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Appealing to Independents: information on negative externalities increases support for environmental corrective taxes

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ABSTRACT
Climate change requires urgent global action, but efforts to implement solutions like a carbon tax face deep political polarization, particularly in the United States. This study explores how framing corrective taxes as welfare-enhancing tools might influence public support. Through a pre-registered survey experiment, we manipulate information about the economic benefits of corrective taxes that address negative externalities, assessing their impact on support across political groups. Our findings reveal that this information significantly increases the belief across all groups that the benefits of a carbon tax outweigh its costs and makes increasing social welfare a more salient goal. While Independents show significant positive shifts in support for carbon taxes, moving from weakly negative to weakly positive stances, Republicans remain largely unmoved, likely due to entrenched ideological resistance.

1. Introduction

Climate change is one of the most pressing global challenges, with its detrimental impacts already manifesting.[1] Despite the need for immediate policy action to reduce emissions, climate action has been insufficient, particularly in the politically polarized United States. Several strategies have been proposed to bridge this divide and garner support for climate change mitigation policies.

In this paper, we focus on one such strategy, which involves making the economic benefits of climate change mitigation more salient. This approach is grounded in the economic concept of negative externalities, particularly as

it applies to climate change. Economic actors often do not bear the full costs of emitting greenhouse gases into the atmosphere, leading to excessive emissions. While policy solutions can be difficult to implement – due to political polarization and conflicts of economic interests – the economic solution to this market failure is rather straightforward: implementing a higher price on harmful activities, such as through a pollution or carbon tax. A carbon tax is a policy mechanism designed to mitigate climate change by placing a financial charge on the emission of carbon dioxide and other greenhouse gases, typically based on the amount of emissions produced. This economic incentive aims to encourage individuals, businesses, and industries to reduce their carbon emissions, thereby curbing the negative environmental impacts associated with excessive greenhouse gas release.

Economists overwhelmingly support carbon taxes as effective tools to reduce greenhouse gases (Geide-Stevenson and La Parra Perez 2021), yet public skepticism remains high (Rhodes *et al.* 2017, Stadelmann-Steffen and Dermont 2018, Carattini *et al.* 2019, Lachapelle and Kiss 2019, Mildenberger 2020). Given this public skepticism, understanding how to increase support for these efficiency-enhancing policies is paramount.

Unlike taxes designed primarily to raise revenue – known as Ramsey taxes – a carbon tax is a corrective tax, or Pigouvian tax. The primary purpose of a Pigouvian tax is to correct a market failure by internalizing the external costs not reflected in the market price of a good or service – in this case, the environmental and social costs of carbon emissions. The revenue generated by a Pigouvian tax is a secondary benefit and can be used in various ways, such as reducing other taxes, funding renewable energy projects, or compensating those disproportionately affected by the tax. However, the primary goal remains to incentivize a reduction in harmful activities, thereby increasing overall societal welfare. This distinction is crucial because public perception often conflates all taxes as mere revenue-raising tools, which can lead to opposition, particularly among those who are tax-averse (Dresner *et al.* 2006, Kallbekken *et al.* 2011).

In this paper, we frame carbon taxes as welfare-increasing tools rather than merely revenue-raising mechanisms. By emphasizing the economic benefits of climate change mitigation through this lens, we aim to address the public's aversion to carbon taxes, particularly among conservatives and Republicans, who may be more responsive to messages that shift the focus away from revenue generation and toward the broader economic benefits of the tax (Campbell *et al.* 1960, Bartels 2005, Graetz 2024).

Framing plays a critical role in shaping public opinion on issues like climate change (Chong and Druckman 2007b). While various studies have explored different framing strategies (Nisbet 2009, Spence and Pidgeon 2010, Gifford and Comeau 2011, Myers *et al.* 2012, MacInnis *et al.* 2015, Wiest *et al.* 2015, Zhang *et al.* 2018), none have specifically

examined the framing of environmental negative externalities outside of a classroom context (Kallbekken *et al.* 2011). Emphasizing this framing is crucial because most people fail to recognize that the primary objective of corrective taxes is to incentivize emissions reduction and thereby increase societal welfare, rather than merely raising revenues.

We use a pre-registered survey experiment to examine how framing carbon taxes as welfare-enhancing tools influences public support for corrective taxes. The control group was simply asked whether they supported a pollution tax and a carbon tax (with the order of questions randomized), without receiving any additional information. In contrast, the treatment group was presented with a brief, non-partisan numerical explanation highlighting how a corrective tax internalizes the external costs of pollution, thereby increasing overall social welfare.

Our findings reveal that the information treatment significantly increased support for both a pollution tax and a carbon tax, but only among those who passed the factual manipulation checks. The treatment also increased the belief that the benefits of a carbon tax outweigh its costs and made increasing social welfare a more prominent consideration.

The treatment's impact varied by party identification. While Independents showed significant increases in support, contrary to our expectations, Republicans remained largely unmoved. These findings suggest that targeting Independents, who are less polarized, with economic messages could be crucial in shaping opinions on climate mitigation policies. Given the difficulty of shifting attitudes on highly salient and polarized issues like climate change, even modest shifts in their attitudes from weakly negative to positive could significantly boost overall support for climate action.

The lack of responsiveness to the treatment from Republicans suggests that partisan identity, particularly within the Republican Party's recent populist turn (Fiorino 2022), may overshadow any potential receptiveness to carbon taxes, even when framed as welfare-enhancing tools. The resistance among Republicans to the economic framing of climate policies may reflect broader skepticism toward climate science itself, rather than the merits of the policy (Taylor 2015). A segment of the conservative base denies the scientific consensus on climate change, complicating the discourse and challenging the implementation of climate policies, even those aligned with market principles. Our findings suggest that implicit partisan biases, especially among Republicans, can significantly diminish the impact of neutral policy information (Haider-Markel and Joslyn 2001, Slothuus and de Vreese 2010, Wiest *et al.* 2015). Thus, promoting policies like a carbon tax within conservative circles requires addressing not only

economic and policy arguments but also the ideological and scientific perceptions that influence policy receptiveness.

2. Expectations

In this section, we outline our expectations.[2] The public consistently expresses concern about climate change, with numerous studies showing strong support for environmental policies in general (Kallbekken *et al.* 2011, Leiserowitz *et al.* 2023, Pew Research Center 2023). For example, in our data, 70% of Americans consider climate change to be a very or somewhat important problem. While experts overwhelmingly endorse the implementation of carbon pricing policies, notably carbon taxes, to address greenhouse gas emissions, these policies face considerable skepticism among the general public. Carbon taxes have faced resistance in referenda and elections (Carattini *et al.* 2019), encountered substantial public opposition (Rhodes *et al.* 2017, Stadelmann-Steffen and Dermont 2018), and sparked political controversy across advanced democracies (Stadelmann-Steffen and Dermont 2018, Lachapelle and Kiss 2019, Mildenberger 2020). In our survey, only 49% of participants rated their support for a carbon tax above 5 on a scale from 0 to 10. This gap between concern for climate change and support for carbon taxation is well-documented in the literature, with tax aversion being a significant barrier to the political feasibility of using price rationing as an environmental protection tool (Kallbekken *et al.* 2011). Although efforts have been made to utilize carbon tax revenues to enhance public support (Amdur *et al.* 2014, Beiser-McGrath and Bernauer 2019, Dolšak *et al.* 2020), real-world experiences reveal limited impacts of rebate programs on fostering backing for carbon pricing (Mildenberger *et al.* 2022). Given the fragile support for efficiency-enhancing policies, the question of whether and how support can be increased is crucial.

A key reason for this lack of support is the public's perception of carbon taxes as typical revenue-raising taxes (Kallbekken *et al.* 2011). People often fail to recognize that a Pigouvian tax, such as a carbon tax, is designed not merely to raise revenue but to correct a market failure by reducing negative externalities like pollution. This misunderstanding diminishes their support, as many view it as just another form of redistribution.

The general failure to recognize that the tax will produce environmental benefits, independent of how the revenues are used, is crucial: as Dresner *et al.* (2006) found, focus groups and businesses tend to see taxes solely as mechanisms for raising revenue, without understanding their incentive effects.

The American public aversion to carbon taxes has been well-documented (Carattini *et al.* 2019, Mildenberger 2020). We argue that Republicans and conservatives, who are generally more averse to taxes, may initially be more

likely to reject a carbon tax if they perceive it as merely revenue-raising (Campbell *et al.* 1960, Bartels 2005, Graetz 2024). However, framing the carbon tax as a welfare-increasing tool, designed to correct a market failure, could mitigate this aversion by shifting the focus away from revenue generation and toward the tax's broader societal benefits.

Given this context, framing a carbon tax as a welfare-increasing tool, rather than a revenue-raising one, has the potential to increase public support, regardless of how the revenues are used. More specifically, we anticipate that explaining the incentive structure of a Pigouvian tax using a numerical example that highlights its role in increasing social welfare could influence public support.

Framing plays a critical role in political communication, influencing how issues like climate change are perceived (Zaller 1992, Entman 1993, Chong and Druckman 2007b). Several studies have analyzed how different frames in climate change communication can affect attitudes and behavior (Nisbet 2009, Spence and Pidgeon 2010, Gifford and Comeau 2011, Myers *et al.* 2012, MacInnis *et al.* 2015, Wiest *et al.* 2015, Zhang *et al.* 2018), including economic framing of climate change. However, few studies have focused specifically on framing environmental negative externalities outside of a classroom context (Kallbekken *et al.* 2011). This is a critical gap, as the failure to recognize the primary objective of corrective taxes, such as carbon taxes, often leads to public misperceptions that these taxes are merely revenue-raising tools. Such misunderstandings may diminish public support, particularly among those who are already tax-averse. By explaining through a numerical example that the primary goal of a carbon tax is to reduce emissions and increase societal welfare – rather than merely raising revenues – we can potentially improve public receptiveness to such policies.

Given the extreme polarization surrounding climate change, traditional communication strategies might be ineffective. To address this challenge, we chose to illustrate the concept of negative externalities using an alternative framing that emphasizes pollution rather than directly addressing climate change (Feldman and Hart 2018, Hart and Feldman 2018, Mossler *et al.* 2017, Petrovic *et al.* 2014). This approach is grounded in evidence suggesting that conventional air pollution is less polarized than carbon pollution and may therefore be more effective in building broader support for climate action (Bickerstaff and Walker 2001, Mossler *et al.* 2017). By clarifying the welfare benefits of a corrective tax within the context of pollution, we aim to increase support for carbon taxes as well.[3]

According to the theoretical framework by Chong and Druckman (2007a, 2007b), how information is presented ('frames in communication') can influence how individuals think about and perceive a situation ('frames in thought'). For a frame to be effective, it must be both understood by the individual (i.e. it must be available) and accessible (i.e. it must have been

recently or regularly encountered). In our study, we apply this framework to explore how an economic framing of policy information – specifically, emphasizing the benefits of mitigating negative externalities – can influence individuals' frames of thought and thereby increase support for such policies. The information treatment is designed to present carbon taxation not merely as a revenue-generating mechanism but as a corrective tool that addresses market failures and enhances social welfare. This approach aims to make the consideration of social welfare benefits from carbon taxation more 'available' and 'accessible' to the audience, thereby enhancing their understanding and receptivity to the policy.

Given this context, our first expectation is that the information treatment, which highlights the negative externalities of pollution and their economic implications, will positively impact support for both an air pollution tax (H1a) and a carbon tax (H1b) compared to the control group. We anticipate that the treatment effect will be consistent across different revenue utilization scenarios (Amdur *et al.* 2014, Beiser-McGrath and Bernauer 2019, Dolšak *et al.* 2020), underscoring the robustness of the treatment's impact on support for a carbon tax, regardless of how revenues are used.[4]

Second, this study seeks to identify the mechanisms underlying the treatment effects. Magistro (2022) finds that people who correctly compute the costs and benefits of a policy are more likely to support or oppose the policy based on the net gains or losses. We expect that exposure to this economic framing will not only enhance the belief that the benefits of the policy exceed its costs (confirming understanding of the new 'frame in communication') but also make the benefits of addressing negative externalities more salient (increasing the 'social welfare' consideration's availability and accessibility) (Chong and Druckman 2007b, Feldman and Hart 2018). Specifically, we anticipate that the treatment group will exhibit a higher level of confidence in the net benefits of a carbon tax compared to the control group (H2). By emphasizing the societal welfare implications of addressing negative externalities, we expect that participants exposed to the treatment will demonstrate a stronger consideration of social welfare concerns, leading to enhanced support for a carbon tax (H3).

Numerous studies have identified moderator variables that condition framing effects, emphasizing that individual predispositions, such as values, play a significant role (Chong and Druckman 2007b). While frames can shape respondents' attributions, these effects are often conditioned by partisan predispositions, highlighting that not all individuals are equally affected by a given frame, especially on highly partisan issues (Haider-Markel and Joslyn 2001, Slothuus and de Vreese 2010, Wiest *et al.* 2015). In the United States, party identification acts as a filter through which information is processed (Campbell *et al.* 1960). This process of 'motivated reasoning' means that individuals respond more favorably to frames promoted by

their affiliated party (Slothuus and de Vreese 2010, Druckman *et al.* 2013). In the polarized context of climate change, partisan individuals may only be receptive to frames consistent with their predispositions and resist those that are incompatible. Political orientation, including ideology and party identification, is a key predictor of environmental beliefs, attitudes, and policy preferences in the US (Leiserowitz 2006, McCright and Dunlap 2011, Batstrand 2015, Hornsey *et al.* 2016). Politically conservative and Republican individuals are generally less likely to support climate change mitigation policies, including carbon taxes.

In this specific context, we frame the implementation of a carbon tax as a measure to increase economic efficiency. Republicans may face cross-pressures between their aversion to revenue-raising taxes, which they often associate with government overreach, and the potential appeal of a tax that is designed to correct market failures and enhance social welfare and economic efficiency rather than redistribute income (Dixon *et al.* 2017).

Republicans and conservatives are generally more skeptical of taxes perceived as revenue-raising or redistributive, often associating them with government overreach and inefficient allocation of resources (Bartels 2005, Graetz 2024). However, they may be more receptive to taxes framed as mechanisms to correct market failures and enhance social welfare, aligning more closely with free-market and efficiency-enhancing principles (Dixon *et al.* 2017). Pigouvian taxes, designed to internalize externalities and improve overall societal welfare, might theoretically appeal to conservatives if understood as tools that promote economic efficiency rather than government-driven redistribution (Mankiw 2009).

On the other hand, the recent populist turn within the Republican Party has likely intensified the aversion to all kinds of taxes, potentially leading to the rejection of even those framed as welfare-enhancing (Fiorino 2022). This aversion is likely compounded by partisan identity, which can lead to the dismissal of any information related to climate change mitigation, especially when such policies are associated with liberal or progressive agendas. A significant segment of the conservative base exhibits a tendency to deny or reject the scientific consensus on climate change, further complicating the discourse around potential solutions and fundamentally challenging the premise of implementing any climate policy, including those framed as market-based and welfare-enhancing (Taylor 2015). This ideological resistance may prevent meaningful engagement with the merits of various policy responses, including carbon taxes, even when they align with principles of economic efficiency and social welfare.

While we acknowledge that Republicans may face cross-pressures between their aversion to redistributive taxes and the potential appeal of efficiency-enhancing policies, we expect that, by shifting the focus away from revenue generation toward the tax's broader societal benefits, the treatment

could resonate more with Republican respondents. This might lead to an increased likelihood of supporting climate mitigation policies framed as tools for increasing overall societal welfare (H4).

3. Data

Starting from a simplified version of an example illustrating the economics of a corrective tax (which we discuss more in detail in the Appendix), we want to test whether giving people information on the aggregate welfare effects of a corrective tax in the presence of a negative externality, could affect attitudes toward not only an air pollution tax but also toward a carbon tax, by making the social welfare dimension of a corrective tax more salient and by changing the perceived costs and benefits of a corrective tax.

For our study, we used individual-level survey data from the Caltech Climate Survey, which was conducted by YouGov, encompassing a nationally representative sample of 2,319 registered voters from the United States. The survey was administered online during the period of June 20 to 27 2023.

Online non-probability samples are often scrutinized for potential selection bias, which might skew outcomes and impact the validity of results, alongside concerns regarding representativeness, as such samples may not accurately reflect the broader population. These factors can potentially affect the generalizability of findings. Nevertheless, these issues do not compromise the internal validity of survey experiments. Furthermore, YouGov stands out as a top survey firm, renowned for its methodological rigor (Miratrix *et al*. 2018). To ensure representativeness, respondents were selected from YouGov's opt-in panel. For each study, YouGov draws a stratified random sample of its panelists to add to an invitation pool who are asked to take a survey. Those who respond to the invitation are then directed to open surveys. The allocation of responding panelists to surveys is guided by an algorithm aimed at evenly distributing participants across strata over the field period, considering factors like the target end date, elapsed time in the field, sample size and definition, and priority.

In this particular study, the sample definition consisted of self-reported active registered voters in the U.S., who were further stratified based on various demographic factors, including age groups (18–29, 30–44, 4564, and 65+), race/ethnicity (white non-Hispanic, African American, Hispanic, and other), gender (male, female), education levels (high school or less, some college, college graduates, and post-graduate), and geographic regions (Northeast, Midwest, South, West). The population targets for these strata were estimated by YouGov, using data from the American Community Survey, conducted by the U.S. Bureau of the Census, as well as 2020 Presidential vote and 2022 Congressional vote. Previous research conducted on other online platforms,

such as Amazon's Mechanical Turk (MTurk) and Lucid, has demonstrated that convenience samples can yield comparable experimental results to surveys conducted on nationally representative samples (Berinski *et al.* 2012, Huff and Tingley 2015, Mullinix *et al.* 2015, Coppock and McClellan 2019).

3.1. Survey experiment

Our survey experiment features two groups: A control group that sees no information vignettes and is only asked whether they support an air pollution tax and a carbon tax, and a treatment group that sees cost-benefit information on the welfare effects of corrective taxes, focusing on how these taxes can increase social welfare.[5] The following sections describe each treatment condition in detail.[6]

3.1.1. Control group

The control group sees the following questions in this order.

- Please tell me on a scale from 0 to 10 how much you personally support the following policy. 0 means no support at all, 10 means complete support (We randomized the order of the options).
  o Introducing a carbon tax.
  o Introducing an air pollution tax.

Since the question of interest revolves around support for a carbon tax, to get at the mechanisms behind support or opposition for it, we ask several questions. Following Feldman and Hart (2018), we measure the perceived benefits and costs of a carbon tax, by asking the following question:

- Think again about the proposed policy of introducing a carbon tax. When considering this policy, do you think the benefits outweigh the costs, or the costs outweigh the benefits? (0 = costs strongly outweigh the benefits, 10 = benefits strongly outweigh the costs).

Next, we want to measure the salience of different policy goals. Without information on its functioning, people might not understand that a corrective tax's main objective is to increase social welfare (rather than merely raise revenue). Hence, we test whether people who see the information treatment are more likely to say that increasing social welfare is one of the most important goals of a carbon tax.

- Which of these goals of a carbon tax are most important to you? (We randomize the order in which they see these options and we put in bold – just here in the manuscript – increasing social welfare).

○ **Increasing social welfare**
○ Reducing emissions
○ Fighting climate change
○ Improving public health
○ Incentivizing use of renewables
○ Incentivizing use of nuclear energy
○ Enhancing national and global security
○ Raising revenue
○ Preserving ecosystems and species
○ Conserving water resources and clean water

Then we ask more specific questions on different policies involving a carbon tax and varying uses of tax revenue, to see if the increase in support for a carbon tax is more specific or generalized. We show the results for these questions in the Appendix.

3.1.2. Treatment group

The treatment includes cost-benefit information on the welfare effects of corrective taxes, explicitly designed to frame the carbon tax as a tool that increases social welfare by correcting negative externalities.

The treatment consists of a pre-treatment vignette and then Table 1. The pre-treatment vignette looks like this:

Imagine a market for smartphones. In a normal year, the quantity and price of smartphones will be determined by people's demand for smartphones and the amount that the phone manufacturers are willing to supply, which means that firms will make 25,000 smartphones and sell them at $650 each.

However, the production of smartphones creates **pollution**, due to the plastics, metals, chemicals, and energy used in manufacturing. This pollution has adverse effects on the environment, climate, and health, thus creating **external costs to society** from the production of smartphones, in addition to the **private costs** that include costs of labor and materials to make smartphones. If we translate this pollution into a dollar amount, we might say that each time a firm produces one smartphone they create $200 of external costs.

However, in a market where manufacturers don't have to pay to pollute, they can create these external costs for free. But, if **a corrective tax (such as an air pollution tax or a carbon tax)** is introduced, the firms would be required to pay $200 per smartphone, to account for these external costs of pollution. This tax thus would make production more costly. Due to this increased cost, the firms would produce fewer smartphones and would sell them at a higher price: 15,000 smartphones at $750 each.

Taking into account the external costs of pollution through a tax raises the price of the smartphones, reduces the number of smartphones made, and also reduces pollution. Does society overall benefit or lose by the introduction of this tax?

Then we ask a manipulation check question:

- According to the passage you just read, what kind of tax is introduced?
  - An income tax
  - A corrective tax
  - A payroll tax

Next, we show the following text along with the table:

Social welfare refers to the overall well-being of a society, which can be affected by various factors, including pollution or the introduction of a tax. One way to measure changes in social welfare is to compare the benefits and costs of a policy change, such as the introduction of a corrective tax, for different groups in society. Based on the scenario described in the prompt you just read about firms producing smartphones, the following table shows gains and losses after introducing a corrective tax (such as an air pollution tax or a carbon tax).

Table 1. Gains and losses in million $, rounded.

	Producers	Consumers	Pollution Reduction	Tax Revenue	Social Welfare
After Tax	−2	−2	+2	+3	= +1

In this case, relative to before the tax, producers lose $2 million in total, and consumers lose $2 million in total, since after the tax manufacturers have to pay more to produce smartphones and consumers have to pay more to purchase them. However, the introduction of a corrective tax leads to a reduction in pollution that brings a benefit of $2 million to society. Furthermore, the tax revenue from the corrective tax of $3 million constitutes an additional benefit, since this money can be, for example, redistributed to citizens as a cash transfer or as a tax credit, or can be used for investment in research and development for green technologies. By taking all these factors into account we can easily calculate that after the introduction of the corrective tax, social welfare increases by $1 million.

Then we ask a second manipulation check question:

- Is social welfare higher or lower after introducing the corrective tax?
  - Lower
  - Higher
  - Not Sure

Finally we ask the same questions as in the control group regarding support for corrective taxes, beliefs in the benefits vs costs of corrective taxes, and the salience of different policy goals.

3.2. Other measures

In addition to the questions discussed above, we also ask a battery of socio-demographic questions, including on gender, age, education, income, political ideology, and race.[7] Furthermore, we measure partisanship, as we anticipate heterogeneous effects by party identification (Democrat, Independent, or Republican). As robustness checks, in the Appendix, we also examined heterogeneous effects by political ideology rather than party identification, and by party identification incorporating leaners with partisans.

4. Methods

Our plan was to employ ordinary least squares (OLS) models as our primary analytical approach. However, upon analyzing the results we noticed that a relatively high number of respondents failed either of the two very simple manipulation checks (30% of respondents in the treatment group), likely suggesting that they did not read the treatment. Respondents who failed either manipulation check spent a median time of 30 seconds on the first prompt (the one outlining the smartphone problem), compared to 60 seconds among those who did not fail, and 22 seconds on the second prompt (on social welfare) compared to 62 seconds among those who got them right.[8] Hence, we have suggestive evidence that they did not pay (as much) attention to the prompts.

Kane and Barabas (2019) proposed the use of factual manipulation checks in survey experiments, which involve embedding factual information into the experimental treatment. By integrating such checks, researchers can determine if participants paid adequate attention to the treatment. If we do not exclude respondents who failed manipulation checks, we estimate an intent-to-treat (ITT) effect, which may be attenuated by respondents who were not attentive to treatment. However, we also realize that, while dropping subjects based on the results of a manipulation check following treatment assignment is common practice across the social sciences, this practice can lead to serious bias (Aronow *et al.* 2019, Varaine 2023).

While a 30% failure rate might initially seem concerning, it aligns with existing literature on the subject. For instance, Kane *et al.* (2023), using mock vignette checks to test attentiveness, report varying pass rates for factual manipulation checks across different studies and sample providers, with rates fluctuating between 30% and 80%. This variability highlights a common challenge in survey-based research: engaging participants with complex material.

In this respect, we recognize the inherent trade-off between simplifying treatments to ensure comprehension and maintaining the realism and depth

necessary to accurately test our hypotheses. Our study sought to balance these considerations carefully, simplifying the presented concepts significantly while striving to preserve their informativeness. For future research, we believe that it would be important to explore different methods to enhance participant comprehension without compromising the treatment's informativeness.

Strategies could include the integration of videos or other interactive content to increase understanding while engaging participants more effectively, and/or integrating monetary incentives to increase the accuracy of responses to factual questions (Bullock *et al*. 2015, Prior *et al*. 2015, Bullock and Lenz 2019).

To account for incorrect answers to factual manipulation check questions, we show results using different model specifications. First, we show ITT effects, using OLS regression, without accounting for the manipulation checks. Second, we exclude respondents who failed either of the manipulation check questions and then use coarsened exact matching (CEM) in order to create pruned samples. Monotonic Imbalance Bounding (MIB) methods, including CEM, should be favored, as they have been shown to dominate other matching methods in reducing imbalance, model dependence, estimation error, bias, variance, mean square error, and other criteria (Iacus et al. 2011, 2012). We hence match treatment (excluding those who failed the manipulation checks) and control groups on the following covariates: education, income, age, gender, race, and party identification. Third, we use instrumental variable estimation to evaluate a randomized survey experiment with imperfect compliance. When there is imperfect compliance, the ITT is diluted. Although in our case assignment of treatment is random, the actual take up of the treatment may not be: specifically, we use failing either manipulation check as a proxy for treatment take-up. Hence, we can use an instrumental variable estimation where treatment assignment is the instrument, while the actual treatment is passing the manipulation checks (Huang 2018). In all the main analyses we control for covariates that may be correlated with the outcome, including age, education, gender, income, race, and party identification, to increase precision. Adjusting for covariates in our analysis enhances the statistical precision of estimated treatment effects by reducing residual variance, assuming these covariates predict the outcome yet remain unaffected by the treatment, as is the case in randomized experiments (Fisher 1932, Lin 2013). For interested readers, we also include unadjusted regressions in the Appendix.[9]

5. Results

The survey experiment provided interesting insights into the impact of the information treatment on support for corrective taxes. Figure 1 shows that
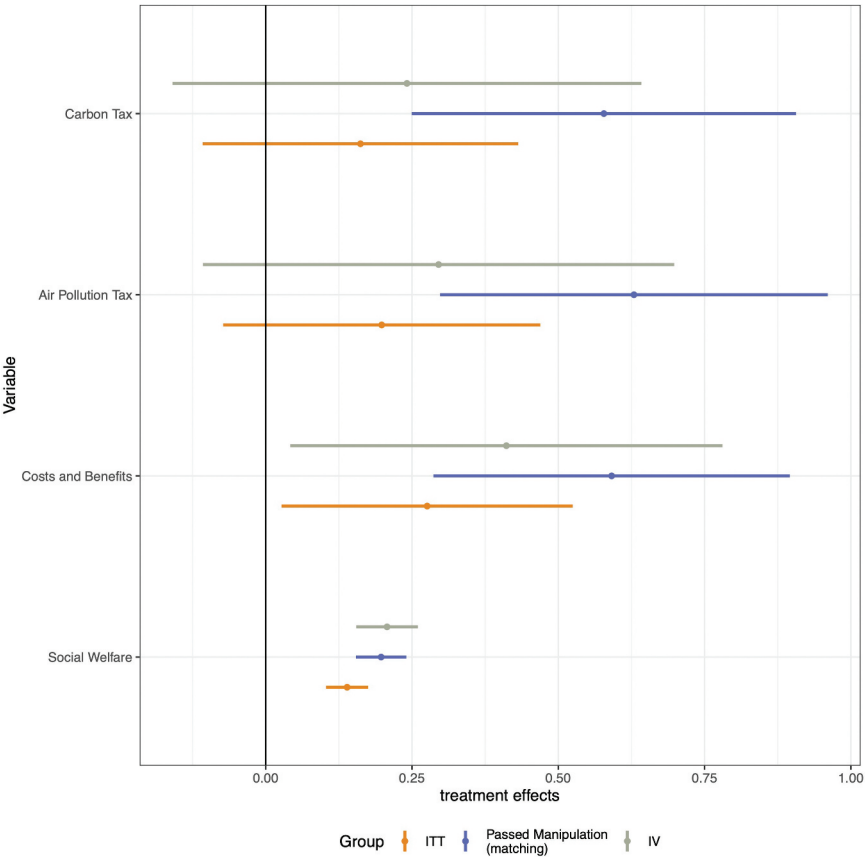
Figure 1. Treatment effects by model specification.

following the treatment, support for both a pollution tax and a carbon tax slightly increased. However, these effects were only statistically significant among respondents who passed the manipulation checks. The treatment also led to a marginal increase in the belief that the benefits of a carbon tax outweigh its costs and an increased likelihood of respondents mentioning social welfare as a primary goal of a carbon tax.[10] Additionally, as shown in the Appendix in Figures A12 and A13, the treatment had varying impacts on support for different carbon tax measures. Support increased for measures involving the use of revenues to reduce sales taxes, distribute cash transfers, and provide tax rebates to firms. However, the effects were not significant for measures aimed at investing in renewables, where support was already higher to start with.

While these effects may appear modest, it is essential to consider the context in which they occur. Across the three models, on average, the treatment led to an approximately 8% increase in the belief that the benefits

of a carbon tax exceeded its costs and an 18% increase in the probability of selecting social welfare as one of the primary goals of a carbon tax, relative to the control group.[11] These findings are particularly noteworthy given the difficulty of influencing public opinion on salient and polarized issues like climate change. The treatment demonstrated the potential to move respondents from just below 5 on a scale of 0 to 10 to just above 5, signaling a critical shift from opposition to support for climate mitigation policies.

The analysis of subgroup effects by party identification revealed some unexpected results.[12] Figure 2 shows that contrary to our expectations, Republicans did not respond to the treatment, and the effects among Democrats were small and mostly non-significant, likely due to ceiling effects, as their support for these measures was already quite high. In contrast, Independents were the most responsive to the treatment. After the information treatment, Independents showed a significant increase in support for both a carbon tax and an air pollution tax, with average increases of 21% and 18%, respectively, across the three models, relative to the control group. Moreover, compared to the control group, they were more likely to believe that the benefits of a carbon tax outweighed its costs by an average of 23% and were 17% more likely to prioritize increasing social welfare as a key objective of a carbon tax. Strikingly, as shown in Figures A9 through A11 in the Appendix, Independents appear to shift from weakly negative to weakly
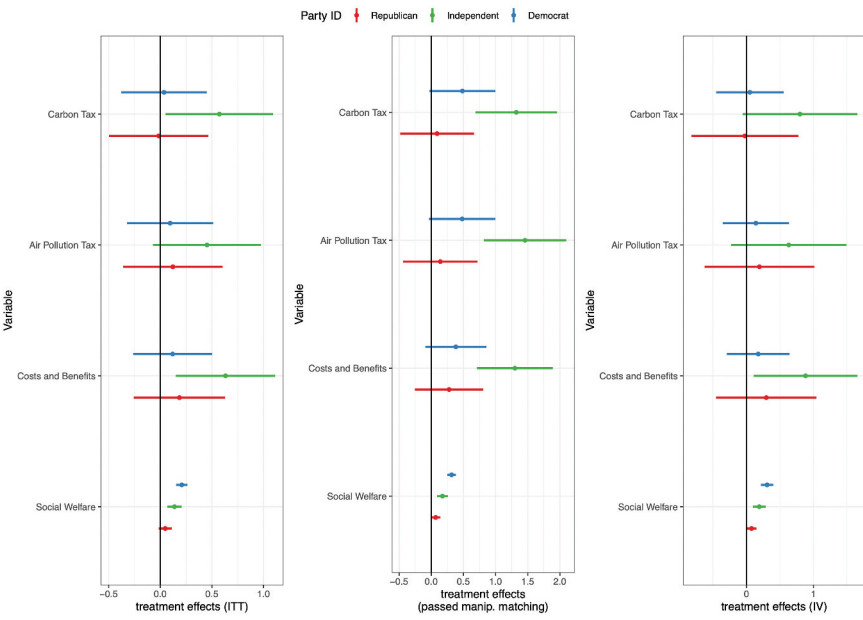

Figure 2. Treatment effects by party ID and by model specification.

positive positions, a change that could have significant implications for support for different climate mitigation measures.

The heightened responsiveness of Independents suggests that they may be more open to information that frames carbon taxes in terms of social welfare benefits. In the literature, there are debates regarding the nature of self-identified moderates and Independents. Some argue that they may be closet partisans (Dennis 1992, Keith *et al.* 1992), while others posit that they have no clear ideological stance (Kinder and Kalmoe 2017). However, more recently, Fowler *et al.* (2023) found that moderates display greater political knowledge and responsiveness to candidate features, indicating that they may be central to electoral changes. Regarding our findings, Independents' responsiveness may be due to less polarized opinions or higher baseline uncertainty, making them more receptive to new information. These findings highlight the importance of further investigating the factors behind Independents' greater responsiveness to economic framing.

Contrary to our expectations, the treatment did not significantly influence Republicans, despite the theoretical appeal of framing corrective taxes as welfare-enhancing tools. This aligns with findings from Cherry *et al.* (2017) and Bohr (2016), suggesting that presenting climate policies as corrections to market failures does not necessarily persuade voters who favor free-market solutions. The Republican Party's recent shift toward populist rhetoric has further entrenched resistance to policies perceived as government overreach, making it challenging to frame Pigouvian taxes in a way that resonates with Republican values (Fiorino 2022). Consequently, partisan identity may exert a stronger influence on policy attitudes than the framing of the policy itself (Haider-Markel and Joslyn 2001, Slothuus and de Vreese 2010, Wiest *et al.* 2015).

6. Conclusion

This study addresses the challenge of garnering support for climate change mitigation policies in a politically polarized environment. Through a pre-registered survey experiment, we investigated how framing carbon taxes as welfare-enhancing tools, rather than merely as revenue-raising measures, might influence public support. We expected that emphasizing the economic benefits of carbon taxes – particularly their role in correcting market failures and increasing social welfare – would resonate more strongly with conservative and Republican respondents, who generally exhibit higher aversion to taxes.

The results show that the information treatment led to a slight, but largely non-significant, increase in support for both a pollution tax and a carbon tax. We found a significant increase in the belief that the benefits

of a carbon tax outweigh its costs and in the likelihood of respondents identifying social welfare as a key goal of the tax. While these effects might seem modest, the potential to shift respondents from weak opposition to weak support could represent a crucial step toward building broader consensus on climate action.

When examining effects by partisanship, Democrats exhibited minimal responses, possibly due to ceiling effects given their already high support for climate action. Contrary to our expectations, the economic framing did not mitigate Republicans' tax aversion, suggesting that partisan identity may overshadow any potential framing effects. In contrast, Independents were the most responsive, showing significant increases in support for carbon taxes and recognition of their social welfare benefits. This suggests that targeting less polarized groups, like Independents, with carefully framed economic messages could be effective in garnering support for climate mitigation policies.

However, the potential for counter framing efforts, particularly in a polarized environment, poses a significant challenge. As Chong and Druckman (2013) note, counterframing can effectively sway individuals with weakly held opinions, such as Independents, making them vulnerable to shifts away from the initial framing. This suggests that while Independents were the most responsive to our welfare-enhancing framing of carbon taxes they may also be the most susceptible to subsequent counterframing efforts that reframe these taxes in a negative light. This highlights the difficulty of sustaining widespread support for environmental policies like carbon taxes in the face of substantial counterframing campaigns. Therefore, while framing can be a powerful tool, its effectiveness must be understood in the context of potential counter framing and the diverse responses across different segments of the population.

Finally, we want to discuss some future directions of our study. Our study was designed to examine the effects of neutral policy information on attitudes toward a carbon tax, deliberately avoiding explicit partisan cues. The literature offers mixed findings on what predominantly shapes Americans' policy attitudes – partisan identity or policy information. Some studies argue that partisan identification is the main driver of opinion formation (Campbell *et al.* 1960, Bartels 2000, Green *et al.* 2004, Iyengar *et al.* 2012), while others highlight the importance of policy information (Ansolabehere *et al.* 2008, Bullock 2011, Peterson 2019, Costa 2020, Treger 2022). This dual influence, further complicated by issue salience, makes studying opinion formation in politically divisive environments challenging (Kam 2005, Carsey and Layman 2006, Arceneaux 2008, Ciuk and Yost 2016). Our findings suggest that even without explicit partisan cues, implicit biases – especially among Republicans – can overshadow the effects of

policy information. This indicates that deeply entrenched partisan beliefs, like climate change skepticism, may filter and negate the influence of policy information. Future research should explore how explicit partisan cues interact with policy framing, and how these dynamics vary across different segments of the electorate.

Notes

1. See, for example, NOAA's technical report on sea level rise: https://oceanservice.noaa.gov/hazards/sealevelrise/sealevelrise-tech-report.html.
2. We registered our pre-analysis plan (PAP) on OSF at https://doi.org/10.17605/OSF.IO/U7T35. See additional information in the Appendix for more details on how we deviated from the PAP.
3. It should be noted that a recent study by Egan *et al.* (2022) indicates that in the American context, climate change and pollution are increasingly viewed through a similar lens by the public, which has influenced the broader environmental agenda and public concern over environmental issues.
4. We will show results for different revenue utilization scenarios in the Appendix. See Figures A12 and A13.
5. See Figures A2 and A3 for screenshots of the treatment prompts as they appeared to YouGov respondents.
6. See Table A1 and Figures A4 through A7 in the Appendix for summary statistics of the key variables of interest.
7. See the Appendix for more details and full wording of these questions.
8. When breaking it down by each question, people who got the first manipulation check wrong spent a median time of 8 seconds on the smartphone prompt, compared to 57 seconds among those that did not fail it. People who failed the second one spent a median time of 24 seconds on the social welfare prompt, compared to 60 seconds among those who got it right.
9. See Figures A14 and A15 in the Appendix.
10. As a reminder, all the dependent variables are measured on a scale from 0 to 10 except for social welfare which is a binary variable taking value 1 if social welfare was mentioned as one key goal of a carbon tax and 0 otherwise.
11. These numbers are computed by dividing the treatment effect by the initial predicted value. Predicted values for each outcome variable and model specification are shown in the Appendix in Figures A8 through A11. Tabular results are available in the Appendix in Tables A2 through A4.
12. Tabular results are available in the Appendix in Tables A5 through A7.

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Ethics statement

The data collection and analysis procedures were reviewed by the Institute Research Board at the California Institute of Technology and were ruled exempt (IR22–1220). It is exempt under 45 C.F.R. § 46.104(d)(2)(i),(ii) as it is research using survey procedures where the identity of the subjects cannot be readily ascertained. The interviewing and survey administration are conducted by YouGov, which provides us with a dataset with no identifying information for the subjects. In other words, we receive data that is completely anonymized.

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