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Geoengineering, moral hazard, and trust in climate science: evidence from a survey experiment in Britain

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Abstract Geoengineering could be taken by the public as a way of dealing with climate change without reducing greenhouse gas emissions. This paper presents the results of survey experiments testing whether hearing about solar radiation management (SRM) affects people's support for taxing polluting energy and/or their trust in climate science. For a nationally representative sample of respondents in Britain, I found that receiving a brief introduction to SRM had no impact on most people's willingness to pay taxes, nor on their trust in climate science. Hearing about this form of geoengineering therefore appears unlikely to erode support for emissions reductions. Specifically for political conservatives asked first about paying taxes, moreover, hearing about SRM increased trust in climate science. These and other results of the experiments also provide partial support for the theory that conservatives' lower trust in climate science generally stems from their aversion to regulatory action by the state.

1 Introduction

Scientists and engineers developing techniques to modify the Earth's climate as a response to anthropogenic climate change would invariably prefer to prevent greenhouse gas emissions in the first place (e.g., National Academy of Sciences 2015; Royal Society 2009; Shepherd 2012). Aside from the scientific and technical challenges, one of the most important concerns about geoengineering is whether the public, and perhaps policymakers, could become less motivated to reduce greenhouse gas emissions if they perceive geoengineering as a simpler, cheaper technical solution. For example, knowledge of geoengineering could undermine support for putting a price on emissions of greenhouse gases—the number one policy recommendation of environmental economists, and one with both strong theoretical foundations and a successful track record in practice (e.g., Parry et al. 2012).

This paper presents results from an experiment wherein half the respondents to a survey in Britain received a brief introduction to one of the two major types of geoengineering—solar

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radiation management (SRM)—while the other half received no such introduction. I investigated whether hearing about SRM affects people's support for greenhouse gas emission reductions (via a tax on polluting energy) and/or their trust in climate science—that is, in scientists and their claim that the world's climate is warming. I also tested whether any effect on either of these outcomes depends on the order in which they are measured; the experiment was therefore a 2 × 2 design.

There have been few prior studies of public opinion about geoengineering, not least because few people know enough about it to have an opinion (see Ipsos MORI 2010; Pidgeon et al. 2012; Corner et al. 2012). When presented with it in focus groups, most people have proven lukewarm about the idea, and especially uncomfortable with technologies for solar radiation management (Corner et al. 2013; Ipsos MORI 2010; Royal Society 2009). Not just the possible deployment of geoengineering technologies but even just decisions about geoengineering research have been contentious (Parson and Keith 2013), such that it would seem that knowing climate scientists are engaged in such research could lower their trustworthiness in the eyes of the public.

Previous research has found that geoengineering appeals more to people subscribing to some political ideologies compared to others—specifically, those with high regard for industry, commerce, and technological rather than regulatory or policy solutions to social problems (Kahan et al. 2015). The analysis presented below therefore tests whether the effects of the two randomly assigned treatments depend on respondents' political ideology, as reflected in the party they expected to vote for in the next British election. In Britain, like in many countries, people who vote for right-of-centre political parties are less trusting in climate science and less supportive of public policies for climate change mitigation (see e.g., Nawrotzki 2012). One possible explanation for this political gradient is that political conservatives' aversion to regulatory solutions motivates their disbelief in climate science (Campbell and Kay 2014; Kahan et al. 2015). That is, the policy and economic implications that follow from accepting climate science are unappealing to people who value industry and free markets and do not want the state constraining them. They reject the scientific consensus on climate change because they dislike the implication that states will have to take regulatory actions to reduce greenhouse gas emissions (Jones 2011; Kahan et al. 2012).

The experiments presented below investigated this possibility by randomly varying the order in which respondents received the questions about trust in climate science and willingness to pay energy taxes for climate change mitigation. If conservatives' disbelief in climate science is motivated by their aversion to state regulatory action, then they should report less trust if made to think first about taxation as a likely policy response to the problem of global warming. Hearing about SRM should however compensate for conservatives' relatively low trust in climate science, by displacing the association in their minds between climate change and regulatory/interventionist action by the state.

2 Context

Geoengineering is intentional climate change (Jamieson 1996), or "the deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change" (Royal Society 2009: 1). Geoengineering might entail the removal of carbon dioxide from the atmosphere, or the reflection of more sunlight back into space. The former methods include ocean fertilization and carbon capture and sequestration through biological or chemical means.

Techniques for solar radiation management (SRM) could be space-based, use stratospheric aerosols, or increase cloud reflectivity or surface albedo (Secretariat of the Convention on Biological Diversity 2012). Experts disagree about the safety, cost, and effectiveness of these techniques, and their use would inevitably be contentious (contrast for example the perspectives of Hulme 2014 and Keith 2013; see also Bellamy et al. 2013; Hulme 2012).

Commentators refer to geoengineering as a "Plan B," "last-ditch response," "technological fix," or "emergency shield" (Rayner et al. 2013; NAS 2015: vii; Millard-Ball 2012: 1047; Victor et al. 2009). As such, many observers worry that knowledge of geoengineering could lead the public and/or policymakers to believe that greenhouse gas emission reductions are unnecessary, as there is a cheaper, easier solution to the problem of climate change. Such a belief could undermine the already weak support for key mitigation actions (e.g., Keith et al. 2010; Schneider 2001). Robock (2008: 17) describes concerns of this kind as "the oldest and most persistent argument against geoengineering," and they are generally referred to as a problem of moral hazard (e.g., Corner and Pidgeon 2014; Royal Society 2009: 39). In an extensive legal commentary on the issue, Lin (2013) concludes that the moral hazard concern should be taken quite seriously.

Other observers, however, provide reasons to be more sanguine about the impacts of geoengineering research and the availability of geoengineering technology. Millard-Ball (2012) for example suggests that the possible side-effects of some geoengineering schemes could be negative enough so as to convince many countries to reduce their emissions, rather than suffer the consequences of unilateral actions by others (for a similar view, see the Secretariat of the Convention on Biological Diversity 2012: 13). Also, like geoengineering, climate change adaptation could be taken by the public as an easy response to climate change; yet studies suggest that an introduction to adaptation is just as likely to increase as to reduce people's support for mitigation (Carrico et al. 2015; Howell et al. 2016). That knowledge of adaptation can make people more concerned about the risks of climate change suggests that knowledge of geoengineering may do the same.

The potential impacts of geoengineering on public opinion, politics, and policy are therefore uncertain. The few studies that have been done of public attitudes towards geoengineering have generally found that members of the public react negatively when first presented with the idea (Pidgeon et al. 2013; Bellamy and Hulme 2011). Mercer et al. (2011), however, found somewhat the opposite, albeit after providing a supportive introduction. In a series of deliberative focus groups in England, Macnaghten and Szerszynski (2013) found that few people are confident in scientists' ability to develop and deploy geoengineering technologies in a safe way.

People who are more supportive of such technologies tend to be more optimistic about scientific research in general (Mercer et al. 2011). This is unsurprising, given that arguments for geoengineering tend to embody quite sanguine views of technology overall (Hulme 2012). In terms of values, Kahan et al. (2015) report more positive views about geoengineering among people they call hierarchical individualists compared to egalitarian communitarians; Bellamy and Hulme (2011) similarly find that hierarchists are much more supportive of geoengineering than egalitarians.

In the only direct test thus far of the moral hazard thesis, Kahan et al. (2015) randomly assigned survey respondents in the U.S. and UK to read one of two different policy recommendations from scientists—for either geoengineering or regulatory limits on pollution. Respondents also read excerpts from a fictional/composite scientific research paper, reflecting the scientific consensus on climate change. Those reading advocacy for geoengineering rated

the research paper as more credible, if they possessed hierarchical-individualist (right-of-centre) political values. If they possessed egalitarian-communitarian (left-of-centre) values, those reading advocacy for geoengineering rated the research paper as less credible. Kahan et al. therefore found contrasting, symmetrical impacts on people with different political ideologies.

Given what is at stake, it is important to be sure that knowledge of geoengineering really can increase some people's trust in climate science. Reproducing this finding was one of the principle goals of the survey experiments presented below, though the present study adopts a different research design.[1] Kahan et al. for example used a strong intervention—requiring that respondents read a lengthy text, with one of the experimental conditions referring to several different kinds of geoengineering. The treatment here provides only a very brief introduction to one specific type of geoengineering. Kahan et al. also did not test the impacts of knowing about geoengineering on normative preferences for measures that would reduce greenhouse gas emissions; the outcomes they investigated were instead the credibility of a single study and their subjects' positive perceptions of the degree of risk presented by climate change. Finally, and perhaps most importantly, their research design forced respondents to think about either geoengineering *or* a regulatory response for climate change mitigation (versus a control), whereas in the experiments presented here these two treatments are crossed. That is, the questionnaire here measured respondents' trust in climate science both (a) with or without a prior introduction to SRM and (b) with or without a prior question about taxation (which would prime respondents to think about regulation as a response to climate change).

This second dimension of the 2×2 experimental design used here also tests another key claim made in the broader literature on risk—one of the more influential theories of the left-right divide on climate science. The theory is that these groups' different levels of trust in climate science derive from their attitudes—acceptance or aversion—towards the key policy responses associated with the science. The main response is regulatory action by the state to reduce greenhouse gas emissions, such as using some kind of price mechanism, like a tax (Bellamy and Hulme 2011; Kahan et al. 2012). According to the theory, then, the political right's lower trust in climate science is due not to anything intrinsic to the phenomenon or to science, but to the policy implications that follow. Kahan et al. (2015) explain the differential impacts of hearing about geoengineering accordingly: right-of-centre voters distrust climate science because they associate it with the regulation of markets and industry, but regard it more favourably insofar as they associate it instead with technology and human ingenuity, such as when given an introduction to geoengineering.

3 Data and methods

The experiments ran on a representative sample of 990 residents of Britain (aged 15+) surveyed face-to-face by the market and opinion survey company Ipsos MORI in January-February 2015. The questions were included at the start of an omnibus survey on a variety of topics.

The first randomly assigned treatment was an introductory text providing a brief introduction to SRM:

[1] Corner and Pidgeon (2014) investigated whether people *believe* there is a moral hazard. My study, like Kahan et al.'s (2015), tests whether there *is* a moral hazard problem.

> To deal with global warming, scientists are developing ways of cooling the Earth's climate, such as by putting large mirrors in space to block some of the sunrays that heat the planet. Another technique they are testing is spraying particles into the atmosphere, to reflect some light from the sun back into space.

As of the summer of 2013, Corner and Pidgeon (2014) found that 28 % of an online panel of Britons had heard of "geoengineering" (Mercer et al. 2011 found similarly). So it should be the case that the majority of the research subjects here knew little to nothing about it, before participating in this study, and the experiment should have captured their first reactions.[2] Both of the SRM techniques mentioned in the brief introduction have been discussed in the scientific literature.[3] It is important to note that the treatment focuses on techniques for solar radiation management rather than carbon dioxide removal (CDR). Given that prior studies have found the public to be most sceptical of SRM (Corner et al. 2013; Ipsos MORI 2010), including stratospheric aerosols and space mirrors in particular (Bellamy et al. 2016; Wright et al. 2014), any impacts on people's trust in climate science could be different if the treatment concentrated on other geoengineering technologies.[4]

The second experimental treatment was to ask respondents the following two questions in random order:

> To what extent, if at all, would you be willing to pay higher taxes for your energy use in order to prevent global warming? Very willing, Fairly willing, Not very willing, or Not at all willing?
>
> To what extent, if at all, do you trust scientists when they say that global warming is happening? Would you say that you trust them… A great deal, A fair amount, Not very much, or Not at all?

These questions measure, respectively, respondents' willingness to pay taxes for climate change mitigation, and their trust in climate science. Given the centrality of taxation to environmental economics, a number of major surveys have previously asked people about their willingness to pay taxes for the sake of environmental protection.[5] Such questions capture a broadly cooperative or uncooperative attitude towards public efforts for climate change mitigation, and have the merit of measuring whether respondents' support for environmental protection is strong enough such that they would even be willing to pay some price for it (Cao et al. 2014). In linking trust in scientists to agreement about the reality of global warming, the second question has fewer precedents. Nevertheless, it is similar for example to a question that Malka et al. (2009) asked in a U.S. study: "How much do you trust the things that scientists say about the environment—completely, a lot, a moderate amount, a little, or not at all?" Like that one, the question used here bridges the issues of trust in scientists and trust in the substance of their claims. Believing in global warming (a fairly abstract phenomenon) requires a person to

[2] Geoengineering has nonetheless been mentioned in the news, and some respondents will already have known something about it.

[3] Angel (2006) and proposes means of using small mirrors in space, and Sánchez and McInnes (2015) provide a recent discussion of the use of a large orbiting mirror.

[4] Introductions to different geoengineering techniques could have different impacts on public support for greenhouse gas emissions reductions. That this study only examines how public opinion responds to brief introductions of two particular techniques is a limitation, and future studies should test the impacts of others.

[5] Examples are the World Values Surveys/European Values Studies and the International Social Survey Programme.

trust the people who claim it is happening, and prior research has shown that concerns about global warming are closely tied to trust in scientists (ibid.).[6]

Other questions in the survey recorded some basic demographic characteristics: age in years, highest educational qualification attained, sex, and residence in a rural versus urban area. Residence was recorded in four categories (rural, suburban, urban, and metropolitan) and I recoded it into two categories (rural and urban). A coarse measure of income was available, but was missing for 43 % of respondents, and both that and employment status were unrelated to the outcomes of interest once other covariates were included in the analytical models I present below. Educational qualifications were: GCSE/O-Level/CSE, vocational qualifications (NVQ1+2), A-level or equivalent (NVQ3), bachelor degree or equivalent (NVQ4), masters/PhD or equivalent, other, no formal qualifications, still studying (and Don't Know). Previous studies have shown that attitudes towards climate change and environmental issues generally correlate strongly with education.

Respondents were also asked to the name the political party they expected to vote for in the next (upcoming) election. The three response options provided were Labour, Conservative, and Liberal Democrat. Based on the Manifesto Project of Volkens et al. (2015), for the last (2010) election Labour's score on an overall Left-Right index was -1.50, the LibDems' 4.66, and the Conservatives 17.54.[7] The index reflects many of the same values as those emphasized by Kahan et al.—state regulation of industry, the pursuit of social equality, and so on—such that partisan differences should be similar to differences in the possession of hierarchical/individualist versus egalitarian/communalist values. Large proportions of the respondents were however undecided about who they would vote for, or did not expect to vote in the next election. An "Other" category included voters for a diverse range of other parties (Greens, UK Independence Party, Scottish and Welsh nationalists, etc.). For descriptive statistics about each variable see Table 1.

I analysed the data using multivariate generalised linear models. Table 2 below shows fitted ordinal probit models such that the probability of observing a given categorical outcome k is:

$$Pr(y = k) = F_N\left(\gamma_k \middle| \mathbf{X\beta}, {\sigma_e}^2\right) - F_N\left(\gamma_{k+1} \middle| \mathbf{X\beta}, {\sigma_e}^2\right),$$

where F_N is the Normal distribution function; the γ's are cutpoints ($\gamma_1 = 0$); $\mathbf{X}$ is a design matrix; $\boldsymbol{\beta}$ a vector of coefficients; and ${\sigma_e}^2$ is fixed at 1. I estimated the models using the MCMCglmm package in R (Hadfield 2010). Adopting a Bayesian approach, the results below do not include standard errors or frequentist p values but the proportion of the posterior distribution for the beta coefficients on the opposite side of the zero from the (reported) mean of each distribution. That proportion directly captures the modelled probability that a relationship estimated to be positive is actually negative, or vice versa.[8] I used uninformative priors in fitting all models.

Item non-response was low for all variables. So as to be able to include the small number of cases with some missing items, I used the "mice" package in R (Van Buuren and Groothuis-

[6] Trust and beliefs are tightly linked, as influential definitions of trust show (see Nannestad 2008).

[7] See: http://manifesto-project.wzb.eu. Benoit and Laver (2007) provide a longer discussion of these three parties' relative placements on a left-right scale, concluding that at some times, in some ways, the Liberal Democrats have fallen to the left of Labour in terms of their policy agenda—and they have often had a stronger focus on environmental protection.

[8] These probabilities therefore quantify how confident we can be that the estimated positive/negative relationship is really positive/negative.

Table 1 Descriptive statistics

Willing to pay	Not at all willing	0.30
	Not very willing	0.26
	Fairly willing	0.37
	Very willing	0.07
	(Missing)	(0.03)
Trust in climate science	Not at all	0.08
	Not very much	0.23
	A fair amount	0.46
	A great deal	0.23
	(Missing)	(0.02)
Residence	Rural	0.42
	Urban	0.58
	(Missing)	(0.00)
Highest qualification	None	0.17
	Vocational	0.32
	A-level	0.20
	Bachelor	0.24
	Postgrad	0.07
	(Missing)	(0.01)
Sex	Female	0.47
	Male	0.53
	(Missing)	(0.00)
Party vote intention	Conservative	0.18
	Labour	0.24
	Liberal Democrat	0.04
	Other	0.11
	Undecided	0.31
	Would not vote	0.12
	(Missing)	(0.07)
Age	Mean	48.0
	Min	15
	Max	97
	Unique N	79
	SD	19.7
	(Missing)	(0.01)

Statistics are proportions for all variables except age, excluding missing values. Total $N = 990$

Oudshoorn 2011) to construct five imputed data sets. The imputation model included age, government office region, income, parental status, qualification, sex, urban/rural residence, employment status, and party vote intention. The assumption behind the technique is that missingness is random conditional on the variables included in the imputation model. I fitted the analysis models to each imputed data set, and then combined the five separate MCMC chains.

4 Results

The two outcome variables of interest are strongly correlated (with a Goodman-Kruskal G of 0.57), though they capture different aspects of people's environmental attitudes. Most people trust climate science (69 % a fair or great deal), while most are hostile to taxes on polluting energy (only 37 % are fairly and 7 % very willing to pay more). In Table 2, the first model for each of the two outcomes includes only observational covariates—demographics, and party

Table 2 Models of willingness to pay tax and trust in climate science

Outcome	Willing to pay tax			Trust in climate science					
Model	W1	W2	W3	T1	T2	T3	T4	T5	T6
Fixed effects									
(Geoengineering Intro)		−0.06 (0.22)	−0.04 (0.40)		0.00 (0.49)	0.27* (0.04)			0.48* (0.01)
(Trust question first)							−0.06 (0.19)	−0.03 (0.43)	0.22 (0.19)
(Geoeng. Intro) : (Trust question first)									−0.46 (0.09)
Labour	−0.04 (0.30)		0.21 (0.10)	0.16* (0.01)		0.33* (0.03)			
Lib Dem	0.16* (0.01)		0.49* (0.04)	0.24** (0.00)		0.39 (0.08)			
Other	0.17 (0.07)		−0.01 (0.47)	0.15 (0.10)		0.30 (0.06)			
No vote	0.43* (0.02)		−0.04 (0.42)	0.23 (0.13)		0.05 (0.41)			
Undecided	0.08 (0.27)		0.22 (0.07)	0.16 (0.12)		0.22 (0.07)			
All non-conservative								0.10 (0.21)	0.37* (0.03)
Female	0.04 (0.40)		−0.03 (0.31)	−0.08 (0.27)		0.17* (0.01)		0.16* (0.01)	0.15* (0.02)
Urban	0.16 (0.06)		0.16* (0.02)	0.02 (0.44)		0.24** (0.00)		0.25** (0.00)	0.25** (0.00)
Age	−0.00* (0.02)		−0.00* (0.02)	−0.00* (0.04)		−0.00* (0.04)		−0.00 (0.07)	−0.00 (0.08)
No qualification	−0.29** (0.00)		−0.29** (0.01)	−0.30** (0.00)		−0.30** (0.00)		−0.28** (0.00)	−0.28** (0.00)
A-Level	0.20* (0.03)		0.20* (0.03)	0.23* (0.01)		0.23* (0.01)		0.24** (0.01)	0.25** (0.01)
Bachelor	0.34** (0.00)		0.34** (0.00)	0.46** (0.00)		0.46** (0.00)		0.47** (0.00)	0.47** (0.00)
Postgrad	0.52** (0.00)		0.52** (0.00)	0.83** (0.00)		0.84** (0.00)		0.86** (0.00)	0.87** (0.00)
(Geoeng. Intro) : Labour			−0.06 (0.39)			−0.34 (0.06)			
(Geoeng. Intro) : Lib Dem			−0.11 (0.39)			−0.31 (0.23)			
(Geoeng. Intro) : Other			0.19 (0.25)			−0.27 (0.15)			
(Geoeng. Intro) : No vote			0.16 (0.28)			−0.24 (0.19)			
(Geoeng. Intro) : undecided			−0.11 (0.29)			−0.40* (0.02)			
(Geoeng. Intro) : All non-conservative								−0.07 (0.35)	−0.47* (0.03)
(Trust Q. First) : All non-conservative									−0.26 (0.18)

Table 2 (continued)

Outcome	Willing to pay tax			Trust in climate science					
Model	W1	W2	W3	T1	T2	T3	T4	T5	T6
(Geoeng. Int.) : (Trust Q. First) : All Non-C.									0.33 (0.18)
(Intercept)	0.55** (0.00)	0.66** (0.00)	0.57** (0.00)	1.22** (0.00)	1.40** (0.00)	1.08** (0.00)	1.43** (0.00)	1.20** (0.00)	0.93** (0.00)
Cutpoints									
	0.83	0.79	0.83	0.95	0.90	0.95	0.90	0.95	0.95
	2.24	2.14	2.24	2.27	2.13	2.27	2.13	2.26	2.27
DIC	2363	2409	2373	2322	2411	2331	2411	2322	2324
N	956	956	956	972	972	972	972	972	972

Coefficients are posterior means, on the probit scale. Figures in parentheses are the estimated probability of each coefficient having the opposite sign; coefficients are marked with * if the probability is less than 0.05, ** if less than 0.01. Conservatives and vocational education (or school to age 16) are the reference categories

vote intention. The second model for each shows the effect of being randomly assigned to the treatment of being told about SRM. The third model interacts the treatment with party vote intention, to see how the effects vary by partisanship.

There are some partisan differences with respect to each outcome, consistent with expectations in light of previous literature, though they are modest: Liberal Democrat voters are more willing than Conservative voters to pay energy taxes, and both LibDem and Labour voters are more trusting in climate science (Models W1 and T1).

Aside from party vote intention, education matters a great deal: respondents with no formal qualifications are the least willing to pay energy taxes, and the least trusting in climate science, while respondents with progressively higher levels of education (A-level or equivalent, bachelor or equivalent, and postgraduate degrees) are increasingly willing and increasingly trusting. The coefficient on age is negative in all models, showing that ceteris paribus older respondents are less willing and trusting. Urban respondents, for the most part, are also greener.

The second models (W2 And T2) show that in neither case does hearing a brief introduction to SRM have any meaningful effect for the typical respondent—the coefficient estimate for the treatment is very close to zero.

The third models interact the effect of hearing about SRM with partisanship. The effect of the treatment on people's willingness to pay energy taxes is not notably different for people intending to vote for different parties. However, the third model of people's trust in climate science shows that there is an effect on trust specifically for Conservatives (the reference category). The introduction to SRM raises Conservatives' trust in climate science, and the coefficient on the randomly assigned treatment is almost certainly (96 % likely) above zero. Conversely, the interaction effects in Model T3 are all strongly negative, meaning that the introduction to SRM has no notable effect on any group other than Conservatives.[9]

[9] Other than for non-voters, the interaction effects in Model T3 are more negative than the base effect (for Conservatives) is positive. This implies that if anything hearing about geoengineering reduces the trust of most non-Conservatives. But the magnitude of this effect is miniscule.

The fourth through sixth models of trust in climate science (T4, T5, and T6) test whether confronting the policy and economic implications of climate science reduces the chances of somebody trusting that science. That is, does it make a difference whether a respondent hears the tax question before the trust question? Model T4 shows that for the typical respondent, the effect of being made to think about the possibility of a tax policy response to climate change is trivially small; if anything, respondents reported lower trust in climate science if they received the trust question *without* hearing the tax question first.

As discussed earlier, however, prior studies have suggested that the effect of this treatment should differ depending on a respondent's political ideology. Model T5 tests this theory, comparing Conservative voters to all other respondents. T5 shows that even for Conservatives specifically there is no notable impact of hearing the trust question before rather than after the tax question. Conservatives (the reference category) are therefore no more likely to distrust climate science if they are first encouraged to consider the possibility of a regulatory/tax response. This result, however, pools the effects of receiving the trust question first across the groups receiving and not receiving the introduction to SRM; yet the effects could be different in these two circumstances.

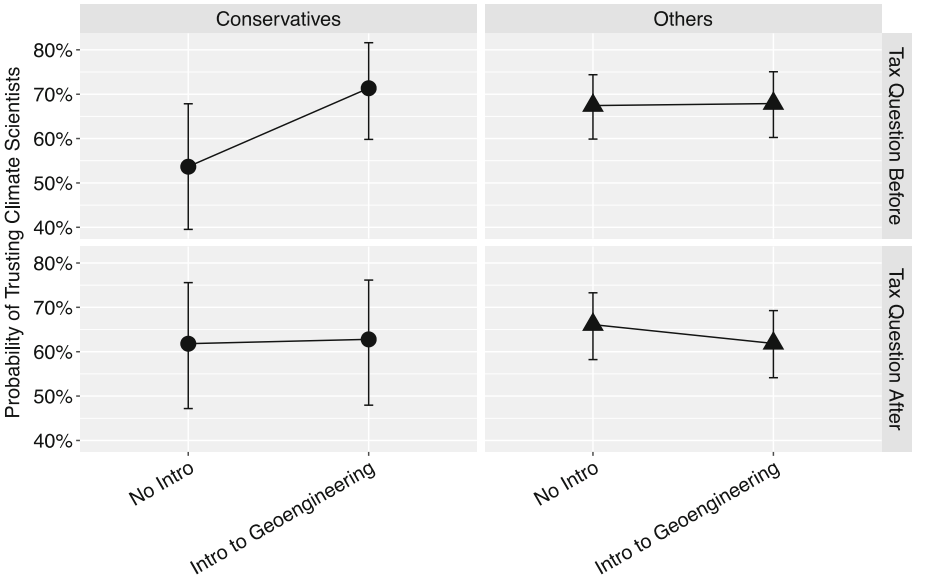
Finally, then, Model T6 tests for an interaction effect between the impacts of hearing about SRM and of being led to think about a regulatory/tax response to climate change. Since the model also distinguishes the effects for Conservatives and for others, it includes a triple interaction. The key questions though, are (a) how Conservatives (the reference category) respond to SRM depending on whether they receive the tax question first, and conversely (b) how the introduction to SRM may condition their response to receiving the trust question before rather than after the tax question. The effects of the introduction to SRM, and the interaction between that treatment and a dummy for being anything other than a Conservative voter, are statistically significant. To clarify what these results mean, Fig. 1 presents the modelled probability of each type of voter trusting climate science, under each of the four conditions.

Figure 1 shows (a) that most people do not respond to a brief introduction to SRM irrespective of whether they are first asked the question about taxation. In contrast, Conservative voters' response to SRM depends on whether they have previously received the question about paying taxes for climate change mitigation. For those asked first about tax, the probability of a Conservative voter reporting "a great deal" or "a fair amount" of trust in climate science rises from 54 to 71 % if they are given an introduction to SRM.[10] Strikingly, in the scenario where Conservatives' trust in climate science is highest, their trust exceeds that of non-Conservatives under *any* combination of the experimental treatments.

Figure 1 also shows that (b), for those Conservatives who received no introduction to SRM, trust in climate science declined if they heard the tax question first—consistent with theory outlined earlier. But that decline was modest—54 versus 62 %—and there is a 19 % chance that the difference is positive not negative (per Model T6). On the other hand, Conservative respondents who did receive an introduction to SRM were more trusting if they received the tax question first (71 versus 63 %), with a 14 % chance of the difference being negative. As such, leading Conservatives to think about the possibility of a regulatory/tax response to climate change does not necessarily lower their self-reported trust in climate science.

The bottom-right quadrant of Fig. 1 shows that non-Conservatives trust climate scientists less if they hear an introduction to SRM (and no question about taxes). This finding is

[10] 95 % Bayesian credible intervals: 39–67 % and 60–81 %, respectively.



Note: Based on Model T6 from Table 2, this figure shows the modelled probability of a hypothetical Conservative or other voter trusting climate scientists a fair amount or a great deal, depending on whether they have received an introduction to geoengineering and whether they have first answered a question about taxation. Vertical error bars are 95% Bayesian credible intervals, and the hypothetical individual is a male urban resident of median age (48), whose highest qualification is vocational.

Fig. 1 Trust in climate scientists

consistent with Kahan et al. (2015). Nevertheless, the magnitude of the effect is small (4 percentage points) and there is a 15 % chance the difference is actually positive. The difference is therefore not significant by conventional criteria, and it is clear that referring to SRM increases the trust of Conservatives much more than it erodes the trust of others.

5 Discussion

The experiments presented here generated no evidence that hearing about solar radiation management affects most people's support for higher energy taxes, nor their trust in climate science. That result comes with one significant caveat, however. Specifically for respondents who said they expected to vote for the right-of-centre Conservative Party, and who were first encouraged to think about the possibility of a regulatory/tax response to climate change, hearing about SRM *increased* their trust in climate science. This result is consistent with Kahan et al. (2015): people who value industry and free markets over equality and market regulation may trust climate science *more* when told that scientists are developing ways of cooling the Earth's climate to compensate for global warming. This result also supports another previous study, which found that focus group participants who were sceptical about climate science reported being more motivated to undertake actions for mitigation when they were told about SRM (Royal Society 2009).

Based on the results of this study, geoengineering does not present a moral hazard. That said, this question is of such importance that future research should test the effects of different treatments, and in different kinds of national contexts. This study's finding that an introduction to SRM may increase British Conservatives' trust in climate science is based on data from just 167 subjects; the relationships investigated here should be tested with a larger N. This study has also only addressed two specific methods of geoengineering, and just one measure of support for climate change mitigation. Though pricing pollution is the top recommendation of environmental economics, there are clearly other means of mitigating climate change: fuel economy standards, subsidies for clean energy, voluntary efforts, etc. Support for these measures might respond differently, and the impacts of hearing about different methods of geoengineering could also vary.

This study has also found that being made to think first about taxation had no impact on most people's trust in climate science. For conservatives who had not heard the introduction to geoengineering, thinking first about taxation did have an effect of this kind, but it was small, and the relationship was reversed for those received an introduction. At the same time, hearing about geoengineering does compensate for conservatives' relatively low trust in climate science. These results therefore provide partial support for the theory that conservatives' distrust of climate science derives from their dislike of state regulatory action.

The fact that conservatives respond positively to SRM only when encouraged to think first about a regulatory/tax response to climate change suggests that geoengineering can displace an association in their minds between climate change and regulatory action by the state. It may be the case that geoengineering strikes conservatives as an interventionist action of the kind they dislike, but when juxtaposed with taxation its technological character more than compensates for its interventionist one. This question remains for future research.

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