Clearing the air: Public health concerns and support for natural gas restrictions in the United States

Elena V. McLean, State University of New York, Buffalo

Taehee Whang, Yonsei University

Joonseok Yang, Sungkyunkwan University[1][2]

Abstract

Earlier policies to reduce greenhouse gas emissions in the U.S. have often treated natural gas as a clean fuel due to its higher energy output per unit of carbon dioxide emitted compared to other fuels. However, recent local decarbonization initiatives seek to restrict residential uses of natural gas. Public support for such policies could be a key factor in determining whether local governments implement natural gas restrictions. It may also indicate the potential for state and federal governments to adopt similar measures. In this study, we conduct an online survey with 2,623 U.S. adults to demonstrate how public support for natural gas restrictions varies based on policy framing. These framings include (1) household economic costs, (2) industry positions, (3) health impacts, (4) contribution to climate change, and (5) political support. Our results show that public support for policies to ban natural gas in new construction is significantly influenced by the health impact of these policies. This finding suggests that U.S. citizens are sensitive to non-economic health frames when evaluating a policy proposal to phase out natural gas use. Meanwhile, factors such as monthly energy costs, industry support, climate effects, and political backing show only a weak influence on public opinion regarding these policies.

Word Count: 10,700

Keywords: natural gas; energy; natural gas ban; public opinion, climate change

1 Acknowledgment: Funding for this research was provided by the Community for Global Health Equity at the State University of New York at Buffalo. Joonseok Yang thanks the Korean Ministry of Education and the National Research Foundation of Korea (NRF-2020S1A3A2A02092791) for support for this research.

2 The authors' names are in the alphabetical order. The authors contributed equally to this work.

1. Introduction

The United States remains one of the most significant greenhouse gas polluters globally, in terms of its aggregate carbon dioxide emissions on a per capita basis [1]. At the same time, the country has become less dependent on coal for its energy needs, as natural gas has replaced coal to a significant extent. In the 1970s, natural gas began to emerge as a critical source of cleaner energy: its resource base was extensive, it had clear environmental advantages, and products and technologies utilizing natural gas turned out to be markedly efficient [2]. In 2021, natural gas accounted for 38 percent of the country's total electricity production, up from 9 percent in the late 1980s, whereas the share of coal in electricity production declined from 58 to 22 percent during the same period [3]. This increasing importance of gas for electricity production can be linked to the rapid growth of shale gas extraction in the U.S. in the 2000s: hydraulic fracturing techniques led to a twentyfold growth in shale gas production between 2007 and 2020 [4]. In addition, natural gas acquired the reputation of a clean fuel due to its lower carbon dioxide-to-energy content compared to coal [5] and became an acceptable replacement for more polluting coal and liquid fuels in the energy system. As a result, many economic sectors, including electricity generation, transportation, and commercial cooling, switched to natural gas to a significant degree.

Despite this perception, gas combustion generates greenhouse gases (GHG) and contributes to climate change. Scholars, policymakers, and environmental activists criticize natural gas use for generating environmental risks for the global climate [6, 7, 8, 9]. In particular, recent studies point to problems of flaring, venting, and methane leaks along the natural gas supply chain [10]. These problems have led to the conclusion that no sustainable energy mix can include any fossil fuels, thereby questioning continued natural gas use. In addition, natural gas tends to exacerbate public health problems as gas development often contaminates air and water, increases industrial noise and traffic, and leads to residential community changes [11]. Finally, the role of natural gas as a transition fuel has come under criticism after 196 countries adopted the Paris Agreement in 2015 in an effort to limit GHG emissions as soon as possible. The agreement requires the natural gas industry to provide a reliable long-term decarbonization strategy (e.g., through production and use of biomethane and low-carbon hydrogen).

One of the recent strategies to address climate change seeks to reduce dependence on natural gas in the residential sector. In 2019, Berkeley, CA, became the first municipality to ban natural gas hookups in new construction [12].[3] Now, over 50 local energy ordinances in California either ban or discourage natural gas connections in new buildings [13]. Other areas in the U.S., including Denver, CO, Brookline, MA, and New York, NY, are turning to similar policies to eliminate natural gas use in new construction, thereby reducing future GHG emissions. Local and state authorities restrict natural gas use by passing an all-electric construction requirement for new homes and commercial buildings. At the same time, these efforts to ban natural gas in new construction have caused a backlash from the gas industry and gas-dependent utilities.

[3] In November 2019, the California Restaurant Association challenged Berkeley's natural gas ban, but a federal district court judge dismissed the lawsuit in July 2021. However, this decision was unanimously overturned in April 2023 by a U.S. Court of Appeals for the Ninth Circuit panel. In response, Berkeley's City attorney petitioned to review the April decision by a larger panel of judges (Har, 2023).

Since 2019, 19 U.S. states, i.e., Alabama, Arizona, Arkansas, Florida, Georgia, Indiana, Iowa, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Ohio, Oklahoma, Tennessee, Texas, Utah, West Virginia, and Wyoming, have passed state-level restrictions that prohibit local governments from banning or placing limits on natural gas use. A number of states are yet to adopt any policies in this regard, and it is clear that the future of natural gas remains a contested political issue.

Adoption of measures restricting natural gas in the residential sector likely responds to public preferences in this policy area. Previous studies suggest that public support is critical for the implementation of renewable energy and climate change policies [14, 15, 16, 17, 18, 19]. However, no research currently investigates factors influencing public opinion on natural gas bans. We aim to close this research gap and seek to explain when the public may support this natural gas restriction. Our study contributes to the understanding of clean and efficient energy policy formulation and adoption by focusing on individuals' preferences over the framing of gas bans, which can directly impact households and provide measurable benefits for individuals. The 2021 Morning Consult survey offers evidence of divergent public preferences when it comes to policies eliminating natural gas in new construction.[4] The survey shows that 44% of adults expressed support for such a ban and 37% did not, while a significant share – 20% – of respondents did not have an opinion on this policy [20] Therefore, there is significant variation in individual preferences in this policy area, and our article seeks to explain which factors account for this variation.

To address this research question, we design a survey experiment. We draw on previous findings in the area of environmental and energy policymaking and public opinion to categorize five dimensions that can be associated with individuals' policy support: (1) economic costs for households, (2) industry positions, (3) health impacts, (4) contribution to climate change, and (5) political support. Based on an online survey of 2,623 U.S. adults conducted in September 2021, our experiment yields results which suggest that, among the five dimensions of policy framing, health concerns are the only significant determinant of public support for the policy eliminating natural gas use. Survey respondents who receive information about the adverse impact of air pollution on their and their children's health tend to express greater support for the proposed gas ban, compared to respondents without exposure to such information. In sum, our study identifies health as a salient dimension of public opinion regarding natural gas bans, while political, economic, environmental, and industry-related motivations do not seem to influence individual responses to a proposal banning natural gas from new residential construction.

2. Insights from Previous Research on Public Support for Environmental and Energy Policies

[4] The Morning Consult survey was conducted online in January 2021. The survey sample of 2,200 respondents was constructed to approximate a nationally representative sample of adults based on gender, age, race, education, and region. We used responses to the following survey question: "Some cities and towns in the United States have passed or are considering legislation to ban the use of natural gas in new construction, largely to limit their carbon emissions. Is this something you would support in your own community?" The available responses were "Yes, definitely support; Yes, probably; No, probably not; No, definitely not support; Don't know/No opinion."

In this section, we survey existing scholarship to introduce the determinants of support for environmental and energy policies more broadly and natural gas policies more specifically. Our review also includes previous studies that explain the role of information in shaping public preferences in this area. Finally, we discuss the role of policy framing and, in particular, emphasis framing in shaping public opinion and policy support.

Environmental and energy policies represent a diverse landscape, with varying levels of public support contingent on the nature and impact of these policies. At the core of these measures is the need to balance immediate economic concerns with long-term environmental sustainability. In the typology suggested by Attari et al. [21], the spectrum of policy interventions ranges from voluntary actions to hard regulations, such as bans. This study explores preferences among individuals for the different types of interventions and shows that while voluntary actions are preferred for their perceived autonomy, regulatory measures, especially bans, tend to garner more support in the context of perceived immediate threats. This differentiation underscores the importance of characterizing environmental and energy policies based on their intervention type to explain the nuances in public sentiment.

The perceived efficacy and fairness of various policy interventions also influence their acceptability. Cherry et al. [22] employ an experimental approach to investigate the public's response to efficiency-enhancing instruments such as taxes, subsidies, and regulations. They report nuanced results: while taxes are often seen as punitive measures, subsidies and some regulations are more readily accepted when presented as instruments to enhance efficiency. Furthermore, the temporal dimension of phasing out policies plays a crucial role in their acceptability. Rinscheid et al. [23] study the public's temporal preferences for phasing out fossil fuel cars in the US, revealing a lower level of support for delayed policy implementation. Echoing these findings, Hoppe et al. [24], focusing on Germany's transition from conventional cars, demonstrate that the socio-political context, combined with the urgency of the environmental crisis, moves public opinion toward a more rapid phase-out of carbon-intensive technologies. When it comes to direct policy effects on individuals or households, existing studies show that economic considerations, including energy costs, shape individual-level preferences over various energy policies [25, 26]. In addition, public health benefits are linked to public support for renewable energy policies [27]. Together, these insights inform our research in identifying political, economic, and other motivations that can explain individual responses to a proposed policy banning natural gas in new residential construction.

Natural gas bans are typically adopted as part of recent environmental and energy policy packages that aim to address climate change. For instance, in 2020 the Climate Smart San José program, which aims to bring the city in compliance with the Paris Agreement, an international climate change treaty, strengthened existing natural gas restrictions in the residential sector by adding a comprehensive all-electric mandate in new construction, among other initiatives.[5]

5 See, for example, Jenny Loft, "News Release: With Expanded Natural Gas Ban, San Jose Electrifies New Buildings and Leads Toward Green Future." 2020/ Dec. 16. Available at: https://www.sanjoseca.gov/Home/Components/News/News/2210/4699

Consequently, the same factors that drive public demand for environmental and energy policies more broadly can help to explain the adoption of natural gas bans.

Studies of support for natural gas extraction and use show association between a wide range of socio-demographic, economic, and political variables, and individuals' policy preferences. Survey research indicates that household income influences support for natural gas extraction and use [16, 28]. Partisanship is another characteristic that shapes attitudes toward gas extraction: Republicans tend to hold more favorable views than Democrats [29], although the relationship disappears when tests account for individuals' risk aversion [30]. A more recent study using data extracted from Twitter shows that unemployment, residence near a gas extraction site, and access to health insurance significantly affect people's attitudes toward natural gas, while Republicans are more supportive of natural gas only in the South [31].

Studies of public opinion on the use of hydraulic fracturing, or fracking, and its regulation serve as another area of research on determinants of individuals' policy preferences. Knowledge about fracking and its environmental effects reduces support for natural gas extraction [29]. At the same time, the source of information plays a role: when "outsiders," particularly anti-fracking activists, discuss negative effects of fracking, members of communities located near natural gas extraction sites view such communication as a threat to their property rights and advocate extraction [32]. In contrast, when residents of communities close to natural gas production sites become aware of the impact of natural gas because of proximity to their homes, their opinions tend to favor bans [33].

Furthermore, the research on the link between negative health impacts of natural gas and individuals' perceptions of natural gas provides mixed findings. Nitrogen dioxide emissions and methane leaks due to natural gas use can increase indoor air pollution, which results in adverse health outcomes [34, 35, 36]. Yet, information about risks associated with natural gas consumption has a mixed effect on people's opinions regarding natural gas. First, survey results indicate that, when people learn about the decline in air quality due to gas production, they are less likely to view natural gas as a safe and environmentally friendly alternative to other types of fossil fuels [37]. However, exposure to information about the potential threat of gas leaks in homes did not have a similar effect [37]. Second, knowledge about the problems of methane leaks and hydraulic pollution is associated with more negative attitudes toward natural gas, but only among liberal respondents [38]. In addition, people's perceptions of natural gas become less favorable when informational materials refer to it as "methane gas" because respondents associate it with pollution and global warming, with a stronger effect among Democrats [39].

Existing studies in this field demonstrate that public support for environmental policies is often conditional on information about these policies and more specifically policy framing. Policy framing entails presenting a particular issue or policy in a way that highlights specific facets while downplaying others [40]. This strategic presentation of information is important as it can sway public opinion and influence policy support. For example, Feldman & Hart [41] experimentally investigate public support for low-carbon energy policies framed in the contexts of climate change, air pollution, or energy dependence. They find that while Democrats remain largely unaffected by the framing shifts, Republican support significantly wanes when policies are tied to climate change as opposed to air pollution or energy security. Similarly, Lockwood

[42] studies public support for climate policies in the UK and finds that framing plays a pivotal role in garnering support for renewable energy expansion. This framing effect is not as pronounced for energy efficiency policies or financial aid to developing countries. However, Bernauer & McGrath [43] suggest that merely reframing climate policy may not substantially enhance public support. Their experiments reveal that public support remains largely invariant to alternative framings, prompting them to advocate for the continued emphasis on climate risk reduction as the dominant policy justification.

Lastly, we consider the role of policy framing, specifically emphasis framing, in shaping public perception and increasing support for policies. Emphasis framing focuses on accentuating distinct aspects of the same core issue [44]. For example, in debates about natural gas restrictions, different frames might spotlight environmental concerns, economic impacts in terms of personal or industry costs, public health implications, or political support. Following this insight, scholars show that measures to reduce energy use gain greater support when framed as improving efficiency, while energy cuts without such policy framing lead to lower support [45]. This variation in emphasis can create markedly different public reactions to the same underlying proposal, underlining the importance of framing in policy discussions and public perception.

3. Research Design

3.1. Experimental Design

To identify which types of information about a proposed natural gas ban may affect public support for this measure, we conducted an online survey experiment. Following previous studies on public support for renewable policies [27], our experiment presents each respondent with a set of statements with information on the natural gas policy. Our experiment design is similar to a 'single-profile' conjoint design that randomizes both the order of different types of information (often called 'attributes') and contents of each type of information (i.e., values) [27, 46]. When a research project investigates a multifaceted phenomenon, such as a government policy, it requires an experiment with treatments that are composed of different pieces of information or features. Our experiment design helps us to identify the causal effect of each piece of information in the treatments on respondents' multidimensional preferences, while mitigating the concern about any order-related effects of presented information [47]. In this experiment design, treatment effects of each piece of information are estimated relative to the reference category (i.e., the control group).

Our experiment begins with the following short description of a proposed natural gas ban:

"Since 2019, over 40 cities in different parts of the U.S. have adopted measures to ban natural gas hookups in newly constructed buildings. These ordinances require or encourage all-electric construction, which means that new homes will have only electric appliances. In the next year or two, a similar measure may be considered in your area, which would eliminate natural gas from all new homes. Consider the following effects of the proposed natural gas ban in your area:"

We then randomly presented key pieces of information regarding this hypothetical proposal to eliminate natural gas from new homes. More specifically, we focus on five policy aspects identified in previous research on public support for environmental and energy policies: (1) economic costs for households, (2) consequences for the gas and renewable energy industries, (3) health effects of natural gas use, (4) climate change implications of natural gas use, and (5) political support for the policy at the local or federal levels.

(1) Economic costs (for households): We present information about estimated economic costs for households (i.e., changes in consumers' energy bills). Studies provide some mixed results regarding the public's willingness to pay higher costs for cleaner energy. On the one hand, scholars find that individuals prefer energy at a lower cost [48]. Therefore, exposure to cost information reduces support for renewable energy policies [49]. In contrast, an average U.S. consumer shows support for a national clean energy standard even if that leads to higher electricity bills [50]. We use the change of $100 in annual consumer expenses in our survey because this value is close to estimated increases in electric bills when consumers switch from gas cookstoves to electric appliances [51]. While consumers may be aware of environmental problems and potential long-term economic benefits of switching to electric appliances, we expect public support for restricting the use of natural gas to decline as their immediate economic costs increase due to the proposed transition away from natural gas.

(2) Industry (gas vs. renewables): Policy consequences for relevant industries (i.e., the natural gas and renewable energy industries) can be another important factor shaping public support for the policy restricting natural gas use. As is often the case with government regulations, some economic actors tend to benefit, whereas others tend to experience costs. In anticipation of such benefits and losses, these economic actors have an incentive to put pressure on the government in favor or against the proposed policy through public opinion. The natural gas industry has been effective in establishing this fuel as a transitional solution to the problem of greenhouse gas emissions [52]. This industry is the most likely source of unfavorable (or anti-policy) messaging because it can expect to lose some market share due to restrictions on gas access in new construction. Therefore, the natural gas industry may attempt to inform the public about adverse economic outcomes to increase opposition to any measures reducing reliance on natural gas. At the same time, the renewable energy industry has grown in importance in terms of its size and a broad range of economic benefits provided to consumers and local economies, including new jobs and business opportunities for local suppliers [53]. This industry stands to gain a larger market share and increase its profits when the government imposes restrictions on the competitor, i.e., the natural gas industry. Consequently, the renewable energy industry has incentives to engage in favorable (or pro-policy) messaging to enhance public support for natural gas restrictions. Thus, we expect that those individuals who receive a negative industry message (i.e., the treatment focused on the policy's adverse effects on the natural gas industry) should become less supportive of the policy, whereas those who receive a positive industry message (i.e., the treatment focused on the policy's benefits for the renewable energy industry) should feel more supportive of the proposed restriction.

(3) Health: Concerns about air pollution and adverse health effects due to pollution increase public support for cleaner energy generation alternatives [54]. Public health improvements resulting from energy policies fit with individuals' perception of localized and more tangible social benefits connected to reduced reliance on fossil fuels [27, 48]. However, these studies do not differentiate between ambient (or outdoor) air pollution, which has the most direct link

with traditional, fossil-fuel energy generation, and household (or indoor) air pollution, which is the focus of this study. When framed in the context of indoor air pollution risks from gas combustion, including the presence of toxins, health concerns might be viewed as pressing and severe. Furthermore, once the health damage occurs, it could be irreversible or result in long-term illness. Thus, we expect that those who are primed with information about adverse health impacts of natural gas combustion should support restrictions on its residential uses.

(4) Climate change (GHG): Overall, environmental concerns influence individual energy preferences. However, these concerns do not focus on the global environment; they tend to be more localized [48, 55]. Hence, clean energy policies with global environmental benefits receive less support than policies producing local benefits [27]. A natural gas ban produces both: localized benefits (i.e., better air quality, which improves health, as discussed above) and global ones (i.e., reduced GHG emissions). In this climate change aspect, continued use of natural gas can be viewed as a double-edged sword. The need to stop using coal is clear, which positions natural gas as an interim fuel on the path of decarbonization [56]. At the same time, this temporary solution is risky: reliance on natural gas could result in carbon lock-in, thereby delaying the process of decarbonization [57]. Therefore, public support for natural gas reflects this duality: the use of natural gas to produce electricity receives support as an environmentally friendly solution, but the recognition of its contribution to global warming reduces support for continued gas use [38]. We expect that if information on climate change effects is influential, individuals informed about natural gas use producing lower GHG emissions, compared to coal use, would oppose natural gas restrictions. However, those presented with information highlighting significantly reduced GHG emissions when homes stop using natural gas should support the proposed natural gas ban. Finally, we add a treatment providing respondents with a combination of these two pieces of information to examine the effect of the combined frame [58].

(5) Political support (local vs. federal): The presence of political support may also be an important factor underlying public opinion on natural gas restrictions. Individuals tend to experience different levels of trust for local, state and federal governments and consequently show varying levels of support for policies adopted by these governments [59]. Citizens also believe that each government level should specialize in certain issue areas [60], and in the U.S. context specifically, the public views energy policy as the policy domain of the national (or central) government [61]. However, support for narrowly-focused energy extraction policies shows variation based on individuals' feelings toward the federal and local governments [62]. Our expectation is that public support will rise in tandem with political endorsements, whether they are local or federal.

Table 1 provides a summary of these five key pieces of information and the contents (often called 'levels'). For each type of information, we need a reference category to be able to estimate treatment effects. This category of respondents – i.e., the control group – was not exposed to any statement in a given information category. In the case of some respondents in the control group, it is possible that they have not received any information on any of these five dimensions. These respondents who were not exposed to any information did not see the following sentence in the short description of the proposed policy: "Consider the following effects of the proposed natural gas ban in your area." We did not exclude any combinations of randomly manipulated information. Supplementary Figure A6 presents a screenshot of a text example that some respondents read and the question that we asked to measure the respondents'

support for the proposed natural gas ban.

Type of Information	Control	Value 1	Value 2	Value 3
Costs	[No information is given]	Cost estimates suggest that all-electric new construction homes would likely see consumer bill savings.	Cost estimates suggest that all-electric new construction homes would likely see a consumer bill increase of less than $100 per year.	Cost estimates suggest that all-electric new construction homes would likely see a consumer bill increase of more than $100 per year.
Industry	[No information is given]	The expected effect of the ban on the natural gas industry is negative, which leads to opposition from this industry.	The expected effect of the ban on the renewable energy industry is positive, which leads to support from this industry.	
Health	[No information is given]	Regarding public health effects, experts expect that the ban will reduce indoor air pollution from gas combustion, including toxins such as nitrogen dioxide, which damages lung and cardiovascular health in exposed individuals.	Regarding public health effects, experts expect that the ban will reduce indoor air pollution from gas combustion, including toxins such as nitrogen dioxide, which damages lung and cardiovascular health in exposed children.	
Climate Change	[No information is given]	When it comes to climate change effects, estimates show that an all-electric single-	When it comes to climate change effects, estimates show that natural gas produces	When it comes to climate change effects, some experts state that natural

		family home would reduce annual greenhouse gas emissions by 76 – 88% compared to a natural gas-fueled home, because burning natural gas creates greenhouse gas emissions, which cause climate change.	approximately 50% less emissions per unit of energy compared with coal, so burning natural gas instead helps to cut greenhouse gas emissions, which cause climate change.	gas produces less greenhouse gas pollution than coal, while other experts argue that burning natural gas still creates greenhouse gas emissions, which cause climate change.
Political Support	[No information is given]	Politically, this type of gas ban receives significant political support at the local level.	Politically, this type of gas ban receives significant political support at the federal level.	

Table 1: Attributes and Levels in the Experiment

We fielded an online survey experiment exposing U.S. adults to information regarding a proposed natural gas ban policy with varying expected effects in different areas, policy content, and political support. A total of 2,623 respondents were recruited by Dynata to participate in this survey in September 2021. Employing various recruitment channels (e.g., open enrollment and partnerships with thousands of websites, and affiliate networks including schools and communities), Dynata possesses a diverse group of panels including people in hard-to-reach groups such as ethnic minorities and seniors. Our survey sample is drawn from Dynata's U.S. panel, which aims to achieve the closest possible match to the U.S. Census and social benchmarks. To assemble a diverse sample that is close to the nationally representative sample, we employed soft quotas with regard to gender, age, regions, and education (based on the adult population, i.e., 18 years of age and older). See Supplementary Table A1 for the summary statistics of survey participants in comparison to the Census averages. Though our sample includes a slightly larger proportion of female respondents, a somewhat less educated and younger group, and underrepresents the West, the differences with the Census averages are marginal, and the sample is largely similar to the Census targets.

To ensure reliable and accurate responses, we first rely on Dynata's in-house screening processes based on "Total Research Quality® system," which monitor data quality employing various methods such as identifying those who engaged in straight-lining through grid questions and speeders. In addition, we screened out responses that did not pass our own validation check embedded in the survey. To further ensure that our respondents had paid attention to the various treatments, we included 'the skip response check,' asking all

respondents to skip the question without choosing any answers in the middle of the survey. Those who did not read the instruction and randomly chose responses were considered inattentive respondents and removed from the sample.

After reading statements with information about the proposed natural gas ban, respondents were asked how much they supported or opposed the hypothetical natural gas policy.[6] The answers to this question are on a 1-5 scale provided to respondents with 1 marked as 'strongly oppose' and 5 as 'strongly support.' To clarify, the respondents were exposed to one hypothetical proposal of a natural gas ban and asked to rate it once.

In the survey, respondents were also asked basic demographic and socio-economic questions, including their 7-point partisan ID, age, gender, race, education, employment status, and the state of residence. Additionally, we asked how often respondents or their family members cooked at home, given that those who cook at home (and cook more often) may have a greater level of sensitivity to certain types of information (e.g., information about health hazards).

3.2. Regression and Subgroup Analysis

To evaluate the causal effects of provided information about the policy on public support for the proposed ban, we estimate an ordinary least-squares regression. Note that in the experiment, respondents receive multiple treatments simultaneously and combinations of treatments have their values and orders randomly assigned; thus, estimating regression models with all of the treatments simultaneously does not lead to biased estimates. To be specific, we estimate the following linear regression model:

$$\mathrm{Y_i} = \alpha + \beta_1 \mathrm{Costs} + \beta_2 \mathrm{Industry} + \beta_3 \mathrm{Health} + \beta_4 \mathrm{Climate} + \beta_5 \mathrm{PoliticalSupport} + \varepsilon_i \qquad (1)$$

where i indexes each respondent, and Y denotes the respondents' support for the natural gas ban policy on a 5-point scale. Costs, Industry, Health, Climate and PoliticalSupport represent a vector of binary indicators for specific values in each treatment attribute. As robustness checks, we estimate OLS models with basic demographic covariates such as gender, income, education, partisanship, and parenthood, and ordered probit models. The results, presented in Supplementary Tables A2 and A3, show that our main findings remain essentially unchanged.[7]

---

[6] The term "ban" denotes a very strict policy type, which completely eliminates the practice subject to this limitation. Given this, respondents who are generally skeptical toward regulation may have a particularly strong (and negative) response toward our proposed gas policy. Nevertheless, respondents may see news outlets, policy reports and scholars referring to "bans" when discussing policies eliminating natural gas appliances or residential hookups (e.g., Davis, 2021; Morning Consult, 2021). Therefore, our survey experiment is providing a realistic description of the policy proposal. If some respondents indicate lower support levels due to our inclusion of the term "ban," our analysis results can be viewed as a conservative estimate of public support for natural gas restrictions. The fact that we find a statistically significant influence of public health concerns despite this potential limitation may give us more confidence in our findings.

[7] In addition to our main result, in models which control for respondents' demographic and socio-economic attributes, we find a negative and statistically significant (at the 0.1 level) coefficient for a combination of the pro- and anti-framing about climate change, although individually these two framings still yield the null effect. This does not affect our main findings about health concerns. To investigate whether there may be interaction effects between the five key pieces of information, we also estimate Average Marginal Interaction Effects by utilizing the

We also explore possible heterogeneous effects in terms of (1) the respondent's gender (male or female), (2) whether the respondent frequently cooks at home, (3) whether the respondent resides in a gas-producing state, (4) whether the respondent's state has already taken policy action on natural gas, and (5) the respondent's party identification (Republicans, Democrats, or independents). We estimate the same OLS models used in the main analysis, but after splitting our data into samples for each category to explore heterogeneity in treatment effects.

To code whether the respondent cooks at home frequently, we use data from the following question: "How often do you or your family cook at home?" with responses based on a 5-point scale (Never / Rarely / Sometimes / Often / Most of the time). We treat those who chose either "Often" or "Most of the time" as the individuals who cook at home frequently. We expect the effects of health-related information to be systematically different for those who cook often, because they may be more directly exposed to adverse health effects of burning natural gas in the kitchen.

In addition, we examine potential heterogeneity in the effects of health-related information based on respondents' states of residence. Specifically, we investigate if the effects vary depending on whether the respondent resides in a gas-producing state, and whether the respondent's state has already adopted a policy banning natural gas or prohibiting such bans. To identify whether the respondent's state of residence produces natural gas, we utilize state-level natural gas production data from the U.S. Energy Information Administration (EIA). We coded respondents as residents of a state producing natural gas if their state has produced any natural gas in 2020. Also, based on the S&P Global Market Intelligence report on gas ban policies in the U.S. from November 2021 [63], we categorized states into 3 groups: states advancing natural gas bans, states prohibiting natural gas bans, and states without any policy actions in this area. Those states that introduced related policies but have not formally adopted them are coded as states without policy actions.

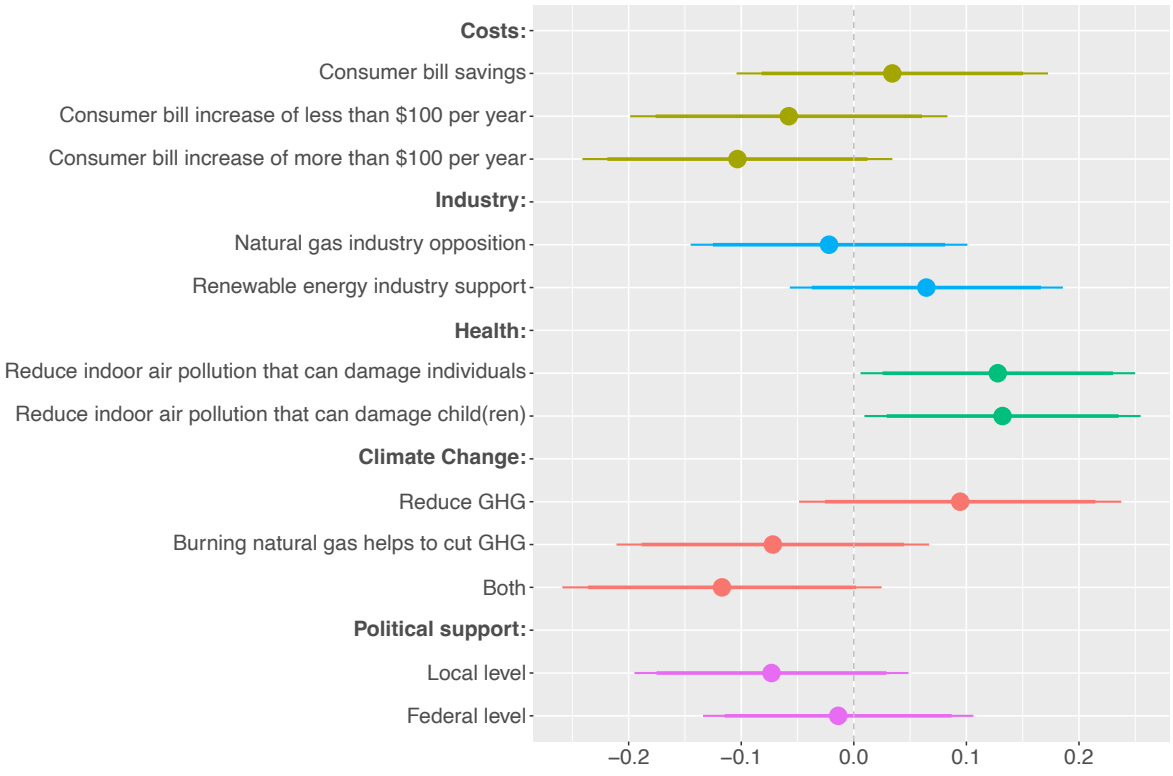
Finally, party identification coding is based on the following question: "Generally speaking, do you usually think of yourself as a Republican, Democrat, or as an independent (check the option that best applies)?" Respondents could choose an ID on a 7-point scale, which we then used to classify a respondent as a Republican (Democrat) if she answered "Strong Republican (Democrat) or Republican (Democrat)". We coded a respondent as an independent if she chose "Independent, but lean Republican", "Independent", or "Independent, but lean Democrat." Our decision to include this dimension in our analysis is driven by existing research, which demonstrates that political partisanship is a powerful determinant of individuals' environmental attitudes and policy preferences in the United States. Egan and Mullin [64] show that the environment moved from the least to the most polarized political issue in nationwide surveys conducted by the American National Election Studies. Research confirmed a rapidly growing degree of polarization in voters' concern about environmental problems [65] and the priority given to the environment [66]. Individuals who identify as political conservatives or

data-driven regularization method proposed by Egami and Imai [80]. The results, presented in Supplementary Table A4, yield no clear evidence for the interaction effects.

Republicans tend to be less concerned about environmental problems, more skeptical of environmental regulations, and less willing to take pro-environmental actions [67, 68, 69]. The impact of party affiliation interacts with educational achievement, as more educated conservatives are even less supportive of environmental policies and display less concern about environmental issues [70]. The partisan gap further widened when climate change became a more urgent and salient environmental issue [64].

4. Discussion of Results

In this section, we report the results of our survey experiment that examines the effects of various treatments on public support for the natural gas ban policy. We summarize our main findings in Figure 1. The coefficients and standard errors for each information treatment are presented in Column (1) in Supplementary Table A2. As this figure shows, among the five dimensions of policy framing, public health information is the only statistically significant determinant of public support for the proposed policy. Specifically, respondents who viewed statements about adverse effects of air pollution on their and their children's health were significantly more likely to support the natural gas ban than those who were not exposed to such information. In substantive terms, respondents' support for the proposed restrictions on natural gas use increased by around 0.13 on a five-point scale when information about the adverse health effects was provided. This implies that citizens are sensitive to non-economic health frames when evaluating the policy proposal to eliminate natural gas use.



Note: This plot presents estimates of the effect of a randomly assigned treatment on a 5-point scale of policy support. The lines refer to 90% (thicker lines) and 95% (thinner lines) confidence intervals based on robust standard errors clustered by

respondents. The estimates are plotted relative to the control group (i.e., those who received no information for a given treatment).

Figure 1: Effects of each treatment on public support for the natural gas ban.

Next, we find only suggestive evidence that consumer costs matter in explaining public support for natural gas bans. Respondents tend to oppose the gas ban when the policy increases their energy expenditures, which is consistent with existing studies on public support for renewable energy and environmental policies [27, 71], but these treatments failed to reach the conventional threshold of statistical significance. We also conclude that the information describing the policy stance of relevant energy sectors, i.e., opposition from the natural gas industry or support from the renewable energy industry, does not affect public preferences toward the natural gas ban policy. This implies that economic frames such as consumer costs and industry support may not be as important as we would expect, compared with non-economic frames, in explaining the public support for restrictions on natural gas use.

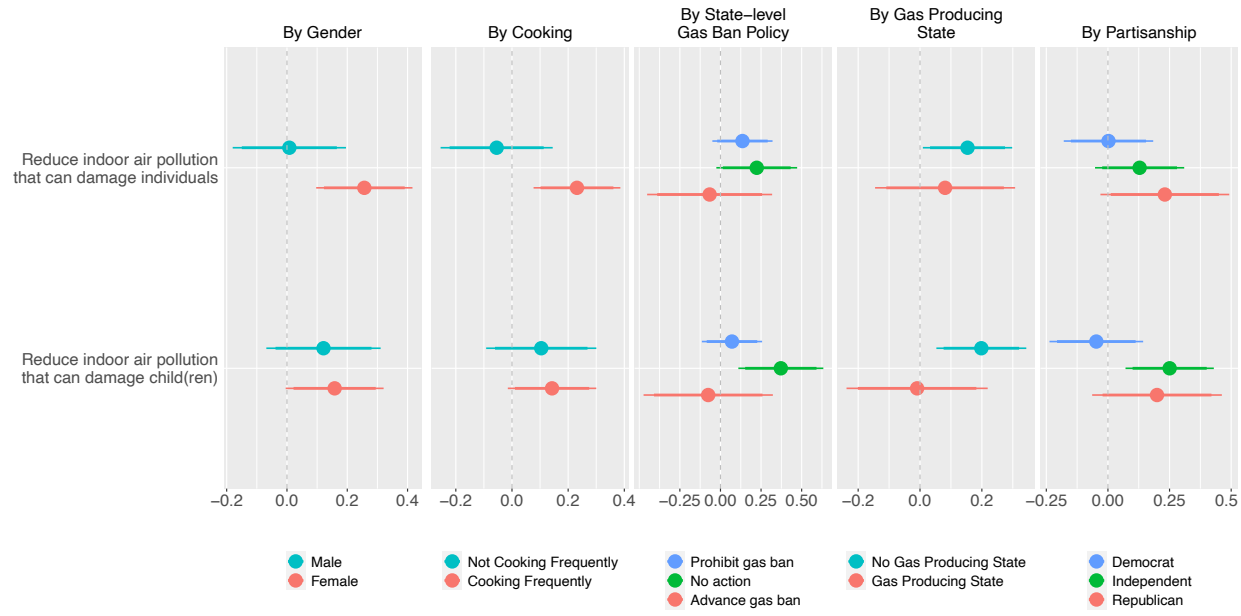
While economic considerations may play a role in public opinion formation, non-economic frames, especially those related to direct and immediate impacts on health, can be more compelling. In particular, the health attribute describes an immediately understandable impact: a threat to oneself or one's children due to air pollution feels personal and salient. Individuals can relate to the idea of health costs imposed on them and their families, which can trigger a more emotional response compared to more abstract concepts such as economic costs. As for the cost attribute, respondents may believe that, although economic challenges such as higher energy bills are disruptive in the short term, it is possible to adapt or switch to alternatives in the long run. However, health damage, once incurred, may be irreversible or have long-lasting consequences. In the case of the industry position attribute, the public may have varying levels of distrust toward energy corporations and their messages, or perceive these companies as purely profit-driven entities. Therefore, individuals may place a low weight on companies' arguments (for or against the proposed policy) when forming their opinions about this policy. The general skepticism about industry motives can overshadow economic considerations.

In addition, we find weak evidence that public support has an association with climate change frames, echoing the findings of previous studies on public opinion toward renewable energy policies [27, 43]. This may suggest the limited effectiveness of climate change frames, which have been viewed by environmental groups as an important tool for influencing public opinion. Various factors could be at play when our survey participants viewed information related to climate change. First, it is possible that many people perceive climate change as a distant and abstract threat. While they might acknowledge it as an issue, they do not necessarily see it as an immediate risk to their personal lives [72]. Second, in some countries, particularly the US, climate change has become a highly polarized political issue. People's beliefs and perceptions about climate change can often align more with their political identity rather than the actual evidence or frames presented to them [73]. Third, it is possible that people may acknowledge the significance of climate change but feel helpless or believe that their individual actions cannot make a meaningful difference. This perceived lack of efficacy can dampen the motivation to support relevant policies [74].

Similarly, our analysis does not yield robust evidence of government officials' sway over public

support. Neither federal nor local politicians appear to have any influence on public opinion regarding the policy banning natural gas use, i.e., public opinion remains the same even when primed with the notion that the gas phaseout has garnered significant political backing at the local or federal level. While political endorsements can be valuable in some contexts, they might not always be effective in swaying public opinion, especially when dealing with contentious or deeply personal issues. First, it is possible that natural gas policies are so salient to the public that external endorsements, even from politicians, have limited influence. Moreover, if an issue is viewed as highly partisan, endorsements from politicians, especially those affiliated with a particular party, might be dismissed by individuals from opposing political factions.

The overall lack of significant findings for the treatments, except for the health concerns, can also be attributed to the fact that the issue of natural gas restrictions has already been known and discussed enough to form individuals' opinions. In this case, most respondents may have already made up their minds regarding restrictions on natural gas use and could not be compelled to change their opinions in most cases, except when presented with the information about harm to their health or their children's health.



Note: This plot presents estimates of the effect of a randomly assigned treatment on a 5-point scale of policy support. The lines refer to 90% (thicker lines) and 95% (thinner lines) confidence intervals based on robust standard errors clustered by respondents. The estimates are plotted relative to the control group (i.e., those who received no information for a given treatment). Supplementary Figures A1-A5 provide results for other treatment attributes.

Figure 2: Heterogeneous effects of the health treatment on public support for the natural gas ban policy by (a) gender, (b) cooking frequency, (c) state policies, (d) residency in gas-producing states, and (e) partisanship.

Next, we explore the possibility that the effect of health-related information may depend on survey participants' characteristics. Figure 2 reports results of these additional tests. Specifically, Figure 2a points to the importance of gender: female respondents are more likely

to support a natural gas ban when they see the health treatment, whereas male respondents' support does not change when we present them with this information. Similarly, Figure 2b indicates that individuals' exposure to harmful products of natural gas combustion due to regular cooking is linked to increased support for the policy in the group that sees health-related information. In contrast, respondents who do not cook at home do not appear to be swayed by adverse health impacts. Together, these two sets of findings are consistent with a traditional gender-based division of household responsibilities, when women tend to do most of the cooking.[8] Given the amount of time women spend close to the source of pollution, they have incentives to pay closer attention to information about the negative health impacts of this type of air pollution.

We also find a divide between states that moved toward banning natural gas, that made such bans illegal, and that have not adopted any policies regarding natural gas use in the residential sector. Figure 2c indicates that information about adverse effects of natural gas combustion on child health is associated with a greater likelihood of increased support for this policy in states without any existing policies. These results suggest that public discussion and debates that typically occur when elected officials engage in policy formulation and adoption, as well as public information campaigns by political and economic actors with some stakes in these policies, help individuals to acquire knowledge and form their opinions about this policy (either in support or against the policy). When they responded to our survey, they had already made up their minds and our treatment was not able to change their prior beliefs. The other group of respondents – i.e., residents of states without any relevant policies – did not experience the same process of policy adoption in their states and hence had fewer opportunities to learn about natural gas bans and adopt a position on this type of policy. These respondents, consequently, had weaker prior beliefs and were more open to react to our public health treatment by expressing a greater level of support for natural gas restrictions.

In addition, we explore differences that can be attributed to characteristics of our respondents' states of residence. Our results show that policy support among residents of gas-producing states does not change when we highlight the health consequences of cooking with natural gas. However, individuals who live in other states are more likely to feel supportive of a gas ban when they receive information about harm to their health or their children's health (Figure 2d). This discrepancy could stem from economic motivations: those who reside in gas-producing states might worry about the loss of jobs and tax revenues from gas production if a natural gas ban goes into effect, and that may cancel out any health concerns.

Another individual-level characteristic that is associated with varying levels of responsiveness to health information is partisanship. Figure 2e shows that independents, when presented with information about the detrimental effects of natural gas combustion on child health, are more likely to support the gas ban policy compared to those who received no such information. At the same time, we do not find significant heterogeneity across parties for our main health treatment. It is possible that independents and partisans respond differently to the information that we provide about health effects [75], which highlights complexities of the interplay between partisanship, information, and policy attitudes. First, independents may be more open to being influenced by new information compared to strong partisans. Partisans, whether

[8] The result is also consistent with the literature on gender and environmental health risk perception, i.e., women are more likely to support regulations related to environmental health risks (Davidson & Freudenburg, 1996).

Democrat or Republican, often have strong positions and are more resistant to treatment information that challenges their pre-existing beliefs. Second, both Democrats and Republicans might exhibit motivated reasoning [76], i.e., they might process information in a way that confirms their prior beliefs. While Democrats are generally more supportive of environmental regulations, their pro-environmental stance may already be factored into their position on natural gas restrictions. Similarly, Republicans, who tend to be skeptical of regulatory actions, could dismiss the health effect information. Finally, the 2021 Morning Consult survey data identifies a substantial partisan gap on the issue of the natural gas ban: while 61% of Democrats indicated that they would support a natural gas ban, only 26% of Republicans would do so [20]. Given that natural gas restrictions have become a polarized issue, strong Democrats and Republicans may have already made up their minds along party lines and could not be swayed by the health information presented.[9]

5. Conclusion

What explains Americans' support for policies that restrict natural gas use by banning gas from new residential construction? While the carbon dioxide emissions resulting from natural gas consumption are lower than from other fossil fuels, scholars and policymakers have become concerned with the deleterious consequences of burning natural gas for human health and the environment. Some U.S. states moved to adopt policies to ban natural gas in new construction, whereas other states are going in the opposite direction by prohibiting local authorities from passing similar bans. At the same time, a number of states are yet to adopt any policies in this policy area. Thus, it is crucial to understand the formation of public opinion on the natural gas ban policy while policymakers attempt to advance new measures to combat climate change and protect human health. This article seeks to understand which factors influence public support for natural gas bans by conducting a survey experiment.

Our results show that the U.S. public expresses greater support for a proposed natural gas ban in new construction when members of the public are informed that natural gas is harmful to their (or their children's) health. Health concerns play a key role in influencing public opinion on this policy. Other treatments, such as information regarding consumer costs, industry position, climate change, and political support, do not yield evidence of statistically significant relationships with public support for natural gas bans. We also find that the effects of health-related information vary with survey participants' characteristics, such as household responsibilities, economic incentives, and partisanship. For example, respondents with more household responsibilities support the natural gas ban when the respondents receive information about health hazards associated with natural gas use. However, survey participants who might expect the loss of jobs and revenues due to the ban tend not to change their opinions when we expose them to the same information. Still, it is important to note that null findings

9 As a robustness check, we re-estimated our models after categorizing independent 'leaners' as either Democrats or Republicans. The results, presented in Supplementary Figure A7, show statistically significant positive effects of health information for Republicans. These findings, when considered alongside the null results for Republicans when excluding independents leaning toward the Republican party within the Republican subgroup, suggest that the positive influence of the health information may be primarily driven by these independents leaning toward the Republican party.

regarding certain information treatments may be attributable to insufficient statistical power of the survey experiment. Thus, our results should not be construed as indicative of the ineffectiveness of information for which we did not find supportive evidence.

These experimental findings offer important policy implications. As the energy system is undergoing a transition away from all fossil fuels, public support is essential for policymakers who seek to advance policies restricting the use of natural gas. Our study suggests that policymakers and other political actors can increase public support for this policy by tailoring its framing to focus on health consequences. These findings are also consistent with previous research that demonstrates the influence of environmental health arguments in the energy transition process. For instance, public health officials and civil society groups successfully used narratives linking coal to poor air quality and health risks to accelerate the phaseout of coal-fired power in Ontario [77]. When the public learns about environmental hazards of fossil fuel energy and considers such hazards an urgent public health problem, public opinion can provide policymakers with an impetus and a mandate to adopt economically costly policies reducing fossil fuel use and counter potential political costs of this transition. Future research may further explore these policy implications by evaluating when the public is more willing to accept public health narratives and overlook the costs of natural gas restrictions and, more broadly, the costs of transition away from fossil fuels and toward renewable energy.

While the main findings offer new insights into the impact of health information, it is also noteworthy that one limitation of this study lies in the concern for external validity. Although experimental methods allow researchers to estimate causal effects, the findings may not be applicable to different issues and contexts. Such limitations in external validity tend to persist, particularly in the fields of environmental and energy research, where societal, political, temporal contexts, as well as framing, can influence the outcomes [78]. To address the concern of external validity, future research should investigate the effects of health information in other contexts with varying public attitudes toward environmental and energy issues, political environments, and geographic locations. Additionally, application of other research methods such as large representative surveys and qualitative studies to examine whether they yield substantively similar findings would be essential to mitigate the limitation of experimental research [79].

References

[1] World Resources Institute. (2020). Climate Watch: GHG Emissions. Available at: https://www.climatewatchdata.org/ghg-emissions

[2] Burnet, W.M. & Ban, S.D. (1989). Changing prospects for natural gas in the United States. Science 244(4902), 305-310

[3] The U.S. Energy Information Administration. (2022). Electricity Explained: Electricity in the United States. Available at: https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php

[4] The U.S. Energy Information Administration. (2021b). U.S. Shale Production. Available at: https://www.eia.gov/dnav/ng/hist/res_epg0_r5302_nus_bcfa.htm

[5] The U.S. Energy Information Administration. (2021a). How much carbon dioxide is produced when different fuels are burned?
Available at: https://www.eia.gov/tools/faqs/faq.php?id=73&t=11

[6] Burney, J.A. (2020). The downstream air pollution impacts of the transition from coal to natural gas in the United States. Nat Sustain 3, 152–160 https://doi.org/10.1038/s41893-019-0453-5

[7] Howarth, R. W. (2014). A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas. Energy Science & Engineering, 2(2), 47-60

[8] McJeon, H., Edmonds, J., Bauer, N., Clarke, L., Fisher, B., Flannery, B., Hilaire, J., Krey, V., Marangoni, G., Mi, R., Riahi, K., Rogner, H., & Tavoni, M. (2014). Limited impact on decadal-scale climate change from increased use of natural gas. Nature 514, 482–485 https://doi.org/10.1038/nature13837

[9] Nace, T., Plant, L., & Browning, J. (2019). The new gas boom: Tracking global LNG infrastructure. Global Energy Monitor

[10] Losz, A. & Elkind, J. (2019). The Role of Natural Gas in the Energy Transition. Columbia SIPA Center of Global Energy Policy Working Paper https://www.energypolicy.columbia.edu/research/commentary/role-natural-gas-energy-transition

[11] Witter, R.Z., McKenzie, L., Stinson, K.E., Scott, K., Newman, L.S. and Adgate, J. (2013). The use of health impact assessment for a community undergoing natural gas development. American Journal of Public Health, 103(6), 1002-1010

[12] Davis, L.W. (2021). What matters for electrification? Evidence from 70 years of US home heating choices. National Bureau of Economic Research Working Paper 28324 http://www.nber.org/papers/w28324

[13] California Energy Commission, Local Ordinance Exceeding the 2019 Energy Code, (2021). Available at: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2019-building-energy-efficiency-3

[14] Bernauer, T. (2013). Climate change politics. Annu. Rev. Polit. Sci. 16, 421-448

[15] Bergquist, M., Nilsson, A., Harring, N. & Jagers, S. (2022). Meta-analyses of fifteen determinants of public opinion about climate change taxes and laws. Nat. Clim. Chang. 12, 235–240 https://doi.org/10.1038/s41558-022-01297-6

[16] Boudet, H.S. (2019). Public perceptions of and responses to new energy technologies. Nat Energy 4, 446–455 https://doi.org/10.1038/s41560-019-0399-x

[17] Dokshin, F.A. (2021). Variation of public discourse about the impacts of fracking with geographic scale and proximity to proposed development. Nat Energy 6, 961–969 https://doi.org/10.1038/s41560-021-00886-7

[18] Hanemann, M. (2012). Public support for clean energy. Nature Clim Change 2, 573–574 https://doi.org/10.1038/nclimate1640

[19] Jacobsson, S. & Lauber, V. (2006). The politics and policy of energy system transformation - explaining the German diffusion of renewable energy technology. Energy Policy 34, 256-276

[20] Morning Consult. 2021. National Tracking Poll #2101101 January 28-30, 2021. https://assets.morningconsult.com/wp-uploads/2021/02/12184654/2101101_crosstabs_MC_ENERGY_Adults_v1-1.pdf

[21] Attari, S. Z., Schoen, M., Davidson, C. I., DeKay, M. L., de Bruin, W. B., Dawes, R., & Small, M. J. (2009). Preferences for change: Do individuals prefer voluntary actions, soft regulations, or hard regulations to decrease fossil fuel consumption?. Ecological Economics, 68(6), 1701-1710.

[22] Cherry, T. L., Kallbekken, S., & Kroll, S. (2012). The acceptability of efficiency-enhancing environmental taxes, subsidies and regulation: An experimental investigation. Environmental Science & Policy, 16, 90-96.

[23] Rinscheid, A., Pianta, S., & Weber, E. U. (2020). Fast track or Slo-Mo? Public support and temporal preferences for phasing out fossil fuel cars in the United States. Climate Policy, 20(1), 30-45.

[24] Hoppe, J., Patt, A., & Tröndle, T. (2023). Public support for phasing out carbon-intensive technologies: the end of the road for conventional cars in Germany?. Climate Policy, 1-16.

[25] Bolsen, T. & Cook, F. L. (2008). The polls-trends: public opinion on energy policy: 1974-2006. Public Opin. Q. 72, 364-388

[26] Farhar, B. (1994). Trends: public opinion about energy. Public Opin. Q. 58, 603-632

[27] Stokes, L., & Warshaw, C. (2017). Renewable energy policy design and framing influence public support in the United States. Nat Energy 2, 17107

[28] Pierce, J. J., Boudet, H., Zanocco, C., & Hillyard, M. (2018). Analyzing the factors that influence US public support for exporting natural gas. Energy Policy, 120, 666-674.

[29] Boudet, H., Clarke, C., Bugden, D., Maibach, E., Roser-Renouf, C., & Leiserowitz, A. (2014). "Fracking" controversy and communication: Using national survey data to understand public perceptions of hydraulic fracturing. Energy Policy, 65, 57-67.

[30] Lee, M. H., & Clark, A. (2020). Partisanship does not tell the full story: The complexities of public opinion and fracking in the United States. Energy Research & Social Science, 70, 101686.

[31] Gong, X., Lu, Y., Beene, D., Li, Z., Hu, T., Morgan, M., & Lin, Y. (2022). Understanding public perspectives on fracking in the United States using social media big data. Annals of GIS, 1-15.

[32] Jerolmack, C., & Walker, E. T. (2018). Please in My Backyard: Quiet Mobilization in Support of Fracking in an Appalachian Community. American Journal of Sociology, 124(2), 479-516. https://doi.org/10.1086/698215

[33] Boudet, H. S., Zanocco, C. M., Howe, P. D., & Clarke, C. E. (2018). The effect of geographic proximity to unconventional oil and gas development on public support for hydraulic fracturing. Risk Analysis, 38(9), 1871-1890.

[34] Basu, R., & Samet, J. (1999). A review of the epidemiological evidence on health effects of nitrogen dioxide exposure from gas stoves. Journal of environmental medicine, 1(4), 173-187

[35] Lebel, E. D., Finnegan, C. J., Ouyang, Z., & Jackson, R. B. (2022). Methane and NO x Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes. Environmental science & technology, 56(4), 2529-2539

[36] Nicole, W. (2014). Cooking up indoor air pollution: emissions from natural gas stoves. In: National Institute of Environmental Health Sciences.

[37] Evensen, D., & Brown-Steiner, B. (2018). Public perception of the relationship between climate change and unconventional gas development ('fracking') in the US. Climate Policy, 18(5), 556-567.

[38] Hazboun, S. O., & Boudet, H. S. (2021). Natural gas–friend or foe of the environment? Evaluating the framing contest over natural gas through a public opinion survey in the Pacific Northwest. Environmental Sociology, 7(4), 368-381

[39] Lacroix, K., Goldberg, M. H., Gustafson, A., Rosenthal, S. A., & Leiserowitz, A. (2021). Different names for "natural gas" influence public perception of it. Journal of Environmental Psychology, 77, 101671.

[40] Druckman, James N. 2011. "What's it all about? Framing in political science." Perspectives on Framing 279:282-296.

[41] Feldman & Hart. 2018. "Climate change as a polarizing cue: Framing effects on public support for low-carbon energy policies" Global Environmental Change

[42] Lockwood 2011. "Does the framing of climate policies make a difference to public support? Evidence from UK marginal constituencies" Climate Policy

[43] Bernauer, T., & McGrath, L (2016). Simple reframing unlikely to boost public support for climate policy. Nature Clim Change 6, 680–683 https://doi.org/10.1038/nclimate2948

[44] Cacciatore, Michael A., Dietram A. Scheufele, and Shanto Iyengar. 2016. "The end of framing as we know it… and the future of media effects." Mass communication and society 19(1):7-23.

[45] Steg, L., Dreijerink, L., & Abrahamse, W. (2006). Why are Energy Policies Acceptable and Effective? Environment and Behavior, 38(1), 92-111 https://doi.org/10.1177/0013916505278519

[46] Hainmueller, J., Hangartner, D., & Yamamoto, T. (2015). Validating vignette and conjoint survey experiments against real-world behavior. Proceedings of the National Academy of Sciences 112.8: 2395-2400.

[47] Hainmueller, J., Hopkins, D. J., & Yamamoto, T. (2014). Causal inference in conjoint analysis: Understanding multidimensional choices via stated preference experiments. Political analysis, 22(1), 1-30

[48] Ansolabehere, S. & Konisky, D. M. (2016). Clean and Cheap: How Americans Think About Energy in the Age of Global Warming. MIT Press, Cambridge, MA.

[49] Bergquist, P., Konisky, D. M., & Kotcher, J. (2020). Energy policy and public opinion: patterns, trends and future directions. Progress in Energy, 2(3), 032003

[50] Aldy, J., Kotchen, M. & Leiserowitz, A. (2012). Willingness to pay and political support for a US national clean energy standard. Nature Clim Change 2, 596–599

[51] Energy and Environmental Economics. (2019). Residential Building Electrification in California: Consumer Economics, Greenhouse Gases and Grid Impacts. https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

[52] Szabo, J. (2022). Energy transition or transformation? Power and politics in the European natural gas industry's trasformismo. Energy Research & Social Science, 84, 102391

[53] Bayulgen, O. & Benegal, S. (2019). Green Priorities: How economic frames affect perceptions of renewable energy in the United States. Energy Research & Social Science. 47, 28-36

[54] Sergi, B., Davis, A., & Azevedo, I. (2018). The effect of providing climate and health information on support for alternative electricity portfolios. Environmental Research Letters, 13(2), 024026.

[55] Howe, P., Mildenberger, M., Marlon, J. & Leiserowitz, L. (2015). Geographic variation in opinions on climate change at state and local scales in the USA. Nature Clim Change 5, 596–603https://doi.org/10.1038/nclimate2583

[56] Janzwood, A., & Millar, H. (2022). Bridge fuel feuds: The competing interpretive politics of natural gas in Canada. Energy Research & Social Science, 88, 102526.

[57] Bernstein, S., & Hoffmann, M. (2019). Climate politics, metaphors and the fractal carbon trap. Nat. Clim. Chang. 9, 919–925

[58] Aklin, M., & Urpelainen, J. (2013). Debating clean energy: Frames, counter frames, and audiences. Global Environmental Change, 23(5), 1225-1232.

[59] Sniderman, P. M., Brody, R. A., & Tetlock, P. E. (1993). Reasoning and choice: Explorations in political psychology, Cambridge University Press

[60] Schneider, S. K., & Jacoby, W. G. (2003). Public attitudes toward the policy responsibilities of the national and state governments: Evidence from South Carolina. State Politics & Policy Quarterly, 3(3), 246-269.

[61] Bolsen, T., Druckman, J.N. & Cook, F.L. (2014). The Influence of Partisan Motivated Reasoning on Public Opinion. Polit Behav 36, 235–262

[62] Ceccoli, S. (2018). Explaining Attitudes Toward US Energy Extraction: Offshore Drilling, the Keystone XL Pipeline, and Hydraulic Fracturing. Social Science Quarterly, 99(2), 644-664

[63] S&P Global Market Intelligence. (2021). Gas Ban Monitor: Calif. count reaches 50 as West Coast movement grows. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/gas-ban-monitor-calif-count-reaches-50-as-west-coast-movement-grows-67732585

[64] Egan, Patrick J. & Mullin, M. (2017). Climate Change: US Public Opinion. Annual Review of Political Science 2017 20:1, 209-227.

[65] Guber, D. L. (2013). A Cooling Climate for Change? Party Polarization and the Politics of Global Warming. American Behavioral Scientist, 57(1), 93–115.

https://doi.org/10.1177/0002764212463361

[66] Egan, Patrick J. Partisan Priorities: How Issue Ownership Drives and Distorts American Politics. Cambridge University Press, 2013.

[67] Konisky, D.M., Milyo, J. and Richardson, L.E. (2008), Environmental Policy Attitudes: Issues, Geographical Scale, and Political Trust. Social Science Quarterly, 89: 1066-1085. https://doi.org/10.1111/j.1540-6237.2008.00574.x

[68] McCright, A, Chenyang X., Dunlap, R.E. (2014). Political polarization on support for government spending on environmental protection in the USA, 1974–2012. Social Science Research 48: 251-260.

[69] Hazlett, Chad, and Matto Mildenberger. 2020. "Wildfire Exposure Increases Pro-Environment Voting within Democratic but Not Republican Areas." American Political Science Review 114(4):1359–1365.

[70] Bolsen, T., Druckman, J. N., & Cook, F. L. (2015). Citizens', Scientists', and Policy Advisors' Beliefs about Global Warming. The ANNALS of the American Academy of Political and Social Science, 658(1), 271–295. https://doi.org/10.1177/0002716214558393

[71] Bechtel, M.M. & Scheve, K.F. (2013). Mass support for global climate agreements depends on institutional design. Proceedings of the National Academy of Sciences, 110(34), 13763-13768

[72] Spence, A., Poortinga, W., & Pidgeon, N. (2012). The psychological distance of climate change. Risk Analysis, 32(6), 957-972.

[73] Dunlap, R. E., McCright, A. M., & Yarosh, J. H. (2016). The political divide on climate change: Partisan polarization widens in the U.S. Environment: Science and Policy for Sustainable Development, 58(5), 4-23.

[74] Lorenzoni, I., Nicholson-Cole, S., & Whitmarsh, L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. Global Environmental Change, 17(3-4), 445-459.

[75] Taber, C. S., & Lodge, M. (2006). Motivated skepticism in the evaluation of political beliefs. American Journal of Political Science, 50(3), 755-769.

[76] Kunda, Z. (1990). The case for motivated reasoning. Psychological Bulletin, 108(3), 480-498.

[77] Rosenbloom, D. (2018). Framing low-carbon pathways: A discursive analysis of contending storylines surrounding the phase-out of coal-fired power in Ontario. Environmental Innovation and Societal Transitions 27: 129-145.

[78] Goodman, J., & Marshall, J. P. (2018). Problems of methodology and method in climate

and energy research: Socialising climate change?. Energy research & social science, 45, 1-11.

[79] Sovacool, B. K., Axsen, J., & Sorrell, S. (2018). Promoting novelty, rigor, and style in energy social science: Towards codes of practice for appropriate methods and research design. Energy research & social science, 45, 12-42.

[80] Egami, N., & Imai, K. (2019). Causal Interaction in Factorial Experiments: Application to Conjoint Analysis, Journal of the American Statistical Association, 114:526, 529-540, DOI: 10.1080/01621459.2018.1476246

Clearing the air: Public health concerns and support for natural gas restrictions in the United States

Supplementary Information

	Our sample	**Census averages**
Female	51.1%	50.8%
High school degree or less	40.5%	38.9%
Age less than 44	49.5%	46.1%
Northeast	19.1%	17.3%
Midwest	21.8%	20.7%
South	42.9%	38.2%
West	16.1%	23.8%

Table A1. The summary statistics of survey participants in comparison to the Census averages.

Ethics statement

The University of […] (IRB) approved the survey experiment described in this article. We have also registered a pre-analysis plan (PAP) on a commonly used repository, but are unable to provide the details due to confidentiality in the blind review process.

Data / Code availability

The data sets and replication code for this study will be available in the Harvard Dataverse repository (https://dataverse.harvard.edu/), once it is accepted.

Our main estimation models do not include demographic and other respondent-level covariates for the following two main reasons. First, the conjoint design randomizes both the order of the treatment attributes and the values in each attribute, and thus we expect the respondent-level covariates to be balanced across the groups, making our estimates of average treatment effects unbiased. Second, the interpretation of the estimates of the covariates in the regression models are not causal since they are, by nature, not randomized. Nevertheless, as robustness checks, we estimate the OLS models including basic demographic covariates such as gender, income,

education, partisanship, and whether the respondent has a child or not. The results, presented in Table A2, show that the inclusion of other covariates does not substantively change our main findings.

Hence, given that our dependent variable---support for the natural gas ban on a 5-point scale---is an ordinal variable, we estimate ordered probit models. We find that our main findings hold for this alternative modeling choice (Table A3).

Supplementary Analysis

Table A2. Comparison of results from the main OLS model and a model with demographic covariates.

	Dependent Variable - Support for the gas ban:	
	(1)	(2)
Costs: Consumer bill savings	0.034	0.080
	(0.071)	(0.068)
Costs:Consumer bill increase of more than 100 per year	-0.058	-0.006
	(0.070)	(0.067)
Costs: Consumer bill increase of less than 100 per year	-0.103	-0.064
	(0.071)	(0.067)
Industry: Natural gas industry opposition	-0.022	-0.031
	(0.062)	(0.058)
Industry:Renewable energy industry support	0.064	0.059
	(0.062)	(0.059)
Health: Reduce indoor air pollution that can damage individuals	0.128**	0.105*
	(0.062)	(0.059)
Health: Reduce indoor air pollution that can damage child(ren)	0.132**	0.134**
	(0.062)	(0.059)
Climate Change: Reduce GHG	0.094	0.104
	(0.073)	(0.069)
Climate Change: Burning natural gas helps to cut GHG	-0.072	-0.075
	(0.072)	(0.068)
Climate Change: Both	-0.117	-0.125*
	(0.072)	(0.068)
Political support: Local level	-0.073	-0.061
	(0.062)	(0.059)
Political support: Federal level	-0.014	-0.026
	(0.062)	(0.058)
Female		0.048

		(0.050)
Urban		0.392***
		(0.052)
College		0.048
		(0.057)
Democrat		0.481***
		(0.057)
Republican		-0.408***
		(0.061)
Income		-0.051**
		(0.024)
Constant	3.210***	3.090***
	(0.091)	(0.115)
Observations	2,623	2,623
R^2	0.009	0.114
Adjusted R^2	0.004	0.108
Residual Std. Error	1.290 (df = 2610)	1.220 (df = 2604)
F Statistic	1.920** (df = 12; 2610)	18.600*** (df = 18; 2604)
Note:	*p<0.1; **p<0.05; ***p<0.01	
	Standard errors are in parentheses	

Table A3. Results from ordered probit models (without and with covariates).

	Dependent Variable - Support for the gas ban	
	(1)	(2)
Costs: Consumer bill savings	0.019	0.060
	(0.058)	(0.059)
Costs:Consumer bill increase of more than 100 per year	-0.045	-0.007
	(0.057)	(0.058)
Costs: Consumer bill increase of less than 100 per year	-0.091	-0.063
	(0.057)	(0.058)
Industry: Natural gas industry opposition	-0.016	-0.023
	(0.050)	(0.051)
Industry:Renewable energy industry support	0.047	0.046
	(0.051)	(0.051)
Health: Reduce indoor air pollution that can harm individuals	0.100**	0.084*
	(0.050)	(0.051)
Health: Reduce indoor air pollution that can harm child(ren)	0.105**	0.110**
	(0.051)	(0.051)
Climate Change: Reduce GHG	0.082	0.097
	(0.059)	(0.060)
Climate Change: Burning natural gas helps to cut GHG	-0.061	-0.067
	(0.058)	(0.059)
Climate Change: Both	-0.096	-0.105*
	(0.059)	(0.059)
Political support: Local level	-0.058	-0.052
	(0.050)	(0.051)
Political support: Federal level	-0.015	-0.026
	(0.050)	(0.050)
Female		0.024
		(0.044)
Urban		0.340***
		(0.045)
College		0.049
		(0.049)
Democrat		0.420***
		(0.049)
Republican		-0.322***
		(0.053)
Income		-0.041**
		(0.021)
Note:	*p<0.1; **p<0.05; ***p<0.01	
	Standard errors are in parentheses	

Table A4. Results from Average Marginal Interaction Effects (AMIE) estimations: to examine potential interaction effects between the five key information, we estimate AMIE by using the data-driven regularization method proposed by Egami and Imai (2019). Here, we present the results for the estimated effects of the combination of two key pieces of information selected by the data-driven screening process suggested by Egami and Imai (2019).

Interaction (Information 1*Information 2)	Message in Information 1	Message in Information 2	AMIE	Std.Err	2.5%CI	97.5%CI
Climate Change*Industry	No info	No info	-0.033	0.11	-0.249	0.184
	Both	No info	0.118	0.111	-0.101	0.336
	Burning natural gas helps to cut GHG	No info	-0.294	0.113	-0.515	-0.072
	Reduce GHG	No info	-0.301	0.145	-0.585	-0.017
	No info	Natural gas industry opposition	-0.194	0.11	-0.411	0.022
	Both	Natural gas industry opposition	-0.122	0.112	-0.342	0.097
	Burning natural gas helps to cut GHG	Natural gas industry opposition	-0.112	0.112	-0.332	0.108
	Reduce GHG	Natural gas industry opposition	-0.081	0.151	-0.377	0.215
	No info	Renewable energy industry support	-0.155	0.146	-0.44	0.13
	Both	Renewable energy industry support	-0.378	0.138	-0.648	-0.107
	Burning natural gas helps to cut GHG	Renewable energy industry support	0.023	0.134	-0.24	0.286
	Reduce GHG	Renewable energy industry support	NA (reference category			
Climate Change*Health	No info	No info	-0.004	0.118	-0.235	0.227
	Both	No info	-0.001	0.112	-0.22	0.218
	Burning natural gas helps to cut GHG	No info	-0.062	0.115	-0.287	0.163
	Reduce GHG	No info	0.191	0.151	-0.104	0.487
	No info	Reduce indoor air pollution that can damage child(ren)	0.028	0.115	-0.198	0.253
	Both	Reduce indoor air pollution that can damage child(ren)	0.045	0.11	-0.17	0.26
	Burning natural gas helps to cut GHG	Reduce indoor air pollution that can damage child(ren)	0.149	0.111	-0.068	0.367
	Reduce GHG	Reduce indoor air pollution that can damage child(ren)	-0.098	0.151	-0.395	0.198
	No info	Reduce indoor air pollution that can damage individuals	0.069	0.144	-0.213	0.351
	Both	Reduce indoor air pollution that can damage individuals	0.049	0.145	-0.235	0.333
	Burning natural gas helps to cut GHG	Reduce indoor air pollution that can damage individuals	0.006	0.14	-0.268	0.279
	Reduce GHG	Reduce indoor air pollution that can damage individuals	NA (reference category			
Climate Change*Political Support	No info	No info	0.002	0.113	-0.22	0.223
	Both	No info	0.022	0.112	-0.198	0.242
	Burning natural gas helps to cut GHG	No info	-0.004	0.111	-0.222	0.214
	Reduce GHG	No info	0.026	0.146	-0.26	0.313
	No info	Political support: federal level	0.045	0.112	-0.175	0.265
	Both	Political support: federal level	-0.094	0.111	-0.311	0.123
	Burning natural gas helps to cut GHG	Political support: federal level	0.087	0.11	-0.129	0.303
	Reduce GHG	Political support: federal level	0.009	0.151	-0.287	0.305

	No info	Political support: local level	-0.011	0.144	-0.293	0.27
	Both	Political support: local level	0.106	0.138	-0.164	0.377
	Burning natural gas helps to cut GHG	Political support: local level	-0.049	0.137	-0.317	0.22
	Reduce GHG	Political support: local level	NA (reference category			
Industry*Health	No info	No info	0.022	0.088	-0.151	0.194
	Natural gas industry opposition	No info	-0.049	0.09	-0.224	0.127
	Renewable energy industry support	No info	-0.125	0.122	-0.363	0.113
	No info	Reduce indoor air pollution that can damage child(ren)	-0.166	0.086	-0.334	0.002
	Natural gas industry opposition	Reduce indoor air pollution that can damage child(ren)	0.042	0.087	-0.13	0.213
	Renewable energy industry support	Reduce indoor air pollution that can damage child(ren)	-0.027	0.122	-0.266	0.212
	No info	Reduce indoor air pollution that can damage individuals	-0.007	0.122	-0.246	0.232
	Natural gas industry opposition	Reduce indoor air pollution that can damage individuals	-0.145	0.123	-0.386	0.097
	Renewable energy industry support	Reduce indoor air pollution that can damage individuals	NA (reference category			
Industry*Political Support	No info	No info	-0.104	0.087	-0.275	0.067
	Natural gas industry opposition	No info	0.097	0.088	-0.076	0.269
	Renewable energy industry support	No info	0.092	0.119	-0.141	0.325
	No info	Political support: federal level	0.089	0.086	-0.08	0.258
	Natural gas industry opposition	Political support: federal level	0.003	0.086	-0.165	0.171
	Renewable energy industry support	Political support: federal level	-0.008	0.122	-0.246	0.231
	No info	Political support: local level	0.1	0.118	-0.132	0.331
	Natural gas industry opposition	Political support: local level	-0.015	0.123	-0.255	0.225
	Renewable energy industry support	Political support: local level	NA (reference category			
Health*Political Support	No info	No info	-0.148	0.087	-0.319	0.023
	Reduce indoor air pollution that can damage child(ren)	No info	0.041	0.086	-0.128	0.209
	Reduce indoor air pollution that can damage individuals	No info	-0.198	0.122	-0.437	0.042
	No info	Political support: federal level	-0.069	0.088	-0.242	0.104
	Reduce indoor air pollution that can damage child(ren)	Political support: federal level	-0.129	0.085	-0.296	0.038
	Reduce indoor air pollution that can damage individuals	Political support: federal level	-0.107	0.123	-0.348	0.133
	No info	Political support: local level	-0.088	0.122	-0.328	0.151
	Reduce indoor air pollution that can damage child(ren)	Political support: local level	-0.217	0.122	-0.455	0.022
	Reduce indoor air pollution that can damage individuals	Political support: local level	NA (reference category			

Fig. A1. Estimation results by gender.

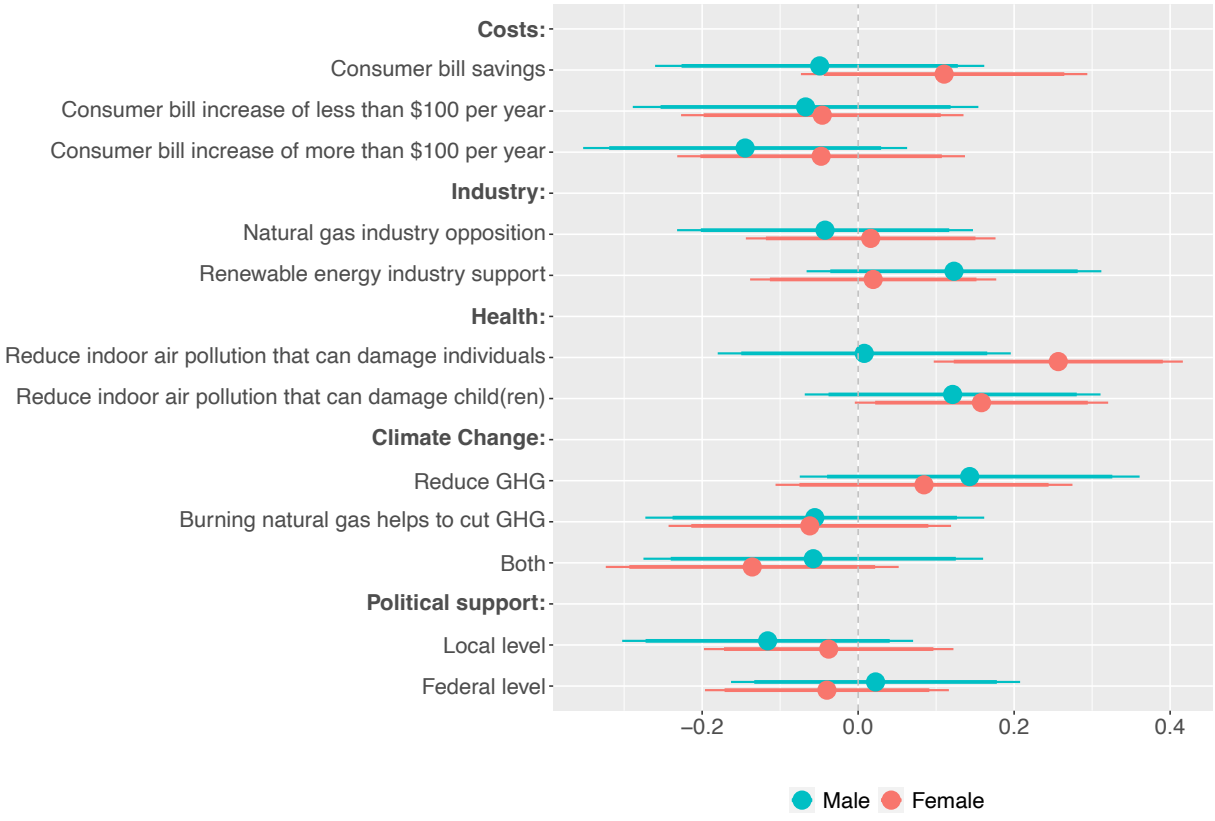


Fig. A2. Estimation results by home cooking frequency.

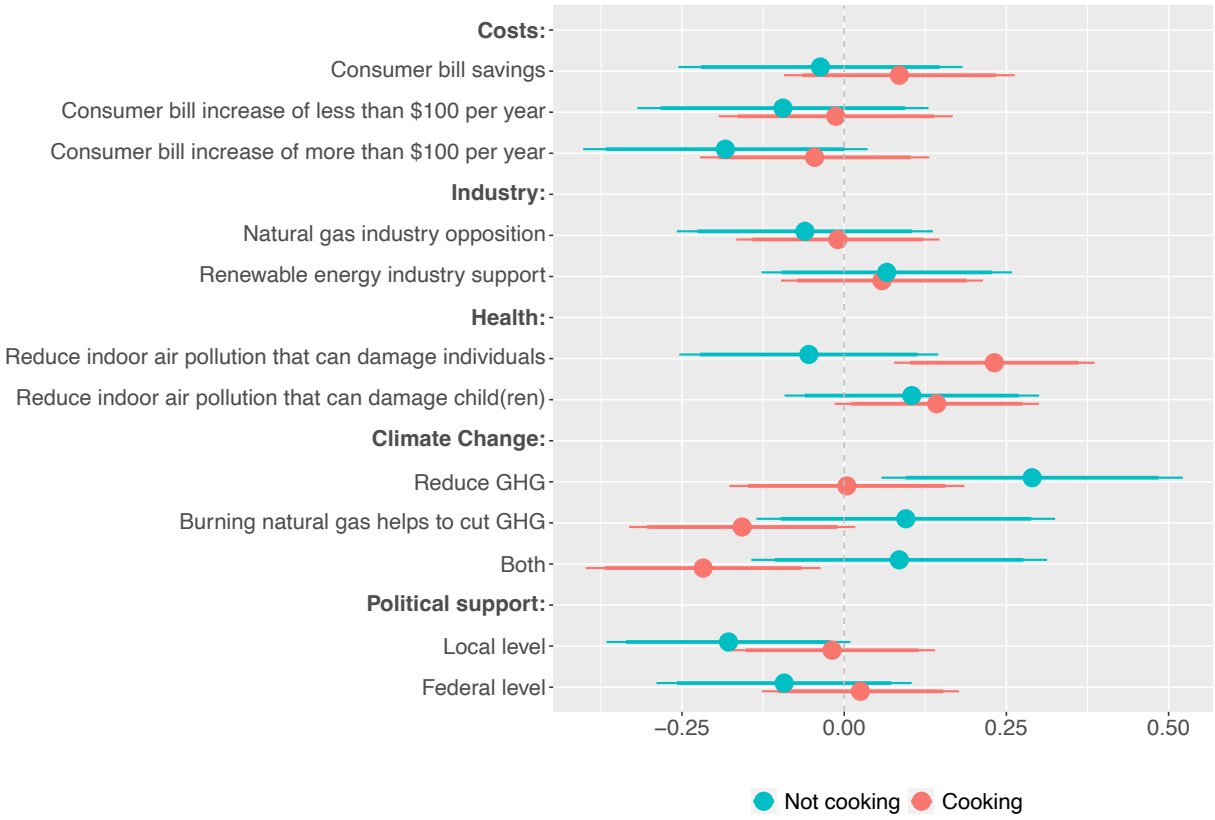


Fig. A3. Estimation results by state-level gas ban policy.

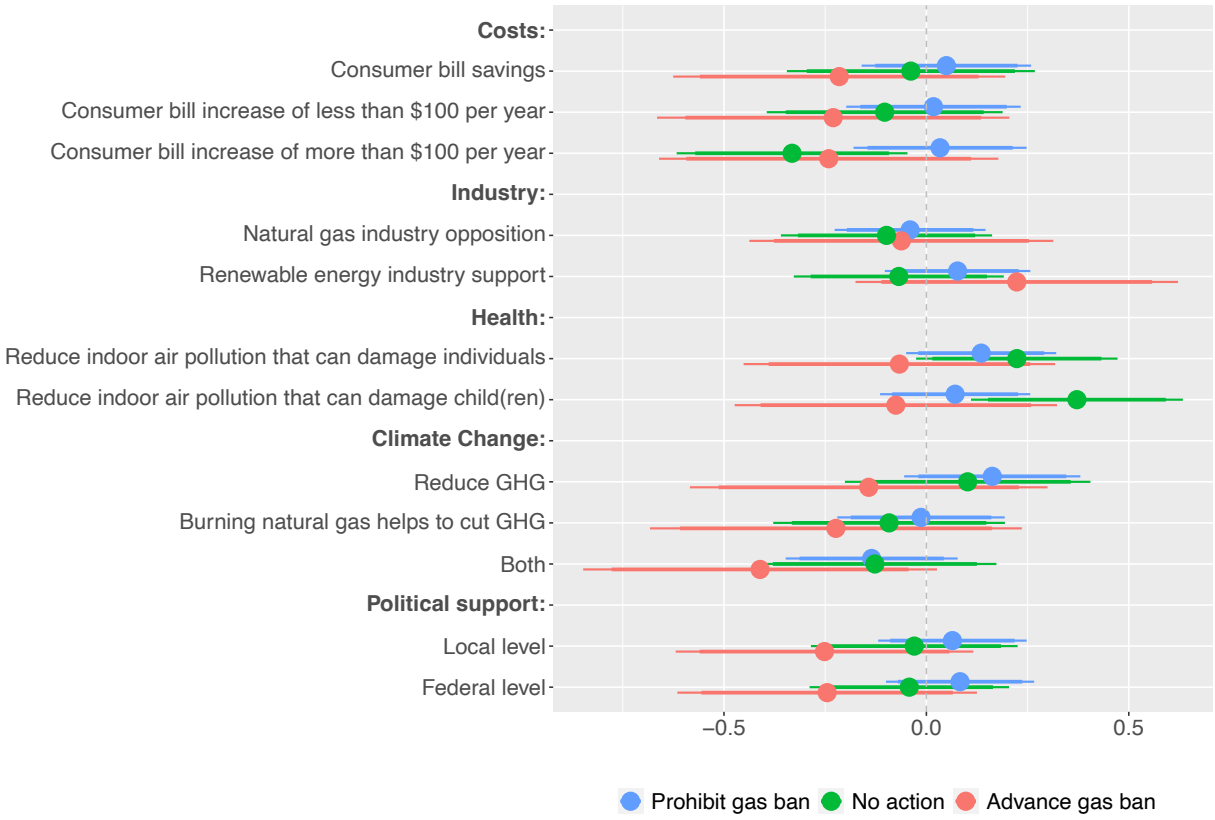


Fig. A4. Estimation results by residence in a gas-producing state.

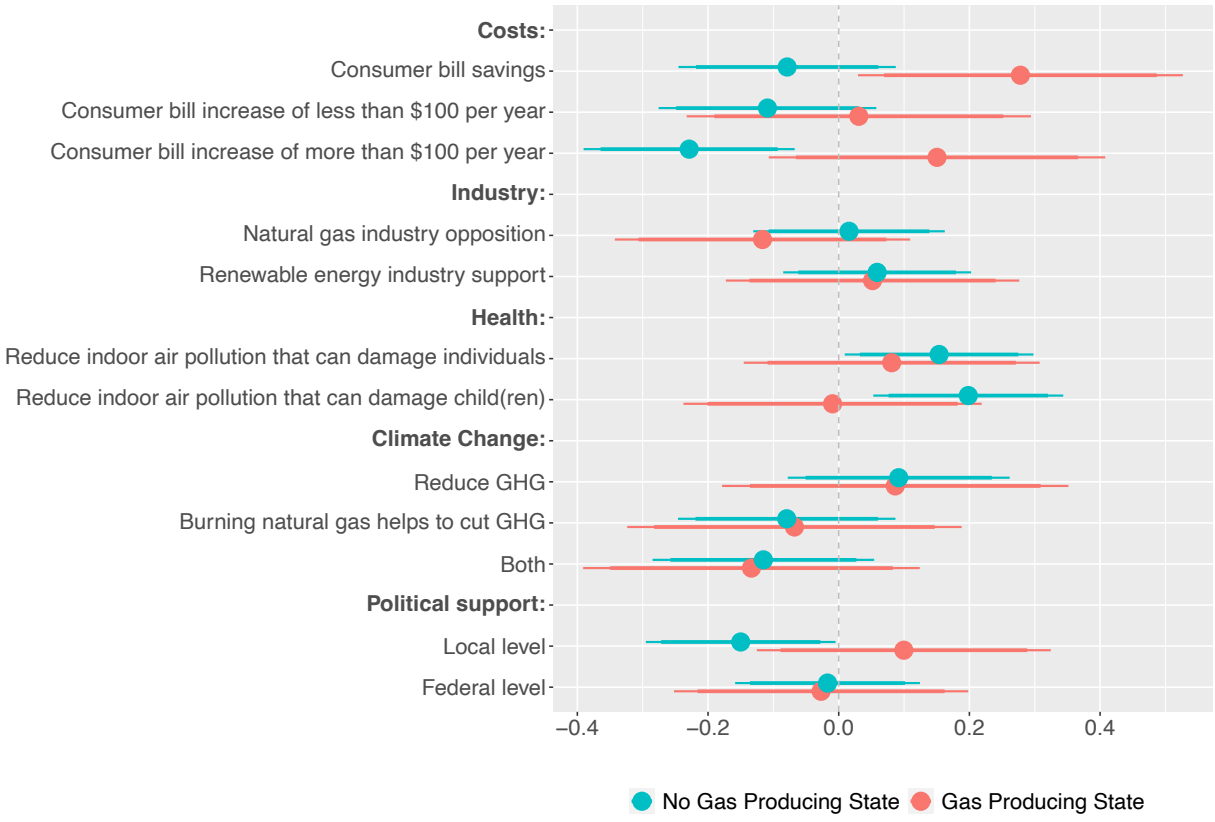


Fig. A5. Estimation results by partisanship.

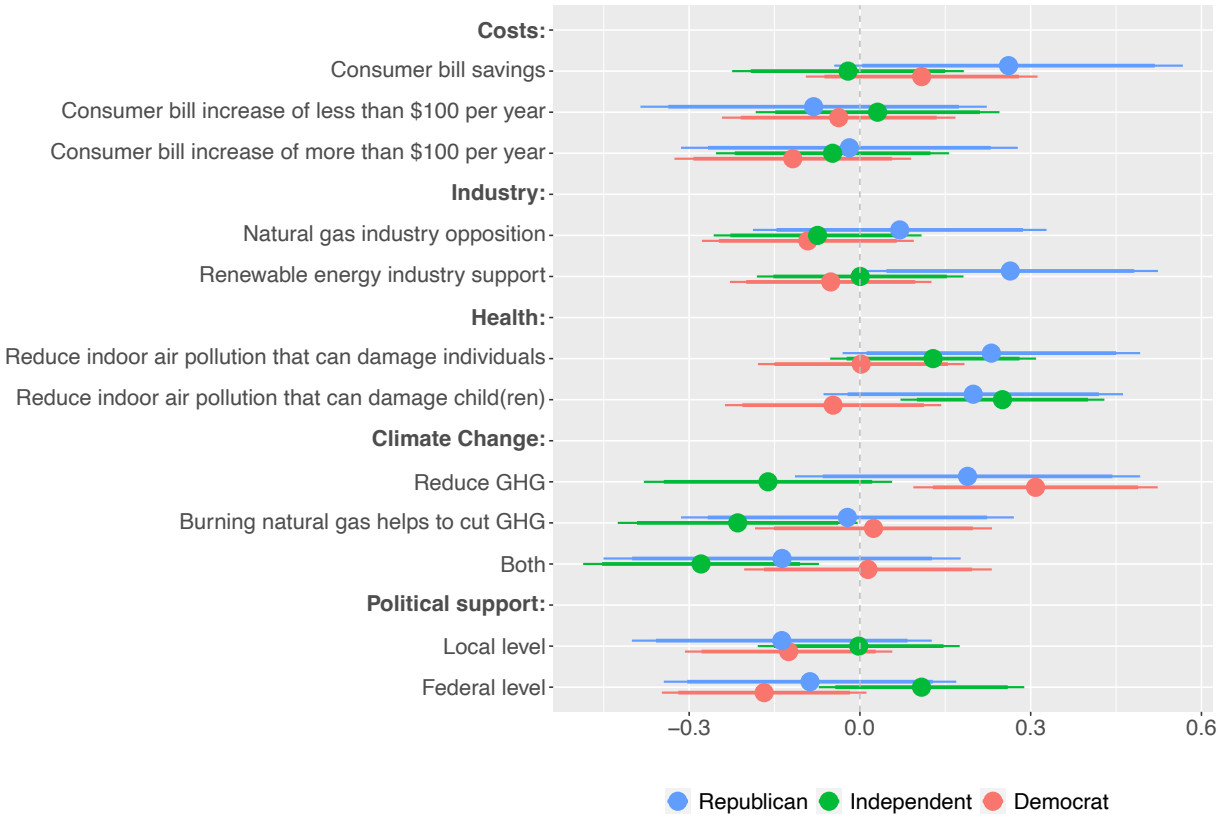


Fig. A6. A screenshot of an example of the texts about the description of the natural gas ban policy presented in the experiment, and the question asked to measure the respondents' support level for the natural gas ban policy.

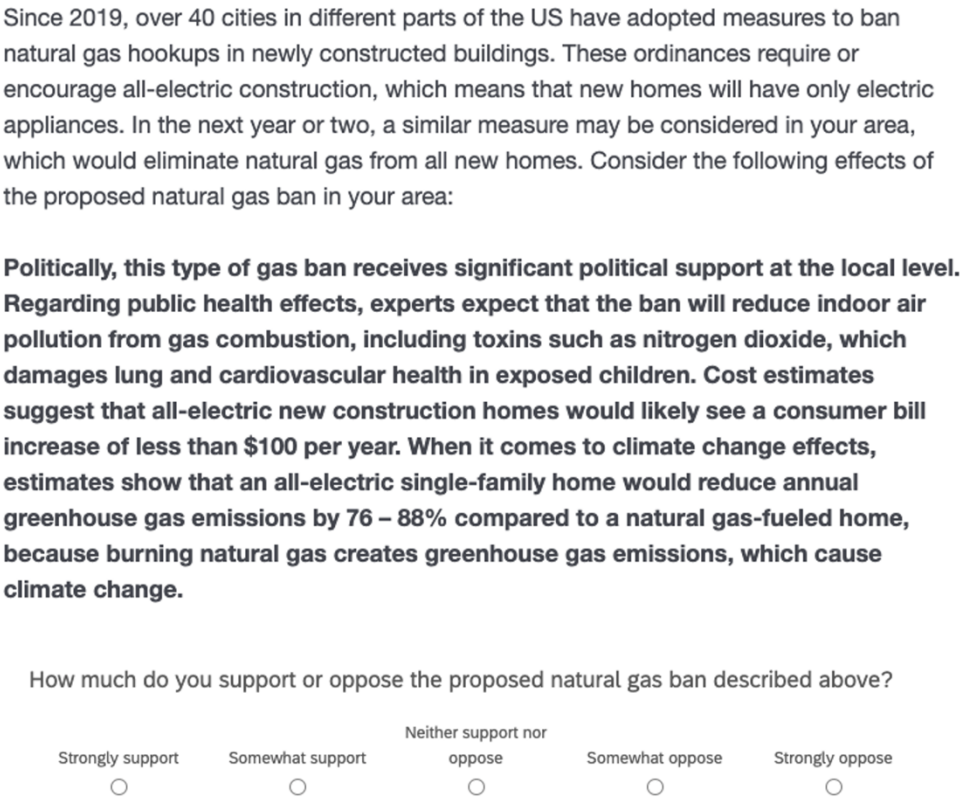


Fig. A7. Robustness check: estimation results for the health information effects by partisanship when categorizing independent 'leaners' as either Democrats or Republicans.