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Spillovers and State Politics: Explaining Variation in U.S. Water Quality Permit Stringency

Neal D. Woods

Department of Political Science, University of South Carolina, Columbia, SC 29208, USA; neal.woods@sc.edu; Tel.: +1-803-777-7389

Abstract: Why do environmental regulators allow some facilities to discharge more water pollution than similar facilities in other locations? Drawing on general theories of regulatory decisionmaking, this study assesses four possible reasons: (1) variation in governments' ability to export pollution to other political jurisdictions, (2) variation in the demographic composition of the neighborhood surrounding the facility, (3) variation in local communities' ability to mobilize for effective collective action, and (4) variation in subnational political context. Analyses of effluent discharge limits imposed by the U.S. states on two common classes of water pollution indicate that state regulators allow greater discharges when the receiving river crosses state lines, and that they are responsive to a variety of other demographic and political factors. The specific factors, however, often vary across the two pollutants assessed. These results suggest that subnational political considerations may shape the conditions imposed in water pollution permits, and, ultimately, water quality outcomes.

Keywords: water quality; point-source water pollution; Clean Water Act; free riding; environmental justice; U.S. state environmental policy

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1. Introduction

Few regulatory decisions impact water quality outcomes, including water contamination and its impact on public health, aquatic life, and ecosystems, as directly as how much pollution to allow a facility to discharge into a waterway. In U.S. clean water regulation, these discharge limits are set by regulators who possess a significant amount of discretion [1], and the limits themselves have been shown to vary substantially for the same pollutant across similar facilities [2,3]. Understanding the sources of this variation thus has important implications for efforts to improve surface water quality in the U.S.

Yet although other aspects of U.S. clean water policy, such as funding for wastewater treatment and drinking water infrastructure [4–8], and regulatory compliance monitoring and enforcement [9–13], have generated substantial empirical literatures, the discharge limits imposed in water quality permits have to date received scant scholarly attention. Moreover, existing studies that do assess variation in these limits largely restrict themselves to examining state-level political factors [2]. However, the broader literature on regulation suggests that, in addition to these state-level considerations, a number of local level influences may affect the restrictiveness of water quality permits, including (1) local demographic factors, (2) local level capacity to engage in political action, and (3) whether the receiving waterbody will transport the pollution out of state.

This study assesses these potential explanations in the context of state implementation of the U.S. Clean Water Act (CWA). It examines the discharge limits imposed in

facility permits for two widespread and important classes of pollution. Using Geographical Information Systems (GIS) to precisely locate facilities and isolate characteristics of the surrounding communities and receiving waterbodies, it finds that (1) facilities that discharge their effluent into rivers where the pollution is likely to flow out of state systematically have more permissive permits, (2) local demographic characteristics also impact permit stringency, though their influence is less consistent across pollutants, and (3) permit stringency is related to a variety of characteristics of the state political environment, including government ideology and environmental interest group strength. In sum, these findings point to the need for a greater understanding of the role that subnational political factors play in determining the amount of pollution that facilities are allowed to discharge into U.S. waterways.

2. Water Quality Regulation in the United States

The primary law governing water quality protection in the United States is the CWA of 1972. Originating as an amendment to the 1948 Federal Water Pollution Control Act, it empowers the U.S. Environmental Protection Agency (EPA) to limit the discharge of pollutants into navigable waterways from point sources, including both industrial facilities and publicly owned treatment facilities. These facilities must obtain a legally binding National Pollutant Discharge Elimination System (NPDES) permit that specifies the frequency, quantity, and location of allowable discharges into waterbodies. The permit also establishes a set of reporting requirements, which are designed to help monitor compliance with permit obligations.

The discharge limits contained in NPDES permits are based on federal standards for the best available technology (BAT) for pollution abatement applicable to the specific industrial process involved, though stricter limits may be mandated if the abatement technology would not assure sufficient water quality [9,14]. The process of translating the general technological standard to emissions limits for a particular point source gives regulators substantial discretion [1]. Consequently, these limits are often the product of negotiations between polluting firms and government officials [9], and have been shown to vary substantially for the same pollutant across similar facilities [2]. Generally speaking, these discharge limits are the primary factor determining the overall stringency of a permit. Other factors that could impact permit stringency in some circumstances include monitoring requirements and special conditions [2].

As with many other U.S. environmental protection laws, the CWA is implemented through a system of partial preemption that allows state governments to assume authority to implement key portions of the act, including the NPDES permit program [15,16]. State environmental agencies may assume this authority by demonstrating to the EPA that they have a program that is at least as stringent as that required by applicable federal law, and that they have sufficient capacity to run the program. If states do not seek primary implementation authority, or primacy, for a program, the EPA runs it through one of its ten regional offices. By now, almost all states have received primacy for the NPDES program, which means that NPDES permits are generally being written by regulators in various state agencies [1]. One consequence of this dispersion of regulatory authority appears to be significant heterogeneity in permitted discharge limits; a study by the U.S. General Accounting Office, for instance, found that the allowable pollution for similarly sized facilities emitting the same pollutant could vary by more than an order of magnitude across states [3].

3. Explanations for Variation in Regulatory Policy Implementation

From the social science literature on regulatory policy implementation, one can draw four broad classes of potential explanations for geographic variation in environmental regulatory stringency, which may then be employed to explain variation in permitted effluent discharge limits.

The first set of explanations revolves around incentives to free-ride on the pollution control efforts of downstream states. State regulators, this argument suggests, may be less concerned with pollution that predominantly impacts other states. In such situations, they may regulate pollutants less stringently, thereby creating pollution spillover effects [17–21]. Thus, the expectation is that facilities located where the environmental consequences of their pollution are more likely to be felt by out-of-state residents should have less stringent permits.

The second set of explanations has to do with local demographic conditions. This argument suggests that the size and composition of the local affected population should affect permit stringency. In particular, a large empirical literature on environmental justice investigates the possibility that areas with lower income populations or a higher percentage of racial minority residents may receive lower levels of environmental regulatory protection [10,22–24]. The results of such studies have been mixed, but in general, recent studies have suggested that there are meaningful disparities in environmental regulation across race and income levels. The expectation is, therefore, that facilities located near lower-income and minority populations will receive more lenient permits.

A third, related set of explanations pertains to local political capacity. The literature on Not in My Backyard (NIMBY) politics suggests that facilities in areas that have greater capacity to overcome barriers to collective action and organize to pursue common interests may receive higher levels of environmental protection. Political capacity may be derived from greater education, homeownership, and residential stability [25–27]. This argument leads to the expectation that facilities located in areas with stronger political capacity should have more stringent permits.

The final set of explanations pertains to state politics. A long stream of literature suggests that state regulators are responsive to political pressures [2,9,28–33]. Thus, the expectation is that environmental agencies in states with more pro-environment mass publics and elected officials and a more active organized environmental movement may face stronger pressure to write permits with more stringent effluent discharge limits, all else equal, than those in states in which these pressures are weaker.

4. Materials and Methods

4.1. Dependent Variables: Permitted Effluent Discharge Limits

The research question motivating this study is as follows: Why do environmental regulators allow some facilities to discharge more water pollution than similar facilities in other locations? To address this question, this study assesses the above theoretical expectations as applied to NPDES permit conditions for point sources of water pollution regulated under the federal CWA. Specifically, it focuses on sources the EPA designates as being "major" facilities. These consist of those private industrial dischargers and publicly owned facilities that are the largest water-polluting facilities in the country, and are utilized here because they are the primary producers of effluent discharges. For the time period covered by the study, there were about 6400 active major facilities in the United States.

The permit conditions examined in these analyses set limits governing the allowable discharge of two major sources of water pollution: biochemical oxygen demand (BOD) and total suspended solids (TSS). BOD is an indicator of the amount of organic pollution, as represented by the amount of dissolved oxygen needed by microorganisms to

break down organic matter in water. TSS is a measure of the concentration of particles in water, both organic and inorganic, exceeding 2 microns in size. For the purposes of this study, these have the advantage of being traditional pollution parameters that are fairly commonly discharged by NPDES facilities, and which have relatively easily interpretable standards [2,34].

For wastewater treatment facilities, national technology-based standards have been set by the EPA for both BOD and TSS at a monthly average of 30 milligrams per liter (mg/L) per source. Nonetheless, as discussed above, state regulators have substantial discretion in applying these standards to individual plants due to differences in the water quality of the receiving waterbody and other factors, and observed standards for wastewater treatment facilities vary significantly [2]. For other types of facilities, the limits for both BOD and TSS may also vary across industries. In the analyses reported below, the dependent variable is the discharge limit imposed on BOD or TSS in the facility's NPDES permit. These data come from the EPA's Envirofacts database.

These facility-specific permit data are then merged with a separate dataset created by Konisky and Woods [11], which contains a rich set of facility-level information regarding facility size, type, and location, as well as the surrounding area's demographic conditions, the facility's free riding potential, and state-level political factors. This dataset was created using detailed location information provided by the EPA's Geospatial Data Access Project to precisely locate each major NPDES permit holder in geographic space, which the authors then overlayed with a map of U.S. Census tracts using Geographic Information Systems (GIS). These GIS data were used in three ways: (1) to develop measures related to the opportunity to free ride on the pollution control efforts of other state governments, (2) to extract a set of demographic information regarding potentially affected local populations, and (3) to create indicators of local political capacity. These data were combined with both facility-level characteristics and a variety of state-level political variables to form the Konisky and Woods [11] dataset.

4.2. Independent Variables: Free-Riding Potential

The potential of a state to free ride by exporting its water pollution to other states depends on the features of the environmental resource receiving the pollution from the NPDES facilities. The analyses include the two types of resources included in the Konisky and Woods [11] dataset: rivers and watersheds. For rivers, information on the receiving stream of each NPDES facility's pollution discharges was obtained from the EPA's Permit Compliance System database, and GIS software was used to determine whether the receiving stream was fully intrastate or whether it crossed two or more states. Cases in which a river composed the border between two or more states, such as the Missouri River and the Ohio River, were coded as interstate (rather than intrastate) resources.

For watersheds, the receiving watershed was classified using the unique hydrologic unit code (HUC) assigned by the U.S. Geological Survey (USGS). The analysis uses 8-digit HUC codes, which are the smallest level of hydrologic units known as cataloging units, which are the geographic area representing part or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature. As with rivers, a GIS intersection utility was utilized to identify whether these watersheds crossed two or more states.

4.3. Independent Variables: Local Demographic Composition

One important set of facility-level attributes relates to the demographic composition of the neighborhood surrounding the facility, which has been shown to impact regulatory inspection and enforcement behavior [10,13,17,23,35–37]. The analysis includes several

attributes of the local population, including population density and the percentage of the population living around facilities that are poor, African-American, and Hispanic. In each case, Konisky and Woods [11] measured the composition of the population living around CWA facilities using an areal apportionment method [38,39]. The scope of the potentially affected local populations was delimited by a concentric circular buffer around each facility with a radius of 1 mile, which was intersected with spatial data from the census maps. These intersections were used as weights for each demographic attribute, where the weight was the proportion of each census unit contained within the circular buffers.

4.4. Independent Variables: Local Political Capacity

A second set of facility-level factors pertains to the political capacity of the local population. Communities with high levels of political capacity are more likely to be able to overcome organizational constraints and collective action problems in order to effectively advocate for stronger environmental regulation [25–27,40]. The analyses, therefore, include three common indicators of political capacity created using the same areal apportionment method discussed above: the percentage of the population with a college education, the percentage of owner-occupied housing, and residential stability, as defined below.

4.5. Independent Variables: State Political Factors

In addition to local factors, a variety of state political conditions may be expected to impact the stringency of NPDES permits. In this respect, it is reasonable to assume that permit stringency is driven by the same political and economic factors that have been shown to influence regulatory monitoring and enforcement behavior [9,13,28,32,33,41]. Accordingly, the analyses include measures of citizen and government ideology developed by Berry et al. [42], and the average League of Conservation Voters' scores of the state's House delegation as an indicator of congressional ideology. Higher values on these measures indicate greater liberalism. The analyses also include state spending on water quality as an indicator of state commitment to environmental protection in this area. In order to reflect the state's interest group environment, the analyses include a measure of the number of environmental interest groups registered to lobby in the state [43].

Regulatory stringency may also be a function of state economic conditions, with poorer economic conditions putting greater political pressure on environmental agencies to loosen regulatory standards. Unemployment rate, in particular, has been found to influence government regulatory behavior [44], and the analysis includes the state unemployment rate as a covariate.

4.6. Independent Variables: Facility Level Controls

The analyses also include a variety of other facility-level characteristics as control variables. To control for the amount of pollution emitted by the facility, the analyses incorporate a variable capturing the facility's flow capacity, which some studies have shown to be correlated with regulatory decisions [35,36]. The analyses also include a variable indicating whether the facility is publicly or privately owned. Prior research suggests that publicly owned facilities are more lightly regulated than privately owned ones [45]. Finally, a set of dummy variables for 2-digit Standard Industrial Classification (SIC) codes is included to control for the type of industry the facility is in. These variables capture the fact that there is substantial variation in the amount and type of pollution discharged by facilities in different industrial sectors.

4.7. Dataset Construction

To ensure temporal comparability, permit conditions for BOD and TSS were measured as of 2005, which is the last year covered by the Konisky and Woods [11] dataset. That

dataset contains complete data for 5129 major NPDES facilities nationwide. Of these, data could be matched with permit data from the EPA Envirofacts dataset that contains BOD discharge limits for 1382 facilities and TSS discharge limits for 2905 facilities.

Although the permit conditions were measured as of 2005, they may have been established earlier. NPDES permits are effective for a period not exceeding five years, and the CWA stipulates that they must be renewed prior to expiration in order to continue to allow pollutant discharges. Despite this requirement, some states have allowed facilities to continue to operate for some period of time on expired permits [2]. When permit holders apply for renewal, all permit conditions are reviewed, and data collected under the previous permit are used to determine new conditions. Existing permit conditions for a given facility have thus generally been established within the prior five years (though it may at times be longer if it is operating on an expired permit). In recognition of this, each of the independent variables in the dataset represents averages over the five-year period between 2001 and 2005, inclusive. For residential stability, the variable represents the percentage of the local population that has lived in the same residence since 1995. Since these variables are slowly changing, choosing an individual year during this period, or even a year shortly before the period, would generally lead to comparable results.

The dataset is limited to states that have been delegated authority to implement the federal CWA, since the logic underlying many of the expected relationships pertains to state governments. By 2005, all but four states had been delegated authority by the U.S. EPA to write NPDES permits. In the remaining states (Idaho, Massachusetts, New Hampshire, and New Mexico), the relevant EPA regional office retained this authority.

The descriptive statistics for the variables in each model are presented in Table 1. Worth particular attention are the statistics for BOD and TSS discharge limits contained in NPDES permits. The mean of each is close to the general baseline EPA standard for wastewater treatment plants of 30 mg/L (26.2 for BOD and 29.6 for TSS). There is substantial variation, however, with standard deviations of 14.32 and 17.81, respectively. The most stringent permitted discharge limits in the dataset are around 1 mg/L for each, while the most permissive are several hundred mg/L. These differences are related in part to differences in technologies and production processes across differing industrial sectors, which are controlled for, to the extent possible, via SIC code dummies in the analyses to follow. These analyses assess the extent to which the remaining variation can be explained by the four sets of explanatory variables discussed above.

Table 1. Descriptive statistics.

Variable	Mean	SD	Min.	Max.
BOD	26.20	14.32	1.2	344.33
TSS	29.59	17.81	1	473
Interstate river	0.27	0.45	0	1
Interstate watershed	0.39	0.49	0	1
Pop. density	1.11	2.38	0	73.55
% Black	10.60	16.31	0	97.45
% Hispanic	7.73	13.99	0	98.11
% Poverty	12.63	8.32	0	60.87
% Owner-occupied	64.43	14.27	0	96.34
% College-educated	19.31	12.15	0	80.92
% Same residence	56.57	12.22	0	100
Govt ideology	47.89	18.50	8.15	85.12
Citizen ideology	49.94	10.56	26.59	87.24
Cong. ideology	42.49	17.95	5.23	95.43
Water quality spending	42.15	56.89	2.11	260.74

Table 1. *Cont.*

Variable	Mean	SD	Min.	Max.
Env. interest groups	17.68	12.38	2	46
Unemployment rate	5.42	0.69	3.44	7.12
Public facility	0.76	0.43	0	1
Flow capacity	38.70	181.57	0	3325

5. Results

The empirical models are estimated via ordinary least squares (OLS) regression, with state-clustered standard errors. Clustering the standard errors at the state level allows for potential correlation in errors across facilities within each state, which, if not accounted for, may lead to a violation of the standard OLS assumption of independently and identically distributed (i.i.d) errors [46]. This modeling approach is appropriate for these analyses because the discharge limits for the facilities in this dataset are set by state environmental agencies, suggesting that dependence across facility observations is likely to be caused by state-level factors. Clustering the standard errors has been argued to be a more straightforward and practical approach for dealing with correlated errors in many state policy contexts than an alternative approach, hierarchical linear modeling, which makes heavier demands on theory and data [46].

The results are presented in Table 2. The results in the first column indicate that facilities that discharge effluent into rivers that ultimately cross state lines receive systematically higher BOD discharge limits. All else constant, these facilities have permits that allow about 2.9 mg/L greater BOD discharges than those whose effluent remains within the state's boundaries. This finding provides support for the free-riding explanation for permit stringency.

Table 2. The determinants of NPDES permit stringency across two pollution parameters.

Variable	BOD	BOD	TSS	TSS
Interstate river	2.873 ** (1.183)		2.602 ** (1.277)	
Interstate watershed		0.302 (1.286)		−0.855 (0.591)
Pop. density	0.433 (0.346)	0.573 (0.381)	−0.507 * (0.272)	−0.401 (0.274)
% Black	−0.043 (0.040)	−0.048 (0.041)	−0.011 (0.042)	−0.013 (0.042)
% Hispanic	−0.060 (0.035)	−0.057 (0.037)	−0.039 (0.070)	0.035 (0.072)
% Poverty	0.138 ** (0.065)	0.131 ** (0.062)	0.140 (0.089)	0.140 (0.089)
% Owner−occupied	−0.030 (0.026)	−0.034 (0.026)	−0.059 (0.039)	−0.061 (0.040)
% College-educated	−0.029 (0.030)	−0.037 (0.032)	−0.019 (0.039)	0.008 (0.037)
% Same residence	0.067 * (0.034)	0.073 * (0.034)	0.091 ** (0.042)	0.096 ** (0.042)

Table 2. *Cont.*

Variable	BOD	BOD	TSS	TSS
Govt ideology	−0.149 ** (0.042)	−0.143 ** (0.045)	−0.068 (0.052)	−0.061 (0.049)
Citizen ideology	0.239 (0.148)	0.248 (0.154)	−0.253 (0.267)	−0.251 (0.265)
Cong. ideology	−0.050 (0.091)	−0.038 (0.096)	0.143 (0.164)	0.140 (0.161)
Water quality spending	0.007 (0.012)	0.006 (0.012)	0.041 ** (0.014)	0.038 ** (0.014)
Env. interest groups	−0.036 (0.072)	−0.016 (0.077)	−0.336 ** (0.073)	−0.334 ** (0.070)
Unemployment rate	−0.575 (1.209)	−0.671 (1.194)	−0.495 (1.074)	−0.687 (1.064)
Public facility	−3.392 ** (1.533)	−4.152 ** (1.456)	1.306 (1.193)	0.861 (1.159)
Flow capacity	−0.000 (0.001)	−0.000 (0.001)	−0.000 (0.001)	−0.001 (0.001)
Constant	12.177 (8.67)	12.936 (8.802)	35.93 ** (8.14)	37.94 ** (7.88)
R^2	0.12	0.11	0.11	0.11
N	1382	1382	2905	2905

Notes: OLS coefficient estimates, with state-clustered standard errors in parentheses. For purposes of clarity, coefficient estimates for SIC code fixed effects are not presented. * $p < 0.1$, ** $p < 0.05$, two-tailed test.

In addition, facilities that are located in poorer communities have less stringent permits, raising questions of environmental justice. Each additional ten percent of the local population that is in poverty is associated with an increase of about 1.4 mg/L in the allowable BOD discharge. States with more liberal state governments, in contrast, have significantly more stringent permits, suggesting that state politics may play an important role in the stringency levels of NPDES permits. Each ten-point increase in government liberalism (on a 100-point scale) is associated with a 1.5 mg/L increase in the discharge limit. Residential stability is associated with higher allowable discharges, all else constant, with a ten percent increase in the percentage of the local population living in the same residence since 1995, leading to about a 0.7 mg/L higher discharge limit. This effect is directionally opposite to expectations, though the magnitude of the effect is not as large as that of other variables in the model. Finally, public facilities have significantly lower limits, with a strong substantive effect of nearly 3.4 mg/L. As with residential stability, the direction of this effect is the opposite of expectations.

The second model uses interstate watersheds as an alternative measure of free-riding potential. This measure does not have a significant effect. The other significant variables, however, mirror those in the first model, with similar substantive effects.

The third model shifts its attention to the TSS discharge limits imposed in water quality permits. Again, the results provide evidence for environmental free riding in permit stringency, with allowable discharges into rivers that cross state lines being about 2.6 mg/L higher, ceteris paribus.

As with the BOD findings, greater residential stability is associated with higher TSS discharge limits, all else constant, which is the opposite of expectations. The other significant variables in this model depart from those of the BOD models, however. The results

indicate that allowable discharges into areas with a denser population are lower, with each 100-person increase in population per square mile leading to a reduction about a 0.51 mg/L reduction in effluent discharge limits, suggesting that regulators may take the size of the potentially affected population into account in setting these limits. States with greater water quality expenditures also tend to have higher allowable discharges, with each USD 10,000 of additional expenditures per facility being associated with 0.04 mg/L higher allowable discharges. Causality is a bit difficult to disentangle here: although water quality spending was hypothesized to be an indicator of state commitment to water quality protection (and thus be negatively associated with allowable pollution discharges in state permits) it may also be the case that greater effluent discharges lead to greater state expenditures on water quality, due to a more substantial surface water pollution problem. Future research may examine this relationship temporally to assess whether water pollution spending is causally prior to changes in pollution levels, or vice versa. Finally, greater numbers of environmental interest groups are associated with more stringent permits, as expected, with each additional interest group being associated with a 0.33 mg/L decrease in allowable discharges.

The final model assesses TSS permits using the interstate watershed measure of free riding potential. As with the second BOD model, this alternative measure is not significant, and the other significant independent variables are unchanged from the previous model.

6. Conclusions

The stringency of NPDES permits has significant implications for water quality outcomes [47]. Among the four classes of explanations for variation in permit stringency examined here, the empirical results provide the broadest support for the effect of free riding potential. Both BOD and TSS permits are systematically more lenient if the recipient river ultimately flows across state lines. This suggests that state regulators may use their permitting authority as a mechanism to export their pollution, capturing the economic benefits of industrial production in their own state while forcing downriver states to absorb at least some of the environmental costs. Such spillover effects, however, are not found for interstate watersheds.

Several aspects of the state political environment also appear to impact discharge limits, though the specific variables that were significant in the analyses varied across the two classes of pollution studied. More liberal state governments (for BOD) and more organized environmental interest groups (for TSS) were found to lead to more restrictive permits, findings that were consistent with expectations. In addition, greater water quality spending was associated with more lenient permits for TSS, a finding that is less easily interpretable and deserves further investigation.

Some variables representing local demographic characteristics were likewise found to be significantly associated with permit stringency, although many were not statistically significant, and the significant variables were not consistent across the two pollution parameters. One finding that stands out for BOD, in particular, is that of higher allowable pollution discharges in higher poverty areas, which may reinforce the concerns of environmental justice advocates, and provide support for policy reforms that explicitly target environmental justice considerations, such as government monitoring and permit audits.

The only class of explanations studied that received no support in these findings was that of local political capacity. Factors related to the ability of communities to mobilize politically were either not significant predictors of permit stringency, or, in the case of residential stability, consistently significant in a direction opposite to what theory would predict. This is consistent with the mixed results these variables have produced in other analyses of government regulatory activity [10,11], though it should be noted that some of

the reasons for the lack of support in these analyses may simply have to do with variable classification. Specifically, percent poverty, though treated here as an environmental justice variable (as is typical in the literature), could also be considered an indicator of (lack of) political capacity, and it is a significant predictor of permit stringency for BOD.

On the whole, these findings provide suggestive evidence that a variety of political considerations may be at play when regulators make decisions about allowable discharges in water quality permits. These conclusions are tempered, though, but the fact that much of the variation in these permits remains unexplained in these empirical models. Moreover, although some consistent findings emerged, many of the significant findings varied across the two pollution parameters examined. This suggests that the role of political factors may vary across pollutants, and other factors that are specific to particular pollutants may play a large role in the permitting process.

Ultimately, therefore, this study merely represents a first step in assessing the factors that lead to variation in discharge limits. Future research may expand upon this work by assessing permit conditions imposed for other types of pollutants, evaluating the temporal stability of these findings across time, and seeking to develop datasets that contain a richer set of facility level control variables that allow for greater understanding of the role that differences in production processes play in determining permit conditions. Such research could also extend this inquiry cross-nationally, investigating the role that the factors assessed here play in determining allowable pollution levels in different legal and institutional settings. Further work on this issue holds the promise of leading to significantly greater understanding of what causes differences in permit stringency, and, ultimately, water quality.

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Abbreviations

The following abbreviations are used in this manuscript:

BAT	Best Available Technology
BOD	Biochemical Oxygen Demand
CWA	Clean Water Act
EPA	Environmental Protection Agency
HUC	Hydrologic Unit Code
NPDES	National Pollution Discharge Elimination System
TSS	Total Suspended Solids
USGS	United States Geological Survey

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