# Running from the EPA? The Effects of Environmental Regulation When Firm and Regulatory Boundaries Do Not Align

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**PRELIMINARY DRAFT**

**Abstract**

The decentralized structure of the US Environmental Protection Agency (EPA) generates systematic differences in environmental regulatory stringency across regions within the US. We study how these regional differences in environmental regulation affect firms' divestiture, abatement, and production-location decisions. We find that stronger EPA enforcement intensity in one EPA region leads firms to divest polluting facilities in that region, while expanding operations in other geographies. These effects are strongest for firms with preexisting production facilities in other areas, particularly when the other regions have a weaker EPA enforcement intensity. In contrast, single-region firms respond to stronger enforcement by increasing pollution abatement activity. Firm employment declines in regions that have stronger enforcement but increases in other regions, consistent with firms shifting production out of areas with stronger enforcement. Firms with larger geographic flexibility strongly reduce local toxic emissions in response to stricter EPA enforcement, but this reduction arises from a shift in the location of production rather than an increase in abatement activity. These results highlight the heterogeneous effects of environmental regulation when regulatory and firm boundaries are not aligned.

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# 1 Introduction

The effectiveness of environmental regulation hinges on how firms respond to a stricter regulatory environment. On the one hand, stricter regulation can encourage polluting firms to increase pollution abatement efforts, adopt cleaner production technologies, and reduce toxic emissions at the source (e.g., Jaffe and Palmer, 1997; Shapiro and Walker, 2018). On the other hand, polluting firms may respond to stricter enforcement by cutting production or shifting the location of production to less regulated geographies (e.g., Becker and Henderson, 2000; Gray and Shadbegian, 2002; Levinson and Taylor, 2008). Understanding the relative importance of these potential responses is important not only for evaluating the local effects of environmental policy, but also for anticipating how one region's policies might affect economic activity and the environment in other areas (e.g., Bartram et al., 2022).

In this paper, we focus on the heterogeneous effects of environmental regulation across firms with different geographic footprints. There is limited evidence that stricter regulation induces polluting firms to move production, partially because the fixed assets in dirty firms are often not particularly flexible to move (e.g., Ederington et al., 2005). However, in some cases, the firms most affected by stronger environmental regulations *already* have an asset base that is geographically diversified across different regulatory environments. This is especially true in decentralized regulatory environments, where the stringency of environmental regulation varies between states or regions within the same country.

One particularly interesting example of within-country variation in environmental regulation arises from regional variation in enforcement activity by the US Environmental Protection Agency (EPA). The EPA has ten regional offices located across the US (see Figure 1). Each regional office operates with a substantial degree of autonomy in the implementation and enforcement of federal environmental regulations. This decentralized structure generates systematic differences in enforcement intensity across regions, shaped by regional

leadership priorities, resource constraints, and local political and industrial situations. As a consequence, two facilities owned by the same firm but located in different EPA regions can face a different level of regulatory stringency.

There are several reasons to expect that these regional differences in the stringency of EPA enforcement might influence firm production decisions. Most directly, stronger regulatory enforcement can increase the costs of production and reduce competitiveness (e.g., Jaffe et al., 1995; Pizer and Kopp, 2005). Recently, Lel (2025) documents adverse labor market outcomes for CEOs of firms subject to EPA enforcement actions. These personal considerations provide additional incentives for executives to mitigate regulatory exposure across the geographical boundaries of the firms they manage.

We use cross-region differences in EPA enforcement activity to explore how firms respond to changes in environmental regulatory stringency. We measure time-variation in regional EPA enforcement intensity as the share of total polluting establishments subject to enforcement actions in a region and year (Seltzer et al. (2022)). Our main idea is that the effects of stronger regional EPA enforcement depend on the firm's preexisting geographic footprint. It is costly for dirty firms to run away from stronger EPA enforcement by moving production to other regions (even within the US), but these relocation costs are substantially lower if the firm already operates facilities in other areas, particularly if the existing facilities operate in the same industry. A corollary prediction is that the incentive to focus on pollution abatement in response to more regulatory stringency should be strongest in firms *without* preexisting facilities in other EPA regions. For these firms, relocating production to avoid enforcement is less feasible, making abatement response more likely when firm and regulatory boundaries align.

We use plant-level data from multiple sources. We use EPA enforcement information from the Enforcement and Compliance History Online (ECHO) and Integrated Compliance

Information System (ICIS) databases, which report inspections, violations, and penalties at the plant level. We also use facility-level pollution data from the Toxic Release Inventory (TRI), which tracks annual emissions of over 770 chemicals. We incorporate information on plant level pollution-prevention activities from the Pollution Prevention (P2) program. Our final sample contains over 200,000 facility-year observations between 1990 and 2021.

We find that stronger EPA enforcement intensity in one (focal) region leads firms to divest polluting facilities in that region, while expanding operations in other geographies. Similarly, firm employment declines in regions with stronger enforcement but increases in other regions, consistent with firms shifting production out of areas with stronger enforcement. Notably, these reallocations are most pronounced among firms with preexisting facilities in lower-enforcement EPA regions.

Firms with larger geographic flexibility strongly reduce local toxic emissions in response to stricter EPA enforcement, but this local reduction in pollution is potentially misleading: multi-region firms appear to reduce emissions primarily by shifting production to other areas rather than increasing abatement activity at the plants they operate in the affected (focal) region. Single-region firms, on the other hand, respond to stronger EPA enforcement by increasing per-plant abatement activity. These findings highlight the different incentives facing firms with preexisting boundaries that do and do not align with the boundaries of the regulatory regime. In particular, the reallocation of polluting activities is most feasible when firms have existing facility networks that allow them to substitute production within-firm but across regions. These findings also illustrate the potential unintended consequences of regional differences in environmental policy, as stronger enforcement in one area is associated with more economic activity in other regions.

We further explore cross-sectional heterogeneity to check the plausibility of our findings and better understand how enforcement intensity shapes firms' divestment responses.

First, firms operating in historically low-enforcement EPA regions respond more strongly to enforcement increases, exhibiting larger effects on divestiture than firms in historically stringent regions, where stricter oversight is more anticipated. Among multi-region firms, the response to stronger enforcement is significantly amplified in firms that already operate facilities in lower-enforcement regions, allowing them to reallocate activity across space. Together, these patterns indicate that regulatory asymmetries and firms' preexisting geographic flexibility play a central role in shaping whether enforcement induces compliance or interregional reallocation of pollution-intensive activity.

To address concerns that regional enforcement intensity may be endogenous to local economic conditions or firm behavior, we implement an instrumental variable strategy that isolate plausibly exogenous variation in enforcement across EPA regions. Using a Bartik instrument that combines national industry-level enforcement shocks with predetermined regional exposure, we find that exogenous increases in enforcement intensity leads to reductions in number of plants in focal region. These effects are concentrated among multi-region firms, indicating that geographic reallocation is the primary channel through which firms respond to stricter enforcement.

Our study contributes to the literature on the real effects of environmental policy and regulation. Several studies focus on the linkages between environmental policy and firm-level innovation, investment, and financing decisions (e.g., Ramadorai and Zeni, 2024; Calel and Dechezleprêtre, 2016; Brown et al., 2022; Seltzer et al., 2022). In contrast, we explore how environmental regulation affects firm location and pollution abatement decisions. In this way, our work adds to a prominent literature that explores whether firms relocate production in response to stronger domestic environmental regulation. Much of this research explores the circumstances under which firms respond to more domestic regulation by moving abroad or shipping pollution to countries with less stringent environmental regulation (e.g.,

Levinson, 1996; Ederington et al., 2005; Levinson and Taylor, 2008). Our work shows that within-country differences in environmental regulation can have an important impact on the geographic boundaries of the firm. We also document the importance of the firm's preexisting geographic footprint: it is easier to move production if the firm already has a production facility in another region, particularly if the region has relatively low EPA enforcement.

Our study builds most closely on research that explores how within-country (primarily across state) differences in regulatory stringency affect the amount and location of economic activity (e.g., Greenstone, 2002; Becker and Henderson, 2000; List et al., 2003). A few studies explore whether firms move production in response to state-level differences in environmental policy (see, in particular, Gray and Shadbegian (2002) and Bartram et al. (2022)). We study a different (regional) setting where (ex ante) firm and regulatory boundaries do not align, and our work shows how a country-level regulatory apparatus like the EPA can have disparate effects when the implementation is decentralized and varies across regions. We also contribute to this literature by looking beyond plant-level births and divestitures to directly explore the tradeoff between pollution abatement and production relocation for single-region versus geographically diversified firms.

Our study also relates to recent research on how various environmental factors influence firm asset location decisions. In particular, Duchin et al. (2025) show that firms divest polluting plants in response to heightened environmental attention or pressure. We link firm divestitures with a different type of environmental "pressure"; namely, stronger regulatory enforcement from the EPA. As such, we identify a unique setting to study how firms respond to heterogeneous regulatory risks. While existing studies largely focus on the impact of environmental regulation or firm governance (Akey and Appel, 2019), there is little evidence on how differences in enforcement intensity across EPA regions shapes firms' geographic boundaries and location of pollution.

Finally, our study contributes to classic questions about how firms define their operational boundaries in the presence of external constraints (e.g., Mullainathan and Scharfstein, 2001; Ronald, 1937). Regional variation in environmental enforcement stringency generates localized compliance costs that can reshape geography of production in multi-region firms. Our study links regulatory enforcement and firm geographical boundaries, showing that variations in enforcement intensity across EPA regions affects firm production location decisions. We highlight an increasingly relevant institutional determinant that shapes the geographic and organizational scope of the firm.

## 2 Literature Review

A burgeoning literature seeks to understand firm environmental behavior (Bellon, 2025a; Akey and Appel, 2021). Some studies focus on how environmental regulations influence firms' behaviors and innovation activities (Ramadorai and Zeni, 2024; Calel and Dechezleprêtre, 2016; Brown et al., 2022; Seltzer et al., 2022). He and Qiu (2025) provide firm-level evidence that EPA enforcement actions significantly increase subsequent green patenting, suggesting that regulatory pressure can stimulate firms' innovation responses to repair reputational damage and improve compliance efficiency. In contrast, Duchin et al. (2025) show that firms may respond to environmental pressures through strategic divestitures of polluting assets, which enhance ESG ratings and lower compliance costs without real pollution reduction. Together, these studies highlight that firms' responses to environmental regulation can range from innovation to factual adjustment that alter reported environmental performance without true abatement effort.

Environmental regulations vary not only in design but also in enforcement intensity, leading firms to adjust their operations across jurisdictions. Bartram et al. (2022) investigate how a firm's financial constraint status affects their responses to environmental regulations. They

show that California's cap-and-trade rule led financially constrained firms to shift emissions to other states, revealing how localized regulation can cause inter-regional leakage. Walker (2011) further suggests that the Clean Air Act Amendments caused substantial job destruction in newly regulated counties. Hanna (2010) finds that the same act Amendments induced U.S. multinationals to expand foreign operations, indicating that stringent domestic regulation can prompt cross-border reallocation of pollution rather than genuine abatement. In contrast, Levinson (1996) argues that interstate differences in environmental regulations do not systematically affect the location choices of most manufacturing plants. This paper studies the heterogeneous response of firms operating in multiple EPA regions versus firms operating in a single region, revealing how asymmetric regulatory stringency affects the geography of polluting activities.

Starting with Magat and Viscusi (1990), a growing body of evidence highlights the critical role of EPA inspections and enforcement actions in improving compliance with industrial effluent standards, underscoring the importance of enforcement intensity for achieving environmental objectives. Goulder and Stavins (2011) examine the coexistence and interactions of federal and state climate policies and argue that overlapping quantity-based regulations frequently lead to emissions leakage and efficiency losses, thereby undermining the overall cost-effectiveness of national environmental policy. Their analysis emphasizes the challenges that arise when policy stringency varies across jurisdictions. Dai et al. (2021) argue that firms outsource their emissions to foreign suppliers rather than investing in abatement.

However, little attention has been given to how similar heterogeneity within the federal system—specifically, variation in regulatory enforcement intensity across the EPA regions—shapes firm environmental strategies and behavior. Prior research shows that the effectiveness of environmental regulation depends not only on policy design but also on enforcement intensity. Differences in enforcement stringency across EPA regions may generate

analogous leakage and relocation effects, as firms respond to uneven regulatory pressures by reallocating polluting activities rather than reducing total emissions. Our study extends this line of inquiry by investigating firm-level evidence on how regional enforcement disparities influence facility divestiture, abatement efforts, and production decisions.

The paper also speaks to the broader literature on the geographical boundaries of firms and how firms allocate resources across its geographic network. Giroud and Mueller (2019) demonstrate that local consumer demand shocks, such as house price declines during the Great Recession, affect employment decisions across multi-establishment firms, even in regions not directly impacted. Giroud and Mueller (2015) show that firms reallocate capital and labor across establishments in response to local productivity changes. By focusing on environmental enforcement as a source of local regulatory pressure, our paper extends this literature to the context of pollution-intensive activities and contributes new evidence on how regulatory institutions shape the geographic and organizational scope of the firm.

# 3 Data and methodology

## 3.1 Data Sources

We use facility-level information on polluting plants from multiple databases maintained by the EPA. The comprehensive EPA database provides detailed facility-level information, such as pollutant emissions, abatement activities, production, and regulatory enforcement.

To obtain toxic emissions and related information, we utilize three databases from the EPA, which we merge using their administrative identifiers. The first data source, *Toxic Release Inventory (TRI)* contains facility locations, parent company names, and parent firms' Dunsnumber. It reports annual, self-reported data on toxic emissions and tracks the releases of 770 chemicals that pose threats to human well-being and the environment. The second

source, *Enforcement and Compliance History Online (ECHO)*, incorporates the Federal Enforcement and Compliance (FE&C) from the Integrated Compliance Information System (ICIS). It tracks civil, judicial, and administrative EPA enforcement cases since 1980, including monetary and compliance costs. To measure the intensity of regulation in an EPA region, we scale the number of enforcement actions by the number of polluting firms in that region (Seltzer et al. (2022)). We also use data from the EPA's Pollution Prevention (P2) database, which provides information on firms' production and abatement activities. [1]

Following Akey and Appel (2021), we match the parent companies of these facilities to the National Establishment Time Series (NETS) to obtain firms' regional employment information in each year.

## 3.2 Variable Construction

To examine firm-level divestiture across EPA regions, we aggregate facility-level data to the parent firm-EPA region level. The main dependent variable is the natural logarithm of the number of polluting facilities a firm operates within a given EPA region. Correspondingly, to proxy the geographical footprint outside that region, we also measure the number of polluting facilities located in other EPA regions. To capture a firm's potential to reallocate polluting activities across EPA regions, we construct a measure of geographic dispersion of a firm. Specifically, we calculate the percentage of a firm's polluting facilities (or toxic emissions) in other EPA regions relative to the firm's total number of plants (or total toxic emissions) of the year.

We draw on environmental variables from the EPA's Pollution Prevention (P2) database to measure abatement activities, which documents facilities' efforts to reduce toxic releases at the source. Under the Pollution Prevention Act of 1990 (PPA), the EPA collects these data

[1] The above-mentioned major databases from the EPA are widely used in the existing studies e.g., Bellon (2025b, 2021); Campa (2018); Levine et al. (2019).

to monitor industry progress in waste reduction and the adoption of safer waste management practices. We count the number of source reduction activities reported in the P2 database as a proxy for a facility's abatement efforts.

We also measure facilities' production activities using the NETS employment data. We match the parent firm to the NETS database and obtain facility-level employment data. Beyond a count of the facilities that a given firm operates, the number and location of employment provide a different measure of the firm's economic footprint.

## 3.3 Summary Statistics

Our sample includes both private and public firms' facilities that report environmental information to the U.S. Environmental Protection Agency (EPA) from 1990 to 2021. The final sample covers over 200,000 facility-year observations from 8,560 unique firms. On average, each firm operates 1.6 facilities. Approximately 27.9% of firms operate polluting facilities in more than one EPA region. Among single-region firms, the average number of facilities is 1.14, whereas for multi-region firms, the average is 1.99. Table 1 reports summary statistics of the key variables.

Our key variable of interest is the EPA's regional regulatory stringency, proxied by the enforcement rate. Figure 2 presents annual enforcement rates for three EPA regions: Region 2 (New York, New Jersey, and Puerto Rico), Region 4 (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee), and Region 9 (Arizona, California, Hawaii, and Nevada). The figure presents substantial heterogeneity in enforcement intensity, both across regions and over time.

# 4 Baseline Results

We begin our empirical analysis by investigating how different EPA enforcement intensity shapes firm's geographic location of polluting activities. We exploit the differences in enforcement intensity across the ten EPA regions while controlling for firm, year (or region-year) fixed effects. If firms take EPA enforcement as a region-specific cost, stronger focal region enforcement would prompt parent firms to reduce or close polluting plants in that region, while potentially leading firms to expand operations elsewhere. Therefore, we first test whether enforcement intensity is associated with facility divestitures in the focal region, followed by analyses of opening facilities in other regions, as well as abatement efforts, employment changes, and polluting outcomes.

## 4.1 Model specification

To examine firms' cross-region decisions responding to different EPA region's regulation stringency, we run the following OLS regression:

$$Y_{i,r,t} = \beta EnforceRate_{r,t} + \alpha_i + \rho_t + \varepsilon_i, \tag{1}$$

where $i$, $r$, $t$ denote firm, EPA region, and year. We include company fixed effects, $\alpha_i$, to account for time-invariant, unobservable firm-level characteristics that might drive firms' polluting and production decisions. We also include year fixed effects, $\rho_t$, to account for time-specific macro trends common to all firms in the sample, such as changes in federal-level EPA policy. For robustness, we also control for region-year fixed effects in place of year fixed effects, to account for EPA-region and year specific shocks that might influence firms' polluting and production decisions.

The dependent variables are at the firm-region-year level. For example, when examining

whether firms close facilities in a region when its regulatory stringency increases, we use $Ln(Next_N_plants)_{i,r,t}$, which captures the number of polluting plants of a firm in the focal EPA region in the following year. The independent variable of interest is, $EnforceRate_{r,t}$, which measures the regulatory enforcement intensity of the EPA in region $r$ and year $t$. We run this regression in firms that are only exposed to one EPA region, firms that are exposed to various EPA regions, and the full sample. This allows us to examine whether firms with greater flexibility in moving polluting activity due to their existing multi-region operation network respond differently to changes in local regulatory stringency, i.e., enforcement intensity.

## 4.2 Divestiture

Table 2 reports the baseline OLS regression results examining how EPA enforcement intensity affects firms' divestiture decisions in a focal region. The dependent variable is the natural logarithm of the number of plants a firm operates in the focal EPA region in year *t+1* for Columns (1)-(3). Column (4) examines whether enforcement intensity in the focal region affects the number of plants operated by the same firm in other EPA regions. Column (1) reports results for the full sample, while Columns (2) and (3) focus on single-region and multi-region firms, respectively. All specifications include firm and year fixed effects, with standard errors clustered at the firm level.

In Column (1), we find a negative and significant coefficient of enforcement rate, indicating that firms are more likely to divest facilities when facing stronger enforcement locally. The coefficient is signficiant at a 1% level. Specifically, a one-percent increase in enforcement rate is associated with 14% decrease in ln(N_plants). Column (2) shows that the coefficient on EnforceRate is small and statistically insignificant for single-region firms, consistent with these firms having limited outside options and therefore less capable to respond to reg-

ulatory pressure through divestiture. In contrast, Column (3) suggests that the coefficient of EnforceRate is negative and significant at a 1% level for multi-region firms. Specifically, a one-percent increase in enforcement intensity is associated with an approximate 17.6% decline in the number of facilities within the focal region.

Column (4) explores whether divestiture in the focal region is accompanied by expansion elsewhere, shedding light on an interregional "whack-a-mole" effect of environmental regulation. Consistent with a reallocation mechanism, higher enforcement intensity in the focal region is associated with a statistically significant increase in the number of plants operated by the same firm in other EPA regions. A one-percent increase in EnforceRate is associated with 7.8% increase in number of plants in other regions for multi-region firms. This pattern indicates that firms do not exit production entirely but instead reallocate polluting activities across regions.

Taken together, the evidence in Table 2 together suggests that when faced with asymmetric enforcement, multi-region firms behave strategically, divesting in strict regions and expanding in lenient ones. Instead of uniformly reducing emissions, asymmetric enforcement intensity leads parent firms to strategic reallocation of pollution-intensive production.

## 4.3 Employment

To further investigate the relocation of pollutions across EPA regions under heightened enforcement intensity in one region, we examine how increased enforcement affects employment reallocation across EPA regions. Columns (1)-(3) in Table 3 presents the results for employment in the focal region, while Column (4) reports the corresponding results for employment in other regions. The dependent variable is the natural logarithm of the number of employees that a firm maintains in the focal region (Columns (1)-(3)) or other regions (Column (4)) in year $t+1$.

Consistent with the divestiture results documented above, Column (1) shows that higher enforcement intensity is associated with a statistically significant reduction in focal-region employment.

The coefficient of $EnforceRate$ is negative and statistically significant at a 1% level. A one-percent increase is associated with a 63.6% reduction in employment in focal region for multi-region firms. Columns (2) and (3) reveal strong heterogeneity across firms. The effect is statistically insignificant for single-region firms, but large and significant at a 1% level for multi-region firms. Together, these results suggest that stronger enforcement induces both facility closures and labor contraction within the focal region. Examining the mirroring effects for employment in other EPA regions, we find that in Column (4), $EnforceRate$ is positive and significant. A one-unit increase in *EnforceRate* in one EPA region is associated with a 30% increase in employment in other EPA regions within the same firm. This finding corroborates the evidence of interregional reallocation of polluting activities within a parent firm when facing asymmetric enforcement intensity.

Overall, the results in Table 3 indicate that environmental enforcement induces interregional labor reallocation, with effects concentrated among multi-region firms.

## 4.4 Abatement activities

In the above subsections, we show that increased enforcement intensity is associated with divestiture and employment reallocation. In this subsection, we investigate whether heightened regulatory enforcement intensity affects polluting firms' emission abatement efforts, proxied by the number of source-reduction abatement activities per plant in year $t+1$ in the EPA's Pollution Prevention (P2) database. Columns (1)-(3) in Table 4 reports the results for firms' abatement activities in the focal region and Column (4) examines the abatement efforts in other regions.

Column (1) shows that, for the full sample, higher enforcement intensity is associated with a statistically significant reduction in abatement activity in the focal region. This pattern is consistent with the divestiture and employment results, suggesting that firms respond to stricter enforcement by scaling back operations rather than increasing compliance efforts in the focal region. However, Columns (2) and (3) reveal an interesting contradiction. For single-region firms (Column (2)), the coefficient on EnforceRate is positive and statistically significant, indicating that firms without geographic alternatives increase abatement activity in response to heightened enforcement. In contrast, for multi-region firms (Column (3)), enforcement intensity is associated with a significant decline in abatement activity in the focal region. This may imply that multi-region firms prioritize relocating polluting activities over investing in local abatement technologies when enforcement intensity tightens.

Column (4) examines whether firms increase pollution abatement activities in other EPA regions where they can expand operations. The coefficient of *EnforceRate* is positive and statistically significant, suggesting increased abatement activities in other regions. This pattern is consistent with production reallocation: once firms shift production to alternative regions, abatement activity increases mechanically as production expands there, even though enforcement intensity in those regions is lower.

Overall, the results support that heterogeneity in EPA enforcement intensity produces a strategic trade-off: firms divest from stricter regions and reallocate operations to lenient regions, but without increases in abatement activities. This pattern highlights an unintended consequence of asymmetric regulation landscape across the EPA regions – stronger regional enforcement may yield factual compliance but not necessarily cleaner production nationwide.

## 4.5 Emissions

In this subsection, we examine how asymmetric regional enforcement intensity affects firms' toxic emissions and production waste, using the data from the EPA's Toxic Release Inventory (TRI). The dependent variable is the natural logarithm of a firm's toxic emissions or production waste in the focal and other EPA regions in year $t+1$. Table 5 Columns (1)–(4) focus on production waste, while Columns (5)–(8) examine toxic emissions. For each outcome, we separately analyze effects in the focal EPA region and in other regions operated by the same firm.

Column (1) shows that increased enforcement intensity is associated with significant reductions in both production waste and toxic emissions in the focal region for the full sample. These results indicate that enforcement pressure reduces pollution-intensive production locally. Column (2) indicates that these effects are statistically insignificant for single-region firms, suggesting limited ability for emission reallocation when firms lack geographic flexibility. Whereas, Column (3) shows large and statistically significant reductions in production waste and toxic emissions in the focal region among multi-region firms. The magnitudes are economically meaningful and larger than those observed in the full sample, consistent with multi-region firms responding to enforcement pressure by shifting production away from regulated regions. Correspondingly, Column (4) shows that enforcement intensity in the focal region is associated with significant increases in toxic emissions in other EPA regions operated by the same firm.

Taken together, the results in Table 5 show that environmental enforcement reshapes the geographic presence of a firm. Stricter enforcement reduces production in regulated regions but induces expansion elsewhere for firms with geographic flexibility, suggesting the spillover effects under the asymmetric environmental regulation regime.

## 4.6 Heterogeneous effects

In this section, we explore several sources of cross-sectional heterogeneity to deepen our understanding of firms' responses to increased regulatory enforcement. Our earlier analyses show that firms react to heightened enforcement intensity by divesting polluting facilities, reallocating operations across regions, and adjusting employment and emissions accordingly. However, these responses may vary depending on firms' operational footprints. In this section, we examine whether firms' geographical diversification influences their responses to heightened regulatory stringency locally.

First, we examine whether having access to lower EPA enforcement region shapes multi-region firms' responses to increased regulatory pressure. To capture this dimension of geographic flexibility, we split multi-region firms into two sub-samples based on whether they already operate facilities in low EPA enforcement regions. Theoretically, increases in enforcement intensity raise the costs of operating in the focal region and create incentives for firms to minimize regulatory burdens through reallocating facilities to other regions where they already has production capacity. The results in Table **??** are consistent with this mechanism and indicate that the effects on divestiture are more pronounced among firms that have already facilities in low-enforcement regions.

In Column (1), a one percent increase in EnforceRate is associated with 0.194% decrease in ln(N_plants) for multi-region firms that operate facilities in low EPA enforcement regions, while the effect is 0.114% decrease among multi-region firms without a facility in low EPA enforcement region. The similar pattern is found in employment and abatement activities, with larger contractions in the focal region among firms that can shift operations to lower-enforcement locations. While the results for the number of plants, employment, and abatement activity provide strong evidence of greater divestiture and relocation among firms with access to low-enforcement regions, the evidence for production waste is more muted

and does not follow the same pattern. This asymmetry response highlights that the firm's reallocation depends on whether the firm has easy access to low-enforcement regions. Firms with geographically diversified production networks can more easily substitute production in low-enforcement regions, while other multi-region firms face higher adjustment costs and thus exhibit weaker reallocation responses.

Next, we investigate cross-sectional heterogeneity by exploiting whether the facilities' parent company operates a facility in another EPA region in the same NAICS-3 industry. Specifically, we partition the sample into two groups: facilities located in regions with relatively high enforcement intensity and those in regions with relatively low enforcement intensity. We hypothesize that firms operating in low-enforcement regions are more sensitive to increases in enforcement rates, as such changes are more unexpected and more likely to prompt firms to take action. Table 7 reports the results and supports this conjecture. We examine the outcomes related to the number of plants, employment, abatement activities, and production activities in the focal region. In Column (1), the coefficient of EnforceRate is negative and statistically significant at a 1% level for regions of lower enforcement rates, indicating a stronger response. A one percent increase in enforcement rate is associated with a 0.162% decrease in ln(N_plants). In contrast, the coefficient of *EnforceRate* is statistically insignificant for facilities in high-enforcement regions, suggesting that firms in these areas are less sensitive to marginal increases in enforcement. Similar patterns hold for employment, abatement, and production outcomes, with effects concentrated in low-enforcement regions and muted or absent in high-enforcement regions. Notably, multi-region firms operating in historically more stringent EPA regions increase abatement efforts when local enforcement rate increases, whereas multi-region firms operating in less stringent EPA regions decrease abatement activities. This contrast suggests that firms in high-enforcement regions may have anticipated and gradually adapted to stricter regulatory oversight over time, while firms in

low-enforcement regions respond to enforcement shocks primarily through contraction and reallocation rather than compliance. Taken together, increases in regulatory stringency matter most when enforcement intensifies in regions where enforcement has been weak in the past, highlighting the role of enforcement surprises and regulatory asymmetry in shaping firms' location and production decisions.

Next, we investigate cross-sectional heterogeneity by exploiting whether the facilities' parent company operates a facility in another EPA region in the same NAICS 3-digit industry. Specifically, we partition the sample into facilities whose parent firm has at least one facility in the same NAICS3 industry in other regions (Columns 1, 3, 5, and 7) and those whose parent firms do not (Columns 2, 4, 6, and 8). Table 7 reports these results and supports the conjecture that firms with same-industry siblings elsewhere are more sensitive to increases in enforcement rates, as they possess the intra-firm flexibility to reallocate production. In Column (1), the coefficient of *EnforceRate* is -0.210 and statistically significant at the 1% level for multi-region firms with same-industry siblings, indicating that a one-unit increase in the enforcement rate is associated with a 0.210% decrease in *ln(N_plants)*, whereas the effect for firms without such siblings is significantly smaller at -0.051. Similar patterns hold for employment, abatement, and toxic emissions: for firms with same-industry siblings, higher enforcement leads to a 0.629% decrease in employment (Column 3) and a 0.568% decrease in toxic emissions (Column 7), both significant at the 1% level. For firms without these siblings, the impact on employment is muted (-0.428), and the effect on emissions is statistically insignificant. Notably, firms with industry siblings elsewhere significantly decrease abatement activities by 0.107% (Column 5), whereas firms without such siblings show no significant change. This contrast suggests that multi-region firms with same-industry siblings respond to enforcement shocks primarily through contraction and reallocation rather than compliance. Taken together, these results highlight that regulatory stringency triggers

the most significant divestment when firms have existing operations in the same industry elsewhere, allowing for easier relocation of production.

# 5 IV results: Enforcement stringency and firm responses

## 5.1 Instrumental Variable

Even though our baseline results show strong patterns that firms react to environmental regulations strategically, there exists an endogeneity concern that enforcement stringency may be correlated with regional economic development and environmental conditions. For example, EPA regional offices may allocate resources toward areas experiencing increased pollution, expansions in pollution-intensive industries, or rises in population density. If polluting firms located in growing areas simultaneously adjust plant locations for reasons that correlate with these underlying conditions, the estimated effects would be biased.

A second concern arises from reverse causality at the firm level. Facility emissions and compliance histories may influence the regional EPA enforcement actions. Facilities with poor compliance records or increasing toxic emissions are more likely to attract regulatory scrutiny. This creates a simultaneity problem that if geographically diversified firms tend to adjust emissions in advance, observed enforcement intensity may be partially driven by firm decisions and thus be endogenous to plant closures.

Taken together, OLS estimates may be biased by unobserved regional shocks and firm-level simultaneity. To address these identification challenges, we employ an instrumental variable that isolates plausibly exogenous variation in enforcement stringency. Specifically, following Bartik (1991), we construct a shift-share instrument that interacts (i) national-level EPA enforcement trends in each industry, which captures aggregate shifts in federal regulatory effort and (ii) region-industry-specific exposure to EPA enforcement actions, measured

by each region's historical shares of the number of facilities in a given industry, measured by the region's predetermined industrial composition before our estimation sample starts in 1990. Specifically, we instrument for region-level environmental enforcement exposure by aggregating the interaction terms between the region's historical industry share, defined as the average fraction of facilities in a three-digit NAICS industry located in a given EPA region relative to the total number of facilities in that region from 1986 to 1989 (prior to the sample period), and the natural logarithm of one plus the total number of enforcement actions in that industry in the year. We collect the facility count data from County Business Patterns, while enforcement data are obtained from the EPA.

National enforcement trends reflect broad national-level policy priorities that are common across regions, while regional exposure proxies for predetermined differences in how strongly local industries are affected by these aggregate enforcement shifts. Since national enforcement efforts are largely driven by broad federal regulatory objectives, rather than regional economic conditions or firm-level compliance efforts, their interaction with predetermined regional exposure generates variation that is likely to be exogenous to contemporaneous local shocks and firm outcomes. Therefore, this shift-share instrument allows us to isolate the component in regional enforcement stringency that is exogenous to local economic and environmental conditions as well as anticipated firm reallocating behavior.

$$\text{Shift-Share Instrument}_{r,t} = \sum_{k} \frac{\text{Facilities}_{r,k}}{\text{Total Facilities}_{r}} \times Ln(1 + Enforcement_{k,t}) \tag{2}$$

where $k$ denotes industry (by NAICS3), $r$ indexes the EPA region, and $t$ denotes year. Regions with greater historical exposure to a given industry experience a larger predicted enforcement "shock" when national enforcement activity increases in that industry. This summation over the interaction terms between local historical exposure and the national industry-wide trends, therefore, captures plausibly exogenous variation in regional enforcement inten-

sity driven by national industry-level enforcement cycles and predetermined regional exposure.

Our identification strategy relies on a two-stage least squares (2SLS) framework, specified as the following two equations with the first-stage model being

$$EnforceRate_{r,t} = \gamma ShiftShareInstrument_{r,t} + \alpha_i + \rho_t + \varepsilon_{i,t}, \tag{3}$$

and the second-stage model being

$$Y_{i,r,t} = \beta \widehat{EnforceRate_{r,t}} + \alpha_i + \rho_t + \nu_{i,t}, \tag{4}$$

where $i$, $r$, $t$ index firm, region, and year, respectively. $Y_{i,r,t}$ captures firm-level outcomes of interest. $\alpha_i$ is firm fixed effects and $\rho_t$ is year fixed effects. To examine heterogeneous effects of enforcement stringency across firms with different geographic footprints, we estimate the model separately for single-region firms and multi-region firms. Conducting the analysis by subsample avoids introducing endogenous interaction terms in the OLS specification and allows for a cleaner comparison of enforcement effects across single-region and multi-region firms.

Table 8 presents the 2SLS estimates of the effect of environmental enforcement on firm divestiture. The analysis focuses on both the full sample and subsamples of single-region versus multi-region firms to identify how regulatory pressure influences firm divestiture and operations. Columns (1)-(3) report the first-stage results for the full sample, single-region firms, and multi-region firms, respectively. The shift-share instrument strongly predicts regional enforcement intensity across all samples. The Kleibergen-Paap F-statistics are far above conventional weak-instrument thresholds in all specifications, indicating that the instrument is highly relevant. For the full sample, the coefficient is -2.802 ($t = -83.23$). The

magnitudes of the coefficients are -2.895 and -2.772 for the subsamples of single-region firms and multi-region firms. The first-stage coefficients of the IV are negative in all specifications, which we interpret as evidence of 'regulatory congestion' or 'capacity constraints,' a phenomenon observed in other regulatory settings (Agarwal et al., 2014; Kedia and Rajgopal, 2011). A surge in national enforcement priorities imposes a disproportionate burden on regions where the targeted industry is heavily concentrated. While regions with few targeted facilities can easily meet the new mandate, high-concentration regions face resource bottlenecks that prevent them from scaling inspections linearly. As a result, regions with high shares of these targeted industries instead show lower realized enforcement rates due to the dilution of constrained regulatory resources.

Columns (4)–(6) report the second-stage estimates. For the full sample, higher enforcement intensity significantly reduces the number of plants operated by a firm in the focal region. The estimated coefficient implies that a 1% increase in enforcement stringency leads to a 0.58% decrease in number of plants in that region in the following year. The effect is economically meaningful and statistically significant at the 1% level. Consistent with the OLS results, the IV estimates reveal heterogeneous effects of firms' geographic boundaries. For single-region firms, the estimated effect of enforcement on plant divestiture is small and statistically insignificant. In contrast, for multi-region firms, enforcement stringency has a large and negative effect on the number of plants in the focal region. The magnitude of the coefficient is -0.638 with a $t-statistic$ of 10.93. This pattern suggests that geographically diversified firms respond to heightened enforcement by closing facilities in focal regions rather than absorbing regulatory pressure locally. The IV estimates are larger in magnitude than their OLS counterparts, which is consistent with downward bias in OLS estimates due to simultaneity and endogenous enforcement targeting.

Table 9 focuses on multi-region firms and examines heterogeneity in their responses to

enforcement stringency based on whether they have facilities in lower-enforcement regions. This distinction proxies for firms' ability to reallocate production across regions when facing heightened regulatory pressure and allows us to test whether easier access to lower-enforcement locations amplifies divestiture responses. We focus on the number of facilities, employment, abatement activity, and production. This analysis focus on multi-region firms.

Columns (1), (3), (5), and (7) presents the results of multi-region firms without facilities in lower regions. Columns (2), (4), (6), and (8) reports the results of multi-region firms that operate other facilities in lower enforcement EPA regions. For multi-region firms without facilities in lower regions, increases in enforcement stringency lead to statistically significant reductions in the number of plants, employment, abatement activity, and emissions in the regulated region. However, the effects are stronger among firms with access to lower-enforcement locations. The estimated effects of enforcement stringency are substantially larger across all outcomes. Higher enforcement induces sharper declines in plants and employment in the regulated region, accompanied by pronounced reductions in abatement activity and emissions. Comparing the magnitudes of the coefficients of instrumented enforcement rate, a 1% increase in enforcement rate leads to a 0.638% declines in the number of plants in the focal region for multi-region firms without facilities in a lower region. However, the magnitude is 1.329% for multi-region firms with facilities in a lower region. A similar pattern is found for employment, where the corresponding declines are 2.423% and 4.066%. The same pattern is observed for abatement activity (0.323% versus 0.799%), production waste (1.919% versus 3.764%), and on-site toxic emissions (1.563% versus 3.324%).

Overall, it suggests that regulatory pressure induces reallocation of production and labor toward less regulated regions rather than purely within-plant adjustments. The contrast between the two subsample firms highlights the role of geographic boundaries in shaping firms' responses to enforcement. While enforcement stringency leads to divestiture for all multi-

region firms, the effects are stronger when firms can shift activities to lower enforcement regions where they already operate other facilities. These findings indicate that environmental enforcement affects firm behavior not only through compliance costs but also through geographical relocation of production activities across EPA regions.

# 6 Conclusion

This paper investigates how regional variations in environmental enforcement affect firms' divestiture, abatement, and production decisions. Using comprehensive facility-level data from the EPA's TRI, ECHO, and P2 databases linked to the National Establishment Time Series (NETS), we construct firm–region panel data from 1990 to 2021. Our results show that increases in enforcement intensity in a given EPA region leads firms to close facilities, reduce employment, and scale back production activities in that region, while simultaneously expanding facilities, operations, and employment in other regions where the firm already operates. Rather than eliminate polluting activities, firms respond to stricter enforcement by reallocating production across regions, generating substantial within-firm geographic substitution.

The effects are most pronounced when firms face large cross-regional regulatory gaps and have alternative production capacity in lower-enforcement regions, highlighting the importance of regulatory asymmetries and firms' geographic boundaries. To address endogeneity concerns, we employ the shift-share instrumental-variable strategy that isolates exogenous variation in regional enforcement. The IV estimates corroborate the baseline results and confirm that increases in enforcement causally reduce regional activity, with larger effects among multi-region firms.

Overall, our findings highlight the spillover effects of regulatory enforcement. Asymmetry enforcement intensity across the EPA regions may unintentionally shift pollution rather

than reduce it. Greater coordination and consistency in enforcement could mitigate these relocation incentives and enhance the effectiveness of environmental regulation. Future research could further explore firm strategy under different enforcement regimes and their long-term implications for both environmental outcomes and regional economic development.

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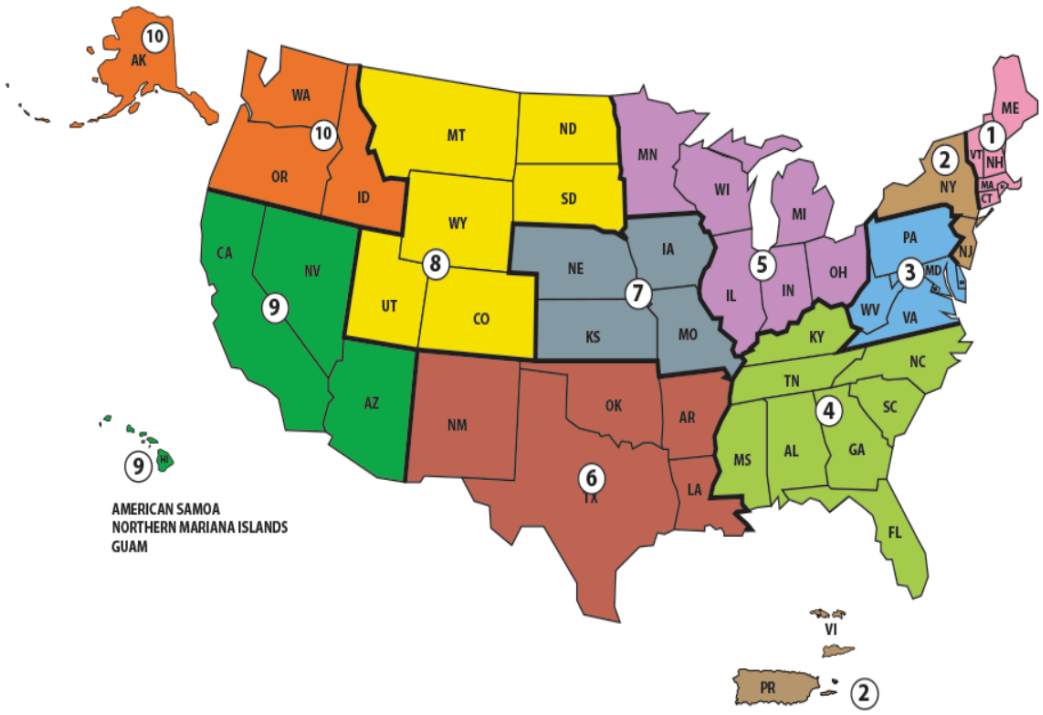
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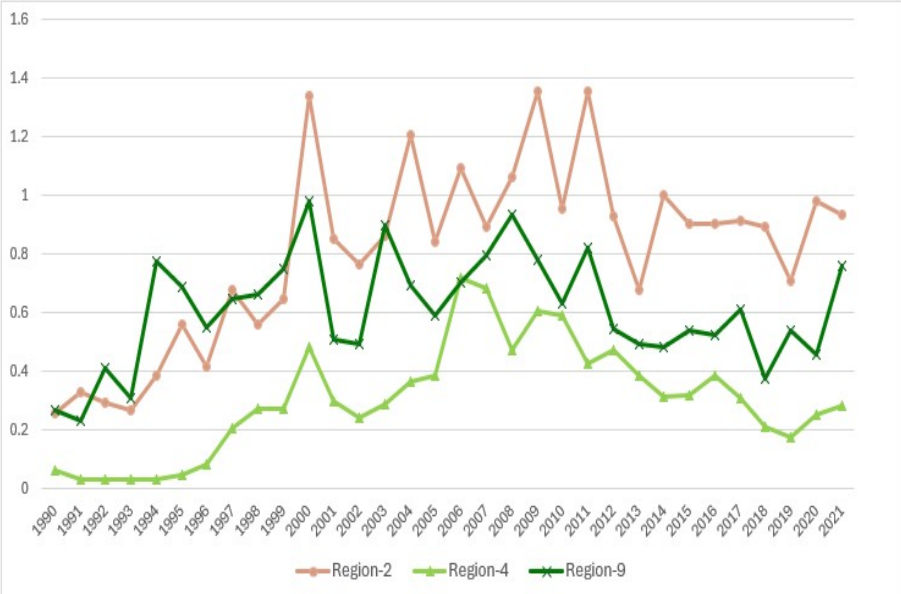
# Figures and Tables

Figure 1: **EPA Region Map**




*Note:* The figure is obtained from the U.S. Environmental Protection Agency website (https://www.epa.gov/aboutepa/regional-and-geographic-offices).

Figure 2: **Regional EPA Enforcement Rate**




*Note:* The figure plots the EPA enforcement rate by year for three regions: Region 2, Region 4, and Region 9. The map of the EPA regions is in Figure 1.

Table 1: Summary Statistics

This table reports the summary statistics for the main variables. All continuous variables are winsorized at the 1st and 99th percentile.

| Variables | Obs | Mean | STD | P25 | Median | P75 |
|---|---|---|---|---|---|---|
| EnforceRate | 248,720 | 0.38 | 0.28 | 0.20 | 0.30 | 0.53 |
| Multi_region | 228,806 | 0.54 | 0.50 | 0 | 1 | 1 |
| ln(Total_plants) | 237,901 | 1.05 | 1.10 | 0 | 0.69 | 1.79 |
| ln(N_plants) | 242,936 | 0.79 | 0.45 | 0.69 | 0.69 | 1.10 |
| ln(otherRegion_N_plants) | 242,936 | 0.88 | 1.05 | 0 | 0.69 | 1.61 |
| ln(abatement_perplant) | 242,936 | 0.00 | 0.00 | 0 | 0 | 0 |
| ln(otherRegion_N_abatement_perplant) | 129,270 | 0.32 | 0.52 | 0 | 0 | 0.51 |
| ln(employment) | 242,936 | 3.33 | 3.28 | 0 | 3.53 | 6.30 |
| ln(otherRegion_employment) | 242,936 | 2.89 | 3.86 | 0 | 0 | 6.76 |
| ln(toxic_emissions) variables | | | | | | |
| All types (total) | 242,936 | 1.86 | 2.21 | 0.00 | 0.80 | 3.31 |
| Water | 242,936 | 0.25 | 0.96 | 0 | 0 | 0 |
| Ground | 242,936 | 0.29 | 1.19 | 0 | 0 | 0 |
| Air | 242,936 | 1.75 | 2.08 | 0.00 | 0.71 | 3.21 |

Table 2: Divestiture

This table presents the OLS regression results examining the effects of EPA enforcement on firm divestiture. The dependent variable (*Ln(N_plants)*) is the natural logarithm of the number of plants of a firm in the focal region in year (t+1). The independent variable of interest is *EnforceRate*, which is the number of establishments being enforced by the EPA divided by the total number of polluting establishments in an EPA region. All continuous variables are winsorized at the 1st and 99th percentiles and standardized. $T$-statistics are in parentheses. Standard errors are clustered at the company level. Coefficients that are statistically significant at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | Ln(N_plants) | Ln(N_plants) | Ln(N_plants) | Ln(otherRegion_N_plants) |
| EnforceRate | -0.151*** | 0.001 | -0.194*** | 0.075*** |
| | (-9.94) | (0.16) | (-10.27) | (6.30) |
| GDP growth | -0.093 | -0.033 | -0.084 | -0.040 |
| | (-1.61) | (-0.54) | (-1.07) | (-0.83) |
| population growth | -2.863*** | -0.050 | -3.702*** | 1.672*** |
| | (-5.33) | (-0.17) | (-5.30) | (3.94) |
| Ln(income) | -0.433*** | 0.057 | -0.448*** | 0.161*** |
| | (-6.81) | (0.98) | (-6.30) | (3.84) |
| Unemployment Rate | 0.005 | -0.005** | 0.017*** | -0.011*** |
| | (1.35) | (-2.33) | (3.82) | (-3.89) |
| Housing Price Index | -0.000*** | -0.000 | -0.000*** | 0.000*** |
| | (-6.22) | (-1.00) | (-7.28) | (6.14) |
| Constant | 5.438*** | 0.169 | 5.642*** | -0.837* |
| | (8.24) | (0.28) | (7.63) | (-1.92) |
| Observations | 242,916 | 100,117 | 142,034 | 242,916 |
| R-squared | 0.437 | 0.553 | 0.441 | 0.900 |
| Company FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Sample | All | Single-Region | Multi-Region | Multi-Region |

## Table 3: Employment

This table presents the OLS regression results examining the effects of EPA enforcement on firm employment in the focal region. The dependent variable (*Ln(Employment)*) is the natural logarithm of the number of employees of a firm in the focal region in year (t+1). The independent variable of interest is *EnforceRate*, which is the number of establishments being enforced by the EPA divided by the total number of polluting establishments in an EPA region. All continuous variables are winsorized at the 1st and 99th percentiles and standardized. *T*-statistics are in parentheses. Standard errors are clustered at the company level. Coefficients that are statistically significant at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | | Ln(Employment) | | Ln(OtherRegion_Employment) |
| EnforceRate | -0.492*** | 0.014 | -0.615*** | 0.265*** |
| | (-9.42) | (0.29) | (-9.79) | (5.53) |
| GDP growth | -0.059 | 0.219 | -0.087 | -0.112 |
| | (-0.30) | (0.81) | (-0.32) | (-0.41) |
| population growth | -11.088*** | -0.947 | -14.148*** | 8.655*** |
| | (-5.84) | (-0.48) | (-6.09) | (4.69) |
| Ln(income) | -0.915*** | 0.509 | -1.034*** | 0.518*** |
| | (-4.21) | (0.84) | (-4.41) | (3.25) |
| Unemployment Rate | 0.074*** | 0.011 | 0.114*** | -0.050*** |
| | (5.88) | (0.72) | (7.45) | (-4.36) |
| Housing Price Index | -0.001*** | 0.000 | -0.001*** | 0.000** |
| | (-4.88) | (0.15) | (-5.30) | (2.55) |
| Constant | 12.949*** | -3.070 | 14.847*** | 1.594 |
| | (5.76) | (-0.49) | (6.11) | (0.97) |
| Observations | 242,916 | 100,117 | 142,034 | 93,632 |
| R-squared | 0.855 | 0.924 | 0.821 | 0.864 |
| Company FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Sample | All | Single-Region | Multi-Region | Multi-Region |

## Table 4: Abatement Activities

This table presents the OLS regression results examining the effects of EPA enforcement on firm abatement activities in the focal EPA region. The dependent variable (*Ln(Abatements)*) is the natural logarithm of the number of abatement activities of a firm in the focal region in year (t+1). The independent variable of interest is *EnforceRate*, which is the number of establishments being enforced by the EPA divided by the total number of polluting establishments in an EPA region. All continuous variables are winsorized at the 1st and 99th percentiles and standardized. *T*-statistics are in parentheses. Standard errors are clustered at the company level. Coefficients that are statistically significant at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | | Ln(Abatemens) | | Ln(OhterRegion_Abatements) |
| EnforceRate | -0.073*** | 0.038** | -0.098*** | 0.063*** |
| | (-4.40) | (2.38) | (-4.68) | (3.63) |
| GDP growth | -0.119 | 0.060 | -0.124 | -0.262** |
| | (-1.38) | (0.51) | (-1.06) | (-2.23) |
| population growth | -2.057*** | -0.517 | -2.327*** | 1.017 |
| | (-3.39) | (-1.02) | (-2.95) | (1.49) |
| Ln(income) | -0.188*** | -0.077 | -0.180** | 0.066 |
| | (-2.90) | (-0.64) | (-2.44) | (1.11) |
| Unemployment Rate | 0.008* | -0.000 | 0.012** | -0.000 |
| | (1.78) | (-0.07) | (2.27) | (-0.10) |
| Housing Price Index | -0.000** | 0.000 | -0.000*** | 0.000 |
| | (-2.15) | (0.34) | (-2.67) | (0.65) |
| Constant | 2.246*** | 0.963 | 2.219*** | 0.038 |
| | (3.32) | (0.78) | (2.89) | (0.06) |
| Observations | 242,916 | 100,117 | 142,034 | 142,034 |
| R-squared | 0.328 | 0.490 | 0.286 | 0.658 |
| Company FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Sample | All | Single-Region | Multi-Region | Multi-Region |

## Table 5: Production

This table presents the OLS regression results examining the effects of EPA enforcement on firm production. The dependent variable is the natural logarithm of toxic emissions of a firm in the focal region in year t+1 (*Ln(Toxic_Emissions)*). The independent variable of interest is *EnforceRate*, which is the number of establishments being enforced by the EPA divided by the total number of polluting establishments in an EPA region. All continuous variables are winsorized at the 1st and 99th percentiles and standardized. *T*-statistics are in parentheses. Standard errors are clustered at the company level. Coefficients that are statistically significant at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | Ln(Toxic Emissions) | | | |
| | Focal region | | | Other region |
| EnforceRate | -0.353*** | -0.088 | -0.487*** | 0.231*** |
| | (-2.98) | (-0.82) | (-3.36) | (2.72) |
| GDP growth | -1.146** | -0.695 | -1.102 | 0.773 |
| | (-2.06) | (-0.88) | (-1.56) | (1.62) |
| population growth | -16.051*** | -1.787 | -17.649*** | 4.250 |
| | (-3.74) | (-0.44) | (-3.31) | (1.36) |
| Ln(income) | -3.282*** | -0.208 | -3.312*** | 0.699** |
| | (-6.58) | (-0.24) | (-5.99) | (2.52) |
| Unemployment Rate | -0.106*** | -0.039 | -0.061* | -0.015 |
| | (-3.64) | (-1.28) | (-1.68) | (-0.76) |
| Housing Price Index | -0.002*** | -0.001 | -0.002*** | 0.001*** |
| | (-6.48) | (-1.52) | (-6.83) | (5.11) |
| Constant | 42.116*** | 8.865 | 42.564*** | 0.878 |
| | (8.18) | (0.98) | (7.45) | (0.31) |
| Observations | 242,916 | 100,117 | 142,034 | 142,034 |
| R-squared | 0.529 | 0.667 | 0.493 | 0.763 |
| Company FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Sample | All | Single-Region | Multi-Region | Multi-Region |

Table 6: Heterogeneous Effects (By Region's Average Enforcement Level)

This table presents the OLS regression results examining the heterogeneous effects of EPA enforcement on firm divestiture in firms that operates facilities in more than one EPA regions. Columns (1), (3), (5), and (7) report the results of the regressions that focus on firms in relatively low enforcement rate EPA regions, while Columns (2), (4), (6), and (8) report the regression results that focus on firms in relatively high EPA enforcement regions. The dependent variables are reported on the top of each column. *EnforceRate* is the number of establishments being enforced by the EPA divided by the total number of polluting establishments in an EPA region. All continuous variables are winsorized at the 1st and 99th percentiles and standardized. *T*-statistics are in parentheses. Standard errors are clustered at the company level. Coefficients that are statistically significant at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| VARIABLES | ln(N_plants) | | ln(Employment) | | ln(Abatements) | | ln(Toxic Emissions) | |
| EnforceRate | -0.162*** | 0.012 | -0.573*** | 0.229*** | -0.068** | 0.080*** | -0.299 | -0.130 |
| | (-5.46) | (0.55) | (-6.27) | (2.80) | (-2.29) | (2.78) | (-1.24) | (-0.65) |
| GDP growth | -0.732*** | -0.467*** | -2.089*** | -0.974*** | -0.828*** | -0.249* | -4.846*** | -1.974** |
| | (-4.46) | (-5.12) | (-4.05) | (-3.00) | (-3.61) | (-1.67) | (-3.40) | (-2.19) |
| population growth | -8.770*** | -2.844*** | -25.649*** | -10.157*** | -4.221*** | -3.076*** | -45.682*** | -3.781 |
| | (-9.09) | (-2.67) | (-8.10) | (-3.06) | (-3.76) | (-2.70) | (-6.28) | (-0.45) |
| Ln(income) | -1.311*** | -0.258** | -3.319*** | -0.751* | -0.597*** | -0.234* | -6.810*** | -2.628*** |
| | (-10.84) | (-2.38) | (-10.12) | (-1.93) | (-4.89) | (-1.89) | (-8.43) | (-2.86) |
| Unemployment Rate | -0.052*** | 0.036*** | -0.082*** | 0.148*** | -0.032*** | 0.024** | -0.378*** | 0.032 |
| | (-9.09) | (4.12) | (-4.50) | (4.51) | (-3.90) | (2.28) | (-8.23) | (0.43) |
| Housing Price Index | 0.000 | -0.001*** | 0.000 | -0.001*** | 0.000 | -0.000*** | -0.001*** | -0.003*** |
| | (0.59) | (-6.23) | (1.44) | (-4.67) | (0.77) | (-2.69) | (-2.89) | (-4.40) |
| Constant | 14.968*** | 3.574*** | 39.590*** | 11.486*** | 6.794*** | 2.672** | 80.633*** | 35.018*** |
| | (11.84) | (3.21) | (11.61) | (2.89) | (5.31) | (2.11) | (9.61) | (3.72) |
| Observations | 91,379 | 50,627 | 91,379 | 50,627 | 91,379 | 50,627 | 91,379 | 50,627 |
| R-squared | 0.528 | 0.529 | 0.853 | 0.862 | 0.349 | 0.334 | 0.542 | 0.589 |
| Company FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Sample | Multi-Region | Multi-Region | Multi-Region | Multi-Region | Multi-Region | Multi-Region | Multi-Region | Multi-Region |
| Region Rate | Low | High | Low | High | Low | High | Low | High |

Table 7: Heterogeneous Effects (Has Facilities in Other Regions and Same Industry)

This table presents the OLS regression results examining the heterogeneous effects of EPA enforcement on firm divestiture in firms that operates facilities in the same NAICS 3-digit industry in other regions. Columns (1), (3), (5), and (7) report the results of the regressions that focus on facilities whose parent firm has at least one facility in the same NAICS3 industry in other regions, while Columns (2), (4), (6), and (8) report the regression results for facilities whose parent firms do not have such sibling facilities. The dependent variables are reported on the top of each column. *EnforceRate* is the number of establishments being enforced by the EPA divided by the total number of polluting establishments in an EPA region. All continuous variables are winsorized at the 1st and 99th percentiles and standardized. *T*-statistics are in parentheses. Standard errors are clustered at the company level. Coefficients that are statistically significant at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| VARIABLES | ln(N_plants) | | ln(Employment) | | ln(Abatements) | | ln(Toxic Emissions) | |
| EnforceRate | -0.210*** | -0.051** | -0.629*** | -0.428*** | -0.107*** | 0.010 | -0.568*** | -0.005 |
| | (-10.19) | (-2.22) | (-9.53) | (-3.31) | (-4.76) | (0.22) | (-3.67) | (-0.01) |
| GDP growth | -0.106 | 0.141 | -0.126 | 0.535 | -0.150 | 0.320 | -1.202 | -0.644 |
| | (-1.24) | (0.81) | (-0.42) | (0.77) | (-1.15) | (1.34) | (-1.59) | (-0.34) |
| population growth | -3.963*** | -1.872* | -14.187*** | -12.374** | -2.787*** | 0.936 | -16.678*** | -15.926 |
| | (-5.15) | (-1.87) | (-5.77) | (-1.97) | (-3.26) | (0.57) | (-2.93) | (-1.20) |
| Ln(income) | -0.486*** | -0.036 | -1.133*** | 0.489 | -0.213*** | 0.025 | -3.332*** | -3.016** |
| | (-6.31) | (-0.36) | (-4.58) | (0.89) | (-2.69) | (0.13) | (-5.67) | (-2.13) |
| Unemployment Rate | 0.021*** | 0.007 | 0.121*** | 0.083** | 0.012** | 0.024** | -0.066* | 0.064 |
| | (4.16) | (1.08) | (7.49) | (2.14) | (1.98) | (1.98) | (-1.68) | (0.74) |
| Housing Price Index | -0.000*** | -0.000 | -0.001*** | -0.001*** | -0.000** | -0.000 | -0.002*** | 0.000 |
| | (-7.33) | (-1.01) | (-5.04) | (-2.85) | (-2.29) | (-0.73) | (-7.20) | (0.03) |
| Constant | 6.117*** | 0.866 | 16.086*** | -2.089 | 2.607*** | -0.262 | 43.529*** | 34.587** |
| | (7.63) | (0.86) | (6.28) | (-0.37) | (3.16) | (-0.14) | (7.18) | (2.37) |
| Observations | 118,955 | 22,986 | 118,955 | 22,986 | 118,955 | 22,986 | 118,955 | 22,986 |
| R-squared | 0.387 | 0.570 | 0.812 | 0.880 | 0.282 | 0.335 | 0.452 | 0.552 |
| Company FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Sample | Multi-Region | Multi-Region | Multi-Region | Multi-Region | Multi-Region | Multi-Region | Multi-Region | Multi-Region |
| Has Same NAICS3 Elsewhere | Yes | No | Yes | No | Yes | No | Yes | No |

## Table 8: IV Regression Main Results

This table presents the IV regression results examining the heterogeneous effects of EPA enforcement on firm divestiture in firms that operates facilities in more than one EPA regions. Columns (1), (2), and (3) report the first-stage IV 2SLS results for the whole sample, single-region firms, and multi-region firms, respectively. Columns (2), (4), and (6) report the second-stage IV 2SLS regression results. The dependent variable is ln(N_plants). The instrumental variable follows a shift–share spirit. It is constructed as the interaction between (i) the fraction of polluting facilities located in a given EPA region relative to all U.S. facilities in the same three-digit NAICS industry and (ii) the natural logarithm of one plus the total number of enforcement actions in that industry in year *t*. *EnforceRate* is the number of establishments being enforced by the EPA divided by the total number of polluting establishments in an EPA region. All continuous variables are winsorized at the 1st and 99th percentiles and standardized. *T*-statistics are in parentheses. Standard errors are clustered at the company level. Coefficients that are statistically significant at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| VARIABLES | | 1st-stage | | | ln(N_plants) | |
| Shift-Share Instrument | -2.802*** | -2.895*** | -2.772*** | | | |
| | (-83.227) | (-46.633) | (-77.278) | | | |
| $\widehat{EnforceRate}$ | | | | -0.580*** | 0.033 | -0.638*** |
| | | | | (-11.10) | (1.08) | (-10.93) |
| GDP growth | 0.677*** | 0.565*** | 0.798*** | 0.330*** | -0.059 | 0.417*** |
| | (22.185) | (10.674) | (21.362) | (4.37) | (-0.91) | (4.17) |
| population growth | 3.805*** | 5.378*** | 4.206*** | 1.084* | -0.282 | 1.184 |
| | (29.830) | (27.378) | (28.210) | (1.91) | (-0.83) | (1.57) |
| Ln(income) | 0.805*** | 0.406*** | 0.876*** | -0.146** | 0.055 | -0.082 |
| | (37.925) | (8.004) | (39.468) | (-2.11) | (0.94) | (-1.02) |
| Unemployment Rate | 0.015*** | 0.026*** | 0.016*** | 0.004 | -0.006** | 0.014*** |
| | (15.619) | (16.440) | (13.961) | (1.16) | (-2.53) | (3.11) |
| Housing Price Index | -0.000*** | 0.000*** | -0.000*** | -0.000*** | -0.000 | -0.000*** |
| | (-22.312) | (11.237) | (-26.786) | (-8.89) | (-1.15) | (-10.13) |
| Observations | 242,916 | 100,117 | 142,034 | 242,916 | 100,117 | 142,034 |
| R-squared | 0.71 | 0.83 | 0.65 | | | |
| kp F-stat | 6926.7 | 2174.653 | 5971.857 | | | |
| Company FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Sample | All | Single-Region | Multi-Region | All | Single-Region | Multi-Region |

## Table 9: IV Regression Heterogeneous Effects

This table presents the second-stage IV regression results examining the heterogeneous effects of EPA enforcement on firm divestiture in multi-region firms. The dependent variables are reported on the top of each column. The instrumental variable follows a shift–share spirit. It is constructed as the interaction between (i) the fraction of polluting facilities located in a given EPA region relative to all U.S. facilities in the same three-digit NAICS industry and (ii) the natural logarithm of one plus the total number of enforcement actions in that industry in year *t*. *EnforceRate* is the number of establishments being enforced by the EPA divided by the total number of polluting establishments in an EPA region. All continuous variables are winsorized at the 1st and 99th percentiles and standardized. *T*-statistics are in parentheses. Standard errors are clustered at the company level. Coefficients that are statistically significant at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| VARIABLES | ln(N_plants) | | ln(Employment) | | ln(Abatements) | | ln(Toxic Emissions) | |
| $\widehat{EnforceRate}$ | -0.638*** | -1.329*** | -2.423*** | -4.066*** | -0.323*** | -0.799*** | -1.563*** | -3.324*** |
| | (-10.93) | (-12.71) | (-13.41) | (-12.49) | (-5.48) | (-6.70) | (-3.86) | (-4.71) |
| GDP growth | 0.417*** | 1.101*** | 1.952*** | 3.851*** | 0.130 | 0.723*** | 0.112 | 2.332* |
| | (4.17) | (6.49) | (5.66) | (6.88) | (0.96) | (3.37) | (0.13) | (1.84) |
| population growth | 1.184 | 2.514** | 5.749** | 8.406*** | 0.151 | 0.657 | -5.807 | 2.936 |
| | (1.57) | (2.46) | (2.28) | (2.65) | (0.18) | (0.58) | (-1.02) | (0.40) |
| Ln(income) | -0.082 | 0.254** | 0.456* | 1.151*** | 0.005 | 0.233** | -2.425*** | -1.402* |
| | (-1.02) | (2.49) | (1.76) | (3.66) | (0.07) | (2.22) | (-4.09) | (-1.92) |
| Unemployment Rate | 0.014*** | 0.056*** | 0.100*** | 0.216*** | 0.011** | 0.037*** | -0.069* | 0.036 |
| | (3.11) | (8.66) | (6.59) | (10.15) | (1.97) | (4.98) | (-1.91) | (0.73) |
| Housing Price Index | -0.000*** | -0.001*** | -0.001*** | -0.002*** | -0.000*** | -0.000*** | -0.002*** | -0.003*** |
| | (-10.13) | (-13.44) | (-9.32) | (-11.27) | (-4.37) | (-6.29) | (-7.73) | (-8.37) |
| Observations | 142,034 | 90,048 | 142,034 | 90,048 | 142,034 | 90,048 | 142,034 | 90,048 |
| Company FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Multi-region | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Has Facilities in Lower Regions | No | Yes | No | Yes | No | Yes | No | Yes |