The Influence of Cultural Worldviews on Public Support for Carbon Capture and Storage with the Risk of Induced Seismicity

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Abstract

We investigate the influence of cultural worldviews on public support for carbon capture and storage (CCS) with the risk of induced seismicity, while controlling for demographic factors, political affiliation, and religious beliefs. Using data from an online survey, we employ the cultural theory of risk framework to examine how hierarchy, egalitarian, individualism, and fatalist worldviews shape attitudes towards CCS when there is a noted risk of small earthquakes occurring due to the CCS. We find that individualism has a negative correlation with CCS support, while fatalism and egalitarianism have positive correlations. The absence of a significant correlation between the hierarchy worldview and CCS support suggests that other factors may be more influential in shaping hierarchists' attitudes toward CCS. We discuss these results in the context of each cultural worldview's relation to nature, noting the importance of considering cultural worldviews alongside demographic variables when assessing public perceptions of CCS, given its known side effect risks. These findings contribute to a deeper understanding of the complex social and cultural dynamics surrounding social acceptance of CCS.

1. Introduction

The dire need to mitigate climate change has led to the development and exploration of various climate mitigation strategies, including carbon capture and storage (CCS). CCS is a process that involves capturing carbon dioxide emissions from industrial sources or directly from the atmosphere and injecting them into underground storage sites. While CCS has the potential to significantly reduce greenhouse gas emissions, it also carries the risk of inducing small earthquakes that may cause slight damage to personal property (Ellsworth, 2013; Walsh & Zoback, 2015). This seismicity risk adds a layer of complexity to public perception and acceptance of CCS as a viable climate change mitigation strategy.

One way to understand risk perception is through cultural worldviews, as described by the Cultural Theory of Risk (Douglas & Wildavsky, 1982; Kahan et al., 2011; Thompson et al. 1990), which helps to understand how individuals' perceptions, attitudes, and responses to environmental risks shape their attitudes towards climate change mitigation strategies. The theory identifies four primary cultural worldviews: hierarchy, egalitarianism, individualism, and fatalism, each characterized by distinct beliefs and values that contribute to unique perspectives on risk management and decision-making in reference

to the natural world. Each of these worldviews also has a certain way that they perceive the fragility or robustness of nature, which is particularly relevant to the study of climate mitigation. These worldviews are represented by a ball in a landscape in Figure 1. Individualists, who believe in less social bonding and fewer societal rules, view nature as benign and resilient to human actions, like a ball nestled in a valley. Fatalists, who believe in less social bonding and more rules, see nature as capricious and unpredictable, with the ball able to roll anywhere. Hierarchists, who believe in having more social bonds and rules, also believe nature is manageable within certain thresholds, like a ball contained in a valley unless pushed too far. Egalitarians, who believe in strong social bonds and internally agreed upon rules, perceive nature as fragile and in a delicate balance with society, like a ball easily tipped to roll down a hill. The egalitarian perspective is important when considering topics such as CCS, where individuals are exploring technological interventions to address human-caused climate concerns.
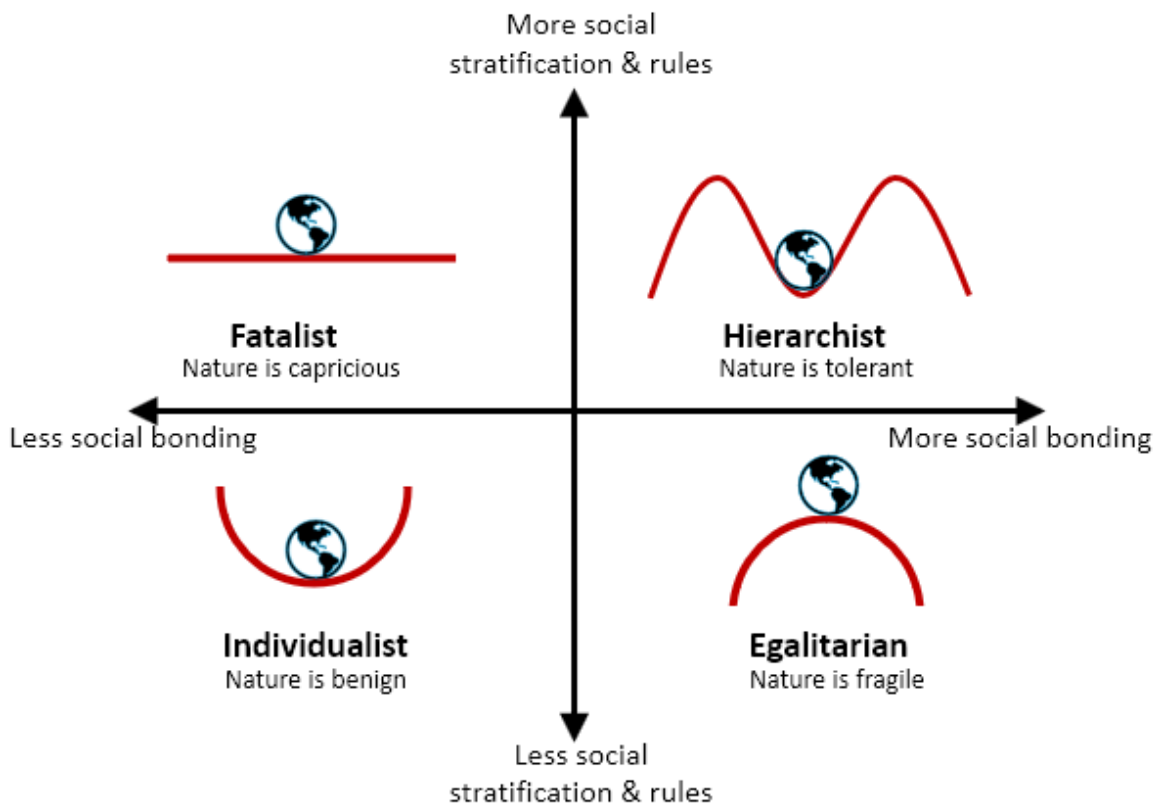

Figure 1: Cultural worldviews theory matrix demonstrating balance with nature (after Thompson et al., 1990). Each worldview and humans' ability to alter nature is explained in terms of a ball on a surface, that can be 'pushed' by human activity.

The influence of cultural worldviews on CCS acceptance is minimally studied. Some previous research has highlighted the influence of cultural worldviews on public perception and acceptance of alternative energies such as wind and CCS (Cherry et al., 2014). However, CCS acceptance may vary depending on

the specific context (Cherry et al., 2014; Tcvetkov et al., 2019), such as support for CCS research and development, or the placement of CCS technology locally. More research is needed to understand the complex social dynamics surrounding CCS acceptance and deployment, as recently demonstrated by Mota-Nieto and García-Meneses (2024).

This report aims to investigate the relationship between cultural worldviews and public support for CCS with the risk of induced seismicity, while controlling for demographic factors, political affiliation, and religious beliefs. We believe it is crucially important to understand how cultural worldviews influence public support for CCS in light of its risks, as cultural worldviews provide insight into humans' relationship with the natural world. In the following sections, we discuss our survey methods, data and results, and explore the implications of our results through the lens of the cultural theory of risk. Our goal is to provide valuable insights that can inform efforts to navigate the concerns surrounding CCS deployment and risks and increase support for climate change mitigation strategies. These results have significant implications for communication strategies, and public engagement efforts related to CCS implementation and climate change mitigation.

2. Survey Methods

2.1 Data

The data come from the SPEER23 Survey, an online survey conducted by the authors at the University of Oklahoma. Using the Qualtrics platform, responses were collected between May and June of 2023 to generate a sample of 2,188 U.S. adults. The sample is designed to approximate a national sample, utilizing quota-based sampling to reflect the U.S. population in terms of age, gender, income, education, race/ethnicity, and census region. The study's procedures received thorough review and approval from the University of Oklahoma Institutional Review Board under protocol #15823, ensuring adherence to standards and guidelines for researching human subjects. For a detailed explanation of the data collection please consult the survey report by Bedle et al. (2024).

2.2 Dependent Variable

Support for carbon capture was measured by asking respondents' level of agreement on whether they would oppose or favor carbon capture and storage. The exact wording of the question was as follows: "How much do you oppose or favor injecting and storing carbon dioxide in the ground to reduce greenhouse gases, even if it triggers small earthquakes that occasionally cause slight damage such as knocking items off bookshelves or picture frames off walls?" The participants were given a six-point response scale with options ranging from 'strongly oppose' to 'strongly favor' – which is treated as a continuous variable.

2.3 Independent Variables

Cultural worldview measures are based on a six-point Likert response scale with options ranging from strongly disagree to strongly agree, and the following wording, based off the work of Douglas & Wildavsky, (1982) and Kahan et al., (2011)[1]:

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[1] See Table 1 for descriptive statistics for focal dependent and independent variables.

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- Hierarchy: I am more comfortable when I know who is, and who is not, a part of my group, and loyalty to the group is important to me. I prefer to know who is in charge and to have clear rules and procedures; those who are in charge should punish those who break the rules. I like to have my responsibilities clearly defined, and I believe people should be rewarded based on the position they hold and their competence. Most of the time, I trust those with authority and expertise to do what is right for society.
- Egalitarianism: My most important contributions are made as a member of a group that promotes justice and equality. Within my group, everyone should play an equal role without differences in rank or authority. It is easy to lose track of what is important, so I have to keep a close eye on the actions of my group. It is not enough to provide equal opportunities; we also have to try to make outcomes more equal.
- Fatalism: Life is unpredictable and I have very little control. I tend not to join groups, and I try not to get involved because I can't make much difference anyway. Most of the time other people determine my options in life. Getting along is largely a matter of doing the best I can with what comes my way, so I just try to take care of myself and the people closest to me. It's best to just go with the flow, because whatever will be will be.
- Individualism: Groups are not all that important to me. I prefer to make my own way in life without having to follow other peoples' rules. Rewards in life should be based on initiative, skill, and hard work, even if that results in inequality. I respect people based on what they do, not the positions or titles they hold. I like relationships that are based on negotiated "give and take," rather than on status. Everyone benefits when individuals are allowed to compete.

Table 1: Descriptive table of dependent and focal independent variables.

Variable	Min	Max	Mean	SD
CCS	1.00	6.00	2.98	1.29
Hierarchy	1.00	6.00	3.80	1.29
Egalitarianism	1.00	6.00	3.83	1.34
Fatalism	1.00	6.00	3.52	1.35
Individualism	1.00	6.00	4.16	1.29

2.4 Control Variables

We include a comprehensive set of control variables known to influence environmental attitudes. Political affiliation and orientation is a strong predictor of attitudes toward climate change attitudes and related behaviors (Dunlap & McCright, 2016; Hornsey et al., 2016; McCright et al., 2016a). As such, we control for political affiliation and orientation to isolate the effect of cultural worldviews on energy preference using dummy indicators with both liberal and Democrat as references.
We also control for a wide range of socioeconomic and demographic factors that are known to relate to CCS and other environmental issues (Boudet et al., 2016; Cherry et al., 2014; Drummond & Fischhoff, 2017; Hamilton, 2011; Krause et al., 2014; Miller et al., 2008; Nielsen et al., 2022; Satterfield et al., 2023). These variables include mean-centered age (with a squared term when significant), sex, race, education, income, marital and parental status, religious service attendance, evangelical identity, biblical views, urbanicity, and region of residence.

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2.5 Analysis

We use OLS regressions to examine the effect of cultural worldviews on support for CCS using the linear CCS scale as a DV. We also include a visual depiction for average worldview score across the six levels of CCS support.

Figure 2: Heatmap demonstrating the average value of each worldview for levels of CCS support. Note that the biggest difference in average values of a worldview across categories of support for carbon capture and storage is for egalitarian, while average values of individualism are lower with more CCS support, and fatalism average values are slightly higher with greater support for carbon capture and storage. While hierarchy is not statistically significant in the OLS, the heatmap does reveal that those who more strongly support CCS, do have a higher hierarchy worldview.

Results

To provide a visual representation of our findings, we include a heatmap found in Figure 2. In this heatmap, we report the average (uncontrolled) cultural worldview score at each level of the CCS scale.

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We find that while average hierarchy values increase across the CCS scale, the rate of increase is minimal. Egalitarian scores increase minimally across lower levels of CCS support but increase sharply at higher levels showing that CCS support is greatest amongst those with especially high levels of egalitarian worldviews. Fatalism scores do not seem to vary between levels of CCS support. Average individualism scores decline consistently at lower levels of CCS support and level off at higher levels – which is almost the inverse of how egalitarianism relates to CCS support.

Table 2: OLS regression for cultural worldviews and CCS support

	b
Cultural Worldviews	
Hierarchy	.038
Egalitarianism	.064 **
Fatalism	.063 **
Individualism	-.056 *
Adj. R^2	.105

Model 1: DV = CCS
* p ≤ .05 ** p ≤ .01 *** p ≤ .001
*Note: Model includes controls for party affiliation, political orientation, age, sex, race, socio-economic status, family status, region, urbanicity, and religious variables

Results for fully controlled OLS regressions for CCS are shown in Table 2. Results show that while controlling for all other factors, hierarchy is unrelated to CCS support – which aligns with results from Figure 2. Results in Table 2 also show that both egalitarianism (b=.064) and fatalism (b=.063) positively correlate with CCS support to nearly the same degree. Conversely, individualism is negatively associated with CCS support (b=-.056). It is interesting to note that while bivariate results show that fatalism is unrelated to CCS support, fully controlled results demonstrate a significant relationship. Additional regression analyses (not shown) demonstrate that regression results omitting control variables show a positive relationship between fatalism and CCS support. This might indicate a suppression effect between cultural worldview variables. More research is needed to investigate this finding.

Finally, we include a heatmap for CCS support across various regions of the United States found in Figure 3. The heatmap indicates that the strongest levels of CCS support are found amongst residents of the Mountain region. CCS support is lowest amongst residents in both the Northeast and Deep South regions of the United States.

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Figure 3: CCS support across the United States. While zip codes were reported in the survey, they are averaged into the nine US Census divisions.

Results in this report illuminate the influence of cultural worldviews on attitudes towards CCS with the risk of induced seismicity and provide valuable insights into how different segments of the public perceive and respond to this climate mitigation strategy. By examining these findings through the lens of the cultural theory of risk and the associated views of nature, we can gain a deeper understanding of the underlying beliefs and values that shape public opinion on this timely issue, especially in the context of cultural worldviews' relation to nature as discussed by Douglas & Wildavsky (2982) and further built upon by Thompson et al. (1990) (which is illustrated in Figure 1). As a reminder, the four worldviews and their corresponding views of nature are: individualism (nature is benign), fatalism (nature is capricious), hierarchism (nature is manageable within limits), and egalitarianism (nature is fragile). Each worldview is associated with different and distinct perceptions of humans' relationship with nature as presented by Douglas & Wildavsky (2982) and refined by Thompson et al. (1990).

The negative correlation between individualism and support for CCS aligns with the individualism worldview of nature as benign and resilient. Individualists, who prioritize personal freedom, autonomy, and minimal government intervention are shown by Cherry et al, (2014) to not support the research funding into CCS technology, and in the SPEER23 survey they did not support the deployment of CCS technology.

In contrast, the positive correlations between fatalism and egalitarianism with support for CCS, despite the risk of induced seismicity, can be interpreted through their corresponding relationship with nature. Fatalists, who view the world as unpredictable and largely beyond individual or collective control, may

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perceive the risks associated with CCS as inevitable and accept the potential outcomes as a matter of chance or fate. This resignation and acceptance of unpredictable consequences may contribute to their increased support for CCS, even with the risk of induced seismicity. Egalitarians with a belief in the vulnerability of the natural world also showed greater support for CCS with the risk of induced seismicity. This seemingly counterintuitive finding may be explained by egalitarians' strong focus on collective action to address environmental challenges. They may view CCS as a necessary step in mitigating climate change, prioritizing the broader societal benefits over the potential localized risks.

The survey results also highlight the absence of a significant correlation between the hierarchy worldview and support for CCS with the risk of induced seismicity, when controlling for demographics, politics, and religion. This suggests that the hierarchy perspective may not be a strong predictor of attitudes towards CCS in this specific context. This result is in agreement with Cherry et al. (2014) who found no significant correlation between hierarchy and general support for CCS. Building support for carbon capture technology among those with a hierarchical worldview may require triggering other aspects of their belief systems, such as trust in institutions and stakeholders involved in CCS projects (Nielsen et al., 2022; Tcvetkov et al., 2019).

As we take these results and attempt to use them for communication strategies or community engagements, it is important to consider the potential influence of direct experience with induced seismicity on risk perceptions and attitudes towards CCS. As Bedle et al. (2022) found, personal experiences with a risk can potentially moderate the influence of cultural worldviews on risk perceptions. Additionally, there may be other effects based on experiences with other technologies, such as fracking, on CCS risk perceptions (Cox et al., 2022). Engaging with diverse stakeholder perspectives and worldviews (Mota-Nieto & García-Meneses, 2024) and addressing concerns about moral hazards, such as the potential for CCS to enable continued fossil fuel dependence (Satterfield et al., 2023), will be crucial for understanding and navigating the complex social dynamics surrounding CCS acceptance and deployment.

In conclusion, our survey results demonstrate the significant influence of cultural worldviews on attitudes towards CCS with the risk of induced seismicity, while also revealing the nuanced nature of these relationships. The findings emphasize the importance of considering cultural factors, alongside socio-demographic variables, when assessing public perceptions of CCS and other climate mitigation strategies.

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