HOW DO U.S. STATE RESIDENTS FORM OPINIONS ABOUT ‘FRACKING’ IN SOCIAL CONTEXTS? A MULTILEVEL ANALYSIS

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Abstract

Increased hydraulic fracturing operations (also known as ‘fracking’) in the U.S. have introduced a larger portion of the public to new and more extensive risks and benefits: from concerns of impacts on water quality and human health to benefits from increased oil and gas production and local economic development. As most policy affecting fracking occurs at the state-level, it is important to understand how citizens’ support for the technology is shaped by their states’ industrial, environmental, and socioeconomic experiences. Using a nationally representative survey, we construct a multilevel model to understand how individuals’ support for fracking varies as a function of both individual- and state-level characteristics. At the state-level, we find that people residing in states with a higher poverty rate and higher ground water use for public drinking supply are

more likely to support fracking. At the individual level, the relationships between risk/benefit perceptions and support vary as a function of the state people live in.

Additionally, the positive relationship between conservatism and support for fracking is stronger for people residing in states with a higher poverty rate. Based on these findings, we discuss the dynamics of public opinion in social contexts and implications on energy policymaking.

Keywords: Hydraulic fracturing; Fracking; Public perception; Risk communication; Energy policymaking

1. Introduction

Hydraulic fracturing, or “fracking,” is one step in unconventional oil and gas production. It involves injecting a mixture of water, sand, and chemicals into a well under high pressure to fracture the oil- and gas-rich shale rock layers as deep as a mile below the surface (Clarke et al., 2015). Industry has used fracking for oil and gas development for decades, but operations expanded rapidly in the past twenty years. From 2003 to 2013, total natural gas and oil production in the U.S. increased approximately 30 percent, largely because of a dramatic growth of fracking operations (International Energy Agency, 2014; U.S. Energy Information Administration, 2015a). As a result, the U.S. has become a major world natural gas producer and natural gas has replaced coal as the dominant energy source for electricity production in the U.S. (U.S. Energy Information Administration, 2014a, 2014b).

The rapid expansion of fracking has raised widespread concerns, however, regarding its potential environmental, economic, and societal implications (Boudet et al., 2014; Clarke et al., 2015; Davis and Fisk, 2014). Proponents argue that fracking has created job opportunities while facilitating a rapid transition to low-carbon energy (Bomberg, 2013; U.S. Energy Information

Administration, 2015a). Opponents, in contrast, are concerned about potential adverse social, environmental, and public health impacts on communities close to the fracking sites, including risk of contaminated groundwater, inflation, increased traffic, and strain on community resources (Goldman et al., 2013; Gosman, 2013).

The vast majority of regulation addressing fracking operations exists at the state level, in part because the 2005 Energy Bill excluded fracking from Environmental Protection Agency regulation (Garmezy, 2013; Gosman, 2013; United States Statutes at Large, 2005). Therefore, although specific costs and benefits can be unevenly spread within each state, it is important to understand how individuals' opinions might be shaped by a state's overall experiences and concerns because of the implications state-wide opinion and experience could have for shaping policy. Although many studies have focused on national opinion of fracking or on opinion within particular states or counties, very few studies have examined the differences in U.S. public opinion of fracking based on state-level differences across the U.S. In this study, our focus on the state as a unit of analysis allows us to identify policy-relevant factors that are involved in creating a social license for fracking at the state level and gives a more detailed picture of the variety within national public opinion on fracking.

Using a national representative survey (N=853) in combination with state-level data, we examine the respective effects of individual characteristics (e.g., political ideology, risk/benefit perceptions, demographics etc.) and state-level ones (e.g., groundwater usage, poverty rate, economic reliance on extractive industries, etc.) on support for fracking. We use a multilevel modeling approach that allows us to analyze potential interactive effects between some of the individual and state-level variables on levels of public support for fracking. These findings have

important implications for understanding public opinion formation within particular geographical boundaries and ultimately for energy policymaking in the U.S.

1.1. State-level experiences and residents' support for fracking

Fracking has not only brought greater domestic energy production but also created economic growth in local communities across the U.S. (Boudet et al., 2014; Community and Regional Development Institute, 2011). The development of fracking often creates local jobs. In addition, landowners can gain supplemental income by leasing or selling their land to oil and gas companies (International Energy Agency, 2014; Theodori, 2009). The economic “booms,” however, come with worries about a future bust for many communities, including concerns of inflation, strain on infrastructure from increased trucking traffic, and new costs on tax payers and agencies either from risks of environmental or health hazards or other increased burdens on communities (Boudet et al., 2014; International Energy Agency, 2014; Theodori, 2009). Landowners might lose value on their property from spills, blow-outs, or other hazards resulting from fracking operations (Radow, 2011), and rapid population growth accompanying increased fracking development can also bring increased crime rates and disrupt local residents' perception of the community's cohesion or character (Berger and Beckmann, 2010; Blevins et al., 2005; Boudet et al., 2014; Jacquet, 2014).

With this mixture of risks, benefits, and uncertainty, most citizens were ambivalent about how they feel about fracking at the time of the 2014 survey used in this analysis, with approximately one third of the population unaware of the technology (Boudet et al., 2014; Clarke et al., 2015). Beginning in 2014, however, Pew Research Center polls found that national levels of support for fracking have been decreasing, with levels of support now lower than levels of opposition to increased use of fracking (Drake, 2015; Funk and Kennedy, 2016; Funk and

Rainie, 2015). In 2012 and 2013, when Pew first included the question, support was higher than opposition, with approximately 50 percent of respondents in favor and fewer than 40 percent opposed (Pew Research Center, 2013a, 2013b, 2012). In 2014, those numbers reversed, with fewer than 40 percent in favor to increased fracking and slightly more than 50 percent against, and that trend held through 2015 and for the most recent survey released in May 2016 (Drake, 2015; Funk and Kennedy, 2016; Funk and Rainie, 2015; Pew Research Center, 2014). The number of respondents who indicated that they had no answer as to whether they were in favor or against increased use of fracking also decreased overtime, from more than 10 percent in 2014 to approximately 5 percent in 2016, suggesting that Americans overall have become more familiar with, or at least opinionated on, the issue. Supplementing national opinion data, research of support for fracking primarily at the county-level reveals that individuals' support can be closely related to local industrial, socioeconomic, and environmental experiences (e.g., Boudet et al., 2016; Kriesky et al., 2013). In this study, we focus on those experiences at the state-level and examine the impacts of states' 1) fracking activities and resource availability, 2) economic conditions, and 3) groundwater use on residents' support for fracking. We analyze these factors and interactions to better understand what experiences, beyond county- or state-level familiarity with fracking, help explain both national public opinion and variations in opinion by state.

1.1.1. Fracking activity and resource availability

Previous studies suggest that residents of states with active fracking operations are more likely to have greater familiarity with fracking and tend to have different views of the risks and benefits involved (Boudet et al., 2016; Clarke et al., 2015; Kriesky et al., 2013; Rabe and Borick, 2011; Theodori, 2009). In Pennsylvania, for example, a survey of residents found that half followed fracking at least "somewhat" closely (Rabe and Borick, 2011). Additionally, residents in "high

fracking activity” areas (e.g., Marcellus Shale in Pennsylvania and the Barnett Shale in Texas) were more supportive of oil and gas operations primarily because of the greater perceived economic benefits generated through the industry (Kriesky et al., 2013). National-scale research, however, found no relationship between residence in a county with active oil and gas production and support for fracking but did find that residence in shale plays, including both developed and undeveloped ones was significantly related to one’s support (Boudet et al., 2016). This finding suggests that people in those areas might view fracking as an opportunity to create economic growth. With these considerations in mind, we propose hypotheses (H) regarding the relationship between the presence of active and potential shale plays in a state and its residents’ support for fracking:

H1: Presence of active shale plays in a state is positively related to its residents’ support for fracking.

H2: Presence of potential shale plays in a state is positively related to its residents’ support for fracking.

We do not distinguish plays that produce predominantly natural gas from those that produce predominantly oil because wells often produce both fuel types (U.S. Energy Information Administration, 2013), and we did not find in the literature a reason separate the two.

1.1.2. Economic conditions

Not surprisingly, research finds that individuals living in regions that are economically dependent on extractive industries are likely to support fracking (Kriesky et al., 2013; Theodori, 2009). Individuals living in counties that have high employment levels in natural resource and mining industries and that have had a high increase in the number of jobs in those sectors from 2000-2012 were significantly more likely to favor fracking (Boudet et al., 2016). The economic

impacts from fracking, however, extend far beyond the county where the drilling activity occurs. A 2015 National Bureau of Economic Research report found that impacts of fracking on wages and employment are more than three times greater at the regional and state levels than the county level (Feyrer et al., 2015). In order to understand the influence of a state's potential economic reliance on fracking on residents' acceptance, we include a measure of the extent to which a state is a "mining" state, using the mining location quotient (U.S. Bureau of Labor Statistics, 2015). It measures each state's relative GDP reliance on extractive industries compared to other states. An advantage of using location quotient instead of the percentage of a state's total GDP that comes from extractive industries is that the location quotient better captures overall reliance on those industries while controlling for differences in states' total GDP and in the total mix of industries that contribute to their GDPs. Location quotient also offers a way to account for states' overall extractive industry reliance, rather than just fracking-related activities, to capture whether a state's identity and experience as a "mining" state can relate to support for fracking in particular. This means the measure could help us understand public opinion in more states than just those with active fracking. To examine how individuals' acceptance might be influenced by their perceived economic benefits from extractive industries, we propose and test:

H3: A state's mining location quotient (i.e. GDP dependence on extractive industry) is positively related to residents' support for fracking.

While economic dependence on extractive industries is one way to capture potential economic gain individuals might perceive from fracking, a state's poverty rate can provide a wider view of its economic standing. Poverty rate could capture how attractive fracking jobs appear, as well as connect to perceptions of some of the more indirect benefits a state could potentially receive, such as overall investment in infrastructure, increased tax pool, and indirectly

related business growth in the service and housing industries. We hypothesize that people living in states with higher poverty rates are more likely to support fracking.

H4: People living states with higher poverty rates are more likely to support fracking.

1.1.3. Groundwater usage

Water and aquifer quality are the most mentioned concerns of those living near fracking wells or near watersheds passing through fracking areas, especially as many of the fracking fluids contain chemicals that are “trade secrets” and therefore not easily available to test their health impacts (Boling, 2012; Davis and Fisk, 2014; Goldman et al., 2013; Gosman, 2013; Theodori, 2009). Tap water catching fire from flammable methane leaking into groundwater has also become the iconic image for those worried about fracking’s adverse environmental impact (Bomberg, 2013; Davis and Fisk, 2014). Given this concern with aquifer contamination, in communities that highly rely on groundwater for public supply, people would likely be more concerned about the potential damage to their water quality and therefore less likely to support fracking.

At the state-level, however, it is possible that people might not be sensitive to the impact of fracking on water quality given their indirect experiences with fracking and/or groundwater sources or usage. Research incorporating measures of water supply as it relates to state policies on fracking found that states with a higher percent of total water supply coming from groundwater actually had weaker chemical disclosure laws pertaining to fracking operations (Fisk, 2013). Lack of chemical disclosure laws in groundwater-reliant states could suggest that groundwater use is not related to substantial risk perspectives and thus is not reflected in more stringent disclosure policies. Given these conflicting evidence and concerns, we raise a research question (RQ) regarding the relationship between a state’s reliance on groundwater for public supply and public support for fracking:

RQ1: How does state's reliance on groundwater for public supply relate to residents' support for fracking?

1.2. Impact of individual-level factors

1.2.1. Risk and benefit perceptions

Previous studies have found direct and significant relationships between risk/benefit perceptions and acceptance for fracking, with risk perception negatively related and benefit perception positively related to individuals' support (e.g., Davis and Fisk, 2014; Jacquet, 2014). The relationship between risk/benefit perception and support, however, can be more nuanced for people within different social contexts (Anderson and Theodori, 2009; Boudet et al., 2016; Theodori, 2009). As seen in the county-level studies, although residents in both high-activity and low-activity counties perceived similar pros and cons from fracking (e.g. economic benefits and environmental costs), they weighed the effects of each differently and hence developed different attitudes toward fracking (Anderson and Theodori, 2009). For example, residents in high activity areas are more likely to be personally involved in oil and gas operations – having signed a production lease for their land or having a family member who has done so – and therefore pay more attention to economic issues than to potential environmental hazards caused by the drilling activity (Kriesky et al., 2013). For those with limited experiences with fracking, however, environmental concerns might outweigh economic concerns, leading to more negative attitudes toward fracking. Given these considerations, we propose a hypothesis regarding the main effects of risk/benefit perceptions and a research question regarding the potential interactive effect between risk/benefit perception and fracking activities at the state level:

H5: Risk perception is negatively, whereas benefit perception is positively, related to individuals' support for fracking.

RQ2: Do the relationships between risk/benefit perceptions and support vary for states that have different levels of fracking activities?

1.2.2. Political ideology

Americans' political ideology closely relates to their endorsement of different energy options, and for fracking in particular, opinion has been sharply divided along partisan lines. A 2015 Gallup poll shows that although 66 percent of Republicans favor fracking, only 26 percent of Democrats hold the same view (Gallup, 2015). Cultural cognition theory posits that individuals tend to form risk perceptions that are congenial to their cultural values, or preferences about how society should be organized (Kahan et al., 2011). In the U.S., conservative Republicans tend to hold hierarchical and individualistic values, which lead them to value industry and commerce activities that fit their preference of free markets while downplaying environmental risks (Kahan et al., 2011). With respect to fracking, conservative Republicans are more likely to favor it without worrying too much about the potential environmental costs (Boudet et al., 2014; Davis and Fisk, 2014). Liberal Democrats, in contrast, with relatively more egalitarian and communitarian worldviews, might see fracking as a source of unjust disparity and therefore be more concerned about the associated environmental risks. We propose:

H6a: Conservative political ideology is positively related to support for fracking.

Additionally, although previous studies have examined the main effects of political ideology and local experiences on support, they have rarely considered the potential interplay between the two. While liberals and conservatives in general have divergent opinions on many energy-related issues, such division might lessen for those facing locally-bounded problems that threaten all community members and require a bipartisan policy solution (Kahan, 2016). For example, a survey of residents in coastal counties in Southeast Florida (one of the most

vulnerable areas in the U.S. to climate change and rising sea levels) found that although respondents were politically divided on the existence of climate change, they overwhelmingly agreed that policy steps should be identified “to reduce risk posed by rising sea levels and to combat the threat that storm surge poses to drinking water supplies” (Kahan, 2016). This finding suggests that when dealing with locally-bounded problems that require a bipartisan policy solution, individuals might disengage identity-protective cognition and rely on local experiences to form attitudes. Given these considerations, we hypothesize that liberals and conservatives living in states that are more desperate for economic growth (as measured by poverty rate) are more likely to support fracking than those living in richer states. In other words, the positive relationship between conservatism and fracking acceptance -- or the difference between liberals’ and conservatives’ support for fracking -- should be reduced for those living in poorer states.

H6b: The positive relationship between conservative ideology and support for fracking is weaker for those residing in states with higher poverty rates.

Similarly, the positive relationship between conservative ideology and support for fracking should be weaker for those residing in states with greater economic dependence on mining industries:

H6c: The positive relationship between conservative policy ideology and support for fracking is weaker for those residing in states with a higher mining location quotient.

1.2.3. Issue importance and factual knowledge

Whether knowledge about an energy technology translates into support is highly variable (Achterberg et al., 2010; Johnson, 1993; Malka et al., 2009; Stoutenborough et al., 2015, 2013; Su et al., 2014; Wallquist et al., 2010; Whitmarsh et al., 2015; Zhu et al., 2016). In the case of fracking, there is evidence that higher levels of familiarity and self-reported knowledge indicate

higher levels of support, suggesting that people who believe themselves to be more knowledgeable about fracking might also be more familiar with the economic potential of this technology (Boudet et al., 2014; Whitmarsh et al., 2015). Studies on the relationship between factual knowledge about energy technologies and perceptions of those technologies, however, find a positive relationship in some cases but no relationship in others (Achterberg et al., 2010; Stoutenborough et al., 2015; Zhu et al., 2016). In addition, how important an individual perceives fracking to be could influence their attitudes toward the technology, similar to the effects of fracking experience on public opinion. We propose two hypotheses testing these relationships:

H7a: Issue importance is positively related to support for fracking.

H7b: Measured factual knowledge is positively related to support for fracking.

1.2.4. News attention

Research has convincingly shown that news media play a critical role in shaping citizens' attitudes toward energy issues (Mazur, 2014; Boudet et al., 2014). It is likely that the ways in which journalists select, emphasize, and present certain aspects of a scientific topic can significantly influence how audience members interpret it (Druckman and Bolsen, 2011; Nisbet and Scheufele, 2009; Nisbet et al., 2002). As a result, citizens rely on these interpretative packages or news frames as mental shortcuts to develop or report opinions (Ho et al., 2010; Scheufele et al., 2008). Previous studies have shown that newspaper use is negatively related individuals' support toward fracking, which is not surprising considering national newspapers' relatively negative frames surrounding the issue of fracking (Mazur, 2014; Boudet et al., 2014). We propose a hypothesis regarding the relationship between attention to science/public affairs news and acceptance for fracking:

H8: News attention is negatively related to support for fracking.

1.2.5. Demographics

Research into what shapes public perceptions of fracking has found that men are significantly more likely to support it (Boudet et al., 2014; Quinnipiac University, 2012). This is the case for a majority of energy and non-energy technologies that carry potential environmental and health risks (Ansolabehere and Konisky, 2009; Ho et al., 2013). Although research has not consistently found an effect of race on support for fracking (Boudet et al., 2014; Davis and Fisk, 2014), white individuals are often more supportive of environmentally risky technologies, especially in combination with gender to produce the “white male effect.” Researchers speculate this “white male effect” could be reflecting other demographic differences – such as income, education, and political affiliation – as well as greater awareness of environmental justice, or the fact that minorities face greater likelihood of risk exposure from industry activities sited in their communities (Boudet et al., 2014; Satterfield et al., 2004). For factors such as education, age, and income, the effects are also less clear. Boudet et al., (2014) found that older people and those holding a bachelor’s degree or higher were more likely to support fracking. Given the significant relationship these demographic characteristics can have with risk perceptions and support for energy technologies, we control for gender, race, age, education, and income.

2. Methods

2.1 Measures

The dependent variable support for fracking was measured with a single 11-point item: “Overall, I support the use of fracking” (“0” = “Do not agree at all”; “10” = “Agree very much”; $M = 4.52$, $SD = 3.05$).

The state-level variables capture state fracking activities and resource availability, groundwater usage, and the poverty rate each state experiences. These state-level variables

include active shale play, potential shale play, groundwater use, poverty rate, and mining location quotient. Active shale play is a dichotomized variable that captures whether or not a state has active fracking in more than one-fifth of the state's area. Potential shale play, likewise, is a dichotomized variable that captures whether those states without fracking have the potential for fracking operations given the presence of shale basins in the state. The data for both measures is from EIA's 2015 map of shale basins and active plays in the U.S. (U.S. Energy Information Administration, 2015b). While the cut-off of one-fifth is arbitrary, the reason for operationalizing the measure that way is that states with active fracking in less than one-fifth of their area likely have a large portion of the population that will be mostly unaware of the fracking or be more likely to have limited experience with fracking. Additionally, no state is near the one-fifth cut-off, with all having either none to a very small area of fracking (coded inactive) or a large area of fracking (active). Therefore, operationalizing the measure at that cut-off was a clear and consistent way to capture widespread fracking at the state-level based on geographic coverage rather than number of wells, which would be more dependent on a state's total area. The few states that have some fracking but are coded inactive are almost all captured in the potential shale play measure because of the potential for growth in those states.

Groundwater use is the percent of public water supplied by groundwater in 2010 (U.S. Geological Survey, 2015). Poverty rate is the average percentage of the state that lived below the federal poverty level from 2010 to 2013, adjusted for regional cost differences (information on measure available at Renwick, 2009; state-level statistics obtained from Short, 2015). Mining location quotient indicates how much a state relies on extractive industries for its GDP as compared to the national average (U.S. Bureau of Labor Statistics, 2015). We created this

measure using the 5-year mean for location quotient for each state. Table 1 shows the descriptive statistics for state variables.

[Insert Table 1 about here]

Risk and benefit perceptions were each measured with a single item on an 11-point scale. Risk perception asked respondents “How risky do you think fracking is for society as a whole?” with 0 = “Not at all risky” and 10 = “Very risky” ($M = 5.99$, $SD = 2.76$). Benefit perception asked “How beneficial do you think fracking is for society as a whole?” with 0 = “Not beneficial at all” and 10 = “Very beneficial” ($M = 5.26$, $SD = 2.86$). Political ideology was a composite of two items, one asking respondents how liberal or conservative they are on “economic issues” and the next asking the same question for “social issues.” Each was on a seven-point scale ranging from “Very Liberal” (coded “1”) and “Very Conservative” (coded “7”). The two were combined using the mean value ($M = 4.17$, $SD = 1.43$, Pearson’s $r = .75$).

Issue importance is a single item asking “How important is fracking to you personally?” with a scale from “0” = “Not at all important” to “10” = “Very important” ($M = 4.40$, $SD = 3.13$). Factual knowledge was measured by a composite of three true and false items: 1) “Scientists are concerned that fracking could cause small earthquakes” (True); 2) “New York, Pennsylvania, California and Washington are all states with active or proposed fracking” (False, as Washington did not have active or proposed fracking); and 3) “Federal law requires companies to disclose all chemicals used in natural gas drilling” (False; Range 0-3, $M = 1.06$, $SD = 0.82$). Each factual knowledge item was on a 4-point scale with “1” = “Definitely true,” “2” = “Likely true,” “3” = “Likely false,” and “4” = “Definitely false.” “Don’t know” was an option for respondents as well. All items were recoded into dichotomized variables reflecting whether respondents correctly answered. For the true item (concerning earthquakes) that meant recoding

responses as “1” = “Definitely/likely true” (correct answer) and “0” = “Definitely/Likely false” and “Don’t know.” Both the false items (concerning states with fracking and federal chemical disclosure laws) were recoded as “1” = “Definitely/likely false” (correct answer) and “0” = “Definitely/likely true” and “Don’t know.” The dichotomized items were then summed to give each respondent a total count of correct answers from 0 to 3. Although the item asking which states have active or proposed fracking is a weaker measure of relevant knowledge than the other two, because the items are summed to form the factual knowledge index, we included all three items. Additionally, the factual knowledge index is positively and significantly correlated with the other measure of knowledge we had available, self-reported or perceived knowledge, which asked respondents how informed they believed themselves to be about fracking ($R = 0.429$). We used the factual knowledge items rather than the perceived knowledge item because factual knowledge was less examined in research of public opinion of fracking.

News attention is a composite of five items, with each item asking respondents to indicate, “How much attention do you pay to news stories about the following topics when you go online/read the newspaper/watch television news”: 1) “international affairs,” 2) “national government and politics,” 3) “science and technology,” 4) “political or ethical implications of emerging technologies,” and 5) “new scientific developments in fields like fracking.” Stories on “science and technology” and “new scientific developments in fields like fracking” overlap, but the latter measure is designed to capture attention to emergent science and fracking more particularly, rather than to science in general. Each of these questions was asked for newspaper, TV, and online-only media use. News attention within each of the three media types was highly correlated (Cronbach’s $\alpha = .84$) and the indices were combined using mean levels of attention ($M = 4.31$, $SD = 2.51$).

Age is a continuous variable ($M = 48.99$, $SD = 16.84$). Gender is a dichotomous variable with female coded as “2” and male coded as “1” (47.8 percent). Race is a dichotomous variable, with white non-Hispanic coded as “2” and non-white and/or Hispanic coded as “1” (25.6 percent). Education is measured by asking respondents to report their years of formal education ($M = 10.47$, $SD = 1.96$). Income is measured using nineteen categories, ranging from “under \$5,000” (coded “1”) to “\$175,000 or more” (coded “19”). The median was “13”, indicating the “\$60,000 - 69,999” bracket ($SD = 4.31$).

2.2. Analytical framework

We used a multilevel modeling (MLM) approach to capture the relationship between group- and individual-level variables and support for fracking. This type of regression-based statistical analysis allows us to account for the fact that citizens residing within a state are not independent from one another and that their attitudes about fracking may be influenced by the state’s context (particularly aspects of their state that are relevant to fracking). Using this method, we could include and test the influence of state-level characteristics as well as individual-level demographics, political ideology, news attention, issue importance and knowledge, and risk and benefit perceptions (Snijders and Bosker, 1999).

To assess the effects of state-level (level-2) characteristics and their influences on individuals’ support for fracking, we test a series of increasingly complex models that incorporate both fixed (constant) and random (varying) effects. We use Restricted Maximum Likelihood Estimation (REML) with robust standard errors to assess the effects and address the potentially non-normal distribution of our dependent variable of support for fracking (Kreft and Leeuw, 1998).

3. Results

We first constructed a null model—an ANOVA with random effects—to model the level-1 intercept of support for fracking as a random effect of participants' state of residence. This allowed us to establish a baseline for subsequent models and to calculate the intra-class correlation (ICC), or variance in the intercept relative to the total variance in our outcome measure of support for fracking. Although there are not set disciplinary guidelines or cutoffs that establish whether an ICC coefficient is large or small (O'Dwyer and Parker, 2014), a positive (i.e., not zero or negative) ICC is indicative of possible group-level effects (Krull and MacKinnon, 2001). The ICC in the null model equaled .02, which indicates that 2% of the total variance in support for fracking is attributed to differences between the states, which is a very small proportion of all the variance. Because the ICC is greater than zero, however, we continued with the analysis to assess whether contextual (between-state) factors do significantly affect individuals' support for fracking. Although OLS regression could be acceptable for the analysis because the state-level variance was not statistically significant in the null model, we opted to use HLM because it offers more robust significance tests than OLS regression (Garson, 2012).

The first model (Model 1) in Table 2 provides the estimates and variance statistics predicting individuals' support for fracking based on only state-level variables. When including these state-level predictors, the average support for fracking across states is considerably lower (3.88, compared to 4.23 in the null model), and the model shows a significant effect of active shale play in one's home state. According to this model, if individuals reside in a state with an active shale play they are more likely to express support for fracking. The proportion of public water supply that comes from groundwater is also marginally significant ($p \leq .10$), which

suggests there could be a relationship between a state's reliance on groundwater and greater support for fracking.

[Insert Table 2 about here]

In the next model, Model 2, we include only individual-level variables—an ANCOVA with random effects—which models whether differences in individuals' support for fracking might be attributed to demographic characteristics and personal beliefs or dispositions about fracking, with state included as a random factor. This model indicates that women and those with less income are significantly less supportive of fracking. It also indicates that higher risk perceptions of fracking predict less support while higher benefit perceptions predict greater support. The importance of fracking to an individual marginally ($p \leq .10$) predictive of support, as is conservative political ideology. Age, race, education, media attention, and fracking knowledge showed no significant relationship to individuals' support for fracking in this model.

Model 3 in Table 2 presents a full random coefficients model, which estimates the intercepts in support for fracking based on individual-level and state-level predictors and interacts individual- and state-level predictors to assess whether the effect of some individual characteristics (specifically risk and benefit perceptions and political ideology) differs based on a person's state of residence. State characteristics significantly influence individuals' support for fracking in this model. People who reside in states with higher poverty rates, greater groundwater use, and active shale plays expressed more support for fracking. These findings support H1 and H4, with the presence of active shale plays and higher poverty rates predicting support, and start to answer RQ1 on the effects of groundwater use. Perhaps counterintuitively, a lower average mining location quotient predicted greater support for fracking, which is opposite of the direction H3 predicted. The result, however, was only marginally significant at the $p \leq .10$ level.

This model also indicates that gender, income, political ideology (now significant at the $p \leq .05$ level), issue importance (now significant at $p \leq .05$), and risk and benefit perceptions have a significant impact on support for fracking. This supports H5 on the negative and positive relationship of risk and benefit perceptions, respectively, H6a on the positive relationship of conservative ideology, and H7a on the positive relationship of issue importance to support for fracking. Although content analysis shows that media discourse about fracking is dominantly negative (Mazur, 2014), frequent attention to science and public affair news is not related to individuals' support, nor is individuals' factual knowledge about fracking. Therefore, H7b and H8 on the roles of factual knowledge and news attention, respectively, do not receive sufficient support.

In Model 3, the random effects of fracking risk and benefit perceptions are significant, which suggests that the extent to which risk and benefit perceptions affect support for fracking varies across states. In other words, although risk and benefit perceptions are significantly related to support for fracking in our sample, these perceptions might have stronger effects on support for fracking in some states than in others.

In Model 4 (see Table 2) we test whether there were cross-level effects between state conditions and individual characteristics on support for fracking. Specifically, we assessed whether active or potential shale plays in a state moderated the relationship between risk and benefit perceptions (RQ2) and whether the average poverty rate or mining location quotient of a state moderated the effect of political ideology on support for fracking (H6b and H6c, respectively). We observed a significant interaction between potential shale plays and benefit perceptions on support (plotted in Figure 1), which indicates that if individuals' states have

potential shale plays then their benefit perceptions of fracking yield higher levels of support for fracking.

[Insert Figure 1 here]

We also observed marginally significant interactions ($p \leq .10$) between active shale play and benefit perceptions (plotted in Figure 2) and state poverty rate and political ideology (plotted in Figure 3). As Figure 2 shows, in states with active shale plays, individuals who associate more benefits with fracking might be more supportive of it than those in states without shale plays, though this relationship is not significant at $p \leq .05$.

[Insert Figures 2 and 3 here]

Figure 3, again while a marginally significant relationship, indicates that states with higher poverty rates (plotted with conditional values of the mean and $\pm$ one standard deviation from the mean) have a stronger effect of conservative ideology on support for fracking. In other words, the positive relationship between conservative political ideology and support for fracking is stronger in states with higher poverty rates, which is opposite the direction predicted by H6b. Table 3 summarizes the results for each hypothesis and research question.

[Insert Table 3 here]

4. Discussion

A growing body of literature suggests that public attitudes toward energy options are not only influenced by individual values and dispositions but also shaped by one's local industrial and natural environments. In this study, by doing a multilevel analysis of combined state- and individual-level data, we show that individuals' support for hydraulic fracturing hinges on both individual variables (i.e. political ideology, risk/benefit perceptions, issue importance) and state-

level industrial and environmental experiences (i.e. availability of fracking resources, groundwater usage).

In particular, a state's overall socioeconomic context in which energy policy decisions are made could play a strong role in shaping public support, as evidenced by the positive relationship between state poverty rates and residents' support for fracking. Not surprisingly, individuals' support for fracking is primarily driven by their benefit perceptions of the technology. Nonetheless, the positive relationship between benefit perception and support is not universally the same. Instead, it is stronger for people residing in states sitting on active and potential shale plays than those living in non-fracking states. Interestingly, although conservative Republicans are generally more favorable about fracking than liberal Democrats, that positive relationship between conservatism and fracking support is even stronger for those living in states with greater poverty. Individuals' preexisting values and perceptions, therefore, do not only exert independent effects on people's attitudes toward fracking. Instead, the characteristics of one's specific social, environmental, and industrial environment at the state-level significantly interact with those effects and subsequently influence individuals' opinion.

Before discussing our findings in details, we should note some limitations of this study. First, although our use of a nationally representative sample supports overall generalizability of the findings, our results may not be generalizable to less populated states, such as Idaho and Maine, where we only had four and two respondents respectively. Additionally, the survey included no respondents from Alaska and South Dakota, and those states were excluded from the analyses. Future researchers should replicate our findings with a much larger sample that proportionally represents each state's population size.

Second, future research could add greater specificity to the connection between local experiences and public opinion of fracking. Poverty rate and mining location quotient, for example, allow us to capture a state's general economic performance and its economic reliance on extractive industries. These are not the only indicators for state economy, however, and can be supplemented by other aspects of a state's economic profile. For example, employment rate might be useful for understanding the extent to which state residents would expect job growth from prospective fracking activities, building on Boudet et al.'s (2016) finding of growth in employment in extractive industries significantly predicting support for fracking at the county level. Additionally, average natural gas or energy costs in a state could play a role in residents' opinions, especially for those who might not have more direct experience with fracking. The effects of either high energy costs or variability in costs would be worth examining. A limitation of the state-level focus for all of these measures, as mentioned previously, is the local variability for each factor. Regions within states – or in states without active fracking that are impacted by fracking through frack sand mining, fracking-related earthquakes, or shared watersheds with fracking states, for example -- can have vastly different experiences. The ability to link more localized and shared experiences to national opinion, however, is also a major advantage of this analysis. Future research should continue to add more detail to this link, perhaps with local case studies and geo-coded national data.

Finally, given the marginal significance of the ideology $\times$ poverty rate interaction, the detected effect size could be minimal. It is worth examining this interaction with different data sources to better understand the relationship between state-level economic standing and individuals' values.

Consistent with previous findings, residents of fracking states are indeed more supportive of fracking. Interestingly, once combined with individual-level variables, however, the presence of active shale plays is no longer a significant predictor of support. This loss of significance suggests that there could be something in common demographically and value-wise for respondents in states with active shale plays. People in states with active shale plays might systematically perceive fracking to be more beneficial and less risky than those living in non-fracking states, for example, which could mediate the effect of active shale plays as risk and benefit significantly relate to support. Additionally, many of the states with extensive fracking – Texas, North Dakota, Wyoming, and Oklahoma – have predominantly conservative residents, but very few of the states with active fracking have predominantly liberal residents. Future research could examine what fracking-heavy states share in terms of ideology and population demographics to see how these variables either coincide with ideal fracking geology or how they politically, economically, and socially encourage fracking to develop more in certain states than in others.

The fact that higher groundwater usage in the state is marginally significantly related to support for fracking could be reflecting the potential for economic benefits from selling groundwater to oil and gas drillers for use in the fracking operations. The water required for fracking operations is in the order of millions of gallons per well (Scanlon et al., 2014), and in states such as Texas, owners of private wells can sell their water to oil and gas drillers (Gold and Campoy, 2011). The perceived benefits of these sales could help explain the positive relationship between groundwater usage and support for fracking. Specific states' water experiences, however, can greatly differ as well, especially for states where more abundant water supplies could mean selling or leasing water is not as profitable or widespread as it is in more arid areas.

Additionally, some researchers have found that housing values near fracking well sites can decrease depending on local factors, one of which can be water concerns (Balthrop and Hawley, 2017; Bennett and Loomis, 2015; Gopalakrishnan and Klaiber, 2014). For example, a study of housing values in Pennsylvania found that one of the greater determinants for whether fracking negatively affected values was if the property was sourced by a private well for water supply (Gopalakrishnan and Klaiber, 2014). The relationship between water source and perceptions of fracking, then, might be better understood by including private water well use. The relationship between public supply and support for fracking, instead, could be reflecting respondents' belief that public supplies are more regulated and/or secure than personal well supplies.

Unfortunately, research examining how experiences with water – beyond the uncertainty around how fracking operations affect ground- and surface water – relate to views of fracking is scarce. As Fisk (2013) found, higher reliance on groundwater in a state was actually associated with less stringent chemical disclosure policies, which at first glance suggests that the positive relationship between groundwater reliance and support for fracking is not reflecting higher perceived security due to stronger water regulation in those states. It might be, however, that in states with less stringent disclosure laws, the laws are less stringent in part because public and policy discussions of the risks involved with fracking operations have been less prevalent. If that is the case, public perceptions in those states could be less affected by negative sentiment or heightened focus on risk. A systematic examination of what advocacy efforts, accidents and other focusing events, and other factors shape policy differences within states is beyond the scope of this analysis. However, relationships between water use, public awareness, and public opinion of fracking in different states -- whether individuals are aware of their state's disclosure practices, where their public water supply comes from, and stringency of fracking regulations --

are unclear and worth examining to better understand how regulation shapes perceptions and vice versa.

The marginal significance of the groundwater use finding as well as the somewhat surprising direction of the relationship measured warrants caution in over-interpreting the results. Likewise, the marginally significant negative relationship between mining location quotient and support for fracking will need further research for the same reasons. Based on these results, however, the negative relationship between greater economic reliance on extraction industries and support for fracking could be reflecting the general trend captured in the national Pew data (Drake, 2015) and case studies (see Kriesky et al., 2013; Theodori, 2009; Rabe and Borick, 2011) that indicate that support for fracking can decrease as individuals become more familiar with the technology.

Overall, however, state-level variables explain a relatively small proportion of the total variance in support. This suggests that the impacts of state-level experiences on attitudes, although significant, are limited in magnitude. The small role of state-experience, however, is not especially surprising. As described throughout this analysis, many relevant experiences with fracking occur at local scales or cross state borders, even if regulation focuses on the state-level. Additionally, most Americans do not have direct experience with fracking. For those individuals, personal values would likely play a larger role in shaping opinions. Finally, as seen in literature covering the impacts and potential impacts of fracking operations, there are mixed results on whether the presence of fracking would boost or worsen economic conditions and what the extent of its environmental and health impacts is. With questions such as whether economic or employment growth outweighs economic costs of higher community strain and resource use or of how regulations are actually enforced and with what impact for environmental and human

health, there is high uncertainty surrounding the impact of fracking. That uncertainty leaves space for a wide range of interpretations and reactions among individuals as they form their opinions, even if they share particular experiences. Despite this high potential for variability, however, it appears certain state experiences are significantly connected to individual experiences and views.

Of the individual-level differences that do account for a dominant proportion of variance in public support for fracking, gender remains one of the strongest indicators of support, followed by benefit and risk perceptions. Males, people with higher incomes, and conservatives are more likely to support fracking. The finding of conservatism being significantly related to support for fracking is consistent with other studies on controversial energy technologies, support for fossil fuel development, and support for fracking (Boudet et al., 2014; Davis and Fisk, 2014). The relationship between political ideology and attitude, however, appears to vary as a function of the specific social contexts surrounding individuals (Kahan, 2016). Although Americans nationally are politically divided on fracking, our results show that the relationship between conservative political ideology and support for fracking is slightly stronger for respondents living in states with higher poverty rates. In other words, in states that are economically desperate, conservative Republicans are more likely to support fracking compared with their peers living in richer states. Liberals, however, appear to be less sensitive to poverty rate in shaping their support for fracking. The result is that the divide in support for fracking based on political ideology is greater in states with higher poverty rates. This finding is after controlling for potential effects of differences in education levels and income, so it does not appear to be due to more conservatives than liberals experiencing poverty in those states. In light of Kahan's (2016) finding that shared local experience outweigh political ideology for

addressing local sea-level rise concerns, our result indicates the interaction between experience and personal values for finding agreed-upon solutions to local issues differs depending on the particular issue and proposed solutions. For fracking, even if residents in states with higher poverty levels agree that action is needed to reduce poverty, they could differ depending on their ideology on whether fracking is an appropriate solution. More liberal respondents might be less likely to see fracking as a way to reduce poverty or more likely to see any poverty reduction it could create as not worth the associated risks of fracking.

Beyond the effects of political ideology, those who think fracking is personally important and perceive more benefits associated with it are more supportive. Risk perception is negatively, whereas benefit perception is positively, related to support. Notably, the relationship between risk/benefit perception and fracking support varies across states, suggesting that residents of different states assign different weights to risk and benefit perceptions when forming attitudes. This finding generally supports our overarching theme that individuals' values and resulting risk/benefit perceptions not only exert independent effects on support but also interact with individuals' concerns of locally-bounded problems to influence attitudes. Individuals' experiences with fracking or with the potential for fracking in their states, therefore, appear to influence the relative weights they assign to benefits when forming attitudes.

5. Conclusion and policy implications

Overall, it is clear that individuals' opinions about fracking are shaped by individual values, characteristics, and perceptions, as well as macro-level political, geographic, and industrial experiences. More importantly, the effects of individual-level factors on acceptance are shaped by the social contexts wherein energy policies are made. For example, partisan division existing in the national population is slightly larger in those states with high poverty rates, with

conservatives appearing to be more driven by the state's longing for economic growth. Additionally, the relationship between risk/benefit perceptions and support varies for residents of states characterized by different socioeconomic and industrial conditions. People living in proximity to fracking operations not only are more likely to perceive greater benefits from fracking but also might rely on these perceptions more than other individuals do when forming attitudes.

These findings have important implications for understanding the nuanced dynamics of how people form opinions about emerging energy technologies within geographic boundaries. For policymakers attempting to leverage public support, it is critical to identify and address concerns that are relevant to local politics and industrial experiences. As fracking will likely grow and increasingly depend on a social license to operate, understanding public perceptions and the values that shape those perceptions is vital to industrial and political stakeholders. Further studies building off this analysis and the growing body of literature on public perceptions of fracking can help ensure fracking develops in a way conscious of what is relevant to local residents and of how a state's overall experiences can shape its residents' support for the technology.

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Figure 1: Interactive effect between potential shale play in a state and fracking benefit perceptions on individuals' support for fracking (y-axis partially shown).

Figure 2: Marginally significant ($p \leq .10$) interactive effect between active shale play in a state and fracking benefit perceptions on individuals' support for fracking (y-axis partially shown).

Figure 3: Marginally significant ($p \leq .10$) interactive effect between state poverty rate and political ideology on individuals' support for fracking (y-axis partially shown). Conditional values of state poverty rate include the mean (15.5%), one SD below the mean (11.8%), and one SD above (19.1%).

Table 1: Descriptive statistics for state-level variables
(reflecting conditions at the time of the survey in 2014)

State	N	% Poverty	Potential Shale Play	Active Shale Play	Mining Location Quot.- 5y Mean	% Ground- water Use
Alabama	9	14.1%	1	0	0.80	34.0%
Arizona	16	19.0%	0	0	1.09	48.0%
Arkansas	3	16.1%	0	0	0.94	31.0%
California	87	23.4%	1	0	0.86	45.0%
Colorado	19	12.8%	0	1	0.96	15.0%
Connecticut	11	12.5%	0	0	1.28	32.0%
Delaware	2	13.9%	0	0	0.00	57.0%
Dist. of Columbia	2	22.4%	0	0	0.00	0.0%
Florida	63	19.1%	0	0	1.16	89.0%

Georgia	30	17.5%	0	0	0.83	22.0%
Hawaii	3	18.4%	0	0	0.60	94.0%
Idaho	4	11.1%	0	0	0.95	89.0%
Illinois	40	14.9%	1	0	1.06	24.0%
Indiana	10	13.2%	0	1	0.97	54.0%
Iowa	9	8.7%	1	0	0.94	79.0%
Kansas	13	11.8%	1	0	0.91	41.0%
Kentucky	8	13.8%	0	1	0.85	12.0%
Louisiana	10	18.3%	1	0	0.89	51.0%
Maine	2	10.7%	0	0	0.82	30.0%
Maryland	9	13.4%	0	0	1.25	11.0%
Massachusetts	20	13.8%	0	0	0.79	28.0%
Michigan	31	13.4%	0	1	1.00	19.0%
Minnesota	25	10.5%	0	0	2.00	65.0%
Mississippi	6	15.3%	1	0	0.89	88.0%
Missouri	19	12.3%	1	0	1.07	35.0%
Montana	2	11.7%	0	1	0.97	48.0%
Nebraska	8	10.3%	1	0	1.54	79.0%
Nevada	6	20.0%	0	0	1.36	23.0%
New Hampshire	3	10.5%	0	0	1.00	38.0%
New Jersey	12	15.9%	0	0	0.74	37.0%
New Mexico	8	16.0%	0	0	0.92	75.0%
New York	36	17.5%	0	1	0.75	20.0%
North Carolina	30	15.4%	0	0	0.94	20.0%
North Dakota	3	9.2%	0	1	2.20	44.0%
Ohio	30	12.6%	0	1	0.90	33.0%
Oklahoma	11	12.4%	0	1	0.91	20.0%
Oregon	15	14.5%	0	0	0.70	21.0%
Pennsylvania	51	12.7%	0	1	1.60	16.0%
Rhode Island	1	14.0%	0	0	0.63	15.0%
South Carolina	8	16.4%	0	0	0.80	18.0%
Tennessee	24	15.6%	1	0	1.01	33.0%
Texas	61	15.9%	0	1	0.98	28.0%
Utah	15	11.1%	0	1	0.88	54.0%
Vermont	2	9.7%	0	0	0.83	32.0%
Virginia	28	13.6%	0	0	1.02	11.0%
Washington	18	12.6%	0	0	1.01	52.0%
West Virginia	6	13.2%	0	1	1.10	18.0%
Wisconsin	23	11.2%	0	0	1.36	54.0%
Wyoming	1	9.7%	0	1	0.88	52.0%
Total	853	14.1%	20.4%	28.6%	1.04	37.8%

Note: Alaska and South Dakota were excluded because we did not have respondents from those states.

Table 2: Multilevel model predicting public support for fracking (individual N = 853, State N = 49).

	Null Model	Model 1	Model 2	Model 3	Model 4
Intercept (γ_{00})	4.23***(.23)	3.88***(.21)	4.48***(.20)	4.40(.20)***	
State-level variables					
Potential shale play (not active)	--	.35(.26)	--	-.08(.12)	
Active shale play	--	.67(.32) *	--	.51(.12)***	
Mining location quot. (MLQ)-	--	-.31(.39)	--	-.42(.24)#	

5y mean					
% poverty rate, regionally adjusted	--	-.00(.03)	--	.04(.02)*	
Ground water use	--	.90(.49)#	--	.52(.53)*	
Individual-level variables ^a					
Age	--	--	.00(.00)	.00(.00)	
Gender (female)	--	--	-.54(.14)***	-.56(.14)***	
Race (white)	--	--	.20(.15)	.17(.15)	
Education	--	--	.01(.03)	.01(.04)	
Income	--	--	.05(.02)*	.05(.02)*	
Political ideology (conservative)	--	--	.12(.06)#	.12(.06)*	
News attention (public & science)	--	--	.04(.03)	.04(.03)	
Issue importance	--	--	.06(.03)#	.06(.03)*	
Issue knowledge	--	--	-.05(.08)	-.06(.07)	
Fracking risk perception	--	--	-.29(.03)***	-.31(.04)***	
Fracking benefit perception	--	--	.66(.04)***	.63(.04)***	
Interactions					
Potential play x Risk perception	--	--	--	--	n.s.
Active play x Risk perception	--	--	--	--	n.s.
Potential play x Benefit perception	--	--	--	--	.10(.05)*
Active play x Benefit perception	--	--	--	--	.08(.04)#
MLQ x Political Ideology	--	--	--	--	n.s.
Poverty rate x Ideology	--	--	--	--	.02(.01)#
Random Effects					
Intercept variance (τ_{00})	.16	.11	.05*	.06	
τ Political Ideology	--	--	--	.04	
τ Risk Perception	--	--	--	.03*	
τ Benefit Perception	--	--	--	.03**	
Residual variance (σ^2)	9.16	9.12	3.43	3.12	
χ^2 Deviance statistics:	4,281.42	4,276.63	3,402.12	3,375.87	

$p \leq .10$, * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Individual-level variables of age, education, income, ideology, news attention, importance, knowledge, risk, and benefit perceptions were grand-mean centered (others were dichotomous and not centered). State-level variables of mining location quotient, percent poverty rate, and ground water use were also grand-mean centered.

Table 3: Summary of findings for the hypotheses and research questions.

Hypothesis/ Research Question	Predicted direction or question	Result
H1	Presence of active shale plays is positively related to residents' support for fracking	Supported
H2	Presence of potential shale plays is positively related to residents' support for fracking	Not significant
H3	A state's mining location quotient is positively related to residents' support for fracking	Not supported: marginally significant in the opposite direction predicted
H4	A state's poverty rate is positively related to residents' support for fracking	Supported
H5	Risk (benefit) perception is negatively (positively) related to support for fracking	Supported
H6a	Conservative political ideology is positively related to support for fracking	Supported
H6b	The positive relationship between conservative ideology and support for fracking is weaker for those residing in states with higher poverty rates	Not supported: marginally significant in the opposite direction predicted
H6c	The positive relationship between conservative ideology is weaker for those residing in states with a higher mining location quotient	Not significant
H7a	Perceived personal importance of fracking is positively related to support for fracking	Supported
H7b	Knowledge is positively related to support for fracking	Not significant
H8	News attention is negatively related to support for fracking	Not significant
RQ1	How does a state's reliance on groundwater for the public water supply relate to residents' support for fracking?	Reliance on groundwater appears to be significantly positively related to support for fracking
RQ2	Do the relationships between risk/benefit perceptions and support vary for states that have different levels of fracking activities?	Perception of the benefits of fracking appear to be stronger predictors of support for fracking in states with active and potential shale plays. <ul style="list-style-type: none"> • This interaction is significant for residents in states with potential shale plays • This interaction is marginally significant for residents in states with active shale plays

HIGHLIGHTS

- Americans' support for 'fracking' relates to their state's economic and industrial experience.
- Percent ground water-use, active shale plays, and poverty rate predict support for fracking.
- Individual-level predictors include gender, political ideology, and risk/benefit perceptions.
- Conservative ideology's positive relationship to support is stronger for those in poorer states.