Does the modernization of environmental enforcement reduce toxic releases? An examination of self-policing, criminal prosecutions and toxic releases in the United States, 1988–2014

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Abstract

According to modernization theory, enforcement schemes that rely on end of the pipe regulation are not as effective at achieving improved environmental performance as market-based approaches that encourage pollution prevention. Consistent with that observation, the US EPA transitioned to the use of self-policing to encourage pollution prevention. Other studies note that environmental compliance is significantly affected by traditional 'command and control' strategies. Using Prais Winston regression we examine these contrasting views by estimating the relationship between toxic releases, self-policing and criminal prosecutions from1988 through 2014. Initial correlations suggest that (1) self-policing is not associated with toxic releases but that (2) criminal prosecutions may reduce toxic releases through general deterrence signals. Subsequent analyses controlling for gross domestic product (GDP) revealed that neither self-policing nor criminal enforcement correlate with toxic releases, but that than GDP was the strongest predictor of emissions. The implications of these findings for the control of toxic emissions is discussed.

Introduction

Broadly speaking, ecological modernization refers to any innovative policy or technical solution that improves the environmental performance of firms by reducing their ecological impacts (Mol 2006). Self-policing has been described as an example of an innovative modernization policy that encourages producers to implement technology and policies that facilitate audits in order to quickly discover and correct environmental violations (Short and Toffel 2008). Under self-policing, firms discover and self-report violations to regulators in exchange for immunity from prosecution and punishment, and should reduce toxic emissions. The US EPA implement a self-policing policy known as the self-audit policy in 1995 (Stretesky and Lynch 2009). Prior studies have questioned the effectiveness of the US EPA self-audit/policing policy (Pfaff and Sanchirico 2004; Stretesky 2006; Stretesky and Lynch 2009).

The traditional alternative to ecological modernization is the use of what are called 'command and control' regulatory policies which employ coercive crime control strategies to enhance compliance through deterrence. Prior research suggests that command and control policies also play a role in controlling toxic emissions. Despite the claims made by ecological modernization and command/control approaches, prior studies have yet to address whether self-policing or command/control policies are more effective for reducing toxic emissions. This study takes up that task by comparing the effects of self-policing and traditional command/control effects (measured by the number of criminal environmental cases filed against firms) on the trend in toxic releases in the United States. We begin by reviewing the basic ideas and assumptions of ecological modernization. Next, we draw upon concepts in modernization to demonstrate how self-policing and ecological modernization are compatible and contrary to command and control enforcement regimes. Finally, we analyze the association between levels of self-policing, the number of criminal prosecutions, and toxic releases in the United States (US) between 1988 and 2014.

Ecological Modernization

Above all, ecological modernization theory suggests that environmental problems can be solved by eco-efficient strategies, signifying that economic expansion and environmental sustainability are compatible. This outcome is referred to as 'environmental-economic decoupling' (Anderson 2005). Decoupling may occur when environmental harm is reduced by environmental policies that force industries to change production technology that enhance environmental protection and stability through state environmental policies that promotes adoption of new technology. In the US, environmental regulations include numerous examples of technology forcing, which is one of the ways that laws can generate environmental-economic decoupling and encourage ecological modernization.

Mol and Spaargaren (1992) suggest contemporary societies now encourage eco-efficiencies and modernization through state regulations. However, the theorized role of the state varies across different strands of modernization theory. For instance, Huber's (2000) modernization view emphasizes institutions of technology and the economy as more central to modernization than the state, and asserts that sometimes the state may be described as an obstacle to modernization (see also, Schnaiberg 1980). In this view, important changes in production and consumption emerge when technology innovations that promote sustainability occur, leading to an international and 'systematic, broad and long-term cooperation between government, research, industry and finance' (Huber 2000:282). That is, modernization promotes the interface between economic development and ecological sustainability by producing the best of both worlds. In short, this view suggests that capitalists will become green as the economy modernizes, producing enhanced environmental protection (for criticism, see, Foster 1999, 2000, 2012). Laws are somewhat irrelevant to this form of ecological modernization and the focus is primarily on technological innovation.

Other varieties of modernization theory suggest the state plays a more central role in

promoting ecological modernization than industry, a suggestion that might be of interest to criminologists. Jänicke (1992:49) argues 'whoever sets up environmental policy at the right time and consolidates them within a legal framework could also be more successful in the realization of ecological objectives.' From Jänicke's (1997) point of view, the institutionalization (i.e., modernization) of environmental policy within the state is absolutely necessary for successful environmental policy, and successful states must have a 'capacity for modernization' and direct ecologically rational production. Despite his view, Huber (2000:77) also recognizes that the rule of law can impact sustainability through environmental 'compliance with the law and administrative regulations, on the basis of [corporate] loyalty to the rule of law.' Criminologically speaking, state ecological modernization policies shift the focus of environmental social control from coercive punitive strategies (i.e., surveillance and punishment) to cooperative compliance. Research has yet to address whether one of these strategies is more efficient than the other in preventing ecological harm or environmental violations.

Criminologically, ecological modernization is also interesting because the theory suggests that economic development and social change will seep into a diverse array of political and economic institutions to promote ecological protection (Mol and Spaargaren 1992), promoting informal social control through agents of change. Mol and Spaargaren (1992:150) point out that this process relies on *agency* when corporations make 'judgments about their sustainability.' Mol and Spaargaren describe this notion as 'ecological rationality.' They argue that ecological rationality allows people to value ecological sustainable practices. When institutions recognize that unsustainable practices should change, they begin to react (Mol and Spaargaren 1992:150). Thus, ecological modernization should increase efforts to promote ecologically sustainable production practices. For example, the rationale behind self-policing is that it encourages companies to use technology to monitor environmental performance and improve compliance management systems

that detect potential ecological problems.

Modernization & Environmental Self-Policing

The idea of self-policing is compatible with Mol and Sparragaren's description of ecological modernization as it emphasizes two different aspects of ecological rationality. The first is the idea that environmental agencies will generally work with industry to achieve ecological rationality by promoting improvements that move from 'end of pipe' enforcement to market driven and eco-efficient outcomes (Carolan 2004). Second, government institutions will develop and push ecological rationality by incorporating policies that improve environmental performance. Mol (2002) suggests that environmental reforms and the emergence of the "rule of law" are consistent with ecological rationality. In short, market-based solutions and voluntary programs that offer economic incentives for environmental improvement are often noted as being consistent with ecological modernization theory.

In recent years, environmental regulators have moved toward adopting market-based voluntary programs to be consistent with the idea of ecological modernization. Mazurek (1998: 6), suggests that market-based voluntary programs increased substantially during the 1990s. Scholz (1984: 388) and Baylis, Connell and Flynn (1998) suggest that state-initiated ecological modernization encourages firms to be good ecological stewards, and improves their environmental records (see also Jänicke 1992) by also encouraging firms to stay 'ahead' of regulation. Baylis et al. (1998) note that even while firms are ignorant about impending environmental regulations and fail to appreciate how regulation would impact them, they still assumed that environmental performance in their sector would continue to become more demanding because regulators and society were interested in sustainable production. Thus, they suggest that firms ask for incentives to monitor and fix problems and improve environmental performance on their own, which would include options such as self-policing.

Environmental self-policing is touted as a useful ecological modernization strategy. It is often described as innovative and market-based (Stretesky 2006). It is market-based because it relies on the polluters themselves to detect and correct violations because it is the right thing to do. Moreover, as a market-based approach, self-policing is supposed to be efficient in solving environmental problems by offering economic incentives to comply, making environmental compliance more widespread and more readily achievable (Freeman 2000:197).[1] In theory, polluters themselves solve pollution problems by monitoring their own waste streams and correcting potential violations as they are discovered as opposed to waiting for the state to raise concerns about environmental performance when it is detected through inspections.

In 1995 the Environmental Protection Agency implemented the "Incentives for Self-Policing: Discovery, Disclosure, Correction, and Prevention of Violations." That policy emerged shortly after the 'second wave' of environmental concern (Mol and Spaargaren, 1992) to persuade companies to implement environmental audits that would identify potential problems and violations that occur in the production process that can be corrected through improved technologies of production. Companies that report and correct violations discovered through systematic audits will not be criminally or civilly prosecuted and shall have their gravity-based penalties eliminated.[2] The use of environmental audits as an alternative mechanism to command and control enforcement strategies is evident. Companies that use the policy may claim to adhere to the triple bottom line where social, ecological and financial costs are all considered. Based on the above, increases in self-policing should be negatively associated with toxic releases in the US over time, which is a testable hypothesis. This hypothesis has not been tested at the federal level

[1] On December 9, 2015, the EPA announced that it is continuing to modernize the implementation of its audit (i.e., self-policing) policy by creating a centralized web-based "eDisclosure" portal to receive and automatically process self-disclosed violations of environmental law. This new system will be automated to allow companies to resolve routine cases quickly.

[2] Penalties are based on economic benefits and gravity. The gravity portion of the penalties is based on the egregiousness of the violation.

over time. At the state level, however, the literature suggests that state self-auditing policies may reduce toxic releases but self-policing policies that waive all immunity may be related to increases in toxic releases (Guerrero and Innes, 2011).

While self-policing may or may not affect firm's environmental compliance, governments also employ coercive general deterrence enforcement strategies to regulate toxic releases, an issue described below.

General Deterrence and Toxic Releases

General deterrence suggests that criminal behavior can be reduced when the state demonstrates that it is not profitable to commit crime by increasing the probability of detection and/or the costs of violating the law. In this sense, general deterrence and ecological modernization select different strategies for producing compliance with environmental regulations. Criminologists have long studied the effect of deterrence on criminal behavior (Paternoster 1987; Pratt et al. 2006) and the study of the deterrence of offenders has "arguably has been the most researched topic in criminology since the latter part of the 1960s" (Akers 1990:654). The idea grew out of a rational approach emphasized in the classical school (Beccaria 1764), which shifted attention from the criminal to the crime (Tittle and Paternoster 2000). The assumption of rational choice models of crime is that social conditions can be manipulated to reduce crime because actors are rational and more or less the same (Cornish and Clarke 1987; 2014). Thus, stimuli (e.g., punishments and rewards) drive people to engage in or desist from crime (Becker 1974). The idea behind deterrence is that people are likely to obey the law because they fear legal sanctions. The greater the certainty, severity, and celerity of punishment, the more likely it is that crime will be prevented (Zimring and Hawkins 1973). While it is recognized that there are cultural and structural constraints on rational choice that may limit deterrence (Vaughn 1998), the notion is that punishment will influence potential offenders. As McMurry and Ramsey (1986:1169) note

> The use of criminal sanctions is receiving increased emphasis in the enforcement of environmental statutes. Federal criminal enforcement programs, after a slow start, are maturing into effective programs with identifiable standards and procedures.

Likewise, the US EPA notes, "Enforcing environmental laws is a central part of EPA's Strategic Plan to protect human health and the environment The EPA has worked to ensure compliance with environmental requirements. When warranted, EPA will take civil or *criminal* enforcement action against violators of environmental law" (http://www2.epa.gov/enforcement/enforcement-basic-information; emphasis added). The EPA also maintains a project devoted to assessing the deterrent messages from environmental enforcement (Kagan, Gunningham and Thorton 2000).

Environmental compliance research has drawn attention to the deterrent effects of environmental enforcement, but that research has produced mixed results. Economic studies have generally supported deterrence arguments (Gray and Shimshack 2011, 2007; Shimshack and Ward 2005) while criminological studies have been more apt to reject deterrence arguments (Braithwaite and Makkai, 1991; Makkai and Braithwaite, 1994; Weisburd, Waring, and Chayet, 1995), while some argue that corporation adhere to law despite the lack of any strong indicators of deterrence, a position known as the "Harrington Paradox" (Harrington 1988).

The general deterrence approach suggests that increased criminal enforcement should be negatively associated with toxic releases. Theoretically, the punishment of some firms encourages all firms to obey the law, causing some to reduce their toxic releases because firms who see others punished will over-comply with to law to ensure that they are well ahead of regulation that may define them as environmental criminals in the future. That is, command and control enforcement may still be relevant to pollution reduction through general deterrent signals that are advertised by law enforcement and regulatory agencies.

From the above, both self-policing and deterrence arguments suggest alternative mechanisms for improving firm compliance with environmental regulations that lead to the

reduction in toxic emissions. Prior research has yet to address whether one of these approaches is more effective than the other. We take up that issue in the analysis that follows.

Data and Methods

Our analysis of aggregate toxic releases endeavors to assess the effect of self-policing and command and control criminal prosecutions (deterrence) brought about by the Department of Justice on the quantity of toxic releases. We use the quantity of releases because those releases should be affected by ecological modernization as well as enforcement of environmental regulations. We examine statistical correlations between self-policing, criminal prosecutions and toxic releases annually for the US between 1988 and 2014. We choose the US as an ideal nation to examine trends in modernization that may be associated with self-policing, criminal enforcement and toxic releases. As Jänicke (1992:49) points out, the US is a "pioneer" in environmental protection and an early adopter of important environmental policy that reflects the modernization process.[3] In short, if an inverse relationship between self-policing, criminal enforcement and environmental performance exists, it should be observed for the US over time.

In addition to toxic release, self-policing and deterrence indicators, data were also gathered on control variables that are plausible predictors of toxic releases that may render any association between enforcement activities and toxic releases insignificant when controlled for in a statistical analysis. The variables employed in the analysis are described below.

Toxic Releases. We examine toxic releases using data on releases reported by firms to the US EPA as recorded in the Toxic Release Inventory (TRI). The US Congress mandated the TRI in the Emergency Planning and Community Right-to-Know Act of 1986. The idea behind the TRI is to track industrial chemical production, treatment, storage and disposal to monitor chemicals used

[3] There is evidence that some parts of the world are better at adopting ecological modernization policies than the United States (see Delmas, 2002)

by industry. The TRI database contains information on industrial releases associated with regulated chemicals from a variety of firms required to report their releases to the EPA (http://www2.epa.gov/toxics-release-inventory-tri-program). Releases are reported annually and can be tracked over time.

Unfortunately, there are problems using TRI as an indicator of trends in industrial pollution (de Marchi and Hamilton 2006). Specifically, reporting requirements change often and new chemicals are added and subtracted from the list of toxic releases required to be reported. Therefore, we examine two TRI indicators that measure on-site and off-site toxins that are disposed and released into the environment. First, we use releases that are standardized by 1988 reporting criteria (ie., TRI reports data for 1988 chemicals only). These releases can be examined over time. Second, as an alternative to the 1988 standardization we use total TRI releases, including years where the chemicals in those releases were changed. Some of the changes in toxic release trends are a result of changes in reporting requirements as opposed to a change in toxic releases. While changes to chemicals listed in the inventory occurred in 1988, 1991 and 1995, the biggest reporting change occurred in 1998 when seven additional industry sectors were required to report their releases to the TRI system. As a result, we account for this administrative change by including a dummy variable (coded "1" for the years 1998 to 2014) that indicates that a significant number of additional chemical releases were reported (as indicated in Figure 1 below) to account for the significant increase in reporting. That additional analysis of all chemicals is included as an alternative to the standardized TRI releases and reported in Appendix A.

[FIGURE 1 ABOUT HERE]

Figure 1 displays trends in TRI releases between 1988 and 2014 for both types of TRI indicators (standardized and unstandardized) and generally shows that toxic releases have declined over time. This decline has often been attributed to changes in environmental policy and the

general implementation of innovative environmental policy such as self-policing as well as an increase in command and control type enforcement (Short and Toffel, 2008). However, changes in toxic emissions can also be influenced by production trends, such as slow or even recessionary economic growth, and thus it is important to control for that possibility in analysis (see discussion of control variables below).

Self-Policing Variable. As suggested by ecological modernization theory, the state is an important actor in the process of environmental regulation and can promote or inhibit ecological modernization through policies that promote the adoption ecological friendly practices (Mol 2006). As noted, in theory these conditions are promoted by self-policing since under that policy companies have incentives to employ monitoring technology to better audit their toxic releases and to discover violations and improve efficiency. Thus, self-policing is consistent with the goal of regulators which is to modernize stationary sources of pollution as opposed to engaging in a regulatory deterrent process.

To examine whether self-policing contributes to ecological modernization trends we employed US EPA data on the number of self-policing cases reported to the EPA. Data on self-policing cases are derived from *Office of Enforcement and Compliance Assurance Annual Reports* that are available at the EPA (Fiscal Year 2006 – 2008) and the EPA's *Audit Policy Update* (Fiscal Year 1996 – 2001). These sources list data on yearly numbers of Audit Policy cases as well as historical trends in the Policy's use between 1995 and 2008. We derived the last six years of Audit Policy Cases (FY 2009 – 2014) from the Environmental Protection Agency Audit Policy website (http://www2.epa.gov/compliance/epas-audit-policy). Self-policing is measured as the number of reported violations regardless of outcome [*Self-Policing*].

As indicated in Figure 1 and the Appendix, these cases range from a low of 0 cases (FY1988 to FY1995; prior to the adoption of the Audit Policy) to a high of 627 cases (FY2005). In general,

self-policing cases expanded between 1995 (when the policy on self-policing was implemented) and 2005, and declined slightly after 2006 (Figure 1). Overall, Figure 1 indicates that the number of reported violations has increased as TRI releases declined, suggesting that there may be a modernization effect through self-policing.

Criminal Prosecution Variable. To examine whether traditional criminal enforcement contributes to the reduction in trends observed in toxic releases we included the number of criminal cases filed by the US attorneys in federal court that focus on natural resource and pollution crimes. In theory, criminal environmental cases should send a strong deterrent message to industries and enhance compliance with environmental regulations leading to reductions in pollution as firms enhance compliance. Data on enforcement cases are derived from *Table 3-A* in the *Statistical Report of the United States Attorney's Office* (Fiscal Year 1988 – 2014). Enforcement is measured as the number of cases initiated by Department of Justice regardless of the outcome [*Prosecutions*]. As indicated in Figure 1 and the Appendix, these cases range from a low of 35 cases (FY1988) to a high of 322 cases (FY1998). In general, these criminal cases have, like self-policing cases, also expanded over time, and in Figure 1 appear to be inversely related to TRI releases suggesting that there may be a general deterrent effect from these prosecutions.

Control Variables. Despite the above initial associations, it remains plausible that toxic releases are influenced by other factors. First, pollution is likely to be affected by the volume of economic activity. To control for that effect, we include gross domestic product [***GDP***] in billions of constant 2009 dollars. Theoretically, economic growth should enhance ecological modernization and promote a reduction in toxic releases over time (Grossman and Krueger, 1991, 1995; for recent reviews of this literature see, Kaika and Zervas, 2013a, 2013b). However, it is also possible that because GDP measures expanded economic growth, an increase in GDP can cause an increase in toxic emissions. Adjusted GDP data were obtained from Johnston and Williamson

(2014). GDP is often used as an economic indicator in trends in studies of other pollutants like carbon dioxide (e.g., Tucker 1995).

Second, we include an indicator of the number of production facilities [labeled ***facilities***]. Logically, toxic releases may be affected by the number of facilities that generate those releases. Data on the number of facilities are obtained from the TRI database (http://www2.epa.gov/toxics-release-inventory-tri-program). Thus, if the number of regulated facilities decreases over time, this might explain the declining trend in toxic emissions. The facilities indicator measures the annual number of TRI facilities that report to US EPA. Third, we include two dummy variables. The first measures significant changes in TRI reporting requirements affected by the addition of six industries to the TRI in 1998 (1=1998 & Post 1998; 0=Pre 1998). Finally, we include a dummy variable to measure political party affiliation for the US President (1=Republican; 0=Democrat). We include this indicator in the analysis as the president nominates political officials who may then shape enforcement priorities (command and control versus compliance and assistance) in federal agencies such as the Department of Justice, the Environmental Protection Agency, and the Federal Bureau of Investigation.

Statistical Analyses

We examine data on self-policing, enforcement and toxic releases using a series of bivariate and multivariate analyses. First, as noted in the time series plot in Figure 1, both self-policing and command and control enforcement appear to be inversely related to toxic releases over time -- that is, as both types of enforcement increase, toxic releases decrease. We assessed the validity of this visual observation using Pearson correlations (r) for the variables included in the analysis, and then proceed to more rigorous multivariate regression equations that include both enforcement variables together along with controls.

Because our data are time series we examined the stationarity of toxic releases and

enforcement. Non-stationarity takes different forms, but occurs when the mean and variance of variables in the analysis changes over time. This is an especially important problem to consider because means and variance at one point in time will underestimate the mean and variance of future points in time predicted by modernization theory, and any correlations between enforcement and toxic releases may be the result of non-stationarity. As a result, we suggest it is necessary to run stationarity diagnostics to determine how to proceed with the analyses of variation in toxic releases.

We used the Dickey-Fuller test to examine non-stationarity (Madalla 1992). Not surprisingly, when the difference in toxic releases is regressed against the lag of releases, the data suggest a deterministic trend ($p<0.05$) as opposed to a random walk or stochastic trend. As a result, we de-trended the data by computing first order differences for each variable in the analysis (Madalla 1992). In the case of toxic releases: if $Toxic\ Releases_{\ t}$ = the value of toxic releases at time t, and t is measured in years, the new variable, criminal enforcement change was created using the equation, $\delta\ Toxic\ Releases = Toxic\ Releases_{\ t} - Toxic\ Releases_{\ t-1}$, for each of the 27 years in the dataset.

We use the stationary variables to estimate the Ordinary Least Squares (OLS) regression model predicting toxic releases (not shown). The correlation between toxic releases and each type of enforcement (i.e., self-policing and criminal prosecutions) is not statistically significant, but autocorrelation may be problematic for self-policing (*Durban-Watson* = 1.27) and criminal prosecutions (*Durban-Watson* = 1.18) as both tests are inconclusive. Thus, OLS results cannot definitively answer whether self-policing, criminal prosecutions and toxic releases are related. As noted by the inconclusive Durban-Watson statistics, autocorrelation may introduce estimation problems in time-series data when it produces inefficient slopes and biased standard errors that distort statistical significance tests. To correct for potential bias we use Prais-Winsten regression as

suggested by Bence (1995). The results of that transformed regression analysis are presented in Table 2. As noted by the *Durbin-Watson* statistics in Table 2, when Prais-Winsten regression is used there is little evidence of autocorrelation in the corrected models and the statistic is very near the ideal value of 2.0 (Madalla 1992). In addition, Variance Inflation Factor (VIF) analysis indicated that multicollinearity does not appear to exist in any of the models estimated as all scores are well below 4 (Madalla 1992). Lastly, model residuals in corrected models are normally distributed. However, since heteroskedasticity is also a concern with time series data, we estimate *Huber-White* robust standard errors and report those standard errors in each model estimated.[4]

Bivariate Results

Figure 1 displays trends in toxic releases and criminal enforcement. As indicated in that graph, there appears to be an inverse correlation between enforcement types and toxic releases between 1988 until 2014. This visual analysis confirms what some policy-makers claim about both types of enforcement (e.g., deterrence and self-policing protects the environment). Unfortunately, it is difficult to make any definitive statements about enforcement and toxic releases based on visual observations of the data. As a result, the time series data presented in Figure 1 should be viewed with caution as correlations are common among time series data and may be influenced by other variables.

Table 1 examines the trends in enforcement and toxic releases in greater detail using bivariate correlations between toxic releases, self-policing, criminal prosecutions and control variables. While these correlations need to be interpreted with extreme caution given the problems noted above, they again lend preliminary support for the position that both types of enforcement (modernized and command and control) aid in the reduction of toxic releases. That is, prosecutions and self-policing are negatively correlated with toxic releases ($r_{\text{self-policing}} = -0.71$, $p<0.05$; r

[4] The exact same results were obtained when robust standard errors were not employed.

$_{prosecutions}$ = –0.75, p<0.05) and suggest that some of the reduction in TRI releases may be due to self-policing policies as well as general deterrence. With respect to earlier observations, these results suggest that both ecological modernization and deterrence restrict toxic releases by firms.

[**Table 1 about here**]

To further examine these relationships, the independent and dependent variables were transformed into yearly change variables (not shown). After doing so, criminal enforcement effects (deterrence) remained ($r_{prosecutions}$ = –0.13, p>0.05) significant as in Table 1 (untransformed variables). Self-policing, however, is now *positively* correlated with toxic releases ($r_{self\text{-}policing}$ = 0.34, p<0.10). This result suggests that increases in self-policing may lead to increases in toxic releases, which may be consistent with prior research on self-policing which indicates that firms report minor rather than more serious environmental violations (Stretesky 2006). As noted, this result questions the visual trends displayed in Figure 1 and the untransformed bivariate correlations shown in Table 1. This finding, while contrary to preliminary analysis, is not surprising given the potential for artificial results that can be produced by non-stationarity in time-series data.

Multivariate Analysis

Table 2 provides Prais-Winston regression estimates for first order differences. Model 1 contains the results for self-policing, Model 2 contains the results for criminal prosecutions, Model 3, contains the results for self-policing and prosecutions and Model 4 contains the results of self-policing, prosecutions and controls.

[**Table 2 about here**]

In Model 1, each additional self-policing action in a given year is associated with a 0.49 million pound annual *increase* in toxic releases across industries (p<0.05). Model 3 suggests similar substantive results when prosecutions are added (b = 0.42; p<0.10). This finding mirrors the change-transformed bivariate results, lending validity to those results. Diagnostic statistics

suggest that autocorrelation, heteroskedasticity, and multi-collinearity are not likely the reason for this finding. When controlling for GDP, facilities, and the president's party in Model 4 the positive correlation between toxic releases self-policing is no longer significant, suggesting that self-policing doesn't harm or help the environment by reducing toxic releases (for a similar conclusion see Stafford 2003).

Table 2 also suggests that criminal prosecutions may be related to reductions in environmental enforcement-- though that result is inconsistent. For instance, in Model 2 prosecutions are negatively related with toxic releases, suggesting that each additional prosecution corresponds to a 0.78 million pound decrease in toxic releases. This finding is not replicated in Models 3 or 4 ($p < 0.10$). As a result, command and control approaches emphasized in criminal prosecutions do not appear to offer much potential for decreasing the overall levels of toxic releases.

One other result stands out as important in Table 2. GDP is strongly and positively related to toxic releases and therefore production appears to be the strongest driver of toxic releases ($b=386.50$; $p<0.01$). This finding deserves some additional attention and will be the focus of the discussion. Overall, the multivariate analyses suggest that neither ecological modernization measured as self-policing nor deterrence measured through EPA criminal prosecutions has a statistically significant effect on toxic release emissions.

Discussion and Conclusions

Ecological modernization approaches suggest that environmental compliance can be enhanced through technological innovations as well as through enhanced use of informal social controls such as self-policing. In contrast, traditional approaches to the social control of pollution suggest the need for coercive compliance strategies to facilitate deterrence, which we measured as the number of criminal environmental prosecutions. In the present study we examined the effects

of both approaches on firms' self-reported toxic emissions from 1988 through 2014. Correlational models suggested both strategies appeared to influence firm toxic emissions, while multivariate models controlling for the volume of economic production (gross domestic product) and firm concentrations (the number of regulated firms) showed no effect for the number of self-policing cases or criminal case filings. Various explanations for these outcomes are possible.

First, it may be that the self-policing has nothing to do with modernization. That is, the number of firms that engage in self-policing does not enhance ecological modernization and fails to generate technology forcing techniques that reduce toxic emissions. As a result, self-policing efforts do not appear to reduce toxic releases. Our multivariate findings are consistent with this perspective and other researchers document similar effects for self-policing and chemical releases at the state level of analysis (Guerrero and Innes, 2011). Second, it may be that self-policing is not sufficiently market-based to change behavior. Regardless, self-policing may have less of an effect on polluters than ecological modernization theory suggests.When it comes to criminal prosecutions, there appears to be a small but inconsistent impact for general deterrence in some models. This may be the result of the small number of environmental prosecutions enacted each year. Nevertheless, the EPA makes attempts to ensure that prosecutions are advertised widely in order to promote general deterrence that might lead to at least some reductions in toxic releases. This study suggests there may not be much merit to this policy approach. That is, while prosecutions are supposed to send a general message to the regulated community that toxic releases should be reduced to stay within compliance, those messages seem to have little effect on toxic releases. As a result, it might be more productive to seek other policies to reduce toxic releases. It may also be the case that criminal cases resist easy quantification because they vary significantly in severity. That is, some prosecutions are for relatively minor crimes and some are for major ones. We model the simple relationship between the level of prosecution and toxic

releases without regard to the impact of any particular case and the stronger or weaker deterrence impacts that a case may send. Thus, it could be that this failure to adequately capture deterrent messages through case severity produces non-findings for enforcement.

Interestingly, the variable with the greatest impact on toxic releases is GDP, a measure of production. As GDP increases, toxic releases also increase. This finding is not surprising to scholars such as Brisman and South 2015. Specifically, they note that producers and the state do not believe that production trends have to change. As a result, production is likely to remain tightly correlated with toxic releases despite trends in enforcement. Moreover, the goal of enforcement agencies is to "manage the risk (or the perception thereof)" (Brisman and South, in 2015:37). As a result, environmental enforcement and self-policing might be expected to increase over time even if these forms of enforcement have little impact on toxic releases.

The observation about the relationship between production and toxic releases is consistent with theoretical arguments and empirical research found in ecological Marxism (Foster 1999, 2000, 2010; Foster and Burkett 2008; Foster, Clark and York 2010; Jorgenson 2011, 2006a, 2006b, 2003) and environmental sociology, and in particular the treadmill of production literature (Schnaiberg 1980). Specifically, ecological Marxism argues that the constant expansion of production necessitates an increase in pollution, an outcome consistent with our GDP-pollution results. Moreover, ecological Marxists have offered a significant critique of the ecological modernization argument (Foster 2012; York, Rosa and Dietz 2003). Consistent with our results in the case of self-policing, ecological Marxist and treadmill of production arguments suggest that the continuous expansion of production, one of the goals of capitalist production which is associated with accelerating profit-making, plays an important role in the *expansion* of ecological destruction and disorganization (Foster 1999, 2000) and rather than producing ecological rationality, profit-base motivations place pressure to increase production and hence the emission of pollutants. In

effect, regulation of any kind (including criminal regulation) will, in that view, be unrelated to toxic emissions because emissions are a consequence of the volume of production. Thus, even while the increase in criminal penalties for environmental violations signals an apparent concern for ecological problems, that concern does not translate into improved environmental performance because production continues to expand.

Considering our findings and the suggestions of ecological Marxism, the solution to controlling ecological emissions must be modified. As noted, emissions are likely influenced by GDP, indicating that increased production drives ecological emissions. Thus, to control emissions, enhanced environmental laws that place tighter restrictions on production appear to be in order. While environmental regulations in the US sometimes requires the use of certain pollution control technologies, they do not address production based technologies. For example, environmental design researchers such as McDonough and Braungart (2010) suggest that many production technologies are ecological inefficient and wasteful (and illogical), and can be redesigned to enhance the environmental performance of firms. Yet, despite significant environmental reform, US environmental regulations still do not require the widespread use of ecological efficient production techniques, but rather promote end of pipe pollution reduction technologies which are less efficient than reducing waste in the production process itself (McDonough and Braungart 2010). Thus, it may be time for US EPA to adopt new strategies, an effort it has partially attempted through its "green chemistry" program (https://www.epa.gov/greenchemistry). For example, the US EPA estimates that enacted green chemistry techniques eliminates 826 million pounds of toxic pollutants annually. However, across the globe, production related waste (e.g., carbon dioxide) is expanding more quickly than green technology waste reduction efforts (Jorgenson and Clark 2012), Thus, there is a need for much more extensive expansion of pollution reduction policy to control toxic emissions. This might include the need for "coupled" environmental-economic

policies such as sustainable economic development, which has long been argued by Herman Daly (1977, 1996), a former senior economist at the World Bank.

In the end we suggest that debates about the role of the state in modernization will not disappear. As Buttel (2000:58) pointed out long ago, "a full-blown theory of ecological modernization must ultimately be a theory of politics and the state…which tend to give rise to private eco-efficiencies and overall environmental reforms." And, according to the third wave of modernization theory the state has an important role to play – even if in the short term – to promote ecological rationalization. We argue that social scientists, and criminologists in particular, who are interested in studying environmental crime should extend their concept of environmental performance to examine the potential aggregate role of enforcement related practices on overall levels of toxic releases and other forms of pollution. Such analyses might be particularly interesting in different countries as it helps establish the potential utility of modernization and command and control regulation approaches as solutions to reducing toxic releases and other forms of pollution. We believe our findings that regulation appears to have little impact on toxic releases has contributed to the debate about this important relationship and hope that it will stimulate future research.

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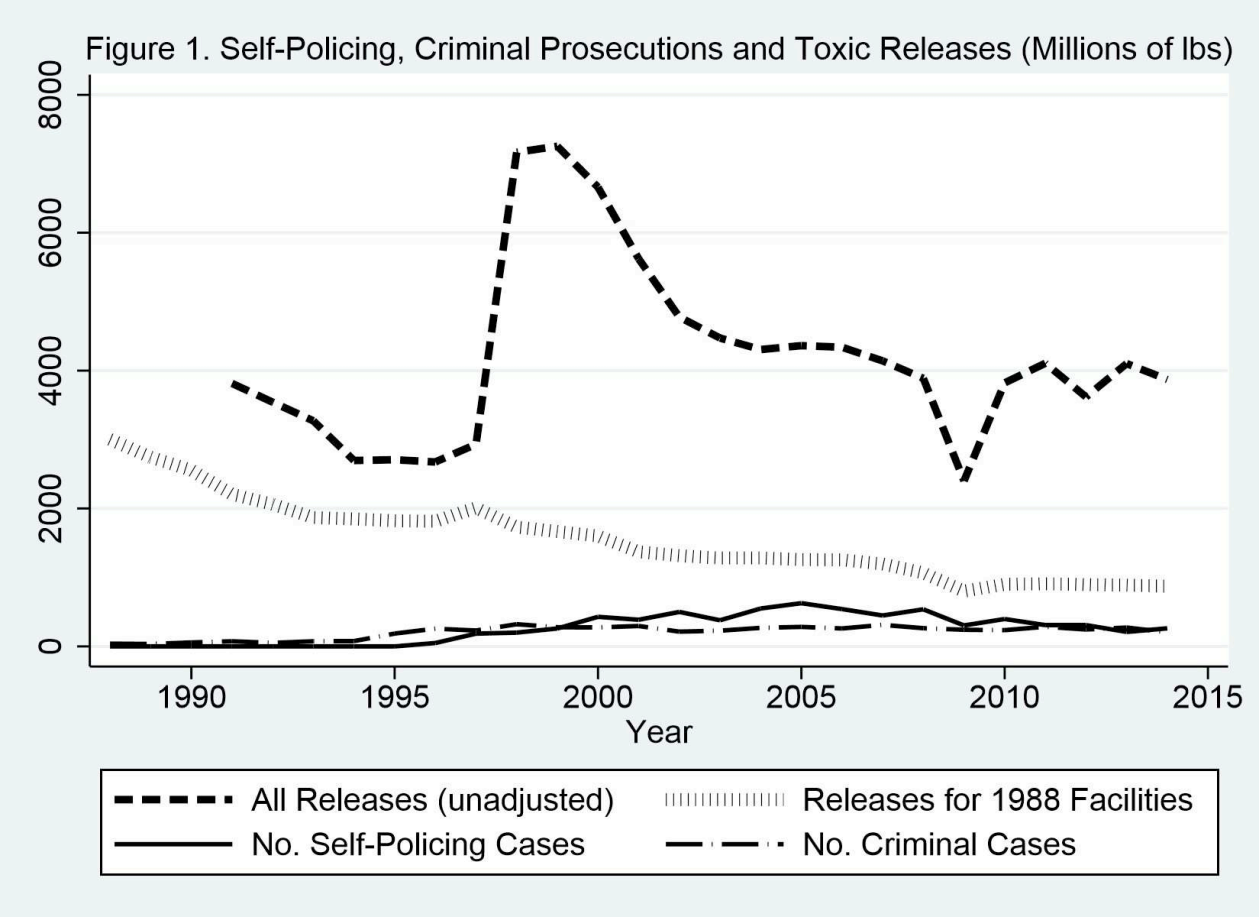
Figure 1. Self-Policing, Criminal Prosecutions and Toxic Releases (Millions of lbs)
0
2000
4000
6000
8000
1990
1995
2000
2005
2010
2015
Year
All Releases (unadjusted)
Releases for 1988 Facilities
No. Self-Policing Cases
No. Criminal Cases

Table 1. Pearson Product-Moment Correlation Coefficients (*r*) and Descriptive Statistics for Variables in the Analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) *Toxic Releases*	1.00						
(2) *Self-Policing*	–0.71*	1					
(3) *Prosecutions*	–0.75*	0.75*	1				
(4) *GDP*	–0.94*	0.79*	0.77*	1			
(5) *Facilities*	0.60*	0.09	–0.44*	–0.58*	1		
(6) *President*	–0.19	0.25	–0.21	–0.10	–0.63	1	
(7) *Paper*	0.19*	0.86*	0.81*	0.88*	0.30*	–0.03	1
Mean	1564	254.9	206.3	12.40	23,726	0.52	0.63
Std. Dev.	598.3	210.2	94.3	2.495	1,322	0.51	0.49
Min. Value	801.9	0	35	8.465	21,535	0	0
Max. Value	3003	627	322	16.47	25,895	1	1

Note: *$p<0.05$; significance (two-tailed).