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Public opinion toward hydraulic fracturing: The effect of beyond compliance and voluntary third-party certification

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ABSTRACT

A survey with an embedded experiment was conducted to test how residents would respond to a commitment by oil and natural gas producers to conduct nearby fracking operations in a manner that is more protective of health and the environment than existing state and federal regulations. The experiment specifically assessed how the use of independent third-party certification of operations coupled with "beyond compliance" practices would influence local public support for oil and gas development. The state of Colorado was chosen due to its long history of oil and gas development, its leadership amongst states in advancing fracking, and the current local-level conflicts surrounding oil and gas development. A public opinion survey (N = 390) of a representative sample of Colorado residents found that "green certification" of a production company's activities led to substantially increased levels of support for a hypothetical nearby oil and natural gas project. Our findings suggest that oil and gas developers can obtain greater public support for their projects by voluntarily engaging in practices that are more protective than current state and federal regulations together with third-party certification of those practices. In effect, these coupled actions serve as a mechanism that promotes a firm's "social license to operate".

1. Introduction

1.1. Current state of domestic fracking

The development of energy resources from unconventional reservoirs such as coal-bed methane, tight oil, and shale gas has significantly increased in the United States in the last ten years. The amount of economically proven reserves of natural gas (NG) recoverable from shale deposits has vastly increased largely due to the combination of horizontal drilling and a stimulation technology known as hydraulic fracturing, or “fracking.” We note that while the term “fracking” has traditionally been used in the oil and gas (O&G) industry to specifically refer to a reservoir stimulation process used in the completion phase of development, we use the term to refer to the entire unconventional development process. Such usage is consistent with how the term is increasingly used in the mass media and social science literature.

Fracking has led to sharp increases in both the amount of proved reserves of NG available as well as the actual production of NG in the U.S. Proved U.S. reserves of NG have risen to a peak of 388.8 trillion cubic feet (TCF) in 2014, which represents an approximate doubling of the amount of proved NG reserves available compared to the early 2000s. In addition, production has risen to a peak of 29.3 TCF in 2015 from only 19.3 TCF a decade earlier in 2005 (U.S. EIA, 2017a). The increase in production of NG in the U.S. is geographically concentrated in several major shale plays, including several prolific plays in the Appalachian region, west Texas and the Niobrara play in Colorado. Projections by the Energy Information Agency indicate that NG from shale will continue to play a dominant role in U.S. domestic production for years to come, especially as electricity production continues to substitute NG for coal as a fuel in the generation sector (U.S. EIA, 2017a).

This increased development has been met with both support and opposition in numerous communities around the nation. Public opposition in some communities is driven by concerns about local environmental and public health impacts, global climate change, and the desire for renewable energy. Strong local opposition towards fracking has resulted in delays in the permitting process for developers and mineral rights owners, as well as restrictions or outright bans on the practice in some states and communities. While state and federal regulations are

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intended to minimize harm to public health and the environment from fracking, existing regulations in actual practice are not 100% effective in preventing exposure and harm—a small but growing body of literature is finding some evidence of environmental exposures and damages from fracking at some sites (for a review, see Hays and Shonkoff, 2016).

It is also important to note that there are minimal federal regulations or standards on what constitutes acceptable fracking processes. Because of the lack of federal standards, state regulatory agencies serve as the principal bodies overseeing fracking. State regulations on fracking are specific to the various regions and variable in both their degree of coverage and compliance rigor. Studies assessing the regulatory oversight in states with significant shale gas development have found much variation in the type of regulatory tools used, the number of elements regulated by each state, and the degree of stringency placed on each element (Richardson et al., 2013; Zirogiannis et al., 2016).

1.2. Concerns regarding fracking

Local public concerns about fracking are partly rooted in concerns about public health and safety, but also relate to ecological concerns and possible disturbances to the character of small towns and rural communities. Kreuze et al. (2016) find in a study of Michigan counties that four out of the top five risks cited by respondents could be classified as “ecological risks,” and included concerns such as large use of freshwater supplies, drinking water contamination, and use of chemical additives in fracking wastewater. Wheeler et al. (2015) identify 16 discrete perceived risks associated with fracking, a large majority of which are ecological in nature.

The resulting community resistance towards fracking is arguably the biggest challenge today facing the O&G industry (Fisk, 2016). Hence, there is reason to believe that fracking companies that go “beyond compliance” by taking extra steps to mitigate their ecological footprint may gain increased acceptance from the local community.

There is also concern within industry and among regulators that some developers engage in less environmentally-protective practices than others. This practice variation has led to discussions about a possible voluntary process of “green” certification, whereby a developer could obtain certification from an independent third party to verify their engagement in practices that go “beyond compliance” with applicable federal and state requirements. In effect, the developer would be certified as a “greener fracking company”, allowing that firm to develop an enhanced reputation compared to uncertified competitors.

The idea is not completely theoretical. In fact, the concepts of “beyond compliance” and “third party certification” are already practiced in a variety of industries such as food safety, and modest first steps have also been taken in the O&G industry. For example, a coalition of companies, foundations and non-profit groups based in western Pennsylvania formed the Center for Responsible Shale Development (CRSD), a nonprofit organization that has developed 15 shale development standards and is implementing a certification process for compliance with those standards (Center for Responsible Shale Development, online). Other third-party and industry programs for oil and NG development include: Carbon Disclosure Project (CDP), Houston Advanced Resource Center (HARC), and International Petroleum Industry Environmental Conservation Association (IPIECA).

This list is not exhaustive, and the aforementioned organizations employ programs that differ in scope and objective. Some focus on the establishment of more stringent performance standards; some provide third-party certification (HARC); and some advance information disclosure and reporting on environmental impacts and safety (CDP, IPIECA). It may be too early to assess the impact of such organizations on the extent of real or perceived environmental impacts from O&G operations, but it is feasible to assess whether this type of non-regulatory process could potentially change the degree of public support for a local fracking project.

In this article, we report on a randomized experiment, embedded in an online survey of Colorado residents, to assess whether stricter voluntary standards coupled with independent certification of a developer's practices might positively impact public opinion toward a hypothetical fracking project. To the best of our knowledge, this is the first public opinion study to examine this institutional innovation in the context of shale O&G development.

The paper is organized as follows. Section 2 provides (a) background information to motivate the selection of Colorado as the state for the experiment; (b) a review of the prior literature on public opinion toward fracking; and (c) a description of other applications of voluntary standards and independent third-party certification. Section 3 presents our research design and method of data collection. Section 4 summarizes the data used to answer our research question, including the experimental results from our survey. Section 5 discusses our findings, some limitations, and future research directions, while Section 6 offers some policy implications.

2. Background

2.1. The history of O&G development in Colorado

Colorado presents a fruitful environment for study due to the state's long history of O&G development, trends in local resource booms and busts, the changing demographic composition of the state's population, and the salience of O&G-related issues in state and local politics. Salience is accentuated by two somewhat conflicting values in the state's political culture: the premium placed on environmental preservation and the respect for the rights of private individuals to develop resources on their property.

Colorado has a rich history of O&G production. The state's first producing oil wells date back to 1881 and the state has seen its number of active NG wells more than double from around 20,000 for much of the early-mid 2000's to 45,903 in 2016 (U.S. EIA, 2017b). Additionally, the outcomes from several in-state boom-and-bust cycles in natural resource extraction (e.g., involving gold and silver mining) are suggested to have shaped Coloradans' individualistic perspective and moralistic political culture, thereby influencing attitudes about public policy and government. Surveys affirm that two political cultures, one strongly supportive of development and the other opposed, continue to clash in the political arena (Cronin and Loevy, 2012).

O&G is not a politically partisan issue in the state: Colorado has had two-term governors from both parties that supported O&G extraction, including Republican Bill Owens (1999–2007), and Democrat John Hickenlooper (2011–2019). The former Mayor of Denver, Hickenlooper is a geologist by training who worked in the state's O&G industry before entering elective politics, and is renowned for his efforts to broker compromises between oil companies and environmentalists on the governance of O&G development. He was succeeded by Jared Polis, a Democrat and an accomplished education advocate who represents a progressive constituency that includes the northern suburbs of Denver and the city of Boulder. While Polis had been called an “enemy” of the O&G industry due to his alignment with anti-fracking views, he recently ran in opposition to Proposition 112, which would have significantly reduced the use of fracking for natural gas in the state by extending the mandatory buffer between new wells and homes, schools, waterways and other “vulnerable” areas. Proposition 112 was rejected by Coloradan voters 43–57 (Irfan, 2018; Matthews, 2017; Marmaduke, 2018).

The post-2010 increases in O&G production activity in Colorado triggered an upswing in activism and protests against fracking (Finley, 2015). From 2012 to 2016, the passage of local ballot measures in five cities—Longmont, Broomfield, Boulder (and all of Boulder County), Lafayette and Fort Collins—resulted in moratoriums being placed on development within these jurisdictions. These were struck down by the Colorado Supreme Court in 2016.

Thus, the politics of fracking in Colorado are sufficiently polarized that a voluntary program of stricter standards and independent certification may be a subtle yet protective way to address and alleviate some local concerns.

2.2. Public opinion toward fracking

Building on the work of Wolske and Hoffman (2013), Graham et al. (2015) reviewed over 50 public opinion surveys on fracking from 2010 to 2014 that cover the U.S. population or regional or state samples in the United States. They found that awareness levels of fracking are quite variable (even in states with extensive amounts of fracking), that attitudes are polarized (with the numbers of supporters often – but not always – exceeding the number of opponents), and that attitudes vary significantly by state and locality. A series of recent national Gallup surveys provide some evidence that public opposition to fracking may be increasing (Swift, 2015).

Analyses of previous surveys in Colorado describe a distribution of public opinion that is not dissimilar to the distributions observed in national surveys. A 2016 survey conducted amongst Coloradans identified as actively involved in or knowledgeable about O&G development at the national level or on federal lands asked respondents to "… indicate what [came] closest to [their] current position in relation to O&G development that uses hydraulic fracturing" (Olofsson et al., 2016). The authors report that 19% of respondents said it should be "stopped", 35% selected "limited", 26% "continued at current rate", 15% "expanded moderately", and 8% "expanded extensively". However, there are indications that Coloradans care deeply about the environment, and some citizens are diametrically opposed to O&G production expansion— a repeated survey of Western U.S. state residents identified that 27% of Coloradans polled in 2013 stated that O&G drilling on public lands should be strictly limited, and that figure rose to 39% in 2017 (Conservation in the West, 2017).

Theoretically, the framing of an issue in terms of its costs or benefits has been shown to lead to different levels of support by drawing attention to certain aspects while detracting from other aspects that can be of equal or greater importance— suggesting that public opinion is malleable (Nisbet et al., 2013; Schuldt et al., 2011; Tversky and Kahneman, 1981). Within the realm of fracking, Christenson et al. (2017) showed that providing arguments favoring the economic benefits of fracking led to greater level of support of the technology, but these effects were cancelled out when participants are also given arguments on the environmental risks of fracking. Additional empirical evidence of malleability arising from issue framing of fracking has been documented via risk perception (e.g. Jacquet, 2014; Howell et al., 2017), and word choice (e.g., Boudet et al., 2015; Stoutenborough et al., 2016). Evidence that attitudes appear to be malleable and public concerns about ecological risks associated with fracking lend credence to the notion that providing information about stricter voluntary standards and independent certification might influence the attitudes of residents near fracking operations.

2.3. The theory of voluntary standards and certification

Suppose an energy firm is offered the opportunity to subject its operations to stricter voluntary standards and independent certification. Why would the firm choose to participate, given that compliance with the stricter standards can be expected to impose greater private costs on the firm?

A variety of theoretical explanations have been offered to explain this seemingly paradoxical behavior. Researchers of public policy theorize that legislative gridlock has inhibited the traditional means of policymaking, resulting in industry-led solutions such as labelling schemes and third-party certification to provide the needed oversight (Klyza and Sousa, 2013). Khanna (2001) finds evidence that participation leads to pressures that supply reputational benefit to firms engaged in voluntary agreements, but only mixed evidence on benefits to the fiscal health of participating firms.

When evaluating the motivations for firms to voluntarily adopt environmental policies that are more stringent than required regulatory policies, the literature differentiates between over-compliance and beyond-compliance; the former refers to firms choosing to undertake specific, stringent policies as part of their rational decision-making business agenda, while the latter has been argued by Oates et al. (1989) to potentially result from the sub-optimal outcome of governmental policymaking. In this vein, under the over-compliance scenario, industry is perceived as a passive receptor of public policy, while beyond-compliance scenario paints industry as active creators of policy. This highlights the contributions of industry in serving as an additional arm for public policymaking.

Efforts to understand the motivations for joining a green club have suggested that firms yield private benefits, solving (at least partially) the so-called Harrington paradox (Heyes, 1998) of why firms would behave in more environmentally-friendly ways than required of them by existing public policies. The concept of "green clubs" was created as a means of understanding the "private benefits" generated from self-regulation (Prakash, 2000; Prakash & Potoski, 2012), where the extension of ownership rights is determined internally (Buchanan, 1965; Cornes and Sandler, 1996). Prakash (2000) conceives the formation of green clubs as a means for participating firms to require specified codes of conduct of its members, in return for some excludable and non-rivalrous benefit. Some of these previously unmeasured private benefits include organizational reputation among the audience that is mainly external to its production processes, such as stakeholders, consumers, environmental groups, and the general public, as a means of product differentiation, or as a form of risk management (Giovannucci and Reardon, 2000; Konefal et al., 2005; Reardon and Farina, 2001). Empirical literature testing the effectiveness of green clubs in improving the member firms' compliance with existing regulation has been invalidated by some within the International Organization for Standardization (ISO) literature (King and Lenox, 2000; Welch, Mazur and Bretschneider, 2000) but affirmed in others (Arora and Cason, 1996; Khanna and Damon, 1999; Potoski and Prakash, 2005; Russo and Harrison, 2001).

Another important strand of the voluntary, non-regulatory approach toward enhanced environmental performance is third-party certification. While the evaluation of third-party certifications and their importance in the food safety industry has been richly researched, to date, no one has fully analyzed the contributions of third-party certification organizations relative to the shale O&G extraction industry. The five concepts of the information economics framework proposed by Deaton (2004) —uncertainty; information asymmetry; opportunistic behavior; divergence between private and social returns; and signaling institutions—apply to an analysis of motives for private companies to seek third-party certification. For example, a mixed level of knowledge amongst the public reflects both uncertainty of the risks and benefits of fracking and information asymmetry between O&G operators and the public. The O&G industry, as with other extractive industries, is often viewed as "opportunistic", extracting the valuable natural resources from an area and then leaving once it is depleted. The divergence between private and social returns from energy production have been documented by the energy injustice literature, which calls fracking sites "energy sacrifice zones" or "national sacrifice zones" (Hernández, 2015; Carre, 2012). Although this paper builds on these four concepts, we focus on the ability for third-party certification to serve as a signaling institution.

Housed in the information economics literature, signaling theory contends that the degree of improvement in safety and law compliance hinges on the independence of the third-party organization to document performance by an industry and signal quality assurance to the consumer. Third-party certifiers are defined as external institutions that independently provide assessment, evaluation, and certification on

quality claims by companies (Deaton, 2004). A failure to convey true independence reduces consumer confidence that the information conveyed via their certification is impartial and objective (Zuckerman, 1996; Tanner, 2000). Within the agrifood system, Hatanaka and Busch (2008) note an increasing use of third-party certification in the proliferation of voluntary standards due to advantages such as objectiveness arising from independence from other actors in supply chains, favorable views of buyers and governments, lower relative costs for undertaking certification, and superior effectiveness rates in identifying non-compliance. In short, certification signals reputation for quality and trustworthiness in the agrifood system, but little is known about whether public concerns about fracking might be allayed by a similar certification process.

The goals and application of third-party certification bodies for enhanced food safety within the food systems industry could provide many parallels to the O&G extractive industry— in both industries, third party certifiers provide assurance (via certification) to consumers of the efficacy of a company's efforts to maintain a given quality or performance standard. In the context of our research experiment, we assess what would be the impact on public acceptance of a hypothetical NG developer if the developer had voluntarily adopted a third-party certification of more environmentally stringent operations versus only complying with required existing O&G development regulations.

2.4. Summary of literature contribution

To the best of our knowledge, no study has explored the effects of non-regulatory, privately-generated performance standards used in combination with independent third-party certification on public opinion toward fracking. In a broader sense, this article introduces an interesting new variable to the rapidly developing literature on factors influencing public attitudes toward fracking. We theorize that coupling industry best practices that go beyond regulatory compliance with third party certification generates a causal impact on respondents' perceptions of risks and benefits, leading to greater levels of support for a fracking project, even when the project is within the respondent's residential community.

3. Methods

3.1. Survey sample

The authors designed and developed a survey to assess public awareness, factual knowledge, and attitudes toward fracking. The GfK Group was commissioned to administer the survey in the fall of 2016. Specifically, we sampled the population of English-speaking non-institutionalized adults (aged 18 and over) who reside in the state of Colorado.

The sample was drawn from GfK's proprietary KnowledgePanel®, a probability-based online panel. GfK recruits its online panel members using address-based sampling from the United States Postal Service Delivery Sequence File, thereby providing nearly complete coverage of US household addresses. Recruited panel members without internet access are provided with a computer and internet access for panel participation. This panel provides samples that are representative of the United States population. Probability-based internet panels have advantages compared to random-digit dialing telephone surveys and other methods, including the potential for reduced measurement error, lower cost, and increased timeliness of response (Chang and Krosnick, 2009; Yeager and Krosnick, 2010). The online survey was conducted between September 8–22, 2016. Non-responders to the initial survey notification email were prompted to respond on days three and thirteen of the fielding period.

A total of 416 completed surveys were obtained with a completion rate of 59.5% among panel members. This completion rate is comparable to other KnowledgePanel® surveys. We considered concerns regarding non-response bias insofar as those with strong opinions about fracking might be more likely to participate. Those concerns are mitigated since panel members were told only that the survey is about energy issues. Respondents did not know that the survey was about fracking prior to their decision to participate. Of the 416 completed cases, 21 cases were removed due to short duration time (4 min or less, as compared to a median of 11 min completion time). Short response time is used to identify individuals who may complete the survey without reading and carefully answering the items (Olson and Parkhurst, 2013). Five additional cases were removed due to evidence of poor reporting including straight-lining and missing data.[1] Ultimately, 390 cases were determined by the authors to be valid cases for analysis. All the valid cases responded to the experimental arm questions, avoiding concerns of potential response bias. The experimental groups were also checked to determine appropriate randomization into experimental conditions by ensuring balance on multiple respondent demographics (results available upon request).

A post-stratification weight was used to increase external validity. The weight accounts for any differential nonresponse that could arise in the fielding period and was created to make the demographic characteristics representative of the state of Colorado. The weight was constructed by GfK using state-level benchmarks from the 2015 American Community Survey Data (ACS) based on the following variables: gender by age; race/ethnicity; metropolitan status; education; and household income. By utilizing Stata ® procedures for complex survey features for analysis, we obtain estimates and standard errors that account for weighting.[2] This weighting and the use of address-based sampling help ensure the representativeness of the sample.

A comparison of weighted sample estimates and ACS population estimates is provided in Table 1. The proportion of respondents closely matches the population proportions on major demographic characteristics.

3.2. Variable measurements

3.2.1. Awareness and Knowledge

The survey begins with a series of awareness, knowledge and attitude questions. The design of the question sequence allows us to compare pre-conceived attitudes toward fracking, prior to exposure to the treatment, to post-treatment attitudes. Before comparing the attitude measurements, we report basic data on awareness and knowledge.

Table 2 below shows the weighted distribution of responses to one general awareness question and four "True-False" knowledge questions. Levels of awareness are high: almost all respondents (96%) reported having heard or seen something pertaining to fracking prior to the survey. However, overall knowledge about O&G development was mixed. Respondents were largely correct about the basic inputs to the hydraulic fracturing process (87%) and that the fracking process may be carried out off-shore as well as on-shore (72%). However, a large share of respondents (63%) were incorrect that fracking typically occurs 50 feet below the water table; it typically occurs hundreds to thousands of feet below the water table. Additionally, only a quarter (26%) of the respondents correctly identified that fracking is not

[1] We determined cases with evidence of poor reporting to be those respondents who gave the same answer to five or more survey questions in a row, for which respondents should provide different answers, and those who chose not to answer multiple survey questions. This suggests that these respondents were not carefully considering their answers to the questions. Removing cases such as these is standard practice in cleaning survey data from web panel survey respondents.

[2] Calculating appropriate standard errors that incorporate the effect of weighting generally increases standard errors relative to unweighted survey data. This bolsters our later finding of statistically significant opinion shifts, as larger standard errors make it relatively more difficult to detect statistically significant effects.

Table 1
Comparison of sample respondents to ACS 2015 Colorado state-wide estimates.

	KNPanel Weighted % (n = 390)	ACS 2015%		KNPanel Weighted % (n = 390)	ACS 2015%
Race/Ethnicity			Household Income		
White, Non-Hispanic	76.0	72.3	Under $25,000	13.2	12.3
Black, Other, or 2+ Races/Non-Hispanic	6.3	9.3	$25,000 to $49,999	20.8	19.6
Hispanic	17.8	18.4	$50,000 to $74,999	19.2	18.7
			$75,000 to $99,999	14.7	14.7
			$100,000 to $149,999	18.2	18.9
			$150,000 and over	14.0	15.9
Age Group			Metropolitan Status		
18–34 years	28.7	31.6	Non-Metropolitan Resident	14.7	13.7
35–44 years	17.6	17.8	Metropolitan Resident	85.3	86.3
45–54 years	17.8	17.1			
55–64 years	17.8	16.6			
65 + years	18.2	17.0			
Education			Employment Status		
Less than High School /High School	31.3	31.5	Employed	64.9	63.8
Some College	33.1	31.8	Unemployed	4.0	4.7
Bachelor's Degree or Higher	35.7	36.7	Not in Labor Force	31.1	31.6
Gender					
Male	47.7	49.6			
Female	52.3	50.4			

Table 2
Summary statistics on awareness and general knowledge of respondents.

Variable	Question	Descriptive Statistics
AWARENESS	Before this survey had you ever seen or heard anything about the terms "hydraulic fracturing" or "fracking"?	Mean: 0.96
		SD: 0.02
	Yes (%)	95.9%
	No (%)	4.1%
KNOW1	A large volume of water, along with sand and chemicals, is used in the fracking process. (TRUE)	Mean: 0.87
		SD: 0.03
	Correct (%)	86.9%
	Incorrect (%)	13.1%
KNOW2	Fracking is typically conducted about 50 feet below the water table. (FALSE)	Mean: 0.37
		SD: 0.04
	Correct (%)	36.6%
	Incorrect (%)	63.4%
KNOW3	Fracking can be carried out on land or at sea. (TRUE)	Mean: 0.72
		SD: 0.04
	Correct (%)	72.4%
	Incorrect (%)	27.6%
KNOW4	Fracking is allowed to be regulated by local governments, as ruled by the Colorado Supreme Court. (FALSE)	Mean: 0.26
		SD: 0.04
	Correct (%)	26.2%
	Incorrect (%)	73.8%

allowed to be governed at the local level. This matter was clarified in a 2016 decision of the Colorado Supreme Court.

Taken together, our data suggest that while Coloradans have a high level of awareness of fracking, their level of knowledge on the technical aspects of the process are mixed and understanding of the local governance aspects is low.

3.2.2. Attitudes

In the next part of the survey, respondents were given basic information about the fracking process, asked about their general favorability or unfavorability toward it, and asked to rate the importance of several positive and negative claimed impacts. We report the findings from the general question about favorability toward fracking in Table 3.

As expected, attitudes toward fracking in Colorado are divided. The share of those with favorable reaction (59%) is greater than that with unfavorable reaction (40%) but notice that more than two thirds (68%) of respondents are clustered in the two middle categories. The more moderate opinion of the sample majority suggests that there may be an opportunity for informational interventions to change attitudes of those sitting “on the fence”.

Table 3
Summary statistics on general attitude of respondents (n = 390).

Attitude1: Based on the information you just received and anything you may have heard, read or observed before this survey, how do you feel about fracking as a way to produce oil and natural gas?

Response options:

Strongly unfavorable	15.4%
Somewhat unfavorable	25.4%
Somewhat favorable	42.9%
Strongly favorable	16.3%
Total	**100%**

Mean: 2.60, SD:0.07.

3.3. Experimental set-up

At the end of the survey, each respondent was provided an identical hypothetical project scenario with the following information:

> “Suppose that an energy development company (the “operator”) has determined that fracking for oil and natural gas in your community is very promising. Some of the proposed sites are located about two miles from where you live.

Table 4
Percent of respondents by support for local fracking project and experimental group assignment (n = 390).

	Experimental group assignment		
	No third-party certification (Control)	*Third-party certification (Treatment)*	*Difference (T-C) in percentage points*
Level of support for local fracking project			
Strongly oppose	26.9	23.2	− 3.7
Somewhat oppose	22.4	7.4	− 15.0
Somewhat support	30.3	52.1	21.8
Strongly support	20.4	17.4	− 3.0
Total	**100.0%**	**100.0%**	

Design-based F(2.82, 1098.89) = 3.6761Pr = 0.014.

The state authorities who regulate oil and natural gas development have evaluated the project to be compatible with Colorado's rules and regulations. The operator has demonstrated to the state regulators that the project, **if** carried out as approved and permitted, will not appreciably damage air, land or water quality, or lead to an increased risk to citizen's health and safety. The activities of the operator will be monitored prior to, during and after production to ensure that there are no significant risks or damages from the development. However, accidents still have occurred.

Experience in other areas indicates that oil and natural gas development **can have both positive and negative impacts**. Positive impacts can include direct job creation, economic stimulus in the area, and energy security for the nation. Negative impacts can include a sharp increase in truck traffic, damage to local roads, and a decline in a community's quality of life, and there can be potential environmental damages to air, water and ecosystems without appropriate monitoring prior to, during, and after production. These positive and negative impacts are still being analyzed by researchers."

The distance of two miles was selected based on hedonic study findings of the impacts of nearby unconventional O&G development on home prices (Boxall et al., 2005; Delgado et al., 2014; Gopalakrishnan and Klaiber, 2013; and Muehlenbachs et al., 2013a, 2013b). The order in which respondents were exposed to the positive and negative impacts in the last paragraph of the scenario was randomized to negate potential ordering effects. Respondents were then randomly assigned into a treatment or control group. The treatment group received the following additional information:

"A respected third-party certification organization "Cleaner Fracking Practices" has developed a set of voluntary performance standards for fracking operators that are stricter than applicable state and federal standards. This organization offers a certification to operators that undertake the following practices:

1. Choosing the safest fracking fluids;
2. Special practices to protect surface and groundwater quality;
3. No venting of flammable gases; and
4. Periodic monitoring of environmental quality for up to one year after well completion

Most operators do not seek this voluntary certification because it is considered too costly to obtain. The operator planning to work in your community has obtained this voluntary certification, and has passed rigorous auditing to ensure safer and cleaner fracking practices."

The four practices above were selected from reviews of lists on certified practices and are commonly cited potential environmental impacts from fracking. The control group did not receive any information about strict voluntary standards or third-party certification.

Respondents were then asked: "Given this background information, would you support or oppose the proposed oil and natural gas development project in your community?", and response options were presented using a four-point Likert scale from "strongly support" to "strongly oppose".

For brevity, this paper refers to the treatment variable of using voluntary, beyond compliance standards and obtaining third-party certification simply as "third-party certification". In other words, the treatment presumes voluntary standards that are stricter (more protective of health, safety and the environment) than the minimum standards required in federal and state regulations in conjunction with receiving external audits.

3.4. Analytic methods

The treatment effect is calculated simply by measuring the difference in the average response of the treatment and control groups. Capitalizing on the random assignment of participants in this experimental design, we obtain unbiased and representative estimates of the treatment effect.

4. Data analysis and results

To test our main hypothesis, we compared the percentage of respondents who reported supporting the local project across the treatment and control groups. We found evidence that the level of support is strongly associated with third-party certification; this relationship is statistically significant at the 0.01 level. Overall, we find that the treatment exposure was associated with decreased opposition and increased support for the local project, as indicated in Table 4.

Collapsing the four-categories of support/opposition into a binary grouping of "support/oppose", we find that 69% of those who received the treatment support the project, which corresponds to an 18%-point increase over the control group. Inspecting the four-category responses, we find that 23% of the respondents who received the treatment condition strongly opposed the local project, while 7% somewhat opposed the local project. In comparison, 27% of the respondents in the control group strongly opposed the local project and 22% were somewhat opposed to the local project. These findings indicate that the experimental treatment induced a 4%-point reduction in strong opposition and a 15%-point reduction in weak opposition.

We also find that the largest difference between treatment and control groups occurred in the category of "somewhat support", where being informed of the third-party certification resulted in a 22%-point increase in support for the local project. This suggests that the greatest shifts come from respondents who are "on the fence" in their attitudes toward fracking— a sizeable group in the population.

Surprisingly, the treatment resulted in a lower proportion of

respondents providing strong support for the local project. This corresponds to only about 3 individuals in the weighted survey results, is not a statistically significant difference, and can be accounted for by sampling and nonsampling error.

To ensure the effect sizes are robust to differences in the composition of the treatment and control groups, we assessed balance and found no significant difference in knowledge level as measured in this survey among treatment and control group respondents at the 10% significance level. Knowledge was measured by averaging the number of correct responses to the knowledge items shown in Table 2.

As a further check, we regressed the unweighted average knowledge score of the respondent on the level of support for the fracking project. The small correlation estimate (0.04) suggests that the level of support for the hypothetical project is unrelated to the respondent's level of knowledge of fracking as measured in our study. We also checked for balance on demographic characteristics plausibly associated with support for fracking. We found that the treatment and control groups were similar on those characteristics as well.

In seeking to understand how the treatment variable may have influenced the attitudes of respondents across multiple attitude measures, we compared each respondent's initial attitude toward fracking at the start of the survey to the respondent's attitude toward the local fracking project framed at the end of the survey. We expected that respondents without strong opinions at the outset are more likely to be influenced by the treatment. While the two questions are not directly comparable, since the first attitude question references general attitude toward fracking while the experimental question references attitude toward a hypothetical local fracking project proposed in the respondent's community, the comparison provides some insight as to which respondents are reacting to the treatment.

Comparing responses to the general favorability toward fracking question and support for the local fracking project is attractive for analytical reasons: both questions assess opinion on a 4-point Likert scale and measure similar concepts of favorability and support; moreover, since the general favorability question was posed at the outset of the survey, it avoids potential contamination from subsequent survey questions and framing effects resulting from the stimulus of the survey.

We report our findings below in Table 5 and note that our findings are statistically significant using a Rao-Scott corrected chi-squared test at the 1% significance level.

We find that in both the treatment and control groups, about three quarters (76%) of respondents expressed the same general attitude toward fracking as when asked for their support or opposition to a local fracking project. However, inspecting the switchers, we observe that the treatment variable induced a 13-percentage point increase (from 6% to 19%) in respondents that initially opposed fracking (generally) but then supported the local project in the experiment. Alternatively, without the treatment, 18% of respondents switched from support to oppose when asked about the hypothetical project while only 5% of respondents in the treatment group moved to opposition.

Table 5
Identification of switchers from prior attitude toward fracking to support for hypothetical local fracking project by experimental group (n = 390).

	Experimental Group assignment	
Tracking switch in general support for fracking to support for local fracking project	*No third-party certification (Control)*	*Third-party certification (Treatment)*
Support/opposition unchanged	75.5	76.0
Switch from oppose to support	6.2	19.1
Switch from support to oppose	18.3	4.9
Total	**100.00%**	**100.00%**
n:	192	198
Mean:	0.43	0.29
SD:	0.1	0.05

Overall, the data support our earlier finding that third-party certification may positively influence public support for the fracking project. In fact, the larger percent of respondents in the control group who switched from support to oppose further suggests that our effect sizes are a conservative estimate of the true extent of changes in attitude.

5. Discussion

Overall, we find that public opinion in Colorado toward a hypothetical nearby fracking project becomes more favorable when the developer pledges to adhere to stricter standards than required by the government and is certified to those standards by an independent third party. The size of the attitude change is substantial and, due to the randomized experimental design and other supporting tests, is unlikely to be explained by extraneous factors.[3]

Additionally, we found that Coloradans have a high level of awareness of fracking, suggesting high salience, yet we find a mixed level of general knowledge of fracking and a low level of understanding of recent governance aspects. Together, these findings paint a picture of a population whose views on fracking are still somewhat malleable. Our evidence of malleability, coupled with the seeming ability of the treatment variable to overcome some initial resistance towards the hypothetical project, is an important finding.

The “social license to operate” (SLO) literature offers a useful framework to understand the mechanism for the experimental treatment. The literature has identified key components to cultivating a SLO—basic acceptance, approval, and perceptions of trust (Thomson and Joyce, 2008) and psychological identification (Thomson and Boutilier, 2011). We argue that the beyond compliance standards foster greater acceptance and approval for the project, while the third-party certification enables greater trust by the community towards the developer.

Additionally, SLO is grounded in the theory that communities and environmental groups hold real power to adversely impact firms that are perceived to threaten the objectives that they hold dear (Gunningham et al., 2004). The literature suggests that the relationships between community stakeholders and company personnel are crucial for developing a social legitimacy for firms to operate under, and that these relationships should be viewed as equally important as other operating impacts such as environmental degradation and nuisance concerns. Parsons (2014) offers that this social license should be viewed as a continuous, interactive process to be sustained over the life of the project so that public acceptance or approval of the activities of a corporation can be cultivated.

While this paper yields an interesting finding with important implications for future O&G development using fracking, there are some notable limitations that need to be addressed in future research.

First, the positive effects of voluntary standards and certification were demonstrated in an uncontested survey environment. No criticism of the voluntary standards, certification process, or the integrity of the developers or certifiers was included. Future research should seek to replicate our experiment in a more contentious environment, perhaps more reflective of the future of O&G development. At the same time, the survey presented current federal and state regulations in a respectable manner. If instead respondents are exposed to harsh criticisms of current regulatory requirements, then certification to higher (more protective) standards may seem even more appealing than what we found.

Second, our experiment cannot parse out the individual contributions of beyond compliance and independent, third party certification.

[3] The significance tests described in Section 4 demonstrate that the experimental and control groups were relatively well-balanced across a number of demographic and knowledge characteristics. Therefore, it is unlikely that any of these factors are responsible for the large shift in opinion that we attribute to our experimental treatment.

Instead, our findings demonstrate the interacted effects of voluntary decision by a developer to abide by stricter standards and be audited by a third-party for compliance. The separate components of the institutional innovation merit further analysis.

Third, our experiment describes a hypothetical fracking project, but the components we studied parallel attempts by the CRSD in western Pennsylvania. CRSD is a collaborative organization that promotes voluntary performance standards and encourages energy companies to apply for a third-party certification of the operator's compliance with CRSD's performance standards. It may be useful to evaluate public reactions to voluntary standards and certification in Pennsylvania, thereby removing some of the "hypothetical" nature of the local project. Additionally, it might be useful to conduct qualitative research in western Pennsylvania, such as interviews with local officials and residents, to determine whether and how the activities of CRSD impact attitudes toward fracking.

Fourth, our findings were obtained from a sample of Colorado residents, and thus may have limited generalizability beyond the state borders. However, three compelling points reduce this limitation—1) Colorado is perceived to have some of the most stringent regulations regarding the use of fracking technology (Busch and Maxwell, 2013; Hirji et al., 2014; Vig and Kraft, 2012); 2) many states such as Texas, Pennsylvania and Michigan have a long history of O&G production that may factor into future development trends (Schenk et al., 2014); and 3) while some demographics of Colorado may be unique in a state-to-state comparison, they may be more comparable to more densely populated counties or metropolitan areas in other states, and thus improve the external validity of our findings. An easy way to overcome this is to reweight the sample accordingly.

Lastly, our experiment does not fully explore the motivations driving respondents whose level of support is *not* enhanced by the treatment variable. Following Spence (1973)'s argument of the importance of countervailing institutions and Tanner's (2000) emphasis on the importance of independence, respondents whom this treatment variable has failed to positively influence could potentially harbor distrust over the true independence of these countervailing institutions. For example, CRSD states as two of the general requirements for auditing firms (AF):

- "The AF shall show evidence that its management system has been accredited to ISO 17201 for EMS (ISO 14001), OHSAS, ACC RCMS or RC 14000 management system certification by an accreditation body that is a member of the International Accreditation Forum (IAF).
- **Or** the AF should be audited by the CRSD to verify that its management system meets the most current edition of ISO/IEC 17021 and the requirements for CRSD accreditation." (bolded for emphasis) (Center for Responsible Shale Development, 2013).

This potential lack of independence between CRSD and the auditing firm (third-party certifier) can be illustrated in Fig. 1 below. The dotted arrow indicates a direct relationship between the standardizing body and the third-party certifier, thus suggesting a violation of independence. The option of the second general requirement violates the independence that Tanner (2000) notes is critical for assessment by third-party certification bodies. This finding has important ramifications for the "green clubs" who seek to maximize their gains, and for firms shopping for membership into these various "clubs". Such a theory is not tested in this paper, and requires further research to determine causality.

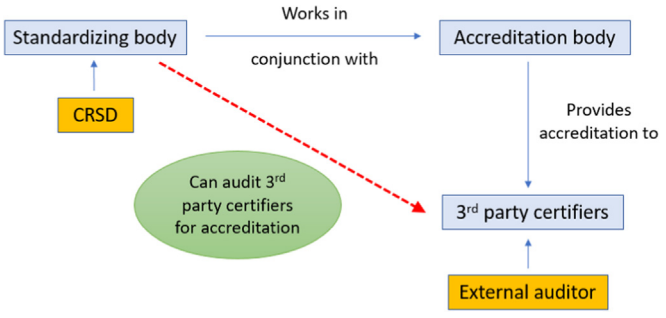

Fig. 1. An illustration of a lack of organizational independence between third-party certification bodies and performance standard initiators.

6. Conclusions and policy implications

Using a rigorous, randomized experimental design with a representative, state-level sample, this study shows that in a population with high levels of awareness, mixed levels of knowledge and divisive attitudes towards fracking, public opinion toward a hypothetical local fracking project improves if the developer makes a voluntary decision to adopt practices that adhere to stricter (more protective) standards than the minimum requirements found in state and federal regulations, and obtains certification from an independent third party for successfully complying with these practices. While our findings were obtained in the State of Colorado, O&G production developments in some other jurisdictions are trending in the same direction as Colorado. Specifically, polarized jurisdictions such as Pennsylvania may be disinclined to prohibit unconventional gas development altogether, and voluntary industry efforts that strengthen public health and environmental protection may have substantial appeal. As unconventional methods are used more internationally (e.g., the United Kingdom, South Africa and Poland), voluntary protection efforts that go "beyond compliance" with regulation may also be given serious consideration.

Our findings highlight the possibility of multiple benefits arising from voluntary third-party certification in the O&G sector. For shale O&G developers searching for ways to reduce community opposition toward specific projects, the findings here suggest a potential for reputational improvement via voluntary participation in a "green club". Particularly when public opinion is malleable, the voluntary policies, though somewhat costly, may yield significant private benefits for the firm.

Over the history of environmental regulation, we have seen the shift away from command-and-control regulations to more flexible policy instruments that safeguard the environment. As noted in earlier sections, self-regulation by multiple industries on various dimensions is on the rise. If the opportunity for certification triggers pro-green competition between developers, it is possible that additional environmental protection may be provided by multiple firms, resulting in a race to the top.

For government bodies, the addition of voluntary, privately-generated performance standards can complement their existing body of regulations and simultaneously serve as potential directions for continuous upgrading of regulatory standards over time, lowering regulatory burden. When regulatory standards are upgraded, resistance from industry may be reduced if it is apparent that compliance with these standards has been demonstrated voluntarily by some firms.

Finally, while this paper does not offer an analysis of the marginal environmental benefit of these voluntary practices, it is well known that state regulations of O&G practices vary considerably in rigor, protectiveness, and real-world enforcement. Where state regulation is weak or poorly implemented, merely going beyond the state regulatory practice may lead to important and significant reductions in the environmental impacts of fracking operations, but still fall short of ecologically-sensitive practices. Additionally, as more firms join the "green club", the total environmental benefits should increase.

While these suggested benefits seem promising, our results suggest that the overall impact of voluntary standards and certification on public opinion toward fracking will be limited, as only a fraction of people will be influenced by voluntary standards and certification. We

found that attitudes may change primarily among respondents whose baseline opinion is tentative or not strongly held, and that these changes are unrelated to how knowledgeable the public is as measured in our study. We offer little evidence that strong opposition to fracking can be overcome through the treatment provided.

Overall, our study suggests that policymakers and stakeholders should consider more widespread use of voluntary "beyond compliance" standards and third-party certification. While such effort will entail some costs, the potential for environmental and human health benefits, reduced operative costs incurred by industry and lower regulatory burden highlights the possibility for a quadruple win. The enhanced public trust that positively influences government, industry and the general public, is important, as the literature on SLO suggests, to ensuring a stable political environment for new and emerging technologies, and should not be underestimated.

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