# Monitoring and Compliance of the Toxics Release Inventory: Does EPA enforcement action change corporate reporting behavior?

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**Abstract**

Without the monitoring and enforcement activities by the Environmental Protection Agency (EPA), environmental laws are primarily non-binding. Toxic Release Inventory is one such policy that requires constant monitoring by the EPA to ensure that the firms comply. The self-reported nature of firms' toxic releases makes it crucial for the EPA to inspect and punish violations of misreporting or non-reporting regularly. This paper examines the impact of past regulatory actions by the EPA on firms' compliance behavior regarding the Toxic Release Inventory (TRI) reporting. Using a dataset spanning more than 30 years, our analysis reveals several key findings. Firstly, there exists a significant correlation between prior inspections and subsequent enforcement actions, with firms having a notable 93% likelihood of facing enforcement following a previous inspection. Additionally, we observe a nuanced relationship between enforcement history and inspection likelihood, suggesting potential resource prioritization by regulatory bodies. Furthermore, our study unveils a "neighborhood effect" in regulatory outcomes, wherein both Neighbor Inspection and Neighbor Enforcement significantly influence a firm's probability of facing enforcement actions. These findings provide valuable insights into the complexities of EPA monitoring and enforcement strategies and their implications for promoting compliance with environmental regulations within the TRI reporting framework.

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# 1 Introduction

The Union Carbide disaster in Bhopal, India, in 1984, and the incident in West Virginia in 1985 served as stark reminders of the potential catastrophic consequences of chemical emergencies. In Bhopal, a gas leak from a pesticide plant owned by Union Carbide resulted in thousands of deaths and injuries, while the West Virginia disaster involved a chemical leak from a storage tank, threatening local communities and ecosystems. These incidents underscored the need for better preparedness for chemical emergencies and increased transparency regarding the presence and handling of hazardous substances.

In response to these concerns, the U.S. Congress passed the Emergency Planning and Right to Know Act (EPCRA) in 1986. EPCRA aimed to address the lack of information available to the public about potentially harmful substances being used and stored in their communities. One of the key provisions of EPCRA was the creation of the Toxics Release Inventory (TRI). The TRI mandates that certain industries report their use, storage, and release of toxic chemicals to the environment.

The TRI serves as a valuable tool for both government agencies and the public. By requiring firms to disclose information about their use of toxic chemicals, the TRI enables state and local governments to better assess potential risks to public health and the environment. Armed with this information, authorities can develop emergency response plans and take proactive measures to protect communities from chemical hazards.

Moreover, the public availability of TRI data empowers citizens to hold companies accountable for their environmental practices. Transparency regarding toxic chemical use creates social pressure on firms to adopt more responsible manufacturing processes and reduce pollution. By incentivizing companies to minimize their environmental impact, the TRI contributes to the overall goal of promoting sustainability and safeguarding public health.

The implementation of the EPCRA and the creation of the Toxics Release Inventory (TRI) represent significant steps toward enhancing chemical safety and environmental protection. By requiring companies to disclose information about their use of toxic chemicals, the TRI enables better preparedness for emergencies, fosters community awareness, and encourages pollution reduction efforts through social pressure and accountability.

The Toxics Release Inventory (TRI) program, while instrumental in promoting transparency regarding the use and release of toxic chemicals, relies heavily on self-

reporting by companies. As such, ensuring the accuracy and reliability of the data requires robust monitoring and enforcement mechanisms. Without adequate oversight by the Environmental Protection Agency (EPA), compliance with TRI reporting requirements becomes non-binding, potentially undermining the program's effectiveness.

Given the significant reliance on TRI data for various economic and public health analyses, the accuracy of the information is paramount. However, several factors can impact the reliability of the reported data. For instance, firms may have incentives to manipulate reporting to present a more favorable image of their environmental performance. This could include overreporting pollution reduction efforts or underreporting actual chemical releases. Additionally, reporting thresholds set by the EPA may introduce biases, as companies may strategically adjust their processes to fall below these thresholds and avoid reporting requirements.

To address these challenges and ensure compliance with TRI regulations, the EPA employs a combination of monitoring, enforcement, and regulatory oversight measures. The agency regularly conducts inspections and audits of regulated facilities to verify the accuracy of reported data and assess compliance with TRI requirements. EPA inspectors, along with attorneys stationed in regional offices and headquarters, play a crucial role in enforcing TRI regulations.

In instances of non-compliance, the EPA has the authority to issue civil penalties, which may include monetary fines and corrective actions to address violations. These penalties serve as deterrents and incentivize companies to adhere to reporting obligations and maintain the integrity of TRI data. Moreover, the threat of enforcement actions helps reinforce the importance of accurate reporting among regulated entities.

Despite these efforts, ensuring the accuracy of TRI data remains an ongoing challenge. Continuous monitoring and oversight by the EPA are necessary to identify and address potential discrepancies or instances of non-compliance effectively. Additionally, stakeholders, including policymakers, researchers, and the public, play a crucial role in scrutinizing TRI data and holding companies accountable for their environmental responsibilities. By maintaining vigilance and strengthening enforcement measures, the EPA can enhance the reliability and usefulness of the TRI program in informing environmental policy and protecting public health.

This paper examines how EPA inspections influence the reporting behavior of firms under the TRI program. The repercussions of these inspections, particularly if they result in civil penalties, impact firms in two significant ways. Firstly, they

can act as a deterrent against dishonest reporting, thereby potentially reducing the rate of violations. Secondly, these inspections may also impact the actual quantity of chemicals released. Furthermore, given that EPA inspections and violations are publicized, the penalties may trigger spillover effects on neighboring facilities, both in terms of their geographic proximity and industry type. Awareness of penalties among nearby firms could prompt changes in their reporting practices regarding chemical releases. Understanding the deterrence effect of EPA inspections is crucial due to the widespread use of this information by various individuals and institutions, making it pertinent for policymaking.

Existing research on compliance behavior has primarily centered on legislation like the Clean Air Act (CAA), Clean Water Act (CWA), and Resource Conservation and Recovery Act (RCRA). However, there is a scarcity of studies examining the accuracy of information reported under the Toxics Release Inventory (TRI) program and the effectiveness of the Environmental Protection Agency (EPA) in maintaining data quality through its monitoring efforts. This empirical study aims to address this gap by investigating the compliance behavior of TRI reporting firms concerning both monetary and non-monetary sanctions. Specifically, the research poses the question: Do firms exhibit a greater or lesser tendency to misreport pollution data to the TRI database following an EPA inspection or enforcement action?

The structure of the paper is as follows: Section 2 offers a concise review of relevant literature. Section 3 outlines the data sources used in the study, along with their associated limitations. Section 4 elaborates on the empirical methodology employed. Section 5 presents the findings of the analysis. Finally, Section 6 concludes the paper.

## 2 Literature Review

The Toxics Release Inventory (TRI) dataset has been a valuable resource for economists examining the impact of pollution on various outcomes. Studies utilizing TRI information have investigated its effects on diverse areas such as housing prices (Banzhaf and Walsh, 2008), health risks (Currie et al., 2013), worker chemical exposure (Finger and Gamper-Rabindran, 2013), and firm behavior (Gibson, 2019). Moreover, the release of TRI information has been associated with significant reductions in pollution emissions, with some studies attributing decreases of up to 45% (**?**).

Several explanations have been proposed to account for the substantial decline in pollution emissions observed following the dissemination of TRI data. One explanation suggests that pressure from stakeholders such as the stock market and journalists played a role (Hamilton, 1995). Environmental advocacy groups and public awareness campaigns have also been credited with influencing firms to reduce their pollution emissions (Lynn and Kartez, 1994). Additionally, the anticipation of future regulatory actions may have incentivized firms to proactively decrease their environmental impact (Grant, 1997).

Despite its usefulness, the accuracy of TRI information remains a significant concern, primarily due to its self-reported nature. Firms are tasked with providing estimates of their pollution releases, as stipulated on the EPA website, which allows for a degree of subjectivity in reporting. De Marchi and Hamilton (2006) shed light on this issue by demonstrating that the substantial decreases in air emissions reported by firms do not align with corresponding reductions in measured concentrations recorded by EPA monitors (Marchi and Hamilton, 2006). This discrepancy raises questions about the reliability of the reported data and underscores the need for closer scrutiny of TRI information.

Further evidence of potential underreporting comes from Koehler and Spengler (2007), who uncover instances of aluminum facilities failing to fully disclose their toxic chemical releases (Koehler and Spengler, 2007). Similarly, Bennear (2008) examines the reporting thresholds set by TRI and reveals that firms may engage in strategic behavior to manipulate their reporting practices. Bennear's findings suggest that up to 40% of the observed reduction in toxic releases in Massachusetts can be attributed to firms' strategic decisions rather than genuine pollution abatement efforts (Bennear, 2008).

Addressing these inconsistencies in TRI data is crucial for ensuring that self-reported data, such as the TRI, remain valuable tools for both researchers and regu-

lators in efforts to reduce pollution levels. One approach taken by the Environmental Protection Agency (EPA) involves auditing select firms and imposing penalties on those found to be misreporting their data. Oestreich (2015) investigates the theoretical incentives for firms' emissions and self-reporting behavior under two different audit mechanisms: random audit and competitive audit. Oestreich's findings suggest that a competitive audit mechanism, where more audit resources are allocated to firms with lower reported emissions relative to their peers, leads to more truthful reporting (Oestreich, 2015).

The effectiveness of EPA monitoring in influencing the compliance behavior of firms has been extensively studied in the literature, with the majority of studies indicating a positive impact. Lui (2012) explores the compliance behavior of firms subject to multiple environmental regulations and finds evidence of negative cross-program effects, with compliance with the Resource Conservation and Recovery Act (RCRA) negatively affecting compliance with the Clean Air Act (CAA) (Liu, 2012). Similarly, Hanna and Oliva (2010) analyze plant-level data on inspections, fines, and emissions, revealing that plants, on average, reduce air emissions by fifteen percent following enforcement actions (Hanna and Oliva, 2010). Shimshack and Ward (2005) observe similar trends in compliance behavior under the Clean Water Act (CWA), with fines for water pollutant violations leading to a two-thirds reduction in statewide violation rates the following year (Shimshack and Ward, 2005).

However, when it comes to the Toxics Release Inventory (TRI) reporting, the question of how EPA monitoring influences compliance behavior remains less explored. Zou (2017) addresses a related question that examines the impact of intermittent monitoring of environmental standards on polluting activities. The paper suggests that under the federal Clean Air Act, there are strategic responses by local entities to the once-every-six-day air quality monitoring schedule. The study utilizes satellite data to demonstrate that air quality tends to be worse on unmonitored days, indicating short-term suppression of pollution on monitored days, particularly during high-pollution periods when non-compliance risk is elevated. Additionally, the paper suggests that cities increase their use of air quality warnings on monitored days, implying a role for local governments in coordinating emission reductions (Zou, 2021).

These studies collectively offer two key insights. Firstly, EPA monitoring and enforcement activities have proven effective in improving firms' compliance behavior with environmental regulations. However, secondly, firms may engage in strategic behavior to circumvent regulations, suggesting that continuous and vigilant monitor-

ing by the EPA may be necessary to ensure sustained compliance. Yet, the limited budget available for EPA inspections poses a challenge, potentially resulting in insufficient monitoring frequency. In such cases, firms may perceive limited consequences for non-compliance, undermining the effectiveness of regulatory enforcement efforts. Addressing this imbalance between monitoring capacity and regulatory compliance incentives is crucial for maintaining environmental standards and achieving desired pollution reduction outcomes.

Building on the insights from the literature review, the next section delves into the empirical analysis using available data to explore the relationship between EPA monitoring, firm compliance behavior, and the accuracy of TRI reporting.

## 3 Data

The compliance data in this study is from the Enforcement and Compliance History Online (ECHO) database. Spanning the years 1988 to 2018, the ECHO database has comprehensive information regarding each EPA inspection and enforcement action. Each entry in the database includes details such as the commencement and conclusion dates of the case, its outcome, and notably, a distinct identifier for each firm. This unique identifier enables the integration of the compliance data with information extracted from the TRI database. In conjunction with the ECHO data, yearly pollution statistics and firm location data spanning the same period are sourced from the TRI database. Table 1 provides a summary table for the total number of EPA inspection cases, enforcement cases, cases penalized, and the average penalty per case for all EPA programs and only for TRI. The average penalty per case assessed for TRI is less than one-third of all EPA programs.

| | Total | TRI |
|---|---|---|
| No. of Inspection cases | 188,437 | 3,241 |
| No. of Enforcement cases | 112,203 | 3,030 |
| No. of cases penalized | 25,763 | 1,458 |
| Average penalty per case assessed | $60,445 | $18,545 |

Table 1. Summary stats about inspection and enforcement cases.

An inherent limitation of relying on ECHO data is the potential underestimation of a firm's misbehavior, as it is contingent upon detection by the EPA. In other words, instances of firms misreporting TRI data may go unnoticed by regulatory authorities, thereby resulting in an incomplete picture of non-compliance. Consequently,

the proxy for misreporting derived from ECHO data may overstate the efficacy of EPA monitoring and enforcement activities in deterring firms from engaging in non-compliant behavior. This limitation underscores the need for a cautious interpretation of the results, recognizing the possibility of underestimating the true extent of misreporting.

Table 2 presents a detailed analysis of EPA enforcement and inspection cases categorized by industry sector, providing valuable insights into the enforcement landscape across various economic domains. Among the sectors, Fabricated Metals emerge as noteworthy, showcasing a particularly high enforcement-to-inspection ratio of 36.59%. This implies that out of the 1,260 inspections conducted within this sector, a substantial portion resulted in 461 enforcement cases, reflecting heightened scrutiny and regulatory action. Similarly, the Computers and Electronic Products industry exhibits a significant enforcement ratio of 35.03%, indicating robust regulatory oversight and enforcement efforts. Conversely, sectors such as Hazardous Waste, Petroleum Bulk Terminals, and Other industries report lower enforcement ratios, ranging between 1.57% and 2.23%, suggesting comparatively fewer instances of regulatory non-compliance or stricter adherence to environmental standards. Additionally, the Chemicals sector, with 3,779 inspections and 364 enforcement cases, demonstrates a ratio of 9.63%, underscoring the nuanced regulatory landscape within this industry. These findings shed light on the varying degrees of regulatory enforcement and compliance challenges across different industrial sectors, thereby informing policy decisions and resource allocations aimed at enhancing environmental protection and enforcement effectiveness.

| Industry Sector | Inspection | Enforcement | Enforcement Ratio |
|---|---|---|---|
| Chemicals | 3,779 | 364 | 9.63 % |
| Fabricated Metals | 1,260 | 461 | 36.59 % |
| Primary Metals | 1,111 | 237 | 21.33 % |
| Food | 916 | 132 | 14.41 % |
| Petroleum | 797 | 69 | 8.66 % |
| Other | 752 | 12 | 1.60 % |
| Transportation Equipment | 666 | 136 | 20.42 % |
| Electric Utilities | 630 | 13 | 2.06 % |
| Hazardous Waste | 583 | 13 | 2.23 % |
| Petroleum Bulk Terminals | 574 | 9 | 1.57 % |
| Plastics and Rubber | 503 | 130 | 25.84 % |
| Computers and Electronic Products | 431 | 151 | 35.03 % |
| Chemical Wholesalers | 429 | 25 | 5.83 % |
| Nonmetallic Mineral Product | 427 | 70 | 16.39 % |
| Machinery | 330 | 93 | 28.18 % |
| Paper | 320 | 36 | 11.25 % |
| Wood Products | 282 | 36 | 12.77 % |
| Electrical Equipment | 249 | 68 | 27.31 % |
| Miscellaneous Manufacturing | 182 | 50 | 27.47 % |
| Printing | 88 | 31 | 35.23 % |

Table 2. EPA Enforcement and Inspection Cases by Industry Sector

## 4 Benford's Law

To examine potential changes in reported numbers before and after an inspection or enforcement action, I employ Benford's law as a diagnostic tool. Benford's Law, also known as the "first-digit law" or the "law of anomalous numbers," is a statistical phenomenon that describes the frequency distribution of leading digits in many naturally occurring datasets. The law states that in many sets of numerical data, the leading digit (i.e., the first digit in a number) is more likely to be small, such as 1, 2, or 3, rather than large digits like 8 or 9. This counter-intuitive phenomenon has been observed in diverse datasets, including financial records, population statistics, scientific data, and even physical constants (Nigrini, 1996; Fewster, 2009; Hill, 1995). The results of this analysis offer insights into whether firms engage in misreporting behavior.

Figure **??** and Figure **??** present the outcomes of applying Benford's law to firms subjected to inspection or enforcement actions. Comparing the distribution of first

digits in reported numbers one year before and after an inspection reveals no substantial changes, suggesting limited evidence of manipulation in reporting behavior by the firms. One interesting result is that we see an increased use of the digit 5 for before and after inspection.

Figure 1. Application of Benford's law for inspection cases

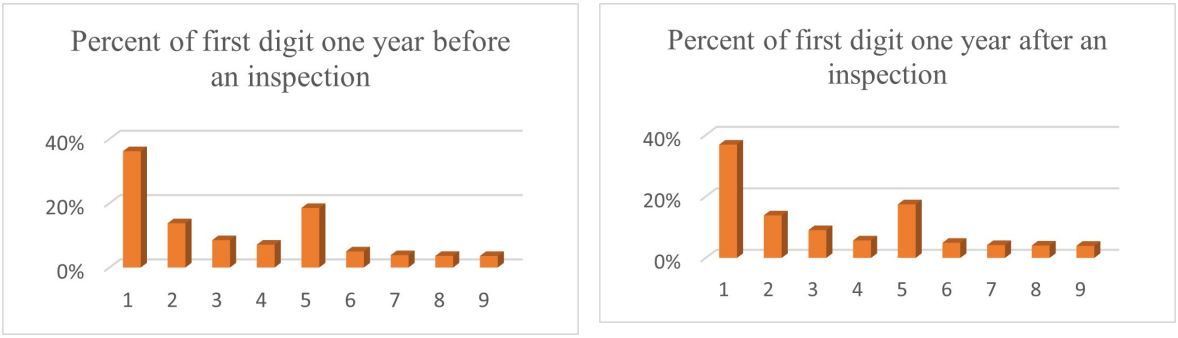
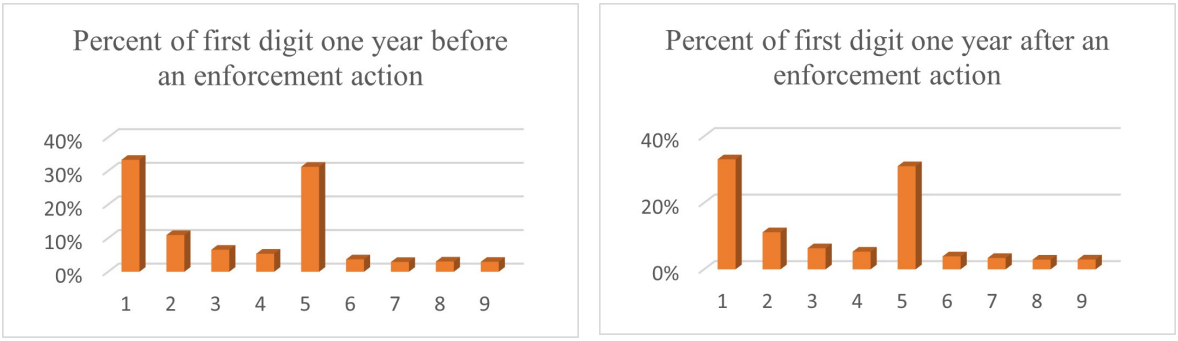



Figure 2. Application of Benford's law for enforcement actions



## 5 Methodology

To analyze how past EPA inspections and enforcement actions influence a firm's future compliance behavior, I employ a Probit model to explain the probability change of compliance and inspection. In the following equation, $Enforcement_{i,t}$ and $Inspection_{i,t}$ is the outcome variable, which equals 1 if the firm is inspected (enforcement action) at time t. $X_{i,t-1}$ is the set of explanatory variables such as industry sector, neighbor inspection history, neighbor compliance history, and individual compliance history in the previous period. $u_i$ and $v_t$ are the zip code fixed effect and year fixed effect and $\epsilon_{i,t}$ is the error term.

$$\begin{aligned} Pr(Enforcement_{i,t}) = 1|X_{i,t-1}) &= \phi(\alpha +_{i,t-1} + u_i + v_t + \epsilon_{i,t}) \\ &= \phi(\alpha + \beta_1 Enforcement_{t-1} + \beta_2 Inspection_{t-1} + \beta_3 Neighbor\ Inspection_{t-1} \\ &\qquad + \beta_4 Neighbor\ Enforcement_{t-1} + u_i + v_t + \epsilon_{i,t} \end{aligned}$$

If the enforcement and inspection actions of the EPA are effective, they should deter firms from making the same mistakes in subsequent periods, which is explained by $\beta_1$ and $\beta_2$ values. Furthermore, the action can also affect nearby firms as the EPA makes enforcement and inspection information public through its website. Neighbor Inspection and Neighbor Enforcement are calculated as the fraction of Inspection/Enforcement cases (not including the firm itself) out of the total TRI reporting in the same zip code in the previous year. I hypothesize that $Enforcement_{i,t}$, and $Inspection_{i,t}$ variables should have negative impacts on the probability that a firm faces an enforcement action or an inspection. Prior EPA inspection or enforcement should decrease the likelihood that the firm misreports. The following section presents the results of the two Probit regressions.

## 6 Results

Table 3 presents the marginal effects for Enforcement and Inspection, shedding light on the interplay between past regulatory actions and their impact on current outcomes. The findings indicate a strong relationship between prior inspection and subsequent enforcement for a firm. Specifically, there is a notable 93% likelihood that a firm will face enforcement activity following a prior inspection. This high probability can be attributed to the time lag between inspection and the regulatory body's assessment of any misreporting, which may lead to enforcement actions in the current

period as a result of findings from the previous inspection.

Conversely, if a firm has undergone enforcement action in the previous period, it becomes less likely to face an inspection in the current year, although this effect is not statistically significant. This suggests a potential prioritization by regulatory bodies to allocate inspection resources to firms without recent enforcement history. Additionally, prior inspection significantly increases the likelihood of the firm being inspected in the current period, with a probability of 43.7%. However, enforcement actions in the prior period resulted in a decreased likelihood of inspection in the current year, indicating a potential focus shift towards firms with no recent enforcement activity.

| Variables | Enforcement | Inspection |
|---|---|---|
| $Enforcement_{t-1}$ | -0.026 | -0.025 |
| | (0.115) | (0.068) |
| $Inspection_{t-1}$ | 0.931*** | 0.437*** |
| | (0.027) | (0.015) |
| $Neighbor\ Inspection_{t-1}$ | 0.034 | 0.628*** |
| | (0.125) | (0.045) |
| $Neighbor\ Enforcement_{t-1}$ | 0.730*** | -0.355* |
| | (0.277) | (0.201) |
| Year Fixed Effects | Yes | Yes |
| Industry Fixed Effects | Yes | Yes |
| Zip Code Fixed Effects | Yes | Yes |
| Observations | 646,056 | 536,271 |

Note: Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Probit results for Enforcement and Inspection

Moreover, the analysis highlights the neighborhood effect of regulatory actions, wherein both Neighbor Inspection and Neighbor Enforcement in the last period amplify a firm's probability of facing an enforcement action. Specifically, if a neighboring firm undergoes enforcement, there is a substantial 35.5% likelihood that the focal firm will be inspected. Similarly, Neighbor Inspection significantly increases the likelihood of a firm undergoing inspection, with a probability of 63.8%. Furthermore, Neighbor Enforcement also influences the probability of a firm facing enforcement, to a greater extent, with a probability of 93.1%. These findings underscore the interconnectedness of regulatory outcomes within neighboring firms and their implications for enforcement activities.

# 7 Conclusion

The findings from this study suggest that EPA inspections and enforcement actions may not necessarily lead to improved compliance behavior regarding TRI reporting among firms. While prior enforcement actions may decrease the probability of subsequent enforcement from the EPA, firms with a history of inspection are more likely to undergo further inspection, indicating a complex relationship between regulatory actions and compliance outcomes.

A notable observation is the potential strategic behavior by the EPA in allocating inspection resources and learning from past monitoring efforts. The significant likelihood of a firm facing enforcement following a prior inspection suggests targeted enforcement efforts, possibly aimed at addressing recurring offenders. This challenges the assumption of random inspections and raises concerns about the potential bias.

Moreover, the disparities in penalties for TRI violations compared to other environmental regulations raise questions about the effectiveness of enforcement mechanisms and the perceived importance of TRI compliance within the EPA's enforcement priorities. The relatively lower penalties for TRI violations, coupled with potential concerns about community health impacts from other environmental violations, may influence the EPA's enforcement strategies and resource allocation.

In conclusion, while EPA inspections and enforcement actions play a crucial role in environmental regulation, the findings suggest a need for further examination of regulatory practices and their implications for compliance behavior. Addressing issues such as strategic enforcement, resource allocation, and penalty adequacy is essential for enhancing the effectiveness of environmental regulations and promoting sustainable compliance practices among firms reporting TRI data.

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