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Going beyond political ideology: A computational analysis of civic trust in science

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Abstract
Numerous studies have been conducted to identify the factors that predict trust/distrust in science. However, most of these studies are based on closed-ended survey research, which does not allow researchers to gain a more nuanced understanding of the phenomenon. This study integrated survey analysis conducted within the United States with computational text analysis to reveal factors previously obscured by traditional survey methodologies. Even after controlling for political ideology—which has been the most significant explanatory factor in determining trust in science within a survey framework—we found those with concerns over boundary-crossing (i.e. concerns or perceptions that science overlaps with politics, the government, and funding) were less likely to trust science than their counterparts.

Keywords
boundary-crossing, computational text analysis, political ideology, trust in science

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1. Going beyond political ideology: A computational analysis of public trust in science

Trust has always been an essential part of society, enabling cooperative relations, building a sense of community, and facilitating collective action (Putnam, 1993). In today's complex and interconnected world, trust is arguably even more crucial; everyone doing their part serves as the foundation of a well-functioning society. While trust is an essential element in all aspects of society, it is especially important in science (Krause et al., 2019). We rely on science in our daily lives to make sense of the world we live in and make educated decisions. For society to successfully implement evidence-based public policies and prevent human society from risks, trust in science is essential (Mann and Schleifer, 2020). For example, policies dealing with climate change can only be implemented when the public is confident in scientific findings regarding climate change/global warming and its importance (Myers et al., 2017). Similarly, the success of vaccine policies hinges on public trust in the vaccine's efficacy and their proactive decision to get vaccinated (Sturgis et al., 2021).

Public opinion serves as a powerful influence on policymaking (Pechar et al., 2018). Unfortunately, in many cases, the policies that are passed and implemented reflect public opinion instead of scientific evidence (Huber et al., 2022), which can be detrimental to society in the long run. Against this background, scholars have explored the factors influencing trust and distrust in science (Jennings et al., 2021). Despite some variations across different studies, the two most important factors identified are education (Desmond, 2022; Hopf et al., 2019) and political ideology (Merkley, 2020; Moon et al., 2022). That is, those who are highly educated and hold liberal ideologies (i.e. politically leftist ideologies in the US context) are more likely to trust science than those who hold conservative ideologies.

However, there are limitations to this line of research. Primarily, the predictors of science trust or distrust identified are derived from survey analyses that use fixed response options. This method does not enable researchers to uncover the detailed reasons or thoughts behind these responses. For example, while studies show that conservatives tend to distrust science more than liberals (Gauchat, 2012), they often lack detailed explanations—beyond speculation—on how liberals and conservatives differ in their views of science, scientists, and the scientific community. This oversight is significant, as recent research indicates that the dynamics of trust or distrust in science cannot be neatly divided into conservative rejection and liberal acceptance.

In this study, we combine survey analysis with computational text analysis to simultaneously model how sociodemographic/political/media factors (derived from traditional survey items) and cultural factors (derived from open-ended survey responses) explain trust/distrust in science. By integrating these methods, we aim to identify factors beyond sociodemographics and political ideology that influence trust in science. We found that concerns over boundary-crossing—meaning perceptions of science overlapping with politics, government, and funding—significantly impact trust in science, even after accounting for political ideology. In other words, individuals who hold such concerns are less likely to trust science. Conversely, those who view science as a distinct, impartial, and highly professionalized institution are more likely to trust it.

In what follows, we provide a literature review of trust in science and discuss the theoretical literature used to motivate what the text data can tell us about differences in trust in science beyond sociodemographic factors. Specifically, we draw on work in cultural sociology on symbolic boundaries and boundary-crossing. Subsequently, we detail our methods, present findings, and conclude with a discussion.

Trust in science

Previous research has continued to attempt to develop the concept of general science trust (Krause et al., 2019). This concept is based on the idea that trust in general science is a crucial element in understanding individuals' heuristics for interpreting scientific information and science communication (Moon et al., 2022). Science organizations strive to maintain public trust as it is essential for individuals' understanding of scientific information (Brewer and Ley, 2013). Trust is referred to as faith in an entity that is informed by one's experiences, values, and mental models (Myers et al., 2017). Within the epistemic approach, science trust is an individual's confidence in scientists' performances and the observance of scientific norms (Wilholt, 2013). Furthermore, trust in science also relies on the perceived value of scientific methods in furthering societal progress (Achterberg et al., 2017). Thus, individuals' trust in science could be derived from their perceptions regarding science's performance, its impact on society, and its interactions with the public (Myers et al., 2017).

In operationalizing trust, most scholars use direct measures for their simplicity and respondent friendliness. However, there are concerns about these methods' limitations, as they may not capture all trust dimensions important to communication researchers and practitioners (Besley and Tiffany, 2023). To tackle these concerns, our study adopts a dual approach: we assess trust in scientists using three survey items with fixed response options and explore the reasons behind trust through open-ended responses, employing computational analyses. This method aims to provide a more nuanced understanding of the factors influencing trust.

Antecedents of science trust

Science trust does not naturally occur but is generated by various factors (Fischhoff, 2013). Trust in science is driven by individuals' perceptions of social entities, including scientists and science communities, as well as non-scientific subjects such as politics, culture, and religion (Brewer and Ley, 2013). Despite its complexity, researchers have been attempting to identify and explain the antecedents of scientific trust and distrust (Krause et al., 2019). Some categories are revealed to be critical factors of trust in science.

Education. Science education equips individuals with the ability to comprehend scientific information, shaping their belief in science and its methods (Riccardi, 2023). It is essential for enhancing scientific understanding, yet the link between scientific knowledge and trust in science is complex. Contrary to the deficit model (Simis et al., 2016), higher science literacy does not always lead to increased trust in science. Although a strong understanding of scientific concepts can reduce mistrust, it does not guarantee trust, as factors such as political views, perceptions of scientists, and personal experiences also play a role. However, since much distrust in science stems from misunderstandings of scientific methods and the scientific community (Priest et al., 2003), it is clear that knowledge from science education significantly impacts public trust in science (Achterberg et al., 2017).

Politically liberal ideology. Political attitudes have an influence on science trust (Myers et al., 2017). Specifically, liberal ideology is likely to promote trust in science by increasing confidence in the scientific community, while conservative beliefs may lead to distrust in science (Gauchat, 2012). In addition, conservative beliefs tend to be associated with doubt about scientific progress (Jones-Jang et al., 2020). Numerous science communication studies delve into the politicization of science and its impacts on public trust in science (Gauchat, 2012; May, 2020). This politicization happened in two dimensions: (1) the transformation of scientific matters into political issues and (2) the political engagement of scientists. The problem is that both politicizations are unavoidable in the real world. Some scientific findings that are related to human society's safety can lead to advocating political actions such as making regulations. Given that science (especially social science) often veers toward liberal ideologies, liberal people are more likely to support science that is aligned with their political direction. For instance, certain conservative segments of the population reject the necessity of vaccination and climate change mitigation. They perceive these measures as government intrusions into private lives, which they believe can compromise personal freedoms (Winter et al., 2022). While science is inherently apolitical, such perceptions might lead the public to believe that science aligns with a liberal stance or associates with a particular political party (Kozlowski, 2022).

Political interest. Individuals who have a high level of political interest will have greater scientific trust. Politicians and political organizations often use science information when communicating or promoting their policies, leading those with a high level of political interest to be exposed to more information regarding science-related issues (Strömbäck et al., 2013). Political interest significantly influences the consumption of science news, providing the public with greater opportunities to access scientific information (Hardy and Tallapragada, 2021). This increased exposure to science information allows individuals to better understand and trust science (Hendriks et al., 2016). In addition, political interest levels can indicate trust in social systems and respect for various societal agents, including scientists (Nisbet et al., 2002). Unlike those with political skepticism, individuals keen on politics often express their beliefs about humanity's advancements in science (Fairbrother et al., 2019). Since science represents a "mediated reality," a comprehensive understanding of it requires diverse background knowledge (e.g. in politics) in addition to pure scientific knowledge. Such a broad perspective can enhance an individual's trust in science (Scheufele, 2014).

News media use. Studies suggest that news media consumption is linked to specific perceptions of science (Hmielowski et al., 2014; Moon et al., 2022). While news frames can vary based on the media channel's objectives, traditional media outlets often rely on science organizations and scientists as sources or fact-checkers when covering scientific topics (Chuan et al., 2019). This increased use of scientific information can stimulate individuals' scientific knowledge and familiarity with science communities (Lee and Ho, 2015). Furthermore, the presence of scientists in the media can enhance public trust in science by disseminating scientific information and strengthening the connection between scientists and the public (Nisbet et al., 2002). Thus, our hypothesis is:

> H1. Education (H1a), liberal ideology (H1b), political interest (H1c), and traditional news (H1d) are positively associated with trust in science.

Social media use. Beyond traditional news outlets, the influence of social media usage on trust in science remains a topic of debate among researchers, given the plethora of divergent research findings (Jennings et al., 2021; Van Dijck and Alinejad, 2020). On one hand, users frequently come across scientific content on social media, as science institutions, governments, and news outlets actively disseminate scientific insights and fact-checking messages online (Martin and MacDonald, 2020). These initiatives by the scientific community provide straightforward access to reliable scientific data, frequently sourced from esteemed media organizations. Moreover, social media paves the way for genuine interactions between scientists and the general public (McClain, 2017).

Such engagements play a significant role in molding positive views of scientists and recognizing their value in society. For instance, Huber et al. (2019) found that social media news consumption is positively related to trust in science, although certain psychographic factors may explain the differences between countries.

However, the proliferation of misinformation or pseudoscientific claims on social media can erode this trust, leading to skepticism or outright distrust in science (Lee et al., 2023a). Social media has emerged as a primary conduit for spreading fake news on scientific topics. Without rigorous fact-checking measures and timely interventions from scientists, individuals' reliance on social media could lead to a decline in trust in science and an increased susceptibility to unscientific rumors (Chung et al., 2023; Jennings et al., 2021; Lee et al., 2023b). Thus, our first research question (RQ) is:

RQ1. How is social media news use related to trust in science?

Symbolic boundaries and boundary-crossing

Studies have shown that political conservatives are frequently skeptical of the relationships between science and the state (Gauchat, 2015), the government (Moore, 2008), and policymaking (Evans and Feng, 2013). These findings point toward a more general tendency for conservatives (more so than liberals) to hold concerns over crossing symbolic boundaries in science.

Symbolic boundaries are shared "conceptual distinctions" used to legitimize the exclusion of some people, objects, institutions, and practices from others (Lamont and Molnár, 2002). They function as socially learned and socially shared classification systems, sorting people, objects, institutions, and practices into in-groups and out-groups (Turner et al., 1979). Drawing from self-categorization and social identity theory, the boundaries between categories are maintained via prototypes—abstractions of category qualities to which candidate objects are compared to assess whether (or the extent to which) the object is an instantiation of that category (Hampton, 1995). Categorization based on prototypes functions to minimize differences within groups and maximize differences between groups (Hogg and Terry, 2000).

Symbolic boundaries can take on a moral imperative (Lamont, 2000). Maintaining boundaries between groups can, by way of analogical reasoning (Rumelhart and Abrahamson, 1973), be likened to keeping profane forces from "polluting" sacred domains (Alexander, 1989; Douglas, 1966). When morally loaded boundaries are perceived as crossed, responses can be strongly normative and emotional (e.g. impassioned rhetoric as to why the contamination is unacceptable).

Scientists regularly engage in boundary work to differentiate science from non-science (Gieryn, 2022). Originally, this demarcation aided both scientists and policymakers in defining the distinct roles of science and policy when addressing societal challenges. Through negotiations, both science and policy can delineate their societal roles, especially in domains where science must examine facts stemming from heated political debates (Wiegleb and Bruns, 2023). Boundary work serves to help the public discern between purely scientific understandings and topics ripe for broader public discussion, ultimately fostering more informed decision-making based on scientific evidence (Gieryn, 2022).

Scientists frequently engage in boundary work to bolster public trust in science by distinguishing it from political debates (Scott, 2016). This process establishes symbolic boundaries in people's minds regarding the societal roles of scientists (Hutcherson et al., 2023). When scientists venture into other societal domains like politics, it is perceived as a potential encroachment on established boundaries (Hendriks and Bromme, 2022). It stands to reason that consumers of scientific information similarly consider boundaries around science as an institution and scientists as a category of people. Media effects research has shown that scientists are "portrayed as an elite and privileged group . . . wearing white lab coats or suits to differentiate themselves" from the general public (Nisbet et al., 2002: 587). In the popular imagination, science is often perceived as an autonomous institution dedicated to generating and disseminating new knowledge for the common good. However, when the public perceives a close interdependence between science and economic and political interests, which prioritize power and profit (aligned with "partial interest" rather than the "common good"), it can undermine public trust in science (Hendriks and Bromme, 2022; Peters, 2015).

Despite the theoretical predictions implied above, the dearth of research on public perception of boundary work and the symbolic boundaries of science leads us to pose a research question rather than formulate a specific hypothesis.

RQ2. How is perceived boundary crossing related to trust in science?

2. Methods

Data

The data for this study were collected through a cross-sectional survey administered by Qualtrics LLC, a polling company that enlists online survey participants who receive compensation for their involvement. The survey was conducted on 9 and 10 November 2022, shortly after the US midterm elections. It involved 797 adult participants and was nationally representative, reflecting demographic proportions based on the 2020 US decennial census.

Measurements

Dependent variable: trust in science. Drawing upon Nisbet et al. (2015), respondents were asked on a 7-point Likert-type scale (1 = strongly disagree, 7 = strongly agree) to indicate the extent to which they agreed with the following statements: "I have a great deal of confidence in scientists/the scientific community," "I generally trust the things that scientists say about previously unknown diseases (or 'new' diseases), such as COVID-19, Ebola, Monkeypox, etc.," and "Scientists know best what is good for the public" (Cronbach's $\alpha = .92$, $M = 5.17$, $SD = 1.62$). Since we used an open-ended question (which we address in more detail shortly) only for the first item, we decided to make it our primary outcome variable to ensure consistency in our analysis.[1] The results remained unchanged when using a composite dependent variable derived from all three items.

Independent variables from fixed response items

Political antecedents. We measured political ideology by having participants place themselves on a 5-point political ideology scale, ranging from 1 (extremely liberal) to 5 (extremely conservative) ($M = 2.69$, $SD = 1.25$). Subsequently, to gauge political interest, participants were asked to rate their level of interest in politics on a 5-point scale, with 1 indicating "not at all" and 5 indicating "extremely" ($M = 3.34$, $SD = 1.07$).

News media use. Drawing upon previous literature (Lee, 2020), we assessed traditional news consumption by having participants rate the frequency of their use of (1) television news, (2) radio news, and (3) print newspapers for acquiring information about social, political, or public affairs on a 5-point scale (1 = never, 5 = daily). The responses to these questions were averaged to create an index of traditional news use (Cronbach's α = .59, M = 2.40, SD = 1.16). Similarly, to measure social media news use, respondents were asked about the frequency of using social media sites (e.g. Facebook, Twitter, YouTube, and so on) to get news about social, political, or public affairs (M = 3.67, SD = 1.48).

Education. Education level was assessed as the highest level of education completed (1 = no formal education, 8 = doctoral degree, M = 5.62, SD = .96).

Independent variable extracted from open-ended response items: word usage. After answering the Likert-type scale trust in science question (the dependent variable in this study), respondents were asked the following question: "We'd like to know more about why you chose the above option. Could you share your thoughts in a little more detail?" Respondents were given a text box to provide an open-ended response.

To the extent respondents distrust science and scientists because of a perceived tendency for boundary-crossing, we should expect people who distrust science/scientists to use more words indicative of the sorts of "conflicts of interest" discourse frequently associated with science skepticism—e.g. "politics," "money," and "government." We might also expect respondents who trust science/scientists to use more words associated with articulating science as more morally rigorous—as a search for truth using objective methods, integrity, and professionalism.

We carried out the following steps to get word usages from the open-ended responses (in this order): transliterated the texts; removed capitalization; removed punctuation external to word sets (so that, e.g. "well-functioning" would not lose its hyphen); replaced contractions (e.g. "that's" became "that is"); removed numbers; removed excess whitespace; removed the words "science," "scientist," and "scientific," as these words were used across virtually all responses given the nature of the writing prompt; removed words that had a character length of two or less; tagged the parts of speech; and lemmatized the words (so that, e.g. "runs" and "ran" became "run," "and "mice" became "mouse").[2] The term frequencies were then binarized since the average response was relatively short, and subsequently, certain frequencies appeared highly skewed although the associated word was used only a few times. Finally, words that were absent from at least 99% of the responses were removed to trim the length of the vocabulary. This workflow resulted in a vocabulary of 110 words, where, per response, 0 = the word was not used and 1 = the word was used at least once.

Control variables. We controlled for a series of demographic variables—namely, age (M = 43.76, SD = 15.15), gender (Male = 1, Female = 2; 49.7% males), race (White = 1, Non-White = 2; 74.5% White), and monthly household income (Mdn = US$5000–US$6999).

Analytical strategy

We first report a series of baseline ordinary least squares (OLS) models without the text variables to show that our sample mirrors other studies in terms of the relationship between sociodemographic factors and trust in science. We then present the results of a ridge regression model that combines the text variables and sociodemographic covariates as predictors of trust in science. Such a model is desired when there are many predictors relative to the number of observations—119 predictors to N = 758 after listwise deletion, in this case—which can introduce a high potential for multicollinearity and overfitting. Ridge regression mitigates these risks by not minimizing the errors between observed and predicted values on the dependent variable in isolation—as is the case with OLS—but instead minimizing these errors while also systematically biasing the size of the coefficient estimates themselves. Biasing the coefficients with small effect sizes toward zero effectively means that the ridge model is able to avoid overfitting (by effectively "turning off" the effects of weak predictors) and minimize the coefficient variances that would otherwise be inflated in a regular OLS model with high multicollinearity.

More technically, ridge regression is a penalized linear model that adds a penalty to the cost function, which is defined as

$$C = \sum_{i=1}^{n} \left(y_i - \sum_{p=1}^{P} \hat{\beta}_p x_{ip} \right)^2 + \lambda \sum_{p=1}^{P} \hat{\beta}_p^2$$

where y_i is the ith respondent's observed trust in science level, x_{ip} is that respondent's observed value on the pth independent/control variable x, and β_p is the coefficient estimate for that variable. Everything to the left of the plus sign is the standard sum of squared errors that is minimized in an OLS model. The term to the right of the plus sign is the penalty term—known as the ridge penalty—which forces the estimator to reduce the sum of squared errors while also taking into account the size of the coefficient estimates themselves.

The λ weight determines how much the penalty term should factor into the cost function, with $\lambda = 0$ being the lower bound that effectively reduces the ridge regression to the OLS estimator. We used 10-fold cross-validation to find the optimal λ. Specifically, we created a vector of 100 possible values and then separated the observations into 10 subsets. We then ran 10 ridge regression models for each λ, where the model was trained on nine of the subsets and then used to predict the trust scores in the heldout subset. Each subset was predicted using a model derived from the other nine subsets for each λ. The average mean-squared error for each λ is then reported. We chose the largest λ that was within one standard error of the λ with the smallest average mean-squared error.[3]

Finally, to generate confidence intervals for the coefficient estimates, we used bootstrapping. We resampled from the data 1000 times, with replacement, maintaining the observed analytic sample size ($N = 758$). We then ran a ridge regression model for each of these bootstrapped samples (using the λ from the "real" regression). The 95% confidence intervals were the values at the 2.5 and 97.5 percentiles in the rank-ordered distributions per coefficient estimate. All predictors in the ridge model are in standardized form with a mean of 0 and a standard deviation of 1, except for the word usage, gender, and race variables, which are dichotomous and therefore left unstandardized.

We opted for a natural language processing (NLP) approach rather than manual coding as our dimension reduction technique. This choice was driven by our aim to uncover latent patterns that could potentially be missed with manual human coding.

3. Results

Sociodemographic factors

First, we present the results based on the traditional OLS approach. As presented in Table 1, those with higher political interest, higher levels of educational attainment, liberal people, and those who consume more news via traditional media tend to trust science more than their counterparts, which is consistent with most of the previous studies in this area. Thus, H1 is supported.

Table 1. Predicting science trust (traditional OLS approach).

	Trust in science
Age	–.00
Gender (ref = female)	.03
Education	.19**
Race (ref = non-white)	.20
Income	.00
Political interest	.12*
Ideology (conservative = high)	–.68***
Social media news	.06
Traditional news	.16**
R^2 (%)	30.0
N	797

OLS: ordinary least squares.
Cell entries are unstandardized regression coefficients.
*$p < .05$; **$p < .01$; ***$p < .001$.

The role of boundary-crossing

Figure 1 presents the results from the ridge regression, which regresses the trust in science variable on the sociodemographic and text covariates together. As the figure shows, a range of sociodemographic, media use, and political factors, along with word usage predictors, are significantly associated with differences in trust in science. The statistically significant sociodemographic predictors of higher levels of science trust are political ideology, traditional news consumption, political interest, and educational attainment. In terms of word usage, a number of statistically significant words ($p < .05$) indicate a relationship between trust levels and boundary crossing. For example, if a response contains the words “grant,” “fund,” “politics,” “government,” and/or “agenda” (among others), then that respondent is likely to be more distrusting of science/scientists.

This suggests that respondents are more distrusting of science when they couch their articulations for why they distrust science in a “conflict of interest” type of discourse, which portrays the scientific field as closely intertwined with politics and financial interests, implying competition among stakeholders with winners and losers, rather than its traditional role as a common good (for further elaboration, refer to Peters, 2015). Importantly, these findings hold true even after controlling for the array of sociodemographic, news media use, and political factors, including political ideology, which has been the most consistent and significant predictor of trust in science. In fact, we ran a version of the model with only “very liberal” and “liberal” respondents included ($N = 377$), and the words predictive of distrust were very similar (see the Figure in Supplemental Appendix A). For example, “government,” “fund,” “politics,” and “grant” all remain predictors of distrust in science, even with only self-described liberals kept in the sample.

Referring back to Figure 1, the words predictive of higher trust in science are also informative. Words such as “educate,” “research,” “knowledge,” “experience,” and “evidence” are all indicative of seeing science as a rigorous, morally upright institution full of highly educated professionals dedicated to knowledge production who have a careful system of checking their claims (i.e. peer review).

To test for a potential interaction effect between political ideology and boundary word use, we also ran an OLS model keeping all sociodemographic/news media use/political variables and

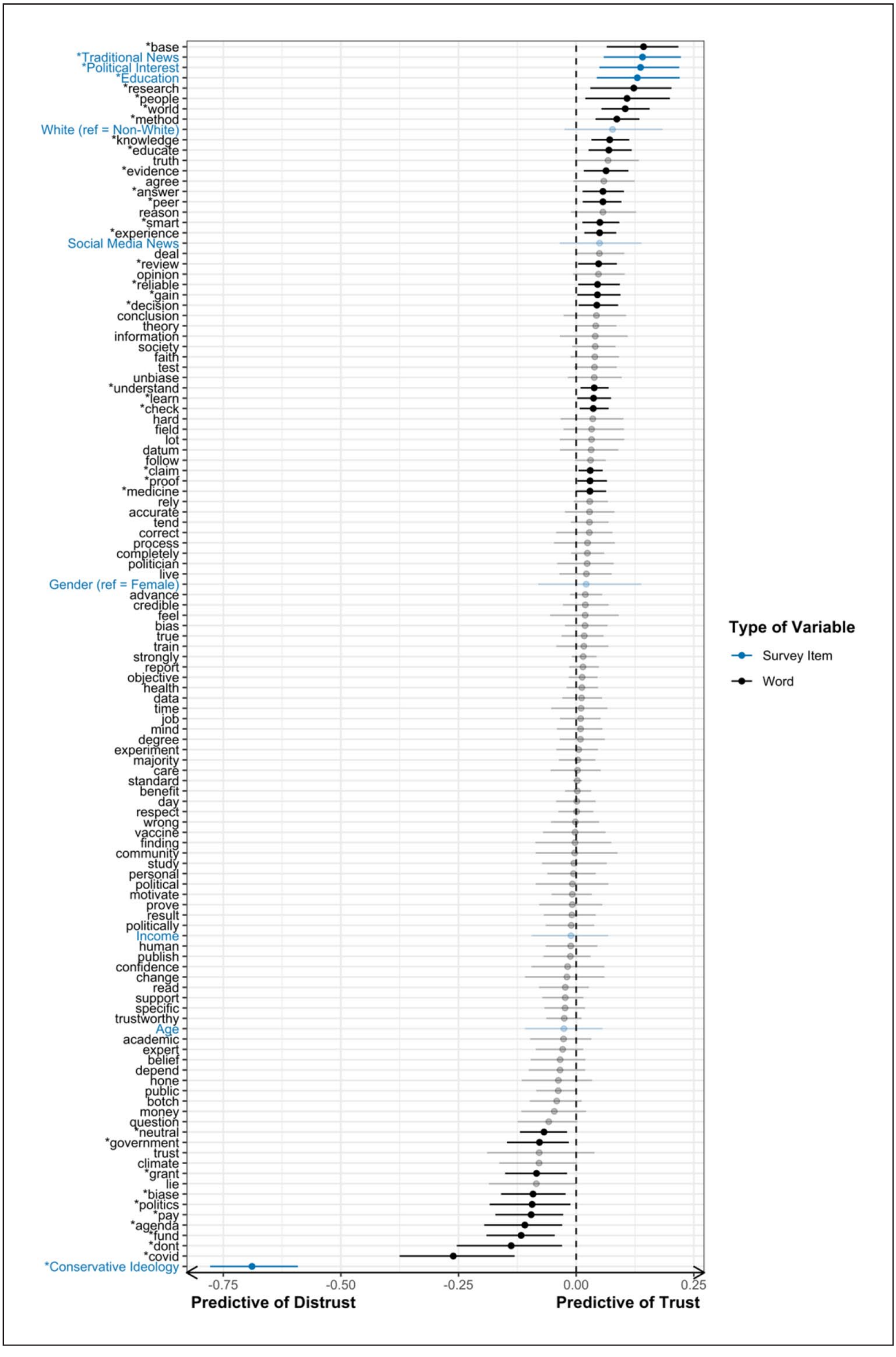

Figure 1. Ridge regression results predicting trust in science levels.

Points are coefficient estimates and bars are 95% confidence intervals derived from 1000 bootstrapped samples. Any bar that does not cross the vertical dashed line is statistically significant at least $\alpha = .05$. Non-significant estimates are in gray. Statistically significant variables have an asterisk next to their *y*-axis labels. All predictors are in standardized form, except for the word usage, gender, and race variables, which are dichotomous. R^2 (%) = 35.1; $\lambda = 0.316$; Intercept = 5.264; $N = 758$.

created a new “boundary word” variable that summed together the “fund,” “agenda,” “bias,” “pay,” “government,” and “politics” word usage variables.[4] Ideology was then interacted with the boundary word variable; the model is in Supplemental Appendix B (second model in the table). Boundary word usage does not seem to vary by ideology. Furthermore, the first model in Supplemental Appendix B—which substitutes the single “boundary word” variable for the 110 words in the ridge model but with no interaction with political ideology—shows the same result as the ridge model: all else equal, using some combination of “fund,” “agenda,” “bias,” “pay,” “government,” or “politics” in their open-ended response is negatively associated with trust in science ($p < .001$).[5]

In summary, concerns over boundary-crossing are negatively associated with trust in science, even after controlling for political ideology. This would suggest that self-identified conservatives and liberals are more likely to distrust science when they hold concerns over boundary-crossing—especially when it comes to funding, politics, and government. This finding is further supported by additional robustness checks, including the analysis presented in Figure A in the Supplemental Appendix, which demonstrates that boundary-crossing words remain predictive of distrust even when the sample is limited to liberal and very liberal respondents. In addition, the table in Supplemental Appendix B indicates that there is no statistically significant interaction between political ideology and the usage of boundary words.

4. Discussion

Science is the foundation of our current understanding of the world, and it enables us to make informed decisions that are beneficial for ourselves and society. Despite its essential role and with the scientific process becoming more rigorous and transparent, various studies suggest that public trust in science is not improving, if not declining (Pew Research Center, 2023). To address this concerning pattern, several studies have investigated the factors that predict trust/distrust in science (Hornsey et al., 2016; Lewandowsky and Oberauer, 2016). The majority of these studies are based on closed-ended survey research. While these studies offer valuable contributions to existing scholarship, they also have limitations—such as researchers being unable to gain a more in-depth understanding due to fixed response approaches in surveys. Alternatively, some studies use in-depth interviews, which provide researchers with insights, but are limited in their ability to make generalizations or systematic comparisons. This study takes a unique approach, combining computational text analysis with traditional survey analysis to complement previous studies in this area.

First, our findings corroborate those from previous research on trust in science. Through both OLS and ridge models, we found that factors such as political interest, traditional news consumption, education, and liberal ideology are essential in predicting trust in science. Our results demonstrate that those with higher levels of political interest, educational attainment, liberal ideology, and those who consume more news via traditional media tend to have more trust in science compared to their counterparts. These findings support Scheufele’s (2014) theoretical framework, highlighting the importance of considering science communication within the broader political landscape. In this context, the exchange of scientific information and its public reception are closely connected to the shaping of public opinion, policy formulation, and decision-making processes, underscoring the complex relationship between public trust in science, socio-political factors, and media consumption habits.

In addition to the previously identified factors influencing trust and distrust in science, our research also reveals that perceptions of boundary-crossing may play a significant role in shaping people’s trust in science. For example, analysis of the open-ended survey question showed that those who distrust science/scientists used more words indicative of “conflicts of interest” discourse, such as “politics,” “money,” and “government.” Interestingly, the effect of boundary-crossing perception on the trust in science outcome variable remained significant even after controlling for political ideology. People who worry that the scientific community is crossing boundaries with politics, government, funding conflict, and so on, tend to trust science less regardless of their political ideology. A replication of the ridge regression with the subsample of self-identified liberal respondents (see Supplemental Appendix A) and a model testing for interaction effects between ideology and word usage (see Supplemental Appendix B) further support our argument.

This finding is in line with recent studies that suggest that both strong liberals and conservatives tend to be prone to conspiracy beliefs (but susceptible to different types of conspiracy stories), as they believe that powerful actors/systems are operating covertly to benefit the other side. This is applicable to our study, as people may think that science can be influenced by politics, the government, or money (reflecting a latent concern with boundaries being crossed), which can aid the opposing side. This implies that the previously suggested explanation of conservatives being more distrustful of science/scientists may not be a complete picture of science distrust. Our study offers additional insights into the factors that influence public trust or distrust in science. It contributes to the existing literature by suggesting a nuanced perspective on the relationship between political ideologies, particularly conservatism, and engagement with contentious issues such as misinformation spread, vaccine hesitancy, and similar topics (Ahmed and Tan, 2022).

Also, our findings on the effect of boundary-crossing on science trust suggest that the public believes in the "purity" of science. Individuals have their own views about the social roles of science. Nisbet et al. (2002) argued that individuals perceive scientists as "priests" who keep their distance from societal conflicts (p. 587). People would feel betrayed if scientists stepped beyond what is seen as their "genuine area." This perception is somewhat opposite to the current trend of science, which emphasizes the consideration of the societal implications of scientific innovations and encourages scientists to be socially active beyond the confines of their labs and fields (Moon and Kahlor, 2022). Our results imply that scientists' social activities may not always improve scientific trust unless the boundary-crossing issue is addressed. Within this contested terrain, we can conclude that science trust is influenced by the preconceived notions of the social roles of science communities and the image of researchers who are independent of external factors.

Our findings prompt theoretical inquiries regarding scientists' credibility in science communication. While scientists are typically viewed as the most authentic and reliable sources of scientific information, the public appears to circumscribe their credibility strictly within their areas of expertise. This perception underscores the public's view of scientists as specialized professionals rather than members of an intellectual elite or a distinct echelon within the scholarly community. On one level, this perspective is sound; a scientist's qualifications in their field do not inherently validate their expertise in unrelated domains without corroborative evidence (Atir et al., 2015). Such discernment can assist the public in navigating potential expert biases (Hansson et al., 2017). Conversely, this stringent view of a scientist's scope might inhibit their broader engagement with the public. In recent times, scientists have increasingly interacted with the public through various media, including social and digital platforms, sharing not just their scientific viewpoints but also personal insights and stances on diverse societal issues. According to our findings, knowledge of scientists' personal endeavors or civic engagements, beyond their strict scientific roles, might erode public trust in science. Yet, past studies in science communication have overlooked this potential pitfall, focusing predominantly on the positive outcomes of scientists' public interactions (Huber et al., 2019; Van Dijck and Alinejad, 2020). This underscores the need for scientists to adopt a strategic approach when communicating about science (Besley et al., 2019).

In addition to the theoretical implications mentioned above, it is important to highlight the methodological contributions of this research. As mentioned earlier, much of the previous research in this field relied on survey analyses using fixed response options, which had limitations in capturing the detailed reasons or thoughts behind participants' responses. By integrating survey analysis with computational text analysis to concurrently model sociodemographic/political factors (derived from traditional survey items) and cultural factors (derived from open-ended survey responses) explaining trust/distrust in science, this innovative method offers valuable insights. This innovative method is expected to be highly useful in exploring other research questions where researchers aim to obtain more nuanced responses from participants beyond fixed-response options, thus making this approach widely applicable across various domains.

Besides these theoretical and methodological implications, this study also offers practical insights. Scholars and policymakers can leverage our approach and findings to gain a granular understanding of the critical drivers of science distrust in the public sphere. The findings could be used to create more targeted public campaigns to cultivate greater trust in science. Our approach also demonstrates how computational text analysis can be used to identify and address the source of negativity (in this case, boundary-crossing). Given these findings, concerned authorities and policymakers should strive to provide greater transparency in how the scientific community and other sectors, such as politics, interact with each other. This may help to reduce some of the public's concerns. Finally, we highlight that boundary-crossing plays a major role in the public's distrust of science. These findings can be used in conjunction with other metrics, such as national survey data, to inform decisions in policymaking.

Despite the aforementioned theoretical and practical implications, several limitations in this study point to directions for future research. First, distrust in science varies by issue, as indicated by Pechar et al. (2018). Our data show that those distrustful of science often cite specific topics like climate change and COVID-19, while those who trust science generally express broad confidence in science and scientists. This suggests that distrust in science may be issue-specific, emphasizing the need for tailored approaches to address issues such as COVID-19 and climate change rather than a blanket approach to science as a whole. Second, a limitation of our text-analytic approach to measuring concerns over boundary-crossing is that it does not allow us to probe precisely why a respondent might perceive political, governmental, or financial interests in science as a boundary issue. For instance, are concerns about funding rooted in a fear of conflict of interest, or do respondents cite instances of bias from scientists aligning with funders? Do concerns differ between private corporations and public funding agencies? Moreover, do these variations in boundary-crossing concerns impact overall trust in science or scientists differently? In-depth interviews could provide valuable insights into these questions. Finally, the R-squared value for the Ridge Regression is 0.351, showing a modest improvement from the 0.3 observed in the OLS regression. This indicates that additional multifaceted social factors may still significantly influence the dependent variable.

5. Conclusion

Public trust in science is essential for the proper functioning of contemporary societies. In recent times, its importance has only grown, as trust in science acts as a pivotal factor in managing and combating current global risks and crises. Nevertheless, despite its normatively important role, trust in science/scientists is not very high, which could impede the progress of scientific research and development as well as the implementation of evidence-based policy. Building upon previous studies on public trust/distrust in science, and by combining traditional and computational methodologies, we suggest that it is crucial to acknowledge that trust/distrust in science is not only a matter of education or ideology but also of how people perceive the influence of other sectors in the scientific arena. Future studies should continue to gain a more sophisticated understanding of people's complex perceptions of scientific issues.

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Supplemental material

Supplemental material for this article is available online.

Notes

1. While we have three fixed-option survey items to measure trust, it doesn't make analytical sense to use different sets of open-ended questions for each trust item and then combine them. Therefore, we proceeded with analyzing only the first item.
2. The POS tagging and lemmatization were carried out using the udpipe package in R (Wijffels et al., 2019).
3. We used the glmnet package in R to perform the ridge regression and 10-fold cross-validation (Friedman et al., 2010).
4. All of these words were simultaneously statistically significant predictors of distrust in science and also words that could be used to reference the contaminating influence of politics and money on science in the respondents' open-ended articulations as to why they distrust science.
5. These "boundary word" model results hold after subsetting the sample to only "liberal" and "very liberal" respondents as well.

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