	(0.00075)	(0.00074)	(0.00067)	(0.00126)	(0.00133)	(0.00103)	(0.00040)	(0.00038)	(0.00027)
DD (LL)	0.00337***	0.00306***	0.00177**	0.00385***	0.00309***	0.00305***	0.00035	0.00079	0.00119	-0.00036	-0.00032	0.00006
	(0.00081)	(0.00083)	(0.00071)	(0.00071)	(0.00069)	(0.00070)	(0.00077)	(0.00079)	(0.00082)	(0.00050)	(0.00050)	(0.00026)
Observations	30,949	30,949	30,949	30,949	30,949	30,815	30,949	30,949	30,658	30,949	30,949	30,927
R-squared	0.42143	0.46825	0.40282	0.46180	0.47892	0.42106	0.35491	0.44161	0.41393	0.28869	0.30055	0.28530
Subdistrict FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Province x Year FE	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y

Notes: This table presents triple-difference estimates of the CSR mandate's effects on reported pollution incidence at the village level using equation (4). The analysis examines reported and acknowledged pollution across different types (any, water, air, and soil). Standard errors are clustered at the subdistrict level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure 5: Reported Pollution Incidence



Notes: This figure presents event study estimates of reported pollution incidence at the village level using equation (4), a triple-difference specification. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2005 (the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the subdistrict level.

Table 8: Triple-Difference Analysis of Provision of Public Goods

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Public goods							
VARIABLES	log (number of private primary schools)		log (number of private lower-secondary schools)		log (number of hospitals)		Share of villages with a police station	
DDD (NRB x LL)	-0.00526	-0.00405	-0.00231	0.00019	-0.00036	-0.00029	0.00228	0.00134
	(0.00341)	(0.00373)	(0.00255)	(0.00243)	(0.00164)	(0.00165)	(0.00260)	(0.00272)
DD (NRB)	0.00143	0.00265	0.00112	0.00003	0.00020	0.00011	-0.00196	-0.00198
	(0.00127)	(0.00172)	(0.00090)	(0.00091)	(0.00049)	(0.00050)	(0.00126)	(0.00133)
DD (LL)	0.00330***	0.00251**	0.00188**	0.00121	0.00053	0.00058	0.00035	0.00079
	(0.00108)	(0.00104)	(0.00082)	(0.00086)	(0.00051)	(0.00051)	(0.00077)	(0.00079)
Observations	38,944	38,944	38,939	38,939	28,914	28,914	30,949	30,949
R-squared	0.79582	0.83065	0.86929	0.88429	0.96959	0.97313	0.35491	0.44161
Subdistrict FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Province x Year FE	N	Y	N	Y	N	Y	N	Y

Notes: This table presents triple-difference estimates of the CSR mandate's effects on the provision of public goods at the village level using equation (4). The analysis examines the availability of private schools, hospitals, and police stations. Standard errors are clustered at the subdistrict level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 9: Heterogeneity Analysis in CO_2 emission

(a) Firm Age and Size in Labor and Capital

	(1)	(2)	(3)	(4)	(5)	(6)
Group category	Firm Age		Number of Workers		Capital Value	
Group	Young	Age Q2	Small L	L Q2	Small K	K Q2
VARIABLES			log (total CO_2 emission)			
DDD (NRB x LL) x [*Group*]	-0.55137	-0.87601**	-0.51749	-0.04010	-0.43036	-0.36942
	(0.38926)	(0.43890)	(0.40443)	(0.43194)	(0.39584)	(0.52129)
DD (NRB) x [*Group*]	0.12525	0.22198	0.18257	-0.03949	0.01669	-0.04955
	(0.23446)	(0.27971)	(0.24980)	(0.25985)	(0.23583)	(0.29920)
DD (LL) x [*Group*]	0.89895	0.15957	1.42764**	0.01647	1.13138	1.02981
	(0.71375)	(0.86216)	(0.72779)	(0.79020)	(0.70696)	(0.75661)
DDD (NRB x LL)	-0.30656	-0.39326*	-0.22424	-0.58669***	-0.29544	-0.38965*
	(0.28133)	(0.22594)	(0.30318)	(0.22742)	(0.26766)	(0.21848)
DD (NRB)	0.22863	0.25312*	0.06600	0.29656**	0.24459	0.25233*
	(0.16582)	(0.13036)	(0.18464)	(0.13488)	(0.15874)	(0.13262)
DD (LL)	-1.06837**	-0.60408	-1.36552**	-0.53861	-1.16105**	-0.78835*
	(0.51503)	(0.39965)	(0.58792)	(0.41486)	(0.51387)	(0.41078)
Observations	123,998	123,998	123,998	123,998	123,998	123,998
R-squared	0.60344	0.60344	0.60420	0.60336	0.60411	0.60383
Establishment FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Sector x Year FE	Y	Y	Y	Y	Y	Y

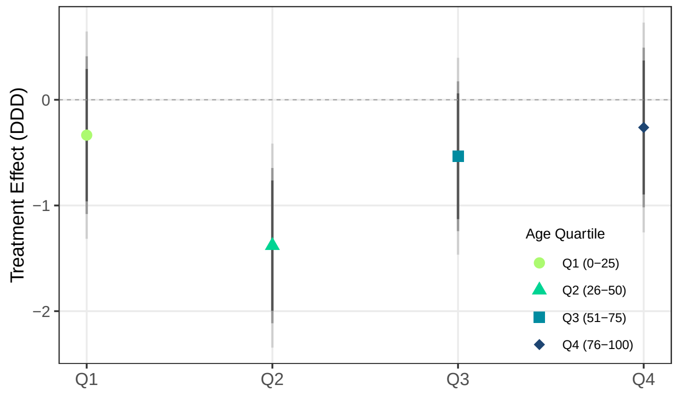
(b) Other Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Group category	Capital Source			Strict Sanction		Other Characteristics		
Group	Domestic Private	Government	Foreign	Investment	Mining	Advertisement	R&D	Less Environmental
VARIABLES				log (total CO_2 emission)				
DDD (NRB x LL) x [*Group*]	-0.27490	0.88710	0.28991	0.41451	-0.30194	0.79189	0.44549	-0.60520
	(0.57350)	(0.86981)	(0.88324)	(0.41038)	(0.31758)	(0.54165)	(1.10179)	(0.66298)
DD (NRB) x [*Group*]	-0.10209	-1.17122**	0.05790	-0.26991		0.42933	-0.30567	-0.37837
	(0.35563)	(0.50676)	(0.53655)	(0.25593)		(0.29695)	(0.43852)	(0.38646)
DD (LL) x [*Group*]	1.24566	0.03852	-1.74732	-0.57128	-0.73788*	-3.81098***	-3.18547	3.09092***
	(1.12254)	(1.52571)	(1.44988)	(0.72127)	(0.40859)	(0.93246)	(2.03867)	(1.00398)
DDD (NRB x LL)	-0.36960	-0.66111***	-0.62207***	-0.71952***	-0.49138**	-0.69832***	-0.63207***	-0.04725
	(0.53497)	(0.19853)	(0.20258)	(0.25327)	(0.22717)	(0.21064)	(0.19737)	(0.63118)
DD (NRB)	0.44383	0.33792***	0.31349**	0.38204**	0.31074***	0.21884*	0.32148***	0.59544
	(0.33266)	(0.11866)	(0.12234)	(0.15261)	(0.11543)	(0.12877)	(0.12052)	(0.36689)
DD (LL)	-1.60015	-0.56956	-0.37554	-0.33127	0.32677	0.14014	-0.39895	-3.21422***
	(1.06044)	(0.36230)	(0.36131)	(0.45354)	(0.27516)	(0.38570)	(0.35795)	(0.92922)
Observations	123,998	123,998	123,998	123,998	123,998	123,998	123,998	123,998
R-squared	0.60366	0.60366	0.60360	0.60360	0.60226	0.60384	0.60366	0.60474
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	Y	Y	Y	Y	Y	Y	Y	Y

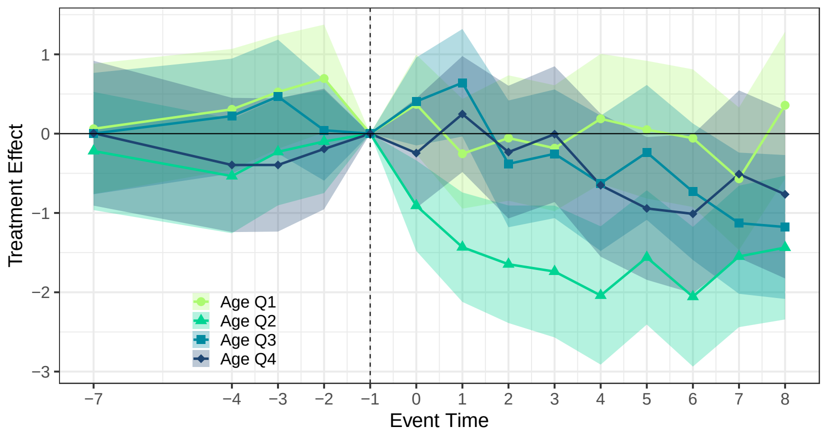
Notes: This table presents heterogeneity analysis of the CSR mandate's effects on total CO2 emissions using equation (3) with interaction terms. Panel (a) examines heterogeneity by firm age and size (labor and capital), while panel (b) examines heterogeneity by other firm characteristics including capital source, industry characteristics, and environmental awareness. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure 6: Selected Results of Heterogeneity Analysis in CO_2 emission

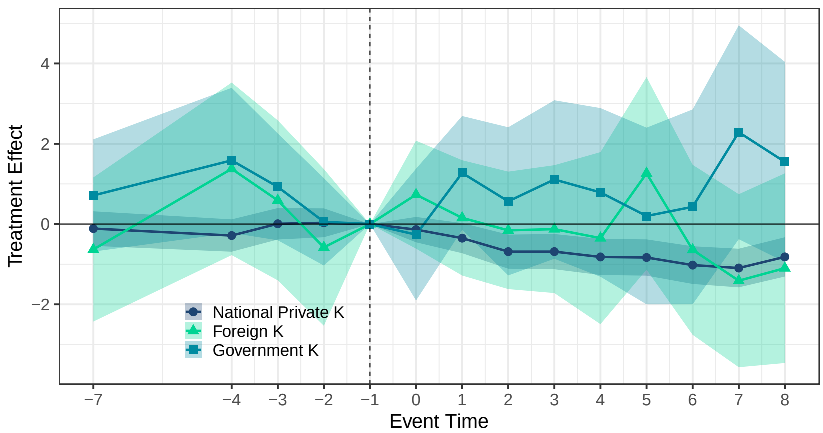
(a) Heterogeneity by Firm Age (DDD)



(b) Heterogeneity by Firm Age (Event Study)



(c) Heterogeneity by Capital Source



Notes: This figure presents selected results from heterogeneity analysis of CO2 emissions using equation (3) with interaction terms. Panel (a) shows heterogeneous treatment effects by firm age quartiles, panel (b) shows event study estimates by age quartile, and panel (c) shows event study estimates by capital source. The vertical axis shows estimated coefficients, and the horizontal axis shows event time relative to 2006 (t=0). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

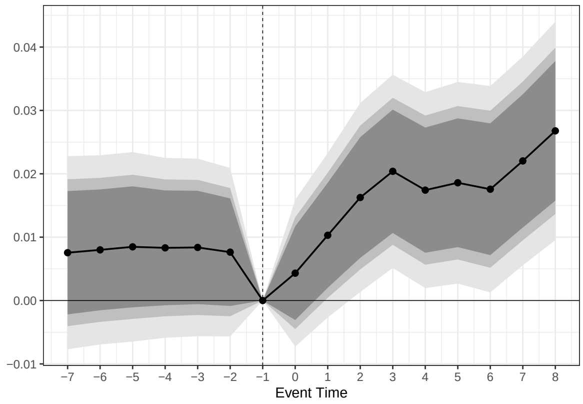
Table 10: Triple-Difference Analysis of Expenditure Allocation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
					Expense share							
VARIABLES	Fuel (production) exp. share		Fuel (generation) exp. share		Material expense share		Wage expense share		Donation expense share		Other expense share	
DDD (NRB x LL)	0.01595***	0.01017**	-0.00054	-0.00092	-0.00190	0.00991	-2.96341	-2.86524	0.00832	0.01046	-0.00665*	-0.01115**
	(0.00387)	(0.00401)	(0.00137)	(0.00156)	(0.00749)	(0.00812)	(2.15080)	(2.15684)	(0.01908)	(0.01562)	(0.00397)	(0.00446)
DD (NRB)	-0.00001	0.00138	-0.00069	-0.00067	-0.00455	-0.00905*	0.78837	0.75599	0.00250	0.00176	0.00254	0.00540*
	(0.00180)	(0.00188)	(0.00049)	(0.00055)	(0.00437)	(0.00467)	(0.70058)	(0.71756)	(0.01681)	(0.01171)	(0.00280)	(0.00306)
DD (LL)	-0.01984***	-0.01830***	-0.00051	-0.00272	0.01437***	0.01611	0.42968	1.70685	0.00001	0.03814	-0.00093	-0.03317***
	(0.00318)	(0.00580)	(0.00110)	(0.00192)	(0.00549)	(0.01495)	(0.51620)	(1.41279)	(0.01452)	(0.04851)	(0.00244)	(0.00679)
Observations	141,573	141,573	141,573	141,573	141,573	141,573	132,731	132,731	141,569	141,569	141,573	141,573
R-squared	0.71165	0.71327	0.43987	0.44113	0.61699	0.61927	0.09505	0.09827	0.07368	0.07738	0.49388	0.49730
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y

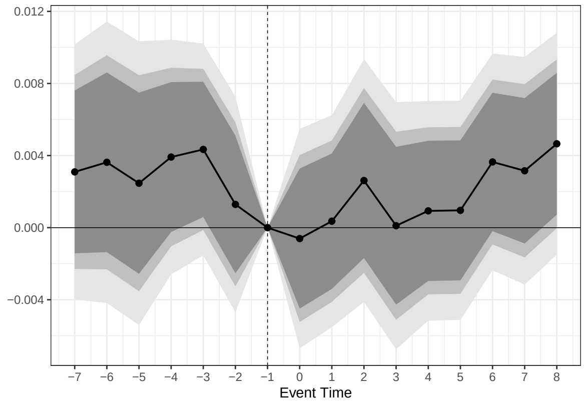
Notes: This table presents triple-difference estimates of the CSR mandate's effects on expenditure allocation shares using equation (3). The analysis examines the share of various expense categories including fuel (production and generation), materials, wages, donations, and other expenses. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure 7: Event Study of Expenditure Allocation

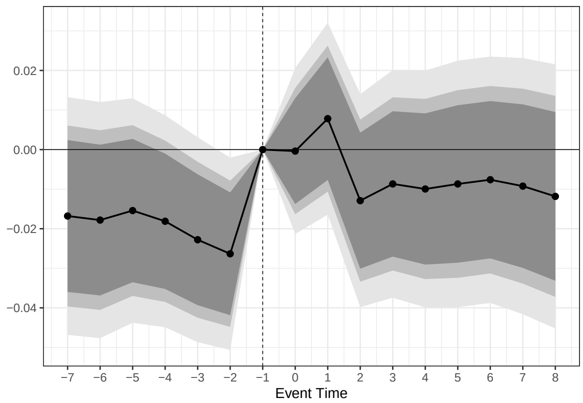
(1) Production-related fuel expenditure share



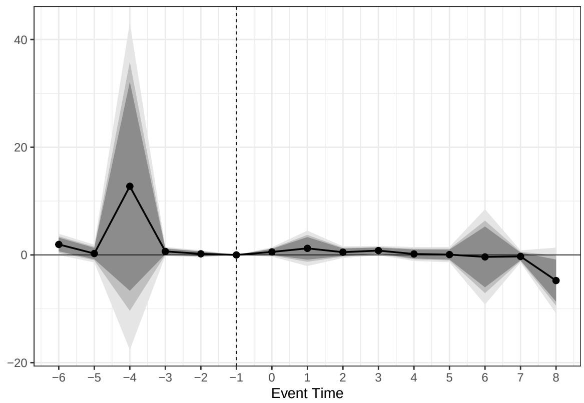
(2) Generation-related fuel expenditure share



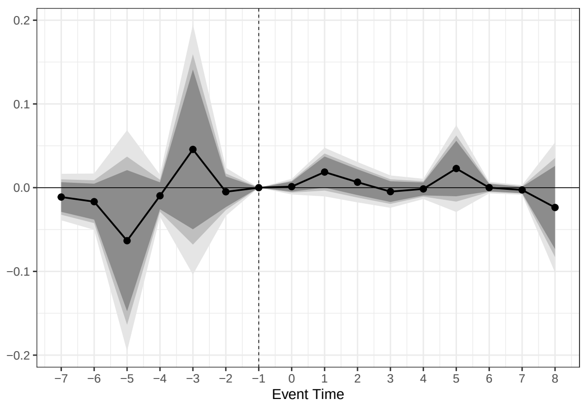
(3) Material expense share



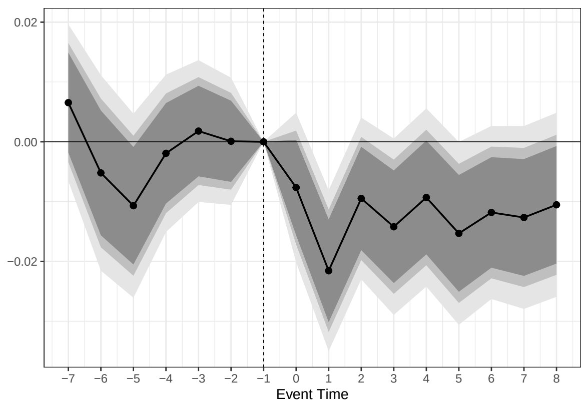
(4) Wage expense share



(5) Donation expense share



(6) Miscellaneous expense share



Notes: This figure presents event study estimates of expenditure allocation shares using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

Table 11: Heterogeneity Analysis in Exit Probability

(a) Firm Age and Size in Labor and Capital

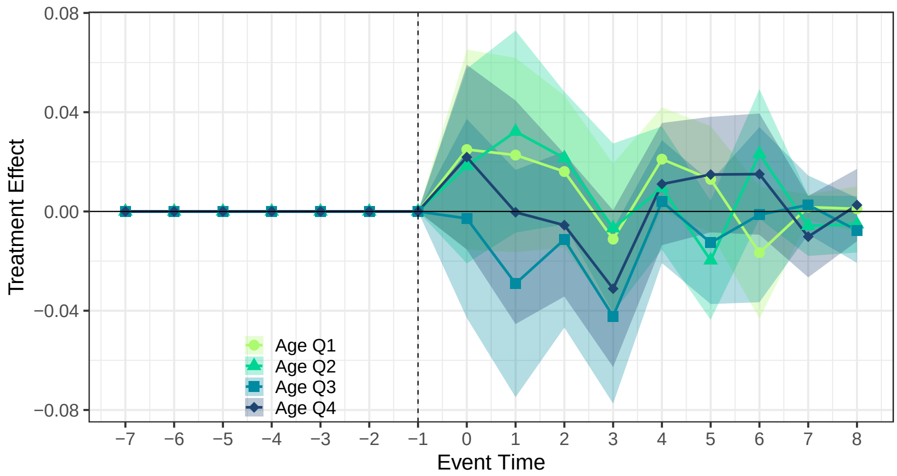
	(1)	(2)	(3)	(4)	(5)	(6)
Group category	Firm Age		Number of Workers		Capital Value	
Group	Young	Age Q2	Small L	L Q2	Small K	K Q2
VARIABLES			Exit			
DDD (NRB x LL) x [*Group*]	0.01370***	0.00821*	-0.00633	0.00143	0.00270	0.00236
	(0.00421)	(0.00477)	(0.00443)	(0.00505)	(0.00425)	(0.00683)
DD (NRB) x [*Group*]	-0.01170***	-0.00705***	-0.00039	0.01915***	-0.00540**	-0.00880**
	(0.00233)	(0.00267)	(0.00254)	(0.00297)	(0.00234)	(0.00380)
DD (LL) x [*Group*]	-0.00879	0.00625	0.01096	-0.00640	0.01272	0.03560*
	(0.00897)	(0.01258)	(0.00897)	(0.00919)	(0.00895)	(0.02009)
DDD (NRB x LL)	-0.00495	-0.00074	0.00289	0.00037	0.00043	0.00240
	(0.00301)	(0.00244)	(0.00275)	(0.00243)	(0.00285)	(0.00232)
DD (NRB)	-0.00448***	-0.00788***	0.00177	-0.01384***	-0.00507***	-0.00550***
	(0.00161)	(0.00133)	(0.00148)	(0.00131)	(0.00156)	(0.00127)
DD (LL)	0.00767	0.00229	-0.00503	0.00553	-0.00345	-0.00448
	(0.00704)	(0.00456)	(0.00632)	(0.00541)	(0.00593)	(0.00392)
Observations	210,592	210,592	210,592	210,592	210,592	210,592
R-squared	0.08573	0.08504	0.08994	0.08653	0.08608	0.08661
Establishment FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Sector x Year FE	Y	Y	Y	Y	Y	Y

(b) Other Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Group category	Capital Source			Strict Sanction		Other Characteristics		
Group	Domestic Private	Government	Foreign	Investment	Mining	Advertisement	R&D	Less Environmental
VARIABLES				Exit				
DDD (NRB x LL) x [*Group*]	-0.00114	0.01122	-0.00456	0.00070	-0.00273	-0.00006	-0.00284	-0.00789
	(0.00655)	(0.01001)	(0.00913)	(0.00444)	(0.00353)	(0.00526)	(0.00870)	(0.00604)
DD (NRB) x [*Group*]	-0.00506	0.00395	0.01179**	0.00276		0.00352	0.00704*	0.00061
	(0.00358)	(0.00596)	(0.00499)	(0.00250)		(0.00277)	(0.00363)	(0.00318)
DD (LL) x [*Group*]	0.02803**	-0.02802**	-0.02449	-0.00481	0.00591	-0.01389*	-0.01912	-0.01245
	(0.01105)	(0.01277)	(0.01560)	(0.00917)	(0.00502)	(0.00797)	(0.01224)	(0.02241)
DDD (NRB x LL)	0.00204	0.00101	0.00135	0.00024	0.00246	0.00134	0.00085	0.00810
	(0.00616)	(0.00215)	(0.00219)	(0.00286)	(0.00257)	(0.00230)	(0.00217)	(0.00560)
DD (NRB)	-0.00432	-0.01010***	-0.00886***	-0.00678***	-0.00968***	-0.00883***	-0.00880***	-0.00948***
	(0.00336)	(0.00118)	(0.00122)	(0.00158)	(0.00115)	(0.00128)	(0.00121)	(0.00293)
DD (LL)	-0.02124**	0.00493	0.00533	0.00458	-0.00121	0.00540	0.00482	0.01450
	(0.00984)	(0.00455)	(0.00489)	(0.00586)	(0.00295)	(0.00516)	(0.00455)	(0.02204)
Observations	210,592	210,592	210,592	210,592	210,592	210,592	210,592	210,592
R-squared	0.08546	0.08563	0.08557	0.08687	0.08367	0.08664	0.08514	0.08614
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	Y	Y	Y	Y	Y	Y	Y	Y

Notes: This table presents heterogeneity analysis of the CSR mandate's effects on firm exit probability using equation (3) with interaction terms. Panel (a) examines heterogeneity by firm age and size (labor and capital), while panel (b) examines heterogeneity by other firm characteristics including capital source and environmental compliance. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure 8: Heterogeneity in Exit Probability by Firm Age



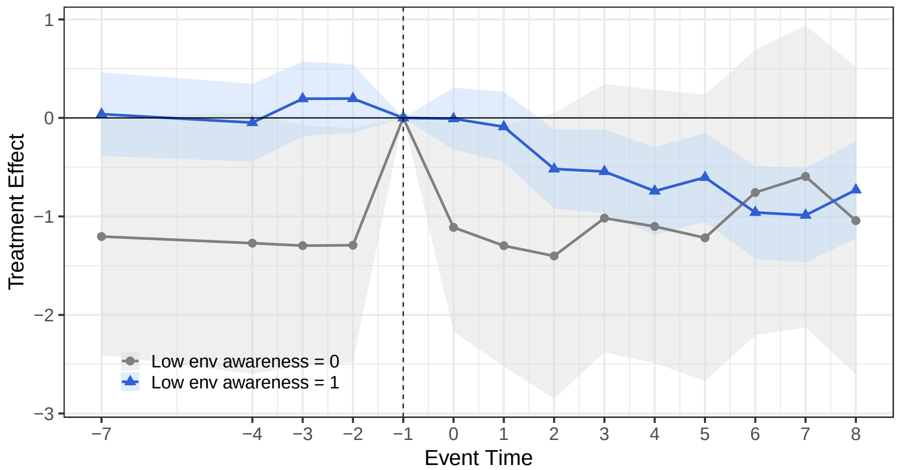
Notes: This figure presents event study estimates of heterogeneous effects on exit probability by firm age quartiles using equation (3) with interaction terms. The vertical axis shows the estimated coefficients, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

Table 12: Triple-Difference Analysis of Fuel Prices

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
					Fuel input price							
VARIABLES	log (coal price)		log (natural gas price)		log (LPG price)		log (kerosene price)		log (gasoline price)		log (diesel price)	
DDD (NRB x LL)	-0.10539	0.00633	0.27662	0.17587	-0.10264	-0.06607	0.00627	0.00146	-0.01052	-0.01146	-0.00705	-0.00396
	(0.10413)	(0.10221)	(0.36986)	(0.44039)	(0.09934)	(0.10909)	(0.02796)	(0.03007)	(0.00983)	(0.01043)	(0.00791)	(0.00842)
DD (NRB)	0.05990	0.04093	-0.10202	-0.18772	0.13912***	0.13751***	0.02196	0.01456	0.05554***	0.05344***	0.08692***	0.08790***
	(0.04036)	(0.04075)	(0.23473)	(0.28587)	(0.04331)	(0.04682)	(0.01445)	(0.01533)	(0.00523)	(0.00560)	(0.00459)	(0.00495)
DD (LL)	0.45394	0.47318	-0.03228	-0.01815	0.30750**	0.23020*	-0.04854	-0.04217	0.05007***	0.05076***	0.01518	0.02095*
	(0.28636)	(0.36094)	(0.33812)	(0.40600)	(0.12877)	(0.13519)	(0.06599)	(0.07153)	(0.01279)	(0.01360)	(0.01114)	(0.01202)
Observations	5,672	4,901	4,801	3,560	13,923	11,816	18,102	16,705	65,824	56,543	101,005	85,943
R-squared	0.57553	0.56955	0.73573	0.73249	0.67207	0.66784	0.93240	0.93223	0.92470	0.92324	0.93640	0.93539
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Dometic private capital	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y

Notes: This table presents triple-difference estimates of the CSR mandate's effects on fuel prices by fuel type using equation (3). The analysis restricts the sample to establishments with domestic private capital in even-numbered columns. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure 9: Heterogeneity in CO_2 emission by Prior Environmental Awareness



Notes: This figure presents event study estimates of heterogeneous effects on CO2 emissions by prior environmental awareness using equation (3) with interaction terms. The vertical axis shows the estimated coefficients, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

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Appendix A. Indonesia's CSR Law and Firm Legal Status

Corporate Law (Undang-Undang tentang Perseroan Terbatas) No. 25/2007 — The following provides a translation of the article on CSR requirements, with the original text shown in parentheses.

Chapter V – Social and Environmental Responsibility, Article 74 (BAB V - Tanggung Jawab Sosial dan Linkungan, Pasal 74)

1. A company that carries out its business activities in fields related to and/or associated with natural resources shall be required to implement Social and Environmental Responsibility. (Perseroan yang menjalankan kegiatan usahanya di bidang dan/atau berkaitan dengan sumber daya alam wajib melaksanakan Tanggung Jawab Sosial dan Lingkungan.)
2. The Social and Environmental Responsibility as referred to in paragraph (1) constitutes an obligation of the company, to be budgeted for and accounted for as part of the company's expenses, the implementation of which shall be conducted with due regard to propriety and fairness. (Tanggung Jawab Sosial dan Lingkungan sebagaimana dimaksud pada ayat (1) merupakan kewajiban Perseroan yang dianggarkan dan diperhitungkan sebagai biaya Perseroan yang pelaksanaannya dilakukan dengan memperhatikan kepatutan dan kewajaran.)
3. A company that fails to fulfill the obligation referred to in paragraph (1) shall be subject to sanctions in accordance with the provisions of laws and regulations. (Perseroan yang tidak melaksanakan kewajiban sebagaimana dimaksud pada ayat (1) dikenai sanksi sesuai dengan ketentuan peraturan perundang-undangan.)
4. Further provisions regarding Social and Environmental Responsibility shall be regulated by government regulation. (Ketentuan lebih lanjut mengenai Tanggung Jawab Sosial dan Lingkungan diatur dengan peraturan pemerintah.)

Limited liability company — Under Indonesian law, limited liability companies, or perseroan terbatas, have to meet the following criteria (Butt and Lindsey, 2018a):

1. Legal Form and Incorporation: Must be established through a notarial deed in Bahasa Indonesia and approved by the Ministry of Law and Human Rights to gain legal entity status.
2. Founders: At least two shareholders required at incorporation; an exception under the Omnibus Law allows micro and small enterprises to be established by a single founder.
3. Capital Requirements: Minimum capital of IDR 50 million (unless otherwise specified for certain sectors), with at least 25% issued and fully paid at incorporation. Foreign-owned companies must have a minimum total capital of IDR 10 billion, including capital and operational funds.
4. Company Structure: Must have a Board of Directors (Direksi) and a Board of Commissioners (Dewan Komisaris).
5. Business Domicile: Must have a registered business address within Indonesia.
6. Business Classification (KBLI): Required to select an appropriate KBLI code; some sectors are restricted or require local partnership.
7. Tax Identification and Licensing: Must obtain an NPWP (Taxpayer Identification Number), a Business Identification Number (NIB), and relevant sector-specific licenses or permits.

Publicly listed company — Under Indonesian law, publicly listed companies must meet the following criteria (Butt and Lindsey, 2018a)

- Defined as companies with at least 300 shareholders and IDR 3 billion in fully paid-up capital.
- Must obtain authorization from the Indonesian Financial Services Authority (Otoritas Jasa Keuangan).
- Required to conduct an initial public offering (IPO) and apply for listing on the stock exchange.
- After listing, companies must adhere to additional requirements such as trading rules, membership regulations, and compliance with the Indonesian Central Securities Depository (Kustodian Sentral Efek Indonesia) and the Indonesian Clearing and Guarantee Corporation (Kliring Penjaminan Efek Indonesia).
- The Indonesian Stock Exchange (IDX), based in Jakarta, has been operational since 2007, hosting 557 listed companies as of 2018.

Investment company — Under Indonesian law, investment companies fall into two categories — Foreign Investment (PMA) and Domestic Investment (PMDN) — both eligible for statutory business facilitations (Butt and Lindsey, 2018b).

- Foreign Investment (PMA): Incorporated as limited-liability companies (PT) with presidential approval via BKPM and subject to BKPM reporting. Capital must be provided by foreign investors, with a minimum total investment of IDR 10 billion and a minimum paid-up capital of IDR 2.5 billion per business line; selected sectors remain restricted.
- Domestic Investment (PMDN): Also PT entities approved through BKPM and required to report to BKPM. Capital must be domestically sourced from Indonesian investors. Small-scale PMDNs face no minimum capital requirement and benefit from simplified licensing; PMDNs generally have access to a broader set of sectors than PMAs.
- Facilities: Statutory incentives include reductions in income, land, and building taxes; exemptions from import duties on specified capital goods and raw materials; accelerated depreciation and amortization; streamlined acquisition of land rights; immigration facilitation for foreign workers; and simplified access to import licenses (Articles 18, 21–24).

Appendix B. Text Data and PROPER Data Description

Text data — For the text analysis, I hand-collected all available annual reports (N = 871) from the websites of publicly listed non-service companies in Indonesia listed in 2015 or earlier. I exclude service sectors: C11 Aerospace & Defense, C21 Diversified Industrial Trading, C22 Commercial Services, C23 Professional Services, C31 Multi-sector Holdings, E51 Tourism & Recreation, E52 Education & Support Services, E61 Media, E62 Entertainment & Support Services, E71 Consumer Distributors, E72 Internet & Homeshop Retail, E73 Department Stores, E74 Specialty Retail, F12 Healthcare Providers, G Financials, H Properties & Real Estate, I11 Online Applications & Services, I12 IT Services & Consulting, I13 Software, J Infrastructure, K Transportation & Logistics, and Z Listed Investment Product.

The resulting sample includes Sector A Energy (A11 Oil & Gas, A12 Coal, A13 Oil, Gas & Coal Supports, A21 Alternative Energy Equipment, A22 Alternative Fuels)—shown in dark green in Figure 1—along with Sector B Basic Materials (B11 Chemicals, B12 Construction Materials, B13 Containers & Packaging, B14 Metals & Minerals, B15 Forestry & Paper), selected Sector C Industrials industries (C12 Building Products & Fixtures, C13 Electrical, C14 Machinery), Sector D Consumer Non-Cyclicals (D11 Food & Staples Retailing, D21 Beverages, D22 Processed Foods, D23 Agricultural Products, D31 Tobacco, D41 Household Products, D42 Personal Care Products), selected Sector E Consumer Cyclicals industries (E11 Auto Components, E12 Automobiles, E21 Household Goods, E31 Consumer Electronics, E32 Sport Equipment & Hobbies Goods, E41 Apparel & Luxury Goods), selected Sector F Healthcare industries (F11 Healthcare Equipment & Supplies, F21 Pharmaceuticals, F22 Healthcare Research), and selected Sector I industries (I21 Networking Equipment, I22 Computer Hardware, I23 Electronic Equipment, Instruments & Components).

Most annual reports in my 871-report sample use both English and Indonesian. The average report contains 112,212 words. Of these, 157 samples also include sustainability reports issued in the same year, acknowledging that while some firms integrate sustainability sections within annual reports, others issue separate sustainability reports.

Text analysis — The text analysis employs hit ratios—the share of sentences in each annual report semantically similar to predefined keyword sets for each category—calculated using BERT (Bidirectional Encoder Representations from Transformers), a deep learning model for natural language processing (Devlin et al., 2019). BERT maps text into high-dimensional vector representations, capturing context-dependent semantics that simple keyword counts miss, including implicit or paraphrased CSR references. Hit ratios measure the salience and pervasiveness of category-specific content in firms' disclosures. The algorithm computes cosine similarity between each sentence embedding and the embedding of the corresponding keyword set. A sentence counts as a ”hit” if its similarity exceeds 0.4, the predetermined threshold.

The predefined keywords for the six categories—CSR, Environment (E), Society (S), Governance (G), CO_2, and Finance (FIN)—are as follows:

- CSR: ”Corporate Social Responsibility”, ”Corporate Environmental and Social Responsibility”, ”CSR”, ”CESR”, ”Tanggung Jawab Sosial Perusahaan”, and ”TJSP”
- E: ”environment”, ”environmental”, ”environmentally”, ”eco”, ”eco friendly”, ”environmentally friendly”, ”green”, ”sustainability”, ”sustainable”, ”sustainably”, ”clean”, ”emissions”, ”carbon”, ”CO2”, ”carbon dioxide”, ”carbon footprint”, ”carbon emissions”, ”greenhouse gas”, ”GHG”, ”climate change”, ”pollution”, ”air pollution”, ”energy”, ”energy transition”, ”energy efficiency”, ”renewable energy”, ”waste

management", "water use", "river use", "biodiversity", "environmental management", "plants", "forestry", and "tree"

- S: "society", "social", "socially", "community", "communal", "employees", "workers", "labour", "labor", "worker safety", "occupational health", "training", "human rights", "community development", "philanthropy", "charity", "customer safety", "diversity", "inclusion", "natural disaster victims", "school", "scholarship", "microfinance", and "micro financing"
- G: "governance", "corporate governance", "board of directors", "audit committee", "internal controls", "compliance", "ethics", "anti-corruption", "whistleblowing", "risk management", "executive", "shareholder rights", "transparency", and "governance policy"
- CO_2: "emissions", "carbon", "CO2", "carbon dioxide", "carbon footprint", "carbon emissions", "greenhouse gas", and "GHG"
- FIN: "finance", "financial", "profit", "revenue", "income", "expense", "expenditure", "shareholder value", "earnings", "balance sheet", "cash", "accounting policy", "financial risk", "liquidity", "capital expenditure", "Capex", "debt", "assets", "liabilities", "financial statements", "sales", "ebitda", "cost", "net", "gross", "eps", "cash flow", "interest", "margin", "operating", "return on assets", "RoA", "return on equity", "RoE", "invested capital", "investment", "equity", and "volume"

PROPER data

- Evaluation criteria: Evaluation is based on (1) compliance (adhering to environmental regulations) and (2) performance beyond compliance (initiatives that exceed basic requirements), such as energy efficiency, waste management, biodiversity conservation, and community development. (Ministry of Environment, Indonesia, 2009)
- Targeting criteria: PROPER assessments target companies according to the following criteria: significant environmental impacts, export-oriented operations, products directly interacting with the public, and publicly listed status (Ministry of Environment, Indonesia, 2009). Due to resource limitations, only a small fraction, 627 firms, were assessed as of 2009, which represents only around 7% of the total 8,000–10,000 potential participant companies. (Ministry of Environment, Indonesia, 2009)
- Sector breakdown as of 2009: Mining, Energy, Oil and Gas = 183; Manufacturing = 220; Agroindustry = 209; Industrial Zones & Waste Processing Services = 15 (Ministry of Environment, Indonesia, 2009)
- Participant growth: 251 (2003) $\rightarrow$ 627 (2008) $\rightarrow$ 1,891 (2013) $\rightarrow$ 2,007 (2018)

Appendix C. Descriptive Statistics

Table C1: Manufacturing Firm Descriptive Statistics (Part 1)

Variable	NRB-LL firms	NRB-non-LL firms	Non-NRB-LL firms	Non-NRB-non-LL firms
LPG quantity (Kg)	Mean: 14216.15000 SD: 345639.40000 Median: 0.00000 Observations: 16819	Mean: 10705.23000 SD: 906428.50000 Median: 0.00000 Observations: 12199	Mean: 13185.78000 SD: 250684.50000 Median: 0.00000 Observations: 34771	Mean: 3082.94400 SD: 77913.85000 Median: 0.00000 Observations: 33638
LPG expense value (1,000 Rp)	Mean: 88254.52000 SD: 1959221.00000 Median: 0.00000 Observations: 16819	Mean: 94396.24000 SD: 5506657.00000 Median: 0.00000 Observations: 12199	Mean: 121305.70000 SD: 2392051.00000 Median: 0.00000 Observations: 34771	Mean: 25598.58000 SD: 562955.20000 Median: 0.00000 Observations: 33638
Coal quantity (Kg)	Mean: 1551378.00000 SD: 36000000.00000 Median: 0.00000 Observations: 21406	Mean: 894722.10000 SD: 26500000.00000 Median: 0.00000 Observations: 15526	Mean: 319301.70000 SD: 4706220.00000 Median: 0.00000 Observations: 44254	Mean: 55080.78000 SD: 977174.50000 Median: 0.00000 Observations: 42812
Coal expense value (1,000 Rp)	Mean: 1068546.00000 SD: 20400000.00000 Median: 0.00000 Observations: 21406	Mean: 694324.30000 SD: 18500000.00000 Median: 0.00000 Observations: 15526	Mean: 470681.90000 SD: 8091424.00000 Median: 0.00000 Observations: 44254	Mean: 76942.35000 SD: 1517542.00000 Median: 0.00000 Observations: 42812
Kerosene quantity (Lt)	Mean: 23032.50000 SD: 1064369.00000 Median: 0.00000 Observations: 21406	Mean: 2899.15200 SD: 32039.79000 Median: 0.00000 Observations: 15526	Mean: 6934.54400 SD: 145801.30000 Median: 0.00000 Observations: 44254	Mean: 5364.86700 SD: 129789.60000 Median: 0.00000 Observations: 42812
Kerosene expense value (1,000 Rp)	Mean: 80030.71000 SD: 4054914.00000 Median: 0.00000 Observations: 21406	Mean: 11833.42000 SD: 190773.80000 Median: 0.00000 Observations: 15526	Mean: 30921.86000 SD: 967345.00000 Median: 0.00000 Observations: 44254	Mean: 19756.99000 SD: 560555.10000 Median: 0.00000 Observations: 42812
Gasoline quantity (Lt)	Mean: 57289.47000 SD: 2319373.00000 Median: 0.00000 Observations: 24464	Mean: 69657.93000 SD: 3996676.00000 Median: 0.00000 Observations: 17744	Mean: 99858.80000 SD: 11600000.00000 Median: 0.00000 Observations: 50576	Mean: 15194.04000 SD: 287934.80000 Median: 0.00000 Observations: 48928
Gasoline expense value (1,000 Rp)	Mean: 208058.00000 SD: 4844827.00000 Median: 0.00000 Observations: 24464	Mean: 169609.00000 SD: 7894883.00000 Median: 0.00000 Observations: 17744	Mean: 570242.90000 SD: 75100000.00000 Median: 0.00000 Observations: 50576	Mean: 70126.65000 SD: 1640158.00000 Median: 0.00000 Observations: 48928
Diesel quantity (Lt)	Mean: 442099.50000 SD: 3282953.00000 Median: 14610.50000 Observations: 24464	Mean: 151468.40000 SD: 3670070.00000 Median: 3780.00000 Observations: 17744	Mean: 499907.80000 SD: 5985967.00000 Median: 10094.00000 Observations: 50576	Mean: 114343.20000 SD: 2152918.00000 Median: 1370.00000 Observations: 48928
Diesel expense value (1,000 Rp)	Mean: 1606911.00000 SD: 18600000.00000 Median: 46975.00000 Observations: 24464	Mean: 719714.90000 SD: 27800000.00000 Median: 12100.00000 Observations: 17744	Mean: 1736197.00000 SD: 18200000.00000 Median: 33689.50000 Observations: 50576	Mean: 464732.90000 SD: 9748282.00000 Median: 3883.50000 Observations: 48928
Gas quantity (m^3)	Mean: 142324.80000 SD: 1902170.00000 Median: 0.00000 Observations: 16819	Mean: 287506.90000 SD: 14700000.00000 Median: 0.00000 Observations: 12199	Mean: 70151.74000 SD: 2473179.00000 Median: 0.00000 Observations: 34771	Mean: 23685.24000 SD: 1935062.00000 Median: 0.00000 Observations: 33638
Gas expense value (1,000 Rp)	Mean: 1008716.00000 SD: 24400000.00000 Median: 0.00000 Observations: 16819	Mean: 608672.80000 SD: 15200000.00000 Median: 0.00000 Observations: 12199	Mean: 494083.70000 SD: 12200000.00000 Median: 0.00000 Observations: 34771	Mean: 102558.00000 SD: 10200000.00000 Median: 0.00000 Observations: 33638

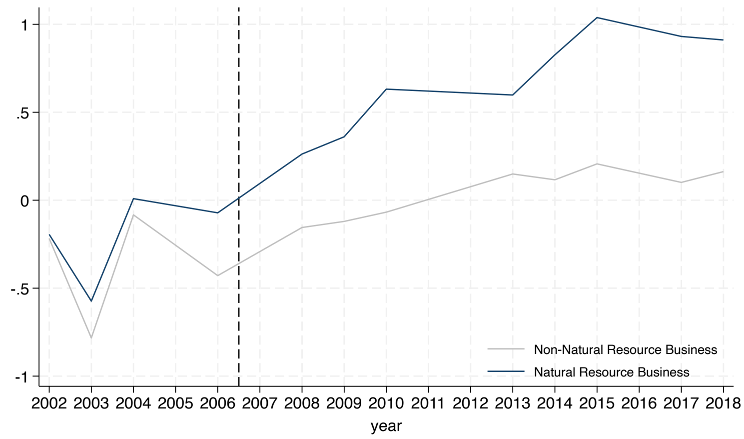
Table C1: Manufacturing Firm Descriptive Statistics (Part 2)

Variable	NRB-LL firms	NRB-non-LL firms	Non-NRB-LL firms	Non-NRB-non-LL firms
Total income (1,000 Rp)	Mean: 9500456.00000 SD: 184000000.00000 Median: 0.00000 Observations: 24464	Mean: 5334414.00000 SD: 141000000.00000 Median: 0.00000 Observations: 17744	Mean: 13000000.00000 SD: 182000000.00000 Median: 0.00000 Observations: 50576	Mean: 2679338.00000 SD: 43500000.00000 Median: 0.00000 Observations: 48928
Produced goods income (1,000 Rp)	Mean: 181000000.00000 SD: 1260000000.00000 Median: 18200000.00000 Observations: 24464	Mean: 57300000.00000 SD: 736000000.00000 Median: 1769787.00000 Observations: 17744	Mean: 210000000.00000 SD: 1470000000.00000 Median: 19400000.00000 Observations: 50576	Mean: 40100000.00000 SD: 324000000.00000 Median: 1998915.00000 Observations: 48928
Manufacturing income (1,000 Rp)	Mean: 6583453.00000 SD: 114000000.00000 Median: 0.00000 Observations: 24464	Mean: 3134332.00000 SD: 96800000.00000 Median: 0.00000 Observations: 17744	Mean: 10100000.00000 SD: 160000000.00000 Median: 0.00000 Observations: 50576	Mean: 1832595.00000 SD: 28100000.00000 Median: 0.00000 Observations: 48928
Electricity generation income (1,000 Rp)	Mean: 1434117.00000 SD: 49100000.00000 Median: 0.00000 Observations: 23373	Mean: 630938.60000 SD: 21400000.00000 Median: 0.00000 Observations: 16594	Mean: 1292688.00000 SD: 29700000.00000 Median: 0.00000 Observations: 48278	Mean: 261602.40000 SD: 9156914.00000 Median: 0.00000 Observations: 45664
Total expense (1,000 Rp)	Mean: 122000000.00000 SD: 942000000.00000 Median: 12100000.00000 Observations: 24464	Mean: 36100000.00000 SD: 488000000.00000 Median: 1021920.00000 Observations: 17744	Mean: 124000000.00000 SD: 768000000.00000 Median: 12700000.00000 Observations: 50576	Mean: 25900000.00000 SD: 207000000.00000 Median: 1320477.00000 Observations: 48928
Material expense (1,000 Rp)	Mean: 103000000.00000 SD: 875000000.00000 Median: 9445105.00000 Observations: 24464	Mean: 28900000.00000 SD: 424000000.00000 Median: 727906.50000 Observations: 17744	Mean: 103000000.00000 SD: 701000000.00000 Median: 9124003.00000 Observations: 50576	Mean: 22100000.00000 SD: 181000000.00000 Median: 1050221.00000 Observations: 48928
Fuel expense (1,000 Rp)	Mean: 5829544.00000 SD: 61200000.00000 Median: 168040.00000 Observations: 24464	Mean: 2928312.00000 SD: 45300000.00000 Median: 74520.50000 Observations: 17744	Mean: 4195018.00000 SD: 84100000.00000 Median: 140952.50000 Observations: 50576	Mean: 998015.80000 SD: 19500000.00000 Median: 29022.50000 Observations: 48928
Donation expense (1,000 Rp)	Mean: 144163.90000 SD: 3631133.00000 Median: 1500.00000 Observations: 24464	Mean: 68859.09000 SD: 1401119.00000 Median: 1200.00000 Observations: 17744	Mean: 244184.40000 SD: 7686976.00000 Median: 1500.00000 Observations: 50576	Mean: 31518.45000 SD: 1006359.00000 Median: 1250.00000 Observations: 48924
Profit (1,000 Rp)	Mean: -112000000.00000 SD: 942000000.00000 Median: -10100000.00000 Observations: 24464	Mean: -30800000.00000 SD: 476000000.00000 Median: -845150.00000 Observations: 17744	Mean: -111000000.00000 SD: 762000000.00000 Median: -9823131.00000 Observations: 50576	Mean: -23300000.00000 SD: 202000000.00000 Median: -1116762.00000 Observations: 48928
Number of workers (Person)	Mean: 343.47630 SD: 801.70520 Median: 137.00000 Observations: 24464	Mean: 153.10200 SD: 526.86850 Median: 42.00000 Observations: 17744	Mean: 496.26610 SD: 1537.14000 Median: 157.00000 Observations: 50576	Mean: 146.90340 SD: 496.77510 Median: 41.00000 Observations: 48928
Wages for production workers (Person)	Mean: 7080648.00000 SD: 40200000.00000 Median: 1530957.00000 Observations: 22935	Mean: 2728682.00000 SD: 21700000.00000 Median: 336000.00000 Observations: 16635	Mean: 7904318.00000 SD: 38100000.00000 Median: 1682772.00000 Observations: 47415	Mean: 1912613.00000 SD: 9978643.00000 Median: 325070.50000 Observations: 45870

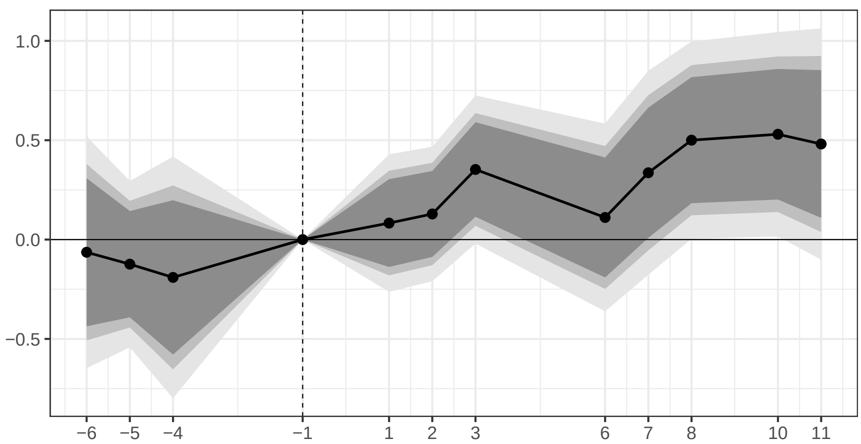
Appendix D. Additional Tables and Figures

Figure D1: Trend Plot and Event Study of Standardized Environment Performance (DD)

(1) Trend Plot of Standardized Environment Performance



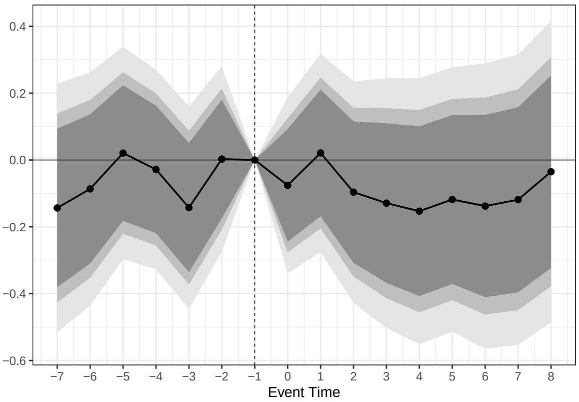
(2) Event Study for Difference-in-Differences specification



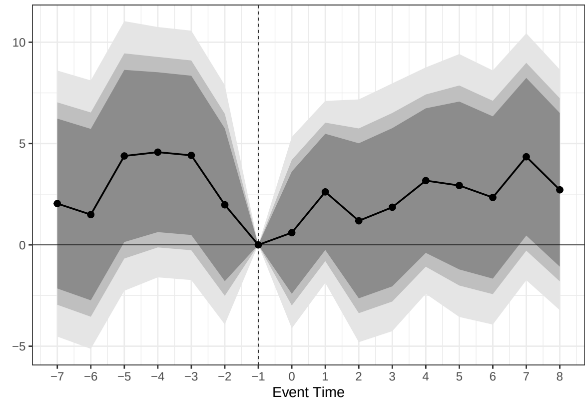
Notes: Panel (1) presents trend plots of standardized environmental performance scores for natural resource businesses (NRB) and non-NRB firms from 2002-2018. Panel (2) presents event study estimates using equation (2), a difference-in-differences specification. The vertical axis shows the estimated DD coefficients $\beta_{DD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

Figure D2: Event Study of Output, Productivity, and Inputs (Part 1)

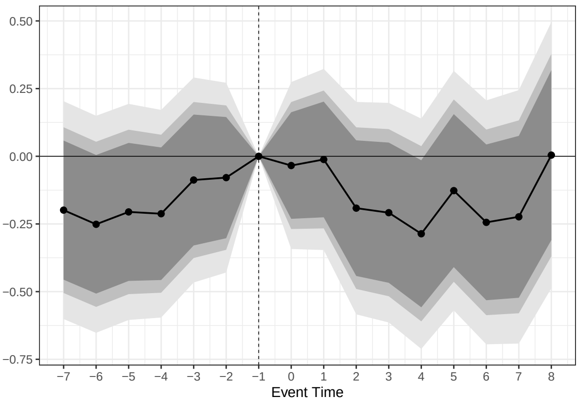
(a-1) log (output value)



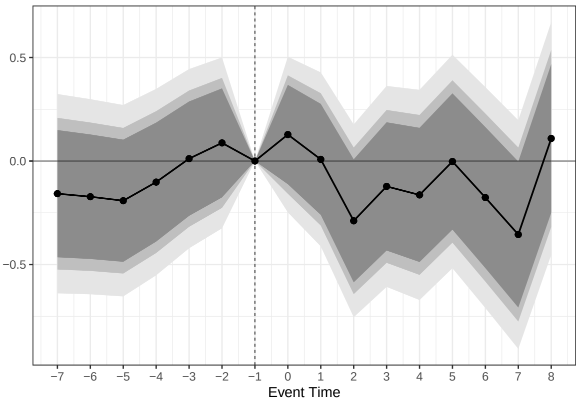
(a-2) log (active production unit ratio)



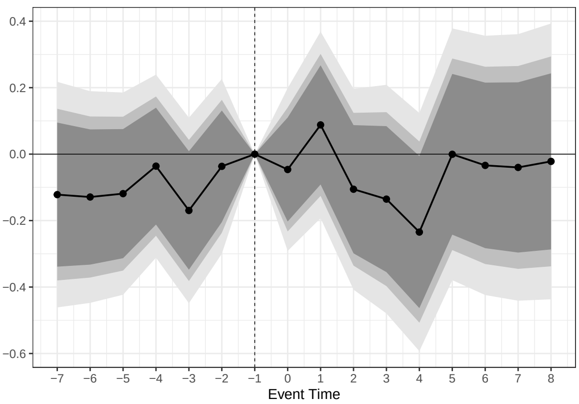
(b-1) log (total fuel expense)



(b-2) log (production-related fuel expense)



(b-3) log (total material expense)



(b-4) log (total lubricant expense)

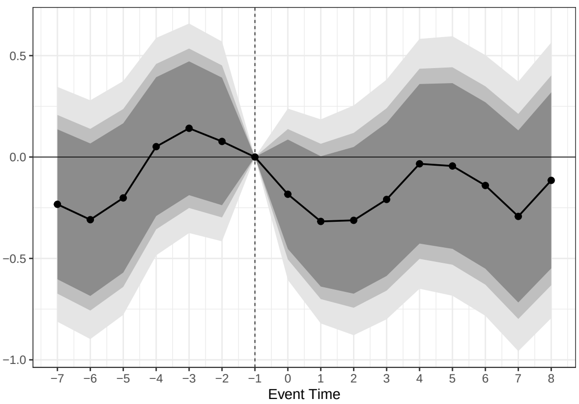
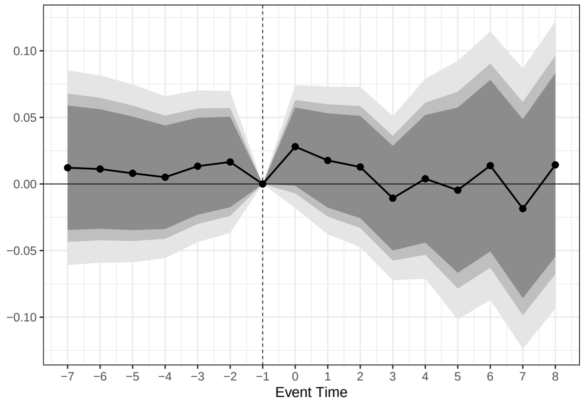
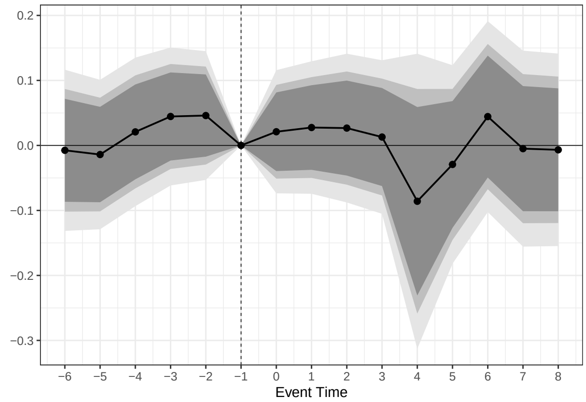


Figure D2: Event Study of Output, Productivity, and Inputs (Part 2)

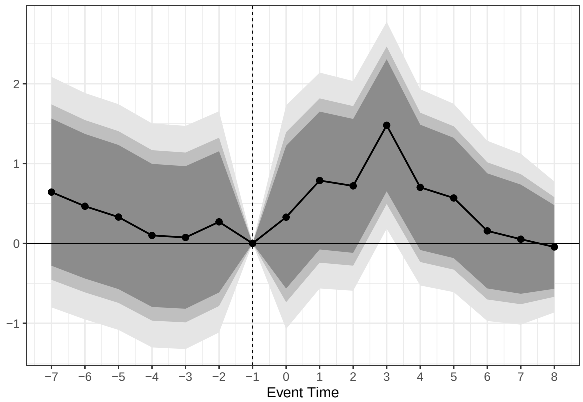
(1) log (total number of workers)



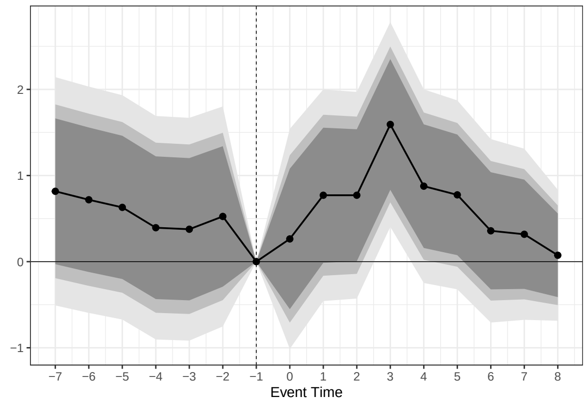
(2) log (total wage expenditure)



(3) log (estimated total capital value)



(4) log (estimated total land value)



Notes: This figure presents event study estimates of output, productivity, and various input measures using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

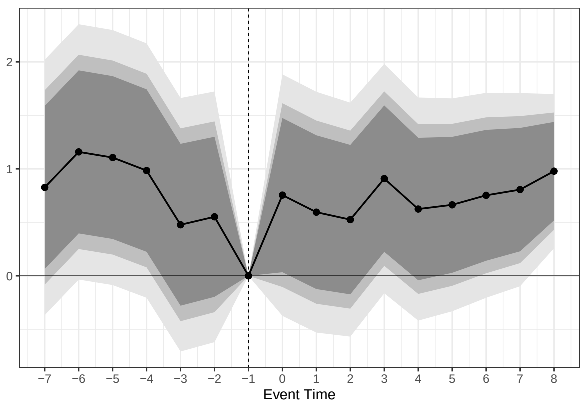
Table D1: Triple-Difference Analysis of Capital and Land Transaction

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Capital/land transaction				
VARIABLES	log (purchased capital value)		log (sold capital value)		log (purchased land value)		log (sold land value)	
DDD (NRB x LL)	-0.36408*	-0.11591	-0.12371	-0.04259	0.10613	0.08481	0.04351	0.06567
	(0.21895)	(0.23276)	(0.12640)	(0.13319)	(0.11861)	(0.12716)	(0.04534)	(0.04867)
DD (NRB)	0.47297***	0.29631**	0.24484***	0.18886**	0.23925***	0.20125***	0.03100	0.02368
	(0.12335)	(0.12958)	(0.07252)	(0.07723)	(0.06796)	(0.07220)	(0.02413)	(0.02571)
DD (LL)	0.29728**	1.39268***	-0.02813	0.06394	-0.00950	0.34210	-0.04756	-0.13716
	(0.13731)	(0.44412)	(0.07196)	(0.26030)	(0.07384)	(0.25764)	(0.03023)	(0.09093)
Observations	132,849	132,849	141,705	141,705	132,851	132,851	141,708	141,708
R-squared	0.51545	0.51769	0.45385	0.45568	0.34865	0.35108	0.26469	0.26733
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y	N	Y	N	Y

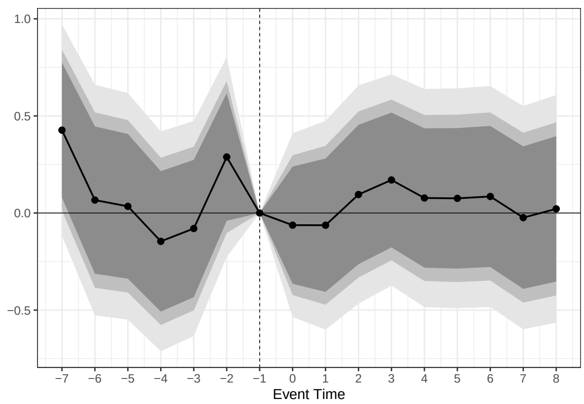
Notes: This table presents triple-difference estimates of the CSR mandate's effects on capital and land transactions using equation (3). The analysis examines purchased and sold values for both capital and land. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure D3: Event Study of Capital and Land Transaction

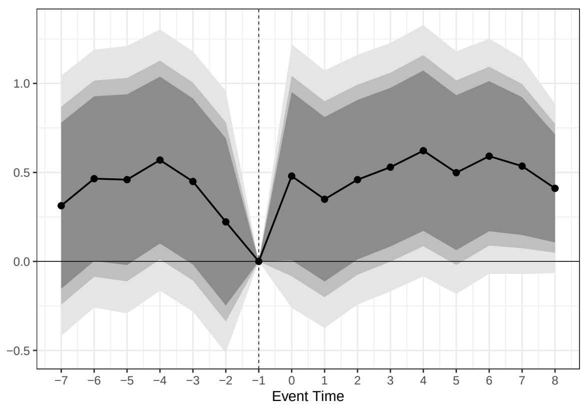
(1) log (purchased capital value)



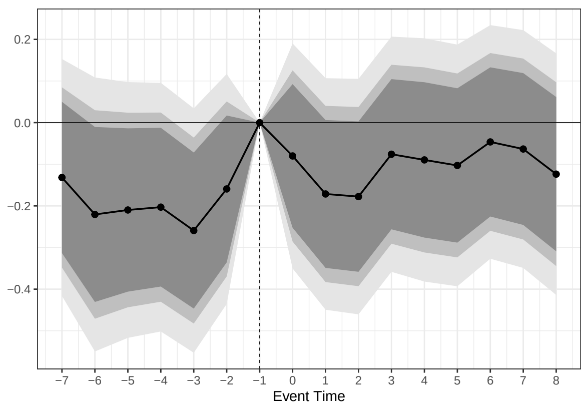
(2) log (sold capital value)



(3) log (purchased land value)



(4) log (sold land value)



Notes: This figure presents event study estimates of capital and land transactions using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

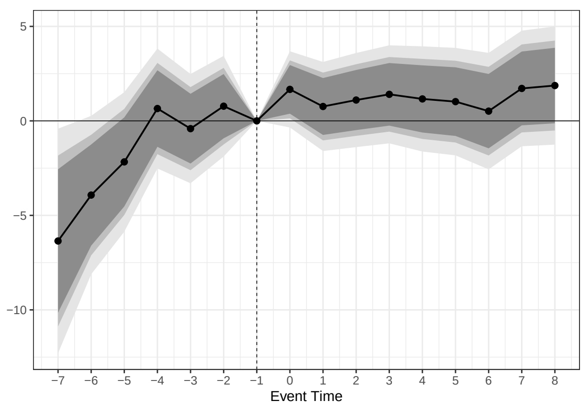
Table D2: Triple-Difference Analysis of Capital Source

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Capital source				
VARIABLES	National capital share		Foreign capital share		Central government capital share		Local government capital share	
DDD (NRB x LL)	3.05780***	2.88001***	-0.53231	-0.45809	-0.01499	0.08888	-2.50705***	-2.50916***
	(0.85993)	(0.94787)	(0.50341)	(0.55763)	(0.35871)	(0.40450)	(0.65129)	(0.71665)
DD (NRB)	-4.29658***	-3.65842***	1.66362***	1.51682***	0.12358	0.04015	2.50070***	2.09469***
	(0.48654)	(0.51943)	(0.30874)	(0.32979)	(0.17547)	(0.18031)	(0.36275)	(0.39295)
DD (LL)	-1.49641***	-15.45115***	0.24178	-0.31468	0.12590	0.95791*	1.12866***	14.80892***
	(0.53081)	(2.83117)	(0.21821)	(1.04330)	(0.32156)	(0.53420)	(0.41457)	(2.63804)
Observations	141,712	141,712	141,712	141,712	141,712	141,712	141,712	141,712
R-squared	0.74758	0.75179	0.84018	0.84070	0.77124	0.77173	0.65936	0.66821
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y	N	Y	N	Y

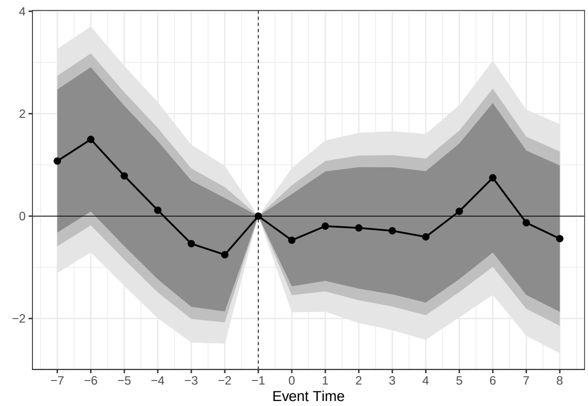
Notes: This table presents triple-difference estimates of the CSR mandate's effects on capital source composition using equation (3). The analysis examines the share of capital from national, foreign, central government, and local government sources. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure D4: Event Study of Capital Source

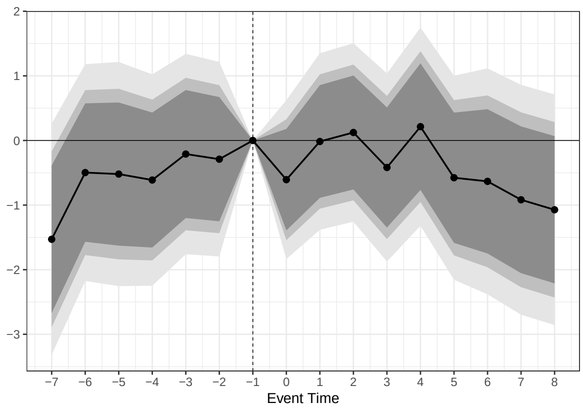
(b-1) National capital share



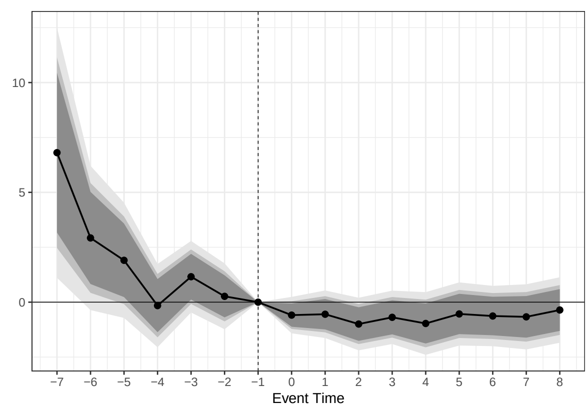
(b-2) Foreign capital share



(b-3) Central government capital share



(b-4) Local government capital share



Notes: This figure presents event study estimates of capital source shares using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

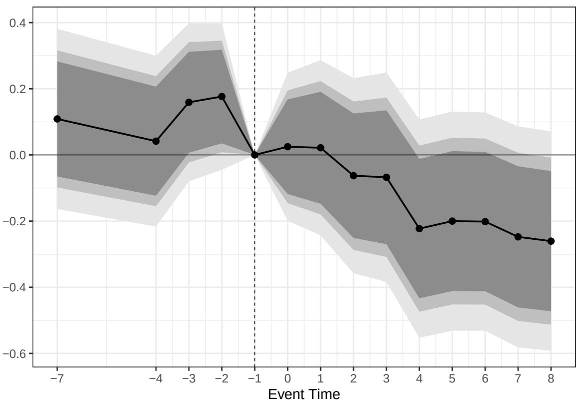
Table D3: Triple-Difference Analysis of Fuel Inputs (Quantity)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
					Fuel input quantiy							
VARIABLES	log (coal quantity)		log (natural gas quantity)		log (LPG quantity)		log (kerosene quantity)		log (gasoline quantity)		log (diesel quantity)	
DDD (NRB x LL)	-0.03824	-0.23241**	-0.10847	-0.19853**	0.35713***	0.17423	-0.07604	-0.00611	0.01477	-0.04603	-0.16807	0.03297
	(0.09815)	(0.10722)	(0.08722)	(0.09638)	(0.09808)	(0.10651)	(0.10508)	(0.10556)	(0.15404)	(0.16490)	(0.15545)	(0.16452)
DD (NRB)	0.45431***	0.59557***	0.30053***	0.33805***	-0.54132***	-0.41778***	0.68206***	0.50214***	-0.23489***	-0.20256**	-0.67838***	-0.73263***
	(0.06642)	(0.07149)	(0.04469)	(0.04874)	(0.06128)	(0.06307)	(0.06272)	(0.06317)	(0.08447)	(0.08852)	(0.08701)	(0.09162)
DD (LL)	-0.37145***	-0.86422***	-0.01578	0.25950	-0.43002***	-0.59149**	0.18713**	0.63924**	0.09514	0.03054	0.28882***	-0.43486
	(0.05128)	(0.14521)	(0.04329)	(0.22600)	(0.06171)	(0.25231)	(0.08442)	(0.26855)	(0.10805)	(0.31145)	(0.10629)	(0.32847)
Observations	123,998	123,998	97,427	97,427	97,427	97,427	123,998	123,998	141,712	141,712	141,712	141,712
R-squared	0.58230	0.59632	0.63895	0.64157	0.56376	0.56735	0.50904	0.51733	0.56685	0.56872	0.63688	0.64023
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y

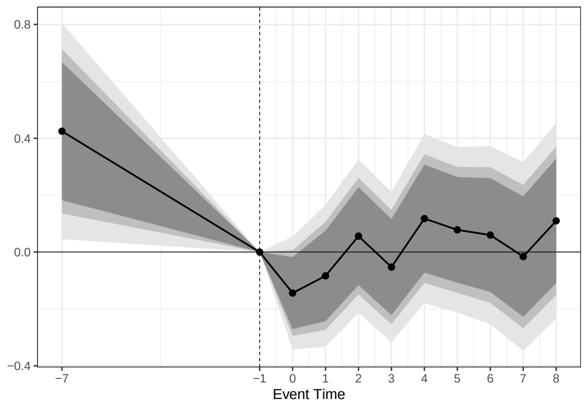
Notes: This table presents triple-difference estimates of the CSR mandate's effects on fuel input quantities by fuel type using equation (3). The analysis examines coal, natural gas, LPG, kerosene, gasoline, and diesel quantities. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure D5: Event Study of Fuel Inputs (Quantity)

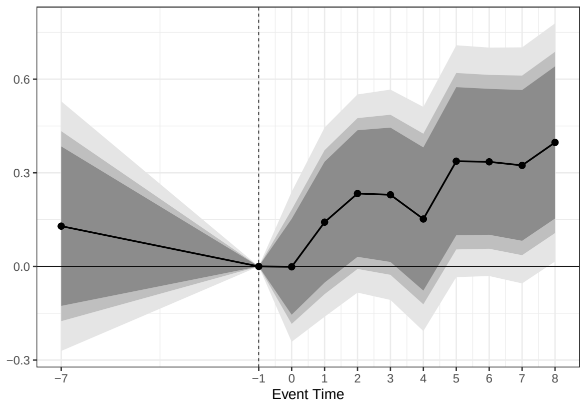
(1) log (coal quantity)



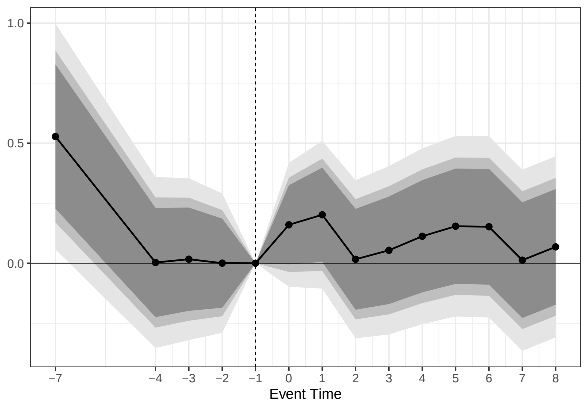
(2) log (natural gas quantity)



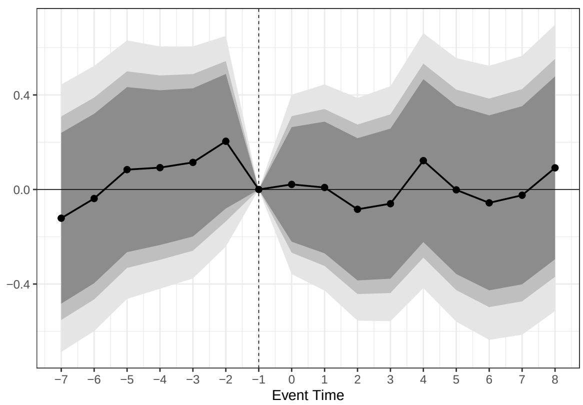
(3) log (LPG quantity)



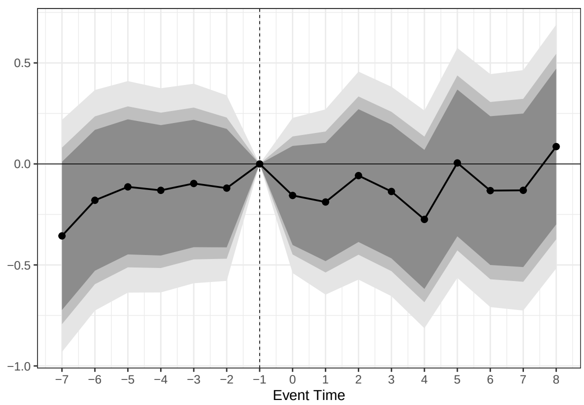
(4) log (kerosene quantity)



(5) log (gasoline quantity)



(6) log (diesel quantity)



Notes: This figure presents event study estimates of fuel input quantities by fuel type using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

Table D4: CO_2 Emission by Fuel Type

Source: U.S. Environmental Protection Agency (EPA) GHG Emission Factors Hub (2025)	kg CO_2 per mmBtu
Coal (Bituminous)	93.28
Kerosene	75.2
Diesel (Distillate Fuel Oil No.1)	73.25
Gasoline (Motor Gasoline)	70.22
LPG (Propane)	62.87
Natural Gas	53.06
Lubricants	74.27

Notes: This table presents CO2 emission factors by fuel type from the USEPA's Emission Factors for Greenhouse Gas Inventories (2025), measured in kg CO2 per mmBtu. These factors are used to calculate CO2 emissions from fuel consumption throughout the analysis.

Table D5: Triple-Difference Analysis of Energy Use and CO_2 Emission, Including LPG and Natural Gas

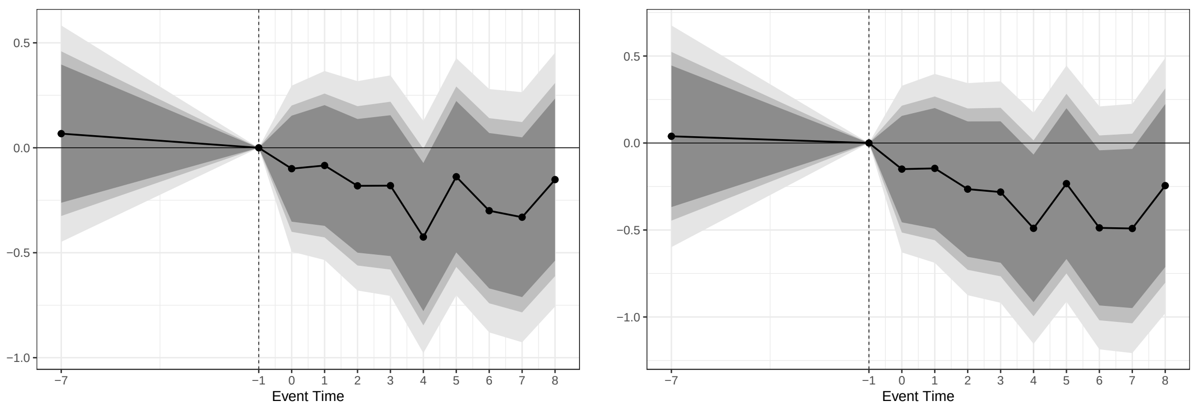
	(1)	(2)	(3)	(4)
	Energy use (including LPG and natural gas)		CO_2 emission (including LPG and natural gas)	
VARIABLES	log (total energy use)		log (total CO_2 emission)	
DDD (NRB x LL)	-0.09216	-0.24378	-0.20779	-0.32942*
	(0.14923)	(0.16187)	(0.17900)	(0.19183)
DD (NRB)	-0.15554*	-0.01869	-0.17585	-0.03737
	(0.09055)	(0.09557)	(0.10713)	(0.11208)
DD (LL)	-0.34628***	-0.99132***	-0.23721**	-0.87776**
	(0.09548)	(0.29684)	(0.11878)	(0.35124)
Observations	97,427	97,427	97,427	97,427
R-squared	0.67130	0.67459	0.65131	0.65433
Establishment FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y

Notes: This table presents triple-difference estimates of the CSR mandate's effects on energy use and CO2 emissions when including LPG and natural gas in the calculations, using equation (3). Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure D6: Event Study of Energy Use and CO_2 Emission, Including LPG and Natural Gas

(1) log (energy use)

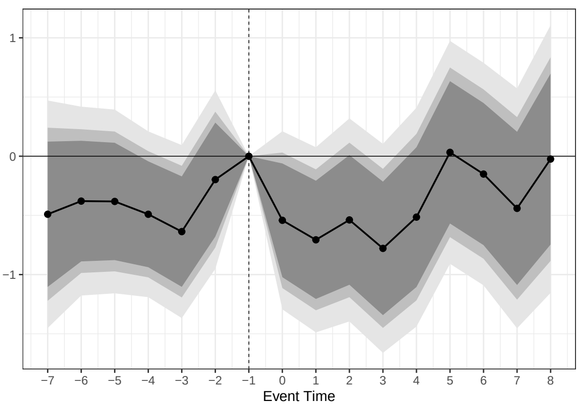
(2) log (CO_2 emission)



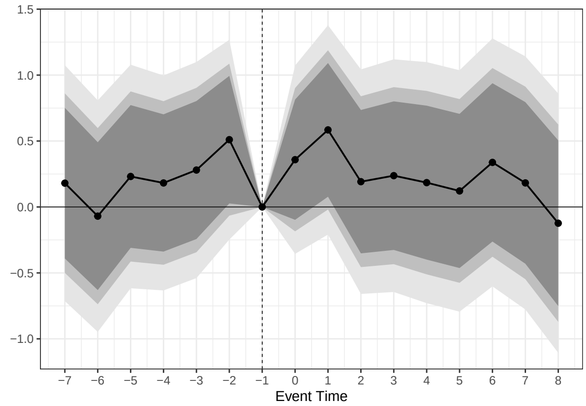
Notes: This figure presents event study estimates of energy use and CO2 emissions including LPG and natural gas using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

Figure D7: Event Study of Profit, Revenue, Expenditure, and Exit (Part 1)

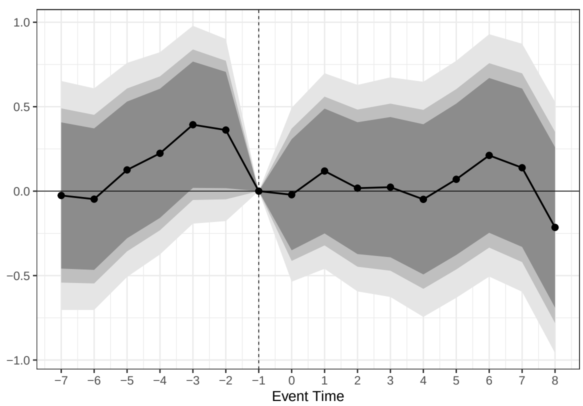
(1) log (profit)



(2) log (total revenue)



(3) log (manufacturing revenue)



(4) Markup

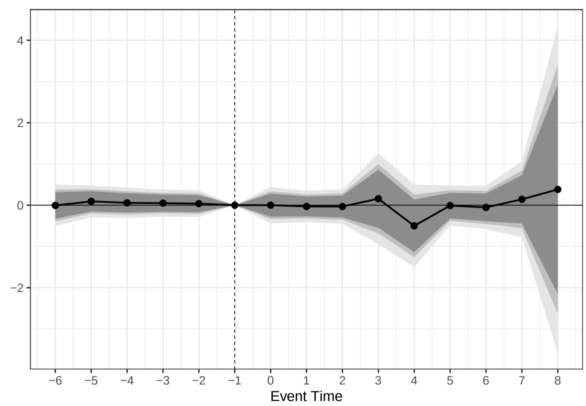
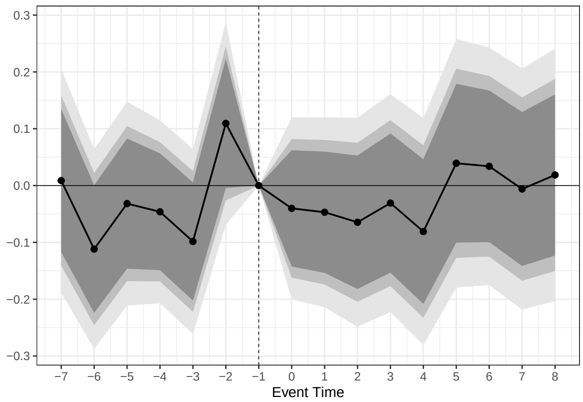
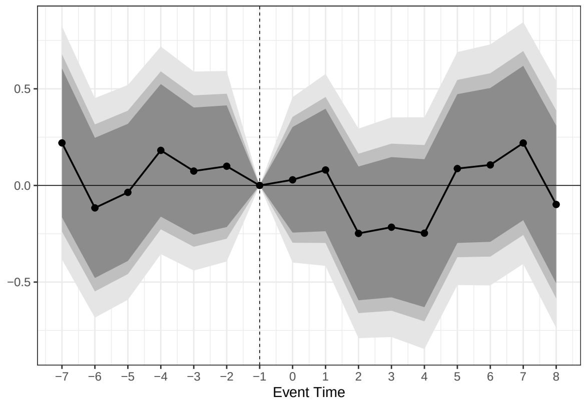


Figure D8: Event Study of Profit, Revenue, Expenditure, and Exit (Part 2)

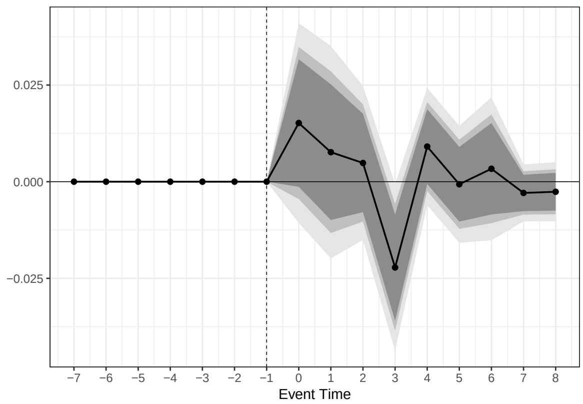
(5) log (total expense)



(6) log (donation expense)



(7) Exit



Notes: This figure presents event study estimates of profit, revenue, expenditure, and firm exit using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

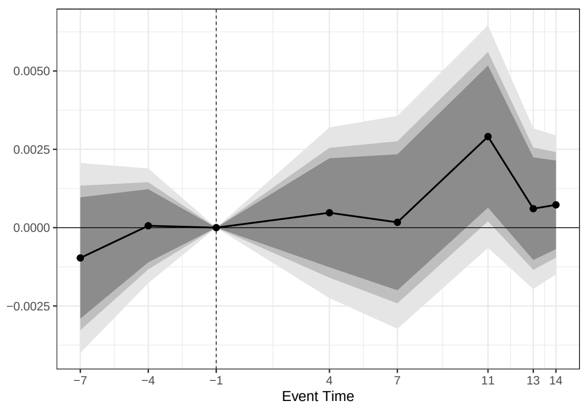
Table D6: Alternative Pollution Mechanisms

	(1)	(2)	(3)	(4)	(5)	(6)
			Alternative mechanisms			
VARIABLES	Share of villages with waste disposal to river		Share of villages with a river under industrial use		Share of villages with a mining site	
DDD (NRB x LL)	0.00072	0.00120	0.00105	0.00070	0.00228	-0.00082
	(0.00072)	(0.00074)	(0.00308)	(0.00307)	(0.00161)	(0.00178)
DD (NRB)	-0.00017	-0.00041**	-0.00075	-0.00062	-0.00157***	-0.00025
	(0.00020)	(0.00020)	(0.00110)	(0.00108)	(0.00051)	(0.00076)
DD (LL)	-0.00033	-0.00047*	-0.00001	0.00007	-0.00030	0.00035
	(0.00023)	(0.00024)	(0.00083)	(0.00085)	(0.00055)	(0.00056)
Observations	30,949	30,949	14,485	14,485	30,949	30,949
R-squared	0.58763	0.60599	0.60602	0.61038	0.61504	0.63216
Subdistrict FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Province x Year FE	N	Y	N	Y	N	Y

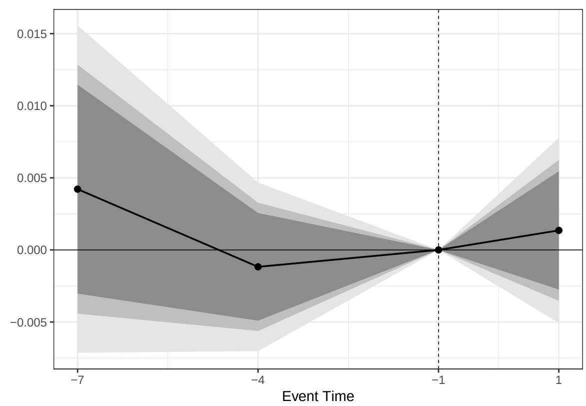
Notes: This table presents triple-difference estimates of alternative pollution mechanisms at the village level using equation (4). The analysis examines waste disposal behavior, industrial river use, and mining site presence. Standard errors are clustered at the subdistrict level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure D9: Alternative Pollution Mechanisms

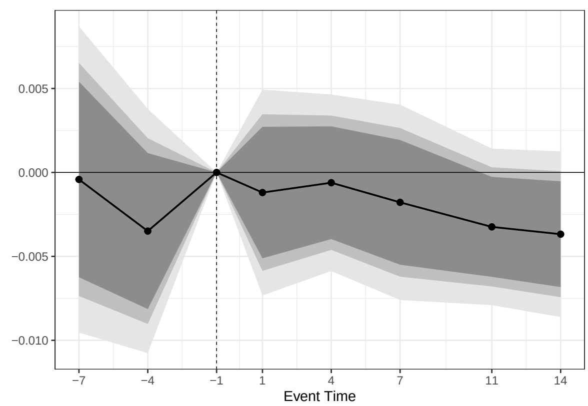
(1) Waste disposal behavior indicator



(2) Industrial river use indicator



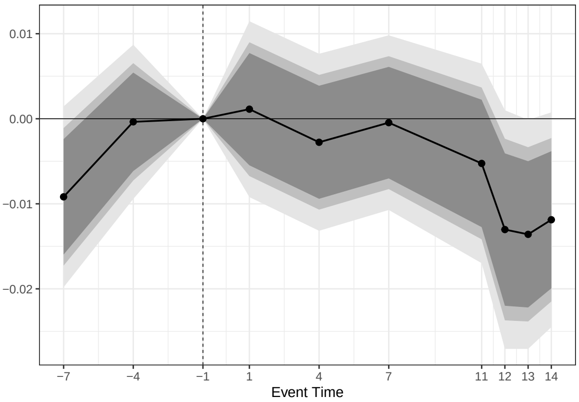
(3) Mining site indicator



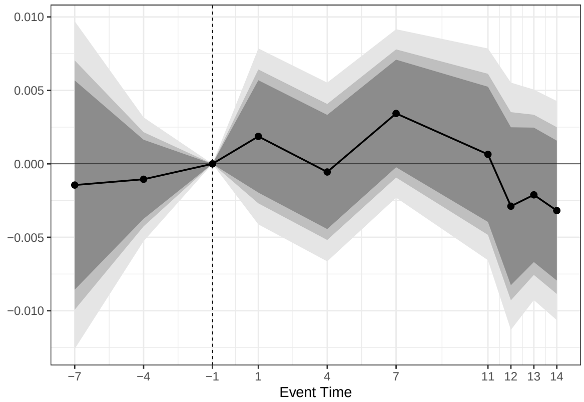
Notes: This figure presents event study estimates of alternative pollution mechanisms at the village level using equation (4), a triple-difference specification. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2005 (the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the subdistrict level.

Figure D10: Provision of Public Goods

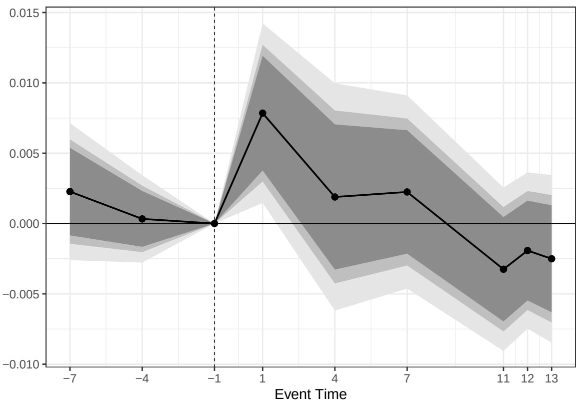
(1) log(number of private primary schools)



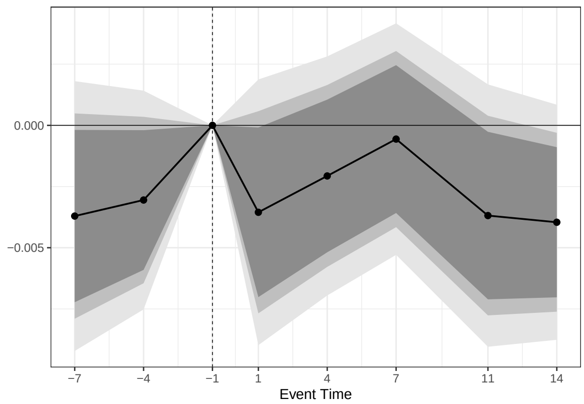
(2) log(number of private junior high schools)



(3) log(number of hospitals)



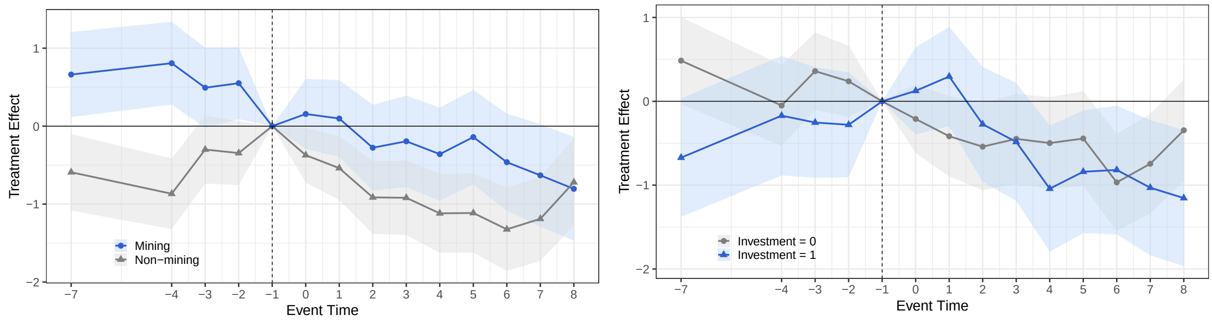
(4) Police station availability share



Notes: This figure presents event study estimates of public goods provision at the village level using equation (4), a triple-difference specification. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2005 (the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the subdistrict level.

Figure D11: Heterogeneity analysis in CO_2 emission

(1) Firms using inputs from the mining sector **(2)** Investor firms



Notes: This figure presents event study estimates of heterogeneous effects on CO2 emissions by mining sector input use and investor status using equation (3) with interaction terms. The vertical axis shows the estimated coefficients, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

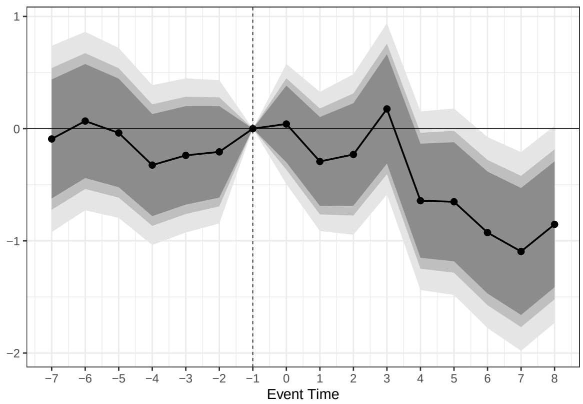
Table D7: Triple-Difference Analysis of Stocked Input Material and Output

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Stocked input material and output					
VARIABLES	log (year-end raw material stock)		log (raw material stock change)		log (year-end finished stock)		log (finished stock change)	
DDD (NRB x LL)	-0.68512***	-0.37782	-0.65998***	-0.37942*	-0.43048**	-0.17699	-0.33302	-0.19200
	(0.22096)	(0.23367)	(0.21376)	(0.22709)	(0.21385)	(0.22678)	(0.20290)	(0.21656)
DD (NRB)	0.44366***	0.25117*	0.31931***	0.17895	0.40006***	0.19070	0.31500***	0.16886
	(0.12311)	(0.13050)	(0.11953)	(0.12680)	(0.12036)	(0.12788)	(0.11438)	(0.12201)
DD (LL)	0.23463	1.33387***	0.26007*	0.97442**	0.24809*	1.13163**	0.21124	1.17309***
	(0.14811)	(0.47175)	(0.13728)	(0.44462)	(0.14483)	(0.45361)	(0.13144)	(0.42949)
Observations	141,538	141,538	117,670	117,670	141,545	141,545	120,531	120,531
R-squared	0.60608	0.60832	0.60621	0.60846	0.62307	0.62520	0.60874	0.61097
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y	N	Y	N	Y

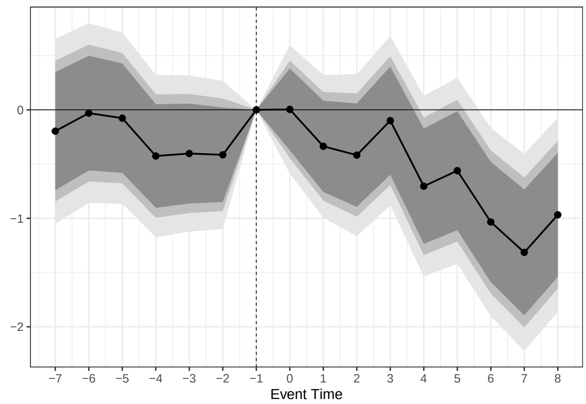
Notes: This table presents triple-difference estimates of the CSR mandate's effects on stocked input materials and output using equation (3). The analysis examines year-end stocks and annual stock changes for both raw materials and finished goods. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure D12: Event Study of Stocked Input Material and Output

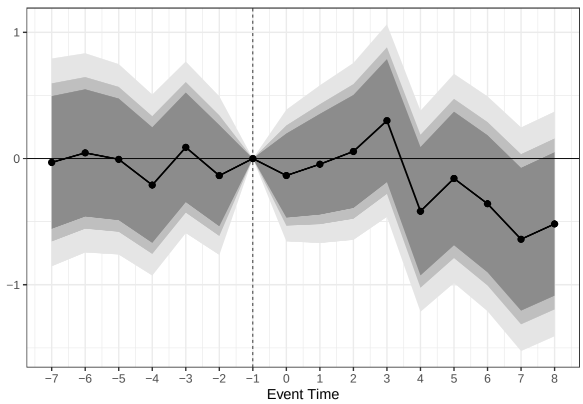
(1) log (year-end raw material stock)



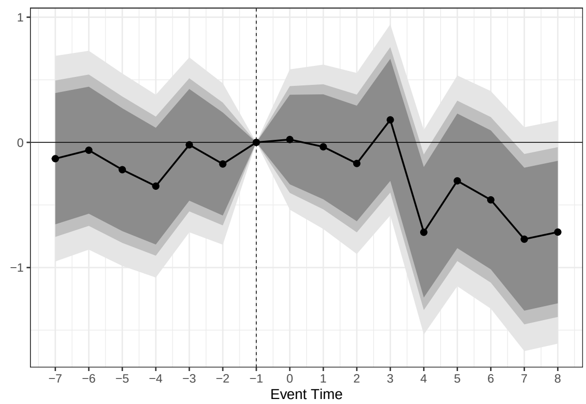
(2) log (annual raw material stock change)



(3) log (year-end finished output stock)

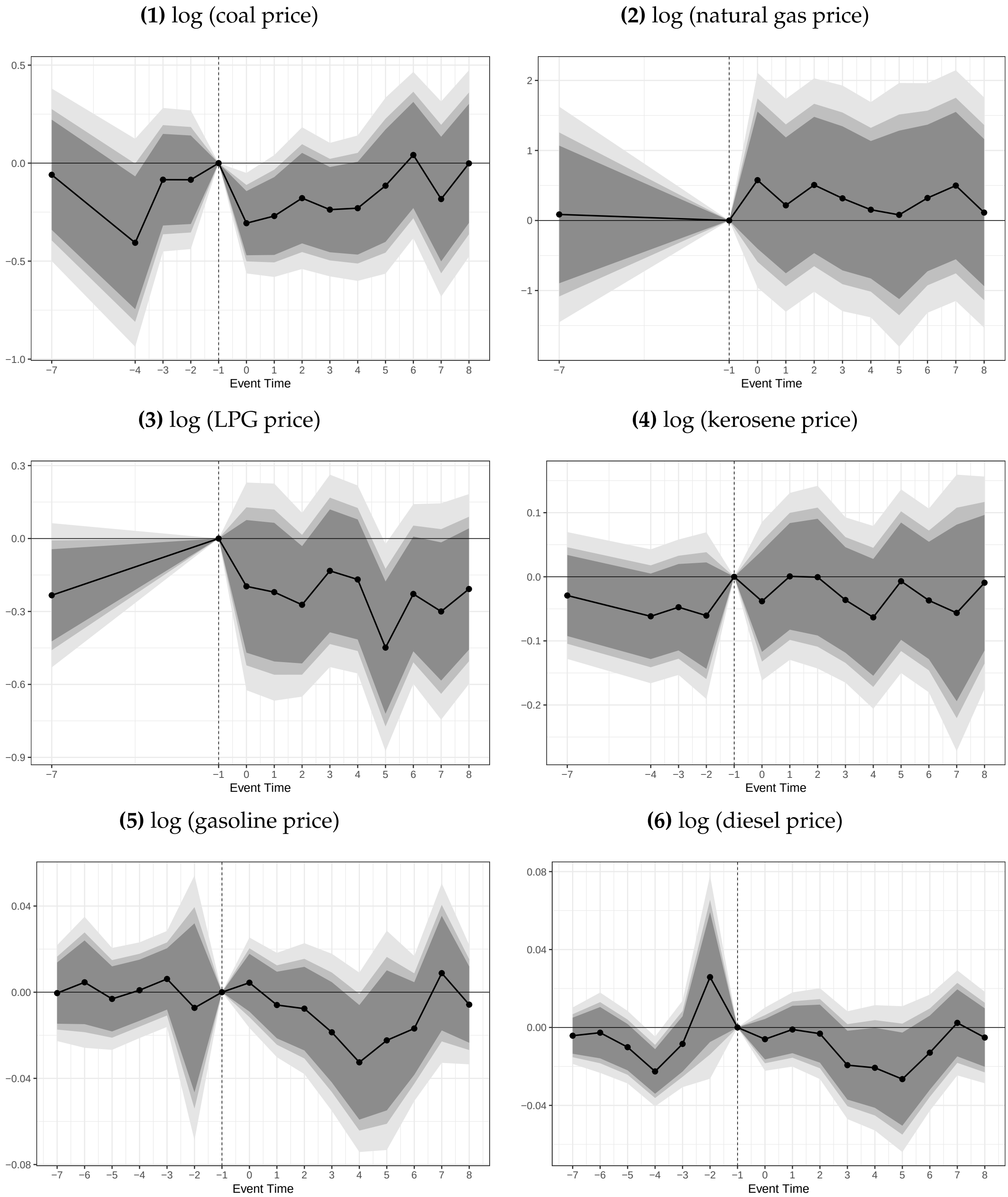


(4) log (annual finished output stock change)



Notes: This figure presents event study estimates of stocked input materials and output using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta^{t=j}_{DDD}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

Figure D13: Event Study of Fuel Prices



Notes: This figure presents event study estimates of fuel prices by fuel type using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

Table D8: Triple-Difference Analysis with Sector-specific Fuel Price Controls

(a) Fuel Inputs (Expenditure)

	(1)	(2)	(3)	(4)	(5)	(6)
			Fuel input expense			
VARIABLES	log (coal expense)	log (natural gas expense)	log (LPG expense)	log (kerosene expense)	log (gasoline expense)	log (diesel expense)
DDD (NRB x LL)	-0.20638**	-0.14103	0.26737**	0.03960	-0.10365	-0.13095
	(0.10527)	(0.10489)	(0.11977)	(0.11138)	(0.18219)	(0.17658)
DD (NRB)	0.59205***	0.43761***	-0.40851***	0.39365***	-0.20140**	-0.46681***
	(0.07048)	(0.05488)	(0.07258)	(0.06602)	(0.09756)	(0.09797)
DD (LL)	-0.10474*	-0.00070	-0.15020*	0.05670	0.22342*	0.17929
	(0.06163)	(0.06351)	(0.07754)	(0.09029)	(0.12947)	(0.12725)
Observations	123,998	97,427	97,427	123,998	141,712	141,712
R-squared	0.59641	0.66014	0.58233	0.52506	0.56976	0.63473
Establishment FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Sector x Fuel price	N	Y	N	Y	N	Y

(b) CO_2 Emission and Energy Use

	(1)	(2)	(3)	(4)	(5)	(6)
		CO_2 emission and Energy use				
VARIABLES	log (total CO2 emission)	log (production-related CO2 emission)	log (generation-related CO2 emission)	log (total energy use)	log (production-related energy use)	log (generation-related energy use)
DDD (NRB x LL)	-0.72491***	-0.82136***	0.29483	-0.53780***	-0.61684***	0.18685
	(0.20336)	(0.22439)	(0.19395)	(0.16275)	(0.17553)	(0.13554)
DD (NRB)	0.39214***	0.66363***	-0.43130***	0.35409***	0.54934***	-0.31665***
	(0.11948)	(0.12970)	(0.10536)	(0.09775)	(0.10383)	(0.07420)
DD (LL)	0.18833	0.12478	0.04247	0.09745	0.05014	0.04277
	(0.14047)	(0.15976)	(0.13758)	(0.10942)	(0.12256)	(0.09546)
Observations	123,998	115,131	115,141	123,998	115,131	115,141
R-squared	0.59886	0.57558	0.58479	0.62495	0.60438	0.58671
Establishment FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Sector x Fuel price	Y	N	Y	N	Y	N

Notes: This table presents triple-difference estimates of the CSR mandate's effects on fuel inputs, CO2 emissions, and energy use with sector-specific fuel price controls using equation (3). Panel (a) examines fuel input expenditures, while panel (b) examines CO2 emissions and energy use. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Appendix E. Electricity Generation Results

Electricity generation outcomes show limited treatment effects, with several measures exhibiting problematic pre-trends that complicate causal interpretation. I examine six electricity-related outcomes in sequence.

Table E1 columns (1)–(2) and Figure E1 Panel (1) examine electricity generated. While post-treatment coefficients center near zero, pre-treatment estimates dip below zero, violating parallel trends. The significantly positive DDD estimate in Table E1 column (2) likely reflects this pre-trend deviation rather than a genuine treatment effect. Table E1 columns (3)–(4) and Figure E1 Panel (2) show similar patterns for generator efficiency, with pre-treatment dips undermining causal inference. The positive DDD coefficient in column (4) again likely captures pre-existing trends rather than policy impacts.

Table E1 columns (5)–(6) and Figure E1 Panel (3) examine electricity sales revenue. Unlike other revenue categories, electricity sales show no significant changes, consistent with stable generation levels documented above. Table E1 columns (7)–(8) and Figure E1 Panel (4) examine generation-related fuel expenses. DDD estimates indicate no significant effects, though the event study reveals modest pre-treatment dips echoing the parallel-trends concerns observed for electricity generation itself.

Table E2 columns (1)–(2) and Figure E2 Panel (1) examine generation-related energy use, while columns (3)–(4) and Figure E2 Panel (2) examine generation-related CO_2 emissions. Both measures display downward pre-treatment trends, weakening the parallel-trends assumption and likely biasing DDD estimates upward. These pre-trend violations limit confidence in the estimated treatment effects for generation-related environmental outcomes.

In summary, electricity generation outcomes show no credible treatment effects. Persistent pre-treatment deviations across multiple generation-related measures suggest that electricity generation did not contribute to the observed improvements in aggregate environmental performance. The environmental gains documented earlier stem primarily from production-related fuel substitution rather than changes in power generation practices.

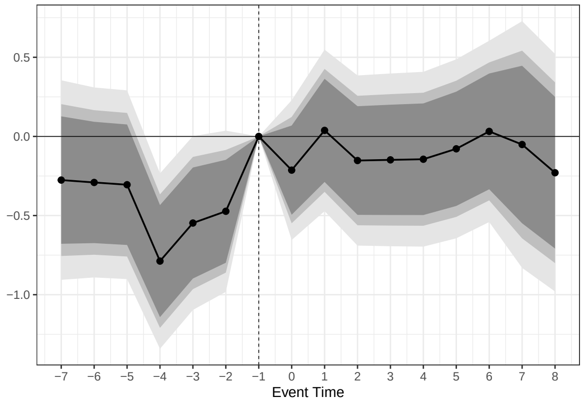
Table E1: Triple-Difference Analysis of Electricity Generation

VARIABLES	(1) log (electricity generated)	(2)	(3) log (generator efficiency)	(4)	(5) log (electricity sold value)	(6)	(7) log (generation-related fuel expense)	(8)
DDD (NRB x LL)	0.18812	0.28188*	0.22194**	0.26061***	0.04532**	0.04001**	0.15454	0.22738
	(0.14829)	(0.16396)	(0.08987)	(0.09880)	(0.02019)	(0.01902)	(0.14579)	(0.16130)
DD (NRB)	-0.22341***	-0.29596***	-0.10773**	-0.18814***	-0.00659	-0.00437	-0.18916**	-0.23860***
	(0.08176)	(0.08875)	(0.04982)	(0.05320)	(0.00829)	(0.01058)	(0.08033)	(0.08757)
DD (LL)	0.03864	-0.15527	-0.12913**	0.20368	-0.00942	-0.03771*	-0.03155	0.03673
	(0.09338)	(0.33871)	(0.05654)	(0.18519)	(0.01397)	(0.02162)	(0.09192)	(0.28160)
Observations	133,909	133,909	141,707	141,707	141,712	141,712	141,712	141,712
R-squared	0.54517	0.54736	0.57645	0.57862	0.31953	0.32127	0.56254	0.56408
Establishment FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y	N	Y	N	Y

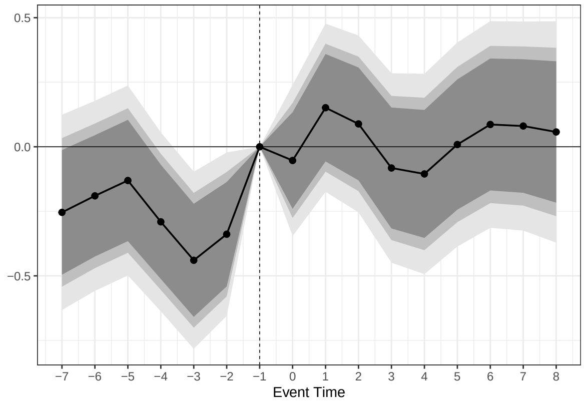
Notes: This table presents triple-difference estimates of the CSR mandate's effects on electricity generation outcomes using equation (3). The analysis examines electricity generated, generator efficiency, electricity sales revenue, and generation-related fuel expenses. Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Results should be interpreted with caution due to pre-treatment trend violations documented in the event study figures.

Figure E1: Event Study of Electricity Generation

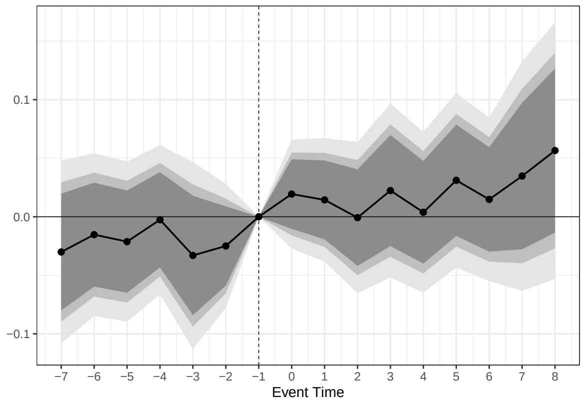
(1) log (electricity generated)



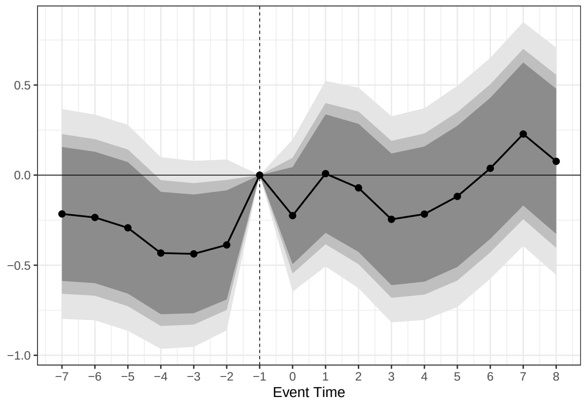
(2) log (generator efficiency)



(3) log (electricity sold value)



(4) log (generation-related fuel expense)



Notes: This figure presents event study estimates of electricity generation outcomes using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

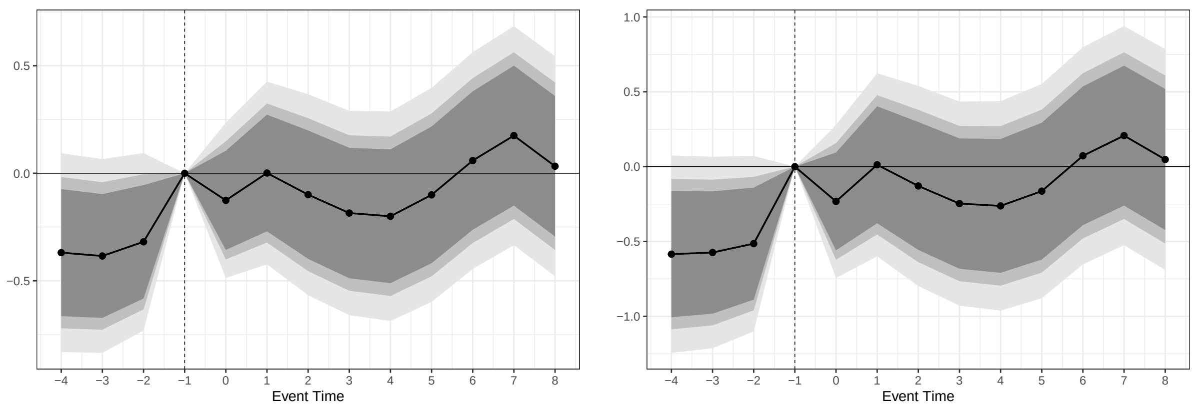
Table E2: Triple-Difference of Electricity Generation Related Energy Use and Emissions

	(1)	(2)	(3)	(4)
VARIABLES	log (generation-related energy use)		log (generation-related CO2 emission)	
DDD (NRB x LL)	0.12831	0.21895	0.22730	0.34105*
	(0.12742)	(0.14092)	(0.18247)	(0.20169)
DD (NRB)	-0.30260***	-0.34759***	-0.42495***	-0.48025***
	(0.07082)	(0.07749)	(0.10117)	(0.11007)
DD (LL)	-0.02670	0.14367	-0.06857	0.12865
	(0.07956)	(0.24043)	(0.11652)	(0.35480)
Observations	115,141	115,141	115,141	115,141
R-squared	0.58720	0.58861	0.58428	0.58566
Establishment FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Sector x Year FE	N	Y	N	Y

Notes: This table presents triple-difference estimates of the CSR mandate's effects on generation-related energy use and CO2 emissions using equation (3). Standard errors are clustered at the establishment level and reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Results should be interpreted with caution due to pre-treatment trend violations documented in the event study figures.

Figure E2: Event Study of Electricity Generation Related Energy Use and Emissions

(1) log (generation-related energy use) **(2)** log (generation-related CO_2 emission)



Notes: This figure presents event study estimates of generation-related energy use and CO2 emissions using equation (3), a triple-difference specification for manufacturing firms. The vertical axis shows the estimated DDD coefficients $\beta_{DDD}^{t=j}$, and the horizontal axis shows event time relative to 2006 (t=0, the omitted baseline year). Shaded areas represent 90%, 95%, and 99% confidence intervals based on standard errors clustered at the establishment level.

Appendix F. CO_2 Emission and Energy Use Calculations

CO_2 emissions and energy use are calculated using the conversion coefficients below and standardized to kg CO_2 and mmBTU per survey unit for each fuel type.

Table F1: CO_2 Emission and Energy Use Conversion Table

Source: U.S. Environmental Protection Agency (EPA) GHG Emission Factors Hub (2025)	kg CO_2 per mmBtu	mmBtu per short ton	kg CO_2 per short ton	mmBtu per gallon	kg CO_2 per gallon	mmBtu per scf	kg CO_2 per scf	Survey unit	EPA unit in survey unit	mmBTU per survey unit	kg CO_2 per survey unit
Coal (Bituminous)	93.28	24.93	2325					Kg	907.1847	22616.1155682000	2109631.2602017000
Kerosene	75.2			0.135	10.15			Ltr	3.785412	0.5110305930	38.4295005936
Diesel (Distillate Fuel Oil No.1)	73.25			0.139	10.18			Ltr	3.785412	0.5261722402	38.5421165947
Gasoline (Motor Gasoline)	70.22			0.125	8.78			Ltr	3.785412	0.4731764750	33.2264520745
LPG (Propane)	62.87	0.091	5.72					Kg	907.1847	82.5538113400	5190.1581189458
Natural Gas	53.06					0.00103	0.05444	M3	0.028317	0.0000290530	0.0015415541
Lubricants	74.27			0.144	10.69			Ltr	3.785412	0.5450992992	40.4845249516

Appendix G. Theoretical Framework (Preliminary)

The general equilibrium climate-economy model of Golosov, Hassler, Krusell, and Tsyvinski (2014) (henceforth GHKT) provides the canonical framework for analyzing optimal carbon taxation. Their key result is that the optimal carbon tax can be expressed as a simple function of damage elasticities and carbon depreciation rates, independent of most economic parameters under log utility and multiplicative damages.

I extend GHKT (2014) to incorporate CSR as a time-varying carbon tax with inverse U-shaped dynamics. Specifically, I model CSR as imposing a carbon tax τ_t^{CSR} that evolves endogenously according to a logistic growth process, rising to a peak and then stabilizing at a steady state. Welfare comparison and simulation are in progress.

I. Review of GHKT (2014)

Economic Environment

Time is discrete and infinite, $t = 0, 1, 2, \ldots$ The representative household has preferences:

$$U_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \log C_t$$

where $\beta \in (0, 1)$ is the discount factor and C_t is consumption.

The economy has a final goods sector and I energy sectors. The resource constraint is:

$$C_t + K_{t+1} = Y_t + (1 - \delta)K_t$$

where K_t is capital and $\delta \in [0, 1]$ is depreciation.

Final goods production is:

$$Y_t = (1 - D_t(S_t))A_{0,t}K_t^{\alpha}N_{0,t}^{1-\alpha-\nu}E_t^{\nu}$$

where S_t is atmospheric carbon concentration, $D_t(S_t)$ is the damage function, $A_{0,t}$ is productivity, and E_t is an energy aggregate.

GHKT Assumptions

- Log Utility:

$$U(C) = \log C$$

- Multiplicative Damages (Damage function):

$$1 - D_t(S_t) = \exp(-\varepsilon_t(S_t - \bar{S}))$$

  where ε_t is the damage elasticity and $\bar{S}$ is pre-industrial carbon concentration.

- Linear Carbon Cycle (Carbon concentration evolution function):

$$S_t - \bar{S} = \sum_{s=0}^{t+T}(1 - d_s)E_{t-s}^{f}$$

  where E_t^f is fossil fuel emissions and $d_s \in [0, 1]$ is the depreciation rate of atmospheric carbon.

Energy Production

There are three energy sectors:

- Oil (sector 1): Exhaustible resource with stock $R_{1,t}$, extraction $E_{1,t}$
- Coal (sector 2): Abundant fossil fuel, $E_{2,t} = A_{2,t}N_{2,t}$
- Green (sector 3): Renewable energy, $E_{3,t} = A_{3,t}N_{3,t}$

The energy aggregate is:

$$E_t = \left(\theta_1 E_{1,t}^{\rho} + \theta_2 E_{2,t}^{\rho} + \theta_3 E_{3,t}^{\rho}\right)^{1/\rho}$$

with $\sum_i \theta_i = 1$ and $\rho < 1$.

Total fossil emissions are $E_t^f = E_{1,t} + E_{2,t}$.

GHKT Optimal Tax

The GHKT optimal carbon tax (per unit of emissions) is:

$$\tau_t^s = Y_t \left[\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \varepsilon_{t+j}(1 - d_j)\right]$$

Under constant damage elasticity $\varepsilon_t = \varepsilon$, this simplifies to:

$$\tau_t^s = Y_t \cdot \varepsilon \cdot \left[\frac{\phi_L}{1-\beta} + \frac{(1-\phi_L)\phi_0}{1-(1-\phi)\beta}\right]$$

where $\phi = \lim_{s\to\infty} d_s$, $\phi_L = \lim_{s\to\infty}(1 - d_s)$, and ϕ_0 depends on initial carbon depreciation.

II. CSR Extensions

I now extend the GHKT framework to incorporate CSR regulations modeled as a time-varying carbon tax with inverse U-shaped dynamics.

CSR as Time-Varying Carbon Tax — I model CSR regulations as imposing a carbon tax τ_t^{CSR} on fossil fuel emissions. Unlike the permanent Pigouvian tax τ_t^s from GHKT, the CSR tax evolves endogenously over time according to a law of motion that captures the lifecycle of regulatory effectiveness.

Assumption 1 (CSR Dynamics)**.** *The CSR carbon tax evolves according to:*

$$\tau_{t+1}^{CSR} = g(\tau_t^{CSR})$$

where $g : \mathbb{R}_+ \to \mathbb{R}_+$ is a continuous, differentiable function with the following properties:

1. *Logistic growth: $g(\tau) = \tau + \alpha\tau\left(1 - \frac{\tau}{\bar{\tau}}\right)$ for some $\alpha > 0$ and $\bar{\tau} > 0$*
2. *Unique steady state: $\bar{\tau}$ is the unique positive steady state with $g(\bar{\tau}) = \bar{\tau}$*
3. *Convergence: For any $\tau_0 \in (0, \bar{\tau})$, the sequence $\{\tau_t^{CSR}\}$ converges to $\bar{\tau}$*

e.g.,) One example specification is:

$$g(\tau) = \tau + \alpha\tau\left(1 - \frac{\tau}{\bar{\tau}}\right) = (1+\alpha)\tau - \frac{\alpha}{\bar{\tau}}\tau^2$$

where:

- $\alpha > 0$ is the growth rate parameter
- $\bar{\tau} > 0$ is the carrying capacity (long-run steady state)

This specification guarantees:
(1) Monotonicity: The function $g(\tau)$ is strictly increasing for $\tau < \bar{\tau}$:

$$g'(\tau) = 1 + \alpha - \frac{2\alpha}{\bar{\tau}}\tau > 0 \quad \text{for } \tau < \bar{\tau}.$$

(2) Concavity: The function is strictly concave:

$$g''(\tau) = -\frac{2\alpha}{\bar{\tau}} < 0 \quad \text{for all } \tau.$$

III. Decentralized Equilibrium with CSR

I next characterize the competitive equilibrium where the government imposes only the CSR tax (no Pigouvian tax).

Household Problem

The representative household solves:

$$\max_{\{C_t, K_{t+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \log C_t$$

subject to:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} q_t (C_t + K_{t+1}) = \mathbb{E}_0 \sum_{t=0}^{\infty} q_t \left[(1 + r_t - \delta)K_t + w_t N_t + \Pi_t\right]$$

where q_t are Arrow-Debreu prices, r_t is the rental rate, w_t is the wage, and Π_t are profits from energy sectors.

First-order conditions:

$$\frac{1}{C_t} = q_t, \quad \frac{1}{C_t} = \beta \mathbb{E}_t \left[\frac{1}{C_{t+1}}(1 + r_{t+1} - \delta)\right]$$

Final Goods Producer

The representative final goods firm solves:

$$\max_{K_{0,t}, N_{0,t}, E_{0,t}} \left\{ Y_t - r_t K_{0,t} - w_t N_{0,t} - \sum_{i=1}^{3} p_{i,t} E_{i,t} \right\}$$

where $Y_t = e^{-\varepsilon(S_t - \bar{S})} A_{0,t} K_{0,t}^{\alpha} N_{0,t}^{1-\alpha-\nu} E_{0,t}^{\nu}$.

First-order conditions:

$$r_t = \alpha \frac{Y_t}{K_t}, \quad w_t = (1 - \alpha - \nu)\frac{Y_t}{N_t}, \quad p_{i,t} = \nu \frac{Y_t}{E_t} \frac{\partial E_t}{\partial E_{i,t}}$$

Energy Producers

- Coal firms (sector 2): Representative coal firm solves:

$$\pi_{2,t} = \max_{N_{2,t}} \left\{ p_{2,t} A_{2,t} N_{2,t} - w_t N_{2,t} - \tau_t^{CSR} A_{2,t} N_{2,t} \right\}$$

  The CSR tax $\tau_t^{CSR} A_{2,t} N_{2,t}$ enters as a negative term in profits, representing the social cost imposed by CSR compliance.

First-order condition:

$$p_{2,t}A_{2,t} - w_t - \tau_t^{CSR}A_{2,t} = 0 \implies p_{2,t} = \frac{w_t}{A_{2,t}} + \tau_t^{CSR}$$

Labor demand:

$$N_{2,t} = \frac{E_{2,t}}{A_{2,t}}$$

- Green firms (sector 3): Representative green firm solves:

$$\pi_{3,t} = \max_{N_{3,t}} \{p_{3,t}A_{3,t}N_{3,t} - w_t N_{3,t}\}$$

  First-order condition:

$$p_{3,t} = \frac{w_t}{A_{3,t}}$$

- Oil sector (sector 1): As in GHKT, with extraction cost and scarcity rent.

Market Clearing

Labor market:

$$N_{0,t} + N_{1,t} + N_{2,t} + N_{3,t} = N_t$$

Capital market:

$$K_{0,t} = K_t$$

Energy markets:

$$E_{i,t} = E_{0,i,t}, \quad i = 1, 2, 3$$

Equilibrium Definition

Definition 1 (Competitive Equilibrium with CSR)**.** *A competitive equilibrium with CSR tax* $\{\tau_t^{CSR}\}_{t=0}^{\infty}$ *consists of allocations* $\{C_t, K_{t+1}, N_{i,t}, E_{i,t}\}$*, prices* $\{w_t, r_t, p_{i,t}\}$*, and profits* $\{\pi_{i,t}\}$ *such that:*

1. *Households optimize given prices*
2. *Final goods firms optimize given prices*
3. *Energy firms optimize given prices and CSR tax*
4. *All markets clear*
5. *CSR tax evolves:* $\tau_{t+1}^{CSR} = g(\tau_t^{CSR})$

Equilibrium Characterization: In progress.