

# Firm Visibility and Voluntary Environmental Behavior

*Evidence from Hydraulic Fracturing*

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Zhongmin Wang

1616 P St. NW  
Washington, DC 20036  
202-328-5000 [www.rff.org](http://www.rff.org)

# **Firm Visibility and Voluntary Environmental Behavior: Evidence from Hydraulic Fracturing**

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## **Abstract**

Larger firms are often found to be more likely to participate in voluntary environmental programs, but few studies have investigated the mechanism through which firm size matters. This paper studies oil and gas firms' likelihood of voluntarily disclosing information about hydraulic fracturing, an industrial process that has revolutionized the natural gas industry and involves the use of toxic chemicals. I find evidence that it is through firm visibility that firm size matters in this context. My findings suggest that voluntary approaches to environmental protection are unlikely to be effective if many targeted firms are not visible to the public.

**Key Words:** voluntary environmental behavior, information disclosure, corporate social responsibility, hydraulic fracturing, firm visibility

**JEL Classification Numbers:** D21, M14, and Q50

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# Firm Visibility and Voluntary Environmental Behavior: Evidence from Hydraulic Fracturing

Zhongmin Wang\*

## 1. Introduction

A growing economics literature has studied voluntary approaches to environmental regulations, including voluntary environmental programs established by regulatory agencies and industry self-regulation (Khanna 2001). An important question of this literature is firms' motivations for participating in voluntary programs, and a common finding is that larger firms are more likely to participate (e.g., Arora and Cason 1996; Videras and Alberini 2000; Kim and Lyon 2011). This literature recognizes that firm size matters through several potential mechanisms but has not attempted to investigate which specific mechanisms really matter. For example, in their study of what motivates a firm to formulate an environmental plan, Henriques and Sadorsky (1996) argue that firm size could reflect firm visibility, but they did not measure firms' visibility. The management and business ethics literature (Smith 2013) has also recognized that firm size matters when it comes to corporate social responsibility (CSR), but few studies in that literature have empirically investigated why firm size matters (Bowen 2000).

In this paper, I study oil and gas firms' voluntary disclosure of fracturing information at FracFocus, a hydraulic fracturing registry website created, in response to public pressure, by two quasi-governmental organizations and supported by oil and gas industry associations. Hydraulic fracturing, an industrial process that has revolutionized the natural gas industry in the United States, involves injecting large volumes of fluids, including chemicals, at high pressure into the rock to create fractures through which oil and gas may flow out. I find strong evidence that it is firm visibility through which firm size affects firms' disclosure probability at FracFocus. In regressions that do not consider measures of firm visibility, firm size has a positive effect, but in regressions that include measures of both firm size and firm visibility, firm visibility has a positive effect but firm size no longer has a positive effect.

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\* Zhongmin Wang, Resources for the Future, 1616 P St. NW, Washington, DC 20036, [wang@rff.org](mailto:wang@rff.org), 202-328-5036. I thank DrillingInfo and Pennsylvania Department of Conservation and Natural Resources for providing data; Eun-Hee Kim, Tom Lyon and Jan Mares for helpful comments; Alex Egorenkov, Xu Liu, Kuangyuan Zhang, and Jackie Ho for research assistance; and Alan Krupnick and the Center for Energy and Climate Policy at Resources for the Future for financial support. Any remaining errors are mine only.

My findings suggest that voluntary environmental programs suffer from the weakness that firms of low visibility are much less likely to participate. This weakness is especially problematic if many targeted firms have low visibility, as in the hydraulic fracturing industry: my sample includes 238 firms, and most of these firms were never mentioned in the news media during the two-year period immediately before FracFocus was created. My findings thus suggest that mandatory disclosure regulations may be needed in such settings. Indeed, a few states have passed regulations that mandate oil and gas firms to disclose at FracFocus.

My paper is related to the vast CSR literature (Kitzmueller and Shimshack 2012) because voluntary information disclosure is a CSR activity. According to Commission of the European Communities (2006, 2), CSR “is about enterprises deciding to go beyond minimum legal requirements and obligations ... to address societal needs. Through CSR, enterprises of all sizes ... can help to reconcile economic, social and environmental ambitions.” The EU definition specifically mentions enterprises of all sizes, but scholarship on CSR has focused largely on large corporations. The economics literature on voluntary approaches to environmental regulations has also focused mostly on large corporations (e.g., Videras and Alberini 2000; Kim and Lyon 2011). Recognizing this glaring gap in CSR research, the business ethics literature has called for more CSR research on small and medium-sized firms (Spence and Rutherford 2003; Moore and Spence 2006; Morsing and Perrini 2009).<sup>1</sup> My paper contributes to this literature by studying a specific CSR activity across firms of all sizes in an industry, and my results provide evidence that a major reason small firms differ from large corporations in terms of CSR is that small firms are less visible than large corporations.

It is interesting to study oil and gas firms’ disclosure behavior at FracFocus in and of itself because of the prominence of the hydraulic fracturing industry. Innovations in hydraulic fracturing and related technologies have enabled the oil and gas industry to generate an extraordinary oil and gas production boom in the past decade or so that has “dramatically changed the energy future of the United States and potentially of the world” (Joskow 2013, 339). Though a great economic success, hydraulic fracturing has also raised environmental concerns. Olmstead et al. (2013), Muehlenbachs et al. (2015), and the references in these two papers summarize the environmental consequences of shale gas development. Davis (2015) argues that

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<sup>1</sup> Spence and Rutherford (2003) and Moore and Spence (2006) are editorials in two special issues of *Journal of Business Ethics* on CSR and small business, and Morsing and Perrini (2009) is an editorial in a special issue of *Business Ethics: A European Review* on CSR and small business.

bonding requirements may be needed because many small natural gas producers may no longer exist or may not have sufficient funds to pay for cleanups by the time external environmental costs are well understood. My findings provide some evidence that small firms, to the extent that they are less visible, do behave differently from large corporations when it comes to FracFocus participation, but my findings do not provide empirical evidence on any fracturing firm's environmental impact.

## 2. Industry Background

The extraordinary boom in oil and gas production in the past decade comes from shale gas (and oil). Shale gas is natural gas produced from shale formations. Column 1 of Table 1 shows the top 13 US states in shale gas production in 2012.

**Table 1. States, Sample Periods, and Disclosure Regulations**

<i>State</i>	<i>Sample period, 4//11/11–</i>	<i>Disclosure regulation</i>		<i>Wells in drilling sample</i>
		<i>Effective date</i>	<i>Where to disclose</i>	
Texas	1/31/12	2/01/2012	FracFocus	1,946
North Dakota	4/09/12	4/10/2012	FracFocus	1,459
Colorado	3/31/12	4/01/2012	FracFocus	1,553
California	12/31/13	1/01/2014	FracFocus	1,261
Oklahoma	12/31/11	1/01/2012	State and FracFocus	449
Pennsylvania	4/13/12	4/14/2012	State and FracFocus	1,103
West Virginia	6/31/13	7/01/2013	State and FracFocus	431
Louisiana	12/31/13	10/20/2012	State or FracFocus	1,051
Montana	12/31/13	8/26/2011	State or FracFocus	343
Wyoming	12/31/13	9/15/2010	State	265
New Mexico	12/31/13	2/15/2012	State	1,099
Michigan		6/22/2011	State	No data
Arkansas		1/15/2011	State	No data

*Notes:* According to Energy Information Administration (EIA) data, the states in this table are the top 13 states in shale gas production in 2012. The effective dates and where-to-disclose information are from state regulations. Between December 11, 2011, and June 31, 2013, West Virginia had a fracturing disclosure law that required firms to disclose to a state agency only.

Chemicals constitute a small fraction of the fracturing fluids, but their total volume can be substantial. Concerned that those chemicals could pollute ground and surface water, many stakeholders, environmental groups in particular, have called for oil and gas firms to disclose the chemicals they use to fracture each well. In response to those calls, the Ground Water Protection Council (GWPC) and the Interstate Oil and Gas Compact Commission (IOGCC), two quasi-governmental organizations that represent the governors and relevant regulatory agencies of

member states,<sup>2</sup> created a fracturing chemical registry website, [www.FracFocus.org](http://www.FracFocus.org). The website went online on April 11, 2011, and oil and gas firms can voluntarily post on this website the location of a well and the chemicals used.

FracFocus is a public-private joint environmental initiative. Its funding comes from the US Department of Energy, state regulatory agencies through the GWPC, and two oil and gas industry associations, the American Petroleum Institute (API) and America's Natural Gas Alliance (ANGA).<sup>3</sup> The oil and gas industry supported the FracFocus initiative for at least two reasons. First, the industry is under great pressure to demonstrate that it is environmentally responsible. The pressure comes not only from environmental groups but also from the fact that many jurisdictions, including the entire state of New York, have passed measures to control or ban fracturing. Members of the Congress also proposed the Fracturing Responsibility and Awareness of Chemicals Act (FRACAct) of 2011, though the proposal died in committee.

Second, the creation of FracFocus can be used to influence subsequent fracturing disclosure regulations. Indeed, the 13 states in Table 1 all passed mandatory fracturing disclosure regulations in the past few years, and 7 of these states have disclosure regulations that require firms to disclose chemicals information to FracFocus only (Texas, North Dakota, California, and Colorado) or to FracFocus plus a state agency (Oklahoma, Pennsylvania, and West Virginia). The Bureau of Land Management's rules on hydraulic fracturing on federal lands also use FracFocus as a public disclosure tool.

In this paper, I focus on the states and the periods for which disclosure to FracFocus is voluntary. In the seven states that mandate disclosure to FracFocus, disclosure to FracFocus was voluntary only before the mandatory regulations were passed. In the other six states in Table 1, disclosure to FracFocus has been voluntary both before and after fracturing disclosure regulations were passed; these six states did not mandate firms to disclose to FracFocus. New

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<sup>2</sup> According to its website ([www.gwpc.org](http://www.gwpc.org)), GWPC is a nonprofit organization whose members consist of state agencies that protect and regulate groundwater resources. According to its website (<http://iogcc.publishpath.com>), IOGCC represents "member governors on oil and gas issues and advocates states' rights to govern petroleum resources within their borders." Secretary of Energy Advisory Board Task Force (2014, 3) refers to GWPC and IOGCC as "two quasi-public organizations dedicated to conservation and environmental protection."

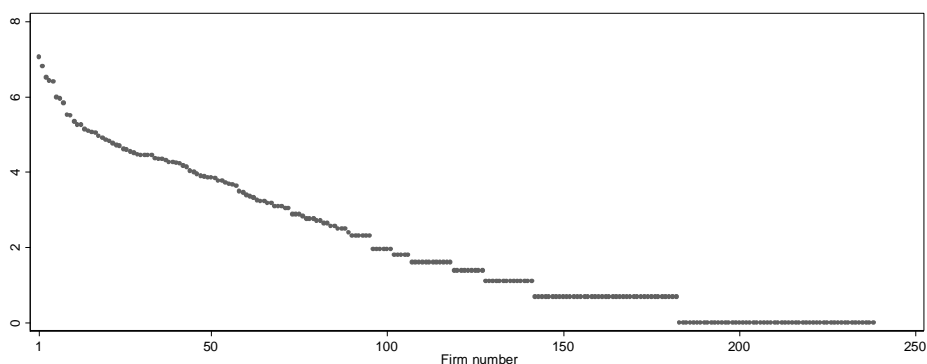
<sup>3</sup> See the response of Stan Belieu, Deputy Director of Nebraska Oil and Gas Conservation Commission, to Questions for the Record from Chairman Wyden, Senate Committee on Energy and Natural Resources, May 23, 2013, at [http://www.energy.senate.gov/public/index.cfm/files/serve?File\\_id=6A83D0C7-8926-4446-BDF8-8F4B28A71881](http://www.energy.senate.gov/public/index.cfm/files/serve?File_id=6A83D0C7-8926-4446-BDF8-8F4B28A71881).

Mexico, Wyoming, Michigan, and Arkansas require firms to disclose information to a state agency only, and Louisiana and Montana require disclosure to either FracFocus or a state agency. It is much easier for the public to access the FracFocus website than to request information from state agencies, which do not post disclosed chemical information on the Internet. The disclosure regulations' timing and where-to-disclose requirements are summarized in columns 3 and 4 of Table 1.

It is useful to note that the mandatory fracturing disclosure regulations in all states allow firms to withhold trade secrets. Partly because firms can claim trade secrets, some reports (e.g., Konschnik et al. 2013) argue that FracFocus is far from ideal but do not dispute that the information disclosed at FracFocus is useful. Moreover, in its review of FracFocus, the Secretary of Energy Advisory Board Task Force (2014, 2) concludes that “FracFocus has greatly improved public disclosure quickly.” Therefore, disclosing information at FracFocus is unlikely to be considered by environmental groups as a form of green wash.

It is also useful to note that the concentration of the shale drilling industry since the early 2000s has been very low, and a large number of small firms drilled only a few wells during their existence (Wang and Xue 2016). In my sample, a total of 238 firms drilled 10,960 wells. Figure 1 shows the (natural) log number of sample wells drilled by each of the 238 firms, sequenced from the most frequent driller to the least frequent. The number of wells drilled per firm ranges from 1,165 (by Chesapeake Energy) to 1. The top 16 firms together drilled only 6,709 (61.2 percent) of the wells. There is a long tail of infrequent drillers: 132 of the 238 firms drilled 1 to 5 wells. Most of these infrequent drillers are quite small and retain few employees (Independent Petroleum Association of America 2012–2013).

**Figure 1. Natural Log Number of Wells Drilled by Each Firm in Sample, Largest to Smallest**





### 3. Conceptual Considerations

The environmental economics literature assumes that a profit-maximizing firm undertakes a voluntary environmental activity only if the benefit of the activity exceeds its cost (Khanna 2001). The cost of disclosing well information at FracFocus is presumably small. It is straightforward for firms to gather and upload well information to the website, and firms can withhold strategically important information by claiming trade secrets. The benefit of voluntarily disclosing at FracFocus comes mostly from the fact that a successful FracFocus can improve stakeholder relations and influence future disclosure regulations. Fracturing firms that do not disclose at FracFocus, however, also enjoy this benefit, though such firms may be seen by active FracFocus participants as free riders. A disclosing firm may also enjoy a better public image, but which firms have higher disclosure rates at FracFocus is not observable to the public.

What types of firms are more likely to disclose at FracFocus? As mentioned in the background section, a salient difference between the many fracturing firms is their size. As mentioned in the introduction, a few studies in the economics literature have found that larger firms are more likely to participate in voluntary environmental programs established by regulatory agencies, and this literature recognizes that firm size matters for several potential factors (Khanna 2001). Larger firms may have more resources and lower abatement costs, may be more exposed to environmental liabilities, and are more visible. In the context of FracFocus, a firm's resources are unlikely to be an important factor because the cost of collecting and uploading well information is quite small, and abatement cost and environmental liabilities have little to do with disclosure at FracFocus.

However, firm visibility appears to be an important factor in this context. More visible firms are subject to more pressure, not only from environmental groups and the news media but more importantly from the main sponsors of FracFocus: the two oil and gas industry associations (API and ANGA) and the two quasi-governmental organizations (GWPC and IOGCC) that operate FracFocus. A few studies in the management and business ethics literature have found firm visibility has a positive effect on firms' participation in corporate philanthropy (Brammer and Millington 2006) and in industry self-regulation (King and Lenox 2000). Therefore, I hypothesize that the more visible a firm is, the higher its disclosure rate at FracFocus.

Other than firm size and visibility, I also consider several other firm characteristics. Since API and ANGA supported the creation of FracFocus, I test whether being members of these two industry associations has a positive effect on disclosure rate at FracFocus. It is also possible that publicly traded firms are more likely to disclose than privately held firms because publicly traded

firms may be subject to stronger public pressure. Lastly, I test whether measures of firms' resources indeed have no effect on disclosure at FracFocus.

A few economic studies have also found that firms producing final goods and in closer contact with consumers are more likely to participate in voluntary environmental programs (Arora and Cason 1996; Khanna and Damon 1999; Videras and Alberini 2000), and several theoretical studies have suggested that firms in more concentrated industries are more likely to participate in voluntary environmental programs (Maxwell et al. 2000). These industry characteristics are naturally controlled in my study because all the firms in my sample are in the same industry.

Other than firm characteristics, the date on which a well was fractured is likely to affect whether this well is disclosed at FracFocus. It takes time for industry associations to encourage firms to disclose at FracFocus, and it takes time for firms to pay attention to FracFocus. Therefore, I expect a well fractured at a later date is more likely to be disclosed at FracFocus.

The characteristics of the state in which a fractured well is located may also affect whether this well is disclosed at FracFocus. Kim and Lyon (2011) find that the strength of environmental groups in the state in which an electric utility company is located affects the firm's participation in a voluntary environmental disclosure program. Different from the power industry, many oil and gas firms operate in several states. Nonetheless, I investigate the possibility that the strength of environmental groups in a state affects the disclosure rate of the fractured wells in the state.

A second state characteristic that may affect disclosure rates is the salience of hydraulic fracturing in a state. Fracturing naturally receives more public and community attention in states where fracturing is widespread, and firms may have stronger incentives to present an environmentally responsible image in such states.

Another state characteristic that may affect disclosure rates is the mandatory fracturing disclosure laws in some states that do not mandate disclosure at FracFocus. Because under such laws well information has to be disclosed to a state agency or to a state agency or FracFocus, firms may simply opt to disclose to FracFocus. Therefore, disclosure rates at FracFocus may be higher with such laws than without.

#### 4. Data

My data set covers a large sample of fractured wells from 2011 to 2013, all wells disclosed at FracFocus from its inception to early May 2014, and firm and state characteristics. Table 2 presents the summary statistics of the main variables.

Availability of fractured well data limits my sample to 11 of the 13 states in Table 1. The sample starting date for each of the 11 states is the date on which FracFocus went online (April 11, 2011). The sample ending dates, listed in column 2 of Table 1, depend on whether a state's disclosure regulation mandates disclosure to FracFocus. If a state does so, the sample ending date is the day immediately before the effective date of the regulation. If a state does not, the sample ending date for that state is December 31, 2013.

**Table 2. Summary Statistics of Main Variables**

<i>Variables</i>	<i>Obs.</i>	<i>Mean</i>	<i>Std. Dev.</i>	<i>Min.</i>	<i>Max.</i>
Is well disclosed at FracFocus?	10,960	.65	.48	0	1
Visibility: news coverage, 2010–2011 (natural log)	238	.98	1.61	0	7.31
Visibility: Wikipedia entry	238	.18	.39	0	1
Size: total revenue, 2012 (natural log of \$)	238	17.00	3.45	11.51	26.84
Publicly traded?	238	.36	.48	0	1
API member?	238	.080	.27	0	1
ANGA member?	238	.063	.24	1	1
Profitability: EBIT/total assets, 2012	86	-.02	.28	-1.80	.33
Leverage: total liabilities/total assets, 2012	86	.58	.22	.16	1.82
Sierra Club members per thousand population	11	1.83	1.13	.65	3.90
Total amount of shale gas production, 2009–2012 (natural log of billion cubic feet)	11	5.74	2.52	1.95	9.27
Mandatory fracturing disclosure law that does not mandate disclosure to FracFocus?	11	.36	.50	0	1

*Notes:* For the news coverage measure of firm visibility, 1 is added into the number of news items for every firm to avoid taking logs of zero. API = American Petroleum Institute. ANGA = America's Natural Gas Alliance. EBIT = earnings before interest and tax.

The sample of fractured wells for nine states comes from DrillingInfo, a market research firm whose data are often used by EIA. My sample focuses on the oil and gas wells drilled into shale formations; such wells were all fractured. The Pennsylvania data come from the Pennsylvania Department of Conservation and Natural Resources, and the Louisiana data come from both DrillingInfo and the Louisiana Department of Natural Resources. I use the date on which the drilling of a well was completed (i.e., the completion date) to decide whether to

include a well in the sample. The number of sampled wells for each state is listed in column 5 of Table 1. The basic information of the wells disclosed at FracFocus was downloaded from the website using self-written Perl scripts. Because every oil and gas well has a unique ID, called the API number, I can identify whether a fractured well in my sample is disclosed at FracFocus.

I measure a firm's size by the natural log of its total revenue in 2012. The total revenue for a publicly traded firm is from Yahoo Finance, and the total revenue for privately held firm is from Hoovers.com, a subsidiary of Dun and Bradstreet. In total, 291 firms appear in the initial sample of fractured wells for which the completion date is available, but the total revenue for 53 private firms is not available. Nearly all of these 53 private firms drilled a very small number of wells, so they are presumably small firms. In this paper, I focus on the 238 firms with revenue information, 85 of which are publicly traded.<sup>4</sup>

I measure a firm's visibility by two approaches. The first approach is based on news coverage of the individual firms. This approach is similar to that used by Brammer and Millington (2006) in their study of British firms' philanthropy behavior. Specifically, I measure the visibility of a firm by the natural log number of articles and transcripts during 2009 and 2010 that mention the name of the firm in Access World News, a news database that covers the full-text content of more than 2,000 newspapers, 200 newswires, and 200 TV channels, plus nearly 300 online-only sources and other news sources in the United States. Because the main business of some of the firms in my sample is not oil and gas drilling (e.g., BHP Billiton), I restrict my search to those articles that mention the word of "fracking" in an attempt to focus on news on hydraulic fracturing. Of the 238 firms, 147 were mentioned in 0 articles, 48 firms in fewer than 10 articles, 30 firms in 11 to 99 articles, and 13 firms in more than 100 articles. When taking logs, I add 1 to each firm's total number of news items to avoid taking logs of 0. The correlation coefficient between firm size and this measure of firm visibility is 0.65.

My second measure of firm visibility is a dummy variable that equals one if a firm has a Wikipedia entry. For a given topic to have its own article, the topic must meet Wikipedia's notability guidelines (<https://en.wikipedia.org/wiki/Wikipedia:Notability>). In particular, Wikipedia's general notability guideline states, "If a topic has received *significant coverage* in

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<sup>4</sup> Two firms are joint ventures between publicly traded firms, and these two joint ventures are treated as privately held companies.

*reliable sources that are independent of the subject, it is presumed to be suitable for a stand-alone article or list*” (emphasis in original).

The phrase “independent of the subject” implies that a firm’s press releases, its website, or works produced by its employees are not considered reliable sources. Wikipedia editors follow notability guidelines to avoid indiscriminate inclusion of topics. Firms with a Wikipedia entry are presumably more visible than firms without. A total of 43 firms in my sample have a Wikipedia entry (as of July 2015). The correlation coefficient between the two measures of firm visibility is 0.64.

Members of API and ANGA can be found on their respective websites. A total of 19 firms in my sample are API members, and 15 firms are ANGA members. Only 5 firms are members of both industry associations. All the API and ANGA members in my sample are relatively large firms in terms of revenue or the number of wells drilled in my sample.

I measure firms’ resources by their profitability and leverage. Unfortunately, these measures are available only for publicly traded firms. I define a public firm’s profitability as its earnings before interest and tax (EBIT) divided by its total assets in 2012, and I define a public firm’s leverage as its ratio of total liabilities to its total assets in 2012.

I measure the strength of environmental groups in a state by the number of Sierra Club members per thousand population in the state in January 2012. The membership data were obtained from Sierra Club. I measure the salience of fracturing in a state by the total amount of shale gas production (in natural log of billion cubic feet) in that state from 2009 through 2012. Shale gas production data come from EIA. Whether a state’s mandatory fracturing disclosure law mandates disclosure to FracFocus and during what period can be found in Table 1.

## 5. Models and Results

I first use logit regressions to estimate how firm and state characteristics and a well’s completion date affect well-level disclosure probability. I then use linear regression models to estimate how firm characteristics affect firm-level disclosure rate.

Table 3 presents the estimated coefficients of the explanatory variables in five logit models in which the dependent variable is a dummy that equals 1 if a fractured well is disclosed at FracFocus. In these regressions, all the firm and state characteristics are cross sectional only. The reported standard errors are clustered by firm to control for within-firm correlations. Model 1 considers all explanatory variables except for measures of firm visibility and firm resources, Model 2 adds the news coverage measure of firm visibility into Model 1, Model 3 adds the

Wikipedia measure of visibility into Model 1, and Model 4 adds both measures of visibility. Model 5 considers only publicly traded firms to test whether firm profitability and leverage matter. In all five models, the completion date of a well always has a positive and statistically significant effect on the well's disclosure probability, but three firm characteristics (i.e., whether a firm is publicly traded, and whether it is a member of API or ANGA) and all three state characteristics (i.e., Sierra Club members, total shale gas production, and whether a mandatory fracturing law mandates disclosure to FracFocus) never have a statistically significant effect.

**Table 3. Well-Level Logit Regressions**

<i>Variables</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Well's completion date	0.003*** (0.001)	0.004*** (0.001)	0.003** (0.001)	0.003*** (0.001)	0.003*** (0.001)
Firm size	0.288*** (0.086)	0.126 (0.081)	0.177* (0.095)	0.067 (0.086)	0.050 (0.118)
Publicly traded?	0.082 (0.548)	0.045 (0.471)	0.458 (0.506)	0.325 (0.469)	
ANGA member?	0.194 (0.405)	-0.418 (0.402)	-0.083 (0.405)	-0.535 (0.430)	-0.429 (0.459)
API member?	0.539 (0.409)	0.153 (0.418)	0.192 (0.368)	-0.073 (0.404)	0.034 (0.436)
Sierra Club members per thousand population in state	-0.063 (0.169)	-0.142 (0.154)	-0.175 (0.194)	-0.212 (0.179)	-0.111 (0.230)
Total shale gas production in state, 2009–2012	0.125 (0.084)	0.036 (0.096)	0.098 (0.086)	0.020 (0.096)	0.044 (0.099)
Does mandatory fracturing disclosure law not mandate disclosure to FracFocus?	-0.621 (0.598)	-0.633 (0.569)	-0.430 (0.554)	-0.524 (0.550)	-0.013 (0.531)
Visibility: news coverage		0.506*** (0.111)		0.458*** (0.110)	0.461*** (0.117)
Visibility: Wikipedia entry?			1.183*** (0.392)	0.779* (0.419)	0.479 (0.532)
Profitability					0.975 (1.459)
Leverage					0.792 (2.146)
Constant	-68.069*** (22.857)	-71.770*** (21.524)	-62.071*** (23.035)	-67.820*** (22.033)	-50.897*** (17.162)
Observations	10,960	10,960	10,960	10,960	8,577

*Notes:* Dependent variable is whether a well is disclosed at FracFocus. Reported standard errors (in parentheses) are clustered by firm. Models 1–4 consider both publicly traded and privately held firms; Model 5 considers only publicly traded firms. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Firm size has a positive and statistically significant effect in Model 1, which does not include measures of firm visibility, but this effect essentially disappears in Models 2–5, which include measures of firm visibility. In Model 4, which is my preferred specification because it includes both measures of firm visibility, the estimated marginal effects (evaluated at the means of the explanatory variables) of one more log unit of news items and the existence of a Wikipedia entry are 0.11 and 0.22, respectively, and the corresponding p-values are 0.001 and 0.062. In Model 5, which considers only publicly traded firms, neither firm profitability nor leverage has an effect, but the news coverage measure of firm visibility continues to have a positive and statistically significant effect.

Table 4 presents the estimated coefficients of firm-level linear regressions in which the dependent variable is a firm's average disclosure rate across all its fractured wells, and firm characteristics are the only explanatory variables. These firm-level linear regressions cannot include state characteristics because most firms operate in multiple states. Models 1–5 in this table are the same as Models 1–5 in Table 3 except that they do not include state characteristics or completion dates. The estimated results from these firm-level regressions are consistent with the results from the well-level logit regressions. In particular, in Model 4, which is my preferred specification, the estimated marginal effects of one more log unit of news items and the existence of a Wikipedia entry on individual firms' average disclosure rate are 0.09 and 0.17, respectively, which are similar to the corresponding estimates from the logit regressions.

The results from both well-level and firm-level regressions consistently indicate that firm size has a significant effect when measures of firm visibility are not included as explanatory variables, but this effect essentially disappears once measures of firm visibility are included. This finding and the results that other firm characteristics have no effects indicate that it is through firm visibility that firm size matters in this context. The finding that measures of firm resources have no effect is expected, since the cost of disclosure at FracFocus is rather small. The finding that none of the three state characteristics matter suggests that the pressure to disclose at FracFocus is not state-specific, which is consistent with the fact that FracFocus is a private-public initiative of national scope.

**Table 4. Firm-Level Linear Regressions**

<i>Variables</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Firm size	0.036*** (0.012)	0.018 (0.011)	0.024** (0.011)	0.012 (0.011)	0.014 (0.027)
Publicly traded?	0.065 (0.081)	0.038 (0.075)	0.067 (0.074)	0.043 (0.071)	
ANGA member?	0.144* (0.085)	-0.013 (0.069)	0.042 (0.087)	-0.063 (0.075)	-0.003 (0.085)
API member?	0.146 (0.089)	0.033 (0.082)	0.038 (0.099)	-0.026 (0.092)	-0.004 (0.109)
Visibility: news coverage		0.096*** (0.020)		0.086*** (0.021)	0.094*** (0.024)
Visibility: Wikipedia entry?			0.258*** (0.093)	0.169* (0.095)	0.039 (0.126)
Profitability					0.197 (0.197)
Leverage					0.034 (0.274)
Constant	-0.369** (0.176)	-0.127 (0.173)	-0.199 (0.172)	-0.041 (0.165)	-0.021 (0.493)
Observations	238	238	238	238	84

*Notes:* Dependent variable is individual firms' average disclosure rate. Robust standard errors are in parentheses. Models 1–4 consider both publicly traded and privately held firms; Model 5 considers only publicly traded firms. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

## 6. Conclusion

In this paper, I have studied which firm characteristics affect oil and gas firms' probability of disclosing their fractured wells at FracFocus, a private-public environmental initiative. My findings contribute to the literature in economics and other disciplines that study firms' voluntary environmental behavior by presenting empirical evidence that a firm's visibility is the mechanism through which firm size affects its probability of disclosing well information at FracFocus. My findings are consistent with the idea that more visible firms are subject to more pressure to exhibit environmentally responsible behavior. My findings suggest that voluntary approaches to environmental regulations are unlikely to be effective when many targeted firms are not visible to the public. Whether firm size also matters through other possible mechanisms in other contexts is a topic for future research. My findings do not imply that small firms are inherently less socially responsible. Small firms may or may not undertake other CSR activities that I have not considered.



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