The Moderating Role of Political Orientation on the Relationship Between Perceived Risks and Public Acceptability of DACCS

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Abstract

Direct Air Capture and Carbon Storage (DACCS) is a relatively new negative emission technology to contribute to the reduction of the existing carbon dioxide (CO_2) in the atmosphere and public acceptability is critical to its implementation. In the present study, we investigate whether and how political orientation moderates the relationship between risk perception and public acceptability of DACCS. Previous research has shown that the public has worries about the risks of implementing DACCS, such as perceived moral and environmental risks, which in turn influence acceptability. Furthermore, there is competing evidence that both politically left- and right-leaning individuals may be more accepting of DACCS than either party. A cross-sectional study with 150 participants was conducted. The results of this study showed that risk perception of DACCS is negatively related to its acceptability and that left-leaning individuals exhibit a higher acceptance toward DACCS. When risks are categorized into environmental and moral risks, perceived moral risks significantly moderate the relationship. These results indicate that the negative relationship between perceived moral risks and public acceptability is stronger among right-leaning individuals than left-leaning individuals. The study concluded with the recommendation to communicate the risks realistically while emphasizing the benefits. Furthermore, policy design should be tailored to different political groups to enhance public acceptability and facilitate the implementation of DACCS.

Keywords: DACCS, negative emission technology (NET), public acceptability, risk perception, environmental risk perception, moral risk perception, political orientation

The Moderating Role of Political Orientation on the Relationship Between Perceived Risks and Public Acceptability of DACCS

In the last ten years, there has been a 47% rise in global CO_2 emissions (International Energy Agency, 2021), resulting in detrimental consequences such as changes in climate, increasing sea levels, heat waves, and severe floods. (Okonkwo et al., 2023; IPCC, 2021). Given this urgent climate crisis, the Paris Agreement aims to keep the global temperature increase well below 2℃ above pre-industrial levels, with efforts to limit it to 1.5℃ if possible (IPCC, 2021). To achieve this goal, reducing the CO_2 emissions produced may not be enough (Young et al., 2023).

A supplement to reduce CO_2 is to capture the remaining CO_2 in the air with negative emissions technologies. One negative emission technology that is relatively new is called Direct Air Capture and Carbon Storage (DACCS). In simple terms, DACCS involves capturing CO_2 from the atmosphere through a network of fans (Keith et al. 2018). The captured CO_2 is liquefied and injected into geologic reservoirs, such as offshore basalt formations. The CO_2 undergoes mineralization in these reservoirs, gradually transforming into carbonate rock (Satterfield et al. 2023; Gíslason et al. 2018). This approach seems promising to store CO_2 over an extended period effectively. As DACCS might be an important technology to combat climate change, the question of how accepting the public is arises.

Public acceptability is crucial in influencing policy decisions, securing funding, and ultimately facilitating successful implementation (Anderson & Peters, 2016). Since DACCS is a relatively new technology, the public has little or no knowledge of it (Cox et al., 2020) and few studies have investigated factors such as acceptability. Previous research on other carbon capture technologies has revealed that public acceptability ranges from favorable to neutral, to strong rejection (Dütschke, 2011). For example, one region in Germany decided to stop using carbon capture and storage, partly due to intense public resistance, including protests

(Dütschke, 2011). Examples like this demonstrate the importance of the public acceptability of such technologies to ensure a successful implementation.

The current study therefore focuses on two key factors that may influence the public acceptability of DACCS: the perceived risks associated with DACCS and individuals' political orientation. Numerous studies have examined the acceptability of technologies, such as wind energy, renewables, and nuclear energy (Bishop, 2011; Franchino, 2014; Milani, 2024). Nevertheless, few studies investigate the relationship between perceived risks and political orientation concerning the public acceptability of DACCS. The research gap highlights the need to explore this relationship; in particular, the role of political orientation as a moderating factor remains unstudied. This is crucial as a lack of knowledge or clear opinion about DACCS could lead to a reliance on individuals´ political orientation to form an opinion. By understanding this, politicians can better anticipate challenges or skepticism and develop effective communication strategies and policy interventions, tailored to different political perspectives, ultimately increasing the likelihood of successful technology adoption (Klebl & Jetten, 2023).

Perceived Risks of DACCS and Public Acceptability

Generally, perceived risks refer to the subjective evaluation of the likelihood of events and the level of concern regarding the outcomes (Sjöberg et al., 2004). Based on the theory of planned behavior (Ajzen, 2020) and the risk perception theory (Slovic, 2020), individuals may experience negative responses, attitudes, or emotions including fear and concern due to the perceived risks. Therefore, individuals who perceive more risks of a DACCS might be less likely to accept its implementation, so the proposed relationship between perceived risks and public acceptability is negative.

In this study, perceived risks refer to two main components. The first component is defined as perceived environmental risks related to the interaction of the DACCS with nature.

The perceived environmental risks represent individuals' subjective judgments about the potential negative consequences of implementing DACCS regarding the effect on the sea and nature, fears of seismicity, leakage, and long-term monitoring (Erans et al., 2022). Studies show that the risk perception of DACCS is higher than that of afforestation because it is perceived to tamper more with nature **(**Wenger et al., 2021). There are also concerns that the root cause of the problem is not being addressed: Carbon emissions from fossil fuels (Perlaviciute et al., 2021). As DACCS requires a large amount of energy, it might rely on energy-dense fuels such as fossil fuels (Qiu et al., 2022).

The second component describes the moral risks, such as a potential delay in investment in renewable energies or the justification of reliance on fossil fuels. Taking it a step further, the public may fear that technologies like DACCS lead to a reduced focus or investment in renewable energy sources (Markusson et al., 2022). Instead of making the difficult decision to transition to cleaner energy sources, decision-makers might even opt for the seemingly easier option of relying on DACCS to mitigate emissions (Baatz, 2016). Alternatively, some might use it to justify the ongoing use of fossil fuels by arguing that negative emission technologies delay the urgency of immediate emission reductions (Anderson & Peters, 2016). Accordingly, research on technologies similar to DACCS has shown that more perceived risks are related to lower public acceptability (Arning et al., 2017; 2020). The aim is therefore to investigate whether the negative relationship between perceived risks and acceptability can be transferred to DACCS.

Hypothesis 1. Higher levels of perceived risks of DACCS are associated with lower levels of public acceptability of DACCS.

Political Orientation and Public Acceptability

As already mentioned, the second factor analyzed in the study to determine its influence on public acceptance is political orientation. Political orientation reflects, in part, a

person´s values and worldviews, playing a key factor in shaping our approach to navigating complex situations (Dake & Wildavsky, 1991; Kim et al., 2021; Wildavsky & Dake, 1990). In this paper, political orientation is defined by a left-right spectrum. When individuals are relatively uninformed about complex topics, they often rely on their values and political ideologies to form opinions (Hart & Nisbet, 2012; Nisbet, 2005). Thus, it is crucial to explore how political orientation influences the public perception of DACCS.

Recent studies have shown that individuals who identify as more left-wing tend to be more inclined than right-leaning individuals to believe that humans are responsible for climate change, to be concerned about it, and to support taking action to mitigate its effects, such as regulating CO_2 levels (Ballew et al., 2019; Hamilton, 2008; McCright, 2010; Wood & Vedlitz, 2007; Kim et al., 2021). Despite potential downsides, the overarching goal of DACCS is to manage climate risk by reducing greenhouse gas emissions (Keith et al. 2018). As this aligns with the goals of left-leaning individuals it could lead them to support DACCS (Clulow et al., 2021). Another reason why left-leaning individuals might support DACCS is that they appear to be more supportive of government intervention (Neumayer, 2004) and tend to be more future-oriented (Strathman et al., 1994).

Meanwhile, studies show that right-wing ideologies tend to have lower openness to experience (Carney et al., 2008) and resistance to change (Jost et al., 2003) than left-leaning individuals. A few, mostly right-leaning individuals, still do not believe in climate change (Dunlap & Jacques, 2013), which would undermine the perceived need for DACCS in general. This suggests that right-leaning individuals may be less open to new technologies, like DACCS. Furthermore, right-wing individuals tend to prioritize the economy over environmental considerations (Gugushvili, 2021), potentially leading them to question the high costs of DACCS (Lee et al., 2023).

In contrast, a politically left-leaning attitude and thus a greater concern about climate change could also increase their risk alertness, risk perception, and worry about unforeseen consequences. They might fear that DACCS is only a short-term solution that does not solve the actual problem of the heavy reliance on fossil fuels (Anderson & Peters, 2016). Furthermore, DACCS requires a large amount of energy and might rely on energy-dense fuels (Qiu et al., 2022). However, left-leaning individuals tend to favor the use of renewable energy and might criticize the likely reliance on energy-dense fuels in DACCS (Biresselioglu & Zengin Kwaraibrahimoglu, 2012). In addition, they may fear that decision-makers will rely on DACCS instead of transitioning to cleaner energy (Markusson et al., 2022; Baatz, 2016), or generally view DACCS as interfering with nature (Satterfield et al., 2023).

In line with this, right-leaning individuals might also see DACCS as an agreeable solution to avoid higher costs later. This is because the consequences of climate change pose a significant economic risk such as EU sanctions for excessive CO_2 emissions (Vandenberghe, n.d.). Moreover, right-leaning individuals are more likely to support other technologies, such as nuclear energy, fossil fuels, and Carbon Capture and Storage (Clulow et al., 2021; Franchino, 2014). A direct comparison between nuclear energy and DACCS might be difficult due to the different consequences, such as accidents and waste disposal problems of nuclear energy. Nevertheless, both have similar environmental benefits and goals in terms of reducing negative emissions. The willingness to accept the risks associated with nuclear energy, fossil fuels, and Carbon Capture and Storage indicates that right-leaning individuals are more open to certain technologies than left-leaning individuals, despite potential drawbacks. The same openness could also apply to DACCS.

Hypothesis 2. Given the convincing studies and arguments in favor of both sides, it remains to be investigated whether left- or right-leaning individuals would be more likely to accept DACCS.

Political Orientation as a Moderator

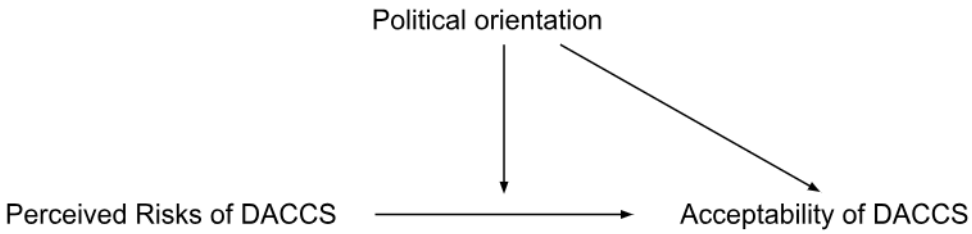
Political orientation can also influence how sensitive individuals are to the risks associated with DACCS. Right-leaning individuals showed less concern about the risks of geoengineering methods such as solar radiation or the high risks of nuclear energy (Kahan et al., 2011; 2015; McBeth et al., 2023). This could indicate that they are less affected by the potential risks of DACCS and might therefore be more willing to accept it. Left-leaning individuals appear to be more sensitive to environmental risks (Wildavsky & Dake, 1990) and less supportive of controversial mitigation measures, such as nuclear energy due to potential risks. This could indicate a similar aversion towards DACCS and thus a lower level of acceptance.

Contrasting research findings show that right-leaning individuals tend to be more sensitive to threats and averse to risks while left-leaning individuals are less sensitive to threats and risks and have a higher openness to experience (Carney et al., 2008; Duckitt, 2001; Jost et al., 2003). However, the studies by Duckitt et al. (2001) and Jost et al. (2003) investigated general threats unrelated to environmentalism. Therefore, the studies that concretely investigate climate-related attitudes and technologies appear more convincing to apply in the current context. For example, studies that support the hypothesis that left-leaning individuals are more sensitive to risks, specifically examine environmental threats (Wildavsky & Dake, 1990). The third hypothesis is therefore based on the studies that investigate related technologies and concepts. The overall model is illustrated in Figure 1.

Hypothesis 3. The negative relationship between the perceived risks and the acceptability of DACCS will be weaker for right-leaning individuals. Left-leaning individuals will strengthen it because they are more sensitive to risks.

Figure 1

Graphical representation of the research model



Method

Participants

This study conducted a priori power analysis in two different ways, depending on the study design. The current paper used the software G-Power, based on Linear Multiple Regression, which indicated that a minimum of 133 participants were required to achieve a small to median effect size (f^2 = .06) and power of .80%. In total, 203 participants took part in the study. After cleaning the data, 150 participants remained in the study (100 female, 46 male, 3 non-binary, 1 preferred not to say). The age range of participants was between 18 and 87 years old (M = 31.39, SD = 16.13). Among them, 22 participants were Dutch, 61 were German, and 29 were British. Other nationalities included Spanish, Bosnian, and Norwegian, among others, with 38 participants identifying as one of these nationalities. Participant exclusion occurred in several situations. Firstly, participants were not included in the sample when they did not give their consent at the beginning and end of the study. Secondly, participants who failed attention checks were excluded, which occurred 53 times, leaving us with a total of 150 participants.

Research Design and Procedure

This study was approved by the Ethical Committee of the Faculty of Behavioural and Social Sciences at the University of Groningen (EC-BSS). The data collection was conducted

over a week beginning on the 17th of May 2024 and ending on the 27th of May 2024. Participants were gathered through convenience sampling, which involved inviting individuals from the researchers' social networks and social media circles to participate in an online survey administered through Qualtrics survey software. This was done by sharing the link to the online questionnaire available in English, Dutch, or German. Furthermore, participation in the study was completely voluntary for every participant. The survey took 10 to 15 minutes to complete.

The survey included questions regarding demographics, familiarity with DACCS, and values, including political orientation, environmental values of their political group, environmental identity, and perceptions of climate change. Additionally, it incorporates information on DACCS technology, administered on two different levels. DACCS was introduced either in a basic manner, providing an infographic about the workings of the technology (low knowledge condition) or providing the infographic and additionally providing a list of advantages and disadvantages of the technology (high knowledge condition). Participants were randomly assigned to one of the two conditions. To check the effectiveness of the manipulation, a timer was included in the questionnaire measuring the time spent by participants engaging with the provided information.

The survey continued with multiple questions regarding the risk and benefit perception of DACCS, followed by the perceived effectiveness of DACCS. Finally, participants answered questions about the acceptability of DACCS. At the end of the questionnaire a debriefing was provided, informing the participants that they had participated in an experimental design. Lastly, contact details of the research team and a box for general comments were provided, to give the participants the opportunity to contact the research team for any further questions or concerns. The full questionnaire used in the present study can be found in Appendix A.

Measures

Attention Check

An attention check was added to assess participants' attention to the content: "Please select 'disagree' as your answer" (1 = *strongly disagree*, 6 = *strongly agree*).

Perceived Risks of DACCS

Perceived risks of DACCS were assessed by asking participants to indicate their level of agreement. These statements were rated on a six-point Likert scale, ranging from strongly disagree (1) to strongly agree (6) (Cronbach´s alpha = 0.72; M = 3.61, SD = 0.69). For an explorative analysis, the risks can be split into perceived moral risks as well as perceived environmental risks. Statements regarding perceived moral risks included three items: "I'm concerned that we leave the risk to the future generation.", "The expansion of renewable energies will be delayed by investments in DACCS projects.", "This technology is merely a pretext to continue burning fossil energy sources. ". Perceived environmental risks included three items: "I'm concerned that a certain amount of CO_2 may come back to the atmosphere even if it is stored on a deep seabed.", "I think CO_2 pumping during the process of DACCS is risky", and "I'm concerned about accidents during transportation of CO_2 captured." The questionnaire utilized for this assessment was adapted from Arning et al. (2020), with modifications made to suit the specific focus of this study.

Political Orientation

Political orientation was measured using a six-point Likert scale, ranging from 1 (left-wing) to 6 (right-wing). The following statement regarding political orientation was adapted from research conducted by Jagers et al. (2018): "It is sometimes said that political opinions can be placed on a left-right scale. This is also known in some countries, like the US, as a liberal-conservative scale. Please indicate your general political opinions on the scale from left-wing (1) to right-wing (6)" (M = 2.47, SD = 0.92).

Acceptability of DACCS

The acceptability of DACCS was measured using four statements. They included “I find the use of DACCS technology acceptable”, “I find it acceptable to implement DACCS technology in my country”, “I find it acceptable to use DACCS technology in order to reach global climate goals”, “I find it acceptable to use more DACCS technology in my country than is used now”. Again, these statements were rated on a six-point Likert scale, ranging from strongly disagree (1) to strongly agree (6), (Cronbach´s alpha = 0.93; $M = 4.28$, $SD = 0.85$).

Data Analysis

Based on the assumptions of multiple linear regression analysis, we checked linearity, normally distributed residuals, multicollinearity, and homogeneity of variance (see Appendix B). Here, no violations were observed. Thus, all assumptions were met. For the analysis, a correlational analysis was conducted to examine the relationships between variables, three hierarchical multiple regression models to explore their predictive power, and a factor analysis to assess the underlying structure of perceived risks. All analyses were performed using SPSS software (version 28). Moreover, the high and low knowledge conditions are not of interest in the current paper, nevertheless, they were thought to affect the acceptability ratings of DACCS. Hence, this variable was included as a covariate.

Results

Correlation analysis

The correlations indicated that perceived risks are significantly negatively correlated with public acceptability ($r = -0.37$, $p < .010$). The higher the perceived risks of DACCS, the lower the public acceptability of DACCS. Perceived risks are also negatively correlated with political orientation ($r = -0.17$, $p < .050$), which means that right-wing individuals tend to perceive lower risks than left-leaning individuals. However, political orientation does not

significantly correlate with public acceptability (r = -0.08, p = .352), which means the political orientation of individuals does not relate to their acceptability of DACCS. Similarly, the level of knowledge does not indicate significant correlations with public acceptability (r = -0.56, p = .500).

Hypothesis testing

To test the hypotheses, three hierarchical multiple regression models were performed. First, the first hypothesis was tested, stating that perceived risks are negatively related to the acceptability of DACCS. Model 1 included perceived risks as the predictor. The results indicate that perceived risks significantly predict public acceptability (see Table 1). Thus, individuals who perceived higher risks of DACCS were less likely to accept DACCS. Model 1 explained 13.7% of the variance in public acceptability (F (1,144) = 22.90 p < .001). Therefore, the first hypothesis is supported.

Secondly, we tested the competing hypothesis that either left-leaning or right-leaning individuals show higher acceptance toward DACCS (H2). Model 2 added the political orientation variable to the predictors. The results show that political orientation significantly predicts public acceptability (see Table 1)[1]. Specifying the competing models, people with a left-leaning political orientation are more likely to accept DACCS. The overall model was significant, explaining 16.2% of the variance in public acceptability (F (2,143) = 13.79, p < .991), an increase of 2.4% compared to Model 1. The addition of political orientation led to a significant improvement in the model fit (F (1,143) = 4.17, p = .043). Thus, the second hypothesis is supported.

[1] Two outliers were identified for the perceived risks and five for public acceptability. Upon removing the outliers, the significant effect of political orientation as an addition to the model disappeared. However, since these outliers were identified as extreme opinions rather than errors, the analysis was continued including the outliers.

Thirdly, we examined the third hypothesis, which posits that right-leaning individuals will weaken the negative relationship between the perceived risks and acceptability of DACCS while left-leaning individuals will strengthen it. Model 3 included an additional variable, namely the interaction of perceived risks and political orientation. The interaction between perceived risks and political orientation was insignificant, indicating that political orientation does not moderate the relationship between perceived risks and acceptability (see Table 1). The overall model remained significant, explaining 16.5% of the variance in public acceptability, adding 0.4% over Model 2 (F (3,142) = 9.37, p = .001). Nevertheless, the addition of the interaction term did not lead to a significant improvement in the model fit (F change (1, 142) = 0.61, p = .437). Therefore, the third hypothesis is not supported.

Table 1

Regression Coefficients for Predictors of Public Acceptability of DACCS

Model		b	SE	t	Sig.	95% CI	
						LL	UP
1	(Constant)	4.28	.07	65.10	<.001	4.15	4.41
	Perceived Risks (PR)	-.46	.10	-4.79	<.001	-.64	-.27
2	(Constant)	4.28	.07	65.82	<.001	4.15	4.41
	PR	-.50	.10	-5.15	<.001	-.69	-.31
	Political Orientation (PO)	-.15	.07	-2.04	.043	-.29	-.01
3	(Constant)	4.27	.07	64.50	<.001	4.14	4.40
	PR	-.48	.10	-4.81	<.001	-.67	-.28
	PO	-.15	.07	-2.12	.036	-.30	-.01
	Interaction (PR*PO)	-.07	.09	-.78	.437	-.26	.11

Note. Dependent Variable: Public Acceptability

Explorative Analysis: The Components of Risk Perception and How They Relate to Public Acceptability

An explorative analysis was conducted to see if perceived risks consist of two components, specifically perceived environmental risks and perceived moral risks. To examine the underlying structure of the variables, first, a factor analysis was conducted. Four items have large positive loadings on factor 1, and two items have large positive loadings on factor 2. Based on the theoretical reasoning above, factor 1 is thus named: perceived environmental risks; factor 2 is named: perceived moral risks. However, the item: 'I am concerned that we leave the risk to the future generation' (see Table 2), seems inadequate in factor 1. Although this item loaded more strongly on the perceived environmental risk factor,

Table 2

Results of the Factor Analysis: Rotated Factor Matrix

	Factor	
	1	*2*
I´m concerned about accidents during transportation of CO_2 captured.	.86	
I´m concerned that a certain amount of CO_2 may come back to the atmosphere even if it is stored on a deep seabed.	.60	.25
I think CO_2 pumping during the process of DACCS is risky.	.48	.28
I´m concerned that we leave the risk to the future generation.	.48	.21
This technology is merely a pretext to continue burning fossil energy sources.	.11	.78
The expansion of renewable energies will be delayed by investments in DACCS projects.	.28	.43

Note. Extraction Methods. Principle Axis Factoring.

Rotation Method: Varimax with Kaiser Normalization.

a content inspection revealed that it aligns better with the perceived moral risk factors. Due to this misalignment between the content and the factor loading, we decided to remove this item from further analysis.

Next, a regression analysis was performed using PROCESS Macro (Hayes & Little, 2022). Firstly, the variable perceived environmental risks was included in the regression analysis. The main effect of perceived environmental risks on public acceptability was significant (see Table 3), indicating that higher perceived environmental risks are associated with lower public acceptability. The main effect of political orientation was insignificant. The interaction effect between perceived environmental risks and political orientation was insignificant, suggesting that political orientation does not moderate the relationship between perceived environmental risks and public acceptability.

Table 3

Regression Coefficients for Effects of Environmental Risks on Public Acceptability of DACCS

					95% CI	
Variable	b	SE	t	p	LL	UP
(Constant)	4.28	.07	61.98	<.001	4.15	4.42
Perceived Environmental Risks (PER)	-.26	.08	-3.14	.002	-.43	-.10
Political Orientation (PO)	-.10	.08	-1.24	.218	-.25	.06
Interaction (PER*PO)	-.02	.09	-.20	.842	-.15	-.19

Note. Dependent Variable: Public Acceptability. Degrees of Freedom (df1) = 3, (df2) = 142

The overall model was significant (F (3, 142) = 3.59, p = .015), explaining approximately 7.0% of the variance in public acceptability (R^2 = 0.07).

Next, the variable perceived moral risks was inspected in the regression analysis. The main effect of perceived moral risks on public acceptability was still significant (see Table 4), indicating that higher perceived moral risks are associated with lower public acceptability. However, the main effect of political orientation was insignificant. The interaction effect between perceived moral risks and political orientation was significant, suggesting that political orientation moderates the relationship between perceived moral risks and public acceptability (see Figure 2). Specifically, for left-leaning individuals, perceived moral risks significantly negatively affect public acceptability. For right-leaning individuals, perceived moral risks have an even stronger negative effect on public acceptability. These results indicate that the negative relationship between perceived moral risks and public acceptability is stronger among right-leaning individuals than left-leaning individuals. The overall model was significant (F (3,143) = 12.29, p < .001), explaining approximately 21% of the variance in public acceptability (R^2 = .21). This partially rejected the third hypothesis, but only concerning perceived moral risks.

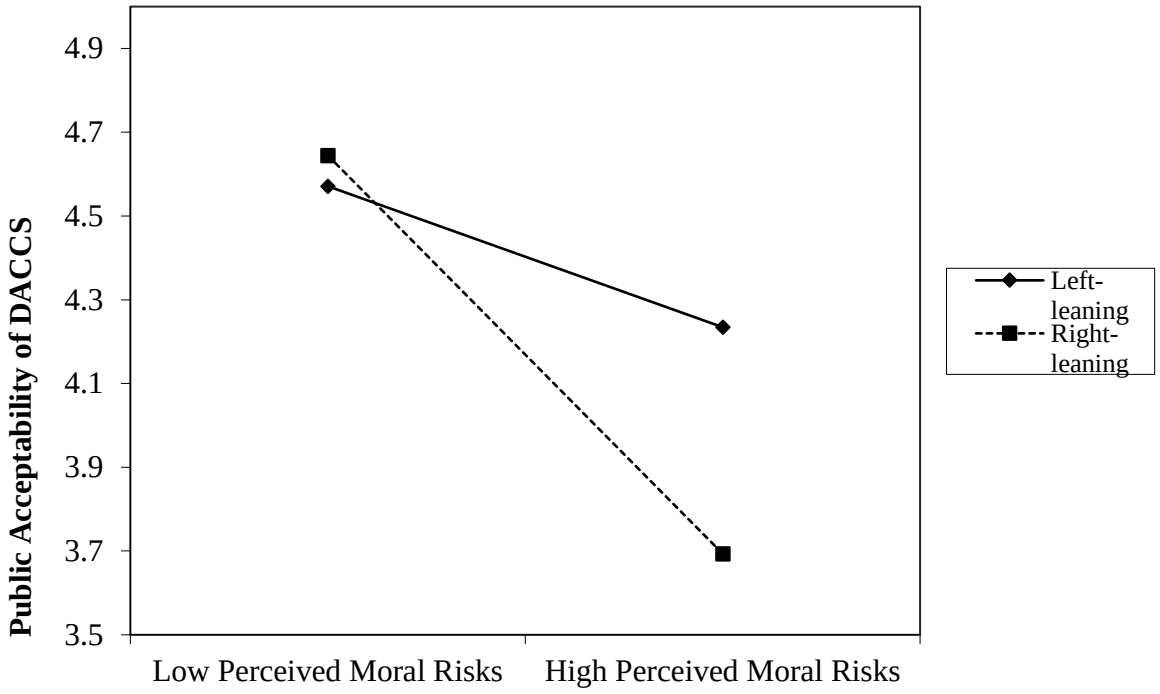
Table 4

Regression Coefficients for Effects of Moral Risks on Public Acceptability of DACCS

					95% CI	
Variable	b	SE	t	p	LL	UP
(Constant)	4.26	.06	66.59	<.001	4.13	4.38
Perceived Moral Risks (PMR)	-.35	.08	-4.64	<.001	-.51	-.20
Political Orientation (PO)	-.13	.07	-1.83	.069	-.27	-.01
Interaction (PMR*PO)	-.18	.07	-2.45	.016	-.33	-.03
PO = -0.469 (left-leaning)	-.27	.09	-2.93	.004	-.45	-.09
PO = 0.531 (right-leaning)	-.45	.08	-5.90	<.001	-.60	-.30

Note. Dependent Variable: Public Acceptability. Degrees of Freedom (df1) = 3, (df2) = 143

Figure 2
Relationship between perceived moral risks, political orientation, and acceptability of DACCS



Note. Perceived moral risks and political orientation are measured continuously but presented here as categorical (low and high; left-leaning and right-leaning) for visual clarity. Low value (left-leaning) = -.92, High value (right-leaning) = .92

Discussion

The purpose of the study was to examine the effects of perceived risks on the acceptability of DACCS, as well as the impact of political orientation and its interaction with perceived risks on the public acceptability of DACCS. The first hypothesis stated that perceived risks of DACCS are negatively correlated with public acceptability. There was indeed a significant negative main effect of risk perception on public acceptability, meaning that people with higher risk perception were less likely to accept DACCS.

The second hypothesis presented the competing models stating that either left-leaning individuals or right-leaning individuals will show a higher acceptability. There was a notable impact of political orientation predicting public acceptability. Specifying the competing

models, people with a more left-leaning political orientation are more likely to accept DACCS.

The third hypothesis posited that politically left-leaning individuals would have a stronger impact on the negative relationship between perceived risks and public acceptability than right-leaning individuals. There was no significant effect of the moderating variable political orientation on the relationship between perceived risks and public acceptability. However, when the perceived risks were split in the exploratory analysis, the results showed a significant effect of political orientation on the relationship between perceived moral risks and public acceptability. Particularly, the results show that the negative relationship between perceived moral risks and public acceptability is stronger among right-leaning individuals than left-leaning individuals. This effect was not found for the perceived environmental risks.

Interpretation and Reflection on Hypotheses

The results show that the first hypothesis is supported, indicating that higher levels of perceived risks are associated with lower acceptability of DACCS. This aligns with the risk perception theory and the theory of planned behavior risks (Ajzen, 2020; Slovic, 2020). According to these theories, perceived risks may lead to negative responses, attitudes, or emotions including fear and concern due to the perceived risks, resulting in lower acceptability. In addition, the perceived control of risks, typically low for big technologies, is frequently linked to lower public approval in general and specifically negatively related to the acceptance of Carbon Capture and Utilization technology (Arning et al., 2020). The results of the current study are in line with these findings, indicating that risk perception indeed plays a crucial role in the acceptability of DACCS.

Also, the results of the second hypothesis show that left-leaning individuals are more accepting of DACCS. As mentioned above, this could be because the overall goal of DACCS is to reduce greenhouse gas emissions. This aligns with the concerns of left-leaning

individuals about climate change and their prioritization of taking action to protect nature, which tends to be higher than that of right-leaning individuals (Ballew et al., 2019; Hamilton, 2008; McCright, 2010; Kim et al., 2021; Wood & Vedlitz, 2007). Additionally, the results align with previous research which indicates that left-leaning individuals show higher support for the implementation of natural gas power plants that incorporate carbon capture and storage (CCS) technology (Karlstrøm & Ryghaug, 2014). Right-leaning individuals however, could be less accepting of DACCS because they tend to be less open to new experiences (Carney et al., 2008) as well as more resistant to change (Jost et al., 2003), which can be applied to DACCS, as it is a new technology. Finally, right-leaning individuals often do not perceive climate change as a threat or do not believe in it altogether (Dunlap & Jacques, 2013), consequently, there would be no use for DACCS overall.

The study investigated the third hypothesis, which included the variables of perceived risks, public acceptability, and political orientation as a moderator. Since no significant effect of perceived risks within the moderation model was found, the study further analyzed perceived risks by dividing the variable into two different components, namely perceived environmental risks and perceived moral risks. Interestingly, while no significant effect was found for perceived environmental risks, the model including perceived moral risks revealed a significant effect. A possible reason why the moderation model that included perceived environmental risks was insignificant could be that many have not yet formed opinions about DACCS because it is relatively new (Perlaviciute, 2021). The public discourse and media coverage, which play a key factor in shaping public perception, are limited so far (Simon & Jerit, 2007). Thus, the lack of public discussion, knowledge transfer, and media coverage could weaken the formation of clear opinions about perceived environmental risk and make political orientation irrelevant for now. Besides that, perceived environmental risks might be unrelated to political orientation, as the proximity of DACCS implementation plays a more

prominent role. This could be explained by the phenomenon that individuals generally support certain matters, but not when they are implemented close to their homes, which is referred to as *not in my backyard* (Dear, 1992). Hence, general environmental risks may be perceived as vague and elusive. As a result, citizens may only express stronger opinions if they are affected locally, while political orientation potentially plays a lesser role.

The second part of the exploratory regression analysis results revealed that perceived moral risks have a significantly stronger negative impact on the public acceptability of right-leaning individuals compared to left-leaning individuals. This significant finding is not in line with the third hypothesis. In contrast to what was hypothesized, right-leaning individuals might be more sensitive to the moral risks of DACCS for several reasons. Generally, they tend to be less open to new things and may hold a more critical attitude towards DACCS (Carney et al., 2008). Moreover, right-leaning ideologies are linked to a lower uncertainty tolerance, implying that potential uncertain risks might be perceived as even stronger (Jost et al., 2003). While most people acknowledge climate change, right-leaning individuals place less importance on it compared to left-leaning individuals (Ballew et al., 2019; Hamilton, 2008; McCright, 2010; Wood & Vedlitz, 2007; Kim et al., 2021). This might make them more reluctant to take additional risks of implementing a new technology for future generations. Furthermore, research suggests that the moral values of right-leaning individuals tend to focus on protecting the ingroup and family´s interests (Graham et al., 2009). Consequently, wanting to protect their own family could be why they are less willing to take moral risks.

The next question is why left-leaning people may be less risk-sensitive regarding the moral risks of DACCS than right-leaning individuals as it does also not align with the third hypothesis. A possible explanation for this could be that left-leaning individuals are often concerned about the environment and want to take action against it (Ballew et al., 2019; Hamilton, 2008; McCright, 2010; Wood & Vedlitz, 2007; Kim et al., 2021). This could imply

that they are more willing to accept possible solutions, such as DACCS, and downplay potential moral risks. Specifically, they might not strongly perceive moral risks, such as DACCS potentially being a pretext to continue burning fossil energy sources or the risk of a delay of renewable energy when investing in DACCS. Thus, if they believe that DACCS is an effective contribution to reducing CO_2, they might be convinced it does more good than harm. Overall, the findings bring important theoretical implications, as they contribute to a broader understanding of which factors influence the acceptability of DACCS.

Limitations and Future Directions

Several limitations of this study need to be addressed. One limitation of this study is the small number of right-leaning participants (20 out of 150), questioning the generalisability of the sample. Therefore, conclusions drawn concerning right-leaning individuals should be treated with caution. Future studies should strive to get a balanced variety of political views by using alternative sampling methods, such as research panels instead of convenience sampling. They should also investigate more closely for which specific reasons right-leaning individuals are less accepting than left-leaning individuals. A potential influencing factor could be trust in the government since it plays an important role in technology acceptance (Siegrist, 2000; Balaskas, et al., 2024). In this regard, left-leaning individuals seem more supportive of government intervention while right-leaning appear to have a stronger general trust in the government in certain aspects (Frackowiak et al., 2023; Neumayer, 2004). As trust in the government appears to influence the acceptance of technologies, but it is unclear in what way, it is important to investigate these factors in future studies. In addition, some participants indicated that they are worried that the costs of DACCS will be extremely high. This was not the focus of the present study; however, it could have influenced particularly right-leaning individuals since they often prioritize economic matters (Gugushvili, 2021). Hence, the two factors could be valuable to explore in future studies.

Another limitation was the information given about DACCS. It was reported by some participants that there was a lack of sufficient information regarding DACCS to come to a definite conclusion. This resulted in participants being unsure about their opinions on whether to accept DACCS or not. Because of that, some participants reported that they chose not to accept it, despite their general curiosity and lack of strong opposition. This feedback is particularly interesting as the variable level of knowledge yielded no significant effect. Thus, the effect of the level of knowledge should be inspected more closely. Future studies could ensure that all participants receive sufficient information or explanation.

In addition, the scale that was used to assess political orientation has a limitation. To simplify the study, a 6-point Likert scale was provided, which means there was no option to choose a neutral middle point, nor other options such as “apolitical” or another type of political identification outside the right-left continuum. Although it simplified the study, including options with a middle on the left-right continuum, an option for apolitical and other political dimensions could be beneficial for future research to gain a better understanding of the influence of political orientation.

Practical Implications

The results of this study highlight the importance of risk perception and indicate that perceived risks are related to lower acceptability. This is an important finding as acceptability is vital for the successful implementation of DACCS. Thus, it is crucial to inform about risks and initiate or organize public discussions to ensure a realistic and accurate perception. Moreover, it might be especially efficient to emphasize the benefits of DACCS. Furthermore, policymakers and organizations promoting DACCS could use the outcomes of this study to design more effective communication strategies that address the concerns of different political groups. These campaigns could be tailored to increase the support of left-leaning people by emphasizing the benefits of DACCS for the climate.

Additionally, they can explicitly address the worries concerning the perceived moral risks of right-leaning individuals. This could be done for example with campaigns that ensure that using DACCS is not only an excuse to continue using fossil fuels. This might be particularly applicable since the support for right-wing parties in European countries has been growing (Brause & Kinski, 2024). In addition, solutions could be created to guarantee the public that using DACCS will not lead to a delay in renewable energy. These practical implications can help to use the findings of this study and other research for the successful adoption of DACCS.

Conclusion

Overall, this study contributed to the existing body of knowledge by investigating the relationship between perceived risks and the acceptability of DACCS. Moreover, it studied the influence of political orientation on the relationship between risks and acceptability. The results suggest a negative association between risk perception and public acceptability of DACCS. The study also indicates a higher acceptability of DACCS among left-leaning individuals and a lower acceptability among right-leaning individuals. Furthermore, the negative relationship between perceived moral risks and public acceptability is stronger among right-leaning individuals than left-leaning individuals. This suggests that left-leaning individuals are less influenced by perceived moral risks concerning the acceptability of DACCS while right-leaning individuals are more influenced by them. These insights are valuable as they can help to design effective communication strategies. Concerning our findings, it is recommended to increase the public knowledge about the actual risks of DACCS, for example through public discussions, while emphasizing the benefits. It might be particularly helpful to develop strategies to reduce the moral risk perception within politically right-leaning groups by addressing them and ensuring a realistic perception.

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Appendix A

Sample Questionnaire

Political Orientation and Values

We are interested in your political orientation and values concerning the environment. Please read the statements below carefully and indicate to what extent you agree with the statements on a 6-point scale from strongly disagree (1) to strongly agree (6).

It is sometimes said that political opinions can be placed on a left-right scale. This is also known in some countries, like the US, as a liberal-conservative scale. Please indicate your general political opinions on the scale from Left wing (1) to Right wing (6).

	1 Left wing	2	3	4	5	6 Right Wing
Where would you place yourself on such a left-right scale?	o	o	o	o	o	o

Your opinions about risks and benefits of DACCS

Based on the information above, we are interested in how you perceive different risks and benefits of DACCS. Please read the statements below carefully and indicate your level of agreement on a 6-point scale from strongly disagree (1) to strongly agree (6)

	1 strongly disagree	2 disagree	3 somewhat disagree	4 somewhat agree	5 agree	6 strongly agree
I think CO2 pumping during the process of DACCS is risky.	o	o	o	o	o	o
This technology contributes to the fight against climate change.	o	o	o	o	o	o
The expansion of renewable energies will be delayed by investments in DACCS projects.	o	o	o	o	o	o
DACCS technology is an environmentally friendly technology.	o	o	o	o	o	o
This technology is merely a pretext to continue burning fossil energy sources.	o	o	o	o	o	o
DACCS decreases the current concentration of carbon dioxide in the atmosphere.	o	o	o	o	o	o
I'm concerned that a certain amount of CO2 may come back to the atmosphere even if it is stored on a deep seabed.	o	o	o	o	o	o

Your opinions about risks and benefits of DACCS continues on the next page

Your opinions about risks and benefits of DACCS (continued)

I'm concerned that we leave the risk to the future generation.	o	o	o	o	o	o
Please select 'disagree' as your answer.	o	o	o	o	o	o
I'm concerned about accidents during transportation of CO2 captured.	o	o	o	o	o	o

Acceptability of DACCS

We are interested in your opinion on how acceptable it is to implement DACCS. Please read the statements below carefully and evaluate them on a 6-point scale from strongly disagree (1) to strongly agree (6).

	1 strongly disagree	2 disagree	3 somewhat disagree	4 somewhat agree	5 agree	6 strongly agree
I find the use of DACCS technology acceptable.	o	o	o	o	o	o
I find it acceptable to implement DACCS technology in my country.	o	o	o	o	o	o
I find it acceptable to use DACCS technology in order to reach global climate goals.	o	o	o	o	o	o
I find it acceptable to use more DACCS technology in my country than is used now.	o	o	o	o	o	o

Appendix B

Table 5

Collinearity Statistics for Regression Model

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Risk Perception (RP)	.88	1.14
	Political Orientation (PO)	.95	1.05
	Interaction between PO and RP	.92	1.08

Figure 3

Histogram of Standardized Residuals Displaying Normality

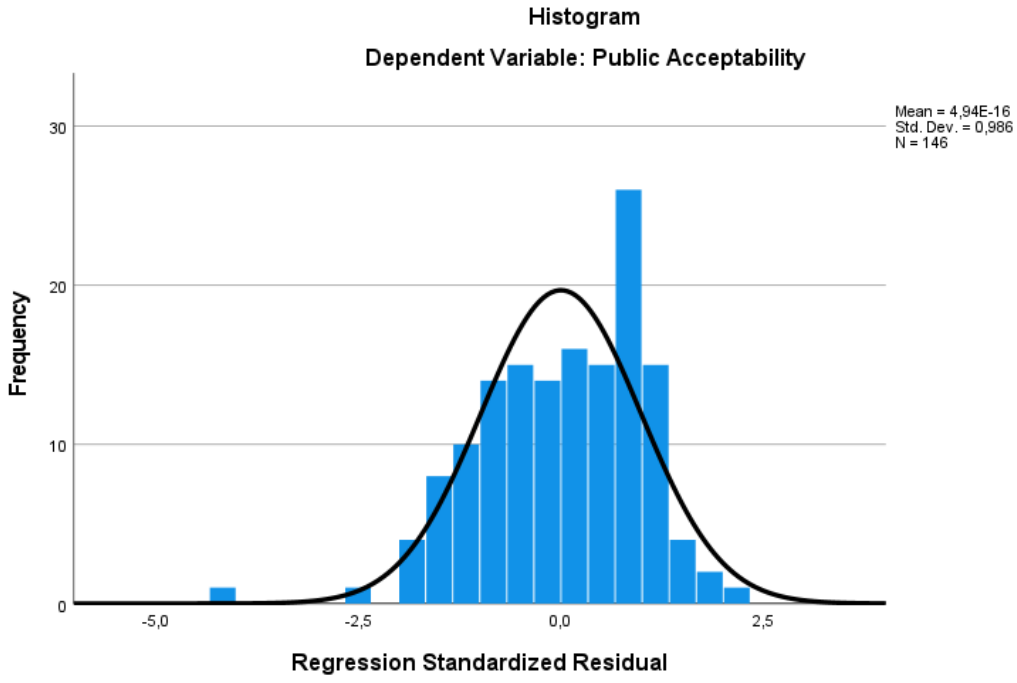

Figure 4

Normal P-P Plot of Regression Standardized Residual

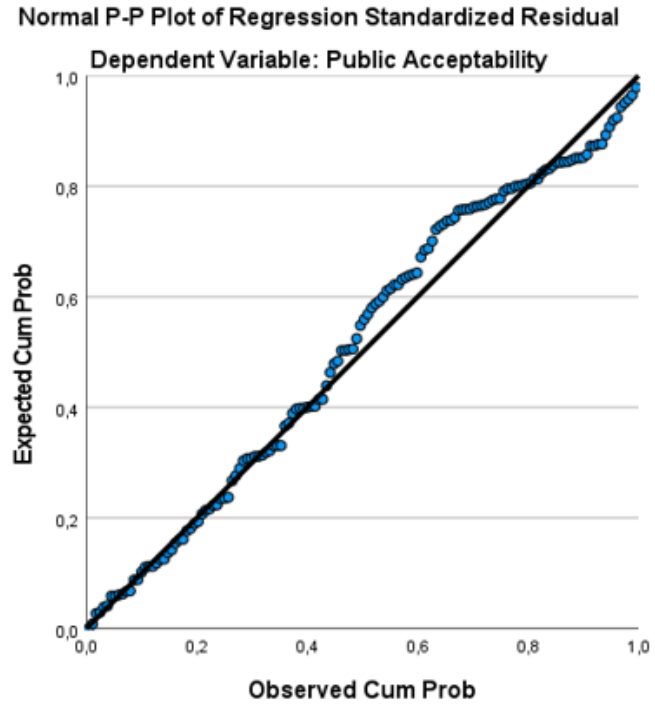

Figure 5

Normal Q-Q Plot of Regression Standardized Residual

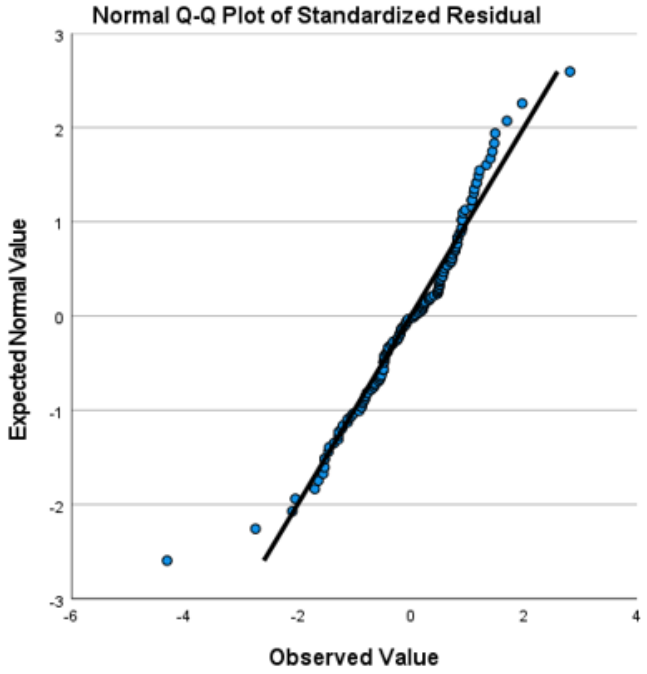

Figure 6

Test for Linearity and Homoscedasticity