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Why don't Americans trust university researchers and why it matters for climate change

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Abstract

Scientists have developed a strong consensus that Earth's climate is changing and that human activities play an important role in these changes. However, current research shows that in the United States, there is significant partisan polarization on climate change and its causes, leading to climate denialism. In this paper, we shed light on the political and social determinants of climate action. Using a May 2022 nationally representative survey of American registered voters (n = 2,096), we examine the multivariate correlates of trust in university research and opinions about climate change. Our results confirm that segments of the American electorate do not believe climate change is a problem for the United States and that climate change is not a consequence of human activities. But we also show that part of the problem regarding climate denialism is a lack of trust in university research. We argue for a comprehensive four-stage research strategy based on the empirical results. First, more research must be done to understand who trusts or distrusts university research on climate change and who is persuadable. Second, more research is needed on climate communication framing and messaging. Third, additional research on appropriate messaging is necessary. Finally, we need to develop a culture of trust in climate research and how it is communicated across society.

1 Introduction

For many decades, scientists have published research findings that indicate the Earth's climate is changing and that human behavior plays an important role in these changes. In the last ten years meta-analyses of scientific studies on climate change found evidence of a strong consensus in the literature, with virtually all published papers agreeing that climate change is real and is being affected by human activities [1,2]. This consensus has been reached over many decades and has won recognition from credible intergovernmental organizations and scientific groups. For example, in the early 1990's the Intergovernmental Panel on Climate Change produced the first two (of six) assessments that provide detailed analyses of how the Earth's

considerations. All replication materials here: https://github.com/danielEbanks/Climate-Trust-Replication.

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climate is changing and the scientific evidence for those changes [3]. By 2004, researchers were reporting that all important scientific organizations whose members had expertise in climate science agreed that climate change was real and that it was being influenced by human behavior—and that most papers published in scientific journals reflected this consensus [4].

In the United States, however, there is significant partisan polarization on issues related to climate change and its causes, with many Republicans disbelieving that climate change is occurring or disagreeing with scientific findings that show climate change is a result of human activities [5]. This "climate denial" narrative may be the result of corporate rhetoric and the activities of some non-profit organizations [6,7]. Interest groups and business associations also have provided resources for political efforts to both political parties, further fueling partisan polarization regarding climate change and its origins in human activities [8–11].

Climate denialism in American popular opinion, and its association with Republican political elites and organizations, is in sharp contrast to the scientific consensus about climate change. That significant climate denialism exists in the United States, despite the scientific research showing that climate change is real and that it is being influenced by human activities, has generated significant frustration in the climate science community. This frustration has reached such a point that some climate scientists have recently argued "for scientists to agree to a moratorium on climate change research as a means to first expose, then renegotiate, the broken science-society contract" [12]. These authors also implied putting social science-driven climate research on the backstage of global climate research.

In their call for a climate science moratorium [12], argue that social science has not been effective in helping resolve the gap between the climate scientists and climate deniers. We believe that this is incorrect, and instead we assert that now is a moment where social science can be more relevant than it has been in the past regarding climate change and sustainability and where social science can help to understand contemporary science denialism [13].

Public trust in science is affected by polarization stemming from psychological, political, and ideological beliefs. People tend to ignore information that goes against their political or personal beliefs, which can lead to polarization over science [14]. Prior research suggests two interrelated behavioral processes may be associated with political polarization over science: Psychological Science Rejection (PSR) and Ideological Science Rejection (ISR). Rekker (2021) presents a useful conceptual framework for for understanding how polarization may be driven by scientific claims, facts, and political beliefs (see Fig 1 in [14]). Studies have shown that PSR may have increased over time, especially in the United States, where people show more sympathy for political or ideological "in-groups" and more hostility towards "out-groups" [15–17]. The ISR perspective sheds light on the rise of populism and declining political trust, new ideologies that contest science, and the polarizing effect of media and communication environments. Gauchat (2012) [17], for instance, shows how the rise of the New Right in the U.S. coincides with increased polarisation regarding public trust in science. Similarly, some media treat science as 'relativistic', i.e., producing coverage of scientific issues as just one opinion among others, and exposing a 'false balance' between scientists and skeptics can distort citizens' perceptions of expert opinion on issues like vaccines and climate change [18,19]. Moreover, studies have also shown that increases in PSR and ISR may also be explained by education attainment as more politically sophisticated citizens have a stronger tendency to align with political elites [14].

Building on theories like ISR and PSR, we shed light on the political and social determinants of climate action. We conceptualize trust in science in relational and institutional terms (discussed in detail in Section 2) use empirical modelling to examine how trust in science is associated with opinions about climate change and who is more trusting of science. Using multivariate analysis of a recent population-representative survey of American registered

voters, we study the factors associated with trust in university research. Thus, our paper explicitly evaluates the following questions in the context of public opinion in the United States: i) How is trust in science associated with belief in the importance of climate change as a problem? ii) How is trust in science associated with beliefs about whether climate change is caused by humans or nature? iii) Who trusts university research centers? Empirical studies like ours are few in the literature, underscores our call for more research like ours.

In this paper, we engage in this debate using data from a recently conducted nationally representative survey of American registered voters (n = 2,096). Our analysis shows that there are segments of the American electorate who do not believe that climate change is a problem for the United States and that climate change is not a consequence of human activities, thus updating previous research. But we also show that part of the problem regarding climate denialism can be a lack of relational or institutional trust in research universities (and, by extension, research science). Our research, coming from a long-standing tradition of academic social science research using representative surveys of public opinion and behavior, shows that this lack of trust has links to climate denialism associated with the anthropogenic cause of climate change. Thus, the path towards a solution to climate denialism is not for climate scientists to go on strike, but rather for universities and scientists to work to re-establish public trust and confidence in our research.

2 Background

2.1 Trust in science and university research

Previous studies have shown that Americans' trust in scientists has historically been high, but there are differences in Americans' trust in science across regional, religious, and partisan lines [20]. More generally, misinformation about science arises from many sources, including individual, group, and societal level factors [10,21]. Past research has identified a variety of factors as being associated with a lack of trust in climate science:

political conservativism [10,20,22–25]; expert cultures and skeptic rationalization [26–28]; and institutional transparency, fairness and public accountability [11,29,30]. Rekker [14] further generalized these factors associated with political polarization regarding science into two interrelated processes: Psychological Science Rejection (PSR) and Ideological Science Rejection (ISR).

This lack of trust in climate science has critical environmental, social and political consequences [11]. It weakens the science-society compact [12] and enables the active resistance of powerful actors with vested interests to change the status quo from which they disproportionately profit [13]. To bridge this trust gap, scholars have studied how to "manage trust" in ways that can strengthen climate action and decision-making. First, trust is a psychological state that is context-specific, involving a trustor and a trustee whose interaction is asymmetric and action-specific [13,29,31]). However, secondly there is no clear understanding of how trust operates at the science-policy interface, which in turn limits the uptake of climate science into policymaking processes [32–35]. Third, it is important to consider maintaining a balance between excessive trust (faith, favoritism, contentment, loyalty) and insufficient trust (skepticism, impartiality, exigency, opportunism) [31].

Cross-national social science research has shown that the public wants scientists to play an active role in the science-policy interface of climate change mitigation that includes advocacy and engagement [4,36]. On a public policy scale, recent evidence shows that public acceptance is a precondition for implementing policies like climate change taxes (carbon taxes) [30]. In this context, factors like distributional fairness, effectiveness and concerns about climate change were found to be strongly associated with public opinion about climate policy [30,37].

Previous research has also shown that knowledge is positively related to climate change opinions, although knowledge alone is not a sufficient precondition to public acceptance of climate policies [38]. Public engagement and accountability by scientists are critical drivers of knowledge translation, further influencing public acceptance of climate research [28,29]. Bergquist et al.'s (2022) meta-analysis found knowledge to be weakly related to public opinion about climate change taxes and laws with no significant differences between subjective and objective knowledge [30]. Also other factors like trust, values and demographic factors (like education, age, income and gender) were not strongly correlated with climate change opinions [11,29,30].

In the case of the United States, opponents and critics of the scientific consensus over anthropogenic climate change have been much more vocal and influential globally. As a result, climate deniers have been successful in confusing public opinion and delaying decisive action [4,39]. However, the origins and motives of the climate change denial movement are highly complex and defined by ideological forces shaped by Republican politics over the last few decades, which bodes ill for climate science and university research [40,41]. For example, a 2016 poll of U.S. adults (n = 1534) found that conservative Republicans are more likely to believe that climate research findings are influenced by scientists' desire to advance their careers (57%) or their political leanings (54%) most of the time [42]. Moreover, this group is less inclined to anticipate adverse effects from climate change or to judge proposed solutions as making any difference in mitigation.

Additionally, this poll found a stark division in opinions about the causes of global climate change. Nearly 50% of U.S. adults say climate change is due to human activity. A similar percentage says either that the Earth's warming stems from natural causes or that there is no evidence of warming [42]. This poll also found that most Americans ($\sim$67%) say climate scientists should have a role in policy decisions about climate issues, with $\sim$23% saying that climate scientists should play only a minor role, and about 9% saying that climate scientists should play no role at all in climate policy [42]. This divide between whether scientists should have a role in policy decisions or not fuels skepticism, with $\sim$22% of the Americans having no trust or not too much trust in climate scientists [42]. In this paper, we update and extend these earlier studies using recent nationally representative survey data and detailed multivariate analyses.

2.2 Conceptualizing trust in climate science

Climate change is a global challenge and needs an interdisciplinary collaborative approach to understand and address this 'wicked problem'. Climate science provides a crucial intersectional example for examining public trust in science (and research). The Intergovernmental Panel on Climate Change (IPCC) emphasizes that public confidence in climate science is needed to ensure that the public and governments that receive their mandates from the public implement consensual mitigation and adaptation policies to prevent the predicted devastation from further global warming [29,43].

There is little interdisciplinary agreement on how to conceptualize trust or distrust. Fage-Butler et al., [29] provide a meta-narrative literature review of the interdisciplinary meaning of trust in climate science. The authors argue that there are six key narratives of trust in the climate science literature, attitudinal, cognitive, affective, contextual, communicated, and contingent (that there are six key narratives underscores the lack of consensus about how to conceptualize trust). In our work we focus on one specific type of attitudinal trust, namely survey-based measurement of trust in university research centers. As we describe in detail below, we use a national survey to ask subjects about whether they trust university research centers.

Fage-Butler et al. note that this type of attitudinal trust is relational in nature. In their paper they state that "Relational trust, on the other hand is more specific; it is articulated with respect to particular institutions or certain actors as sources of information or as those taking some form of action on climate change." [29] Thus in our paper we define trust in this attitudinal-relational manner, which is quite similar to what other researchers have called "institutional trust."

Many scholars have defined trust in this way, and measures of institutional trust like the one we use in this paper have been included in surveys for decades. This has produced an extensive literature that studies attitudinal trust in many different institutions and organizations. There are important social science studies about trust in governmental institutions [44,45], trust in the news media [46], in how governments responded to the COVID-19 pandemic [47], and of course in the many institutions and organizations that work in the climate change and sustainability area [48].

In the institutional trust literature, emphasis is placed on the relationship between institutional performance and institutional trust. [49] This of course makes sense; individuals interact with institutions, hear about the experiences of others with the institutions, and they develop trust (or a lack of trust) based on this information. If the institutional experience is not positive, for example in situations where the institutions are corrupt, those negative experiences can diminish trust in institutions [50,51].

However, we are not studying trust in governmental institutions, or other major organizations like the news media. Rather we are studying trust in scientists and specifically in university research centers, which are unlikely to be institutions that many Americans have a direct experience with. Thus, the evaluations of many Americans towards scientists and university research centers, and their trust in those institutions, may be based less on direct experience but more on heuristics like partisanship, ideology, and religiosity [52–55]. These factors form an important component of our model for trust in university research science centers, as we discuss in the next section.

3 Materials and methods

Data and survey design

The survey data we use in our analysis was collected May 18–24, 2022. The survey was implemented online by YouGov, using respondents from their online opt-in panel to be representative of all U.S registered voters. For this study, the sample definition was self-reported active registered voters in the U.S., who were stratified on age (18–29, 30–44, 45–64, and 65+), race/ethnicity (white non-Hispanic, Black, Hispanic, and other), gender (male, female), education (high school or less, some college, college graduates, and post-graduate), and geographic region (Northeast, Midwest, South, West). The population targets for these strata come from model estimates by YouGov using the 2019 American Community Survey and November 2020 Current Population Survey, conducted by the U.S. Bureau of the Census, and TargetSmart Voter Files.

This sample was weighted to gender, age, race, education, geographic region, and vote in the 2020 U.S. Presidential election. The weights were developed using a raking methodology [56]. Raking is commonly used in survey methodology for estimating weights when the population information is not completely known, usually situations where the univariate population parameters are known but their multivariate distributions are not known. Raking proceeds iteratively: it starts by post-stratification of the sample using one population feature, then the next feature, and so on until the weight variable no longer changes. The weights range from 0.1 to 4.2, with a mean of 1.0 and a standard deviation of 0.4. The implied design effect for

unequal weights is 7.7%. With this adjustment, the margin of error for population proportions would be 2.3%.

There are many potential sources of variance and bias that tend to inflate the root mean squared error above the reported margin of error. The sampling frame does not include any voters without access to the internet (representing approximately 7% of the U.S. population), but the sample is balanced on the variables described above to the population of adult voters. Participation in the panel is voluntary and potentially correlated with variables measured in the survey. The estimates are approximately unbiased if sample selection is conditionally independent of survey variables conditional upon the weighting variables and target population estimates are consistent. Similar assumptions are needed for alternative sampling methodologies and interviewing modes.

The survey included a number of questions about climate change. We use three questions from our survey as dependent variables in the analyses that we report in the next section of this paper. The wording of these questions is presented in Table 1.

For our purposes, two of those climate change questions are used in our analysis: how important is climate change as an issue for the U.S. in the next decade, and whether climate change is caused by human activities or is a natural event. The responses to those questions form the dependent variables in two of our models. In the original survey data, the importance of climate change question had four answers: that it is very important, somewhat important, not important, or is not a problem. We recode these four categories into important (very or somewhat important) and not important (not important or not a problem). We recode this dependent variable to be binary for ease of interpretation, in the paper's S1 Text we present alternative model specifications that analyze the four-category ordinal variable; those models produce results that are more difficult to interpret but which are substantively similar to the results we report in the paper.

The cause of climate change question in our survey had only two responses, whether climate change was caused by human activities or is a natural event. We used this two-response format in our survey to align the survey responses the recent scientific consensus from the IPCC that while climate is always changing due to natural forces, human activities have accelerated this change. For our analysis we use this dichotomy, that climate change is being caused by human activities or by natural events.

The original response distributions for both of these questions from our survey are given in Table A in the S1 Text. As we discuss below, as these two outcome variables are binary responses, we use logistic regression to estimate the model coefficients and standard errors.

The important feature in all our models is trust in university research centers. In our survey, we asked respondents a number of questions about their trust in different institutions, and for this analysis we use the responses to the question asking if they trust in research university centers. The answers to that question provide the dependent variable for another of our statistical models (see Fig 1, further details is presented in the S1 Text).

Empirical models

The three models contain a number of other measures from the survey. First, we include measures of domain specific information (questions that assess the respondent's knowledge about climate change) and general political information (questions that measure the respondent's knowledge about American politics). The wording of both our domain specific and general political information questions are in Table 1 and in the Supplementary Information. Finally, our models contain measures controlling for race and ethnicity, gender, educational attainment, region, religious affiliation, frequency of attending religious services, partisanship,

Table 1. The wording of the survey questions used in this study. Further details about the dependable variables are presented in Table A to Table D in the S1 Text.

Question framing	Preamble	Response choices
Climate change importance: How much of a problem do you believe climate change may be in the next ten years for the United States?	Climate change has been in the news recently. Climate change is based on the observation that the Earth's average temperature has been increasing for the past 150 years.	Very important problem; Somewhat important problem; Not very important problem; Not a problem at all
Climate change cause: How about you? Do you think that climate change is caused by human activities or that it is a natural event?	Some people say that climate change is caused by human activities. Others say that climate change is a natural event.	Human activities; Natural event
University research centres: How much do you trust each of the following institutions?	One a scale from 0 to 10, where 0 means you don't trust the institution at all and 10 means you trust it completely	0 (no trust) - 10 (Complete trust)
Demographic features: General	Gender (Woman;Man); Race (Black; Hispanic/Latino; Other; White); Education attainment (Ed) (High School (HS) or less; College graduate; Some college; Postgraduate); Age: In what year were you born? Region (South; Midwest; Northeast; West)	Select one choice
Demographic identity: Religious denomination (Rel)	How do you identify your religious group?	Protestant; Catholic; Jewish; Others
Demographic identity: Religious Service Attendance (Attend)	How frequently do you visit your place of worship?	Frequently; Often; Sometimes; Never
Political identity: Partisanship	Generally speaking, do you think of yourself as a. . .?	Republican; Democratic; Independent, Other, Not sure
Political identity: Ideology	In politics today, do you generally think of yourself as. . .?	Extremely liberal, Liberal, Slightly Liberal, Moderate, Slightly Conservative, Conservative, Extremely conservative, Don't know
Information sources (News)	What was the source of your environmental and political news in the past week?	Environment info: TV; Radio; Print; Online Political info: TV; Radio; Print; Online
Domain-specific information: Environment info	The global average temperature increased between 1901 and 2016 by: (1.1F, 1.8F, 2.5, 5F); How many weather- and climate-related billion dollar disastersdid the U. S. experience in 2020? (5, 12, 20, 35); What was the costliest hurricane in U.S. history? (Katrina, Harvey, Sandy, Andrew); The sea level along the U.S. coastline is predicted to rise in the next 30 years by: (2–3 inches, 5–6 inches, 10–12 inches, 24–26 inches) Is the United States a party to the Paris Agreement, an internationaltreaty seeking to limit global warming? (Yes, No)	Select one choice
Domain-specific information: Political info	What office does Kamala Harris hold?: (U.S. Senator, Vice President, Secretary of State, Governor); What office does Samuel Alito hold? (Speaker of the House, Supreme Court Justice, Secretary of Defense, U.S. Senator); 3. How many representatives are there in the U.S. Congress? (435, 100, 50, 500); Who is the Secretary of Treasury: (Janet Yellen, Jerome Powell, Deb Haaland, Steven Mnuchin) Who is the Secretary of Defense? (Lloyd Austin, Merrick Garland, Anthony Blinken, Xavier Becerra)	Select one choice

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ideology, and news sources. Additional information about these variables in Table 1 and the S1 Text.

First, we estimate a logistic regression model for the importance of climate change. The critical hypotheses that we test with this model regard partisan and ideological polarization, as we expect to find that more liberal and Democratic registered voters are more likely to respond

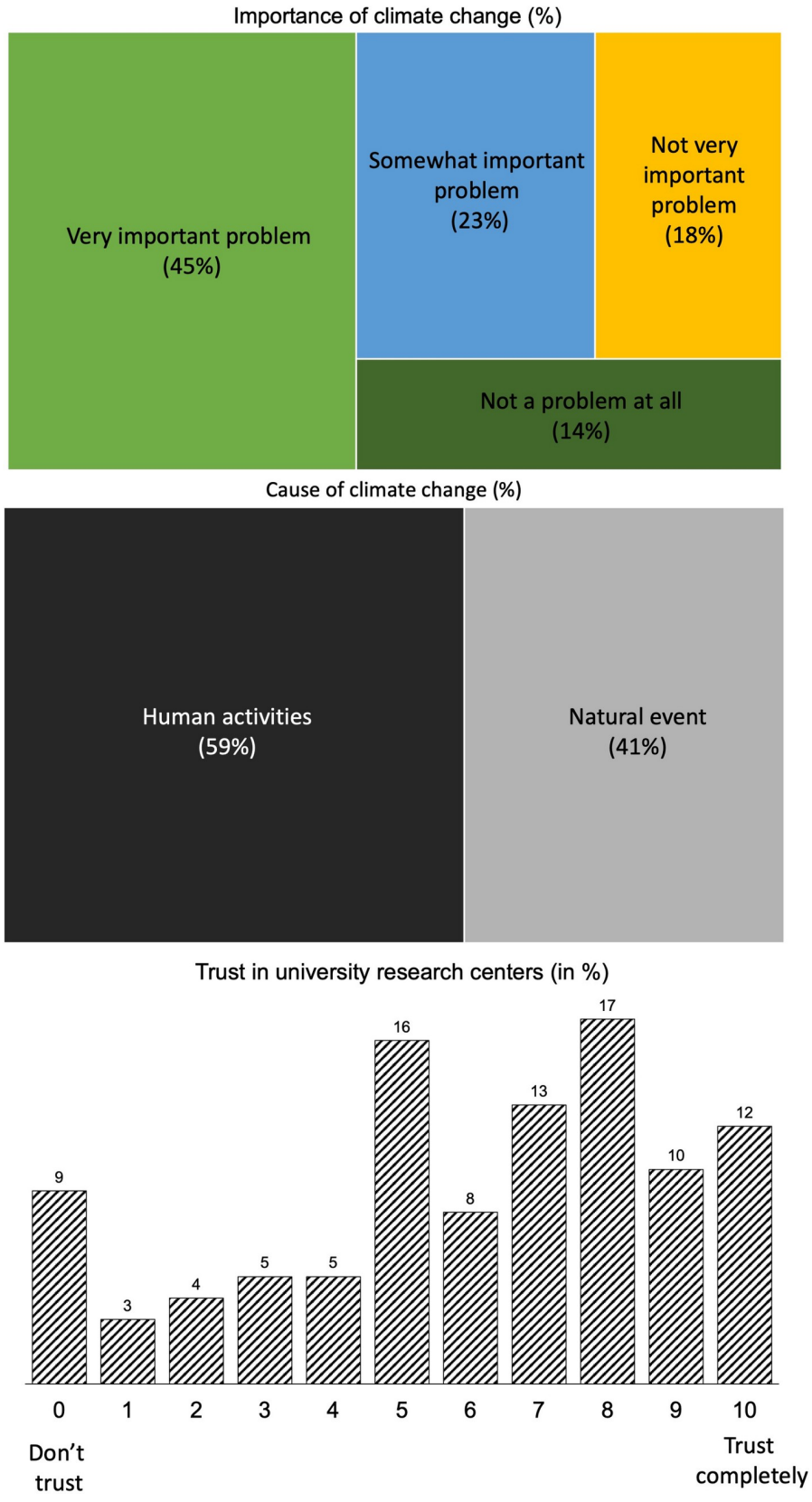

Fig 1. Distributions of dependent measures (in %, n = 2,096).

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that climate change is an important problem for the U.S. The other critical hypothesis is that controlling for partisanship, ideology, and all of the other features in our model, we expect to see that voters with low or moderate trust in university research centers will be less likely to respond that climate change is an important problem, relative to those with high trust in university research centers (we recode the trust responses into these three categories to simplify the analysis).

Second, we study whether our survey respondents respond that climate change is being caused by human action or by natural changes. Again, the key hypotheses regard partisanship and ideology, as we expect to find that those who are ideologically liberal or who are Democratic are more likely to respond that climate change is caused by human activity, than are conservatives or Republicans. The other key hypothesis is that controlling for these political and ideological factors (and the others in the model), those who have low or moderate trust in university research scientists will be less likely to respond that climate change is caused by human actions than are those with high trust.

In our case, the logistic regression model has a functional form (following [57]):

$$p_{ij} = Pr(y_i = j|X_{ij}) = F(X_{ij}\beta) \quad (1)$$

where i indexes individuals, j indexes alternatives, $X_{ij}\beta$ represents the linear function of coefficients β and features X_{ij} in our model, and F represents the logistic transformation. Our models have binary outcomes (so $j = 1$), and our features (X_{ij}) represent the set of demographics, identity-related, partisan and ideological, and trust variables discussed above. In particular, we rely on self-reported levels trust in university centers as a measure of relational trust. We ask respondents to report levels of trust towards a generic class of institutions which perform scientific research. One way to interpret this model is that we measure the extent to which self-identified high-trust and low-trust respondents report agreement with the scientific consensus related to climate change. As the logistic regression model is nonlinear, we provide the nonlinear estimates in the paper's S1 Text and present the estimated average marginal effects below in the paper [57].

The final research question we discuss in the next section regards who trusts university researchers. Establishing this will provide insight into our paper's closing discussion regarding how climate change scientists might reframe or change their approach to public messaging about the importance and causes of climate change. This model has as a dependent variable response to our survey's trust in university research centers question: as that question gave respondents the ability to use a 0–10 scale, we will use ordinary least squares regression to estimate the parameters of this model. Here, we estimate the correlates of self-reported levels of trust in university researcher centers directly. This allows us to make inferences related to which demographic variables are correlated with self-reported levels of trust in relation to an important class of scientific institutions.

As we use ordinary least squares regression, the model parameters are easier to depict and interpret (following [58]):

$$y_i = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \mu_i \quad (2)$$

where y_i is our outcome variable, i indexes individuals, α is a constant, β_k are coefficients to estimate, the X_{ik} are the k features in our model, and μ_i is an error term. Ordinary least squares regression estimates can be interpreted directly, and thus we provide in the paper the coefficients and their estimated standard errors in graphical form.

As discussed above, the YouGov provided the survey weights which was used to adjust the sample to make inferences for the national population of American registered voters (these

weights are discussed in more detail in the S1 Text. To use these weights in our logistic models and regression analyses, we estimate these models using the 'survey' package in R [56,59].

4 Results

4.1 Is climate change a problem?

We begin with our model that provides results for the registered voter's opinion that climate change is an important problem. For the purposes of our analysis, we have recorded the four responses to our question into a simple dichotomy, important (very or somewhat important) or not important (not very important or not a problem at all). This allows us to estimate the model using logistic regression, and we report the logistic regression coefficient estimates and confidence intervals in the Supplementary Information (see Fig A and Table E in S1 Text). In order to produce more easily understood estimates, we transform the logistic regression results into average marginal effects, which for this first model are shown in Fig 2. This allows easy comparison of the estimated magnitude of each feature's correlation with the outcome, controlling for the other features in the model.

Starting with the demographic features in the model, we see a few statistically significant demographic features in this model. The first regards age: relative to those under 30, these results indicate that those aged 45 to 64 and those aged 65 and older are less likely to say that climate change is an important problem. We also see that women are more likely than men to say that climate change is an important problem, though the estimate is of slight magnitude. The other demographic features—race/ethnicity, education, region, religious affiliation and attendance—do not produce results that are statistically distinct from zero.

Next, in these results we see some statistically significant information and information source associations. Those who score higher on our domain-specific environmental information scale are more likely to say that climate change is an important problem for the U.S., while those who score higher on our political information scale are less likely to say that climate change is an important problem; both of these estimates are of relatively small magnitude. Similarly for information sources, the results reported in Fig 2 indicate that those who follow the news on television or print are more likely to believe that climate change is an important issue. We do not obtain statistically significant results regarding those who get their information from radio or online sources.

Next, in this model we see statistically significant and relatively sizeable estimates for the political features: partisanship and ideology. Relative to Republicans, we see that Democrats are more likely to say that climate change is an important problem. And relative to conservatives, those who identify as moderates or liberals are more likely to say that climate change is an important problem in the U.S. These estimates are larger in magnitude that any of the demographic and informational features in the model.

Finally, and perhaps most importantly, at the top of the graph we present the average marginal effects for two of the response categories for our trust in science feature (here the baseline category is high trust). These results indicate that registered voters in our sample who say they have low trust in science are much less likely to respond that climate change is an important problem in the U.S, relative to those who have high trust. Also, those who said that they have moderate levels of trust in scientists are less likely to say that climate change is an important problem in the U.S, relative to those who have high trust. These results are statistically significant, and of sizable magnitude (roughly comparable in magnitude to the estimated average marginal effects for partisanship and ideology).

In conclusion, so far, we have established that trust in science is strongly and statistically associated with whether a registered voter in the U.S. believes that climate change is an

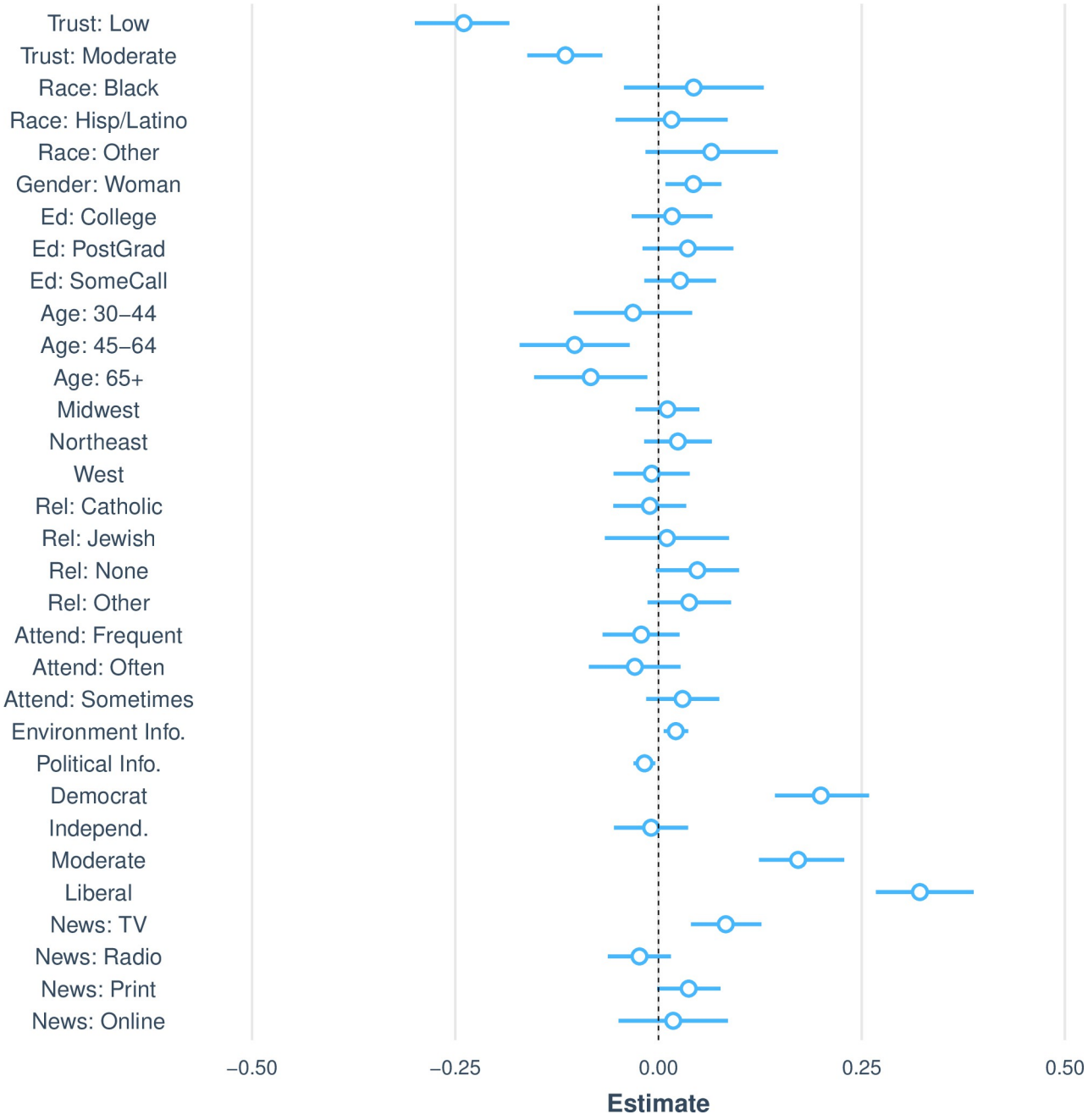

Fig 2. How much of a problem is climate change? logistic regression AME results. Note: Average marginal effects from a logistic regression model and 95% confidence intervals. Model coefficients and standard errors are reported in the SI.

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important problem in the country. As the model controls for partisanship, ideology, information and information sources, and demographic features that are may be correlated with climate change opinions, this helps to make the case that trust in science has an association with climate change concerns, independent of these other features.

4.2 Is climate change caused by humans or nature?

To examine the association between trust in university scientists and the importance of climate change, and to whether climate change is caused by humans or by natural events, we use a similar methodological approach. We present the logistic regression average marginal effects in Fig 3. The logistic regression coefficients are shown in Fig B and Table E in the S1 Text. Recall that the outcome variable is coded so that if the respondent said that climate change is caused

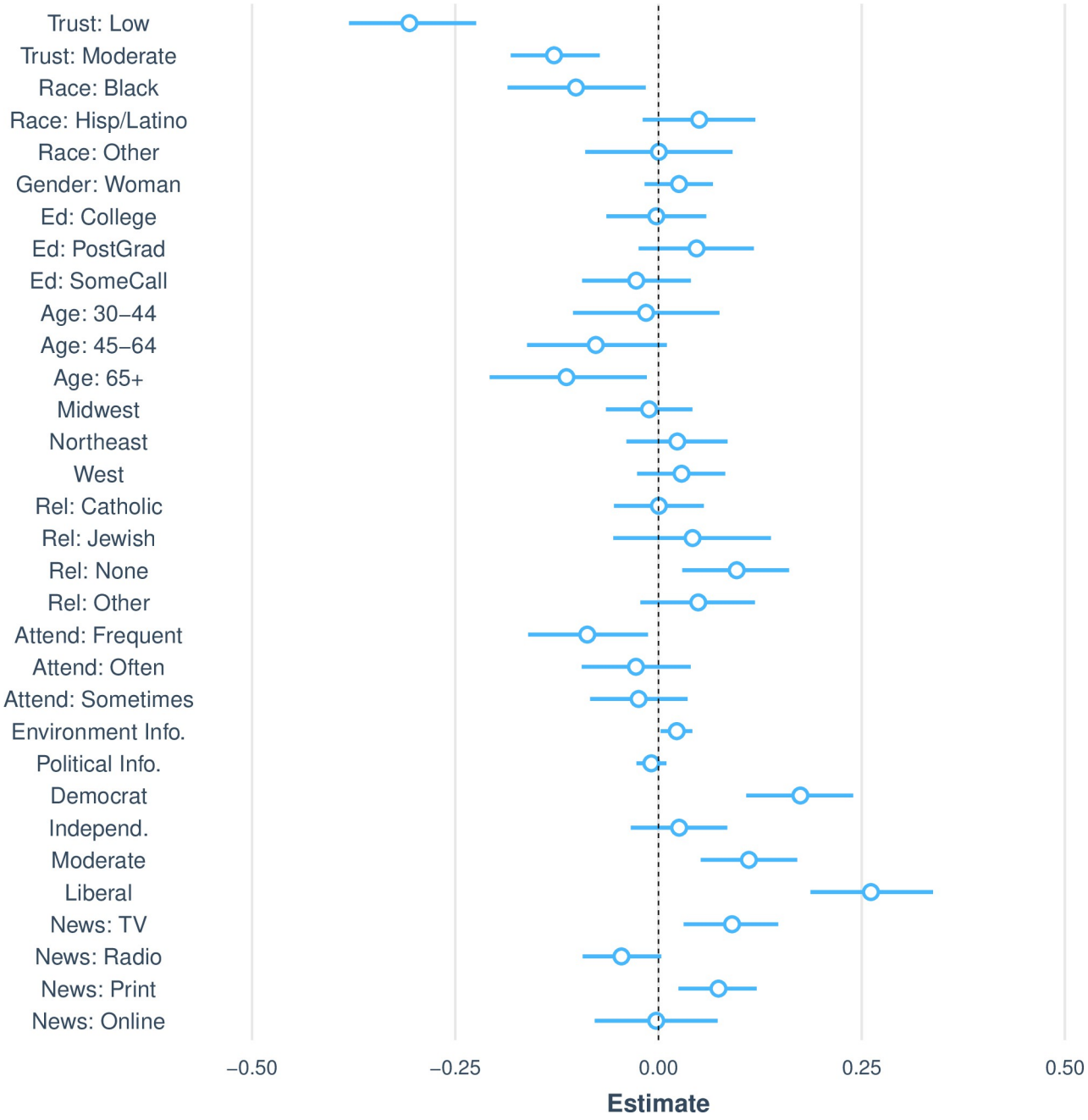

Fig 3. Is climate change caused by humans or nature? logistic regression AME results. Note: Average marginal effects from a logistic regression model and 95% confidence intervals. Model coefficients and standard errors are reported in the appendix.

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by human activities that takes a value of 1 while if they said it is caused by natural events it takes a value of 0. Thus positive estimates indicate that a change in the feature increases the likelihood that the respondent would say that climate change is caused by human activities, while negative estimates indicate that a change in the feature is associated with an increased likelihood that the respondent would say that natural events are causing climate change.

As shown in Table A in the S1 Text, 59% of the survey respondents said climate change is caused by human activities. At the same time, 41% attributed it to natural phenomenon. Our logistic regression results show few statistically significant demographic features attributable to race and ethnicity; the one exception is that Black registered voters in our sample are more likely to believe that climate change is being caused by natural events than white registered voters. Those aged 45 to 64 and older than 65 are less likely to say climate change is caused by human activities. We also see Hispanics/Latinos are more likely (with higher estimates) than any other race to say climate change is caused by human activities (see Fig 2). In the same demographic category, we find that those who have at least a postgraduate degree are more likely to support that climate change is caused by human activities. We check for the robustness of this result to choice of functional form in Fig C and Fig D in the S1 Text. We estimate model coefficients for both a Linear Probability Model and Ordered Logit specification, and we find that the results are consistent with those reported in the main text.

In the model, we see that women are more likely than men to say that climate change is caused by human activities. Our results show that religious affiliation is associated with this belief. For instance, Jewish and non-Catholic respondents are more likely to believe climate change has anthropogenic sources. However, respondents who said they have no religious affiliations were significantly more likely to support this belief (see Fig 2, "Rel:None"). In contrast, those who frequently attend religious services are more likely to believe climate change is due to natural causes. Previous research has argued that those who attend religious services tend to believe that climate change is due to natural causes [60–62].

Finally, our findings support existing literature connecting political conservatism and climate change beliefs, as discussed in detail in Section 2. In the model, Democrats, Moderates and Liberals are statistically more likely to say that climate change is caused by human activities. Similiar to the results from section 4.1 regarding trust in science (baseline category is high trust), the average marginal effects show that those who say they have low trust in science are much less likely to respond that climate change is caused by human activities, relative to those who have high trust (see top of graph in Fig 2). Also, those who said that they have moderate levels of trust in scientists are less likely to say that climate change is caused by human activities, relative to those who have high trust.

4.3 Who trusts university research centers?

We use ordinary least squares regression for our third model—examining who trusts university research centers. We show the results from this regression graphically in Fig 4 and in tabular form in Table E in the S1 Text. The outcome variable is coded so that higher values indicate that the subject had higher levels of trust. Regarding the demographics features in the model, we see some evidence that non-whites in our sample (those in the "Other" category) are more trusting of university research centers than registered white voters. We also see that that those aged 45 to 64 and older than 65 are less likely to trust university research centers than those aged less than 30.

In this model, religiosity and religious denominations show intriguing correlations with trust in university research centers. Beginning with the religious denominations, the baseline denomination in our model specification is Protestant belief. We see that relative to Protestant

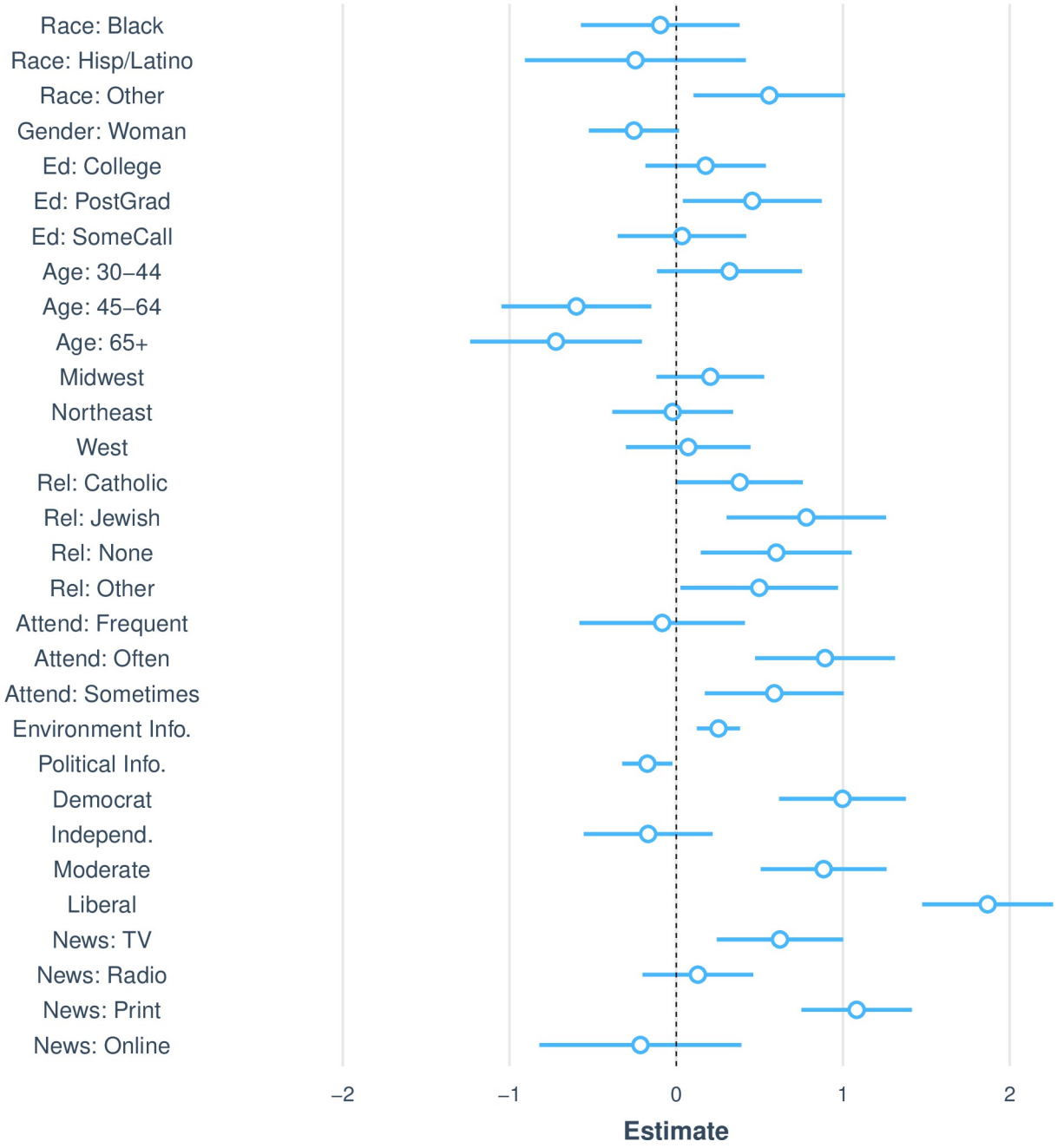

Fig 4. Who trusts university research centers? regression results. Note: Regression coefficient estimates and 90% confidence intervals. Model dependent variable is trust in university research centers, higher scores indicate higher trust.

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belief, all of the other denominations (including "none") are associated with higher levels of trust in university research centers. Perhaps the easier way to interpret this result is that Protestant registered voters are less trusting of university research centers than those of all other denominations, and those who do not have any religious affiliation. While those who said that they frequently attended religious services were not statistically more likely to be trusting of university research centers than those who never attended religious services, the results in Fig 4 indicate that those who often or sometimes attend religious services reported higher

levels of trust in university research centers than those who never attend religious services. As for our previous model, we check for the robustness of this result to functional form in Fig E in the S1 Text. We estimate model coefficients for a Linear Probability Model, and we find that the results are consistent with those reported above.

Regarding race and ethnicity, the model results show that both Black and Hispanic/Latinos were less likely to trust university research centers than other race groups in the survey sample. Moreover, in contrast to the results in sections 4.1 and 4.2, we find that women are statistically less likely to trust university research centers. Finally, in terms of education, respondents with a postgraduate education are significantly more likely to have greater trust than those with at most a high school education (see Fig 4).

Regarding partisanship and ideology, Democrats and moderates are more likely to trust university research centers than independents. The regression model results also show that information sources play a critical role in determining trust in university research. For instance, we find that those who are have better domain-specific information about the environment are more likely to trust university research centers, while those with higher levels of general political information are less likely to trust university research centers. Furthermore, those who get their information from print-based and television news sources have been significantly more likely to trust university research centers. Interestingly, we find that respondents who get their information from online news sources were less likely to trust university research centers, though this result is not statistically significant.

5 Discussion and conclusion

Lack of trust in science and challenges to science have pernicious consequences as they can be used to slow or stop important policy progress to mitigate the effects of global climate change [10,63]. Lack of trust in climate science can also slow or stop scientific progress—witness how environmental and ethical concerns led to the postponement and then cancellation of recent climate engineering projects (among others) like Stratospheric Particle Injection for Climate Engineering (SPICE) project in 2012 and Stratospheric Controlled Perturbation Experiment (SCoPEx) in 2021.

In this paper we used recent data from a population-representative sample of American registered voters (n = 2,096) to study whether trust in scientific research centers is associated with beliefs about climate change and it's causes. We also studied the correlates of trust in university research centers. In general, our survey results have supported some previous studies, discussed in in section 2.

Our study is novel as we contribute to empirically investigating features of relational trust between demographic features, political and religious identities, news and communication sources, and climate change beliefs across a population scale. First we use data from a population-representative sample of American registered voters, thus our results generalize to that important population. Second our survey data is from May 2022, collected quite recently, providing a timely analysis of opinions about climate and scientific research. Third we approach our hypothesis testing using comprehensive multivariate statistical models, which combined with the sample we use (N = 2,096) gives us an ability to estimate the association between the features in the model and the outcome measures controlling for a wide array of other factors.

Our results indicate that those who have low or moderate levels of trust in university research centers are less likely to believe that climate change is an important problem in the United States. Also, those who have low or moderate levels of trust in university research centers are less likely believe that climate change is cause by human activities, which supports the results of [20,26].

In our final analysis we identified segments of the American electorate that are more trusting of university research centers: younger registered voters (under 30 years of age), non-Protestants, those who attend religious services often or sometimes, Democrats, ideological Moderates and Liberals, and those who get their information from television or print sources. These results support findings in previous studies [30,62].

Apart from the known demographic and political features that influence trust in university research and belief in climate change (see section 2), we find information source association statistically significant in determining whether Americans believe climate change is a problem. Those who possess domain-specific environmental information are more like to say that climate change is a significant problem. Similar effects are observed for those who follow the news on television or print (see Fig 1). In comparison, we did not obtain statistically significant results regarding whether climate change is important for those who get their information from the radio or online sources. We observed that radio users believe the climate is a natural phenomenon with moderate estimates (see Fig 2). Furthermore, those respondents who associated their primary news source with online platforms were least trusting of university research (see Fig 3).

What do these results imply for how we can improve trust among Americans in university research centers—in the hopes that will then lead to greater agreement with scientific consensus that climate change is an important problem for the United States and that it is being caused by human activities? We argue for a comprehensive four-stage strategy.

First, more research like ours needs to be done to understand specifically who currently trusts university research on climate change and sustainability, who does not, and who is persuadable. Each segment requires a different approach. Those who currently trust university climate and sustainability science need to have their trust reinforced; those who do not currently trust university climate and sustainability science will need a longer-term strategy aimed at changing their minds (which is a difficult thing to do). Science should be made accessible and interpretative. Perhaps most importantly, those who are persuadable, who can lean either towards more or less trust, need the most immediate attention: what information, framing and messages will push them to being strongly trusting of university research on climate and sustainability?

Second, and relatedly, we need more research on the framing and messages needed to strengthen trust for the already trusting and persuade those with more malleable opinions. Furthermore, these results suggest scientists cannot necessarily expect that these groups will automatically trust their work, even if their research is of high quality and well-evidenced. Instead, scientists need to be more sensitive to understanding how to translate and discuss their work in ways that are understandable, and which generate trust among the public. We believe that the Generalizing Persuasion Framework (GPF) may be useful for guiding the next stages of study regarding trust in climate and sustainability science [64]. Scientists will need to be briefed about how to best frame and discuss their research in ways that will establish trust in their work. For instance, we refer in Section 1 to Rekker's [14] generalizable object of science polarization framework, which provides two interpretative lenses to understand Psychological Science Rejection (PSR) and Ideological Science Rejection (ISR). Frameworks like these may be helpful for improving public trust in science by identifying PSR and ISR trigger points.

Similarly, Druckman's [64] conceptualization of GPF allows identification of contradictory statements through a multidimensional lens involving different actors, treatments, outcomes and settings (see Table 1 in [64]). As we highlighted above, GPF can guide in selecting appropriate speakers, topics, message content, and framing of climate action to lead to desired outcomes across diverse attitudes, behavior, emotions and identities that may help in handling

PSR and ISR. Future research should study the effectiveness of various components in GPF for improving trust in university research.

Third, additional research on the appropriate messengers is necessary. It is not necessarily the case that the best messengers for establishing trust in university research are the researchers themselves, instead other types of ingroup messengers might be best for communicating climate research [14,65]. While additional research is necessary, our survey results indicate that religious organizations and leaders might provide an important mechanism for the generation of higher levels of trust in university research. There may be other trusted leaders and influencers, who when provided well-crafted messages can help solidify trust and persuade those who might have more malleable opinions.

Finally, for the longer term, and for trying to develop a culture where scientific research and communications are trusted, studying how to build that trust in the context of primary and secondary climate and sustainability education curriculum is needed [66]. This is more than determining the optimal ways to educate primary and secondary students about climate change and sustainability, what is also needed is developing educational approaches and materials that help students better understand the scientific process and how they can best understand and interpret scientific materials. Only by educating the next generations can we minimize distrust of scientific research in the longer term.

This observational study has certain limitations associated with the use of survey designs to study opinions about climate change and trust in climate science. Future work will build on this research by developing better survey-based methods for measuring these opinions, leveraging lessons from global climate change surveys to develop new and improved survey questions. One important example will be to use more nuanced survey questions about the causes of climate change; rather than using a simple dichotomy that climate change is being caused by human activities or natural events, we will explore ways to allow survey subjects to provide more nuanced responses. We will also explore the use of survey and field experiments to draw causal inferences about the dynamism of relational trust in science and climate action.

Supporting information

S1 Text. Expanded survey methodological details and regression robustness.
(PDF)

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References

1. Cook J, Nuccitelli D, Green SA, Richardson M, Winkler B, Painting R, et al. Quantifying the Consensus on Anthropogenic Global Warming in the Scientific Literature. Environmental Research Letters. 2013; 8 (2):024024.
2. Cook J, Oreskes N, Doran PT, Anderegg WR, Verheggen B, Maibach EW, et al. Consensus on Consensus: A Synthesis of Consensus Estimates on Human-Caused Global Warming. Environmental Research Letters. 2016; 11(4):048002.
3. Intergovernmental Panel on Climate Change. Climate Change: The IPCC 1990 and 1992 Assessments; 1992. https://www.ipcc.ch/site/assets/uploads/2018/05/ipcc_90_92_assessments_far_full_report.pdf.
4. Orekses N. The Scientific Consensus on Climate Change. Science. 2004; 306:1686.
5. Karol D. Red, Green, and Blue: the Partisan Divide on Environmental Issues. Cambridge University Press; 2019.
6. Oreskes N, Conway EM. Merchants of doubt: How a handful of scientists obscured the truth on issues from tobacco smoke to global warming. Bloomsbury Publishing USA; 2011.
7. Brulle RJ. Institutionalizing delay: foundation funding and the creation of US climate change countermovement organizations. Climatic Change. 2014; 122(4):681–694.
8. Mildenberger M. Carbon captured: how business and labor control climate politics. MIT Press; 2020.
9. Stokes LC. Short Circuiting Policy: Interest Groups and the Battle Over Clean Energy and Climate Policy in the American States. Oxford University Press; 2020.
10. Hornsey MJ, Lewandowsky S. A toolkit for understanding and addressing climate scepticism. Nature Human Behaviour. 2022; 6(11):1454–1464. https://doi.org/10.1038/s41562-022-01463-y PMID: 36385174
11. Motta M. The enduring effect of scientific interest on trust in climate scientists in the United States. Nature Climate Change. 2018; 8(6):485–488. https://doi.org/10.1038/s41558-018-0126-9
12. Glavovic BC, Smith TF, White I. The Tragedy of Climate Change Science. Climate and Development. 2021; p. 1–5. https://doi.org/10.1080/17565529.2021.2008855
13. Cologna V, Oreskes N. Don't Gloss Over Social Science! A Response to Glavovic et al. (2021) "The Tragedy of Climate Change Science.". Climate and Development. 2022; p. 1–3. https://doi.org/10.1080/17565529.2022.2076647
14. Rekker R. The nature and origins of political polarization over science. Public Understanding of Science. 2021; 30(4):352–368. https://doi.org/10.1177/0963662521989193 PMID: 33594929
15. REILJAN A. 'fear and loathing across party lines' (also) in Europe: Affective Polarisation in European Party Systems. European Journal of Political Research. 2019; 59(2):376–396. https://doi.org/10.1111/1475-6765.12351
16. Iyengar S, Sood G, Lelkes Y. Affect, not ideology. Public Opinion Quarterly. 2012; 76(3):405–431. https://doi.org/10.1093/poq/nfs038
17. Gauchat G. Politicization of science in the public sphere. American Sociological Review. 2012; 77 (2):167–187. https://doi.org/10.1177/0003122412438225
18. Van Aelst P, Str¨omb ack J, Aalberg T, Esser F, de Vreese C, Matthes J, et al. Political Communication in a high-choice media environment: A challenge for democracy? Annals of the International Communication Association. 2017; 41(1):3–27. https://doi.org/10.1080/23808985.2017.1288551
19. Koehler DJ. Can journalistic "false balance" distort public perception of consensus in expert opinion? Journal of Experimental Psychology: Applied. 2016; 22(1):24–38. https://doi.org/10.1037/xap0000073 PMID: 26752513
20. Krause NM, Brossard D, Scheufele DA, Xenos MA. Trends–Americans' Trust in Science and Scientists. Public Opinion Quarterly. 2019; 83(4):817–836.
21. Scheufele DA, Krause NM. Science Audiences, Misinformation, and Fake News. Proceedings of the National Academy of Science. 2019; 116(16):7662–7669. https://doi.org/10.1073/pnas.1805871115 PMID: 30642953
22. Hamilton LC, Hartter J, Saito K. Trust in Scientists on Climate Change and Vaccines. SAGE Open. 2015; 5:1–13.
23. Leiserowitz AA, Maibach EW, Roser-Renouf C, Smith N, Dawson E. Climategate, Public Opinion, and the Loss of Trust. American Behavioral Scientist. 2012; 57:818–837.
24. McCright AM, Dentzman K, Charters M, Dietz T. The Influence of Political Ideology on Trust in Science. Environmental Research Letters. 2013; 8:044029.

25. Safford TG, Whitmore EH, Hamilton LC. Questioning scientific practice:Linking beliefs about scientists, science agencies, and climate change. Environmental Sociology. 2019; 6:194–206.
26. Cologna V, Siegrist M. The role of Trust for Climate Change Mitigation and adaptation behaviour: A meta-analysis. Journal of Environmental Psychology. 2020; 69:101428. https://doi.org/10.1016/j.jenvp.2020.101428
27. Goodwin J, Dahlstrom MF. Communication strategies for earning trust in climate change debates. WIREs Climate Change. 2013; 5(1):151–160. https://doi.org/10.1002/wcc.262
28. Sarathchandra D, Haltinner K. Trust/distrust judgments and perceptions of climate science: A research note on skeptics' rationalizations. Public Understanding of Science. 2019; 29(1):53–60. https://doi.org/10.1177/0963662519886089 PMID: 31691642
29. Fage-Butler A, Ledderer L, Nielsen KH. Public trust and mistrust of climate science: A meta-narrative review. Public Understanding of Science. 2022; p. 096366252211100. https://doi.org/10.1177/09636625221110028 PMID: 35946959
30. Bergquist M, Nilsson A, Harring N, Jagers SC. Meta-analyses of fifteen determinants of public opinion about climate change taxes and laws. Nature Climate Change. 2022; 12(3):235–240. https://doi.org/10.1038/s41558-022-01297-6
31. Stevens M, MacDuffie JP, Helper S. Reorienting and recalibrating inter-organizational relationships: Strategies for Achieving Optimal Trust. Organization Studies. 2015; 36(9):1237–1264. https://doi.org/10.1177/0170840615585337
32. Franco G, Cayan D, Luers A, Hanemann M, Croes B. Linking climate change science with policy in California. Climatic Change. 2007; 87(S1):7–20. https://doi.org/10.1007/s10584-007-9359-8
33. Buizer J, Jacobs K, Cash D. Making short-term climate forecasts useful: Linking science and action. Proceedings of the National Academy of Sciences. 2010; 113(17):4597–4602. https://doi.org/10.1073/pnas.0900518107 PMID: 20133668
34. Lacey J, Howden M, Cvitanovic C, Colvin RM. Understanding and managing trust at the Climate Science–Policy Interface. Nature Climate Change. 2017; 8(1):22–28. https://doi.org/10.1038/s41558-017-0010-z
35. Sheppard BH, Sherman DM. The grammars of trust: A model and general implications. The Academy of Management Review. 1998; 23(3):422. https://doi.org/10.2307/259287
36. Cologna V, Knutti R, Oreskes N, Siegrist M. Majority of German citizens, US citizens and climate scientists support policy advocacy by climate researchers and expect greater political engagement. Environmental Research Letters. 2021; 16(2):024011. https://doi.org/10.1088/1748-9326/abd4ac
37. Kysel a E, Sˇcasny M, Zvˇeˇrinov a I. Attitudes toward climate change mitigationˇ policies: A review of measures and a construct of policy attitudes. Climate Policy. 2019; 19(7):878–892. https://doi.org/10.1080/14693062.2019.1611534
38. Sarewitz D. Does climate change knowledge really matter? WIREs Climate Change. 2011; 2(4):475–481. https://doi.org/10.1002/wcc.126
39. Collomb JD. The ideology of climate change denial in the United States. European Journal of American Studies. 2014; 9(1). https://doi.org/10.4000/ejas.10305
40. Tollefson J. How Trump damaged science—and why it could take decades to recover; 2020. Available from: https://www.nature.com/articles/d41586-020-02800-9.
41. Oreskes N. The scientific consensus on Climate Change. Science. 2004; 306(5702):1686–1686. https://doi.org/10.1126/science.1103618 PMID: 15576594
42. PEW. The politics of climate; 2020. Available from:https://www.pewresearch.org/science/2016/10/04/the-politics-of-climate/.
43. Hugel S, Davies AR. Public participation, engagement, and climate change adaptation: A review of the research literature. WIREs Climate Change. 2020; 11(4). https://doi.org/10.1002/wcc.645 PMID: 35859618
44. Citrin J, Stoker L. Political Trust in a Cynical Age. Annual Review of Political Science. 2018; 21(1):49–70.
45. Hetherington MJ. Why trust matters: Declining political trust and the demise of American liberalism. Princeton University Press; 2005.
46. Stromback J, Tsfati Y, Boomgaarden H, Damstra A, Lindgren E, Vliegenthart R, et al. News media trust and its impact on media use: toward a framework for future research. Annals of the International Communication Association. 2020; 44(2):139–156.
47. Devine D, Gaskell J, Jennings W, Stoker G. Trust and the coronavirus pandemic: What are the consequences of and for trust? An early review of the literature. Political Studies Review. 2021; 19(2):274–285. https://doi.org/10.1177/1478929920948684 PMID: 35082554

48. Huber RA, Greussing E, Eberl JM. From populism to climate scepticism: the role of institutional trust and attitudes towards science. Environmental Politics. 2022; 31(7):1115–1138.
49. Berg L, Hjerm M. National Identity and Political Trust. Perspectives on European Politics and Society. 2010; 11(4):390–407.
50. Mishler W, Rose R. What are the origins of political trust? Testing institutional and cultural theories in post-communist societies. Comparative political studies. 2001; 34(1):30–62.
51. Mishler W, Rose R. What are the political consequences of trust? A test of cultural and institutional theories in Russia. Comparative Political Studies. 2005; 38(9):1050–1078.
52. Cacciatore MA, Browning N, Scheufele DA, Brossard D, Xenos MA, Corley EA. Opposing ends of the spectrum: Exploring trust in scientific and religious authorities. Public Understanding of Science. 2018; 27(1):11–28. https://doi.org/10.1177/0963662516661090 PMID: 27458117
53. McCright AM, Dentzman K, Charters M, Dietz T. The influence of political ideology on trust in science. Environmental Research Letters. 2013; 8(4):044029. https://doi.org/10.1088/1748-9326/8/4/044029
54. McCright AM, Dunlap RE, Marquart-Pyatt ST. Political ideology and views about climate change in the European Union. Environmental Politics. 2016; 25(2):338–358.
55. Neumayer E. The environment, left-wing political orientation and ecological economics. Ecological economics. 2004; 51(3–4):167–175.
56. Lumley T. Complex Surveys: A Guide to Analysis Using R. John Wiley & Sons; 2011.
57. Glasgow G. Interpreting Discrete Choice Models. Cambridge University Press; 2022.
58. Kuhn M, Johnson K. Applied Predictive Modeling. Springer; 2013.
59. Lumley T. Analysis of Complex Survey Samples. Journal of Statistical Software. 2004; 9:1–19.
60. Schuman S, Dokken JV, Niekerk Dv, Loubser RA. Religious beliefs and climate change adaptation: A study of three rural South African communities; 2016. Available from: https://doi.org/10.4102/jamba.v10i1.509.
61. Zaleha BD, Szasz A. Why conservative Christians don't believe in climate change. Bulletin of the Atomic Scientists. 2015; 71(5):19–30. https://doi.org/10.1177/0096340215599789
62. Hayhoe D, Bloom MA, Webb BS. Changing evangelical minds on climate change. Environmental Research Letters. 2019; 14(2):024016.https://doi.org/10.1088/1748-9326/aaf0ce
63. Lewandowsky S, Oreskes N, Risbey JS, Newell BR, Smithson M. Seepage: Climate change denial and its effect on the scientific community. Global Environmental Change. 2015; 33:1–13. https://doi.org/10.1016/j.gloenvcha.2015.02.013
64. Druckman JN. A Framework for the Study of Persuasion. Annual Review of Political Science. 2022; 25:65–88.
65. Fielding KS, Hornsey MJ, Thai HA, Toh LL. Using Ingroup Messengers and Ingroup Values to Promote Climate Change Policy. Climatic Change. 2020; 158:181–199.
66. Monroe MC, Plate RR, Oxarart A, Bowers A, Chaves WA. Identifying effective climate change education strategies: a systematic review of the research. Environmental Education Research. 2019; 25(6):791–812. https://doi.org/10.1080/13504622.2017.1360842