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Sarah L. Stafford
William & Mary, slstaf@wm.edu

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A Study of Natural Gas Pipeline Enforcement by States in the USA

Sarah L. Stafford

Address for correspondence: Sarah L. Stafford, College of William and Mary, P.O. Box 8795, Williamsburg, VA 23185 (slstaf@wm.edu).

Abstract

This article analyses the role that US states play in enforcing federal natural gas pipeline regulations. The paper finds that states are more likely to have responsibility for enforcing these regulations if they have larger networks of gathering and transmission lines and if their citizens are more liberal and more pro-environment. Conversely, states with a larger natural gas industry are less likely to assume oversight. However, whether a state has assumed oversight has no significant effect on either state enforcement efforts or pipeline performance. The most effective state enforcement tool is monetary penalties, which significantly decrease incidents and property damage.

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1.0 Introduction

According to the Pipeline and Hazardous Materials Safety Administration (PHMSA) of the US Department of Transportation (DOT), from 2003 to 2013 there were almost 2,400 natural gas pipeline incidents which resulted in a total of 129 fatalities, 529 injuries and $2 billion dollars in property damage. The largest of these, such as the 2014 natural gas pipeline explosion that levelled two buildings in New York City, capture the public's attention and can even result in Congressional calls to increase pipeline safety regulation. However, pipelines are often the only economically viable means of transporting natural gas and other forms of transport are likely to pose similar, if not greater, potential for harm. Since natural gas plays a major role in US energy policy, making the transport of natural gas through pipelines as safe as possible is an extremely salient issue that is unlikely to go away in the near future. In fact, even though the USA currently has a natural gas pipeline network of over 300,000 miles of transmission lines and 2.1 million miles of distribution lines, the recent increase in energy production from new sources such as the Bakken shale in North Dakota and the Marcellus shale in the mid-Atlantic is driving pipeline operators to expand the existing gas pipeline network. According to the Interstate Natural Gas Association of America, over $250 billion dollars of additional pipeline infrastructure will be built over the next 25 years to accommodate projected energy production. With an expanded natural gas pipeline network, safety and environmental performance concerns will become an even more important regulatory and policy concern.

While the approval of new pipelines in the USA is the responsibility of the Federal Energy Regulatory Commission (FERC), once built the performance and safety of pipelines is the responsibility of the US DOT. In 2005, PHMSA was established as a division of DOT to oversee pipelines, both those that transport natural gas as well as those that transport petroleum products and other hazardous liquids. Within PHMSA, the Office of Pipeline Safety (OPS) implements the regulatory programme for pipelines. OPS is a relatively small agency. There are currently just under 140 inspectors working for OPS out of five regional offices. The majority of pipeline safety inspections are conducted by 300 to 350 state inspectors. States typically inspect and enforce all intrastate pipelines, while both state and federal regulators inspect interstate pipelines. Overall, states are responsible for inspecting approximately 90 per cent of total natural gas pipelines. However, to date there has been very little analysis, at least in the USA, of the enforcement of natural gas pipeline safety regulations. The one exception is a paper by Stafford (2014). That paper focuses on the effect of federal enforcement on both natural gas and hazardous liquid pipeline performance. The paper examines the performance of the largest pipeline operators in the USA and finds that neither federal inspections or penalties are effective in increasing performance, although the number of federal cases initiated against an operator does have a significant effect on many forms of performance. The paper also includes some controls for state enforcement efforts and finds evidence suggesting that pipelines that operate in states with higher levels of inspections and penalties perform better than pipelines that operate in states with lax controls. This paper seeks to expand upon those findings to better determine how state enforcement efforts affect natural gas pipeline safety and performance. To our knowledge, no other papers have examined this issue empirically.

One of the key dimensions of pipeline safety regulation in the USA is that both the state and the federal government implement and enforce the regulations. The Natural Gas

Pipeline Safety Act of 1968 gives states the right to participate in regulating and enforcing pipeline safety as long as the state meets certain requirements for participation. States must seek authorisation, also known as primacy, to regulate and enforce part or all of the pipeline regulations within their borders. Not all states seek primacy, and some states only seek partial primacy. This paper examines the factors that affect whether a state has primacy for natural gas pipelines from the federal government. It then looks for differences in the level of enforcement efforts and pipeline performance in states that take this additional responsibility compared with states that do not. Finally, the paper analyses the effect of state enforcement efforts on the safety and environmental performance of the natural gas pipeline industry. The remainder of the paper is organised as follows: the next section provides a brief review of the relevant literature; Section 3 briefly describes the natural gas pipeline industry; Section 4 presents an analysis of state assumption of primacy for interstate natural gas pipelines; Section 5 examines state enforcement efforts and the performance of all natural gas pipelines; and Section 6 discusses policy implications and concludes.

2.0 Related Literature

The most relevant literature for this paper is the literature on state regulation and enforcement of industry environmental and health and safety regulations. In this literature there are several distinct strands that are related to this study: papers that examine state assumption of primacy for implementation of a federal regulatory programme; papers that examine the effect of primacy on the performance of regulated entities; and papers that more generally examine the effectiveness of state enforcement efforts at increasing the performance of regulated entities.

In addition to natural gas pipeline regulations, many of the other US environmental, health, and safety regulations passed in the late 1960s and 1970s allow states to assume primary authority for implementing and/or enforcing the federal regulations. Once the federal government has created a detailed regulatory programme, states can apply for primacy to implement parts or all of the regulations in their own state. One of the conditions for approval is that the state programme be at least as stringent as the federal programme, thus preserving the standards set by the federal regulator. Assuming primacy over federal regulation allows states to continue to play a significant role in the design and implementation of their own programmes as long as those programmes are consistent with and at least as protective as the federal programme. In authorised states, the federal government provides partial funding through the use of state grants. The federal agency responsible for a particular programme implements and enforces the programme in states that do not assume primacy. Additionally, in most cases the federal agency can revoke the state's authority to implement or enforce a particular regulation if the state's programme is not consistent with the federal standards.

Each state must make the decision of whether or not to adopt primacy. In a state where citizens are strongly pro-environment and support stringent regulations, state leaders may want to assume primacy in order to provide maximal protection for the environment. Alternatively, states may want to assume primacy in areas where their citizens or business interest favour a more relaxed regulatory stance as a way of protecting their constituents from overzealous federal regulators. Chang *et al.* (2014) develop a model where the federal

authority endogenously sets the federal policy and then allows states to adopt primacy. Their model can generate both scenarios discussed above: cases where primacy is attractive to states that prefer more stringent regulation and cases where states assume primacy in order to weaken enforcement.

A handful of empirical analyses have examined the determinants of state assumption of primacy for a range of US regulations.[1] While the exact variables differ across studies, most include some measure of the severity of the problem the regulation is designed to fix, the role the regulated industry plays in the state economy, and political factors in the state. One of the most consistent findings for environmental regulations is that states with higher levels of industrialisation are more likely to have assumed primacy (Woods, 2005). The other findings tend to vary across studies. For example, even though the assumption of primacy in environmental regulations has been used by many as a proxy for pro-environment attitude on the part of a state, Woods (2005) finds that primacy in US air and water regulations is unrelated to other measures of a state's stance towards environmental issues or policy. Moreover, he finds that states that have assumed primacy in air and water regulations are less likely to have adopted policy innovations in those areas. Conversely, Chang *et al.* (2014) find that US states with stronger environmental preferences assume primacy sooner than less green states for both water and hazardous waste regulations.

Very little has been written on the direct effect of primacy on states' efforts at implementing and enforcing regulatory programmes. One exception is Thompson and Scicchitano (1985) who find that states with primacy for US Occupational Safety and Health Administration (OSHA) regulations have higher inspection and citation rates than states where the federal government implements the regulations, although penalty rates are lower.[2] Instead, a number of papers focus on the effect of primacy on regulatory performance. Recall that in theory states may assume primacy either to increase or decrease the level of regulation. Given the mixed results from studies that examine the factors that drive states to assume primacy, this strand of the literature focuses on determining whether, in practice, assuming primacy increases or decreases the performance or outcomes of regulated firms.

Sigman (2005) analyses the water quality of rivers around the USA and examines whether the primacy status of upstream states impacts the water quality of rivers. She finds that water quality is significantly lower when upstream states have assumed primacy under the Clean Water Act which is consistent with states assuming primacy to weaken the regulatory programme. On the other hand, Bradbury (2006) focuses on state primacy for OSHA regulations and finds that primacy states have a lower rate of fatal injuries. In a related study focusing on the construction industry, Morantz (2009) also finds that state primacy for OSHA regulations significantly decreases reported fatalities, but finds a

[1] Cutter and DeShazo (2007) and Meyer and Konisky (2007) examine a related question — the delegation of regulatory authority from states to local governments.

[2] A few papers have considered a separate but related question — the extent to which state characteristics that are related to the assumption of primacy (political ideology, economic context, and so on) affect a state's implementation and enforcement efforts. See, for example, Davis *et al.* (1989) which examines the characteristics that effect whether a state carries out the requirements of the Surface Mining Control and Reclamation Act of 1977 or Atlas (2007) which examines the characteristics that affect the size of penalties in the RCRA hazardous waste programme.

significant increase of reported non-fatal injuries. One possible interpretation of these results is that rather than absolutely strengthening or weakening a regulatory programme, states with primacy may choose to focus on different aspects of the regulatory programme than the relevant federal agency.

A few studies more generally consider the effectiveness of state enforcement efforts at increasing either compliance with regulations or firm performance. Stafford (2003) considers a wide variety of state efforts at increasing hazardous waste compliance at regulated facilities and finds that the number of state inspections (normalised by state gross domestic product) does not have a significant effect on violations at regulated facilities. In a paper that uses spatial econometric techniques, Gray and Shadbegian (2007) find that state air inspections do significantly increase compliance with air pollution regulations, although they do not have a significant effect on air emissions.

This paper will contribute to these various literatures or regulatory federalism by examining not only the assumption of primacy for natural gas pipeline regulations, but also the effect of primacy on the state enforcement efforts. The paper will also provide insight into the general effectiveness of state regulatory enforcement efforts in achieving the desired outcome — fewer natural gas violations and accidents.

3.0 Overview of the US Natural Gas Pipeline Industry

Pipelines form the primary transportation system for natural gas in the USA. Once natural gas is extracted from a well, it is typically transferred to a gas processing plant via gas gathering pipelines. After being processed, the natural gas is transported — often over long distances — through high-pressure transmission pipelines that deliver the natural gas to the various distribution systems. Lower pressure distribution pipelines then transport the natural gas to various end users — industrial, commercial, and residential. According to the PHMSA, the USA has around 16,500 miles of gas gathering pipelines, 320,000 miles of transmission pipelines, and 2.1 million miles of distribution lines. There are approximately 2,500 natural gas pipeline operators — just over 100 of these operators own pipelines in multiple states while the remaining operators have pipelines in only one state. Pipeline operators may focus on just one type of pipeline (for example, transmission or distribution) or may manage multiple types of pipelines.

Natural gas distributors in the USA have long been subject to regulation by state and local governments as utilities. In 1938 the passage of the Natural Gas Act allowed the federal government to regulate natural gas pipelines for the first time. The Act gave the Federal Power Commission (FPC) jurisdiction over both the interstate transportation and sale of natural gas as well as the ability to set standards for new interstate pipeline construction. In 1977 the FPC's regulatory power over pipelines was transferred to FERC which continues to regulate the siting of and rates for pipelines today. The first statute to explicitly regulate pipeline safety was the Natural Gas Pipeline Safety Act of 1968 which created the OPS within the DOT to oversee and implement pipeline safety regulations. Concern over pipeline safety and dissatisfaction with OPS's performance has led Congress periodically to try to improve the regulation of pipelines through additional legislation including the Pipeline Safety Reauthorization Act of 1988, the 1992 Pipeline Safety Act, the Accountable Pipeline Safety and Partnership Act of 1996, the 2002 Pipeline Safety

Improvement Act, the 2006 Pipeline Inspection, Protection, Enforcement and Safety Act, and the 2011 Pipeline Safety, Regulatory Certainty, and Job Creation Act. Together, these legislative efforts have enabled federal regulations covering a wide range of standards and practices for pipeline materials, design, construction and operation including operator training, emergency response, monitoring, and testing.

As discussed earlier, the Natural Gas Pipeline Safety Act of 1968 gave states the right to participate in regulating and enforcing pipeline safety and established requirements for state participation. Currently states can participate in three different types of programmes:

- 60150(a) Certification — Gives states primacy in both inspection and enforcement of intrastate pipelines;
- 60106 Agreement — Gives states primacy in inspection of intrastate pipelines, but enforcement is conducted by federal authorities; and
- Interstate Agent — Gives states primacy in inspection of interstate pipelines, but enforcement is conducted by federal authorities.

In states without an authorised natural gas pipeline programme, federal regulators are responsible for both inter- and intra-state inspections and enforcement. In addition to

Table 1
State Natural Gas Pipeline Programmes in the USA

States with 60105(a) Certification that also act as Interstate Agents		
Arizona	Michigan	Ohio
Connecticut	Minnesota	Washington
Iowa	New York	West Virginia
States with 60105(a) Certification that are not Interstate Agents		
Alabama	Maine	Oklahoma
Arkansas	Maryland	Oregon
California*	Massachusetts	Pennsylvania**
Colorado	Mississippi	Rhode Island
Delaware	Missouri	South Carolina
Florida	Montana	South Dakota
Georgia	Nebraska	Tennessee
Idaho	Nevada	Texas
Illinois	New Hampshire	Utah
Indiana	New Jersey	Vermont
Kansas	New Mexico	Virginia***
Kentucky	North Carolina	Wisconsin
Louisiana	North Dakota	Wyoming
States with a Section 60106 Agreement		
Pennsylvania (gas cooperatives)	Virginia (municipal systems)	
States without a Natural Gas Pipeline Program		
Alaska	Hawaii	

Notes: *Does not include municipal systems. **Does not include gas cooperatives. ***Does not include municipal systems.

authorising the state programmes, PHMSA also provides grant funding to support state programmes. Currently up to 80 per cent of state programme costs may be funded by PHMSA.

Table 1 provides a list of the states by type of state programme. All of the 48 contiguous states have primacy for intrastate natural gas pipelines. Additionally nine states have primacy for inspection of interstate pipelines. Hawaii does not have any state pipeline programme, which is perhaps unsurprising as it has the lowest number of pipeline miles for all of the 50 states (723 miles) as well as the fewest miles per person (just over half a mile per person). Alaska does not have an independent state pipeline programme. Instead, pipelines in Alaska are regulated by the Joint Pipeline Office (JPO), a unique authority established by Alaska and the federal government in 1990 to coordinate monitoring and overseeing of the Tran-Alaska Pipeline System and a pipeline project to commercialise North Slope gas. The JPO oversees both petroleum and natural gas pipelines within Alaska and the adjoining Outer Continental Shelf.

4.0 State Primacy for Natural Gas Pipeline Regulations

Following the literature discussed in Section 2, the primacy analysis includes explanatory variables that capture aspects of the main three competing explanations for the variance in state environmental policies: the severity of the 'problem' in the state, state ideology and politics, and the economic and institutional context. Unlike some of the primacy papers discussed, this analysis does not try to examine the relationship between factors 'internal' to the states (such as those discussed above) and 'external' factors such as policy diffusion and economic competition among states. The reason for the focus on internal factors alone is based on the particular nature of the natural gas industry. Unlike other sectors where states may compete among one another to try to attract firms to locate in their state, the location of natural gas pipelines is primarily dictated by the location of natural gas deposits, the location of natural gas customers, and geography. Also, recall that all of the 48 contiguous states have primacy for intrastate natural gas pipelines, thus the focus of the primacy analysis is on the differences between states that have primacy for interstate natural gas pipelines. As noted above, because Alaska and Hawaii do not have independent state pipeline programmes, they are not included in the analysis.

Following Woods (2005), the binary dependent variable in the primacy analysis is equal to one if the state has 60150(a) Certification and zero otherwise. I use a probit model to determine which of the explanatory variables have a statistically significant effect on whether a state has primacy for natural gas pipelines. Table 2 presents the variables used in the analysis and their means and standard deviations. The variables can be grouped into three basic categories: variables designed to capture the extent of the potential natural gas pipeline problem in the state; variables designed to capture ideology and politics in the state; and variables designed to capture the economic and institutional context of the state.[3]

[3] An alternative approach would be to model the decision to adopt primacy as a hazard model. However, due to data limitations I was unable to conduct such an analysis. Given that the primacy decision can be revisited by states, this approach focuses not on the timing of the adoption decision itself but rather on the factors that determine whether a state currently has primacy for natural gas pipelines.

Table 2
Variables Used in the Primacy Analysis

Variable	*Description*	*Mean*
Primacy	Equal to one if the state has primacy for interstate natural gas pipelines	0.19 (0.39)
Transmission miles	Miles of natural gas transmission pipelines in the state in thousands	6.71 (9.80)
Gathering miles	Miles of natural gas gathering pipelines in the state in thousands	0.36 (1.01)
Distribution miles	Miles of natural gas distribution pipelines in the state in thousands	25.6 (22.1)
Obama 2008	Equal to one if state voted for Obama in the 2008 presidential election	0.56 (0.50)
Environmental org. revenue	Revenue received by environmental organisations in the state in 2010 in millions	279 (376)
State government ideology	State government ideology in 2010 (100 = most liberal)	52.5 (25.2)
Natural gas production	Natural gas production in billion cubic feet	412 (1,096)
Natural gas consumption	Natural gas consumption in billion cubic feet	460 (580)
Environmental expenditures	Percentage of state expenditures directed toward environment and natural resources in 2010	1.47 (1.21)
Income	Per capita income in 2010 in thousands	38.7 (5.7)
RCRA authorisation	Percentage of RCRA regulations for which state has primacy	83.9 (20.0)

Note: Standard deviations in parentheses.

To measure the extent to which pipelines could endanger human health and the environment, I include the total miles of natural gas pipeline in the state broken out by type of pipeline, as the potential for damage could vary based on the type of pipeline. To capture the politics and ideology of the citizens of a state, I include *Obama 2008*, a binary variable equal to one if the state voted for Obama in the 2008 presidential election. To capture the level of interest in the environment in the state, I include *Environmental Org Revenue* which measures the total amount of contributions received from environmental non-profits in the state in 2010 according to the National Center for Charitable Statistics' Guidestar Database. *State Government Ideology* measures the ideological position of the state government, including the governor and the major party delegations of each house of the legislature, with a higher score indicating a more liberal position.[4]

To capture the economic importance of the natural gas industry to the state, I use two measures from the US Energy Information Administration, *Natural Gas Production* and *Natural Gas Consumption*. To capture the overall importance of the environment to the state, I include *Environmental Expenditures* which measures the percentage of total state government expenditures that go to protecting the environment and natural resources in

[4]I use the ADA/COPE measure of state government ideology constructed by Berry *et al*. (1998) and updated using more recent data, available at http://rcfording.wordpress.com/state-ideology-data/, last accessed 24 June 2016.

Table 3
Results of the Interstate Primacy Probit Analysis

Explanatory variable	*Coefficient*	*Standard error*
Transmission miles	1.38**	0.70
Gathering miles	5.93*	3.01
Distribution miles	−0.07	0.08
Obama 2008	6.44**	2.99
Environmental org. revenue	0.01**	0.003
State government ideology	−0.05*	0.03
Natural gas production	−0.03*	0.02
Natural gas consumption	−0.01	0.01
Environmental expenditures	−0.55	0.91
Income	0.27	0.18
RCRA authorisation	0.04	0.03
Constant	−17.85*	10.64

Notes: *Significant at the 90 per cent level. **Significant at the 95 per cent level.

the state using data from the US Census Bureau's Annual Surveys of State & Local Government Finance. I also include state per capita *Income*. Finally, to capture the institutional capacity of the state to assume primacy, I include the proxy *RCRA Authorization* which measures the percentage of the RCRA hazardous waste programme for which the state has assumed primacy using data from EPA's State Authorization Tracking System.

Table 3 presents the result of the probit analysis of interstate gas pipeline primacy adoption.[5] Focusing first on the measure of the potential size of the problem, note that both *Transmission Miles* and *Gathering Miles* have positive and significant coefficients while *Distribution Miles* has a negative and insignificant coefficient. Given that distribution pipelines are unlikely to cross state boundaries, the insignificant coefficient on *Distribution Miles* is not that surprising. Transmission pipelines are likely to cross state boundaries, so the positive and significant coefficient on *Transmission Miles* is consistent with the idea that states with more potential for damage from interstate pipelines are more likely to have primacy for those pipelines. Gathering pipelines tend to be intra-state. However since gathering pipelines connect to transmission pipelines, gathering pipelines are highly correlated with transmission lines (correlation coefficient of 0.93) which may explain the positive and significant coefficient on *Gathering Miles*.

Turning next to the political and ideological variables, note that all three have significant coefficients. Both *Obama 2008* and *Environmental Org Revenue* have positive coefficients which is consistent with more liberal voters and citizens who value the environment encouraging the state to assume primacy of the interstate pipeline in order to more carefully regulate them. Interestingly, the coefficient on *State Government Ideology* is negative and significant, which is the opposite of what one would expect if liberal state governments wanted to assume primacy to increase oversight of interstate pipelines. One possible explanation is that having controlled for the interests of voters, more liberal state governments

[5]I also conducted similar analyses using per capita and per acre measures where applicable. The results were generally consistent with those presented in Table 3, but the regression presented in Table 3 has the best fit. These additional results are available from the author upon request.

are more willing to trust the federal government to appropriately regulate interstate pipelines.

The negative coefficients on *Natural Gas Production* and *Natural Gas Consumption* are both consistent with the theory that states may want to have primacy to be more strict in regulating interstate pipelines than the federal government and that states with more economic interests are less likely to want to have strict regulations. Put more concisely, states that are more dependent on the natural gas industry are less likely to want primacy over interstate pipelines. Note that only the coefficient on natural gas production is significant at conventional levels, perhaps because the concentrated economic interests of natural gas producers are more salient to states than the more diffuse interests of natural gas consumers. Also note that *Environmental Expenditures* do not have a significant coefficient nor does *Income*. Finally, the extent to which a state has assumed primacy for RCRA (*RCRA Authorization*) also has no significant effect, which is consistent with the literature on primacy which finds that the factors driving primacy tend to be very dependent on the nature of the regulations.

5.0 State Enforcement Efforts and Natural Gas Pipeline Performance

This part of the analysis focuses on state enforcement efforts and their effect on the performance of natural gas pipelines. Initially, I focus on the role that primacy plays in determining the level of a state's enforcement efforts and the performance of its pipelines. I then consider more generally the relationship between state enforcement efforts and natural gas pipeline performance. I measure a state's enforcement efforts using four variables: the number of inspection days at natural gas pipelines in the state, the number of compliance actions conducted, the number of penalties assessed, and the dollar value of penalties assessed. Data on the annual number of inspection days for each state was collected through a Freedom of Information Act request to PHMSA. The data for the other three variables are available from the PHMSA website. Because states vary significantly in the total miles of pipeline in the state from a low of 760 miles in Vermont to over 16,000 miles in Texas, each of the four effort variables is normalised by the miles of gas pipeline in a state. While inspection days and penalty number and dollar value are self-explanatory, the definition of a compliance action is less obvious. According to PHMSA, a compliance action is 'an action or series of sequential actions taken to enforce pipeline regulations'. A compliance action can cover multiple violations and can range from as little as a letter warning future penalties for continued violations to an administratively imposed penalty to a criminal sanction.

Table 4 presents the mean and standard deviation for each of the effort variables for 2009–11 for all 48 contiguous states as well as for primacy states and non-primacy states. I use three years of data to get an overall representation of states' effort levels and conclude the analysis in 2011 to exclude any potential for changes in federal enforcement stemming from the passage of the 2011 Pipeline Safety, Regulatory Certainty, and Job Creation Act. On average states spend just under 30 days a year (88 in three years) inspecting 1,000 miles of pipeline. Over three years, for each 1,000 miles of pipelines states conduct an average of 10 compliance actions and assess four penalties with a total dollar value of just over $23,000. Not surprisingly, as demonstrated by the standard deviations for these effort

Table 4
Mean State Enforcement Efforts per Thousand Miles of Natural Gas Pipelines, 2009–11

Group	*Inspection days*	*Compliance actions*	*Number of penalties assessed*	*Value of penalties assessed*
Overall	88	10	4	$23,053
($N = 48$)	(73)	(32)	(21)	($68,687)
Primacy states	112	3	1	$23,190
($N = 9$)	(72)	(3)	(1)	($37,110)
Non-primacy states	82	12	5	$23,020
($N = 39$)	(73)	(35)	(22)	($74,470)

Note: Standard deviations in parentheses.

measures, there is a wide range of efforts across states. What is perhaps more surprising is the fact that the correlation between these different effort measures is not particularly high: the correlation between inspection days and compliance actions is 0.41 and the correlation between inspections and number of penalties is only 0.13. Compliance actions are more highly correlated with number of penalties (0.67) although the correlation between compliance actions and the value of penalties is only 0.42. As one might expect, the highest correlation is between number of penalties and penalty dollars, with a correlation coefficient of 0.68. Primacy states have more inspection days and a higher dollar value of penalties assessed, but neither difference is statistically significant. Primacy states have fewer compliance actions and penalties assessed per mile, but once again neither difference is statistically significant. Recall that in theory states may adopt primacy both to strengthen or weaken a regulatory programme — these results do not provide compelling evidence that either is occurring across the board with respect to natural gas pipelines.

Even though none of the effort variables are statistically different for primacy/non-primacy states, the real test is not whether the inputs into enforcement are different, but whether the outcomes — that is, the performance of the regulated entities — are different. PHMSA tracks four performance measures that are meaningful for natural gas pipelines: the number of incidents, injuries, and fatalities, and the total value of property damage. PHMSA defines an incident as any event that results in a death or personal injury necessitating in-patient hospitalisation; 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 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 judgement of the operator. Injuries include any injury that requires medical attention. Fatalities and property damage are self-explanatory. As was the case for the effort measures, I use three years of data and normalise the performance measures by the miles of gas pipeline in a state.

Over three years, states experience on average under one incident per 1,000 miles. Injuries are more rare than incidents, with only one injury per 10,000 miles every three years. Thankfully, fatalities are even more rare with only one fatality per 50,000 miles every three years. Property damage is much more common with an average of over $90,000 a year in property damage for every 1,000 miles of pipeline. There is also a lot

Table 5
Mean Performance per Thousand Miles of Natural Gas Pipelines, 2009–11

Group	*Incidents*	*Injuries*	*Fatalities*	*Property Damage*
Overall	0.77	0.10	0.02	$279,447
($N = 48$)	(2.42)	(0.13)	(0.05)	($707,068)
Primacy states	0.39	0.11	0.02	$90,459
($N = 9$)	(0.20)	(0.08)	(0.02)	($48,987)
Non-primacy states	0.85	0.10	0.03	$323,059
($N = 39$)	(2.68)	(0.14)	(0.05)	($779,403)

Note: Standard deviations in parentheses.

of variation in both incidents and property damage, with less variation in injuries and fatalities. Only incidents and property damage are highly correlated, with a correlation coefficient of 0.71. The remaining correlation coefficients are all less than 0.25. Table 5 presents the mean and standard deviation for each of the performance variables for 2009–11.[6] Given that each of the variables measures an undesirable outcome, lower values indicate better performance. Comparing the primacy and non-primacy states, note that in terms of incidents, fatalities, and property damage, primacy states have a better mean level of performance, although the differences are not statistically significant at conventional levels.

Since there are no statistically significant differences in either enforcement inputs or outcomes per pipeline mile across the board for primacy and non-primacy states, the final part of the analysis focuses on the relationship between enforcement inputs and outcomes regardless of primacy. To conduct this analysis, I construct a panel data set of natural gas pipeline performance and enforcement efforts for the 48 contiguous states. The data set consists of annual state enforcement data from 2006 to 2011 and annual state pipeline performance data from 2007 to 2012. I use a fixed-effects time series analysis, lagging the enforcement efforts by one year to mitigate concerns about the potential endogeneity of the enforcement efforts.[7] There is no missing data on either state efforts or performance, thus the panel is both fixed and balanced. Using a fixed-effects model allows one to control for fixed factors that do not change over time including factors that cannot be observed such as the underlying differences that drive some states to adopt primacy and/or additional natural gas pipeline requirements. Thus it focuses on the relationship between the inputs into the enforcement process and the outcomes. In addition to the effort variables, I include three time-varying explanatory variables: *State GDP* to control for differences in the economic conditions in each state and *Natural Gas Production* and *Natural Gas Consumption* to control for differences in the utilisation of pipelines across the states. As was the case for earlier analysis, all variables are normalised by the number of natural gas pipeline miles.

[6]I also considered a 10-year period of performance, 2004–13. The results for those 10 years are qualitatively the same as those for the three-year period reported in Table 7.
[7]An F-test indicated that time fixed-effects did not improve the model.

Table 6
Results of the Fixed-Effects Regression for Pipeline Performance, 2007–12

Explanatory variable (per mile of NG pipeline)	*Incidents per mile*	*Injuries per mile*	*Fatalities per mile*	*Property Damage per mile*
Inspection days$_{t-1}$	7.28	−0.41	0.65	7.91
	(9.77)	(0.31)	(0.69)	(7.38)
Compliance actions$_{t-1}$	1.21	−0.02	0.24	2.35
	(2.62)	(0.11)	(0.24)	(2.32)
Number of penalties assessed$_{t-1}$	−9.14	0.35	−1.81	−9.68
	(13.11)	(0.26)	(2.65)	(14.05)
Value of penalties assessed$_{t-1}$	−0.39**	−0.02	−0.01	−0.22*
	(0.14)	(0.02)	(0.01)	(0.12)
State GDP$_t$	−0.51	0.01	−0.03	−0.40
	(0.41)	(0.01)	(0.03)	(0.31)
Natural gas production$_t$	0.06	−0.02	0.01	0.06
	(0.07)	(0.02)	(0.01)	(0.05)
Natural gas consumption$_t$	0.01	−0.01	0.001	0.02
	(0.01)	(0.01)	(0.001)	(0.06)
Constant	4.69	0.01	0.26	3.31
	(3.14)	(0.11)	(0.21)	(2.40)

Notes: All variables normalised by state natural gas pipeline miles. Robust standard errors in parentheses.
*Significant at the 90 per cent level. **Significant at the 95 per cent level.

Table 6 presents the results of the fixed-effects regressions. For the four lagged effort variables, only *Value of Penalties Assessed*$_{t-1}$ has a consistently negative sign and is significant in two of the four regressions — the regressions for Incidents and Property Damage. These results provide evidence that penalties for pipeline violations can act as an effective deterrent and improve overall performance and safety, since increasing the dollar value of penalties assessed by a state does have the desired effect of decreasing the number of incidents and the level of property damage caused by natural gas pipelines. The fact that there is no significant effect on injuries and fatalities may be due to the fact that injuries and fatalities are less likely to occur in the first place. Additionally, injuries and fatalities may be due to factors that are not easily addressed by enforcement efforts. For example, the fatal New York gas pipeline explosion in 2014 has been blamed on the aging pipeline infrastructure, something that is not directly addressed by pipeline regulations. Thus penalties for pipeline violations may not address many of the root causes of pipeline injuries and fatalities. Note that although *Number of Penalties Assessed*$_{t-1}$ does not have a significant coefficient in any of the regressions, the coefficient is negative in three of the four regressions which also is consistent with penalties having a deterrent effect on poor pipeline performance.

Interestingly, although Stafford (2014) found evidence suggesting that states with greater enforcement efforts encouraged individual pipelines to perform better, this analysis does not find that state inspections have any significant effect. Not only is the coefficient on *Inspection Days*$_{t-1}$ not significant, in three of the regressions the coefficient is positive. This finding is analogous to Stafford's finding that federal inspections do not have a significant effect on individual pipeline performance. The coefficient on *Compliance Actions*$_{t-1}$ is also not significant in any of the regressions and is positive in three of the regressions providing

no evidence that compliance actions in and of themselves without any penalties attached have any effect on performance. One possible explanation for this result could be that compliance actions include a number of different actions that vary significantly in severity and consequences. Thus a letter of warning which may have no consequences is counted the same as the imposition of criminal sanctions. Unfortunately, the data available from PHMSA do not allow one to separate minor actions from more severe ones.

Taken together, these findings are perhaps not that surprising to someone who believes in an economic model of regulatory violations. Such models, based on Becker's (1968) model of crime, assume that a regulated entity's decision to comply with regulations is a rational one based on the objective of profit maximisation. Thus regulated entities only comply with regulations when the cost of non-compliance exceeds the cost of compliance. In such a situation, monetary penalties would be the primary mechanism for states to influence pipeline compliance and in turn those aspects of performance that are most directly tied to compliance. One could argue that overall incidents and property damage are more likely tied to regulatory compliance than injuries and fatalities due to the nature of events (such as explosions) that are most likely to lead to injuries and fatalities. Under the economic model of compliance, other efforts such as inspections and compliance actions would not change behaviour themselves, although inspections and compliance actions may be important intermediate inputs in assessing penalties.

6.0 Policy Implications and Conclusions

The safety and performance of natural gas pipelines is an issue that reappears in the media every time there is a fatal pipeline explosion. Given recent history and an expanding network of gas pipelines, such events are likely to happen again in the not so distant future. In the USA, attention to the issue after a particularly disastrous event has in the past legislative responses to strengthen gas pipeline regulations or increase regulatory enforcement. However, it is not clear that such responses will actually serve to significantly affect the number of injuries and fatalities associated with natural gas pipelines.

Given that enforcement of pipeline safety regulations in the USA takes place at both the federal and state level, this paper examines the role that states play in overseeing natural gas pipelines to better understand what can be done at the state level to improve natural gas performance. Looking first at the drivers behind state assumption of primacy with respect to interstate natural gas pipelines, I find that states with larger networks of gas gathering and transmission lines are more likely to have primacy, perhaps because they are faced with a larger potential problem from gas pipelines and prefer to have the power to enforce regulations for all pipelines, both intra- and inter-state, that pass through their borders. Political factors also play a role, with states with more liberal voters and more pro-environment groups being more likely to have primacy. However states for whom the natural gas production industry is an important contributor to the economy are less likely to have primacy.

Focusing on state enforcement efforts and pipeline performance, I find no statistically significant differences across the board either in enforcement efforts or pipeline performance for primacy and non-primacy states — perhaps because states may not all assume primacy for the same reasons. Thus if states want to increase pipeline performance, assuming primacy

without making other changes is unlikely to increase pipeline performance. When I examine the relationship between state enforcement efforts and performance directly, I find that the one factor that does have an effect on performance is the amount of penalty dollars assessed on natural gas pipelines. However, penalties only have a significant effect for incidents and property damage. These results are consistent with an economic model of regulatory compliance where pipeline operators comply with regulations only when it is cheaper to comply than to not. Increasing penalties is a key factor in making non-compliance more expensive than compliance. If compliance is directly tied to incidents and property damage, then increasing penalties will result in lower levels of incidents and property damage, as we observe. The lack of a significant relationship between penalties and injuries and fatalities could be due to the fact that compliance is not as tightly correlated with injuries and fatalities as it is with incidents and property damage.

If the real concern is decreasing injuries and fatalities associated with natural gas pipelines, then increasing inspections — as is often called for in response to pipeline disasters — does not appear to be the optimal solution. While raising penalties may improve overall compliance and general performance, it is less clear that higher penalties will have the desired effect of preventing additional devastating explosions. To reduce the likelihood of such events and the resulting injuries and fatalities, we need to look for other policy solutions that directly address the root causes of those events.

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