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Exploring Support for Shale Gas Extraction in the United Kingdom

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The development of shale gas in the United Kingdom (UK) using hydraulic fracturing, more commonly known as 'fracking', remains in its infancy. Yet understanding public attitudes for this fledgling industry is important for future policy considerations, decision-making and for industry stakeholders. This study uses data collected from the University of Nottingham UK nationwide online survey (n=3,823) conducted in September 2014, to consider ten hypotheses about the UK public's attitudes towards shale gas. From the survey data we can see that 43.11% of respondents support shale gas extraction in the UK. Furthermore, our results show that women, class DE respondents, non-Conservative party supporters, and respondents who positively associate shale gas with water contamination or earthquakes are less likely to support the extraction of shale gas in the UK. We also discuss potential policy implications for the UK government arising from these findings.

Key words: Hydraulic fracturing, United Kingdom, Attitudes, Support

1. Introduction

The extraction of shale gas/oil through hydraulic fracturing, more commonly referred to as 'fracking', has become a controversial topic in both the United States (US) (Boudet et al., 2014; Davis and Fisk, 2014; Evensen et al., 2014) and in the United Kingdom (UK) (Cotton et al., 2014; Williams et al., 2015). Hydraulic fracturing as a means to extract shale gas/oil has experienced significant growth in many states in the US. This rapid expansion of shale gas development in the US since the early 2000s has resulted in shale gas accounting for 67% of the US's natural gas production in 2015 (USEIA, 2016a). The result of this rapid growth in US shale gas development has been to lower the price of natural gas and to be the key driver in making the US a net exporter of natural gas by 2017 (USEIA, 2016b).

The situation in the UK is very different; shale gas exploration is in its infancy with only a few test drill permits issued to date. The first permit was issued to Cuadrilla in 2007 to explore the Bowland shale in Lancashire, with the first test drilling taking place in March 2011. Drilling was suspended following two small earthquakes on 1 April and 27 May, 2011 (measuring 2.3 and 1.5 on the Richter scale respectively) near the drilling sites (Green et al., 2012). Two years later, Cuadrilla drilled an exploratory borehole at Balcombe, West Sussex in August 2013. There were much publicised protests against unconventional hydrocarbon development near the drilling site between July and September 2013 (Tarver, 2013). Cuadrilla announced that they had finished drilling in September 2013 (Cuadrilla, 2013). Despite such protests twenty-seven new areas totalling over 1,000 square miles in Northern England and the Midlands region of England were approved for possible shale gas exploration in August 2015 (Bawden, 2015).

A number of alleged negative environmental impacts are associated with hydraulic fracturing. Perhaps the most widely-cited negative impact is the potential contamination of drinking water, as featured in the controversial film *Gasland* (Fox, 2010). Other negative impacts associated with shale gas development include earth tremors, the large quantities of water consumed during the hydraulic fracturing process, heavy traffic to drilling sites, fracturing wastewater disposal and the infrastructure¹ needed to transport the gas or oil from the well (Jacquet, 2014).

One of the key arguments presented in favour for the development of shale gas is that it could be a transition fuel from a high to low-carbon society (GreenWise, 2012). This would be achieved primarily through the displacement of coal in the energy system because shale gas produces around half the greenhouse gas emissions of coal at the point of production (MacKay and Stone, 2013).² Additionally, the development of shale gas in the UK could reduce the UK's reliance on imported natural gas. The UK imported 43% of its natural gas in 2012 (UKOOG, 2013) and is expected to import around 70% of its natural gas by 2030 (DECC, 2015b).

With the development of UK shale gas in its infancy and the growing debates around whether domestic exploration should continue, the public's attitudes towards this potential energy source is a key issue in determining government policy, industry practice and stakeholder engagement. Research concerning public attitudes towards shale gas is an emerging field and the focus of extant literature has been on attitudes towards shale gas/hydraulic fracturing in the US. There are a limited number of surveys and data available in the UK. Research into attitudes towards shale gas in the UK is a field that, at the moment, is data poor. Surveys are, however, an important

¹ E.g. pipelines.

² Although this figure is critically dependent upon assumptions about levels of methane leakage, 'fugitive emissions', in the production process (Cathles et al, 2014; Howarth, 2015).

tool to assess attitudes towards emerging fields like shale gas extraction/hydraulic fracturing in the UK.

We provide a first overview of attitudes towards shale gas extraction in the UK using national survey data, thereby filling a gap in the existing literature.

2. Literature review and hypotheses

The literature focusing on shale gas in the UK remains limited. There is some literature relating to policy aspects of shale gas, i.e. regulation (McGowan, 2014), discourse analysis about the UK hydraulic fracturing debate (Cotton et al., 2014; Williams et al., 2015), examining the debate in UK newspapers relating to hydraulic fracturing (Jaspal and Nerlich, 2014) and public perceptions relating risk perceptions and policy support in three UK regions (Whitmarsh et al., 2015). There is, to our knowledge, no literature about attitudes towards shale gas extraction using a comprehensive national UK survey. Our article attempts to fill this gap. Our choice of hypotheses and independent variables are informed by testing a number of theories relating to attitudes towards shale gas in the US and concerns about environmental issues.

2.1 Demographics

Socio-demographic characteristics are expected to contribute to attitudes towards shale gas (Boudet et al., 2014). Socio-demographic characteristics, including gender, age, household income, educational attainment and social class³ play an important role in explaining attitudes to e.g. political parties, welfare policies or support for emerging technologies (Nawrotzki and Pampel, 2013; Svallfors, 2012; van der Eijk et

³ Social class has, to our knowledge, not previously been used in the attitudes towards shale gas literature.

al., 2007). Men are generally more positive towards conventional/non-renewable emerging technologies whereas women are less supportive of non-renewable emerging technologies, but are more supportive of renewable emerging technologies (Ansolabehere and Konisky, 2009; Siegrist et al., 2007; Xiao and McCright, 2014). For example, women in Switzerland were more accepting, saw more perceived benefits with lower perceived costs for renewable solar energy and wind energy than men. Additionally, men in Switzerland were more accepting and saw more perceived benefits with lower perceived costs for conventional energy than women⁴ (Visschers and Siegrist, 2014). US and Swedish studies carried out in the last ten years found that women were more concerned about the environment and less likely to support non-renewable emerging technologies than men⁵ (Ansolabehere and Konisky, 2009; Firestone and Kempton, 2007; Hunter et al., 2004; Liu et al., 2014; McCright, 2010). There are different explanations for this discrepancy in acceptance of emerging technologies and environmental concern between the genders. Men generally display a lower level of risk perception than women and are therefore more supportive of emerging technologies and display lower levels of environmental concern. Women, by contrast, are more risk averse than men (Kahan et al., 2007; Kahan et al., 2009; Pidgeon and Demski, 2012; Satterfield et al., 2004; Sherman, 2004). This informs hypothesis 1: *Women are less likely than men are to support shale gas extraction in the UK.*

It has been argued that attitudes towards the environment are developed during childhood and the teenage years (Inglehart, 1990; Inglehart and Abramson, 1994).

These attitudes are not expected to change much once an individual reaches

⁴ Men were still more accepting of, saw more perceived benefits and lower perceived costs with wind and solar power than for the other forms of energy.

⁵ It is worth noting that gender differences in the US were found only for Caucasian respondents as reported by Kalof et.al. (2002). However, a study that looked at gender and minorities found that women and minorities displayed similar levels of environmental concern (Bord and O'Connor, 1997).

adulthood. We theorise that attitudes towards the environment and in our research towards shale gas extraction are developed at a young age. Younger respondents will likely have been educated through the UK school curriculum which includes anthropogenic climate change and its causes. As a result, the younger respondents are more likely to be aware of negative impacts of fossil fuels and also more supportive of renewable energy sources (Hayward, 2012). Older respondents are therefore thought to be more supportive of shale gas extraction as they have not received the same level of education about the environment as younger respondents (Nawrotzki and Pampel, 2013; Zhou, 2015). This view accords with Ingelehart's (1981) 'socialization hypothesis' that basic values reflect the prevailing conditions of pre-adult years. This age/attitude association is confirmed in the US context by Boudet et al. (2014). Older respondents have also been found to be less supportive of green technologies e.g. wind power (Boudet et al., 2014; Firestone and Kempton, 2007) and are therefore expected to be more supportive of shale gas. Hypothesis 2: *Older respondents are more likely to support shale gas extraction.*

Franzen and Meyer (2010) theorise that individuals with higher incomes are more likely to display higher levels of environmental concern. Boudet et.al. (2014) and Davis and Fisk (2014) did not find a statistically significant relationship between income and attitudes towards shale gas extraction. Zhou (2015) argues that individuals with lower incomes are less likely to be concerned about the environment as their focus is on supporting themselves and are therefore not able to pay a premium for environmentally friendly options. The role of income as an association to an individual's environmental concern is contested and Xiao and Dunlap (2007) argue that income is not a good indicator for environmental concern. Whether income is related to environmental concerns and attitudes towards shale gas is contested in the

US context. We include household income as an independent variable as previous research is inconclusive and does not include the UK.

Hypothesis 3: *Individuals with higher household income are less likely to support shale gas extraction.*

Educational attainment, like income, is contested in the literature. Some findings indicate that individuals with higher educational attainment are less likely to support shale gas extraction (Jacquet, 2012; Jacquet and Stedman, 2013). More recent findings by Boudet et.al. (2014) did find that higher educational attainment is related to higher support for shale gas extraction. Literature considering environmental concern indicates that higher educational attainment is related to greater environmental concern (McCright and Sundström, 2013; Nawrotzki, 2012; Zhou, 2015) and higher support for wind power (Firestone and Kempton, 2007).

Hypothesis 4: *Individuals with higher educational attainment are less likely to support shale gas extraction.*

Social class as an indicator of attitudes has been discussed in relation to a number of topics including attitudes towards welfare provisions, see for example (Svallfors, 2006) but has, to our knowledge, been ignored in attitudes towards the environment and shale gas. Individuals belonging to social classes C2 and DE may be less able to move away from areas with environmental impact than higher social classes (Stephens et al., 2001). However, the possibility of increased employment opportunities for respondents identifying as class C2 or DE in areas where shale gas extraction is approved cannot be ignored. We include social class with the objective that it will add to the knowledge of attitude formation toward shale gas extraction.

Hypothesis 5: *Social classes AB are more likely than other social classes to support shale gas extraction.*

2.2 Shale gas knowledge

Individuals who have a limited knowledge about energy technology are generally less likely to support a technology they are not familiar with (Jho et al., 2014; Slovic, 1987) . Knowledge about shale gas and hydraulic fracturing is conversely expected to result in a lower support for shale gas rather than a higher support. This has been widely documented in research towards support for shale gas extraction in the US (Boudet et al., 2014; Brooks, 2013) and in one UK survey (DECC, 2015a). A focus group (n=71) study funded by the Department of Energy and Climate Change (DECC) in the UK also found that increased knowledge resulted in individuals being less supportive of shale gas and hydraulic fracturing (TNS BMRB, 2014). The knowledge question discussed in section 3.2 allows us to control for the effect of knowledge of shale gas.

Hypothesis 6: Respondents who answer the knowledge question correctly are less likely to support shale gas extraction.

2.3 Party affiliation

Party affiliation has an effect on support for environmental protection in the US and conservatives/Republicans are more likely to support hydraulic fracturing than liberals/Democrats. (Boudet et al., 2014; Davis and Fisk, 2014). The Conservative Party in the UK are vocal supporters of shale gas and hydraulic fracturing (Conservative Party, 2015). A longitudinal UK study found that individuals who vote for the Conservative Party are less likely to be concerned about the environment. This study also reported increasing variance in environmental attitudes, suggesting higher levels of polarization on this issue dimension (Melis et al., 2014). This informs

hypothesis 7: *Conservative party supporters are more likely to support shale gas extraction.*

2.4 Newspaper readership and environmental concerns

How shale gas is portrayed depends on the political affiliation of the newspaper. We are interested in whether newspaper readership affects support for shale gas extraction. Almost 30% of survey respondents do not read a newspaper. It is therefore of particular interest if this group of respondents displays a different stance towards shale gas than respondents who do read a newspaper. Newspaper coverage of shale gas in UK broadsheet⁶ newspapers in 2011 and 2012 indicates that The Telegraph and The Times, the right leaning broadsheet newspapers, focus on reporting positive aspects of shale gas and hydraulic fracturing including energy security and the possibility for lower gas prices. The Independent and The Guardian, centre and left leaning broadsheet newspapers, focus on negative aspects of shale gas and hydraulic fracturing including the risk of drinking water contamination and earthquakes (Jaspal and Nerlich, 2014).

Hypothesis 8: *Readers of 'right' leaning broadsheet newspapers are more likely to support shale gas extraction.*

Media coverage in the UK has primarily focused on two environmental concerns relating to shale gas extraction: earthquakes and drinking water contamination. A main focus on earthquakes was made after the two tremors in Lancashire following Cuadrilla's test drilling in 2011. The film *Gasland* (Fox, 2010) received attention in the UK and helped, in part, to introduce UK audiences to the potential risk of drinking water contamination in proximity to hydraulic fracturing and

⁶ Considered high quality newspapers.

shale gas development. It has been argued that the anti-shale message, including messages about earthquakes and drinking water contamination, has been more successful than the pro-shale message in the UK (Bomberg, 2015). Residents in the US who live near shale gas sites report that they perceive water pollution to have increased after shale gas development in their area (Theodori, 2009). Individuals in the UK do not yet have experience of shale gas developments. It is therefore particularly interesting to examine their attitudes towards their perceived concerns of shale gas in comparison to the US ‘publics’ where large scale shale gas development is present in a number of states.

Hypothesis 9: Individuals who do not associate shale gas with water contamination are more likely to support shale gas extraction.

Hypothesis 10: Individuals who do not associate shale gas with earthquakes are more likely to support shale gas extraction.

3. Data and methodology

3.1 Survey design and data collection

The survey data presented in this article is part of a survey project fielded by YouGov⁷ in the UK on behalf of the University of Nottingham. The survey has been fielded eleven times since March 2012. The survey is the most comprehensive UK wide survey that has been fielded repeatedly over several years. The 10th survey presented here was conducted between 9th and 11th of September 2014 and was completed by 3,822 respondents. Respondents were asked 25 questions relating to shale gas and hydraulic fracturing in the UK. The survey also contains 13 demographic background questions. YouGov UK has approximately 400,000

⁷ Internet surveys and face-to-face interview surveys produce similar outcomes in terms of explanatory power (Sanders et al., 2007).

members⁸ that allow for a nationally representative sample of potential respondents who must supply socio-demographic information including age, gender, social class, household income and newspaper readership to ensure that survey samples contain a nationally representative sample.

There are three further national UK surveys relating to attitudes towards shale gas: one conducted by Opinium Research for GovToday and a second conducted by Populus for UK Onshore Oil and Gas (UKOOG). The third survey is a general survey by the Department of Energy and Climate Change (DECC) that has been fielded a number of times but the DECC survey only has two questions⁹ relating to shale gas. The three studies above have mainly been reported online by the organisations carrying out the research and in some cases by the media and have not, to our knowledge, been used in scholarly research (see Opinium Research, 2014; UKOOG, 2014¹⁰; DECC, 2015a).

3.2 Survey variables

All variables are listed in Table 1 with information about descriptive statistics. The variables include basic socio-demographic information such as age and gender, social class, household income, general election vote in 2010, newspaper readership, a shale gas knowledge question and two variables relating to perceived negative impacts of shale gas extraction.

⁸ YouGov uses PanMan, a panel management software system, for sampling and it uses targeted quota sampling. Panel members receive e-mails that notify them of surveys that need respondents. A panel member may be e-mailed due to a need for respondents for survey X but the panel member may be transferred to survey Y instead as the survey needs may have changed since the e-mail invite was generated. The system used by YouGov addresses fast responder bias as panel members are sent a link to the system not individual surveys. YouGov survey data does not include a response rate but the overall survey response rate for YouGov surveys is around 20% and the average response time is 19 hours (YouGov, 2015).

⁹ DECC Public Attitudes Tracker Wave 15 (2015). Wave 16 fielded in February 2016 includes additional questions relating to fracking.

¹⁰ The UKOOG survey has been criticised for its methodology and for being carried out by a pro-shale gas group, see e.g. BBC, 2014 <http://www.bbc.co.uk/news/business-28735128>.

[Table 1 about here]

The knowledge question requires respondents to answer:

"This is a fossil fuel, found in sedimentary rock normally more than 1000 meters below ground. It is extracted using a technique known as hydraulic fracturing, or 'fracking'. Is this fossil fuel:

- a) Boromic gas
- b) Coal
- c) Xenon gas
- d) Shale gas
- e) Tar-sand oil
- f) Don't know

All respondents of the September 2014 survey were invited to complete the full survey irrespective of whether they correctly identified shale gas in the knowledge question.

The dependent variable "should shale gas extraction be allowed in the UK" has been re-coded with the 'don't know' responses coded as the middle category. The 'no' responses are coded as 1, 'don't know' as 2 and 'yes' as 3 to allow for easier interpretation of the multivariate analyses¹¹.

¹¹ Respondents were offered the response options 'yes', 'no', and 'don't know'. Following other social science work (see, for example, Bishop et al., 1978: 84; Rose, 2014: 34) we treat 'don't know' as a middle response between 'yes' and 'no'. This allows us to retain a significant proportion of cases that would otherwise be deleted. As Wang (1997: 231) notes, simply deleting 'don't know' responses can almost never be theoretically justified. Including 'don't know' as a middle response provides a greater granularity to our understanding of attitudes. While we could theoretically have included the don't know responses with either the 'yes' responses or the 'no' responses, both of these options rest on very strong assumptions about how people who are unsure actually feel, which in turn risks distorting the results (see also Wang, 1997: 220). However, notwithstanding the choice to include 'don't know' as a middle response, the results found are substantively the same when instead analysing the data in dichotomous 'yes'/no' form, with 'don't know' responses deleted.

The choice of independent variables is informed on variables that have been found to be relevant in shale gas research in the US (Boudet et al., 2014; Davis and Fisk, 2014; Jacquet and Stedman, 2013; Kriesky et al., 2013).

The original variables for educational attainment and newspaper readership contained 20 and 16 categories respectively. The educational attainment variable was recoded to 9 categories. Newspaper readership was recoded to 7 categories¹².

All independent variables except age were recoded to dummy variables to provide a better understanding of which factors affect support for shale gas extraction in the UK.

3.3 Methodology

We ran an OLS regression model to enable us explain support or opposition to shale gas extraction in the UK. Missing values were deleted using listwise deletion. We also ran an ordered logistic regression model as the dependent variable is a three category ordered categorical variable, see for example (Kriesky et al., 2013). All the results were substantively similar¹³ to the OLS regression model and the choice was made to use OLS as this allows easier interpretation of results by a general audience. Weights were not used for any of the analyses. We ran a Variance Inflation Factor post-estimation after the model to ensure that the results were not affected by multicollinearity.¹⁴ We used O'Brien (2007) to guide our interpretation of the VIFs. The five highest VIFs were 4.29, 4.13, 2.73, 2.67 and 2.62. The model was left intact as the VIFs do not warrant removing variables from the model (O'Brien, 2007).

¹² Newspapers were recoded based on the information available here http://news.bbc.co.uk/1/hi/uk_politics/8282189.stm.

¹³ The ordered logistic regression results are available upon request.

¹⁴ Additionally, we also tested that the independent variables are not highly correlated prior to subjecting them to multivariate analysis. The results are available from the authors upon request.

4. Results and discussion

We are interested in understanding support for shale gas extraction in the UK and that is the main focus of this article. Our study is the first study using comprehensive national survey data to understand support for shale gas extraction in the UK. The theoretical foundations for our study are multi-disciplinary including the US shale gas literature, attitudes towards nanotechnology and attitudes towards environmental protection. Table 1 showed that 43.11%¹⁵ of survey respondents support shale gas extraction, 29.32% oppose it and 27.57% ‘don’t know’ whether it should be allowed in the UK.¹⁶ The regression model allows us to gain a better understanding of the reasons for support or opposition to allowing shale gas development in the UK. The theoretical foundations informed our ten hypotheses that will be evaluated in detail below.

[Table 2 about here]

The result from our regression model is presented in Table 2, variables that are statistically significant ($p\text{-value} \leq 0.05$) are presented in bold to allow for easier interpretation. Table 2 includes both ‘un-standardised’ b-coefficients and ‘standardised’ beta-coefficients to allow for easier comparison between variables. We discuss unstandardized b-coefficients when we discuss our results. The model has an R^2 of 0.393 and an adjusted R^2 of 0.387 which means we are able to explain almost of 40% of the variance in the dependent variable.

¹⁵ This is for the total sample with unweighted data. The reports (O’Hara et.al. 2014 and 2015) only include respondents who answer the knowledge question correctly. 48.59% of respondents who answer the knowledge question correctly support shale gas extraction in the UK.

¹⁶ Respondents of the September 2014 survey are more supportive of shale gas/hydraulic fracturing than respondents in the Opinion Research survey where 23% support shale gas and the DECC wave 14 public attitudes tracker survey where 21% support shale gas. They are less supportive than the respondents in the UKOOG survey where 57% support shale gas extraction.

Hypothesis 1: *Women are less likely than men are to support shale gas extraction in the UK.* Our regression model shows that women in the UK are less likely ($b = -0.247, p < 0.001$) to support shale gas extraction than men. This finding is in line with findings from the US where women are also less likely to support shale gas extraction (Boudet et al., 2014; Davis and Fisk, 2014). Our second hypothesis: *older respondents are more likely to support shale gas extraction* is not supported as age is not statistically significant in our study although it is close to achieving statistical significance ($p = 0.067$). This is supported by findings that older respondents usually are less concerned about the environment (Nawrotzki and Pamper, 2013; Zhou, 2015) and Boudet et al.'s (2014) findings from the US where a higher age is related to higher support for shale gas extraction.

Hypothesis 3: *Individuals with higher household income are less likely to support shale gas extraction* is not supported. The only income group that is statistically significant is the £70,000 to £99,999 income bracket and this group is more supportive ($b = 0.209, p < 0.001$) of shale gas extraction than the incomes below £25,000 reference group. This may indicate that higher income groups in the UK have different patterns of attitude formation than higher income groups in the US.

Hypothesis 4: *Individuals with higher educational attainment are less likely to support shale gas extraction* is not supported in our findings as none of the education variables are statistically significant at $p \leq 0.05$. Postgraduate degree has ($b = -0.074, p < 0.10$) which in some literature is considered statistically significant and those with a postgraduate degree are less likely to support shale gas extraction than the reference group, respondents with a Bachelor's degree.

Hypothesis 5: *Social classes AB are more likely than other social classes to support shale gas extraction* is partially supported as respondents belonging

to social class DE are less likely ($b = -0.089$, $p < 0.05$) to support shale gas extraction than the AB reference group. Social class is of particular interest to follow up once shale gas extraction is taking place in the UK. Individuals identifying as social classes C2 or DE may be more restricted in relation to moving from areas where shale gas is extracted if they do not support it. However, another possibility is that these groups will be more supportive as shale gas extraction may bring extra employment opportunities to their area.

Hypothesis 6: *Respondents who answer the knowledge question correctly are less likely to support shale gas extraction* is not supported as respondents who provide the wrong answer ($b = -0.175$, $p < 0.001$) for the knowledge question or state that they do not know ($b = -0.197$, $p < 0.001$) are less likely to support shale gas extraction than respondents who answer the knowledge question correctly. Knowledge leads to increased support as British respondents who correctly identify shale gas, i.e. have knowledge of shale gas, and are more supportive of shale gas extraction unlike their US counterparts. Interestingly, this result goes against the findings of the 14th DECC Public Attitudes Trackers which found greater levels of opposition from respondents who said they “knew a lot” or “knew a little” about it (DECC, 2015a).

Hypothesis 7: *Conservative Party supporters are more likely to support shale gas extraction* is strongly supported by our regression findings. Respondents who identified as having voted for the Conservative Party in the 2010 general election were considerably more likely to support UK shale gas development than respondents who had voted for other political parties. Green Party supporters are unsurprisingly least likely to support shale gas extraction ($b = -0.644$, $p < 0.001$). This is in line with findings the US where Republicans are more likely to support shale gas extraction than Democrats (Boudet et al., 2014).

Hypothesis 8: *Readers of right leaning broadsheet newspapers are more likely to support shale gas extraction.* Newspaper readership has mixed results as respondents who read left leaning broadsheets ($b = -0.206$, $p < 0.001$), or local newspapers ($b = -0.162$, $p < 0.01$), or do not read a newspaper are less supportive of shale gas extraction than respondents who read a right leaning broadsheet newspaper. Neither the right nor left leaning tabloid variable are statistically significant.

Hypothesis 9: *Individuals who do not associate shale gas with drinking water contamination are more likely to support shale gas extraction* is supported. Respondents who associate shale gas with contaminated drinking water ($b = -0.718$, $p < 0.001$) or who do not know whether shale gas is associated with contaminated drinking water ($b = -0.170$, $p < 0.001$) are far less supportive of shale gas extraction than respondents who do not associate shale gas with contaminated drinking water.

Hypothesis 10: *Individuals who do not associate shale gas with earthquakes are more likely to support shale gas extraction* is also strongly supported. The results are similar to the water contamination variable. Respondents who do not know whether to associate shale gas with earthquakes ($b = -0.201$, $p < 0.001$) and those who associate shale gas with earthquakes ($b = -0.437$, $p < 0.001$) are less likely to support shale gas extraction.

5. Conclusions and policy implications

The results provided above are mainly in line with results from US surveys. Women, respondents belonging to social class DE, answer the knowledge question incorrectly or 'don't know', identify as supporters of any other party than the Conservatives, read a left leaning broadsheet or a local newspaper, associate shale gas with contaminated drinking water or earthquakes or do not know whether to associate shale gas with contaminated drinking water or earthquakes are less likely to support shale gas extraction than the reference categories. Respondents belonging to the £70,000-99,999 income bracket is more likely to support shale gas extraction than the reference category. Interestingly, US and UK respondents display similar levels of overall support for shale gas development despite the stark differences in industry maturity between the two countries; with the US high-level of industry maturity and the UK's infancy shale gas industry. It is likely that test drilling permits will be issued in 2016 for some of the twenty-seven areas approved for shale gas exploration. Only once more extensive test drilling has been completed will we know whether shale gas extraction in the UK is financially viable. It would be very interesting to conduct a follow up study once shale gas extraction has begun in a larger proportion of the UK. Our current study adds to knowledge about support for shale gas exploration in the UK context as nearly all existing literature focus on the US.

There are possible policy implications from this study relating to support for extracting shale gas in the UK. Although the Conservative Party fully supports shale gas exploration in the UK, there is a large discrepancy between what the government wants and what UK residents want, as only 43.11% of the respondents in our survey support shale gas extraction. The strongest opposition to shale gas extraction in the UK is found among Green Party members and those who associate shale gas

extraction with drinking water contamination or earthquakes. Respondents who associate shale gas with contaminated drinking water and/or earthquakes may be more predisposed to focus on negative aspects related to shale gas extraction. This has the risk of leading to confirmation bias where individuals who already have some negative opinions about shale gas extraction are more likely to focus on additional negatives rather than positives relating to shale gas (see e.g. discussion in TNS BMRB 2014). Respondents who answer the knowledge question correctly are more supportive of shale gas extraction.

While we do not take a view on the desirability or otherwise of shale gas extraction for a government committed to its development, this may suggest that there would be advantage in overcoming what may be people's 'rational ignorance' (Schumpeter, 1987 (1943)) toward specific policy issues (Galston, 2001). Aside from longer-term concerns around civic education, this will require the lowering of information costs, although this is difficult with highly politicised issues where frames and relevant 'facts' are all highly contested.

The Social License to Operate (SLO) framework offers one possible resolution to the problem of contested information and low levels of social acceptance. Its viability can be tested adding relevant variables to future surveys. Public support for shale gas is low in the UK. The SLO framework has been used for wind farms (Hall, 2014) and social acceptance of high voltage power lines (Batel et al., 2013) but neither has been applied for shale gas. Applying the SLO framework to test whether individuals approve of shale gas extraction in their local area after receiving consultation materials as suggested in TNS BMRB (2014). Finally, shale gas extraction is likely to remain highly contested in the UK in the foreseeable future.

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<i>Variable</i>	<i>Categories</i>	Descriptive statistics
Support shale gas extraction (DV)	1. No 2. Don't know 3. Yes	1. 29.32% 2. 27.57% 3. 43.11%
Age	18-88	Mean: 47.65 SD:15.84
Gender	0. Male 1. Female	47.58% male
Education	1. No formal education 2. Vocational qualification 3. Left school at 16 4. Secondary school 5. Some higher education 6. University degree 7. Postgraduate degree 19. Don't know 20. Refused	1. 5.94% 2. 12.61% 3. 14.86% 4. 14.10% 5. 16.19% 6. 24.30% 7. 9.16% 19. 1.23% 20. 1.62%
Social class	1. AB 2. C1 3. C2 4. DE	1. 38.06% 2. 27.49% 3. 14.75% 4. 19.70%
Household income	1. Don't know/refused 2. <£25,000 3. £25,000-49,999 4. £50,000-69,999 5. £70,000-99,999 6. £100,000-149,999 7. >£150,000	1. 24.54% 2. 28.96% 3. 28.85% 4. 9.47% 5. 5.39% 6. 2.01% 7. 0.76%
Knowledge question	1. Boromic gas 2. Coal 3. Xenon gas 4. Shale gas 5. Tar-sand oil 6. Don't know	1. 0.81% 2. 5.21% 3. 0.63% 4. 75.15% 5. 1.41% 6. 16.79%
Vote 2010	1. Conservative 2. Labour 3. Liberal Democrats 4. Scottish National Party 5. Plaid Cymru 6. Green Party 7. UK Independence Party 8. British National Party 9. Other party 10. None of these 11. Don't know	1. 26.37% 2. 32.12% 3. 8.53% 4. 2.59% 5. 0.42% 6. 1.78% 7. 4.73% 8. 0.50% 9. 0.50% 10. 19.28% 11. 3.19%
Newspaper readership	1. Broadsheet right leaning 2. Broadsheet left leaning 3. Tabloid right leaning 4. Tabloid left leaning 5. Local newspaper 6. Other newspaper 7. No newspaper	1. 6.93% 2. 7.38% 3. 32.88% 4. 7.27% 5. 7.56% 6. 8.13% 7. 29.85%
Contaminated drinking water	1. Associate with shale gas 2. Don't associate with shale gas 3. Don't know	1. 39.50% 2. 23.38% 3. 37.12%
Earthquakes	1. Associate with shale gas 2. Don't associate with shale gas 3. Don't know	1. 42.19% 2. 24.46% 3. 33.45%
		N=3,823

Table 1 Descriptive statistics

Table 2 OLS regression results

<i>Independent variables</i>	<i>b</i>	<i>Beta</i>	<i>Std. Err.</i>	<i>p-value</i>
Age (Male ref.)	0.001	0.026	0.001	0.067
Gender (Bachelor's ref.)	-0.247	-0.147	0.022	0.000
No formal ed.	-0.030	-0.008	0.053	0.570
Vocational ed.	-0.010	-0.004	0.039	0.800
Left school at 16	-0.062	-0.026	0.038	0.101
Secondary school	0.016	0.007	0.036	0.661
Some higher ed.	-0.023	-0.010	0.035	0.518
PG degree	-0.074	-0.025	0.042	0.077
Don't know ed. (AB ref.)	0.082	0.016	0.069	0.232
Class C1	-0.051	-0.027	0.028	0.065
Class C2	-0.020	-0.008	0.035	0.563
Class DE (<£25,000 ref.)	-0.089	-0.042	0.033	0.007
Don't know income	-0.045	-0.025	0.030	0.099
£25,000-49,999	0.010	0.005	0.029	0.727
£50,000-69,999	0.010	0.004	0.042	0.805
£70,000-99,999	0.209	0.056	0.053	0.000
£100,000-149,999	0.011	0.002	0.081	0.889
>£150,000	-0.046	-0.005	0.126	0.714
(Knowledge question: correct ref.)				
Knowledge question: don't know	-0.197	0.088	0.033	0.000
Knowledge question: wrong (Conservative ref.)	-0.175	-0.057	0.041	0.000
Labour	-0.228	-0.127	0.031	0.000
Liberal Democrats	-0.101	-0.033	0.043	0.021
SNP	-0.327	-0.062	0.071	0.000
Plaid Cymru	-0.447	-0.034	0.167	0.007
Green Party	-0.644	-0.101	0.085	0.000
UKIP	-0.120	-0.030	0.054	0.026
BNP	-0.055	-0.005	0.153	0.719
Party other	-0.217	-0.103	0.034	0.000
Party don't know (Broadsheet right ref.)	-0.290	-0.061	0.065	0.000
Broadsheet left	-0.206	-0.064	0.059	0.000
Tabloid right	0.006	0.003	0.047	0.895
Tabloid left	-0.116	-0.036	0.061	0.056
Local newspaper	-0.162	-0.051	0.058	0.005
Other newspaper	-0.101	-0.033	0.057	0.076
No newspaper (Don't associate w. water cont. ref.)	-0.145	-0.079	0.047	0.002
Associate w. water cont.	-0.718	-0.418	0.034	0.000
Don't know water association (Don't associate w. earthquakes ref.)	-0.170	-0.098	0.036	0.000
Associate w. earthquakes	-0.437	-0.257	0.033	0.000
Don't know earthquakes	-0.201	-0.113	0.037	0.000
Constant	3.143		0.070	0.000
R ² = 0.3870				
N= 3,822				

Appendix A

Table A.1 includes the descriptive statistics for respondents saying ‘no’, ‘don’t know’ or ‘yes’ to allowing shale gas extraction in the UK. Women are more than twice as likely as men to respond ‘don’t know’ Younger respondents are more likely to respond ‘don’t know’ than older respondents, with respondents older than 71 least likely to respond ‘don’t know’. There is no obvious pattern for ‘don’t know’ responses for income categories as the ‘don’t know’ responses appear randomly distributed among income groups. The same applies to political parties.

<i>Variables</i>	<i>No</i>	<i>Don't know</i>	<i>Yes</i>
Male	25.73	17.76	56.51
Female	32.58	36.48	30.94
Under 30	33.62	32.20	34.18
31-40	28.68	34.07	37.24
41-50	32.73	28.39	38.88
51-60	28.77	26.15	45.08
61-70	26.23	21.99	51.78
Over 71	19.23	15.81	64.96
Don't know income	30.38	34.86	34.75
<£25,000	31.26	27.82	40.92
£25,000-49,000	29.19	23.21	47.60
£50,000-69,000	28.45	25.14	46.41
£70,000-99,000	17.96	23.79	58.25
£100,000-149,000	28.57	20.78	50.65
>£150,000	20.69	24.14	55.17
Conservative Party	15.38	23.53	61.09
Labour Party	34.91	28.92	36.17
Liberal Democrats	36.50	24.75	38.75
SNP	54.17	17.71	28.13
Plaid Cymru	28.57	0.00	71.43
BNP	42.31	11.54	46.15
Green Party	59.68	30.65	9.68
UKIP	21.43	20.41	58.16
Didn't vote	28.83	37.90	33.27
Don't know vote	35.23	44.32	20.45

Table A.1 Cross-tabulation for support for shale gas extraction (DV) by select independent variables