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Will Additional Federal Enforcement Improve the Performance of Pipelines in the U.S.?

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Abstract

This paper provides the first empirical analysis of the effectiveness of regulatory enforcement in increasing the environmental and safety performance of U.S. natural gas and hazardous liquid pipeline operators. The analysis combines data on federal regulatory inspections, enforcement actions, and penalties with data on injuries, fatalities, property damage, and barrels of product lost through pipeline "incidents" for 2006-2011 for the 344 largest pipeline operators in the U.S. The results of the analysis do not provide compelling evidence that either federal inspections or civil penalties are particularly effective in increasing performance; however, the number of federal cases initiated against an operator does have a significant effect on many forms of performance, although not for incidents in general. The results also suggest that some targeting of federal enforcement resources is based on past performance, but there may be room for even more effective targeting. Finally, the analysis reveals interesting patterns between state and federal enforcement efforts.

Keywords: Regulation, Environmental Performance, Enforcement, Pipelines

JEL Classification: K42, L95

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1. Introduction

Over the past several years, the role that oil and natural gas pipelines might play in increasing the U.S.'s energy independence has gained significant attention. In particular, TransCanada's proposed Keystone XL Pipeline has been the subject of heated debate between those that believe the project is a critical part of the U.S.'s energy security strategy and will have a positive effect on the country's economy and those that believe the project imposes unacceptable risks for the natural environment including devastating sensitive environments and polluting important water sources. A number of relatively recent events have reinforced the arguments that pipelines pose serious threats to human health and the environment: in September of 2010 a natural gas pipeline explosion in San Bruno, California resulted in a massive fire that killed eight people, injured dozens of others, and destroyed over 100 homes and in July of 2011 an Exxon Mobil pipeline rupture spilled over 1,000 barrels of oil into the scenic Yellowstone River.

In late 2011, the U.S. Congress approved and President Obama signed the Pipeline Safety, Regulatory Certainty, and Job Creation Act to improve the performance of pipelines. The act was passed during the 112th Congress, one of the least productive – if not the least productive – legislative session in recent history [1]. The act drew unanimous support from both parties in part because of public outcry over the San Bruno explosion and the Yellowstone River spill. However, the act was a compromise and did not include all of the recommended policy changes that were proposed by the National Transportation Safety Board for increasing pipeline safety [2]. The main provisions of the act are an increase in funding for federal inspections of pipelines (the "Job Creation" part of the act) as well as an increase in the fines associated with violations of pipeline regulations. In accordance with the act, the administration's 2013 fiscal year budget increased funding for the Pipeline and Hazardous Safety Materials Administration by 60 percent and added 120 new federal inspectors.

While numerous studies have assessed the effectiveness of federal enforcement in improving compliance with general environmental regulations, to my knowledge there has never been a systematic evaluation of the effect of federal enforcement efforts on pipeline performance. Thus it is not clear whether the Pipeline Safety, Regulatory Certainty, and Job Creation Act will actually accomplish its stated goal of increasing pipeline performance. In particular, because the act was prompted by public pressure to do something about pipeline performance, as May [3] points out, the compromise solution may not fully address the underlying regulatory failure. The goal of this paper is to provide the first empirical analysis of the effect that federal pipeline enforcement on pipeline performance. The results of this analysis should provide insight into whether the changes mandated under the Pipeline Safety, Regulatory Certainty, and Job Creation Act are likely to achieve their goal of improving pipeline safety.

2. Background on the Pipeline Industry

Many liquid products are most cost-effectively transported via pipelines. However, many of the products transported by pipeline can pose significant threats to human health and the environment if leaked or released from the pipeline. Although pipelines are designed and constructed to maintain structural integrity since the transported materials have intrinsic value (unlike many effluent substances, such as hazardous wastes or by-products), many factors make it difficult to avoid leaks and other releases during a pipeline's lifetime. Natural disasters, such as flooding, earthquakes, and storms, can result in pipeline failures, as can accidental human, machine, and animal intrusions. Additionally, pipelines may develop leaks or ruptures due to corrosion from the materials being transported or material fatigue from fluctuating temperature and pressure conditions.

In the U.S. over 2.5 million miles of pipelines transport natural gas, petroleum products and other hazardous liquids. Overall, pipelines are a relatively safe mode of transportation compared to alternatives such as tankers and rail cars, and the pipeline transmission safety record has improved significantly over time. However, more than 100 significant pipeline releases occur each year, and deaths from pipeline accidents are, unfortunately, not rare occurrences.

Prior to 1968, pipelines were not subject to safety or environmental regulations. In 1968, Congress established the Office of Pipeline Safety (OPS), a division of the Department of Transportation (DOT), to develop and implement safety regulations for natural gas pipelines. Hazardous liquid pipelines were added to OPS's portfolio in 1979, but until 2002 OPS was generally seen as ineffectual, with weak enforcement and ineffective rules [4]. In 2002, Congress passed the Pipeline Safety Improvement Act, which increased penalties and enforcement authority, and limited OPS discretion.

OPS sets the federal standards with which all pipeline operators must comply. As is true with many other regulations, states can and do pass supplemental regulations. Additionally, pipelines in "high consequence" areas are subject to a stricter set of controls due to the increased risk for damage to human health or the environment. Both federal and state regulators enforce OPS regulations. In theory, standard inspections are conducted every couple of years on all pipelines and more often on pipelines with higher potential risks. If a pipeline crosses state borders, enforcement generally falls to OPS, while states inspect most intrastate lines. However, not all states have been certified or approved to conduct intrastate inspections; in unapproved states federal regulators conduct all pipeline inspections. Conversely, OPS has authorized some states to act as its agent and inspect the sections of interstate pipelines that run through the state in addition to intrastate pipelines. To complement formal enforcement, regulated pipelines must also self-inspect and report any violations discovered during the course of required inspections.

OPS is a relatively small agency. In 2011 prior to the passage of the Pipeline Safety, Regulatory Certainty, and Job Creation Act, there were under 120 inspectors working for OPS out of five regional offices (Trenton, NJ; Atlanta, GA; Kansas City, MO; Houston, TX; and Denver, CO) [5]. An additional 300 state inspectors carry out the majority of pipeline inspections. Standard inspections are designed to ensure that operation and maintenance procedures, abnormal and emergency operating procedures, damage prevention and public education procedures, and pipeline installation, connection, repair, and operations are in compliance with the relevant regulations. Construction inspections include a review of material and component design specifications, welding procedures and welder qualifications, corrosion protection, and installation as well as post-construction testing. Integrity management inspections are designed to determine whether an operator uses all available information about its pipeline system to assess risks and takes appropriate action to mitigate those risks.

OPS can initiate an enforcement case when an inspection identifies a violation of pipeline regulations or in response to an accident. The type of enforcement action taken depends on the significance of the violation. Minor problems occurring for the first time may only receive a warning letter, while more significant violations may require a compliance order that specifies actions the operator must take to come into compliance (e.g., requiring operators to replace pipeline sections or implement corrosion control and remediation strategies) or a civil penalty. Civil penalties are generally reserved for serious violations leading to deaths, injuries, or significant environmental damage. Regulators may impose civil penalties as severe as $100,000 for each day a violation existed, up to a maximum of $1,000,000. Since 2008, OPS has proposed over $21 million in civil penalties [6].

There are currently 2,705 regulated pipeline operators in the U.S. Of these, 1,921 operate less than 10 miles of pipeline, 440 operate between 10 and 100 miles of pipeline, and 344 operate 100 miles or more of pipeline. In 2010, 22 fatalities and 109 injuries were attributed to pipeline incidents. Of course these numbers are quite variable – over the last 20 years, the number of fatalities has ranged from a low of 7 in 2001 to a high of 53 in 1996. Similarly the number of injuries has ranged from a low of 36 in 2006 to a high of 127 in 1996. Of course injuries and deaths are not the only damages that result from poor pipeline performance. In 2010, pipeline incidents resulted in almost $1.4 billion dollars of property damage and almost 175,000 barrels of spilled hazardous liquids. On the enforcement side, in 2010 federal regulators conducted around 600 pipeline inspections, initiated just over 200 enforcement actions and assessed over $4.5 million dollars in penalties. During the same time period state regulators logged almost 38,000 inspection days, discovered almost 14,000 violations, initiated over 4,000 enforcement actions, and assessed over $13 million dollars in penalties.

3. Related Literature

The objective of this paper is to better understand the role that federal inspections and enforcement actions play in increasing pipeline performance and compliance. To my knowledge, there are no existing papers that explicitly model compliance with pipeline regulations, either theoretically or empirically.[1] However, there is a large literature examining compliance with environmental regulations more broadly, and I use this as a starting point for the analysis.

The traditional economic view of environmental compliance and performance assumes that a regulated entity's decision to comply with environmental regulations is a rational one based on the objective of profit maximization. The basic framework for these models is Becker's [8] paper on the economics of crime, which was adapted by Russell, Harrington, and Vaughan [9] to provide a comprehensive application to environmental regulation. While a number of interesting variations on these models have been developed over the past two decades to allow for various complexities such as imperfect information, self-reporting, principal-agent relationships, and dynamic settings, in all of these deterrence-based models compliance and performance are ultimately improved by increasing the expected cost of noncompliance – either by increasing the likelihood that a violator gets caught or by increasing the level of sanctions associated with violations.

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[1] There are a number of papers that analyze pipeline incidents from an engineering perspective to better understand the distribution of pipeline failures (see, for example Sosa and Alvarez-Ramirez [7]). These papers do not examine regulatory structures or policies.

While deterrence-based models dominate the economics literature on environmental enforcement, a number of papers in other fields have recognized alternative motivations for compliance or reasons for nonperformance. For example, a regulated entity may comply with regulations out of an inherent sense of duty to obey rules or because of social pressure, even if the probability of detection is very low or the punishment for a violation is negligible. Alternatively, even with severe sanctions or a high probability of detection, if a regulated entity's managers do not understand the regulatory requirements, or have poor internal controls, even well intentioned regulated entities may still violate regulations. Finally, some violations, such as those triggered by extreme weather, may occur despite a regulated entity's fully compliant operations. In such cases, deterrence-based measures would prove generally ineffective at increasing performance. Of course, while some theoretical models focus on a particular motive underlying the compliance decision, in practice the compliance decision is likely to depend on a number of different objectives and factors that differ across facilities.

According to Gray and Shimshack [10], most policy-makers and scholars believe that an enforcement regime of inspections and sanctions is generally effective at increasing compliance with environmental regulations, and most regulated entities cite rigorous monitoring and enforcement as a primary motivator of their environmental compliance decisions. A number of empirical analyses confirm these beliefs. For example, Gray and Deily [11] and Gray and Shadbegian [12] examine air pollution compliance for steel mills and pulp and paper mills in the U.S., respectively, and find that both inspections and enforcement actions have a statistically significant positive impact on compliance. Looking at compliance with U.S. water regulations, Earnhart [13] and Glicksman and Earnhart [14] similarly find that inspections and sanctions deter violations and reduce emissions at water treatment plants and chemical facilities, respectively. Stafford [15] shows that compliance inspections and penalties for violations have a significant deterrent effect on violations at facilities subject to hazardous waste regulations.[2]

These results from the environmental compliance literature echo findings in other regulatory areas. In particular, a number of papers examine the deterrent effect of Occupational Safety and Health Administration (OSHA) inspections and sanctions on workplace injuries. Many of these papers find that inspections and sanctions do deter injuries, although the effects of deterrence depend significantly on the characteristics of the regulated entity being inspected or sanctioned and whether the inspection results in a sanction [16, 17, 18]. The goal of this paper is to add evidence from another closely related regulatory sector, pipelines, on the deterrent effect of federal inspections and enforcement actions in increasing compliance and performance.

4. Framework for the Analysis and Description of the Data

While pipelines are fixed structures, they are not constrained within a particular geographic area like most entities subject to environmental and safety regulations. While many pipeline are relatively short, there are also operators that have thousands of miles of pipeline crossing numerous state borders. Federal and state regulators do divide pipelines into 'inspection units'. For operators with short pipelines, the entire company may constitute one inspection unit while larger operators may be divided based on operating areas (e.g., cities or metropolitan areas) or company organization (e.g., all elements

[2] See Gray and Shimshack [10] for a comprehensive survey of the empirical literature on environmental monitoring and enforcement.

reporting to a single vice president). Unfortunately, data on pipeline performance and enforcement is not available at the inspection-unit level. Thus this analysis focuses on the aggregate performance of individual pipeline operators, rather than the performance of a particular section of a pipeline. This analysis is most analogous to firm-level studies of compliance and environmental performance, such as Khanna and Anton [19] and Thornton, Gunningham, and Kagan [20], although it is based on data reported to the federal government rather than data collected through a voluntary survey.

As discussed earlier, there are 2,705 regulated pipeline operators in the U.S, over two-thirds of who operate less than 10 miles of pipeline. This analysis focuses on the 344 operators that operate 100 miles or more of pipeline. These operators represent over 90% of all pipeline incidents that occurred between 2006 and 2011 and 80% of all federal inspections during that same time frame. OPS defines an incident as any event that results in a death or personal injury necessitating in-patient hospitalization; an explosion or unintentional fire; any event that results in property damage of $50,000 or more (excluding cost of material lost); any event that results in unintentional loss of five gallons or more of hazardous liquid or carbon dioxide or three million cubic feet of gas; any emergency that results in an emergency shutdown of a facility; or any other event that is significant in the judgment of the operator.

The Pipeline and Hazardous Materials Safety Administration (PHMSA) provides data on the performance of pipeline operators starting in 2006.[3] The performance measures include the total number of reported incidents, fatalities, and injuries each year; the total dollar amount of property damage reported each year; and the reported total

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[3] The OPS is an office within the PHMSA.

barrels of product spilled and the net barrels of product lost each year. While these data are self-reported, the civil penalties for not reporting an incident within 30 days can be up to $1 million dollars and any individual that "willfully and knowingly violates" the requirements can face a criminal fine of up to $25,000 and be imprisoned for up to five years. Additionally, many of the pipeline incidents directly affect or involve third parties, making it much less likely that operators could under-report those incidents. For example, almost three-quarters of the pipeline fatalities and three-quarters of the pipeline injuries reported during the 2008 to 2012 period involved third-party (non-industry) individuals.[4]

Table 1 presents a summary of the performance measures for 2010 for the operators in this study. First, note that for all of these measures, the majority of operators have nothing to report. The most widely reported measure is property damage, followed closely by incidents. Property damage is reported more often than incidents because events that cause less than $50,000 in property damage are not considered incidents if they do not also result in fatalities, significant injuries, or sufficient loss of material. Given the relatively small number of operators that report in a given year, I aggregate performance data for 2009 and 2010 to increase the number of operators reporting. The mean and standard deviations for the aggregated data are presented in Table 2 which includes summary statistics for all variables used in the analysis. Note that the summary statistics are for all operators in the study, not just those reporting.

One of the principal challenges that can arise when trying to estimate the effectiveness of inspections and enforcement on performance is that of endogeneity or reverse causality, which can occur if there are omitted explanatory variables or the

[4] See "Consequences to the Public and the Pipeline Industry" available at http://primis.phmsa.dot.gov/comm/reports/safety/cpi.html (last accessed July 11, 2013).

compliance and enforcement decisions are made simultaneously. With respect to the omitted variables concern, due to data limitations the analysis may not include some factors that affect both the operator's environmental performance as well as the regulator's decision to conduct inspections. For example, significant flooding in an area may cause pipelines to rupture, but might also bring increased inspections to that area. With respect to the simultaneity concern, contemporaneous inspections may be endogenous to the number of incidents reported if inspections serve as a significant mechanism through which incidents are discovered or reported. Similarly, the number of enforcement cases and amount of proposed penalties in a particular period are likely to depend on the number of incidents and fatalities that occur in that same time period. To address this concern I lag the enforcement variables, which may be endogenous, and I also include the lagged dependent variable as an explanatory variable. Ideally I would also use an instrumental variables approach to control for endogeneity, but due to the limited information available about pipeline inspections and enforcement, I have not been able to find any valid instruments to use for such an approach.

The first set of explanatory variables presented in Table 2 depicts the level of federal and state enforcement for each operator in the analysis. The three federal measures – *Federal Inspections*$_{06\text{-}08}$, *Federal Cases Initiated*$_{06\text{-}08}$, and *Federal Proposed Penalties*$_{06\text{-}08}$ – each capture a different aspect of the specific deterrence a particular operator faces from federal sources, as they capture the level of inspections and enforcement for that specific operator during the 2006-2008 period. In contrast, the three state measures are all general deterrence measures that capture the general level of enforcement for the states through which the operator's pipelines run. The state measures are general measures rather than specific measures because the state data is only available at the aggregate level. For each state I first normalize the relevant variable *X* – *State Inspections*$_{06\text{-}08}$, *State Actions Taken*$_{06\text{-}08}$, and *State Assessed Penalties*$_{06\text{-}08}$ – by the total number of pipeline miles in the state. For each operator *i*, I then use data on the total number of pipeline miles the operator has in each state *j* to construct each measure *X* for that operator as follows:

$$\sum_j Miles_{ij} * \frac{X_j}{Miles_j}$$

The state inspection data was obtained through a Freedom of Information Act request, while the data on state compliance actions taken and penalties assessed was collected from the PHMSA website.

The next set of explanatory variables measures past reported performance (i.e., reported performance during the 2006-2008 period) and, due to limited data capturing operator characteristics, is used in conjunction with the analogous 2009-2010 variables to control for differences in underlying propensities to comply with pipeline regulations. Additionally, Sosa and Alvarez-Ramirez [7] show that the number of previous incidents positively correlates with future incidents. One of the operator characteristics that I can control for is the *Miles* of pipeline the operator owns. Both *Miles* and *Miles Squared* are included in the analysis to account for the fact that longer pipelines have more opportunities for failure. I also include the dummy variable *Intrastate* that indicates whether the pipeline is confined within a single state. While OPS concentrates enforcement efforts on interstate pipelines, federal inspectors do inspect intrastate pipelines on occasion. *Number of States* measures the number of states through which the pipeline passes, while the four regional dummies capture the Census region(s) in which the operator operates. Finally there are four dummy variables that capture the type of pipelines and the materials transported in the pipelines that each operator owns:

- *Gas Gathering* lines collect and move natural gas from wells or offshore vessels to storage or processing facilities.
- *Gas Transmission* lines transport natural gas from gathering lines or storage facilities to distribution centers, storage facilities, power plants, and industrial customers and municipalities. These are generally the longest type of gas lines and are usually underground.
- *Gas Distribution* lines move natural gas to industrial customers and residences and are usually located in underground utility easements along streets.
- *Hazardous Liquid* lines transport petroleum products and other hazardous liquids, usually over long distances and underground.

5. Results and Policy Implications

Table 3 presents the results of the ordinary least squares regression for each of the 2009 to 2010 reported performance variables. In the first column, the dependent variable is the number of incidents reported in 2009 and 2010. Looking first at the federal enforcement variables, notice that none of the coefficients are negative. Moreover, the positive coefficients for $\textit{Federal Cases Initiated}_{06\text{-}08}$ and $\textit{Federal Proposed Penalties}_{06\text{-}08}$ are both significant – the opposite of what one would expect if past enforcement actions served to increase overall environmental performance. One possible explanation could be that it takes a long period of time for operators to change their performance; thus, operators with past incidents that warranted significant enforcement may be more likely to continue to report a high number of incidents. To control for this, I did include past incidents (*Dependent Variable$_{06\text{-}08}$*) in the regression, which also has a positive and significant sign, but it may not be a perfect control. The results for the state enforcement variables are more consistent with expectations. Both *State Inspections$_{06\text{-}08}$* and *State Penalties Assessed$_{06\text{-}08}$* have negative coefficients, and the former is significant.

Looking across the other performance variables, it is interesting to note that the results for the enforcement measures are quite mixed. *Federal Inspections$_{06\text{-}08}$* and *Federal Proposed Penalties$_{06\text{-}08}$*, always have positive coefficients, and those coefficient are significant in a number of the regressions. On the other hand, *Federal Cases Initiated$_{06\text{-}08}$* has a negative coefficient for all but the *Incidents* regression, and the coefficient is significant for all but the *Fatalities* regression. The state enforcement results are also mixed. In contrast to the negative relationship between federal cases and performance – or, more correctly, non-performance – all of the significant coefficients on *State Actions Taken$_{06\text{-}08}$* are positive. Similarly, while federal proposed penalties are positively related to non-performance in most of the regressions, all of the coefficients on *State Penalties Assessed$_{06\text{-}08}$* are negative. *State Inspections$_{06\text{-}08}$* has a negative and significant coefficient only in the *Incidents* regression, but has a positive and significant coefficient in the *Net Barrels Lost* regression. While one might expect that some of this inconsistency could be caused by multicollinearity among the federal and state enforcement variables, the variables are not as highly correlated as one might expect. Only three pairs of variables have a correlation coefficient above 0.6: *Federal Inspections* and *Federal Cases Initiated* have a correlation coefficient of 0.67; *Federal Inspections* and *State Inspections* have a correlation coefficient of 0.70, and *State Inspections* and *State Actions Taken* have a correlation coefficient of 0.76.

Clearly these results paint a very mixed picture of the effectiveness of federal and state enforcement efforts at deterring poor environmental performance at pipelines. In particular, in terms of predicting the success of the Pipeline Safety, Regulatory Certainty, and Job Creation Act in increasing pipeline safety, there is no evidence that indicates federal inspections or fines increase environmental performance, although there is some evidence that state inspections and penalties can have such an effect.[5] While *Federal Cases Initiated*$_{06\text{-}08}$ does have a relatively consistent negative and significant effect on non-performance, the Pipeline Safety, Regulatory Certainty, and Job Creation Act explicitly focuses on increased federal inspections rather than more rigorous enforcement; thus, it is not clear how the number of cases initiated will change with increased enforcement resources.

The remaining results in Table 3 provide some insight into why federal enforcement may not be particularly effective at decreasing poor environmental performance. First, observe that the coefficient on the lagged dependent variable in each regression (listed as *Dependent Variable*$_{06\text{-}08}$) is positive and significant for four of the regressions. Thus, for overall incidents, injuries, gross barrels spilled, and net barrels lost, there is considerable persistence across time – particularly when one recalls the difference in time frames across the two variables (three years to two years). The less predictable nature of fatalities and

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[5] One might be concerned that due to the self-reported nature of the data, some incidents are systematically going unreported in way that biases the findings of this study. Appendix A presents the results of a sensitivity analysis that suggests that under-reporting cannot explain the lack of significant negative coefficients on federal inspections.

property damage makes intuitive sense and is consistent with the Sosa and Alvarez-Ramirez [7] finding that more severe incidents are unpredictable.

I had expected that the non-performance measures would all be positively related to the length of the pipeline, but interestingly *Miles* has the expected positive and significant coefficient only in the *Incidents* regression. For *Fatalities*, *Injuries*, and *Property Damage*, longer pipelines have fewer negative outcomes, *ceteris paribus*. Also, across all of the regressions the coefficient on *Miles Squared* is negative (although significant in only two of the six regressions). Of course, there are a number of other variables that indirectly capture the length of the pipeline, including the state enforcement variables. However, these results suggests for at least some of the performance variables, there may be important non-linearities.

While very few of the remaining explanatory variables have a consistent effect on the performance variables, note that *Gas Gathering* has a significant and positive coefficient in the *Fatalities*, *Injuries*, and *Property Damage* regressions. Comparing the size of the three significant *Gas Gathering* coefficients to the mean and standard deviation for the three performance measures, note that operating a gas gathering pipeline is quantitatively a very important determinant for fatalities, injuries and property damage and may help explain why federal and state level enforcement actions are not more important deterrents for at least these types of non-performance.

Although lagging the federal enforcement variables and conditioning on prior values of the dependent variables should help to identify and estimate causal effects, as discussed in section 4 one might still be concerned that these results could be due to endogeneity. In similar situations other researchers have employed an instrumental variables approach to try to control for potential endogeneity, but given the limited information available about pipeline inspections and enforcement, I have not been able to find valid instruments for such an approach. As an alternative, I use Manski's partial identification approach [21, 22] to estimate plausible bounds for the causal effects of federal enforcement. As discussed in more detail in Appendix B, this partial identification approach suggests that all of the positive coefficients on the federal enforcement variables in the *Incidents*, *Property Damage*, *Gross Barrels Spilled*, and *Net Barrels Lost* regressions are plausible even if one assumes that regulators do target operators with higher levels of non-performance for enforcement actions. However, partial identification suggests that significant positive coefficients on the federal enforcement variables for the *Fatalities* and *Injuries* regressions would not be consistent with that assumption. Interestingly, I do not find any positive and significant coefficients for the federal enforcement variables in either the *Fatalities* or the *Injuries* regressions.

To provide additional insight into the mixed results presented in Table 3, I also analyzed federal inspections and enforcement as a function of past performance. Table 4 presents the results of ordinary least square regressions of $\textit{Federal Inspections}_{09\text{-}10}$, $\textit{Federal Cases Initiated}_{09\text{-}10}$, and $\textit{Federal Proposed Penalties}_{09\text{-}10}$ as a function of the lagged performance measures, the lagged dependent variable, and the explanatory variables used in the performance regressions. Looking first at the results for the *Federal Inspections* regression, note that only $\textit{Fatalities}_{06\text{-}08}$ has a positive and significant coefficient among the performance measures, indicating that federal inspectors do target operators for inspections if there have been fatalities at the operator's pipelines in the recent past. Interestingly, the coefficient on $\textit{Injuries}_{06\text{-}08}$ is negative and significant which is not consistent with the idea of targeting based on past performance. This pattern shows up in both of the other regressions; that is, the coefficient on *Fatalities*$_{06\text{-}08}$ is positive and significant for both *Federal Cases* and *Federal Penalties*, while the coefficient on *Injuries*$_{06\text{-}08}$ is negative for both and significant for *Federal Cases*. *Barrels Lost*$_{06\text{-}08}$ is also a significant determinant of *Federal Cases Initiated*$_{09\text{-}10}$, while *Incidents*$_{06\text{-}08}$ and *Property Damage*$_{06\text{-}08}$ are significant determinants of *Federal Proposed Penalties*$_{09\text{-}10}$.

For both *Federal Inspections* and *Federal Cases* there is some persistence across the two periods given the positive and significant coefficients on the lagged dependent variable. There are a number of possible explanations for this result. Recall that pipelines which pass through "high consequence" areas are subject to more stringent regulation and may also face more inspections. Similarly, pipelines carrying particularly hazardous materials may be inspected more often. Interestingly, there is a negative relationship between current and lagged *Federal Penalties*, so that facilities that faced higher penalties in the past face lower penalties currently, *ceteris paribus*.

Next, consider the lagged state enforcement variables. *State Inspections*$_{06\text{-}08}$ has a positive coefficient in all three regressions, and it is significant for *Federal Cases* and *Federal Penalties*. If state inspections uncover behavior that helps federal regulators initiate enforcement proceedings, one would expect to see a positive relationship between these variables. Interestingly, the negative and significant coefficient on *State Actions Taken*$_{06\text{-}08}$ suggests that federal regulators may take into account state actions and hold off on their own enforcement actions against operators that have been subject to state actions in the recent past. However, the positive and significant coefficient on *State Penalties Assessed*$_{06\text{-}08}$ in the *Federal Cases* regression is inconsistent with such an interpretation.

Looking next at the operator characteristics variables, as expected longer pipelines face more inspections than shorter pipelines, although they are not subject to more federal cases or higher federal penalties. This finding makes sense, as inspections should depend on the potential for harm, while enforcement actions should depend on the presence of actual harm or violations. The insignificant coefficients on all of the regional dummies indicate there are not significant differences in the number of inspections based on the regions through which a pipeline runs. However, there are significant differences in the number of federal cases and penalties proposed by region, even after controlling for performance. While there are many possible explanations for these findings, they are consistent with regulators in different regions having different opinions about when cases should be initiated and how penalties should be set. Interestingly, even though the regressions in Table 3 suggest that pipeline performance depends on the type of pipeline – *Gas Gathering*, *Gas Distribution*, etc. – there is no variation in federal enforcement across the different types of pipelines.

6. Conclusion

The goal of this paper is to provide insight into the role that federal inspections, enforcement actions, and fines have had on pipeline performance and, in particular, to examine whether the increased inspections funding and civil penalties mandated under the Pipeline Safety, Regulatory Certainty, and Job Creation Act are likely to increase pipeline safety. The results of the analysis do not provide compelling evidence that either federal inspections or civil penalties serve as particularly effective deterrents. In fact, I find that lagged federal inspections and penalties are positively associated with environmental non-performance, although the results have to be interpreted with some care as lagging the enforcement variables may not fully correct for omitted variables or endogeneity between enforcement and performance.

Interestingly, my analysis does find that the number of federal cases initiated against an operator does have a significant deterrent effect on many forms of non-performance, although not for incidents in general. Thus, in theory increasing the number of federal cases would result in better environmental performance. However, the Pipeline Safety, Regulatory Certainty, and Job Creation Act focuses on increasing inspections and fines, not increasing the number of cases, although additional cases could indirectly result from the Act.

The analysis of federal inspections, enforcement cases, and proposed penalties suggests that some targeting of federal enforcement resources is based on past performance, but the results suggest that there may be room for improvement. If federal enforcement resources were better targeted, the deterrent effect of such resources might increase. The analysis also points out some variation across regions in enforcement that could indicate inefficient resource deployment. Finally, the analysis reveals interesting patterns between state and federal enforcement efforts. Additional research to better understand the relationship between such efforts could help increase our understanding of how such resources are currently coordinated and whether better coordination might increase deterrence.

Table 1: 2010 Performance Measures for Operators with 100 or More Miles of Pipeline (N=344)

Performance Measure	Facilities with Nothing to Report	For Facilities that Report			
		Mean	Std. Dev.	Minimum	Maximum
Number of Incidents	236 (69%)	3.96	4.75	1	26
Number of Fatalities	340 (99%)	2.75	3.50	1	8
Number of Injuries	337 (98%)	9.14	18.57	1	51
Property Damage (in Million $s)	235 (68%)	10.40	67.50	0.003	601
Gross Barrels Spilled (thousands)	285 (83%)	2.91	10.21	0.002	70.19
Net Barrels Lost (thousands)	298 (87%)	2.66	10.68	0.001	70.19

Table 2: Summary Statistics for the Variables Used in the Analysis

Variable	Description	Mean	Std. Dev.
Performance Measures (Dependent Variables)			
$Incidents_{09\text{-}10}$	Number of incidents reported during 2009-2010.	2.51	6.33
$Fatalities_{09\text{-}10}$	Number of fatalities reported during 2009-2010.	0.04	0.47
$Injuries_{09\text{-}10}$	Number of injuries reported during 2009-2010.	0.23	2.79
Property $Damage_{09\text{-}10}$	Property damage reported during 2009-2010 in million $s.	3.63	38.29
Barrels $Spilled_{09\text{-}10}$	Barrels reported spilled during 2009-2010 in thousands of barrels.	0.65	4.44
Barrels $Lost_{09\text{-}10}$	Net barrels reported lost during 2009-2010 in thousands of barrels.	0.45	4.04
Enforcement Measures			
Federal $Inspections_{06\text{-}08}$	Number of federal inspections at the operator's facilities during 2006-2008 (100's).	0.33	0.73
Federal Cases $Initiated_{06\text{-}08}$	Number of federal enforcement cases initiated against operator during 2006-2008.	1.24	2.40
Federal Proposed $Penalties_{06\text{-}08}$	Proposed Penalties on the operator during 2006-2008 (million $'s).	0.39	0.25
State $Inspections_{06\text{-}08}$	Weighted sum of total state inspections during 2006-2008 (100's).	0.79	1.58
State Actions $Taken_{06\text{-}08}$	Weighted sum of total state actions taken during 2006-2008.	8.87	18.90
State Penalties $Assessed_{06\text{-}08}$	Weighted sum of total state penalties assessed during 2006-2008 ($100,000's).	0.07	0.28
Past Performance Measures			
$Incidents_{06\text{-}08}$	Number of incidents reported during 2006-2008.	3.93	9.75
$Fatalities_{06\text{-}08}$	Number of fatalities reported during 2006-2008.	0.03	0.20
$Injuries_{06\text{-}08}$	Number of injuries reported during 2009-2010.	0.07	0.46
Property $Damage_{06\text{-}08}$	Property damage reported during 2006-2008 in million $s.	2.06	8.63
Barrels $Spilled_{06\text{-}08}$	Barrels spilled during 2006-2008 in thousands of barrels.	0.92	5.04
Barrels $Lost_{06\text{-}08}$	Net barrels lost during 2006-2008 in thousands of barrels.	0.52	3.62

Variable	Description	Mean	Std. Dev.
Other Operator Characteristics			
Miles	Miles of pipeline, in thousands	1.42	2.60
Intrastate	= 1 if all operations in the same state	0.39	0.49
Number of States	Number of states through which the operator's pipeline passes.	3.17	3.28
Region 1	= 1 if any pipeline is located in the Northeast.	0.11	0.32
Region 2	= 1 if any pipeline is located in the Midwest.	0.38	0.49
Region 3	= 1 if any pipeline is located in the South.	0.63	0.48
Region 4	= 1 if any pipeline is located in the West.	0.29	0.45
Gas Gathering	= 1 if operations include natural gas gathering.	0.24	0.43
Gas Transmission	= 1 if operations include natural gas transmission.	0.75	0.44
Gas Distribution	= 1 if operations include natural gas distribution.	0.26	0.44
Hazardous Liquid	= 1 if operations include hazardous liquid transmission.	0.44	0.50

Table 3: OLS Results for Various Measures of Environmental Performance

	Incidents	Fatalities	Injuries
Federal Inspections$_{06\text{-}08}$	0.33 (0.34)	0.04 (0.06)	0.43 (0.32)
Federal Cases Initiated$_{06\text{-}08}$	0.17* (0.09)	-0.02 (0.01)	-0.18** (0.08)
Federal Proposed Penalties$_{06\text{-}08}$	1.32** (0.64)	0.02 (0.11)	0.70 (0.58)
State Inspections$_{06\text{-}08}$	-0.68** (0.34)	-0.05 (0.05)	0.003 (0.31)
State Actions Taken$_{06\text{-}08}$	0.01 (0.02)	0.02** (0.002)	0.15** (0.01)
State Penalties Assessed$_{06\text{-}08}$	-0.73 (0.59)	-0.12 (0.10)	-0.65 (0.54)
Dependent Variable†$_{06\text{-}08}$	0.47** (0.02)	0.13 (0.13)	0.58** (0.30)
Miles	0.75** (0.30)	-0.08* (0.05)	-0.63** (0.27)
Miles Squared	-0.02** (0.01)	-0.002 (0.002)	-0.01 (0.01)
Intrastate	0.37 (0.36)	-0.01 (0.06)	-0.15 (0.32)
Number of States	0.31** (0.10)	0.02 (0.02)	0.04 (0.09)
Region 1	0.20 (0.58)	0.04 (0.09)	-0.23 (0.53)
Region 2	-0.51 (0.41)	0.03 (0.06)	0.22 (0.37)
Region 3	-0.52 (0.42)	-0.10 (0.07)	-0.58 (0.38)
Region 4	-1.12** (0.42)	-0.002 (0.07)	0.21 (0.39)
Gas Gathering	0.04 (0.36)	0.13** (0.06)	0.82** (0.33)
Gas Transmission	-0.71* (0.40)	-0.08 (0.07)	-0.31 (0.37)
Gas Distribution	0.56 (0.40)	0.07 (0.06)	0.43 (0.36)
Hazardous Liquid	0.51 (0.39)	-0.07 (0.06)	-0.39 (0.36)
Constant	-0.18 (0.61)	0.04 (0.10)	0.26 (0.55)
R-squared	0.84	0.27	0.33

Sig. at the 5% level; *Sig. at the 10% level.; † Equal to the dep. var. for the period 2006-2008.

Table 3, Continued

	Property Damage	Gross Barrels Spilled	Net Barrels Lost
Federal Inspections$_{06\text{-}08}$	0.08* (0.04)	0.55 (0.45)	0.42* (0.25)
Federal Cases Initiated$_{06\text{-}08}$	-2.04* (1.06)	-0.39** (0.12)	-0.51** (0.07)
Federal Proposed Penalties$_{06\text{-}08}$	77.80** (7.76)	3.93** (0.82)	1.07** (0.46)
State Inspections$_{06\text{-}08}$	2.55 (4.22)	0.41 (0.45)	0.66** (0.25)
State Actions Taken$_{06\text{-}08}$	1.37** (0.20)	0.004 (0.02)	-0.01 (0.01)
State Penalties Assessed$_{06\text{-}08}$	-14.17* (7.25)	-0.33 (0.76)	0.38 (0.42)
Dependent Variable†$_{06\text{-}08}$	0.22 (0.25)	0.62** (0.04)	1.11** (0.03)
Miles	-7.73* (3.69)	-0.19 (0.39)	-0.08 (0.21)
Miles Squared	-0.19 (0.13)	-0.01 (0.01)	-0.02** (0.01)
Intrastate	-3.88 (4.40)	-0.60 (0.46)	-0.31 (0.26)
Number of States	0.75 (1.22)	-0.05 (0.12)	-0.12* (0.07)
Region 1	6.71 (7.14)	-0.35 (0.76)	-0.56 (0.42)
Region 2	0.02 (4.94)	-0.59 (0.52)	0.12 (0.29)
Region 3	-13.02** (5.11)	-0.65 (0.54)	-0.08 (0.30)
Region 4	-8.49* (5.14)	-0.60 (0.55)	0.11 (0.30)
Gas Gathering	8.58* (4.45)	-0.13 (0.47)	-0.04 (0.26)
Gas Transmission	-12.00** (4.98)	0.52 (0.53)	0.31 (0.29)
Gas Distribution	3.05 (4.85)	-0.56 (0.51)	-0.76** (0.28)
Hazardous Liquid	-5.46 (4.78)	0.51 (0.51)	0.16 (0.28)
Constant	17.31** (7.31)	0.97 (0.77)	0.58 (0.42)
R-squared	0.36	0.46	0.80

** Sig. at the 5% level; *Sig. at the 10% level.; † Equal to the dep. var. for the period 2006-2008.

Table 4: OLS Results for Various Measures of Federal Enforcement, 2009-2010

	Federal Inspections	Federal Cases Initiated	Federal Proposed Penalties
$Incidents_{06-08}$	0.25 (0.22)	0.003 (0.008)	0.002** (0.001)
$Fatalities_{06-08}$	43.14** (8.20)	1.02* (0.31)	0.08* (0.05)
$Injuries_{06-08}$	-13.31** (3.50)	-0.32** (0.13)	-0.02 (0.02)
Property $Damage_{06-08}$	0.10 (0.21)	-0.01 (0.01)	0.008** (0.001)
Barrels $Spilled_{06-08}$	0.05 (0.47)	-0.01 (0.02)	0.001 (0.002)
Barrels $Lost_{06-08}$	-0.07 (0.65)	0.06** (0.02)	-0.001 (0.003)
Dependent Variable†$_{06-08}$	0.18** (0.03)	0.21** (0.03)	-0.06* (0.03)
State $Inspections_{06-08}$	0.02 (0.03)	0.006** (0.001)	0.00002** (0.0001)
State Actions $Taken_{06-08}$	-0.26* (0.16)	-0.12** (0.01)	-0.0013* (0.0007)
State Penalties $Assessed_{06-08}$	3.78 (5.52)	0.37* (0.21)	0.02 (0.02)
Miles	6.03** (2.84)	-0.15 (0.11)	0.016 (0.013)
Miles Squared	-0.18* (0.11)	-0.0003 (0.004)	-0.0011** (0.0005)
Intrastate	-3.28 (3.37)	0.27** (0.13)	0.01 (0.01)
Number of States	0.62 (0.94)	0.08** (0.03)	0.004 (0.005)
Region 1	1.56 (5.42)	0.44** (0.21)	0.10** (0.03)
Region 2	-2.42 (3.79)	0.28* (0.14)	0.01 (0.02)
Region 3	-1.90 (3.91)	0.08 (0.15)	0.02 (0.02)
Region 4	-0.04 (3.92)	0.34** (0.15)	0.03* (0.02)

**Signif. at the 5% level; *Signif. at the 10% level; † Equal to variable at the top of the column for 2006-08

Table 4, Con't

	Federal Inspections	Federal Cases Initiated	Federal Proposed Penalties
Gas Gathering	-2.18 (3.36)	0.03 (0.13)	0.003 (0.016)
Gas Transmission	-0.43 (3.85)	0.05 (0.15)	0.026 (0.018)
Gas Distribution	-2.73 (3.70)	-0.09 (0.14)	0.005 (0.018)
Hazardous Liquid	0.66 (3.66)	0.17 (0.14)	0.026 (0.018)
Constant	3.43 (5.67)	-0.52** (0.21)	-0.84** (0.27)
R-squared	0.59	0.63	0.43

**Signif. at the 5% level; *Signif. at the 10% level; † Equal to variable at the top of the column for 2006-08.

Appendix A: Sensitivity Analysis for Self-Reported Performance Data

If non-performance is systematically under-reported by operators that are not subject to federal enforcement, the results in Table 3 would be biased upward. To investigate whether under-reporting could provide an explanation for the positive and/or insignificant coefficients on the federal enforcement variables in the regressions presented in Table 3, I conducted the following experiment to see how badly under-reported the performance data would have to be to estimate negative and significant coefficients for the federal enforcement measures.

The experiment is based on the conjecture that operators accurately self-report if they are or have recently been inspected but may choose to under-report if they are not inspected regularly. Since the performance data used in the Table 3 regressions cover the 2009-2010 period, I assume that operators that are subject to federal inspections during 2009 and 2010 are accurately reporting their performance but that operators that are not subject to federal inspections during that period may be under-reporting. This assumption is consistent with the mean values of the performance variables for the two groups. As shown in Table A1 the mean value of all of the performance measures except $Injuries_{09\text{-}10}$ is less for the non-inspected group than for the inspected group, and all of the differences are statistically significant at the 5% level.

For those operators that were not inspected by the OPS during 2009-2010, I constructed "adjusted" performance variables where the adjusted variable is equal to the self-reported performance variable plus one standard deviation (calculated over the entire sample of 344 operators). For operators that were inspected by OPS, the adjusted variable is equal to the self-reported performance variable. I then ran the Table 3 regressions using the adjusted performance measures. Table A2 shows the coefficients and standard errors for the three federal enforcement variables for these adjusted regressions. Note that these results do not change the overall conclusions from Table 3. As shown by the insignificant coefficient on *Federal Inspections*$_{06\text{-}08}$ in all of the six of the regressions, there is no evidence that federal inspections improve operator performance, even with these adjustments for potential under-reporting. With the adjustments, the coefficient on *Federal Cases Initiated*$_{06\text{-}08}$ does become significant in the Fatalities regression, which is consistent with the study's finding that initiating federal cases can increase environmental performance. With respect to *Federal Penalties Proposed*$_{06\text{-}08}$, the only qualitative difference for the adjusted regressions is that the coefficient is no longer significant in the Incidents regression.

Even if I adjust the performance variables for the operators that are not inspected by the OPS during 2009-2010 by adding 4 times the standard deviation to the initial level of performance, I cannot overturn the inspection result – the coefficients on *Federal Inspections*$_{06\text{-}08}$ remain insignificant in all six regressions. However, for this extreme adjustment the coefficient on *Federal Cases Initiated*$_{06\text{-}08}$ does become negative and significant in the Injuries regression as well.

Table A1: 2009-2010 Performance Measures

Performance Measure	All Operators (N =344)		Operators Inspected in 2009-2010 (N = 147)		Operators Not Inspected in 2009-2010 (N= 197)	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
$Incidents_{09-10}$	2.51	6.33	5.06	8.81	0.60	1.91
$Fatalities_{09-10}$	0.04	0.42	0.05	0.30	0.04	0.57
$Injuries_{09-10}$	0.23	2.79	0.16	0.76	0.27	3.63
Property $Damage_{09-10}$	3.63	38.29	5.78	49.66	2.03	26.88
Gross Barrels $Spilled_{09-10}$	0.65	4.44	1.41	6.70	0.08	0.56
Net Barrels $Lost_{09-10}$	0.45	4.04	0.96	6.12	0.07	0.56

Table A2: OLS Regression Results for the Federal Enforcement Variables when Adjusted 2009-2010 Performance Measures are the Dependent Variables

Adjusted Performance Measure	Federal $Inspections_{06-08}$	Federal Cases $Initiated_{06-08}$	Federal Proposed $Penalties_{06-08}$
$Incidents_{09-10}$	-0.03 (0.48)	-0.18 (0.12)	1.30 (0.87)
$Fatalities_{09-10}$	0.02 (0.06)	-0.04** (0.02)	0.05 (0.12)
$Injuries_{09-10}$	0.29 (0.34)	-0.32** (0.09)	0.72 (0.62)
Property $Damage_{09-10}$	5.64 (4.67)	-4.02** (1.16)	78.20** (8.52)
Gross Barrels $Spilled_{09-10}$	0.35 (0.47)	-0.65** (0.13)	4.01** (0.86)
Net Barrels $Lost_{09-10}$	0.21 (0.30)	-0.72** (0.08)	1.08** (0.05)

Appendix B: Partial Identification of Causal Effects for Federal Enforcement Variables

Charles Manski [20] is one of the primary contributors to the recent literature on partial identification. The partial identification approach focuses on establishing plausible values for treatment effect parameters that are consistent with the observed data under relatively weak assumptions. Using these weak assumptions, researchers can develop bounds for causal effects rather than point estimates. In this appendix I use Manski's approach to develop plausible bounds for the causal effects of federal enforcement on pipeline operator performance under minimal assumptions.

Because the basic partial identification approach developed by Manski [21] focuses on binary treatments, I created three binary treatment variables, $\textit{Federally Inspected}_{06\text{-}08}$, $\textit{Federal Case Initiated}_{06\text{-}08}$, and $\textit{Federal Proposed Penalty}_{06\text{-}08}$. The objective of partial identification is then to develop bounds for the effects of each of these three treatments on the six performance variables: $\textit{Mean Incidents}_{09\text{-}10}$, $\textit{Mean Fatalities}_{09\text{-}10}$, $\textit{Mean Injuries}_{09\text{-}10}$, $\textit{Mean Property Damage}_{09\text{-}10}$, $\textit{Mean Gross Barrels Spilled}_{09\text{-}10}$ and $\textit{Mean Net Barrels Lost}_{09\text{-}10}$.

Let T_i =1 if operator *i* is treated and = 0 if operator *i* is untreated. Let Y_{1i} be the performance of operator *i* when treated and Y_{0i} be the performance when untreated. Then the individual impact of the treatment on operator *i* is $\Delta_i = Y_{1i} - Y_{0i}$. Of course, we cannot observe both Y_{1i} and Y_{0i} as the operator cannot be both treated and untreated. Thus to estimate the causal effect of the treatment, we estimate the average treatment effect which is equal to the difference between the expected values of Y_1 and Y_0 in the population (i.e., $ATE = E[Y_1] - E[Y_0]$) using observable information from different operators. If the expected average treatment effect differs across those operators that are treated and those that are untreated, then the *ATE* is the weighted average of the average treatment effect on the treated and the average treatment effect on the untreated. More specifically, let w_1 equal the proportion of operators that are treated. Then

$$ATE = w_1 * E[Y_1 - Y_0 | T_i = 1] + (1 - w_1) * E[Y_1 - Y_0 | T_i = 0].$$

As a first step, in estimating the ATE, I assume that the potential performance rates for both treated and untreated operators lie within the support observed in the data on performance from 2006 to 2010. Under this assumption the maximum possible negative treatment effect (i.e., improvement in performance) would occur when an operator's untreated performance would be equal to the maximum value and that same operator's treated performance would be equal to 0.[6] The maximum possible positive treatment effect would occur when an operator's untreated performance would be equal to 0 and that same operator's treated performance would be equal to the maximum value. Let M be the maximum observed performance level. Then

$$0 - M \leq E[Y_1] - E[Y_0]) \leq M - 0.$$

As shown in Table B1, using the historical maximum values for each of the six performance variables provides initial bounds on the possible treatment effect, although by construction these bounds are relatively large as well as symmetric.

The next step in the partial identification approach is to further refine the bounds using the relatively weak assumption that the mean observed performance data for the treated group (D_1) gives us an unbiased estimator of the expected performance of the treated group when treated ($E[Y_1 | T_i = 1]$) and that the mean observed performance data for the untreated group (D_0) gives us an unbiased estimator of the expected performance for the untreated group when untreated ($E[Y_0 | T_i = 0]$). Recalling that the ATE is a weighted

[6] The nature of the performance variables rule out negative values, so 0 is the smallest possible value.

average of the expected causal effects for the treated and untreated groups, the bounds become:

$$w_1*(D_1 - M) + (1- w_1)*(0 - D_0) \leq E[Y_1]- E[Y_0]) \leq w_1*(D_1 - 0) + (1- w_1)*(M - D_0).$$

As shown in Table B1, this relatively weak assumption substantially shrinks the bounds of the *ATE*.[7]

Given the concern that treatment selection may be endogenous, we can further shrink the bounds by making another weak assumption: that the average performance for treated firms is weakly higher than the average performance for untreated firms both with and without treatment, or

$$E[Y_1|T_i = 1] \geq E[Y_1 | T_i = 0] \text{ and } E[Y_0|T_i = 1] \geq E[Y_0|T_i = 0].$$[8]

Under this assumption the upper bound becomes

$$w_1*(D_1 - D_0) + (1- w_1)*(D_1 - D_0) = D_1 - D_0,$$

while the lower bound is unchanged. Thus if one assumes positive selection, as shown in Table B1 the bounds on the *ATE* for *Mean Fatalities*$_{09\text{-}10}$ and *Mean Injuries*$_{09\text{-}10}$ rule out any quantitatively significant positive effects while the bounds on the *ATE* for the remaining performance variables do allow for quantitatively significant positive effects. Comparing these results to the sign and significance of the coefficients in Table 3, partial identification suggests that all of the positive coefficients on the federal enforcement variables in the *Incidents*, *Property Damage*, *Gross Barrels Spilled*, and *Net Barrels Lost* regressions are plausible even if one assumes that regulators do target operators with higher levels of non-

[7] Manski calls this the "No Assumptions" bound.
[8] Manski terms this the "Monotone Treatment Selection" assumption.

performance for enforcement actions.[9] However significant positive coefficients on the federal enforcement variables for the *Fatalities* and *Injuries* regressions would not be consistent with that assumption. Interestingly, I do not find any positive and significant coefficients for the federal enforcement variables in either the *Fatalities* or the *Injuries* regressions.

[9] Because the regressions presented in Table 3 use continuous rather than binary federal enforcement variables, the size of the coefficients cannot be directly compared to the bounds.

Table B1: Partial Identification Bounds on Average Treatment Effects

	Mean Incidents$_{09\text{-}10}$	**Mean Fatalities$_{09\text{-}10}$**	**Mean Injuries$_{09\text{-}10}$**	**Mean Property Damage$_{09\text{-}10}$**	**Mean Gross Barrels Spilled$_{09\text{-}10}$**	**Mean Net Barrels Lost$_{09\text{-}10}$**
Historical Maximum	[-28,28]	[-8,8]	[-51,51]	[-601,601]	[-70.19,70.19]	[-70.19,70.19]
Inspected$_{06\text{-}08}$						
Observed Data	[-12.16,15.84]	[-3.75,4.25]	[-23.92,27.08]	[-281,320]	[-32.59,37.60]	[-32.67,37.52]
Positive Selection	[-12.16,2.06]	[-3.75,0.00]	[-23.92-0.08]	[-281,1.47]	[-32.59,0.57]	[-32.67,0.38]
Case Initiated$_{06\text{-}08}$						
Observed Data	[-9.75,18.25]	[-3,5]	[-19.17,31.83]	[-225,376]	[-26.06,44.13]	[-26.15,44.05]
Positive Selection	[-9.75, 2.26]	[-3,0.01]	[-19.17,-0.04]	[-225,2.25]	[-26.06,0.73]	[-26.15,0.50]
Penalty Proposed$_{06\text{-}08}$						
Observed Data	[-3.96,24.04]	[-1.17,6.83]	[-7.47,43.53]	[-87,514]	[-10.29,59.90]	[-10.32,59.87]
Positive Selection	[-3.96, 4.02]	[-1.17,0.03]	[-7.47,0.08]	[-87,7.02]	[-10.29,0.58]	[-10.32,0.18]

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