Threat of China's nuclear dominance boosts Americans' support for nuclear energy

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Highlights:

- Fear of nuclear plant radiation depresses public support for nuclear energy expansion
- A US sample of respondents were told of a high profile nuclear plant closure
- Hearing of China's rapid expansion of nuclear energy capacity increased support
- Support increased for renewing licenses of nuclear plants and building new plants
- Another frame on increased emissions only increased support for license renewal

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Abstract

Sections of the American public are skeptical of radiation safety. This skepticism can be challenging to the expansion of nuclear capacity in the United States despite its benefit as a stable source of clean energy. Here we implement a survey experiment to determine what information is most persuasive to reducing this skepticism. Informing respondents about China's aggressive construction of nuclear plants and the United States' premature closures boosts support for both license renewal of existing plants and building new nuclear plants. Moreover, under this information frame the majority of the sample supported both policies. A separate information frame that posed nuclear energy as necessary for achieving net-zero goals only raised support for license renewal of existing plants but not building new plants. Both frames equally increased support for nuclear energy among women and Democratic party voters, groups that are generally more skeptical of nuclear energy. The threat of China's dominance boosted nuclear support among several additional groups such as Independent voters and middle-aged voters that the clean energy frame did not. Our experiment demonstrates that respondents averse to nuclear risk can support nuclear energy by weighing risk-benefit trade-offs without necessarily receiving information about why the risks are negligible.

Keywords : nuclear energy; geostrategic competition; Sino-US rivalry; radiation risks; nuclear plants

1 Introduction

On its face, nuclear power could be a middle ground between energy security advocates and environmental advocates. It reduces US national reliance on imported fossil fuels while offering a pathway to achieving net-zero emissions. Yet concerns about nuclear disasters and the leeching of radioactive substances during production and waste disposal have made such a compromise unappealing to environmentally-minded constituents.

Nuclear experts lament that radiation concerns from nuclear energy production are exaggerated. Survey studies have shown that the public often overestimates the risk of radiation from nuclear power plants while underestimating the risks associated with medical X-rays, especially compared to the evaluations of nuclear professionals (Slovic 2012; Perko 2014). Moreover, medical studies have not found evidence of increased cancer rates in communities near nuclear installations (Jablon, Hrubec, and Boice 1991; Kim, Bang, and Lee 2016).

However, in participatory democracies, public perceptions—whether accurate or inflated—carry considerable weight. Many decisions related to nuclear energy, including the location

of nuclear power plants, waste disposal facilities, and transportation routes, are subjected to intense local public scrutiny. These concerns can also play out nationally, such as in the case of the Yucca Mountain nuclear facility in Nevada (Ramana 2011). Even individuals unconcerned by radiation risks may oppose nuclear facilities in their vicinity due to fears of long-term declines in property values (Gawande, H. Jenkins-Smith, and Yuan 2013).

Nuclear skepticism has mired the renewal of nuclear licenses and building new plants in burdensome regulatory schemes (Slovic 2012). Despite America's dominance in harnessing nuclear power, these burdens have now slowed down the deployment of new reactors and hastened the retirement of existing stock. In contrast, countries such as China and India are rapidly adding nuclear capacity (IAEA 2024).

Past efforts to build public support for nuclear energy have focused on correcting perceived risk distortions through information treatments. However, such attempts often fail to move attitudes, likely due to strong associations between nuclear energy and nuclear weapons (Slovic 1987; Baron and Herzog 2020; Abdulla et al. 2019).

Instead of aiming to reduce perceived risks, we test whether reframing the debate as a trade-off between familiar risks (radiation) and less familiar benefits (lower emissions or competitiveness in a global energy race) can shift public opinion.

Our survey experiment tests two pro-nuclear persuasive frames. The first highlights nuclear energy's role in reducing carbon emissions and meeting net-zero climate goals, echoing past messaging efforts (Ansolabehere and D. Konisky 2014; Feldman and Hart 2018). The second, more novel frame invokes geopolitical competition: respondents are told that China is rapidly expanding its nuclear capacity, while the US falls behind. Although national competition has been tested in domains such as workplace automation (Wu 2024), international aid (Chung, Pechenkina, and Skinner 2023), and foreign interventions (Levin and Musgrave 2023), it has not been applied to the nuclear energy debate.

To situate the intervention in a real-world context, all treatments referenced the closure of the Indian Point nuclear plant in New York. The plant was in the process of extending its operating license when a combination of economic factors and environmental opposition led to its shutdown (Yee and McGeehan 2017). Riverkeeper, the environmental group spearheading the opposition, claimed that the nuclear power plant discharged radioactive isotopes into the Hudson River and is an ecological liability. The movement to close the plant received high-profile support from celebrities and then Governor Andrew Cuomo (Booth and Cameron 2023).

Our survey experiment was fielded to a representative sample of 2,211 US registered voters. The sample was randomly divided into four groups. A pure control group received no prompt. A second control group received information about the Indian Point closure

only. Two treatment groups received that same information plus either (1) a clean energy frame or (2) a China competition frame. After reading the prompt, all participants were asked about their support for renewing existing nuclear licenses and building new plants.

Both pro-nuclear frames increased support for nuclear license renewal compared to both the pure and context control group, pushing the overall support level to above 50% among treated respondents. Only the China frame, however, also raised support for building new plants above the 50% threshold.

The frames' persuasiveness differed across groups. Women and Democratic Party voters—groups usually opposed to nuclear energy—were more likely to support building new nuclear plants under both frames. In contrast, Independents and middle-aged respondents were persuaded only by the China competition frame. While the frames had no statistically significant impact on men and Republican party voters, this was more to do with their higher baseline support for nuclear energy than with the content of the frames. Despite the increase in support by women, their support for building new nuclear plants did not exceed 40 percent under any frame.

These findings suggest that framing nuclear energy within the context of geopolitics can be highly persuasive. Specifically, emphasizing China's rapid nuclear expansion and portraying the US as lagging behind a geopolitical rival could activate concerns about maintaining US leadership and energy independence. Such framing would likely resonate across partisan lines, as it taps into broader anxieties about global competition and national strength.

In the next section, we will briefly discuss the history of nuclear persuasion literature and the rationale for the specific frames used. Then we introduce the survey and the specific prompts used in the framing experiment. After reporting our topline results, we investigate the heterogeneity of the treatment effects by subsetting the sample along demographic characteristics such as age group, education, sex, and partisanship.

2 Nuclear persuasion research

Dwight D. Eisenhower was a persuasive proponent of nuclear energy. His advocacy of *atoms for peace* ushered in a period of high support for nuclear energy that lasted more than 20 years, until several high-profile accidents caused reductions in support among the American public (Bolsen and Cook 2008).

2.1 A brief history of nuclear persuasion research

Attempts to understand these aversions to nuclear power began in the risk literature. A series of studies by Paul Slovic reported several inconsistencies in the way radiation risk is processed as opposed to other types of risk. Slovic, Fischhoff, and Lichtenstein (1979) reports systematic differences in how nuclear experts rate nuclear risks versus the general public. And Slovic (1987) finds that the public seems to dread radiation more than other hazards that are more likely to cause death and destruction. Yet making them aware of the actuarial risks did not alter risk perceptions. More recent experimental efforts also attest to the dread effect (Abdulla et al. 2019).

Given the discrepancy between experts and laypeople, many studies have considered that scientific sophistication and knowledge can explain these differences. Stoutenborough and Vedlitz (2016) finds that the greater the knowledge about energy production, the more moderate risk perceptions are. These lower risk perceptions also correlated with greater support for nuclear energy (Stoutenborough, Sturgess, and Vedlitz 2013; Ansolabehere and D. Konisky 2014). Others have discovered that those living closer to nuclear facilities also become more tolerant of the risks over time and supportive of nuclear energy (Greenberg 2009; H. C. Jenkins-Smith et al. 2011).

Yet survey findings on proximity or knowledge only imply a correlation. It is possible that those who are more favorable towards the industry know more about it. Or that those who are more tolerant of nuclear risks live close to facilities. If this is the case, persuasion through informational treatments on risk could be less effective than estimates from surveys imply.

Purely educational efforts to allay radiation risk perceptions deliver mixed results, usually increasing awareness of the true risk but not meaningfully changing risk perceptions or increasing support for nuclear energy (Perko et al. 2012; Abdulla et al. 2019).

2.2 Persuasion with trade-offs

Given the durability of nuclear risk perceptions, we do not expect that simply correcting these misperceptions will meaningfully shift public opinion. Prior research suggests that attempts to directly downplay perceived nuclear risks are often ineffective, due in part to the emotional salience of radiation and nuclear accidents. Instead, we adopt a different strategy: highlighting the benefits that are forgone when no level of radiation risk is deemed acceptable.

Specifically, we focus on two types of trade-offs: 1) the risk of radiation exposure versus the need for a stable, low-emissions energy supply, and 2) the risk of radiation versus the

imperative of maintaining US competitiveness in a global energy landscape. While concerns about radiation may be valid, they coexist with other salient concerns, such as energy shortages, air pollution, and geopolitical vulnerability, that may alter the calculus of public support. We test two frames that present nuclear energy as a necessary tool to address these competing concerns: one focused on the environmental costs of reduced nuclear capacity, and the other on China's rapid nuclear expansion as a geopolitical challenge.

First, we expect that when framing nuclear energy as an avenue to maintain a stable supply of clean energy will reduce public opposition[1]. This prediction is informed by several studies in the renewable energy space. In a survey experiment, Stokes and Warshaw (2017) finds that support for renewable portfolio standard policies increases if the policies are framed as a way to reduce harmful air pollution. In the nuclear domain, Ansolabehere and D. Konisky (2014) shows that exposure to information about toxic emissions from fossil fuels significantly boosts support for nuclear power. More recently, Bolsen, Druckman, and Cook (2014) finds that air pollution arguments increased support for nuclear energy moderately, but support increased more drastically when supplemented with scientific evidence that nuclear waste storage can be achieved safely.

Our second expectation centers on the role of geopolitical competition, specifically, US-China rivalry, as a persuasive frame for nuclear support. Although this frame has not been previously tested in the nuclear energy context, there is growing evidence that it can shift public opinion across a range of policy areas. In recent years, both US and Chinese leaders have expressed concern over economic interdependence and technological competition. If these elite concerns reflect broader public sentiment, then highlighting China's growing nuclear capacity may increase support for domestic nuclear investments.

Framing energy development in terms of national security and international rivalry has proven effective in related areas. For instance, Hazboun et al. (2019) find that, among several tested frames, energy security elicits the highest support for renewable energy. Gainous and Merry (2021) similarly show that national security concerns, especially dependence on oil from adversarial states like Venezuela, Russia, and Saudi Arabia, can increase support for climate action, though these effects are sometimes polarized by partisanship.

Geopolitical competition frames have also been influential in shaping public preferences on trade, aid, and technology policy. Carnegie and Gaikwad (2022) demonstrate that Americans prefer trade with allies over rivals like Russia. In the foreign aid domain, Chung, Pechenkina, and Skinner (2023) find that framing Latin American aid as part of a US-China donor rivalry increases public willingness to fund international assistance. In the technol-

[1]We opt for an air pollution argument than a climate change argument, because several studies warn of backlash effects to such a framing. See (Feldman and Hart 2018; Hazboun et al. 2019) .

ogy realm, Wu (2024) shows that priming US-China rivalry raises support for workplace automation and reduces demand for government regulation of technological change.

Taken together, this evidence suggests that geopolitical competition is a powerful heuristic for activating support for policies that bolster national capacity. Therefore, we expect that framing nuclear energy in terms of US-China rivalry will have a positive effect on nuclear support. In the next section, we describe the survey design and experimental implementation.

3 Data

The survey was conducted online by YouGov. The questionnaire was developed by researchers at the California Institute of Technology. The data collection and analysis procedures were reviewed by the California Institute of Technology's Institutional Review Board and ruled exempt under 45 C.F.R. § 46.104(d)(2)(i),(ii) as it involves research using survey procedures where the identity of the subjects cannot be readily ascertained (Caltech IRB IR22-1220).

Respondents were recruited from YouGov's opt-in online panel to be representative of the population of US registered voters. The 2,211 subjects in the survey were interviewed by YouGov between June 26, 2024 and July 3, 2024. YouGov provided weights that were calculated using gender, age, race and education (as collected by the US Census Bureau), and the 2020 Presidential vote, 2022 Congressional vote, and the respondent's baseline party identification (the respondent's more recent answer to YouGov's party identification questions prior to November 1, 2022, and weighted to the estimated distribution at that time). These weights range between 0.1 and 5.0, with a mean of 1.0 and a standard deviation of 0.6. These weights are used in all the analyses reported in this paper. YouGov estimates the survey's margin of error to be approximately 2.4%.

This survey contained questions asking the respondents about their demographic characteristics (age, gender, race, education attainment, and their geographic region). It also asked their partisan identification and risk tolerance (measured here by asking respondents to choose between a certain 1000 USD and a lottery where there was a 50-50 chance of no winnings or 2000 USD).

3.1 The experiment's layout

A randomly selected quarter of respondents ($n = 584$) were chosen as the 'pure control' group, which is the label we will use for this group below. These respondents were asked the

following three questions without any prompting.

A To what extent do you believe the claims of environmental activists that nuclear energy production contaminates groundwater?

   (a) Fully believe

   (b) Somewhat believe

   (c) Do not believe

B Do you support or oppose renewing licenses for existing nuclear plants in the United States?

   (a) Support

   (b) Oppose

   (c) Neither support nor oppose

C Do you support or oppose building new nuclear power plants in the United States?

   (a) Support

   (b) Oppose

   (c) Neither support nor oppose

We allow for responses such as 'Neither support nor oppose' to prevent ambivalent respondents from inflating standard errors. Interpretation of effects on such responses is difficult. For instance, an increase in the number of 'Neither Support or Oppose' responses could mean that opposing respondents are now more ambivalent, that supporting respondents are now more ambivalent, or both have simultaneously occurred. Because of this difficulty, we only interpret changes in the 'Support' responses, but provide the full range of results for all responses.

Another randomly selected quarter of the sample (544 respondents) was given information about the context of Indian Point's closure and asked the same three questions as above. We refer to this group of respondents as the 'context control' group. They were shown the following:

> Bowing to pressure from environmental activists, the state of New York closed its Indian Point nuclear power plant in 2021. The activists claimed that the power station released radioactive isotopes into the Hudson river and contaminated groundwater. New York state has two other operational reactors that face similar opposition and whose licenses are set to expire at the end of the decade.

This second group serves as an additional control group if needed to difference out the effect of contextualizing plant closures. We refer to the group that saw the introduction as the 'news only' group.

The rest of the sample was divided into two groups to test the two pro-nuclear arguments. They were given the same news about Indian Point followed by a pro-nuclear framing. These frames are named the 'increased emissions' frame and the 'China competition' frame respectively.

The increased emissions frame seen by 550 reads,

> Bowing to pressure from environmental activists, the state of New York closed its Indian Point nuclear power plant in 2021. The activists claimed that the power station released radioactive isotopes into the Hudson river and contaminated groundwater. New York state has two other operational reactors that face similar opposition and whose licenses are set to expire at the end of the decade.
>
> Opposition to nuclear energy production is a challenge to achieving net-zero emissions. After shuttering the plant, New York filled the energy deficit by ramping up energy production from natural gas, thereby increasing emissions.

The China competition frame seen by 533 reads,

> Bowing to pressure from environmental activists, the state of New York closed its Indian Point nuclear power plant in 2021. The activists claimed that the power station released radioactive isotopes into the Hudson river and contaminated groundwater. New York state has two other operational reactors that face similar opposition and whose licenses are set to expire at the end of the decade.
>
> Opposition to nuclear energy production is a challenge to ensuring a stable supply of clean energy. International Atomic Energy Agency (IAEA) data shows that the United States leads the world in the number of reactors in permanent shutdown with 41 and currently has no planned construction for new nuclear reactors. On the other hand, China has 25 nuclear reactors under construction.

To show that the treatment was truly randomized, we demonstrate the distribution of demographic groups' age, education, gender, and partisan affiliation. Independent voters were slightly undersampled for the increased emissions frame, but all other distributions were similar to that of the control group. See Figure A.1 in the supplementary material.

The following section shows the topline support levels for each of the four sub-samples after which persuasion effects for each of the two frames are estimated in relation to the

pure control group. To separate out the effects of contextualizing the issue in New York, persuasion effects will also be estimated against the context control group.

4 Results and discussion

We begin with topline support levels in percentages for the two control groups (pure and 'news only') and the two pro-nuclear frames (Figure 1). This is to give the reader a sense of the levels. The persuasion effects are then reported in Figure 2. Following this, we decompose the treatment effect along reported demographic characteristics, partisanship, and induced risk tolerance.

To signal the implications of the results we color code pro-nuclear responses in red, anti-nuclear responses in blue, and ambivalent responses in gray.

4.1 The topline treatment effects

Figure 1 provides summaries of the responses based on the allocated frame.

Baseline support for both policies (relicensing and building) to expand nuclear power production was below 50% in both control groups.[2] This skepticism was most pronounced for building new plants; the support for which was under 50% for both control groups.

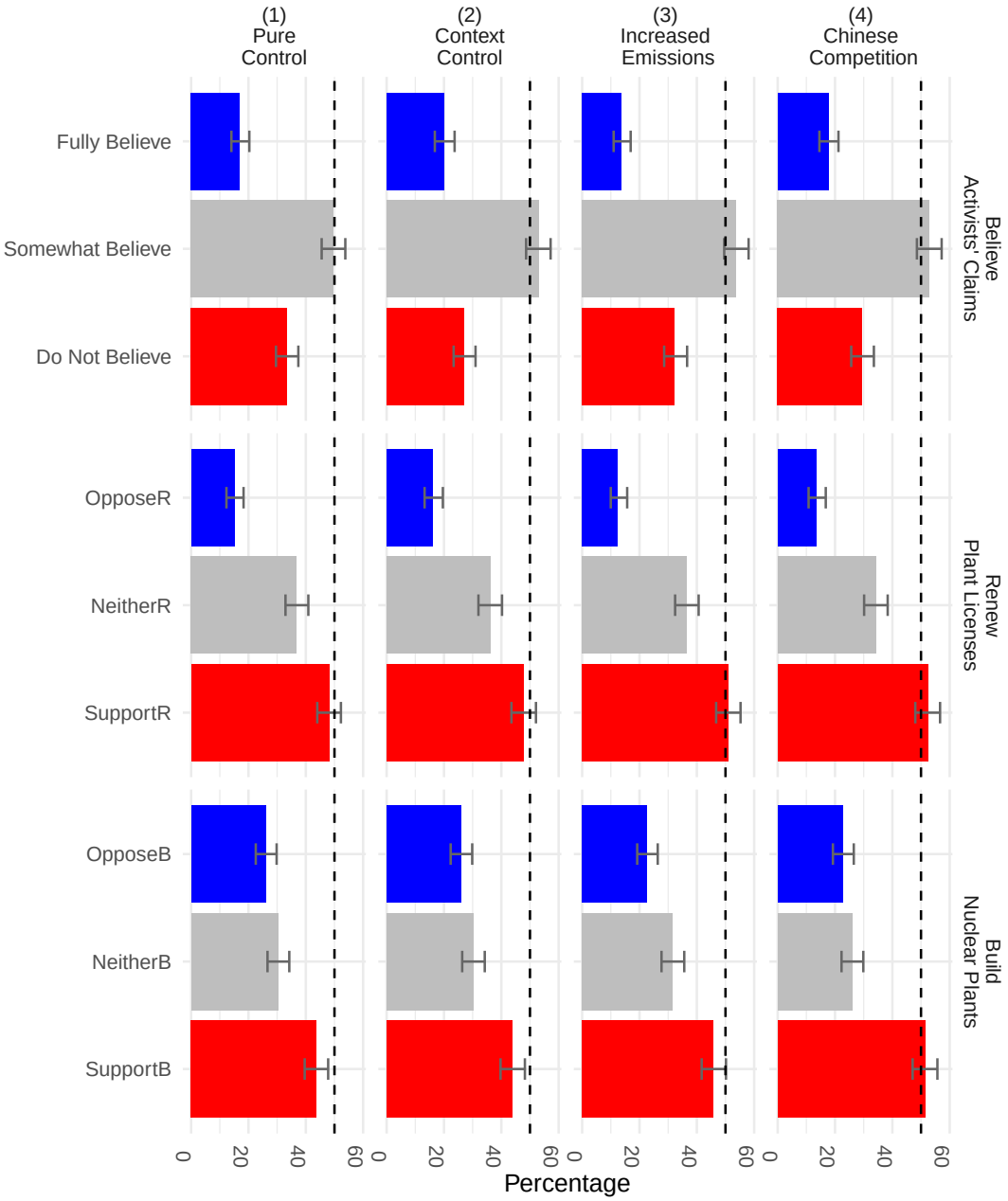
The support for building increased from under 50% in the control samples to over 50% under the Chinese competition frame, the largest increase of support in the experiment. Support for building under the increased emissions frame did not clear 50%. Support for relicensing was above 50% under all frames, but it is difficult to discern from these figures if the increase in support is noteworthy.

Figure 2 illustrates the persuasion effects of the frames relative to the pure control frame. The persuasion effect is calculated using an indicator function for having received the prompt (0 for pure control and 1 for a frame) controlling for a set of demographic characteristics including gender, age, education, and partisan lean. Implementation was using the sample-weighted multinomial logistic regression, the predictions of which were used to calculate the average marginal effect using g-computation[3].

[2]The baseline support levels in our survey differ somewhat from contemporary national polls ((Brenan 2023) through Gallup). These differences are likely due to the different wording of the question. We ask for level of support for specific policies such as renewal of nuclear licenses and building new plants, while Gallup asks to record support level for the use of nuclear energy as one of the ways to provide electricity for the United States. This latter way of questioning seems to be elicit more support (55%) than the question of expansion of nuclear capacity.

[3]See documentation for `marginaleffects` package (Arel-Bundock, Greifer, and Heiss 2024).

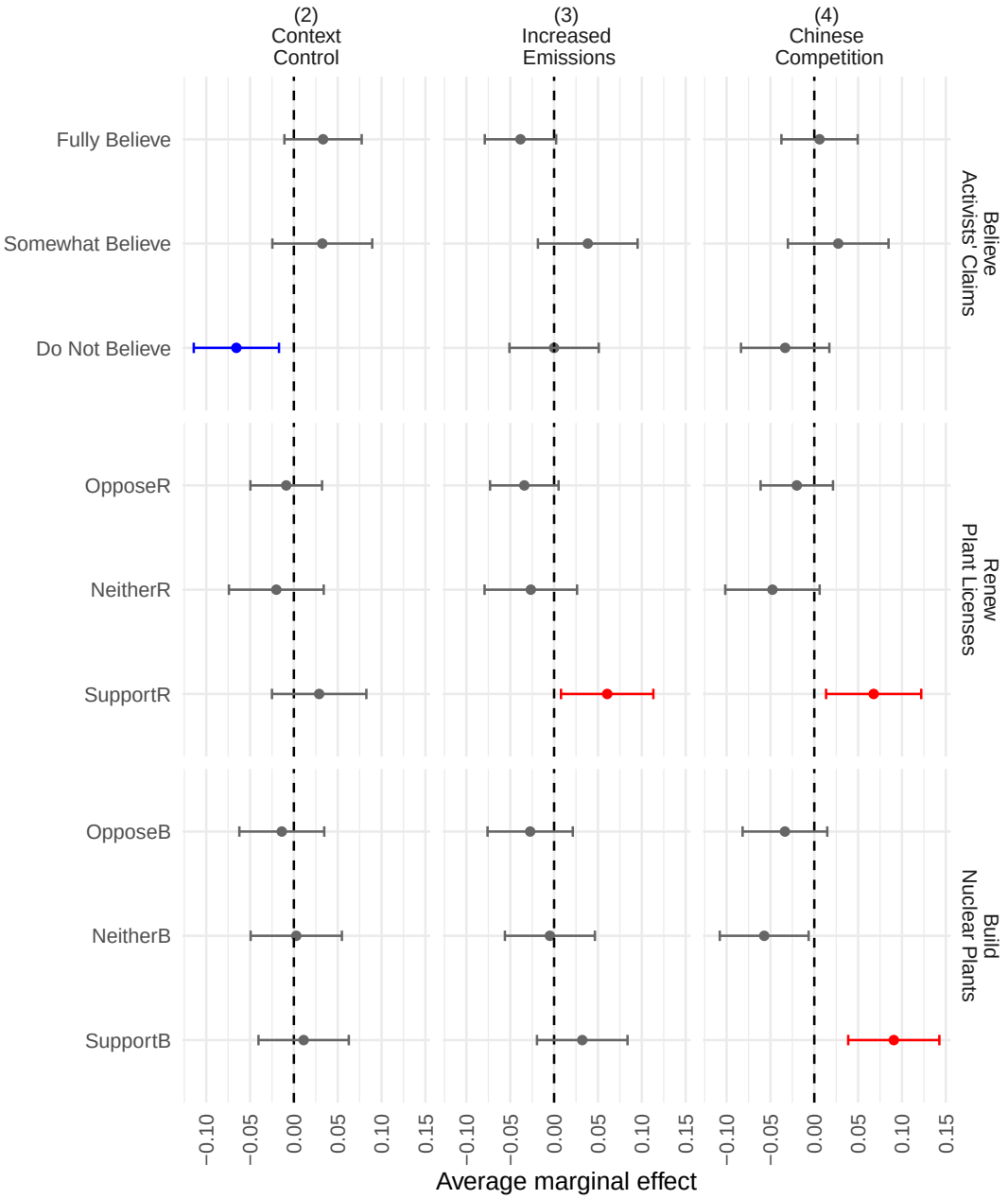
Figure 1: Overall support levels



The four columns correspond to the two control groups and two pro-nuclear frames. The answers to the questions 'Do you believe activists' claims', 'Do you support renewing nuclear plant licenses', and 'Do you support building nuclear power plants' are on the rows. The dashed line marks 50%.

The largest effect was on support for building under the Chinese competition frame (0.09), followed by support for renewing under that same frame (0.066) and support for relicensing under the increased emissions frame (0.06). Perhaps surprisingly, the increased emissions frame did not considerably increase support for building even though it did for relicensing.

Figure 2: Effects of frames



The three columns correspond to the context control group and the two frames. The answers to the questions 'Do you believe environmentalists' claims', 'Do you support renewing nuclear plant licenses', and 'Do you support building nuclear power plants' are on the rows.

There were no statistically significant differences in the responses to nuclear support questions between the pure control group and the context control. But the context control group was less likely to distrust activist claims in comparison to the pure control group. Notably, this greater trust of activist claims did not translate to reduced support for any of

the policies. Further, once supplemented with pro-nuclear frames, the pro-activist effect was neutralized.

We re-estimate these treatment effects under several other specifications to test their robustness. Figure A.2 in the supplementary shows the effects without covariate adjustments. Due to the decrease in precision, the effect on renewal support under the Chinese competition frame was no longer significant (null of H3 cannot be rejected). However, the p-value of 0.06 for the test was very close to the rejection threshold of 0.05. Had our test being a one-tailed test, we would have rejected this null, concluding that the persuasive effect was significant. Following Lin (2013), we also implemented another covariate adjusted regression but with additional covariate-treatment interactions. These results were very similar to the results reported above in figure 2.

Our results in Figures 2 and A.3 hold even once corrected for multiple hypothesis testing using a Bonferroni correction. If unadjusted for covariates, only the persuasive effect of the Chinese competition frame on building will be significant at the more stringent 97.5% level.

Figure A.4 in the supplementary file shows the treatment effects for the two pro-nuclear frames against the context control group instead of the pure control group. Only support for building under the Chinese competition frame increased significantly compared to the context control. Support or opposition for relicensing did not change significantly. There are two explanations for this. One is that the level of support for relicensing was higher to begin with. The other is that, despite not being significant, support for relicensing slightly increased under the context control, so that when compared to that control group the persuasion effect looks too small. Unsurprisingly, trust in activist claims reduced from the context control.

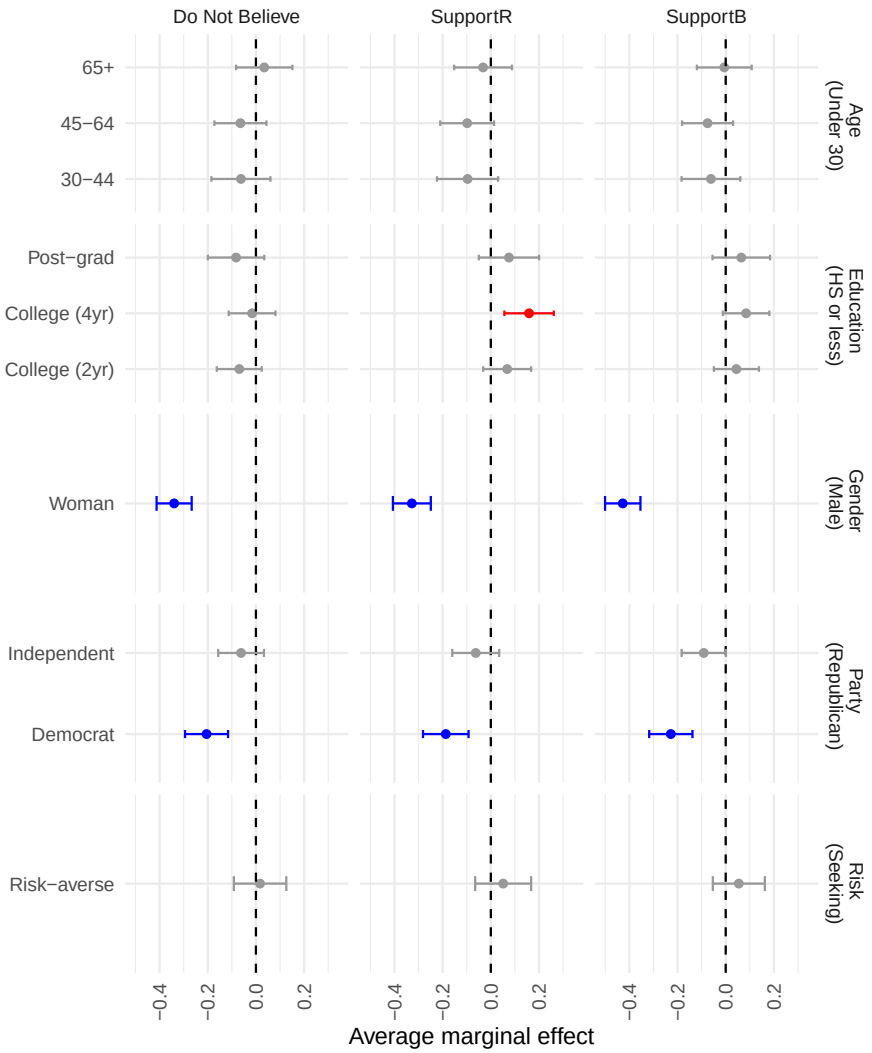
4.2 Persuasion effects conditional on observable groups

The overall results average out heterogeneity in persuasion. We are concerned about two main types of effects: ceiling effects and backfire effects. Ceiling effects arise when groups that were already supportive of nuclear power will have little room to be more supportive because of restrictions on the measurement scale. Backfire effects dampen the overall persuasion effect because groups move in different directions. Several framing experiments report such effects (Gainous and Merry 2021; Feldman and Hart 2018).

Prior to analyzing this heterogeneity, it is helpful to demonstrate which sections of the public are likely to hold pro-nuclear stances. For this, we analyzed gaps in support between various subgroups in the control sample based on age, education, gender, party identification, and risk tolerance. The largest gap in support was between men and women. Men support

renewal (building) of nuclear plants at a rate of 66% (64%), while women's support for renewal (building) was at 35% (27%). The next largest gap was between Democrats and Republicans, with Republicans supporting renewal (building) at a rate of 63% (57%) and Democrats supporting renewal (building) at a rate of 33% (33%). Gaps were less apparent for all other demographic groups. See figure A.10 for a visualization of these results.

Figure 3: Predictors of pro-nuclear views in the control group



The three columns correspond to the pro-nuclear answers to the questions 'Do you believe activists' claims', 'Do you support renewing nuclear plant licenses', and 'Do you support building nuclear power plants'.

Figure 3 formalizes these gaps by presenting support level between demographic categories relative to a reference category. The reference category for the variables age, education, gender, party, and risk tolerance were respectively 18-29 year olds, those with high-school diplomas or less, men, Republican-leaning voters, and risk-seekers. These reference cate-

gories are also indicated in the right margin of the figure. All effects in Figures 3 and A.11 should be interpreted as relative to these reference categories. As before, a positive effect (in red) is a pro-nuclear stance, and a negative effect (in blue) an anti-nuclear stance.

Women and Democrat-leaning voters are less likely to hold pro-nuclear stances. The college-educated generally tend to be more supportive of nuclear energy, though this effect is only significant for relicensing. These differences are consistent with previous findings (Brody 1984) and other national polls (Newport 2012; Brenan 2023).

Repeating the same analysis with the anti-nuclear responses reveal similar patterns (refer to figure A.11 in the supplementary file). Women and Democrat-leaning voters are more likely to hold anti-nuclear stances. And so were Independent voters. Those with any college education were less likely to hold anti-nuclear stances.

4.3 Heterogeneous effects

As remarked previously, we have several reasons to suspect heterogeneous persuasion effects. For one, the previous analysis on the control group shows the diversity of views on nuclear energy. It is reasonable to expect that given these differences, various subgroups will react differently to the frames. Understanding these differences, can also explain some of the surprises in the topline results. Why does the Chinese competition frame increase support for building new plants but not the increased emissions frame?

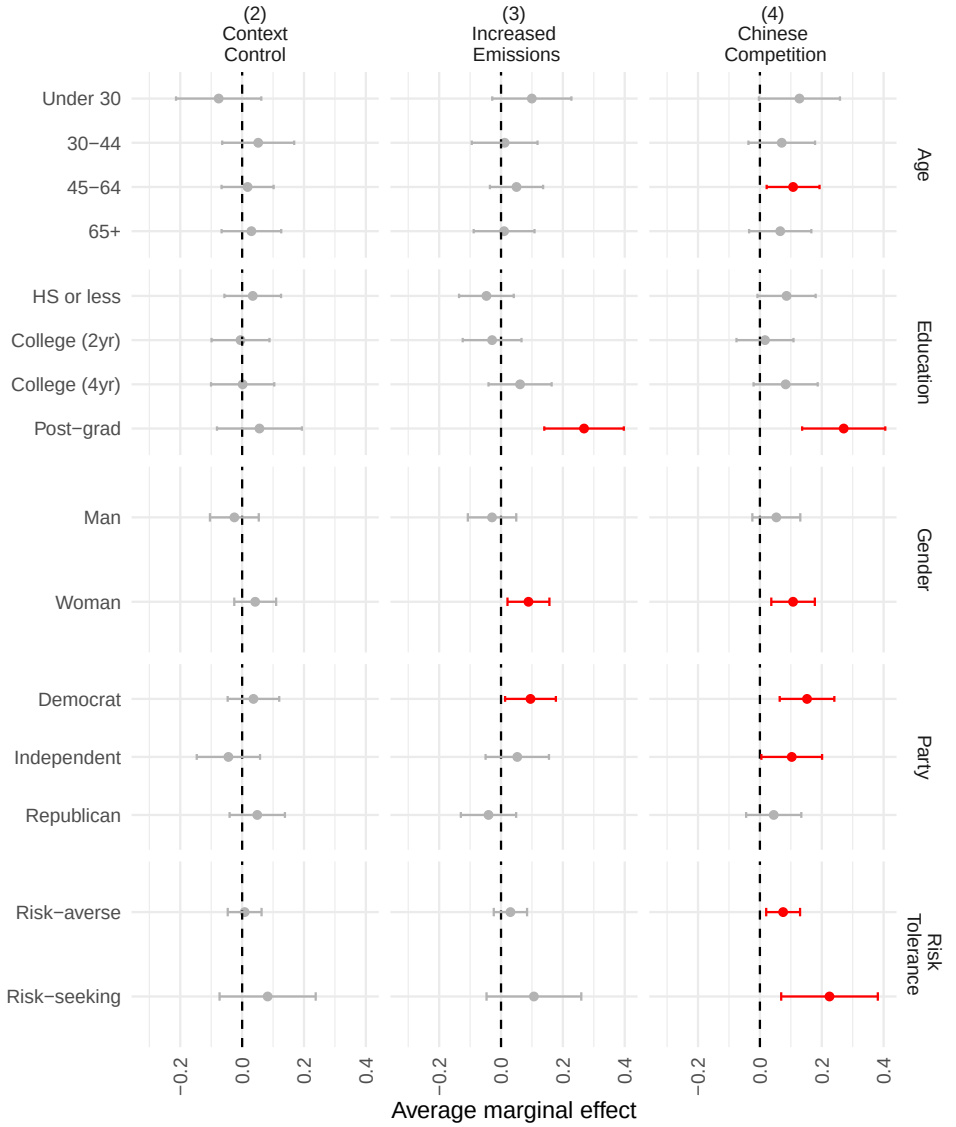
To demonstrate heterogeneous persuasion effects, a covariate-adjusted regression with `treat*covariate` interaction terms was implemented. The covariates were the same as those that were considered previously. Then significance tests are performed to test the persuasive effect of the frames on each demographic group.

Figure 4 shows the effects on support for building new nuclear plants. The persuasion effects were most notable (in the pro-nuclear direction) for those with post-graduate education, women, and Democrat-leaning voters. These groups were persuaded by both pro-nuclear frames, and were also the only groups to be persuaded by the increased emissions frame.

Those aged 45-64, and Independent voters were additionally persuaded by Chinese competition frame. Compared to their counterparts in the pure control group, both the risk-seeking and the risk-averse were persuaded in the pro-nuclear direction by the Chinese competition frame, although the effect on the risk-seeking was twice as large as the effect on the risk-averse.

All sub-group treatment effects under the Chinese competition prompt were positive. Under the increased emissions frame, some groups moved against support, although none of

Figure 4: Heterogeneous effects of frame prompts on the 'Support' for building new plants



The three columns correspond to the context control and the two frames. The rows denote the sub-group on the left margin. The reported 95% confidence intervals are the difference between the treatment and control group for that demographic group with other factors held constant.

these negative effects were significant. Men, Republican-leaning respondents, and those with no college education all showed a negative movement. These backfire effects are a possible explanation for why the increased emissions frame was less effective at increasing support for building. But this is more speculative than conclusive. Men and Republican voters had high levels of support to begin with, and therefore we cannot necessarily distinguish between small backfire effects and ceiling effects without individual baseline information. Despite the lack of any discernible movement, nuclear support levels of men and Republicans were still

considerably higher than that of women or Democrats after any of the frames.(See figures A.5-A.9 in the supplementary material).

A similar analysis for license renewal revealed that the post-graduate educated were moved to support renewal under both pro-nuclear frames and only group to do so under the increased emissions frame. Respondents without any college education, Democrats, and the more risk-seeking were also more supportive of relicensing under the Chinese competition frame. In stark comparison to support for building, women showed no significant movement on support for relicensing under any of the frames.

The context control (compared to the pure control) increased support for relicensing among Republicans, and though not significant, the post-graduate educated and the risk-seeking increased support for relicensing by about the same amount as the Republicans. Those under 30, however, reduced support for relicensing under the context control. On the matter of building, none of the groups showed significant differences between the two control groups.

5 Conclusions and Policy Implications

The future of American nuclear energy is a matter of public opinion as much as it is of economics. While some nuclear power plants have closed due to poor economics, others have closed while fighting intense public opposition. Indian Point in New York, the subject of this survey, is an example of the latter kind. Activist pressure regarding radiation and meltdown risks forced its closure despite the reactor's structural viability. Diablo Canyon — California's only nuclear power plant—also faces similar pressure.

While all closures are arguably due to the cost of nuclear energy relative to other renewables, recent reopenings (Three Mile Island) and license extensions (Diablo Canyon) show that nuclear energy is still in demand even as renewable energy prices have started to come down. The modern knowledge economy, with its 24-hour data centers and warehouses, looks increasingly power-hungry (De Vries 2023).

Despite the need for cheaper and more reliable sources of energy, the American public support for expanding nuclear power remains below majority support. This skepticism leads to increased regulatory burdens on operators and makes deployment slower, particularly if the reactor design is new. The recent activation of Vogtle 3 on July 31, 2023, marks a rare event, as it had been 7 years since a new nuclear reactor had come online in the United States. And it has been 50 years since a new commercial reactor design approved by the Nuclear Regulatory Commission became operational.

The scholarship on nuclear energy persuasion has focused its efforts on changing risk

perceptions. But, this path seems to be fraught by the public's dread of radiation. Our approach is to study respondents in the more realistic scenario where the technology's risk coexists with its benefit. The public, it seems, was far more willing to accept the risk if supplemented with information about the benefits.

Respondents were most persuaded by the comparison between America's stagnation and China's progress on nuclear energy. This frame increased the national support for nuclear energy production from the low 40s to above 50 percent. Both frames convinced women and Democrat-leaning respondents to increase their support for building new nuclear plants, with Democrat-leaning voters also supporting renewal of existing plants.

This finding opens new ground in nuclear risk communication. But it also leaves several questions unexplored. For example, we cannot be certain what motivated respondents to support nuclear expansion after learning of China's expansion. Did they feel that China's construction of nuclear power plants lowered costs of production and made China more economically competitive? Or did they feel that this nuclear capacity made them a more formidable opponent in a war? Or did the information that Chinese citizens were willing to tolerate more nuclear plants also moderate risk perceptions in Americans?

Despite the effectiveness of frames in this setting, other practical matters get in the way of external validity. Respondents are exposed to a variety of information on the matter of energy policy, including counter-frames that can dampen the effect of the frame. Their support may depend on their perceived level of bias towards other energy alternatives, such as fracking or solar energy. More crucially, respondents who support building new plants in general may not support building them closer to their home (Ansolabehere and D. M. Konisky 2009).

License renewal and new nuclear plants is not the only controversial nuclear issue. Long-term disposal of nuclear waste, and transportation of nuclear waste also face opposition from local communities and environmental groups. Moderating public opposition to nuclear energy has been difficult because of its reputation as a risky technology. Yet, respondents in our sample have shown a willingness to trade-off this risk particularly when made aware of China's progress. What needs to be furthered is how they rationalized this support.

CRediT author statement

Ransi Clark: Conceptualization, Formal analysis, Visualization, Writing - Original Draft. **Beatrice Magistro**: Conceptualization, Validation, Writing - Review & Editing. **R. Michael Alvarez**: Conceptualization, Supervision, Writing - Review & Editing, Funding Acquisition.

Competing interests

The authors declare that they have no competing interests.

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Data Availability

The data and code necessary to replicate the quantitative results reported in this paper will be place into a public repository upon acceptance of this paper for publication.

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