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Navigating Rivalry and Insight: Bureaucratic Behaviors in Decentralized Regulatory Systems

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ABSTRACT

We study how regulatory competition and learning shape bureaucratic behaviors under regulatory federalism in the US, focusing on Clean Air Act enforcement within intra-firm networks. Using facility-level panel data on inspections from 2005 to 2017, we examine how sibling facility violations influence state regulators' scrutiny of focal facilities. These mechanisms predict opposite effects: learning increases scrutiny, while competition decreases it. Our findings provide evidence for both mechanisms, with their relative strength varying under different conditions. Regulators increase scrutiny following violations by same-state sibling facilities, highlighting strong learning effects when information is accessible and accountability pressures are high. Conversely, scrutiny decreases after violations by same-industry siblings in competitor states, demonstrating competitive incentives when business opportunities are relevant. These results clarify the interplay between competition and learning in regulatory federalism and offer practical insights for mitigating adverse competition dynamics and strengthening learning to enhance decentralized regulatory systems.

1 | Introduction

Federalism underpins many protective regulations in the United States, particularly those concerning social welfare, workplace safety, and environmental protection. Under this arrangement, the federal government sets overarching standards and requirements, while much of the implementation is delegated to state-level agencies, creating a complex landscape of responsibilities shared across multiple levels of government (Woods 2008). This complex structure grants state bureaucrats significant discretion in enforcement decisions and places them in a challenging position where they must navigate competing demands (Shimshack 2014). On one hand, they are responsible for ensuring compliance with federal standards and being accountable to federal agencies like the Environmental Protection Agency (EPA) and to the residents of their states. On the other hand, they must also respond to the demands of state-level political institutions, such as governors and state legislatures, which may prioritize economic growth and business development over regulatory strictness.

One prominent debate regarding bureaucratic behaviors within regulatory federalism concerns whether state regulators engage in a "race to the bottom." This theory suggests that state regulators, competing to attract businesses, may strategically weaken regulatory enforcement, which could compromise regulatory effectiveness (Konisky 2008; Woods 2020). However, the literature offers mixed findings. While some studies find evidence for the race-to-the-bottom argument (Woods 2006), others point to the opposite dynamic—"race to the top"—in which states adopt stricter regulatory standards to achieve social or environmental gains (Fredriksson and Millimet 2002; Howell and Magazinnik 2017). In addition to these competitive pressures, prior research likewise indicates

Evidence for Practice

- State regulators in federal systems balance compliance and economic development goals, and these dual pressures shape how they respond to peer violations within firms.
- Regulators relax environmental enforcement when economic opportunities are salient, but reputational concerns and federal oversight limit race-to-the-bottom dynamics.
- Regulators strengthen enforcement when they have better access to peer violation information, underscoring the value of transparency for regulatory learning.
- Enhancing information sharing and transparency can improve decentralized enforcement by fostering regulatory learning, curbing economic pressures, and promoting accountability.

that regulators may engage in learning when adjusting their enforcement strategies, particularly in the context of regulating misconduct. Specifically, when regulates violate existing standards, the information gained can prompt regulators to strengthen enforcement and improve compliance. Despite these insights, prior research lacks an integrated examination of how these distinct mechanisms, regulatory competition and regulatory learning, coexist and interact within the same institutional setting, thus limiting our understanding of bureaucratic behaviors in complex, decentralized federalism systems.

Specifically, a close examination of prior research reveals that much of the existing literature has focused on broad enforcement patterns at the state level, which presents several limitations. First, regulatory behaviors can be more nuanced and targeted; state regulators may choose to act only when certain conditions are met, for example, by focusing on specific regulates where the competition dynamic is particularly relevant (Carruthers and Lamoreaux 2016). By focusing solely on broad state-level patterns, prior studies might have overlooked important within-state variations in enforcement behaviors and failed to capture nuanced inter-state dynamics, potentially contributing to the conflicting conclusions in the literature. Second, distinguishing competitive motives from learning dynamics remains challenging, as both can produce similar enforcement patterns when examined at the state level (Carruthers and Lamoreaux 2016).

This study addresses these limitations by examining the interplay of regulatory competition and learning dynamics within intra-firm networks under the Clean Air Act (CAA), a prominent example of regulatory federalism governing air pollution in the US We investigate how state regulators adjust enforcement stringency toward a focal facility after its sibling facilities, owned by the same corporate parent, incur environmental violations.

Sibling facility violations simultaneously activate both mechanisms but with opposing predictions. The learning mechanism suggests that regulators will increase scrutiny of the focal facility, updating their perceptions of its environmental performance and reputation based on information from sibling violations. Conversely, the competition mechanism predicts decreased scrutiny, as violations often necessitate costly corrective actions that disrupt production at sibling facilities, prompting multi-unit firms to relocate or expand operations elsewhere (Rijal and Khanna 2020; Gibson 2019). Anticipating such relocations, state regulators may reduce enforcement stringency to signal a business-friendly environment and attract potential investments.

We argue that the relative strength of these mechanisms, and thus which dominates, varies under different conditions. The unique context of intra-firm networks, where capital is highly mobile, provides a distinctive opportunity to disentangle these mechanisms empirically. By analyzing regulatory responses at the facility level, we can identify which mechanism prevails across different scenarios.

Using regulatory inspection data under the CAA from 2005 to 2017, we find evidence for both mechanisms operating under different conditions. Regulators increase inspections of a focal facility after violations by sibling facilities within the same state, indicating strong learning effects when information is readily accessible and federal oversight constrains competitive behavior. Conversely, regulators reduce inspections following violations by same-industry sibling facilities in economically competitive states, demonstrating that competition dominates when business opportunities are highly relevant and accountability constraints are weaker.

These findings advance two core public administration debates on intergovernmental coordination and bureaucratic accountability. First, while existing research emphasizes formal institutionalized intergovernmental coordination mechanisms (Kapucu et al. 2024; Xiang and Chen 2024), our study reveals how informal dynamics, competition and learning, shape intergovernmental relationships. The competition dynamics help explain coordination failures when subnational governments prioritize local economic interests (Askim et al. 2024), while the learning mechanism demonstrates how information accessibility and institutional oversight can mitigate harmful competitive dynamics (Berman et al. 2024; Callahan et al. 2025). Second, our findings advance understanding of bureaucratic accountability by showing how administrators navigate competing accountability relationships (Rimkutė and van der Voet 2024; Bozeman et al. 2024; Hansen et al. 2025), with identical information (sibling facility violations) triggering different responses depending on which accountability relationship dominates.

These insights extend beyond environmental policy to other decentralized systems where subnational and federal authorities share implementation responsibilities, common structures across federal systems including the United States, Canada, Australia, and Germany. Our theoretical framework likewise applies to policy domains where similar structural features enable both learning and competition dynamics, such as financial oversight, occupational safety regulation, food safety inspection,

and social welfare. These insights can inform strategies to strengthen learning mechanisms, mitigate adverse competition dynamics, and enhance the effectiveness of decentralized governance systems.

2 | Literature Review

Bureaucrats operate within a complex web of federal, state, and local institutions, and their behaviors are influenced by various actors, including the President, Congress, courts, federal agencies, and interest groups, while also responding to political and socioeconomic conditions at the state and local levels (e.g., Shimshack 2014; Woods 2008; Konisky and Teodoro 2016; Li 2023; Erlich et al. 2021; Park and Liang 2024; de Boer et al. 2018). For state-level bureaucrats, interactions with other states add further complexity, as they engage in both competition and collaboration in response to policy and economic pressures (e.g., Monogan III et al. 2017; Howell and Magazinnik 2017). In regulation, this interplay manifests primarily through regulatory competition and regulatory learning.

2.1 | Regulatory Competition

Regulatory competition, commonly referred to as a "race to the bottom," suggests that states, in pursuit of economic growth and business investment, may compete to lower regulatory standards, particularly in environmental policy, thus weakening environmental protections. This dynamic is widely studied in US environmental federalism, where states possess discretion in setting and enforcing many environmental regulations within federal frameworks (Konisky 2008; Monogan III et al. 2017). Empirical studies have highlighted the competitive interactions among state regulators. For example, Neal D. Woods (2020) shows that states are more likely to adopt "No More Stringent" laws—which restrict state environmental agencies from exceeding federal standards—when neighboring states have already adopted similar policies. This pattern also extends to the enforcement of existing regulations, with states converging their enforcement practices toward their competitors' lower standards, as seen in surface-mining regulations (N. D. Woods 2006).

While the aforementioned research highlights concerns about a universal race to the bottom, other studies present a more nuanced perspective, suggesting these concerns may be overstated. Potoski (2001) finds that many states exceed federal minimum standards under the CAA, indicating interstate competition does not uniformly drive states toward the lowest regulatory baseline. Similarly, Fredriksson and Millimet (2002) observe that states' responses to their peers' regulatory stringency sometimes lead to a "race to the top," where states incrementally strengthen environmental protections. Konisky (2007) identifies a dual dynamic where states adjust standards both upward and downward, reflecting the complex interplay of political and economic factors. Carruthers and Lamoreaux (2016) further argue that regulatory convergence often stems from harmonization or imitation driven by internal political pressures, rather than competitive dynamics, as the conditions for a consistent race-to-the-bottom, high business mobility and explicit government targeting, are rarely met.

2.2 | Regulatory Learning

In contrast to regulatory competition, which emphasizes economic pressures, regulatory learning focuses on how states adapt their policies based on the experiences of their peers and their own prior decisions (Volden et al. 2008). Due to varying levels of political and economic development, some states encounter specific policy challenges earlier than others, allowing them to pioneer solutions from which later adopters can learn (Liu et al. 2025).

Regulatory learning is often studied in the context of policy diffusion (Shipan and Volden 2008, 2012; Volden et al. 2008; Moyson et al. 2017; Yi et al. 2018; Yi and Chen 2019; Yi and Liu 2022). For instance, Shipan and Volden et al. (2008), in their pioneering analysis of anti-smoking policies across 675 US cities, identified four key mechanisms of policy diffusion: learning from earlier adopters, economic competition,[1] imitation of larger cities, and coercion by state governments. Their findings emphasize the importance of learning and imitation in the convergence of regulations. Moreover, Volden et al. (2008) further illustrated that regulators learn not only from their peers, but also from their own past decisions and experiences. These insights extend to environmental policy, where regulatory learning is a key factor in explaining the adoption of policies across jurisdictions (Yi and Chen 2019; Liu and Yi 2023; Guo and Ba 2020; Yang and Zhu 2025).

2.3 | Limitations in the Literature

While the literature on regulatory competition and learning provides valuable insights, significant gaps remain. First, many studies focus on broad patterns of regulatory adoption and enforcement at the state level, often overlooking nuanced strategies. For instance, most businesses are not highly mobile across state lines due to constraints related to supply chains, labor and product markets, and local infrastructure (Carruthers and Lamoreaux 2016). This suggests that regulatory competition may not target all businesses equally, but instead focus on those that are more mobile. By examining only general state-level patterns, important insights into bureaucratic motivations may be overlooked.

Second, distinguishing regulatory competition from learning remains ambiguous. Existing studies often focus exclusively on either competition or learning, rarely integrating both theories within the same context. However, both mechanisms can result in regulatory convergence (Carruthers and Lamoreaux 2016), leaving the underlying cause unclear. This issue also partly stems from the predominant focus on state-level policy adoption and implementation, which often uses states as the unit of analysis. This approach overlooks important intra-state variations that could help disentangle the underlying mechanisms. For example, if regulators only target specific facilities through competition or learning, a comparison with other facilities within the same state could rule out the alternative mechanism and the impact of broader state-level sociopolitical factors that shape regulatory behaviors.

3 | Theoretical Framework and Hypotheses

This study explores how violations by sibling facilities, owned by the same corporate parent, trigger both regulatory competition and learning mechanisms, each of which predicts an opposite enforcement response. We analyze how the relative strength of these mechanisms varies based on industry and state alignment between focal and sibling facilities.

3.1 | Regulatory Competition in Intra-Firm Networks

Regulatory competition is likely to emerge when investments and businesses are mobile or perceived as such by regulators (Carruthers and Lamoreaux 2016). Within multi-unit firms, this competition intensifies, as resources, capital, and investments are more mobile within intra-firm networks (Dickler and Folta 2020; Li and Lyon 2024). Such mobility of resources is also evident in environmental enforcement. Research shows that firms respond to strict environmental regulations by shifting production, and thus emissions, to subsidiary facilities located elsewhere (Gibson 2019; Rijal and Khanna 2020).

In the context of this study, violations at sibling facilities will disrupt their production as they need to take corrective actions such as upgrading equipment, altering processes, and paying fines, leading to increased compliance costs and scrutiny (Congressional Research Service 2014). These disruptions often prompt firms to consider relocating or expanding operations elsewhere (Cui and Moschini 2020; Rijal and Khanna 2020). Anticipating such moves, state regulators, who hold primary enforcement responsibility and significant discretion, may relax enforcement on a facility to position their state as more attractive than other potential locations for the firm's prospective investments. However, the likelihood and intensity of these responses depend on the relevance of the business opportunities, shaped by the industry and location match between the focal facility and its violating siblings, as detailed below.

3.1.1 | Industry Alignment

Same-industry facilities offer greater business opportunity relevance due to shared knowledge, capacities, and operational synergies. Firms often leverage same-industry networks to adapt to regulatory shocks (Rijal and Khanna 2020; Cui and Moschini 2020), making potential relocations or expansions triggered by same-industry sibling violations more attractive to state regulators seeking to capture mobile investments. Thus, we expect regulators to relax enforcement stringency more significantly when violations involve same-industry siblings compared to different-industry siblings.

3.1.2 | State Alignment

In general, a focal facility's sibling facilities can operate in an economically competitor state, a non-competitor state, or the same state. First, we expect a more substantial reduction in enforcement stringency on the focal facility when its sibling facilities in competitor states, as opposed to non-competitor states, incur violations. Competitor states, sharing similar economic, logistical, labor market, and consumer market characteristics, offer more viable options for business expansion triggered by sibling facility violations (Konisky 2007), making potential investment and business opportunities more relevant among them.

Second, when the focal facility and its violating siblings are in the same state, state regulators are less able to show leniency toward the focal facility. Under the CAA's federalism framework, the EPA retains oversight authority to ensure adequate state implementation: it reviews state enforcement data and reports, conducts program evaluations, can condition or withhold federal grant funds, and, in cases of persistent failure, can withdraw state primacy and assume direct enforcement (Woods 2008; Atlas 2007). Violations by in-state sibling facilities therefore not only reflect poorly on those facilities but also imply a failure on the part of the state's regulatory agencies, potentially damaging their credibility. Such reputational damages could invite closer EPA supervision and public scrutiny (Bustos 2021; Etienne 2015; Li 2023, 2024a, 2024b; Davidson et al. 2025), thereby limiting state regulators' latitude to reduce enforcement stringency on the focal facility, whose corporate affiliation with the violating ones makes leniency politically and reputationally costly. By contrast, when violations occur at sibling facilities in other states, the focal facility's home state regulators face weaker accountability pressures, as these violations fall outside their jurisdictional responsibility.

Building on this analysis, competition strength is determined by state and industry alignment between the focal facility and its violating siblings. Competition is strongest when both state and industry alignment are present (competitor-state-same-industry siblings), moderate when only one dimension aligns, and weakest when neither aligns or when regulatory constraints limit competitive behavior.

3.2 | Regulatory Learning in Intra-Firm Networks

Regulatory enforcement commonly follows a targeting model, where the intensity of inspections and sanctions is adjusted based on a facility's compliance history, with “good” performers receiving leniency and “bad” ones facing stricter enforcement (Harrington 1988; Hansen and Nielsen 2022; Hansen 2023). This approach, embedded in EPA policies (US EPA 2016), may extend to intra-firm networks, as violations by sibling facilities can tarnish the reputation of a focal facility, potentially leading regulators to impose stricter enforcement on the focal facility. Importantly, the extent of learning depends on the relevance and accessibility of information about sibling facility violations, which are also influenced by industry and location matches.

3.2.1 | Industry Alignment

When a focal facility and its sibling facilities are in the same industry, shared operations and compliance requirements make violations at sibling facilities more relevant, intensifying regulatory learning (Paruchuri et al. 2019). As a result, enforcement

stringency on the focal facility is more likely to increase when sibling facilities in the same industry incur violations.

3.2.2 | State Alignment

Geographic location also shapes regulatory learning. States differ in their attention to policy developments and enforcement actions in other states (Shipan and Volden 2008; Konisky 2007), which affects both the likelihood and degree of learning. First, learning is expected to be most pronounced when the focal facility and its violating sibling facilities are in the same state. These facilities are subject to the same regulators, who have full access to information about the violations. Such direct oversight makes the violations more salient to state regulators, thus increasing the likelihood that regulators would adjust their enforcement strategies based on these experiences. As Volden et al. (2008) suggest, regulators tend to learn more from their own experiences than from those in other jurisdictions.

Second, learning is also likely to be significant when violations occur in competitor states, as regulators closely monitor policy developments in rival states (Konisky 2007). Conversely, sibling violations in non-competitor states result in weaker learning effects due to reduced regulatory attention to these states.

Learning strength is therefore determined by both information accessibility (state alignment) and relevance (industry alignment). Learning is strongest when both factors are high, moderate when one is high but the other is low, and weakest when both are low.

The learning mechanism outlined above emphasizes regulators' motivation to use technical or reputational knowledge, gained from sibling facility violations, to enhance enforcement effectiveness. However, similar enforcement responses may arise from alternative motivations. For example, risk-averse regulators may increase scrutiny of the focal facility as a precaution, fearing that leniency could invite additional violations and expose them to blame (Heyes 2000). Regulators may also tighten enforcement to demonstrate vigilance and distance themselves from firms with compliance problems, thus shielding themselves from accusations of regulatory capture or inadequate oversight (reputational shielding; Bustos 2021). In other cases, enforcement may increase primarily for symbolic reasons, signaling responsiveness to stakeholders and preserving legitimacy, rather than reflecting a substantive reassessment of risk (symbolic enforcement). Beyond these motivations, the organizational diffusion literature suggests that agencies may respond to sibling violations by imitating the practices of peer agencies under uncertainty, a process known as mimetic isomorphism (Dimaggio and Powell 1983). All these motivations—risk aversion, reputational shielding, symbolic enforcement, and imitation—are typical systematic preferences embedded within bureaucratic behaviors and all produce the same observable outcome as learning (increased inspections) but stem from bureaucratic self-preservation or conformity rather than improved risk targeting. We acknowledge that regulators may be driven by these alternative motivations instead of the learning mechanism we emphasize.

4 | Theoretical Expectation

Our theoretical framework details two distinct mechanisms, regulatory competition and learning, that may influence how regulators treat a focal facility after its sibling facilities incur violations. These mechanisms operate simultaneously but lead to opposite outcomes, which enables us to identify the dominant mechanism under different conditions. Such identification, however, does not preclude the nondominant one from also playing a role.

Based on the above analysis, the relative strength of the two mechanisms depends on the relevance of business opportunities (determining competition strength) and the accessibility and relevance of information about sibling facility violations (determining learning strength), respectively—both of which are shaped by the industry and location matches between the focal facility and its siblings. Table 1 summarizes our assessment of how strongly each mechanism is likely to operate under different scenarios and the mechanism expected to dominate. This approach admittedly involves subjective judgment. Therefore, we formally hypothesize only for the three scenarios where we have the strongest theoretical expectations.

5 | Empirical Context, Data, and Methods

Our empirical context focuses on the enforcement of the CAA, the primary law governing air pollution in the US Under the CAA's cooperative federalism framework, the US Environmental Protection Agency (EPA) sets national standards, while implementation and enforcement are delegated to states through a "primacy" system (Konisky 2007; Monogan III et al. 2017; Potoski 2001). States develop EPA-approved State Implementation Plans (SIPs), which authorize environmental agencies—such as the Texas Commission on Environmental Quality or the California Environmental Protection Agency—to conduct regulatory functions such as permitting, monitoring, inspections, and enforcement. These state environmental agencies, which we refer to as state regulators, operate under the authority of state governments and report to state political leadership. As such, their enforcement activities reflect not only federal mandates but also state-level policy priorities, including economic development and competitiveness (Woods 2008; Yackee and Yackee 2006).

State regulators ensure compliance by monitoring facilities' environmental performance and sanctioning violations when they occur. Violations can be identified through direct monitoring, inspections, citizen reports, or self-disclosures by the regulated entities (Congressional Research Service 2014). Upon discovering noncompliance, state regulators initiate enforcement actions ranging from informal measures, such as warning letters and notices of violation, to more formal sanctions, including compliance orders and, in some cases, civil or criminal legal actions (Congressional Research Service 2014). States are also required

TABLE 1 | Theoretical predictions and net effects across scenarios.

Scenario (violations by...)	Regulatory competition (based on business opportunity relevance: state + industry alignment)	Regulatory learning (based on information access + relevance)	Expected net effect	Hypothesis
Same state, same industry siblings	Low (Constrained by federal oversights[a])	High (Full access + high relevance)	Learning dominates	H1: Enforcement on a focal facility increases following violations by its same-state-same-industry siblings.
Competitor state, same industry siblings	High (State + industry alignment)	Moderate (Limited access + high relevancy)	Competition dominates	H2: Enforcement on a focal facility decreases following violations by its competitor-state-same-industry siblings.
Non-competitor state, same industry siblings	Moderate (Industry alignment only)	Moderate (Low access + high relevancy)	Ambiguous or no effect	—
Same state, different industry siblings	Low (Constrained by federal oversight[a])	Moderate (Full access + low relevancy)	Learning dominates	H3: Enforcement on a focal facility increases following violations by its same-state-different-industry siblings.
Competitor state, different industry siblings	Moderate (State alignment only)	Moderate (Limited access + low relevancy)	Ambiguous or no effect	—
Non-competitor state, different industry siblings	Low (No alignment)	Low (Low access + low relevance)	Ambiguous or no effect	—

Note: This table presents theoretical predictions for how state regulators adjust their scrutiny of a focal facility after significant violations occur at its different types of sibling facilities, based on competition and learning mechanisms.

[a]Constrained by federal oversight: State regulators face federal oversight and public criticism when violations occur within their jurisdictions, limiting their ability to compete through reduced enforcement.

to report federally reportable violations (FRVs), which include significant CAA violations, to the EPA in a timely manner. While the EPA provides guidelines for these activities, states have considerable discretion in determining the frequency and intensity of monitoring and enforcement (Shimshack 2014).

These enforcement and compliance activities are compiled in the EPA's Enforcement and Compliance History Online (ECHO) database, which serves as the primary data source for our study. ECHO tracks inspections, sanctions, and violations related to the CAA, offering detailed records of facilities' compliance and regulatory actions. In addition to ECHO, we also use the EPA's Toxics Release Inventory (TRI) database, which requires facilities to report annual data on the management of toxic chemicals. The TRI data are particularly valuable for assessing facility production levels and, more importantly, for identifying sibling facilities within the same corporate network, allowing us to analyze intra-firm dynamics.

5.1 | Sample

Our sample includes facilities regulated under the CAA and the TRI from 2005 to 2017. The TRI database complements CAA data by providing detailed firm-level information, including parent companies. While TRI data exclude smaller facilities, they effectively capture major air polluters, making the sample suitable for analyzing regulatory learning and competition (Gibson 2019).

5.2 | Identifying Sibling Facilities

Sibling facilities are identified using TRI data. Facilities sharing the same parent company are categorized by industry and state match. Industry match is determined using the four-digit North American Industry Classification System (NAICS) codes. Sibling facilities that share the same NAICS code are classified as same-industry; otherwise, they are considered different-industry. State match is divided into three levels: same state, competitor states, and non-competitor states.

The literature employs several methods to define competitor states, including geographic adjacency, similarity in economic structure, and the economic regions defined by the Bureau of Economic Analysis (BEA) (Fredriksson and Millimet 2002; Konisky 2007). We adopt the BEA regions as our primary measure as they best approximate the integrated regional economies (shared supply chains, labor markets, logistics) that make relocation or expansion most feasible for multi-unit firms in our context. We note, however, that our competition results are sensitive to this choice; robustness checks using neighboring states and economically similar states as defined by Crone (2005) yield null results (see Supporting Information), suggesting that competitive pressures operate most clearly within economically integrated regions.

The BEA divides the US into eight regions, grouping states based on factors such as geographic proximity, industry composition, economic interdependencies, and shared economic challenges or opportunities. States within the same BEA region often share common economic characteristics and have overlapping industry structures. For example, they may have a dominant industry that drives their economies, similar population demographics, or face comparable environmental and natural resource constraints. They may also share similar policy environments, labor market conditions, and infrastructure systems. The geographic proximity of states within a BEA region also facilitates easier integration of new or expanded operations into existing supply chains and production networks. Because of these economic and geographical similarities, states within the same BEA region are more likely to be competitors in the context of this study.

Combining these two dimensions of industry match and state match, we identify six distinct groups of sibling facilities: (1) same-state-same-industry siblings, (2) same-state-different-industry siblings, (3) BEA-state-same-industry siblings, (4) BEA-state-different-industry siblings, (5) NonBEA-state-same-industry siblings, and (6) NonBEA-state-different-industry siblings.

5.3 | Dependent Variable

5.3.1 | Inspections

We measure regulatory scrutiny using the number of inspections per facility in 6-month intervals. Inspections include on- and off-site reviews of monitoring data (e.g., continuous emissions monitoring reports), permits, logs, visual inspections, and stack tests (US EPA 2016). Though routine CAA inspections are required, regulators have considerable discretion over the timing, frequency, and intensity of inspections (Shimshack 2014; US EPA 2016). Since inspections are resource-intensive, their frequency reflects perceived noncompliance risk. Our use of inspection counts, rather than binary indicators of whether an inspection occurred, thus effectively captures this discretionary variation in regulatory attention.

This measure aligns with established practice in the literature and is supported by research demonstrating that facilities respond significantly to inspection activities, suggesting that inspections represent meaningful regulatory pressure rather than purely symbolic actions (Hanna and Oliva 2010). While inspection count cannot capture all dimensions of regulatory intent, such as depth or rigor, it provides a meaningful proxy for the intensity of regulatory oversight that facilities experience. In a robustness check, we disaggregate our outcome variable into full inspections (more comprehensive) and partial inspections (narrower and less resource-intensive) and separately examine how violations affect each type.

5.4 | Independent Variables

5.4.1 | Violations

The key independent variables are significant CAA violations by sibling facilities in different alignment categories. Depending on the sibling facilities' state and industry alignment, these

TABLE 2 | Descriptive statistics.

Variables	Obs	Mean	SD	Min	Max
Number of same state, same industry siblings	153,214	0.753	1.501	0	10
Number of same state, diff industry siblings	153,214	0.558	1.439	0	16
Number of BEA state, same industry siblings	153,214	1.582	4.020	0	41
Number of BEA state, diff industry siblings	153,214	1.604	4.109	0	39
Number of non-BEA state, same industry siblings	153,214	4.681	10.176	0	94
Number of non-BEA state, diff industry siblings	153,214	7.143	15.709	0	101
Inspection count	153,214	0.942	3.271	0	437
Violation dummy: self	153,214	0.037	0.189	0	1
Violation dummy: same state, same industry siblings	153,214	0.027	0.163	0	1
Violation dummy: same state, diff industry siblings	153,214	0.024	0.154	0	1
Violation dummy: BEA state, same industry siblings	153,214	0.040	0.197	0	1
Violation dummy: BEA state, diff industry siblings	153,214	0.036	0.187	0	1
Violation dummy: non-BEA state, same industry siblings	153,214	0.116	0.320	0	1
Violation dummy: non-BEA state, diff industry siblings	153,214	0.137	0.344	0	1

Note: Observations are at the facility–time level, measured over half-year periods.

violations are expected to activate the competition and learning mechanisms to different degrees, with one likely to dominate in specific scenarios. Table 1 summarizes the predicted dominant mechanism for each scenario and the rationale behind these predictions.

Violations under the CAA vary in severity. Minor violations (e.g., late report submission, recordkeeping errors, or missing required signs) are typically easy to correct and do not lead to significant sanctions or regulatory responses. As these minor infractions are less likely to trigger either the competition or learning mechanisms central to the study, we focus on significant violations, specifically FRVs.

FRVs, such as exceeding emissions limits, failing to obtain required permits, or tampering with emissions control devices, can cause significant harm to public health and the environment. Such violations not only tarnish a firm's reputation but also, in most cases, trigger immediate corrective actions, such as upgrading pollution control systems, modifying operational practices, and paying fines. These corrective measures can be costly and disruptive to production, potentially prompting firms to explore opportunities to relocate or expand operations elsewhere. As a result, significant violations, compared with minor ones, are more likely to activate both the competition and learning dynamics. Due to the relative infrequency of these significant violations, however, most facilities incur no more than one violation per half-year period (the level of observation). We therefore code violations by the focal facility and its six sibling facility categories as dummy variables. Table 2 presents descriptive statistics for key variables.

5.5 | Methods

To assess regulatory competition and learning mechanisms, we regress the number of inspections a facility received within a half-year period on the CAA violations committed by the facility itself and by its six categories of sibling facilities in the preceding half-year. Following common practice in the environmental enforcement literature (Shimshack 2014), we lag violation measures by one period as regulators need time to adjust their enforcement strategies. This lag also helps mitigate concerns of reverse causality. For robustness, we also

conduct analyses with 1-year and 3-month lags. Specifically, we estimate the following model:

$$\begin{aligned} Inspection_{it} = {} & \beta_1 Violation\_St1In1_{i(t-1)} + \beta_2 Violation\_St1In2_{i(t-1)} \\ & + \beta_3 Violation\_St2In1_{i(t-1)} + \beta_4 Violation\_St2In2_{i(t-1)} \\ & + \beta_5 Violation\_St3In1_{i(t-1)} + \beta_6 Violation\_St3In2_{i(t-1)} \\ & + \beta_7 Violation\_Self_{i(t-1)} + \alpha_i + \varphi_t + \theta_{kt} + \gamma_{st} + \rho_{ct} + \varepsilon_{it.} \end{aligned}$$

where $Violation\_St1In1_{i(t-1)}$, $Violation\_St1In2_{i(t-1)}$, $Violation\_St2In1_{i(t-1)}$, $Violation\_St2In2_{i(t-1)}$, $Violation\_St3In1_{i(t-1)}$, $Violation\_St3In2_{i(t-1)}$, and $Violation\_Self_{i(t-1)}$ represent the violations by the six categories of siblings and the facility itself, respectively (St1: same state; St2: competitor states; St3: non-competitor states; In1: same industry; In2: different industries). The coefficients on these measures capture the impact of violations by each category of sibling facilities, and the facility itself, on the regulatory scrutiny faced by facility i.

Our analysis incorporates a variety of fixed effects to control for potential confounding factors. Specifically, we include the following.

Facility fixed effects, α_i, control for time-invariant characteristics specific to each facility that could be correlated with both violations and inspections, such as industry classification, geographic location, and the size of the sibling network. Facility fixed effects also absorb firm-level characteristics, such as a company's environmental policies and management style.

Time fixed effects, φ_t, capture national-level factors that vary over time and affect all facilities uniformly, such as technological advancements, national economic conditions, and changes in federal government or EPA priorities.

Recognizing that not all national factors affect facilities equally, our industry-by-time fixed effects, θ_{kt}, account for industry-specific time-varying factors. For instance, the EPA may develop industry-specific enforcement priorities, and economic shocks can disproportionately impact certain sectors.

State regulators bear primary responsibility for CAA implementation, and enforcement strategies can be influenced by time-varying state-specific factors such as economic conditions, gubernatorial priorities, or state legislature actions. State-by-time fixed effects, γ_{st}, account for these variations.

County-by-time fixed effects, ρ_{ct}, help to control for local time-varying conditions, such as changes in socioeconomic or political environments, which may influence both facility behaviors and regulatory actions. The inclusion of county-by-time fixed effects also helps address concerns related to the National Ambient Air Quality Standards (NAAQS), a key provision of the CAA. The EPA designates counties that fail to meet the NAAQS as "nonattainment areas," requiring states to submit implementation plans with additional and more stringent requirements for affected facilities (Gibson 2019). By including county-year fixed effects, we account for the potential impacts of NAAQS nonattainment on both violations and inspections.

The comprehensive fixed effects address many concerns about omitted variable bias, but a few remain. First, facility-level time-varying factors, such as changes in personnel, facility size, or operational practices, are not directly accounted for in the main model. However, it is worth noting that mere omission of these factors does not constitute an endogeneity concern; they would only bias our estimates if systematically correlated with sibling facility violations, which is the core focus of the study. Second, firm-level time-varying factors present another potential concern. For instance, some firms may operate networks of facilities that share serially correlated characteristics, such as deteriorating management or aging infrastructure, which could increase the likelihood of violations and simultaneously attract greater regulatory scrutiny across the network. Such dynamics could generate a spurious correlation between sibling facility violations and inspections, potentially confounding the interpretation of regulatory responses. We investigate these concerns in the robustness checks.

6 | Results

We estimate the model using linear regression, which provides a practical and straightforward estimation approach. While Poisson or negative binomial models are commonly used for count data, these models failed to converge due to our high-dimensional fixed effects, which are necessary to control for confounders. Moreover, our outcome variable, inspection counts with many distinct values, approximates a continuous variable, particularly after accounting for overdispersion through these extensive fixed effects. Linear regression thus offers a flexible, robust, and interpretable strategy for estimating marginal effects while accommodating our rich fixed effects structure.

The estimated results are presented in Table 3. Each column in the table corresponds to a different model specification with its own set of fixed effects. For clearer visualization, these results are also depicted in Figure 1. Despite variations in fixed effects across specifications, the results remain consistent. Our interpretation is primarily based on Specification (4), which includes the most granular fixed effects. In general, the empirical findings align well with our theoretical expectations, revealing three main patterns in bureaucratic behaviors.

First, consistent with previous studies and the targeting model of enforcement, our findings suggest that regulators tend to intensify their scrutiny of a facility following its own violations. Specifically, when a facility incurs violations in the preceding period, the number of inspections it receives in the subsequent period increases by 0.22, representing a substantial 23% increase from the baseline of 0.94 inspections per period. This supports the idea that regulators adjust their enforcement strategies based on a facility's environmental performance and reputation, allocating more oversight to facilities with a history of noncompliance.

Second, regulatory scrutiny significantly increases for a focal facility following violations by its same-state sibling facilities, regardless of industry match. Notably, the magnitude of this increase is comparable to that following the focal facility's own violations, suggesting that misconduct by same-state siblings has

TABLE 3 | Regulatory responses to violations in intra-firm networks.

	DV: Count of inspection			
1-period lagged violation by …	**(1)**	**(2)**	**(3)**	**(4)**
Same state, same industry siblings	0.195*** (0.052)	0.177*** (0.053)	0.135** (0.053)	0.153*** (0.058)
Same state, diff industry siblings	0.227*** (0.059)	0.220*** (0.060)	0.180*** (0.059)	0.235*** (0.063)
BEA state, same industry siblings	−0.116*** (0.042)	−0.112*** (0.043)	−0.107** (0.043)	−0.099** (0.049)
BEA state, diff industry siblings	0.038 (0.045)	0.030 (0.046)	0.008 (0.045)	−0.002 (0.050)
Non-BEA state, same industry siblings	0.055** (0.028)	0.051* (0.029)	0.053* (0.029)	0.025 (0.032)
Non-BEA state, diff industry siblings	0.003 (0.030)	0.006 (0.031)	−0.003 (0.031)	−0.042 (0.033)
Self	0.285*** (0.040)	0.259*** (0.041)	0.193*** (0.040)	0.220*** (0.044)
Constant	0.920*** (0.009)	0.922*** (0.009)	0.928*** (0.009)	0.929*** (0.010)
Time (half year) fixed effects	Yes	Yes	Yes	Yes
Facility fixed effects	Yes	Yes	Yes	Yes
Industry by time (half year) fixed effects	No	Yes	Yes	Yes
State by time (half year) fixed effects	No	No	Yes	Yes
County by time (half year) fixed effects	No	No	No	Yes
N	147,321	147,093	147,093	130,729
R^2	0.417	0.425	0.455	0.611

Note: This table presents the estimated regulatory responses to violations within intra-firm networks, with results also visualized in Figure 1. All violation indicators are represented as binary variables (1 = violation, 0 = no violation). Standard errors, shown in parentheses, are clustered at the facility level.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

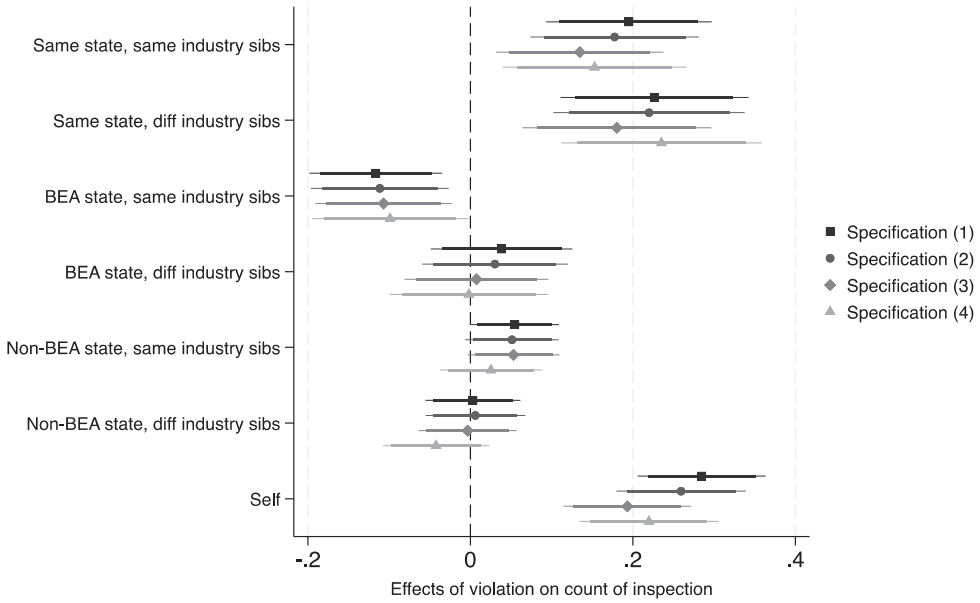

FIGURE 1 | Regulatory responses to violations in intra-firm networks. *Note:* This figure presents the estimated regulatory responses to violations within intra-firm networks, corresponding to estimates reported in Table 3. The dependent variable is the count of inspections a facility receives over a six-month period. All violation measures (*y*-axis) are half-year lagged dummy variables (1 = violation, 0 = no violation). Standard errors are clustered at the facility level. The points represent the estimated coefficients, while the thick bars show the 90% confidence intervals, and the thin bars represent the 95% confidence intervals.

a similarly strong regulatory impact. This pattern underscores a robust learning effect within the same state, where information about sibling violations is highly accessible. Moreover, because these sibling facilities fall under the same regulators' jurisdiction, their violations reflect poorly on the regulators, potentially inviting federal oversight and public scrutiny. These reputational risks likely reinforce the learning response, motivating regulators to strengthen enforcement.

In addition, regulators increase inspections of a focal facility by a similar amount following violations by both same-industry and different-industry siblings within the same state. This pattern suggests that detailed technical knowledge of the violations, more likely shared among same-industry siblings, plays a relatively limited role in driving heightened scrutiny. Instead, the learning mechanism appears to be shaped primarily by reputational spillovers associated with the shared corporate identity of sibling facilities.

Third, our findings indicate that regulators significantly reduce enforcement stringency on a focal facility following violations by same-industry sibling facilities located in other states within the same BEA region (i.e., competitor states). Specifically, the number of inspections decreases by 0.099, representing a 10% reduction from the baseline inspection level of 0.94 inspections per period. This decline in regulatory scrutiny supports our prediction that regulatory competition can outweigh regulatory learning when business opportunities are highly relevant and external constraints on competition (e.g., federal oversight and public scrutiny of regulators) are weak.

Lastly, as predicted, regulatory responses to violations by other categories of sibling facilities are either statistically insignificant or relatively small. To assess the validity and stability of our findings, we conducted several robustness checks (see Appendix for details). These include the addition of time-varying state-level covariates to control for political and economic conditions, tests for serially correlated common shocks using lead violation measures, and a disaggregation of inspection types (partial vs. full). We also assessed the sensitivity of our results to alternative definitions of competitor states, variation by presidential administration, and different observation windows for inspection counts (3-month and 1-year intervals instead of 6 months).

7 | Discussion and Conclusion

This study examines how learning and competition shape bureaucratic behaviors within a federal system, focusing on state regulators' enforcement of the CAA in intra-firm networks. Specifically, we investigate how regulators adjust enforcement stringency toward a focal facility after its sibling facilities incur violations. Such violations can simultaneously trigger both mechanisms: regulators may learn from sibling violations, updating their perceptions of the focal facility's reputation and environmental performance, and potentially increasing scrutiny. On the other hand, violations often necessitate corrective actions that disrupt production at the offending sibling facilities. Multi-unit firms often respond by relocating or expanding operations to other sites, creating incentives for states to ease enforcement on the focal facility to signal a more business-friendly regulatory environment.

Our findings provide evidence for both mechanisms, with their relative strength determined by the relevance of business opportunities and the accessibility of information about sibling violations. Regulators tend to decrease inspections at a focal facility when its same-industry sibling facilities in competitor states incur violations, suggesting that competition dominates in contexts where business opportunities are particularly salient. Conversely, regulators increase inspections at a focal facility after violations by sibling facilities in the same state (regardless of industry match), indicating that learning prevails in these situations. This is likely due to greater access to information about the violations and heightened accountability pressures from citizens and federal authorities. This study makes important theoretical contributions to understanding bureaucratic behaviors in decentralized regulatory systems. First, it clarifies the interplay between two key motivations: regulatory competition and learning. While previous studies have documented convergence in state-level enforcement (Konisky 2007; Woods 2006), they have been unclear whether such convergence stems from learning, competition, or both, as these mechanisms can yield similar outcomes (Carruthers and Lamoreaux 2016). Our empirical setting, regulatory responses within intra-firm networks, where each mechanism predicts an opposite outcome, allows us to illustrate their coexistence and how each dominates under different conditions.

The findings also contribute to the literature on intergovernmental coordination. The competition dynamics we identify help explain why coordination efforts may fail even when formal arrangements exist, while the learning mechanism shows how effective oversight and information accessibility can alleviate harmful competition and promote positive learning across jurisdictions (Berman et al. 2024; Coutin et al. 2025).

In addition, the research advances understanding of bureaucratic accountability by demonstrating how state regulators navigate competing accountability relationships—federal oversight and citizen expectations versus local economic development pressures (Rajala and Jalonen 2025; Bozeman et al. 2024). We show that the same information (sibling facility violations) can trigger different bureaucratic responses depending on which accountability relationship dominates, revealing how multiple accountability pressures shape behavior in complex institutional settings.

These insights extend beyond US environmental policy to other federal and decentralized systems worldwide. The theoretical framework applies to many contexts where subnational authorities implement policies under federal oversight while competing for mobile economic resources. This includes domains such as financial oversight, occupational safety, and food safety across federal systems in countries like Canada, Australia, and Germany. The dynamics uncovered in this study carry significant potential for improving the efficiency and effectiveness of these decentralized systems.

One major concern in decentralized enforcement systems is the potential for a "race to the bottom" that can compromise

regulatory effectiveness. While this study finds evidence of the competition dynamic when business opportunities are particularly compelling (e.g., those arising from violations by same-industry siblings in competitor states), this pattern is not pervasive, suggesting there are potential ways to mitigate it. Notably, we do not observe the competitive dynamic following violations by same-industry siblings within the same state. Although state regulators might still have similar incentives to reduce enforcement stringency to retain business, they appear constrained, likely due to heightened pressure from the media, citizens, and federal oversight, and more effective learning from their own enforcement experiences.

These findings suggest several strategies that can mitigate the adverse effects of regulatory competition. First, federal agencies could strengthen oversight of state regulators that may be inclined toward excessive competition in regulation. Second, facilitating interstate information sharing on significant violations may foster regulatory learning, potentially offsetting the competitive tendencies. Moreover, greater public transparency and awareness of violations could empower citizens to hold regulators accountable and discourage under-enforcement.

Several limitations should be acknowledged. First, our findings on competitive dynamics are sensitive to how competitor states are defined. As effects appear only with BEA regions, and not with adjacency or Crone's definitions, our competition estimates should be read as conditional on regional economic integration. Second, states within the same BEA region may not all compete strongly with one another, while some competitive relationships may extend across regions. Third, our binary classification of competitor versus non-competitor states likely oversimplifies the complex interstate dynamics. These limitations may attenuate the observed competitive dynamics relative to a more precise characterization. Fourth, inspection counts, although useful, do not capture the intensity or duration of inspections and may overlook more subtle shifts in enforcement strategies. Finally, while we interpret increased inspections following sibling violations as evidence of regulatory learning, we acknowledge that alternative motivations, such as risk aversion, reputational shielding, or symbolic enforcement, may produce observationally similar patterns. Our data cannot disentangle these processes, but future research could pursue designs that better differentiate them. For instance, survey or interview evidence could illuminate whether regulators view sibling violations as technical warning signals (learning) or as reputational threats (shielding). Alternatively, researchers could examine whether enforcement responses vary systematically with the technical similarity of violations (suggesting knowledge-based learning) or with the political salience of violations (suggesting symbolic or reputational motives).

Conflicts of Interest

The authors declare no conflicts of interest.

Endnote

[1] The economic competition mechanism in policy diffusion literature shares conceptual similarities with our regulatory competition argument, as both involve states responding to economic pressures from competitor jurisdictions. However, they operate in different contexts with distinct outcomes. Policy diffusion's economic competition typically leads states to adopt similar policies to remain competitive, producing policy convergence. Our regulatory competition mechanism leads states to decrease enforcement stringency to attract mobile businesses, producing divergent regulatory treatment of a focal facility vs. its violating siblings rather than convergent policies. Given these different outcomes, we ground our theoretical framework for the regulatory competition argument primarily in the race to the bottom literature while acknowledging these conceptual connections to the broader diffusion scholarship.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** puar70063-sup-0001-Supinfo.docx.