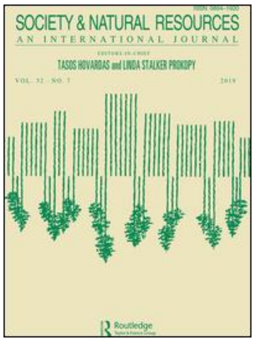

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Local Residents' Attitudes toward Shale Gas Exploitation: A Case Study in Sichuan, China

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ABSTRACT

This study investigates local residents' attitudes toward shale gas exploitation in China through interviews of 730 residents of Sichuan Province and explores determinants of their support or opposition. It is the first study in China to explore local residents' attitudes on this subject and we identify underlying factors contributing to such attitudes, including energy poverty, environmental awareness, and risk and benefit perceptions. The results show that the respondents are generally supportive of shale gas development. Fewer than 20% of them report opposing such development. The respondents' supportive attitudes are significantly associated with their positive benefit perceptions, trust in public entities, perspectives on impacts and risks of shale gas exploitation, and knowledge of shale gas technology, while oppositional attitudes are significantly associated with risk perception, energy poverty, and environmental awareness.

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Attitudes; China; environmental awareness; energy poverty; risk perception; shale gas exploitation

Introduction

Shale gas, an unconventional type of gas exploited by new technologies of horizontal drilling and hydraulic fracturing, has gained increasing attention in recent years. The exploitation of shale gas offers benefits to local economies; however, both horizontal drilling and hydraulic fracturing technologies also lead to environmental risks including water pollution, air pollution, noise pollution, threats to natural ecosystems, and risks of disasters such as local earthquakes and landslides (Israel et al. 2015; Ladd 2013). These factors in turn lead to debate over shale gas exploitation, resulting in a surge of research interest in understanding the public's attitudes toward it (Boudet et al. 2014; Whitmarsh et al. 2015).

As the world's third country to realize commercial development of shale gas, China should not be an exception in studying public attitudes. However, it is rare to see studies on public attitudes in China, particularly on opinions of local residents near shale gas exploitation sites. In contrast with other countries such as the U.S. and Canada, the stage and intensity of shale gas development in China are still initial and relatively low. China however owns the world's greatest technically recoverable shale gas resources, estimated at 1,115 trillion cubic feet by the U.S. Energy Information Administration

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(EIA), but did not realize commercial shale gas production until 2012. In 2014, China produced 1.32 billion cubic meters (bcm), far behind the U.S. (379 bcm) and still well behind Canada (5.94 bcm). In 2018, China's production of shale gas reached 10.8 bcm.[1] The current development goal, as stated in the government document "Shale Gas Development Planning (2016–2020)," is to achieve annual 80–100 bcm production by 2030. Such vast and rapid new expansion would have significant impacts on Chinese residents living near such development sites, and their attitudes should be explored.

This study is also the first to explore the influence of energy poverty on respondents' attitudes toward shale development. Most shale gas wells are in rural areas, where residents have lower average income and rely heavily on traditional use of biomass[2] for energy, especially for cooking. Though modern energy modalities such as electricity and natural gas are becoming more prevalent with the infrastructure construction of recent decades, Chinese rural households still largely use biomass or coal because of their affordability. We would like to understand whether development of shale gas is likely to win support from local residents suffering from energy poverty in China.

Literature Review

As an emerging technology about which public knowledge is limited, shale gas has received broad worldwide academic attention regarding public attitudes toward, and perceptions of, shale gas exploitation. Prior literature has suggested wide regional differences in such attitudes (Borick, Rabe, and Lachapelle 2014; Drake 2015; Lachapelle and Montpetit 2014; Kromer 2015; Mazur 2016), potentially due to a variety of contextual factors that may or may not interact with individual characteristics, for instance, shale play residences and extractive history (Boudet et al. 2016; Howell et al. 2017). Research along these lines has employed qualitative methodologies such as interviews to understand reasons contributing to public attitude formation toward shale gas. Major reasons cited for public opposition include safety, undesirable environmental and ecological impacts, and conflicts with individual values (Boudet et al. 2014; Israel et al. 2015; Simonelli 2014; Theodori 2012; Whitmarsh et al. 2015). The biggest reason for public support has been economic benefit-local community gain (or hope for such) from shale gas exploitation (Anderson and Theodori 2009; Brasier et al. 2011; Schafft, Borlu, and Glenna 2013).

Other studies have used structured quantitative surveys to explore factors underlying public attitudes. Higher perceived risk from development is found to significantly reduce the likelihood of public support for the technology (Van der Horst 2007; Wolsink and Devilee 2009). Previous studies have suggested that public attitudes toward shale gas technology depend not only on risks associated with fracking but also on perceived economic benefits (Davis and Fisk 2014; Lachapelle and Montpetit 2014). Therefore, we propose the following hypotheses:

H1: People who perceive higher risks from shale gas exploitation will be more likely to oppose it.

H2: People who perceive higher benefits from shale gas exploitation will be more likely to support it.

Besides, the existing literature have identified a wide array of perceptual factors predicting public attitudes toward shale gas development including institutional trust, political ideology, environmental perspective, access to and attitudes of mass media, other information sources, and demographics. Trust in institutions has been found to significantly influence public attitudes and behaviors toward various environmental risks (Lange and Gouldson 2010; Renn 1992). In particular, trust in government has been identified as being critical in determining public acceptance of emergent technologies, and trust as well in the oil/natural gas industry and other agents has been found to be associated with public acceptance in the specific context of shale gas development (Willits, Theodori, and Luloff 2016). Based on the aforementioned literature, we propose the following hypotheses:

H3: Trust in specific entities is a significant positive predictor of public support for shale gas exploitation.

Additionally, personal beliefs and values, particularly environmental values, are related to public attitudes toward shale gas development. Using the eight-item New Ecological Paradigm (NEP) scale, Jacquet (2012) and Brasier et al. (2013) examined how the public's risk perceptions are associated with environmental attitudes, finding that a higher environmental attitude ranking is associated with higher risk perception. Whitmarsh et al. (2015) introduced the roles of environmental identity (e.g., "I think of myself as someone who is concerned about the environment") and climate change skepticism (i.e., beliefs about the reality, causes and effects of climate change) as factors, finding that people with lower environmental identity and higher climate skepticism are more favorable to shale gas. Thus we hypothesize that public environmental attitudes are significantly negatively associated with support for development.

H4: People who anticipate greater severity of future environmental problems are more likely to oppose development.

H5: People who perceive greater current environmental degradation are more likely to oppose development.

Moreover, public attitudes arehighly dependent on available sources of information about shale gas (Theodori et al. 2014) and the specific content of the information provided (Whitmarsh et al. 2015). More specifically, the gain or loss framing of information regarding risks and benefits has been found to significantly influence changes in public attitudes toward shale gas (Whitmarsh et al. 2015). Mass media also can affect public awareness and discourse of fracking (Boudet et al. 2014; Vasi et al. 2015). For example, people who watch TV frequently are more likely to support fracking, while people who read newspapers frequently are less likely to support it (Boudet et al. 2014). Furthermore, previous studies have addressed knowledge as an influencing factor (Boudet et al. 2014; Clarke et al. 2016; Whitmarsh et al. 2015; Willits, Theodori, and Luloff 2016). The study of Whitmarsh et al. (2015), for example, found that prior knowledge is positively associated with favorable attitudes.

Gender, age, and education are the most frequently noted demographic variables to predict attitudes toward shale gas development (Boudet et al. 2014; Clarke et al. 2012; Jacquet 2012; Kriesky et al. 2013; Whitmarsh et al. 2015). Those studies found that, in general, men are more likely to support shale gas drilling than women, but the effects of age and education vary. For example, in the studies of Clarke et al. (2012) and Jacquet (2012), younger U.S. respondents were more likely to oppose shale gas drilling, while no evidence of age influenced the U.K. public's attitudes was found in Whitmarsh et al. (2015). Boudet et al. (2014) showed that increased education can lead to stronger support for hydraulic fracturing, but Jacquet (2012) found that better-educated respondents were more likely to have negative attitudes toward it. To sum up, age and education have had inconsistent influences in predicting attitudes toward shale gas exploitation but male gender has a consistent positive influence.

To our best knowledge, no study to date has considered the influence of energy poverty on public attitudes toward shale gas exploration. People suffering energy poverty seem likely to oppose energy development if they both have to bear related risks while not directly benefiting from increasing abundance of energy sources. Energy-poverty alleviation is a key policy goal toward larger national aims of ending poverty (Sagar 2005). Ürge-Vorsatz and Herrero (2012) argued that low household income, high energy price, and low dwelling energy efficiency were three main factors contributing to energy poverty. Many previous studies have underscored the issue of international or regional energy poverty, with attention respectively to sub-Saharan countries, Brazil, India, Japan, Pakistan, and rural Bangladesh. (Barnes, Khandker, and Samad 2011; Bensch 2013; Khandker, Barnes, and Samad 2012; Okushima 2016; Pachauri et al. 2004; Pereira, Freitas, and da Silva 2011; Sher, Abbas, and Awan 2014). Khandker, Barnes, and Samad (2012), for example, applied cross-sectional data from the 2005 India Human Development Survey and found that the most effective way to reduce energy poverty is through rural electrification and more use of modern cooking fuels. Pereira, Freitas, and da Silva (2011) reexamined the concept of energy poverty line in Brazil and evaluated the effectiveness of expanded access to electricity, also finding that rural electrification significantly alleviates the energy poverty level. Okushima (2016) employed various poverty and vulnerability measures to examine the dynamics of energy poverty in Japan, concluding that Japan faces a worsened energy poverty problem arising from the increase of energy prices and reduction of income.

Although China had only four million people without access to electricity in 2010 (IEA 2012), almost 30% of the population still uses biomass for cooking, of whom around 90% are in rural area. Tang and Liao (2014) found that over three-fourths of rural households use coal and biomass as the primary household cooking energy. Besides, the Energy Poverty Research of China Energy Research Report (Wei et al. 2014) reported that one-third of rural households used traditional biomass or coal for cooking in 2011. Similarly, the Chinese Household Energy Consumption Report (Zheng 2015) reported that biomass and coal accounted for 61% and 15%, respectively, of the energy used by Chinese rural households in 2013.

Hence we propose the following research question:

> RQ1: Is supportive attitude toward gas development significantly correlated with energy poverty?

Survey Design and Methodology

Survey Design

To design an adequate questionnaire, we first conducted a separate online survey of a relatively expert sample to collect their opinions on shale gas development. This was distributed online by a well-recognized Chinese magazine called Energy Observer, readers of which mainly work for enterprises or research institutes in the fields of environment, electricity, oil, and gas. A total of 292 replies nationwide were collected; 49% of respondents had professional experiences and skills in shale gas, 31% were in shale gas policy and law, while 18% had relevant engineering expertise. Following previous literature and this online expert survey, we selected a total of eight potential benefit and ten risk items in re shale gas development and, on this basis, designed the local resident survey questionnaire.

The authors selected two counties, Weiyuan County and Gong County, in the Changning-Weiyuan area in Sichuan Basin for this survey. Weiyuan County is in the Weiyuan area and has China's earliest shale gas well, and Gong County is in the Changning area and has China's first large-scale shale gas production area. The total populations of Weiyuan and Gong counties at the end of 2016 were, respectively, 728,000 and 437,000. Several face-to-face pretests in the villages of Weiyuan County were conducted in March and April 2016 and the survey questions were slightly revised based on pretest results. The official survey was conducted by face-to-face interviews in April and May 2016 in 13 villages of Weiyuan County and 15 villages of Gong County, where we randomly selected villages and randomly sampled households. All villages in these counties, importantly, had experienced a moderate level of damages in the 2008 Great Sichuan Earthquake.

Figure 1 shows the survey area. In this area the geologic features are piedmont-structured, with hilly topography and loose surfaces, crisscrossed by ravines and gullies, along with a shortage of water adding to the difficulties of shale gas drilling; well leakage and wall caving frequently happen, and repeated well refills and side tracking are demanded. Also simultaneous leakage, gush, and collapse can trigger chemical leakage, resulting in water and air pollution and stratum contamination during exploitation. Such conditions of shale gas deposits are likely to cause severe environmental problems from exploitation.

Measures

The participants were asked to respond to a sequence of questions about their overall attitudes toward shale gas exploitation, along with a series of questions regarding energy usage, risk perception, benefit perception, awareness of environmental problems, trust of specific entities, perspective, knowledge questions, media/information questions and awareness of shale gas accidents. Respondents' demographic characteristics were also collected. The series of questions were adapted from previous studies to develop the measures (Anderson and Theodori 2009; Boudet et al. 2014; Israel et al. 2015; Kreuze, Schelly, and Norman 2016; Stedman et al. 2012), and Table 1 summarizes the measures and descriptive statistics of questionnaire items.

The measure of degree of energy poverty was composed using the multi-dimensional energy poverty index (MEPI) introduced by Nussbaumer, Bazilian, and Mod (2012) with slight adjustments based on China's circumstances. Participants were asked (1) "What types of fuel do you mainly use?" and (2) "What types of fuel do you mainly use to cook?" with "electricity," "natural gas," "liquefied gas," "cylindrical briquette,"

Figure 1. Geographical location of survey area in China.

"diesel," "firewood," "solar energy," "biogas," and "other" as response options. In addition, participants were asked whether they had (1) a refrigerator, (2) a radio or television and (3) Internet access in their homes, with simple "yes" or "no" response options. We asked about Internet access instead of specific telecommunication equipment because the nature of telecommunication infrastructure and the popularity of mobile phones in Chinese rural areas are inadequate to measure energy poverty. Responses to the aforementioned five questions were weighted and summed, with the value of MEPI ranging from 0 to 1. A higher MEPI indicated a higher degree of energy poverty, with the resident being not energy-poor if MEPI $= 0$.

Preliminary Tests

Treatment of Missing Data

With a response rate of 99%,[3] our survey has interviewed 730 residents in total (30% in Weiyuan County and the rest in Gong County), among which only 98 (13.4%)

Table 1. Measures, mean, and standard deviations among response items.

Item	Measure	Mean	SD
A. Attitude toward shale gas exploitation			
1. Overall attitude	In general, are you for or against shale gas exploitation? Strongly oppose = 1, oppose = 2, neutral = 3, support = 4, strongly support = 5	4.07	1.16
B. Energy poverty			
2. Multidimensional Energy Poverty Index (MEPI)	Weighted sum of five questions re whether respondent uses modern cooking fuel ($w = 0.4$), has access to electricity ($w = 0.2$), has a fridge ($w = 0.13$), has a radio or television ($w = 0.13$) and has internet ($w = 0.13$)	0.19	0.22
C. Perceived risks			
3. Groundwater contamination	To what extent do you perceive each risk item as risk of shale gas exploitation? Not at all = 0, very small extent = 1, small extent = 2, moderate extent = 3, great extent = 4, very great extent = 5	2.72	1.89
4. Surface water contamination		2.20	1.94
5. Air pollution		2.10	1.84
6. Animal habitat degradation		1.11	1.63
7. Vegetation degradation		1.44	1.73
8. Health problems of residents near wells		2.10	1.94
9. Health problems of residents far from wells		1.24	1.46
10. Noise pollution		3.00	1.84
11. Geologic hazards		2.58	1.99
12 Traffic congestion		1.87	1.98
D. Perceived benefits			
13. Local economic stimulation	To what extent do you perceive each benefit item as benefit of shale gas exploitation? Not at all = 0, very small extent = 1, small extent = 2, moderate extent = 3, great extent = 4, very great extent = 5	2.71	1.85
14. Increased local job opportunities		2.02	1.81
15. Facilitation of local infrastructure construction		2.25	1.96
16. Real estate income increase		1.75	1.76
17. Local population increase		1.79	1.76
18. Local service industry development		2.18	1.91
19. Enhancement of local residents' sense of pride		1.99	1.96
20. Energy price reduction		1.79	1.95
E. Awareness of environmental problems			
Group 1: anticipated future environmental problems			
21. Natural disruptions	Whether the following six categories of problems will be more severe in the future? No = 0, Yes = 1	0.78	0.41
22. Increasing temperature		0.89	0.31
23. Clean water scarcity		0.83	0.38
24. Clean air scarcity		0.77	0.42
25. Less food productivity		0.63	0.48
26. Worse living environment		0.49	0.50
Group 2: perceived current environmental problems			
27. Perceive problems throughout China	To what extent do you perceive current environmental problems nearby and throughout China? Very slightly = 1, slightly = 2, moderate = 3, severe = 4, very severe = 5	3.37	1.10
28. Perceive problems nearby		2.80	1.22
F. Trust on specific entities			
29. Central government	To what extent do you trust the central government/ the local government/ the petroleum companies? Totally distrusted = 1, distrusted = 2, neutral = 3, trusted = 4, totally trusted = 5	4.45	0.78
30. Local government		3.44	1.29
31. Petroleum companies		3.33	1.19

(*continued*)

Table 1. Continued.

Item	Measure	Mean	SD
G. Perspectives on shale gas impacts and risks			
32. Can be avoided	To what extent do you say the negative impacts (if any) of shale gas development can be avoided/controlled/observed? Can't be at all = 1, can't be = 2, neutral = 3, can be = 4, can fully be = 5	2.01	1.28
33. Can be controlled		3.29	1.39
34. Can be observed		3.44	1.35
H. Knowledge of shale gas			
35. Knowledge of shale gas technology	Sum of the accuracy of responses to ten true/false statements about shale gas (incorrect = 0, correct = 1)	6.95	1.43
I. Information sources			
36. Number of information sources	Multiple response question with options of the local community (public forum or village committee notice board), the government (lectures or education), the petroleum companies (reports from Petro China or Sinopec), Internet, newspapers, television, radio, relatives or friends, other residents, and well guards and project staff.	2.39	1.57
37. Extent of information received	Very little = 1, little = 2, neutral = 3, much = 4, very much = 5	2.80	1.05
38. Trust on information sources	Totally distrusted = 1, distrusted = 2, neutral = 3, trusted = 4, totally trusted = 5	3.75	0.91
J. Others			
39. Awareness of shale gas accidents	Have there been any accidents involving shale gas well(s) near your hometown? 0 = I don't know, 1 = Yes	0.13	0.34
K. Demographic variables			
40. Age	Real number	52	13.7
41. Gender	Female = 0, Male = 1	0.57	0.49
42. Education years	Elementary school = 6, Junior high school = 9, Senior high school = 12, Some college/vocational school = 15, College graduate = 17	7.22	3.47
43. Chinese Communist Party	No = 0, Yes = 1	0.14	0.35
44. Cadre	No = 0, Yes = 1	0.12	0.33
45. Individual Income (after tax)	No income = 1, Less than RMB 5,000 = 2, RMB 5,000–9,999 = 3, RMB 10,000–19,999 = 4, RMB 20,000–39,999 = 5, RMB 40,000–79,999 = 6, RMB 80,000–119,999 = 7, RMB 120,000–159,999 = 8, RMB 160,000–199,999 = 9, More than RMB 200,000 = 10	11.5K	15.4K

respondents completed the whole questionnaire. Specifically, 44 out of 58 questions (75.9%) have a missing data rate lower than 5% (36 cases) yielding a total missing rate by 5.04%. Following Howell's (2013) recommendations, the missing data treatments of this study begin with a missing completely at random (MCAR) test and then a missing at random (MAR) test (if needed). The Little's (1998) MCAR test suggests a significant result ($\chi^{3}_{17111=18613.4}$ $p < .001$) which implies the causes of the missing were not completely at random, whereas a follow-up MAR test on those 14 suspected items (i.e., having a missing rate higher than 5%) indicates that it is safe to assume the dataset has the missingness at random ($\bar{t} = 1.40$, *n.s.*). Hence, missing values were replaced using the Expectation-Maximization (EM) algorithm[4] in SPSS 17.0, providing a comprehensive data set of all measures considered in this study.

Factor Analysis

All the question items were entered into scale reliability tests by a factor analysis together with calculations of Cronbach's alpha and average inter-item correlations, and Table 2 reports the results. The factor analysis with Equamax rotation yielded a total of eight factor solutions, in which items with factor loadings $\lambda > 0.35$ defined seven scales. This suggests that risk perception was shaped by seven items ($\alpha = 0.85,$ average interitem correlation = 0.45), and the benefit perception variable was also shaped by seven items ($\alpha = 0.84,$ average interitem correlation = 0.43). The items of awareness of environmental problems yielded two factors: anticipated future environmental problems, shaped by six items ($\alpha = 0.73,$ average interitem correlation = 0.32), and perceived current environmental problems, shaped by two items ($\alpha = 0.65,$ average interitem correlation = 0.48). The trust factor is shaped by three items ($\alpha = 0.70,$ average interitem correlation = 0.43), and two items shaped a perspective factor ($\alpha = 0.64,$ average interitem correlation = 0.47). Though knowledge of shale gas technology and number of information sources yielded a factor, it had a lower level of reliability ($\alpha = 0.45,$ average interitem correlation = 0.47) and thus won't be composited into a variable. The MEPI alone shaped the last factor: energy poverty with $\alpha = 0.36$.

Results

Participants

Demographically, the sample was 42.6% female. Respondents averaged 52 years of age and 7.22 years of education, and with 87% of respondents having not graduated from high school. The sample earned on average RMB ¥11,500 in annual individual income, and only 16% of respondents earned RMB ¥30,000 or more per year. 14% of participants were Chinese Communist Party members. 90% of respondents had previous earthquake damage experience and a quarter of the respondents (25%) had experienced landslides.

Hypothesis Tests: Correlation Analysis

The correlation analysis in Table 3 indicates the level of support for each of our five hypotheses. Respondents were more likely to oppose shale gas exploitation if they perceived higher risks resulting from it ($r = -.32$), anticipated more severe future environmental problems ($r = -.30$) and perceived higher current environmental degradation ($r = -.32$), while they were more likely to support the development if they perceived higher benefits ($r = .42$) and if they had greater trust in specific entities, primarily governmental ($r = .46$). In terms of research question, the results show that favorable attitudes toward shale gas development are significantly (but not very strongly) negatively correlated with degree of energy poverty ($r = -.10$), indicating that respondents facing a relatively high degree of energy poverty were somewhat, but not greatly, more likely to oppose it.

Table 2. Principal axis factors, scale reliabilities, and average inter-item correlations.

	Factors										
Variable	1	2	3	4	4	5	6	7	8	Scale α	Average inter-item correlation
A. Risk perceptions											
1. groundwater contamination	.53										
2. surface water contamination	.57										
3. air pollution	.62										
4. animals' habitat degradation	.56										
5. vegetation degradation	.52										
6. health problems of residents near wells	.84										
7. health problems of residents far from wells	.78										
Risk perception factor(items 1–7)										.85	.45
B. Benefit perceptions											
8. local economic stimulation		.66									
9. increased local job opportunities		.64									
10. facilitation of local infrastructure construction		.61									
11. real estate income increase		.67									
12. local population increase		.65									
13. local service industry development		.71									
14. enhancement of local residents' sense of pride		.54									
Benefit perceptions (items 8–14)										.84	.43
C. Awareness of environmental problems											
15. natural disruptions			.45								
16. increasing temperature			.35								
17. clean water scarcity			.61								
18. clean air scarcity			.63								
19. less food productivity			.47								
20. worse living environment			.50								
Anticipated future environmental problems(items 15–20)										.73	.32
21. perceive problems throughout China				.54							
22. perceive problems nearby				.49							
Perceived current environmental problems (items 21–22)										.65	.48
D. Trust in specific entities											
27. central government							.54				
28. local government							.58				
29. (government-owned) petroleum companies							.60				
Trusts (items 27–30)										.70	.43
E. Perspectives on shale gas impacts and risks											
31. can be avoided								.55			
32. can be controlled								.58			
Perspectives (items 31–32)										.64	.47
F. Knowledge and Information sources											
34. knowledge of shale gas technology						.52					
35. number of information sources						.44					
										.45	.29
G. Energy Poverty											
38. Multidimensional Energy Poverty Index									.36		

Note: Entries with factor loadings >0.35 have been reported.

Table 3. Means, standard deviations, and intercorrelations among variables.

Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Attitude	4.08	1.16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Risks	1.84	1.30	−.32[a]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Benefits	2.10	1.33	.42[a]	−.18[a]	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MEPI	0.19	0.22	−.10[a]	.02	−.15[a]	—	—	—	—	—	—	—	—	—	—	—	—	—
Future	0.73	0.28	−.30[a]	.38[a]	−.22[a]	−.06	—	—	—	—	—	—	—	—	—	—	—	—
Current	3.08	1.00	−.32[a]	.38[a]	−.21[a]	−.03	.48[a]	—	—	—	—	—	—	—	—	—	—	—
Trusts	3.74	0.87	.46[a]	−.31[a]	.41[a]	−.03	−.33[a]	−.37[a]	—	—	—	—	—	—	—	—	—	—
Perspectives	3.38	1.16	.28[a]	−.25[a]	.27[a]	−.04	−.19[a]	−.16[a]	.30[a]	—	—	—	—	—	—	—	—	—
Knowledge	6.95	1.43	−.01	.20[a]	.06	−.08	.08	.23[a]	−.19[a]	.02	—	—	—	—	—	—	—	—
Information	2.39	1.57	.20[a]	−.07	.41	−.19[a]	−.08	−.10	.17[a]	.17[a]	.29[a]	—	—	—	—	—	—	—
Age	52.00	13.69	.17[a]	−.14[a]	−.07	.26[a]	.14[a]	−.11	.20[a]	.03	−.23[a]	−.13[a]	—	—	—	—	—	—
Male	0.57	0.49	.18[a]	−.14[a]	.07	.12[a]	−.10	−.06	.05	.09	.23[a]	.11	.18[a]	—	—	—	—	—
Education	7.22	3.47	.07	−.02	.16[a]	−.20[a]	.05	.04	.03	.11	.42[a]	.26[a]	−.35[a]	.22[a]	—	—	—	—
Party	0.14	0.35	.15[a]	.02	.13[a]	−.01	−.01	.01	.12[a]	.10	.16[a]	.15[a]	.08	.16[a]	.27[a]	—	—	—
Cadre	0.12	0.33	.18[a]	−.04	.16[a]	.01	−.02	−.01	.13[a]	.10	.23[a]	.22[a]	.06	.17[a]	.25[a]	.43[a]	—	—
Income[b]	11.49	15.46	.09	.00	.14[a]	−.16	.05	.02	−.00	.07	.19[a]	.22	−.26	.26[a]	.37[a]	.13[a]	.09	—

Note: Attitude: respondents' overall attitude; Risks: respondents' perceived risks; Benefits: respondents' perceived benefits; MEPI: the degree of respondents' energy poverty; Future: respondents' anticipated future environmental problems; Current: respondents' perceived current environmental problems; Trust: respondents' trust on specific public entities; Perspectives: respondents' perspective on impacts and risks; Knowledge: respondents' knowledge of shale gas technology; Information: number of information sources respondent received; Age: respondents' age; Male: respondents' gender; Education: respondents' highest year of education achieved; Party: respondent is Chinese Communist Party member; Cadre: respondent is a cadre; Income: respondents' individual income. Correlations in bold test hypotheses and research questions.

[a]Significant at $p < .001$.

[b]RMB1,000.

Hypothesis Tests: Regression Analysis

We applied an ordinary least squares (OLS) regression model incorporating all potential predictors and demographic characteristics to further test our hypotheses. Table 4 reports the results. To obtain an optimized model, we first examined all considered variables in model I. Then, in model II we selected the significant variables in model I as considered variables, obtaining consistent significant results ($R^2 = 0.36$). Overall, the hypotheses proposed were all supported:

H1: People who perceived higher risks from local shale gas development were more likely to oppose it ($\beta = -.11,\ p < .01$);

H2: People who perceived higher benefits from local shale gas development were more likely to support it ($\beta = .22,\ p < .01$);

H3: Trust in government and related institutions was a significant predictor of public support for local shale gas development ($\beta = .23,\ p < 0.01$);

H4: People who anticipated more severe future environmental problems from local shale gas development were slightly more likely to oppose it ($\beta = -.05,\ p < .1$);

H5: People who perceived higher current environmental degradation were more likely to oppose it ($\beta = -.10,\ p < .1$);

In terms of the research question, we found that energy poverty was significantly negatively associated with support for local shale gas development ($\beta = -.08,\ p < .1$).

Table 4. Predictors of overall attitude.

	Model I				Model II			
Predictors	*B*	*SE(B)*	95% Confidence intervals	*β*	*B*	*SE(B)*	95% Confidence intervals	*β*
Perceived risks	−.10***	.03	(−.16, −.03)	−.11***	−.10***	.03	(−.17, −.04)	−.11***
Perceived benefits	.19***	.03	(.14, .25)	.22***	.19***	.03	(.13, .24)	.22***
Degree of energy poverty (MEPI)	−.45**	.19	(−.82, −.07)	−.08**	−.41**	.19	(−.78, −.04)	−.08**
Anticipated future environmental problems	−.23*	.13	(−.49, .03)	−.05*	−.23	.13	(−.49, .03)	−.05*
Perceived current environmental problems	−.12***	.04	(−.20, −.04)	−.10***	−.12***	.04	(−.20, −.04)	−.10***
Trust in public entities	.32***	.05	(.21, .42)	.24***	.31***	.05	(.21, .41)	.23***
Perspectives on impacts and risks	.07**	.03	(.01, .14)	.07**	.07**	.03	(.01, .14)	.07**
Knowledge of shale gas technology	.05*	.03	(.00, .11)	.07*	.06**	.03	(.01, .11)	.07**
Number of information sources	−.02	.02	(−.06, .03)	−.02				
Age	.01***	.00	(.00, .02)	.14***	.01***	.00	(.01, .02)	.15***
Gender	.14	.09	(−.03, .31)	.06				
Education years	−.01	.01	(−.03, .01)	−.04				
Chinese communist party (1 = Yes)	.16*	.10	(−.03, .35)	.05*	.18*	.09	(−.01, .36)	.05*
Cadre (1 = Yes)	.20*	.10	(.00, .41)	.06*	.20*	.10	(.00, .40)	.06*
Average annual individual income	.00	.00	(.00, .00)	.06				
Town effect control			Yes				Yes	
F			21.22***				26.07***	
Degree of freedom			(18,711)				(14,175)	
Pseudo R^2			.37				.36	
N			730				730	

*Significant at $p < .1$, **significant at $p < .05$, ***significant at $p < .0$.

Discussions

Our study suggests that the majority of local Chinese respondents are supportive, different from the findings of US national and some regional studies (i.e., New York) indicating that the majority of Americans oppose hydraulic fracturing (Borick, Rabe, and Lachapelle 2014; Drake 2015; Kromer 2015). In some countries and regions, publics maintain a generally negative attitude toward hydraulic fracturing, which has led to nationwide bans in France and Bulgaria and growing controversies across the entire EU, South America, and some Australian states (Ladd 2013; Smith 2013; Luke, Brueckner, and Emmanouil 2018). Given that exploitation of shale gas poses potentially greater environmental and health risks in China than in western countries due to denser population and weaker environmental surveillance and regulation, the evidence that Chinese residents tend to favor shale gas may seem difficult to understand at the first glance. But a closer examination of characteristics such as risk and benefit perception, environmental awareness and trust, as well as the status of energy poverty, provides the explanation.

Consistent with prevrios Residents with higher risk concerns are more likely to oppose shale gas exploitation, while those who perceive more benefits tend to be more supportive, also consistent with previous studies (Anderson and Theodori 2009; Boudet et al. 2014; Brasier et al. 2011; Israel et al. 2015; Jacquet 2012; Schafft, Borlu, and Glenna 2013; Theodori 2012; Whitmarsh et al. 2015). During our survey, when asking respondents whether they perceive each risk item, we noticed many respondents took the initiative to mention risks they perceived, but few similarly mentioned benefits they

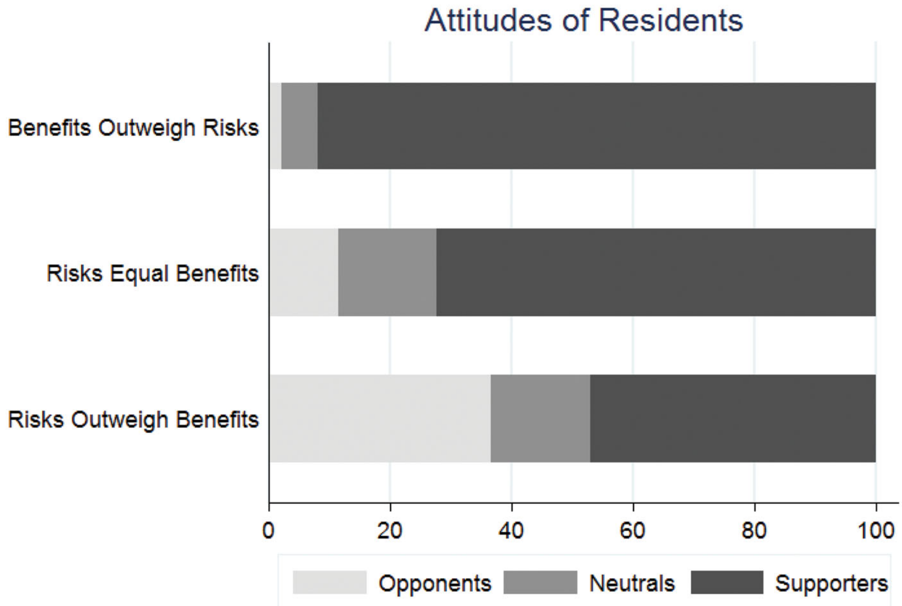

Figure 2. Relative risk/benefit comparison and attitudes toward shale gas exploitation (%).

perceived on their own initiative. This suggests that risks of shale gas exploitation are more readily perceivable than benefits, giving respondents presumptive reasons to oppose the activity.

After an array of questions about benefits and risks, respondents were asked "Which is greater, the benefits or risks of shale gas exploitation?" with response options including: "Benefits outweigh risks," "Benefits equal risks," "Risks outweigh benefits" and "Uncertain." Over 60% of respondents stated that risks outweigh benefits, while only about 20% stated that benefits outweigh risks. Besides separately considering perceived risks and benefits, we additionally investigated the impact of relative risk and benefit perception compiled from the perceived risk scale. Figure 2 illustrates respondents' attitudes toward shale gas exploitation while considering their relative ratings of risks and benefits. Most respondents who believe that benefits equal or outweigh risks say they are supporters of local shale gas development or are neutral. However, almost half of those who think risks outweigh benefits are also supporters of shale gas exploitation, while less than 40% are opposed to it. This apparent conflict between attitude and risk/benefit perception may be more plausible if respondents perceive higher risks than benefits but believe adverse impacts caused by shale gas exploitation can be controlled.

During the survey, many respondents also claimed to support shale gas exploitation because it was a national action from the top down. Respondents' trust in governments and state-owned petroleum companies were significant predictors of support or opposition. The dominant political ideology in China leads to higher trust in the central government. Shale gas development is meanwhile carried out in response to instructions by the central government, with the local government a pivotal stakeholder along with local residents, at least nominally. Respondents in our survey were asked to rate the extent of their trust in central/local governments; three-fourths of respondents reported they trust the central government and almost half the local government. Residents were also asked to indicate whether both central and local governments should be responsible for shale gas risks, and over 85% of respondents said yes. We infer therefore that the public in China is likely to support projects based on government policies with the result that supporters predominate in our survey.

Besides, we also found environmental awareness played a crucial role in predicting residents' attitude toward shale gas exploitation. Residents observe noticeable environmental degradation and worry that environmental problems are worsening. The regression results show that local residents' attitude to development is significantly negatively associated with their perception of environmental degradation, indicating the public will be more opposed if they perceive higher environmental degradation, which supports hypotheses H4 and H5.

Perceived environmental degradation can be seen by residents as a threat to their place attachment, defined as positive behavioral, emotional, and cognitive association that individuals experience between themselves and their social and physical environments (Devine-Wright 2013). Prior studies suggest that place attachment is a key social-psychological factor that drives public opposition to energy projects, in which stronger attachment to place is associated with greater opposition to such development (Venables et al. 2012). Though the variable of anticipation of future negative environmental impacts was insignificant as a predictor, negative signs on the public attitude in both specifications suggest that the public will be more opposed to development.

MEPI has a negative and significant effect on residents' attitude toward shale gas development, on top of what we found in the correlation analysis. Residents with energy poverty problems were more likely to oppose shale gas exploitation. A relatively high proportion of these residents perceive no benefits of shale gas exploitation, in particular no energy price decrease. Though distribution of shale gas as household energy has been realized in Gong County, residents who use it still have had unexpectedly to pay the same energy price. For further analysis, we divided our sample into three groups: the first facing no energy poverty ($MEPI = 0$), the second facing a relatively low degree of energy poverty ($MEPI < 0.5$) and the third facing a relatively high degree of energy poverty ($MEPI > 0.5$).

Results reported in Table 5 show that 22% of respondents faced a relatively high degree of energy poverty and 41% a relatively low degree, with 37% not suffering from energy poverty. All of the first, high-poverty group, use non-modern cooking fuels, which contributes >0.4 of the weight to the degree of energy poverty in the MEPI measure. In our survey sample, 27% of participants do not use modern fuel sources

Table 5. Relationships between the degree of energy poverty and attitudes.

		The degree of energy poverty		
			MEPI > 0	
	Pearson's *R*	MEPI = 0 (No energy poverty)	MEPI < 0.5	MEPI> =0.5
Observations		*N* = 272	*N* = 297	*N* = 161
Attitude toward shale gas exploitation	−.10***	(%)	(%)	(%)
Opponents		8.46	10.10	18.63
Neutrals		10.66	12.12	10.56
Supporters		80.88	77.78	70.81

such as electricity, natural gas, liquefied petroleum gas, or solar energy for cooking. The MEPI measuring energy poverty is significantly negatively correlated not only with individual income ($R = -0.16$) but also total household income ($R= - 0.22$), showing also, unsurprisingly, that the energy-poor household is usually income-poor. The above results show that the issue of energy poverty in our study area is mainly caused by unaffordability of energy and correlated with the use of highly polluting traditional fuels, quite similar to what IEA (2012) reported.

Significant evidence of energy poverty remains in that these residents still use traditional biomass for cooking, giving no improvement for them in terms of modern cooking energy. These residents suffering from energy poverty have not benefited from shale gas exploitation, giving them no incentive to support the project. In addition, government agencies and petroleum companies had announced they were offering subsidies to residents in shale gas exploitation areas, largely as compensation for cultivated land occupation and house demolition. During our interviews, however, we found most residents reported that they had not received any subsidies since construction of shale gas wells, contributing to their somewhat conflicted psychology.

Concluding Comments

The Chinese government has been taking an active role in developing shale gas, driven by growing energy demand. This study examines local residents' attitudes toward nearby shale gas exploitation and their possible determinants, including energy poverty. We found that, despite reservations and no apparent direct benefits to themselves, local residents were generally supportive of shale gas development. Roughly 70% of sampled respondents expressed support or "strong support" for shale gas exploitation, and less than 20% opposed or strongly opposed such activity. Perceived risks, degree of energy poverty, and respondents' environmental awareness were significantly negatively associated with their attitude toward local shale gas development, while perceived benefits and trust in governmental entities, perspectives on impacts and risks and knowledge had a significantly positive influence on respondents' attitudes.

Respondents overall were surprisingly optimistic about shale development, especially given that over 60% of them perceived significant risks from such activity as greater than its benefits, and nearly a third reported believing that adverse impacts caused by shale exploitation cannot be controlled. This apparent attitudinal conflict reflects not only the fact that local residents support this policy because it is a national project that also brings them and their hometown a sense of pride, but also the lack of effective risk communication by the government and petroleum company to local residents. Indeed, many respondents stated that the government or company didn't organize any events or activities to provide information about the shale gas project or to communicate with the respondents.

At the same time, respondents trust remains positively associated with their supportive attitudes. In this regard, governments could consider developing a "community permission to proceed" mechanism, as recommended in Wheeler et al. (2015), or depend on analogous efforts by environmental NGOs. The dearth of public perceptions about the benefits of shale gas exploitation indicates it is important to enhance public participation in shale gas projects and to inform local residents about both positive and negative impacts of its development, with particular attention to those suffering from energy poverty. Better communication about the benefits of shale gas projects can reduce conflicts between the local government and residents.

The attitudinal conflict may also reflect the fact that many local respondents are not aware of potential environmental impacts on their community from shale development, especially given that current development is at an early stage. As noted by Schafft, Borlu, and Glenna (2013), the intensity of shale gas development is significantly positively associated with respondents' risk perceptions. Once shale gas development becomes a large-scale activity, community disruption, habitat fragmentation, and other local effects are more likely to become significant. In Sichuan Basin, where population is high (in some areas), or watersheds are present (in others), or ecosystems are particularly sensitive, environmental risks could be noticeable, in particular in the absence of effective environmental regulation and sector-specific regulation of shale gas extraction (Krupnick, Wang, and Wang 2014; Yu et al. 2018).

China needs a more independent and comprehensive regulatory system with strict enforcement to ensure protection of residents and the environment. Close surveillance and regulation by both central and local governments can play a crucial role in controlling risks of shale gas exploitation. Residents remain suspicious about the impartiality of the local Sichuan government in regulating shale gas development projects because it is a major stakeholder in that development. Public participation has already been explicitly mentioned in many environmental related laws and regulations launched by the central government, and local governments should make greater efforts to facilitate public participation in the decision-making process to foster a symbiosis of energy development and environmental protection at the central government level.

Notes

1. 2014 production was reported by the International Energy Agency (https://www.iea.org/ugforum/ugd/shalegas/), while 2018 figures were reported by the Ministry of Natural Resources of China (http://www.gov.cn/xinwen/2019-07/16/content_5410035.htm).
2. Traditional biomass includes wood, charcoal, agricultural residues and other solid waste.
3. To ensure a higher response rate, the interview was arranged in the weekend, while villagers were at home resting. The interviewees were notified that their completion would be rewarded 50 RMB, almost an half-day's local employment wage.
4. Howell (2013) recommended that the treatment of missing data should begin by identifying the causes of missing data, no matter which imputation approach (e.g., mean imputation, hot deck imputation, or EM algorithm) has been selected. The EM algorithm, developed by Dempster, Laird, and Rubin in 1977, has a relative solid theoretical support by Maximum Likelihood Principle and is wildly applied and cited. We thus applied the EM algorithm in our study.

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