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General public reactions to carbon capture and storage: Does culture matter?

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ABSTRACT

We scrutinise the controversial carbon capture and storage (CCS) technology from a cross-cultural perspective. The reaction of the public to CCS will considerably affect the development of the technology. Previous research has identified general and local mechanisms in how the general public reacts to CCS. Researchers have noticed that differences exist between countries, but the effects of cross-cultural differences have not been explored in detail. We argue that it is crucial to understand how public perceptions of the technology emerge and form in their individual contexts or embedded in large-scale cultural frameworks.

Public reaction to CCS is structured in two dimensions—risk perception and benefit perception—and we design a model with individual and national cultural level predictors. We indicate that effects of individual level variables such as familiarity with technology, or sociodemographic variables such as education, are important but their effects are likely mediated and confounded by the cultural setting people operate in. The results show that, in parallel with other factors such as trust, risk perception is affected by cultural dimensions such as uncertainty avoidance and the society's short-term or long-term orientation.

We provide a framework to understand why and how societies challenge the technology.

1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) includes carbon capture and storage (CCS) as one of the key technologies for climate change mitigation, and their scenarios show that CCS may contribute 15–55% of cumulative global mitigation until 2100 (Metz et al., 2005). The principal aims of CCS technology are to avoid undesired greenhouse gas emissions while using fossil fuels for energy generation, and mitigation of carbon dioxide (CO_2) emissions from large-scale emitting industries such as cement and steel. However, the implementation of CCS has lagged behind the scenarios. CCS technology consists of three steps: capture, transport, and storage. Cost of capture is generally regarded as a major constraint, making it questionable that a global rollout of CCS will actually consist of more than demonstration plants and a few attempts at commercial plants. The second step in CCS is transport. Technically, transportation of CO_2 is feasible based on the existing technologies (Hendriks et al., 2007). The last part of the technology concerns storage. The storage phase is one of the most controversial parts of CCS because of the large uncertainty involved, for example, the possibility of CO_2 leakage (Metz et al., 2005). The number and location of safe reservoirs are the major concerns. Storage possibilities are restricted, even though from a technical perspective there appears to be enough capacity to store global CO_2 emissions for many decades. Much uncertainty exists about the suitability of the various storage options, as well as much societal opposition once a particular storage site has been selected (Huijts et al., 2007). Opponents are concerned about the risk of a large or small amount of gas leakage, warning against the hazard of seismic activity due to underground pressure change as a result of geological storage.

The development and deployment of CCS technology rely on public perception and acceptance of the technology in line with the technical aspects of the technology (Oltra et al., 2012; Seigo et al., 2014a; Seigo et al., 2014b; Dowd et al., 2014; Schumann, 2015). Oltra et al. (2010) assert that risk perception of CCS is the concern of policymakers and industries. According to Seigo et al. (2014a) the study of the public perception of the technology enables stakeholders to prevent conflicts and disputes.

Several factors exist which affect the risk perception and understanding of the technology. In this study, we discuss an important but under-researched factor: cross-cultural characteristics. A few studies have shown the importance of cultural values and traits in risk perception and understanding of a technology (Kahan, 2009; Slovic, 2000; Weber and Hsee, 1998; Bontempo et al., 1997; Thompson and Wildavsky, 1982) but they did not bring about macroculture or what

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we call national culture. Karimi et al. (2016) demonstrate the role of national cultural orientation in the formation of public opinion and risk perception of CCS. In their study, they developed two indices—risk perception (RP) and benefit perception (BP)—to indicate that paying attention to the culture of a society is an advantage in the study and planning of a CCS project. They correlated the indices with the six cultural dimensions of Hofstede to offer supporting evidence for their hypothesis (Karimi et al., 2016). However, in this study, we apply a multilevel regression analysis with individual level variables, such as knowledge of CCS and climate change, age, education, and the BP and RP indices. Our aim is to precisely explain the importance and role of cross-cultural differences and the reaction of people in different countries towards the technology vis-à-vis the other factors and demonstrate how those differences operate. We address the following question in this research: How do the national cultural characteristics of a society affect the risk perception of, and public reactions to, CCS?

In this paper, we discuss the existing studies on risk perception, social acceptance, and social acceptability of CCS and what is lacking in this field. Then, we describe our model and how our research contributes to reducing those gaps. The paper continues by describing the data, data analysis, and the method used. We end with a discussion of the data analysis, interpretation of the results, and the conclusion section.

2. Background

2.1. Social sciences and carbon capture and storage: an overview

Research on public risk perception and understanding of CCS is challenging because of the technical attributes of the issue, which make it harder for laypeople to understand. In addition, CCS is still in the early stage of development and so there is little experience of the technology within societies and therefore no clear understanding of it (Shackley et al., 2005). Seigo et al. (2014b) reviewed 42 journal papers in the field of public perception of CCS. They sorted the articles into 14 categories such as problem perception, trust, perceived cost, experience, and knowledge, but none of the papers considered the issue of national culture. In this section, we review key research in the social science of CCS, and end the section with those papers that raise the issue of national culture.

Researchers have tried to estimate the effect of providing information on public reactions by means of an experiment or a questionnaire. Results have varied both in magnitude and sign, with positive, negative, and non-significant results depending on the procedure (de Best-Waldhober et al., 2009; Shackley et al., 2005; Sharp et al., 2009; Curry et al., 2004). One strand of research that tries to measure general public reactions has focused on localities containing proposed CCS facilities. Here, the reactions of the local public to storage projects have been under considerable scrutiny (Braun, 2017; Krause et al., 2014; Terwel et al., 2013; Wallquist et al., 2012; Haug and Stigson, 2016; ter Mors and Groeneweg, 2016; Terwel and ter Mors, 2015; Terwel et al., 2014; Zaal et al., 2014; ter Mors et al., 2014; ter Mors et al., 2012; Terwel and Daamen, 2012; Groothuis et al., 2008; Schively, 2007; Huijts et al., 2007; Terwel et al., 2012; Brunsting et al., 2011; Pietzner et al., 2011; Dütschke, 2011; Tokushige et al., 2007). Not-in-my-backyard (NIMBY) effects (general support for CCS adoption but opposition to local projects) have been differentiated from general reactions by measuring the reactions of the offsite and onsite public (Terwel and Daamen, 2012). NIMBY reactions have been explained by individual values, namely the perception of the effects of CCS in society at large (Krause et al., 2012). However, it is interesting to note that Terwel and Daamen (2012) show that “the psychological structure of attitudes towards CCS” is fairly similar for people living onsite and offsite within a society.

Trust in government and key stakeholders has been shown to be a crucial factor in the inclination to protest, risk perception, and benefit perception (Yang et al., 2016; Terwel and Daamen, 2012; Seigo et al., 2014a; Earle and Siegrist, 2008; Midden and Huijts, 2009; Terwel, 2009; Terwel et al., 2011; Brulle et al., 2012). For instance, Yang et al. (2016) demonstrate the significant impact of trust in the authorities and the technology on risk and benefit perception, and also on the social acceptability of CCS. Furthermore, trust in non-governmental organizations and research institutes is the highest so people tend to rely on what they advocate or can verify and would prefer to engage them in the decision-making process more than the other stakeholders (Eurobarometer, 2011; Terwel et al., 2011).

Lack of knowledge and information usually features as a key factor in the risk perception of the technology (Tokushige et al., 2007; Itaoka et al., 2009; Dowd et al., 2014; Schumann, 2015; Curry et al., 2004; Shackley et al., 2005; Sharp et al., 2009; de Best-Waldhober et al., 2009; Gough et al., 2014). However, outreach methods and the process of dissemination per se have different degrees of influence on risk perception (ter Mors et al., 2010; Ashworth et al., 2010; Ashworth et al., 2015). In contrast, some studies posit that increasing knowledge and information will not lead to reduced risk aversion because respondents always incorporate several factors other than just the technical properties into their reactions (Satterfield et al., 2009; Kahan 2009; Seigo et al., 2014b). Upham and Roberts (2011) claim that after their studied public received information about CCS, their perception of the technology changed to negative.

Gough et al. (2014) identify three factors affecting public perceptions of CO_2 transportation as a part of the CCS chain: lack of knowledge about the technology, institutional factors, and risks of the technology. Oltra et al. (2012) identify six factors affecting public reactions to CCS: sociopolitical context, community characteristics, risk perceptions, project characteristics, the engagement process, and actions of stakeholders. These factors are based on case studies of five European Union CCS research, development, and demonstration (RD&D) and commercial projects.

There has been some research on CCS in which national culture has been noted as a key contributor to public perceptions, and further research in this area has been suggested. Ashworth et al. (2013) showed by conducting empirical research that definite differences exist in the understanding of CCS in different countries. The study indicates that although some shared concerns about CCS among people from different countries exist, the approach to and perception of the technology varied between countries even after all the participants had been provided with enough information about the technology. Nonetheless, the authors did not discuss the source of these discrepancies in perception.

Oltra et al. (2012) refer to the role of cultural orientations in risk perception of new technologies by making reference to the work of Wildavsky and Dake (1990). Nonetheless, neither Oltra et al. nor Wildavsky and Dake indicate the role of national culture and cross-cultural differences and the way they affect the risk perception of CCS in particular, and new technology in general. This is the same for the other studies on the risk perception and social acceptance of CCS (for instance see Oltra et al., 2010; Upham and Roberts, 2011; Brunsting et al., 2011; Evar, 2012). Dowd et al. (2014) refer to the effects of values that people hold on the benefit perception of CCS without further elucidation. Seigo et al. (2014a) also state that “cultural context” might affect CCS risk perception and hence propose further research within a cross-country framework. Moreover, Bradbury (2012) claims that sociocultural characteristics influence public perception of CCS.

We take up this research and aim to show that national culture is another factor which directly affects not just the understanding and perception of, and reaction to, CCS but also influences some of the aforementioned factors. In other words, our analysis looks at national culture to see whether it can explain the source of the discrepancies among people from different countries.

2.2. National culture

Weber and Hsee (1998) assert that it is important to explore the