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Abstract

As the most suitable sites for wind energy development, rural areas are integral to the growth of the renewable energy sector in the U.S. A crucial aspect of siting decisions lies in the opinions of the local community, for which environmental attitudes have a significant effect. One of the most prominent measures of these attitudes is belief in climate change. In this paper, we use data from a national survey of public opinion on energy policy to investigate the dynamics of belief in anthropogenic climate change based on rurality and the presence of existing wind turbines. Additionally, we analyze demographic data to better understand what underlies any variation in belief between those areas. We find that there is significantly more climate skepticism in rural populations than urban populations and in areas with turbines than without. We also find significantly higher belief that climate change is human-caused in urban areas compared to rural areas. However, through further analysis, we find that these locational variations are mediated through demographic factors associated with those areas—the most consequential being political affiliation. As a result, we do not find that rurality or wind turbine presence have a direct effect on belief in climate change. The higher rates of climate skepticism in rural areas should not be seen as discouraging, but rather as an insight that the framing of wind energy development should focus on economic aspects instead of environmental ones.

Introduction

Rural communities are intrinsically linked to the growing wind energy landscape of the U.S. According to the American Wind Energy Association, or AWEA (2017), over 99% of operating wind capacity is currently in rural areas. Compared to urban spaces, these areas have higher wind velocities and more open space, resulting in a higher wind potential and ability to house large infrastructure such as turbines and transmission lines, both key components to an effective wind energy site.

Aside from logistical aspects, public opinion is arguably the most crucial consideration in siting decisions; local attitudes significantly affect implementation and acceptance of wind energy into the community. While supporters frame wind energy as a clean and renewable energy source or praise its economic benefits to the community, opposers often express concerns that the turbines will degrade aesthetics or reduce the quality of life for neighboring residents (Rand and Hoen 2017, Sovacool and Ratan 2012). Of course, there are countless more claims across the spectrum of public opinion. However, at the core of these debates is the environmental aspect: the role of wind energy as a source for climate change mitigation. Environmental sentiment—a prominent example being climate change belief and skepticism—can be an important component of shaping underlying attitudes toward wind energy in local communities (Jepson et al 2012, Olson-Hazboun et al 2016). As such, local belief in climate change is a compelling factor to examine to gauge public perception on wind development, as well as other forms of renewable energy.

As the U.S. progresses towards a more sustainable energy economy by expanding clean energy infrastructure, it is becoming increasingly important to understand these dynamics of public attitudes in areas deemed most suitable for wind energy development. In this study,

differences in anthropogenic climate change belief between areas of varying rurality and presence of existing wind turbines will be presented, analyzing national survey data. In addition, we will delve in further to the background and associated traits of differing beliefs.

Literature Review

Belief in climate change is a complex subject influenced by a network of factors. One of these such factors is location; higher levels of belief in climate change are found in urban areas, compared to rural areas (Howe et al 2015). These locational variations in attitudes are often associated with other elements. In the UK, Whitmarsh (2011) found that the high levels of climate skepticism in rural locations are mediated by political affiliation and environmental values: residents of rural areas are more likely to be politically conservative and less likely to assert pro-environmental values. However, political parties do not necessarily determine level of belief in climate change; Mildenberger et al (2017) observed regional variation in belief within political parties, especially among Republicans. Variation in belief could also be observed in Canada, despite its high likelihood of belief in climate change across the country. The highest levels of belief were held in the six largest urban areas in the country, which contrasted with lower levels in surrounding rural regions (Mildenberger et al 2016). These differences are further exaggerated when respondents are asked if climate change is anthropogenic. Beliefs were highest in the most urban areas, while the lowest beliefs were observed in greenhouse gas intensive rural areas, namely the rural regions containing oil sands developments.

As can be seen from these findings, climate change is not solely a binary issue of belief or disbelief. According to Islam et al (2013), climate skepticism can be separated into three main categories: trend, attribution, and risk. Farmers are a crucial group to focus on in this topic due to

the direct connections between the climate and their livelihoods, and their firsthand experiences in the impending realities of agricultural effects. In spite of this strong link between the natural environment and life experience, the dominant political orientation, gender, and ethnicity of farmers in the U.S. represent groups more likely to be resistant to climate change belief. A large majority of U.S. farmers is Republican, male, and white, and this combination of demographic traits has been demonstrated as the most likely group of adults not to believe in climate change in the U.S. (McCright and Dunlap 2011, USDA Census). However, previous literature suggests that most farmers are not skeptical of the trend itself; in other words, farmers generally believe that climate is changing (Stuart 2017, Safi et al 2017, Islam et al 2013). Debates arise in the perception of attribution risk, or the causes of climate change. Stuart (2017) found that only 4% of corn farmers in the Midwest stated that the cause is solely anthropogenic. On the other hand, the growing awareness of human impact is demonstrated by the 59% of farmers that believe that humans play at least some role in climate change, many of them asserting that the natural cycles play significant roles, or uncertainty (Stuart 2017). Perhaps the most divisive attitudes are associated with the risk of climate change. Despite the vulnerability of farmers against effects of climate change, their risk perception is relatively low (Safi et al 2012, Islam et al 2013). Political orientation and belief in climate change are the principal predicting factors of risk perception, with conservatives and non-believers of climate change more likely to be skeptical of risk.

An interesting dynamic in climate change belief lies in areas with wind turbines. Much previous literature has investigated the varying attitudes of those who live in close proximity to wind turbines regarding wind energy, with many accounts citing economic benefits and community pride as principal factors fostering positive attitudes (Bidwell 2013, Greene and Geisken 2013, Brannstrom et al 2011). Of these studies, economic and social factors still loom

large in those that explored the environmental attitudes of wind turbine neighbors. Jepson et al (2012) find a seemingly contradictory, pro-wind but environmentally skeptical discourse in Western Texas, in which residents value the economic turnaround via wind revenues and the sense of prosperity that the turbines have come to symbolize. Surveys and interviews with residents revealed a general lack of desire to be associated with environmentalism, and disbelief in the feasibility of changing rooted anti-environmentalist sentiments; on the other hand, the association of wind energy with the region's farming/ranching economy and prosperity were deeply valued. Similarly, in the Great Plains, Sowers (2006) observes the lack of environmental or energy related reasoning in the acceptance of wind energy. Instead, the pro-wind attitudes are due to turbines' symbol of agricultural prosperity and community pride. Lastly, Slattery et al (2012) reports a significant amount of pro-wind respondents that believe using fossil fuels in electric generation is not harmful to the environment. Much like the other two cases, wind energy support is based more on economic and community benefits, rather than the view of wind energy as a tool to ameliorate climate change.

Methods

Data Sources

Data for this paper was obtained from The National Survey on Energy and Environment (NSEE), conducted by the Center for Local, State, and Urban Policy (CLOSUP) at the University of Michigan and the Muhlenberg College of Public Opinion. NSEE administers a biannual telephone survey of a random sample of U.S. residents over the age of 18, seeking to capture public opinion on energy and climate policy. The dataset used in this paper includes 17

survey waves, from Fall 2008 to Spring 2017. This survey included landlines, and beginning in 2011, cell phones. Response rates ranged from 9% to 31%, with a total sample size of 14207.

Variables and Analysis

The dependent variable is the survey respondents' belief of the cause of climate change. The survey asks this as a two-part question. The first: "Is there solid evidence that the average temperature on earth has been warming in the past four decades?" A follow-up question is asked among those who answer "yes": "Is the earth warming because of human activity or natural patterns?" Responses from these two questions were recoded into a new, 5-way variable of the level of anthropogenic climate change belief with 1 indicating the highest level of belief in anthropogenic climate change, and 5 the lowest:

1: Those who believe climate is changing and is human caused,

2: Those who believe climate is changing and is due to a combination of humans and natural patterns,

3: Those who said they believe the climate is changing but answered "not sure" or refused to answer the follow-up question about its cause,

4: Those who believe climate is changing and is due to natural patterns,

5: Those who do not believe the climate is changing.

Those respondents who refused to answer the initial question about there being solid evidence of climate change or who volunteered that they were "not sure" whether there was such evidence were excluded from this analysis. This 5-way model served as the dependent variable in the crosstabs and ordinal regressions ran in SPSS, to assess the significance of the independent variables.

The key independent variables of interest in this paper are rurality and presence/absence of wind turbines. The former is quantified through the use of RUCA (Rural-Urban Commuting Area) codes, which classify U.S. zip codes into groups of varying urbanity based on Census data of work-commute patterns and population density. Using this code, zip codes from survey respondents were classified into two categories—"urban" and "rural"—according to the RUCA C classification.

The presence or absence of wind turbines was determined by using a geodatabase of existing wind turbines from the American Wind Energy Association (AWEA). A geographical join was used to calculate the number of wind turbines in each U.S. zip code. This data was reclassified into a binary variable of 0: turbines absent or 1: turbines present for each zip code and appended to the survey response.

Demographic variables of respondents captured on the public opinion survey were also added to the analysis. These included ordinal variables of age (groups between 18-65+), highest level of education (from less than high school to graduate or professional degree), income (Less than $20,000 to over $100,000), and political views (very conservative to very liberal). Also included were a binary variable of gender (male or female), and dummy variables of political party (Republican / not Republican and Democrat / not Democrat). All variables analyzed and their summary statistics are presented below in Table 1.

To analyze the data, crosstabs were run with the independent variables RUCA C and presence/absence of wind turbines, both with the data weighted and unweighted. Ordinal regressions were run for all independent variables, including the demographics.

Table 1. Variable Descriptions

Variable	**Variable Description/Definition**	**Weighted mean/proportion (SE)**
Dependent Variable		
Belief of cause of climate change	5 category; (-9: unsure about climate change, 1: human caused, 2: combination of humans and natural patterns, 3: unsure believer, 4: natural patterns, 5: do not believe in climate change)	3.072 (0.015)
Independent Variables		
Age	4 category; (1: 18-29, 2: 30-44, 3: 45-64, 4: 65+, 5: refused but 18+, 98: not sure, 99: refused)	2.627 (0.009)
Highest level of education	5 category; (1: less than HS graduate, 2: HS graduate, 3: some college or technical school, 4: college graduate, 5: grad or professional degree, 98: not sure, 99: refused)	3.11 (0.009)
Family Income	6 category; (1: less than 20,000, 2: 20,000-40,000, 3: 50,000-60,000, 4: 60,000-80,000, 5: 80,000-100,000, 6: 100,000+, 98: not sure, 99: refused)	3.21 (0.016)
Political beliefs	5 category; (1: very conservative, 2: somewhat conservative, 3: moderate, 4: somewhat liberal, 5: very liberal, 98: not sure, 99: refused)	2.81 (0.011)
Gender	1: Male, 2: Female	1.51 (0.004)
Democrat/not	0: Not Democrat, 1: Democrat	0.387 (0.004)
Republican/not	0: Not Republican, 1: Republican	0.256 (0.004)
RUCA C	1: Urban, 2: Rural	1.14 (0.003)

Results

Crosstabs: Rurality and Presence/Absence of Turbines

Crosstabs run on RUCA C, comparing climate change attribution beliefs between urban and rural populations, came back with significant differences in two areas. Compared to rural populations, urban residents were significantly more likely to say that climate change is human caused, and significantly less likely to say that climate change does not exist at all.

The crosstabs on the absence vs. presence of wind turbines generally produced similar patterns to the urban vs. rural populations from the RUCA C crosstabs, but with only one significant difference. Compared to those who do not live in an area code with a wind turbine, those who do live near a wind turbine were significantly more likely to say that they did not believe in climate change. As demonstrated in Tables 2 and 3, results from weighted and unweighted cases did not differ substantially, and exhibited significant differences in the same categories, suggesting that these results are robust to the sampling design. Figure 1 and 2 show depict the distribution of responses from the urban vs. rural and turbine absent vs. present groups, both weighted and unweighted.

Table 2. RUCA C Crosstabs

	Weighted			**Unweighted**		
	Absent	*Present*	*Significance*	*Absent*	*Present*	*Significance*
1: Human caused	30.6%	28.5%		30.0%	29.3%	
2: Combination of humans & natural patterns	13.2%	14.6%		12.4%	12.9%	
3: Unsure believer	3.6%	2.7%		3.4%	2.5%	
4: Natural patterns	27.3%	23.5%		27.2%	22.9%	
5: Do not believe in climate change	25.3%	30.8%	*	27.0%	32.5%	*
Mean	3.036	3.133	0.342	3.087	3.164	0.433
n	9643	260		9750	280	

Table 3. Any Turbines Crosstabs

	Weighted			**Unweighted**		
	Urban	*Rural*	*Significance*	*Urban*	*Rural*	*Significance*
1: Human caused	31.0%	27.5%	*	30.5%	27.0%	*
2: Combination of humans & natural patterns	13.0%	13.8%		12.3%	13.2%	
3: Unsure believer	3.5%	3.9%		3.4%	3.5%	
4: Natural patterns	27.5%	25.0%		27.3%	25.3%	
5: Do not believe in climate change	25.0%	29.7%	*	26.6%	31.1%	*
Mean	3.023	3.157	0.004	3.071	3.203	0.005
n	8679	1375		8741	1446	

Figure 1.

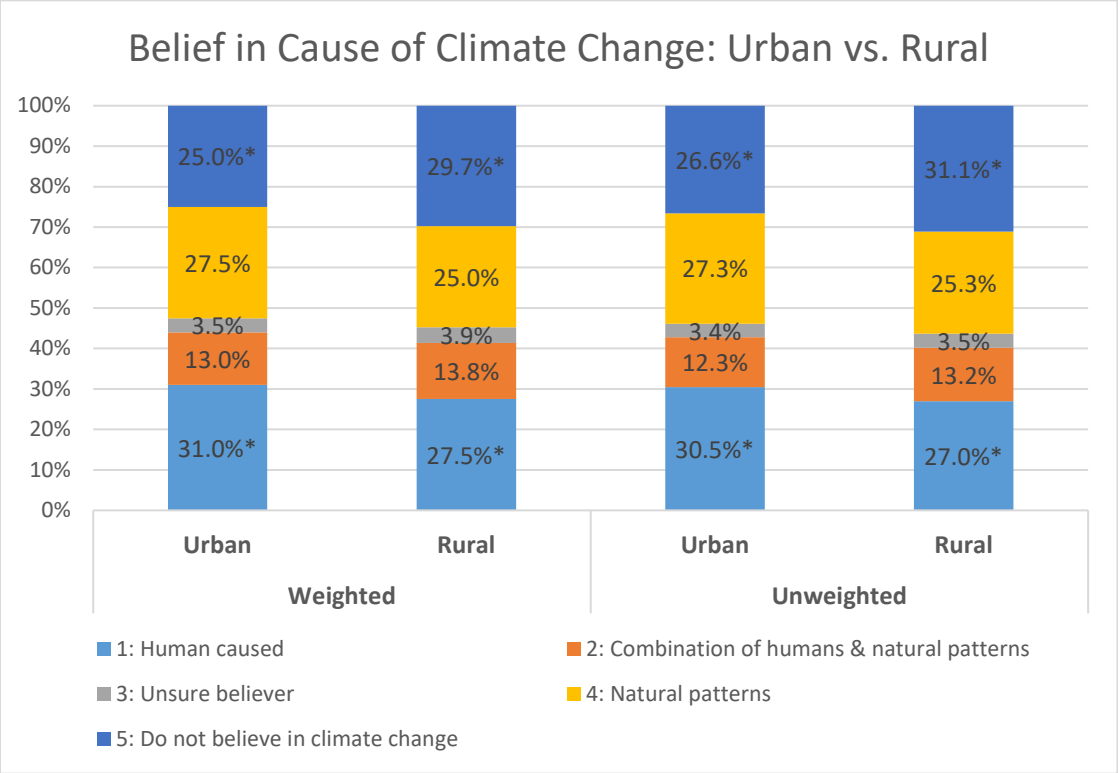
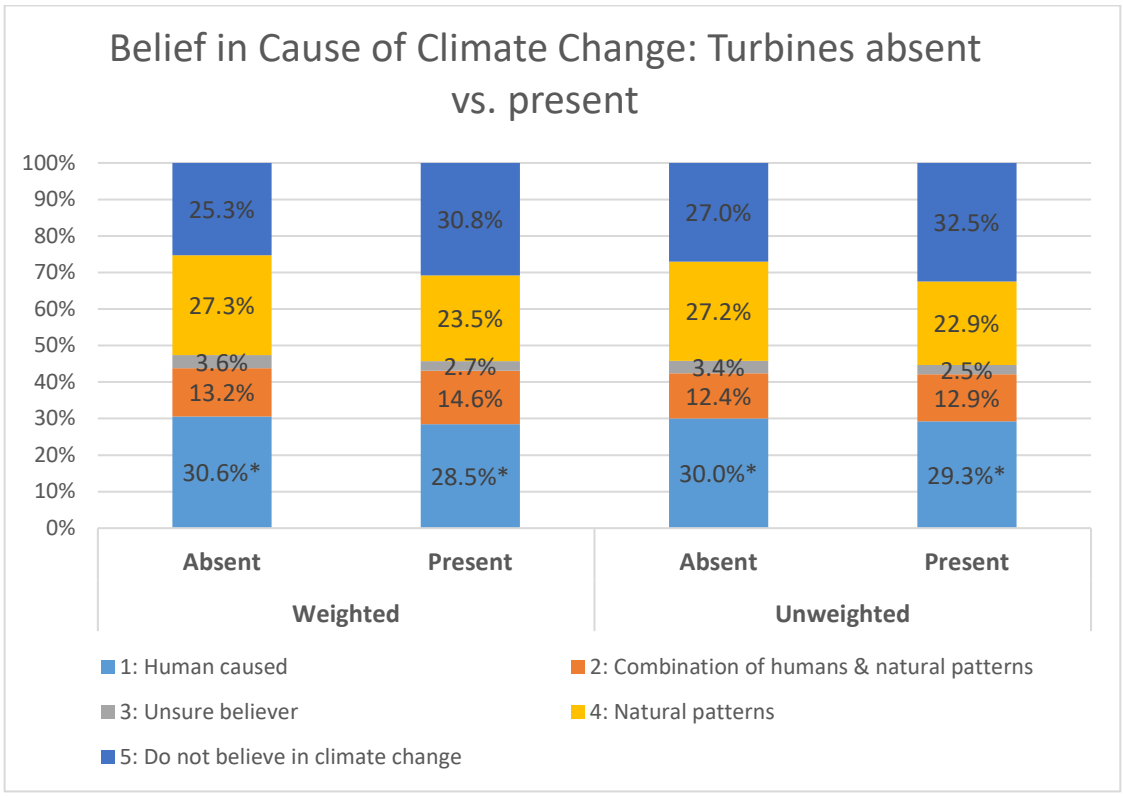


Figure 2.



* represents variables for which differences were significant.

Ordinal Regression

The ordinal regression on the two key independent variables of RUCA C and Any Turbine came back with non-significant results. On the other hand, all analyzed demographic variables were significant below p-values of 0.01, except income, for which the p-value was between 0.01 and 0.05. The coefficient was positive for age, indicating that the older the population, the higher up in the five-step scale of doubt in human caused climate change, signifying lower levels of belief in anthropogenic climate change. Education level, income, and political views were negatively correlated with anthropogenic climate change belief, indicating that the lower the highest education level and income, and the more conservative one's political views are, the less they believed in anthropogenic climate change. Males were more likely to express higher doubt in anthropogenic climate changes than females, as were non-Democrats than Democrats, and Republicans than non-Republicans.

The Nagelkerke pseudo R-squared value indicates that 13.2% of the total variability in responses can be explained by the model. Coefficients and p-values for all variables are summarized below in Table 4.

Table 4. Ordinal Regression Results

N	5299	
Pseudo R-Square (Nagelkerke)	0.132	
Variables	**Coefficient**	**P-value**
Age	0.124	0.000***
Highest level of education	-0.120	0.000***
Income	-0.038	0.034**
Political views	-0.330	0.000***
Gender	0.154	0.003***
Political party 1 (Democrat/not)	0.464	0.000***
Political party 2 (Republican/not)	-0.338	0.000***
RUCA C	0.058	0.434
Any Turbine	0.007	0.964

P-value: ***p<0.01, **p<0.05, *p<0.10

Analysis

On their face, just looking at basic frequencies comparing urban and rural populations demonstrate that, compared to rural populations, urban populations held significantly higher levels of belief that climate change is human caused, and lower levels of climate change skepticism. This is consistent with previous literature on locational variations in attitudes about climate change; the regional dynamic in which rural populations have a greater tendency of not believing that the earth is warming has been widely observed, not only in the U.S., but also in Canada and the UK (Howe et al 2015, Mildenberger et al 2016, Whitmarsh 2011). Similarly, climate change skepticism was a factor of significant difference in the turbine present vs. absent communities as well, the former expressing higher levels of skepticism. Although no previous studies were found that explicitly compare climate change attitudes between these two groups, case studies by Slattery et al (2012) and Jepson et al (2012) indicate relatively high levels of environmental skepticism within communities with wind turbines, suggesting a pattern

congruent with our results. Given that most turbines are sited in rural areas, this phenomenon is likely associated with the aforementioned urban-rural dynamic in climate change belief. In terms of environmental belief, there was no evidence that turbine communities deviated from rural areas as a whole. In fact, the levels of climate skepticism were very similar between these two groups, showing that these communities welcome wind development for reasons beyond climate change.

However, once you control for demographic and political characteristics of respondents, the non-significant regression results suggest that these locational variations are mediated through the demographic factors associated with those places, rather than rurality and turbine presence having direct effects on residents' beliefs. This idea is consistent with the indirect effect of location on climate skepticism, shown by Whitmarsh (2011).

As such, the analysis of demographic variables is essential to gain insight to what is most directly correlated with certain beliefs. Results on age, gender, and education level were consistent with trends from previous literature; those who are older, male, and have lower education levels tended to have higher rates of skepticism in anthropogenic climate change (Whitmarsh 2011, Islam et al 2013). Previous studies on the effects of income on climate change belief have been largely inconsistent (Islam et al 2013). Thus, it makes sense that although income did come back as a significant variable in the regression, its coefficient was the lowest of all significant demographic factors, indicating that the correlation of income with anthropogenic climate change belief is relatively weak.

On the other hand, the strongest correlations were observed in factors related to political beliefs, specifically in political views and parties. This result is congruent with existing literature, which has widely discussed the polarization of climate opinions between

Republicans/conservatives and Democrats/liberals, the latter group holding higher levels of belief in anthropogenic climate change (McCright and Dunlap 2011, Whitmarsh 2011, Stuart 2017). This distinctive link of political views and partisanship to climate change beliefs adds to a growing recognition of the undeniable political divide in the U.S.

Conclusion

Overall, this paper suggests that the variations in anthropogenic climate change belief among urban vs. rural and turbine absent vs. present populations are mediated by associated demographic factors, of which political affiliation is most consequential.

A limitation of this research stems from the fact that results were based on responses from a voluntary survey on the topic of climate change. As such, there is a possibility of self-selected biases, or an effect on how respondents chose to answer the questions, although statistical analysis included weighted data. In addition, belief in anthropogenic climate change does not necessarily equate to support for wind turbines, as argued by Slattery et al (2012) and Jepson et al (2012). This contingency is one that should be carefully considered in the application of these results.

Nevertheless, the results of this research not only confirms the divergence of climate attitudes among various demographics, but also illustrates the dynamic of these attitudes within rural communities. This understanding is crucial because most of the infrastructure promoting a transition to clean energy will be sited in such areas. The higher proportion of populations who do not believe that the earth is warming in these rural areas should not be viewed as a discouraging note to clean energy advocates; in fact, it gives insight to how the siting process should be formed to gain public support. These results suggest that the framing of wind (and

other clean energy infrastructure) development there should focus on the economic arguments, instead of environmental ones. As mentioned in the literature review, case studies of wind turbine communities have observed the dominance of economic factors as reasons for wind energy support, with little to no consideration for environmental reasons (Jepson et al 2012, Sowers 2006, Bidwell 2013). Rather than arguing that these infrastructures support the mitigation of climate change, those who are advocating for their siting are well advised to stress economic benefits, such as increased tax revenues, job growth, and community prosperity.

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