How to Increase Public Support for Carbon Pricing with Revenue Recycling

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Abstract

The public acceptability of a carbon price depends on how the revenues it generates are used. In a fully incentivised experiment with a large representative sample of the German population, we compare five different revenue recycling schemes. We show that uniform carbon dividends receive substantially more support than a carbon dividend that favours poorer people, than earmarking revenues for climate projects, and especially than using revenues for the general budget of the government. Among the uniform carbon dividend schemes, a Climate Premium that pays a fixed upfront transfer equal to the expected carbon revenues receives more support than a carbon dividend scheme where the size of the transfer is determined ex-post on the basis of the actual revenues. Furthermore, we show that participants and experts underestimate public support for carbon pricing.

There is a broad consensus among economists that carbon pricing is one of the most effective and efficient policies to mitigate climate change[1]. Yet, it is fairly unpopular. In Switzerland, a proposal to increase an existing carbon price was rejected in a 2021 referendum; in France, the yellow vest movement forced President Macron to withdraw a carbon tax on fossil fuels; in the US, carbon pricing is so unpopular that none of the major political parties embraces it. Overall, only 23% of global greenhouse gas emissions are subject to carbon pricing[2].

There are several reasons for popular resistance[3]. Some voters do not trust the government and believe that a carbon price is just a tax increase in disguise[3–5] or they simply do not want taxes to be raised. Others feel that carbon pricing is unjust because it disproportionately harms the poor[6,7]. Many people see that they have to pay more, but they do not see the benefits in terms of reduced emissions and tax revenues that can be used for other beneficial purposes[8,9]. Can policymakers design carbon pricing schemes that address these concerns and gain more public support?

Previous research has shown that specific uses of the revenues can increase public support for carbon pricing[10,11], in particular, earmarking revenues for green investments or energy efficiency programmes[12] and returning revenues to citizens ("carbon dividends")[10,13–15]. Uniform carbon dividends (equal per capita transfers to all citizens) have also been shown to reduce inequality both within and between countries, addressing concerns about the regressivity of carbon pricing[16,17]. However, the literature is inconclusive regarding which revenue recycling scheme receives the most public support[3,6].

This paper makes three main contributions. First, it shows experimentally that public support for a carbon price is highest for uniform carbon dividend schemes that return the same amount of money to everyone. These schemes perform substantially better than a carbon dividend that favours poorer people and a scheme that earmarks revenues for climate projects. Using revenues for the general budget of the government, the most common approach in practice, receives by far the least support. We compare two uniform carbon dividend schemes. In the "Redistribute All" scheme, participants receive an equal share of actual carbon revenues. However, they do not know the exact amount when they cast their vote. In contrast, the "Climate Premium"[18,19] pays an upfront compensation equal to the expected revenues from carbon pricing. Under this scheme, voters do not face any uncertainty, which makes the benefits of carbon pricing more salient. The Climate Premium receives more support than Redistribute All.

Second, the paper uncovers several misperceptions. It shows that people greatly underestimate the effect of carbon pricing on consumption and, hence, on emission reduction. Beliefs about the policies' effectiveness in curbing climate change have been shown to have a strong impact on voters' support[20], but so far there is only indirect and mixed evidence on how people expect others to adjust consumption following the implementation of a carbon price[16,21]. Furthermore, the paper shows that people greatly underestimate the support for carbon pricing among their fellow citizens. This result replicates previous findings and it is important

because people offer less support to a policy if they believe that others support it less[22]. We complement our study with an "expert survey" that elicits the predictions of environmental, behavioural, and public economists. These experts also systematically underestimate public support for carbon pricing, which may explain why they fail to persuade policymakers to embrace it. The expert survey also provides a benchmark for assessing the novelty of our findings. Expert surveys are increasingly used to improve the rigour and credibility of experimental research in the social sciences.[23,24]

Our third contribution is methodological. In contrast to previous analyses, our study is based on a fully incentivised experiment with a large, representative sample of the German population. In the experiment, subjects make purchase decisions that result in real carbon emissions, and they have to pay a real carbon price of €50 per ton of CO_2. We measure public support by letting people vote on the introduction of carbon pricing. Our design combines the best aspects of and improves upon both surveys and laboratory experiments, the two methods commonly used to study support for climate policy[10,16,20,25–33]. Surveys often use representative samples, but they are not incentivised and have been shown to overestimate public support for pro-environmental policies[34]. In contrast, our design uses monetary incentives to elicit participants' true preferences. Laboratory studies, instead, are usually incentivised, but they rely on small and non-representative samples (often undergraduates) and use experimental designs in which externalities are monetary. In contrast, our experiment uses a representative sample of the population and real CO_2 emissions as externalities.

In a large survey with 40,000 respondents in 20 countries, Dechezleprêtre et al.[20] have shown that the public support for climate policies is fairly similar across developed countries. Therefore, our results are likely to be generalisable to countries other than Germany. Furthermore, our novel experimental design can be adapted to study the acceptability of other policies that put a price on unsustainable behaviour, such as plastic taxes, congestion pricing, and other "sin" taxes.

Results

We conducted an experiment with 1,100 participants who are representative of the German population. Participants were asked to make two purchase decisions about valuable but CO_2-generating virtual products. In each decision, the participants decide whether to buy 0, 1, or 2 products. The first decision involved a low price per product, while the second decision had an additional carbon price of €3 (€50 per ton of CO_2). Following these decisions, the participants voted on whether to implement the purchase decision *with* or *without* the carbon price.

All decisions in the experiment have real consequences. The participants' purchase decisions resulted in monetary payoffs and real CO_2 emissions. Participants could earn €0, €4, or €6 by buying 0, 1, or 2 products in the decision without the carbon price, and €0,

€1, or €0 for the same choices in the decision with the carbon price. They generated 60 kg of CO_2 for each product they bought. Furthermore, every participant had an equal chance (2%) of determining whether the purchase decisions with or without the carbon price were payoff-relevant for the group of 50 individuals that they were part of.

In five randomly ordered within-subject conditions, the participants voted on whether or not to implement carbon pricing schemes that differed in how revenues from carbon pricing were used. In the "State Budget" condition, the money went to the general budget of the German federal government. In the "Climate Projects" condition, the revenues were spent on government-approved environmental projects. The other three conditions mimicked "carbon dividend" schemes: In the "Redistribute All" and "Redistribute Poor" conditions, the revenues were divided equally either among all participants or among those participants who had reported an income below €2,100 (median income). In the "Climate Premium" condition, participants were promised a fixed and immediate payment in case the carbon price was implemented. In two between-subjects treatments, we used a €1.70 premium (roughly the estimated per capita revenue) and a €1.40 premium (a likely underestimate that avoids a possible deficit), respectively.

Finally, we conducted an expert survey ($N = 369$) with environmental, behavioural, and public economists working in Germany, Austria, and Switzerland (response rate 28.0%). We asked these experts to estimate the purchase decisions and the vote shares for carbon pricing in the different conditions.

Buying behaviour

Fig. 1a illustrates the distribution of purchase decisions without the carbon price. Although it is profitable to buy both products, only 34.3% of our sample do so, suggesting that many participants are foregoing private gains for the sake of the environment. This result suggests that the participants expect their decisions to affect real CO_2 emissions. Indeed, 77.9% explicitly confirm that they believe that their purchases had the environmental consequences described in the instructions. Fig. 1b shows a sharp and significant drop in the number of units bought (and thus of CO_2 emissions) when the carbon price is introduced (average units purchased per person: 1.06 without vs. 0.59 with the carbon price; two-sided paired t-test; $t(1099) = 24.10$; $p < 0.001$). The figure illustrates that only a small percentage of subjects (2.9%) purchase two products when a carbon price is in effect. This choice is, in fact, dominated because it does not yield any benefits to the individual, but it results in the emissions of 120kg of CO_2. Fig. 1c shows in detail how participants adapted their consumption with the introduction of a carbon price. Only a small percentage of subjects purchased more products with the carbon price than without it (4.3% of those who could). These results suggest that the vast majority of participants understood the experiment (more details in Supplementary Methods).

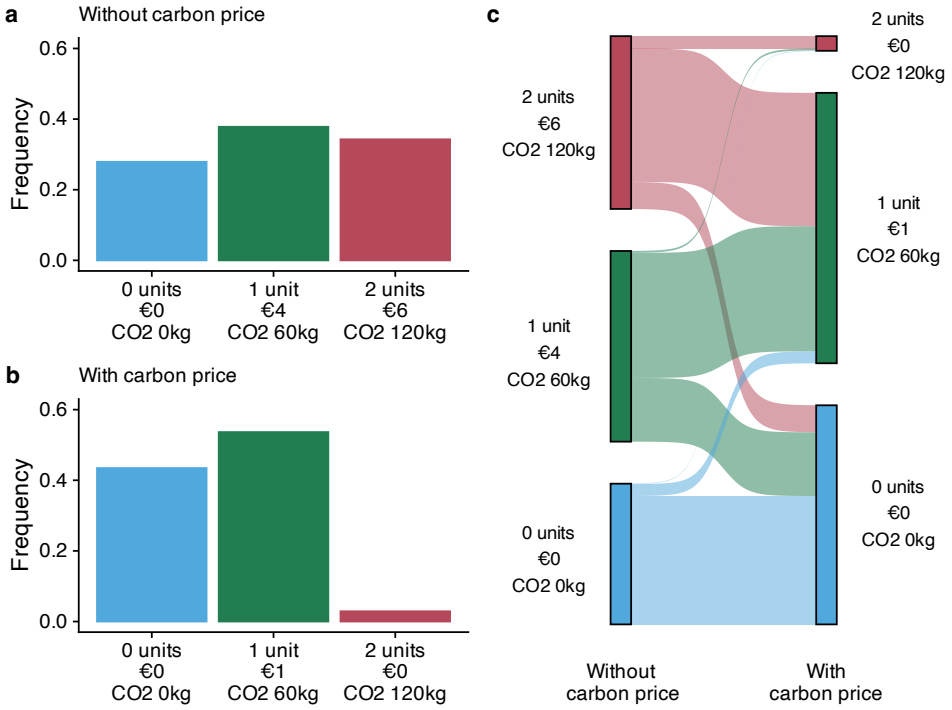

Fig. 1: Purchase decisions with corresponding payoffs and CO_2 emissions without (a) and with (b) the carbon price. (c) A Sankey diagram representing participants' responses to a price increase. The results remain unaffected by variations in task comprehension or attentiveness levels (Supplementary Fig. 9).

Voting behaviour

Fig. 2 displays the voting decisions. There is substantial heterogeneity in support depending on the revenue recycling scheme. When revenues go to the general budget of the federal government, a minority of participants votes for carbon pricing (47.3%). This is reflected in reported low trust in the government: 52.5% (21.5%) disagreed (agreed) with the statement "I have confidence in the German government to use taxpayers' money wisely."

However, the majority approves the carbon price under the other revenue recycling schemes. In conditions Climate Projects and Redistribute Poor, 62.6% and 62.7% of the votes are in favour of the carbon price. This percentage increases to 68.8% in the Redistribute All condition and further jumps to 73.1% in the Climate Premium condition. All of these schemes receive significantly more than 50% of the votes (two-sided test of proportions; $p < 0.001$). Interestingly, Redistribute All fares better than Redistribute Poor, because richer participants are significantly less likely to vote in favour of the latter (McNemar's test; 54.5% vs. 68.8%; $z = 6.63$; $p < 0.001$) while poorer participants support both schemes similarly (McNemar's test; 70.6% vs. 68.8%; $z = 1.09$; $p = 0.275$). The share of votes in favour of the Climate Premium is significantly higher than for any other scheme (McNemar's tests; vs. State Budget $z = 14.84$, vs. Climate Projects $z = 7.35$, vs. Redistribute Poor $z = 7.55$, vs. Redistribute All $z = 3.49$; all $p < 0.01$ with Bonferroni correction). Supplementary Information B.2 addresses the issue of order and demand effects, demonstrating that the results are not influenced by these factors.

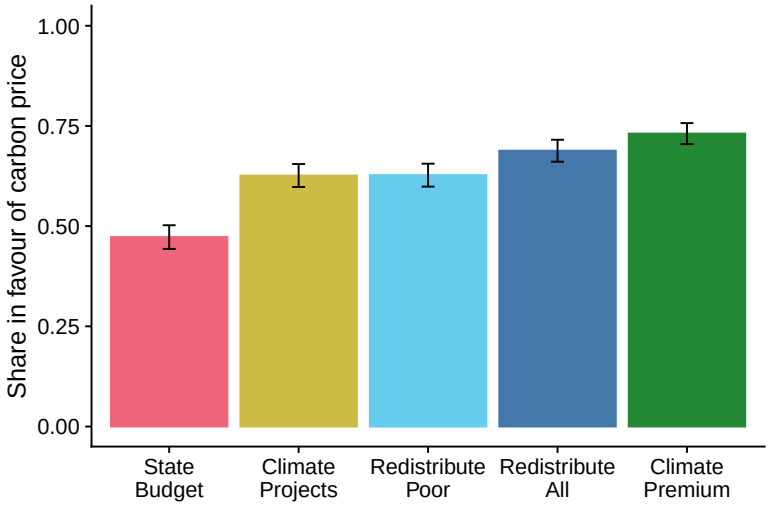

Fig. 2: Share of participants voting in favour of the carbon price under the five revenue recycling schemes. The bars indicate 95% CI. The results remain unaffected by variations in task comprehension or attentiveness levels (Supplementary Fig. 9). Supplementary Table 6 shows which demographic characteristics are predictive of overall voting behaviour.

Overall, these results show that the Climate Premium is the most popular scheme, and they confirm that revenue recycling is an effective lever to increase support for carbon pricing. The Climate Premium receives 25 percentage points more support than giving money to the state and between 4 and 10 percentage points more than the other revenue recycling schemes.

Other desirable properties of a Climate Premium

In this section, we show that the Climate Premium is budget-friendly, it receives majority support among all demographic groups, and it is the proposal that the fewest number of participants consider to be the worst policy.

First, the Climate Premium is budget-friendly. In the €1.70 treatment, the premium was calibrated such that the total transfer was expected to be similar to the carbon pricing revenues. The calibration was successful: revenues turned out to be €1.78 per person ($SD = 1.64$, 95% CI $[1.687, 1.881]$). However, we also conducted a much more conservative €1.40 treatment to test whether the support is sensitive to the amount of the premium. This is not the case: even with the reduced premium, the Climate Premium receives more votes than any other revenue recycling mechanism (McNemar's tests; vs. State Budget $z = 9.87$, vs. Climate project $z = 5.08$, vs. Redistribute Poor $z = 5.72$, vs. Redistribute All $z = 3.03$; all $p < 0.05$ with Bonferroni correction; Supplementary Fig. 6). Furthermore, there is no significant difference between support for the Climate Premium with a €1.40 and €1.70 payment (two-sided test of proportions; 74.0% vs. 72.2%; $z = 0.68$; 95% CI $[-0.034, 0.071]$; $p = 0.497$). Hence, the Climate Premium can be budget-friendly without compromising support.

Second, the popularity of the Climate Premium is not specific to one particular group of voters. Supplementary Fig. 7 and Supplementary Table 5 show that the Climate Premium

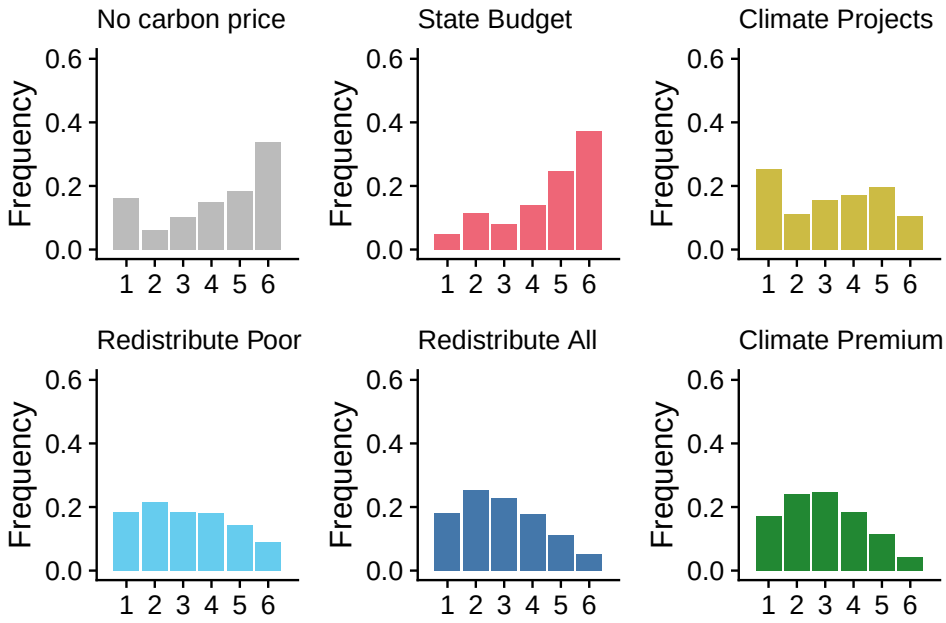

Fig. 3: Ranking of the five revenue recycling schemes and "No carbon price". Each panel shows the distribution of ranks the subjects give to each policy from 1 (the most preferred) to 6 (the least preferred). See Supplementary Methods **??** for the construction of the variable.

receives majority support in all demographic groups, including among conservatives (58.8%) and people who self-report that they are not much concerned about climate change (51.3%). Hence, the Climate Premium seems acceptable to a wide range of demographic groups and political parties, a property that it shares only with the Redistribute All condition.

Finally, it is more difficult to implement a policy that is strongly opposed by some minority groups. In fact, there is recent evidence that politicians prefer policies that few people see as the worst possible option[35]. Fig. 3 shows that only 4.2% of the subjects consider the Climate Premium the worst policy. This number is significantly lower than the corresponding shares for State Budget (37.2%), Climate Projects (10.6%), and Redistribute Poor (9.1%), and insignificantly so for Redistribute All (5.2%). The number is also significantly lower than the share of subjects who consider no carbon price as the worst option (33.7%). According to this metric, the Climate Premium outperforms all other policies (except Redistribute All) (see Supplementary Information A.1 for the details on the statistical test[36]).

While very few subjects consider the Climate Premium to be the worst option, there are also only a few subjects (17.2%) for whom it is their most preferred. There are more subjects who rank Climate Projects and Redistribute Poor first, but also more who rank them last. Thus, the Climate Premium, which gets a medium rank from most participants, is less polarising. This result suggests that the Climate Premium is most successful because it is a good compromise.

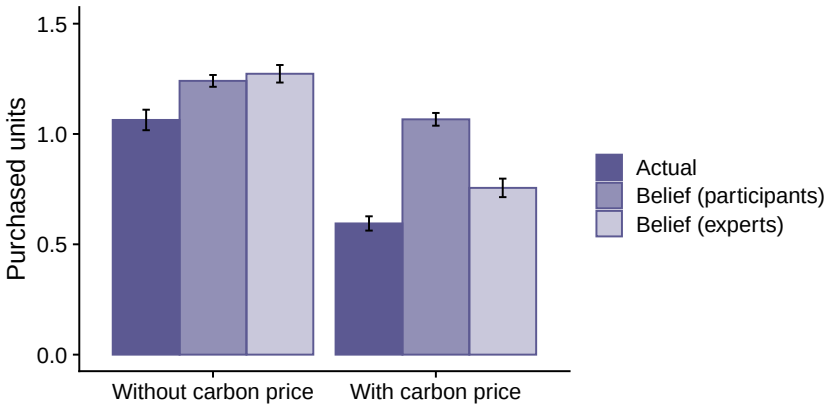

Fig. 4: Actual and guessed number of products purchased. The bars indicate 95% CI.

Misperceptions

Voting decisions are affected by expectations about the behaviour of others[8]. In our experiment, the decision to vote for the carbon price depends on the belief on how this price will affect the purchasing behaviour of all other subjects: the change in behaviour will affect the amount of carbon emissions and revenues. Therefore, at the end of the experiment, we elicited the participants' beliefs about how many units are bought with and without the carbon price. We also elicited subjects' beliefs about the voting results in different conditions.

Beliefs about buying behaviour. The participants significantly underestimated the effect of the carbon price on buying behaviour. Fig. 4 shows that, on average, participants believe that the carbon price reduces purchases by 0.17 units ($SD = 0.41$), significantly less than the actual drop of 0.47 units (two-sided paired t-test; $t(1099) = -13.56$; 95% CI $[-0.338, -0.252]$; $p < 0.001$), which is more than 2.5 times as large. This misperception is important because beliefs about the effectiveness of climate policy are a key driver of public support[20]. Supplementary Information B.4 depicts how misperceptions correlate with voting decisions.

Furthermore, the same Fig. 4 shows that the participants overestimate the number of units bought when the carbon price is in place. Participants buy only 0.59 units on average, but they believe that the number is 1.07, almost twice as high. This misperception makes it unlikely that the participants voted in favour of the Climate Premium because they mistakenly believed they would receive a higher payment in the Climate Premium than in the Redistribute All condition. Such a belief would have arisen if the participants had underestimated the consumption with the carbon price.

These misperceptions are consistent with previous evidence that individuals ignore the effect of taxes on prices[37] and underestimate other people's behavioural responses to policy changes[8].

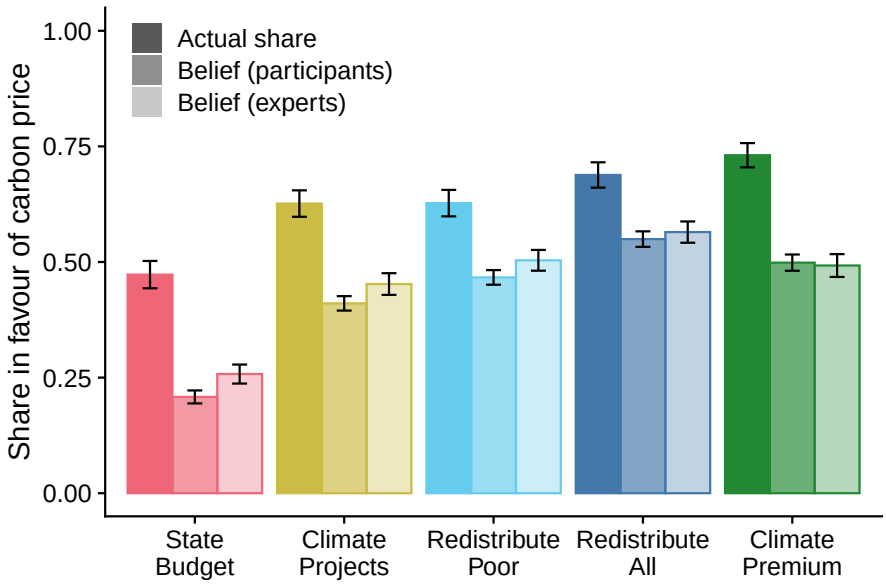

Fig. 5: Actual and guessed shares of participants voting in favour of the carbon price. The bars indicate 95% CI.

Beliefs about voting behaviour. Fig. 5 shows that participants strongly and significantly underestimate the support for carbon pricing, regardless of the revenue recycling scheme. Averaged over all conditions, they predict 42.7% instead of 62.9% of votes in favour of the carbon price. The underestimation is especially large in the State Budget (26.5 percentage points) and Climate Premium (23.2 percentage points) conditions. Other studies have shown that correcting similar misperceptions raises individual willingness to act against climate change as well as support for climate policies[22,38].

Expert predictions

In contrast to the participants, the experts did not underestimate the effect of the carbon price on consumption (Fig. 4). On average, they predict that the carbon price results in a drop of 0.52 units, which is not significantly different from the actual drop of 0.47 (Welch's t-test; $t(1032) = 1.691$; 95% CI $[-0.008, 0.104]$; $p = 0.091$). However, experts significantly underestimate the support for carbon pricing for all schemes. Averaged over all conditions, experts expect that 45.4% of votes are in favour, while the actual number is 62.9%. Importantly, while experts correctly predict the three carbon dividend schemes to be the most popular, they mistakenly believe Redistribute All and Redistribute Poor to get more support than the Climate Premium. Hence, the economics profession is too pessimistic about public support for carbon pricing schemes and holds mistaken beliefs about which scheme is the most popular. The underestimation of public support by expert economists may explain why they fail to persuade policymakers to embrace carbon pricing.

Discussion

This paper shows that support for carbon pricing is maximised if revenues are redistributed as a Climate Premium: a salient, upfront, fixed, and equal payment. A uniform carbon dividend that redistributes actual revenues ex-post is a close second. The Climate Premium strongly outperforms other revenue recycling schemes that have been more commonly studied, such as a carbon dividend that favours the poor and schemes that use tax revenues to finance environmental projects or go to the general budget. In addition, the Climate Premium has several properties that make it appealing to policymakers: it is budget-friendly, achieves majority support in all demographic groups, and it is one of the policies that is rated the least preferred by the fewest people.

The experiment provides additional support for important earlier findings. First, it confirms that revenue recycling is a strong driver of support for carbon pricing and that people oppose transferring the carbon revenues to the general budget[3]. Second, it confirms that people underestimate others' support for costly climate policies[22] and shows similar underestimation among experts. Third, it shows that people underestimate the effectiveness of carbon taxes in reducing emissions[16].

Finally, the paper provides a methodological innovation. The literature on public support for carbon pricing has so far relied either on unincentivised surveys or on experiments with non-representative subjects. This paper, instead, combines these two approaches in a fully incentivised representative survey experiment, which has several advantages.

First, it provides financial incentives for the participants to truthfully report their preferences for carbon taxes. This feature mitigates concerns that participants' responses are influenced by image concerns and desirability bias, which might artificially inflate the stated support for carbon pricing. The presence of incentives is particularly important since we compare different revenue recycling schemes. In fact, previous evidence indicates that the magnitude of the bias in survey responses varies with the type of policy the participants have to opine upon[34] and that private economic interest shapes what people think is fair[39]. If people have to put their money where their mouth is, they find it less appealing to give money to the poor or to climate projects. This may explain why we find relatively less support for Redistribute Poor and Climate Projects than studies that are based on unincentivized surveys.[6,40]

Second, in the experiment, consumption and voting decisions result in real CO_2 emissions, while most other experiments on climate policies use monetary externalities on fellow subjects. In our setting, less consumption results in lower CO_2 emissions, which has a negligible effect on the climate. This is also true if a small country (such as Germany) reduces its carbon emissions. While the experimental task is abstract, the participants' voting decisions correlate with their political preferences (Supplementary Information A.1.4 and Supplementary Table 7). This finding suggests that our framework yields externally valid results.

Third, our experiment uses a representative sample of the population. Thus, the results

are not biased by a selective subject pool, such as the young, well-educated, and mostly liberal undergraduate students that are typically used in economic experiments.

Despite these advantages, a limitation of the method is that the stakes involved are smaller than in real life and that participants receive a reward for participating in the experiment. These features may affect baseline support for carbon pricing. It is also possible, as in any experiment, that the baseline support is sensitive to the framing of the questions. However, as all these elements are constant across conditions, they cannot explain the variation in support between policies, which is the main focus of this paper.

Methods

Main experiment. The experiment was carried out in June 2023 in collaboration with Bilendi, a market research company specialising in online surveys with proprietary panels in several European countries. There were 1,100 participants representative of the German population with respect to age (above 18), gender, income, education, and region of residence (see Supplementary Table 1 for a summary of demographic characteristics). The instructions, available in Supplementary Information C, utilised straightforward language, visual aids, comprehension questions, and attention checks to ensure that participants understood the procedures.

Participants could buy zero, one, or two virtual products. The first product had a value of €7, the second a value of €5. Participants could buy the second product only if they bought the first. The purchase of each product resulted in the emissions of 60 kg of CO_2 (see below). In the first decision, each product had a price of €3. Thus, participants earned €4 if they bought one product ($7 - 3$) and €6 if they bought two ($7 + 5 - 3 - 3$). In the second decision, the price of each product increased to €6. Consequently, participants earned €1 for purchasing one product ($7 - 6$) but nothing for buying both ($7 + 5 - 6 - 6$). This price increase mirrors the effect of a carbon price of €50 per ton of CO_2. It is in line with the \$51/t social cost of carbon, a measure of the negative effects of CO_2 emissions, used by the US government in its cost and benefit assessments at the time of designing the study. At this stage, participants did not know that the price increase was due to a carbon price. Participants always first made the purchase decision without the carbon price and then the one with it. We chose this order because we want to study support for the introduction (or increase) of a carbon price. Therefore, we wanted the first decision, which could act as a baseline in the minds of participants, to have no carbon price.

Decisions had real-world consequences. The payment received by each participant at the end of the experiment and the amount of CO_2 emissions depended on the number of products they bought and which of the two decisions was implemented at the voting stage. We committed to buy offsets from Carbonfund.org for 60 kg of CO_2 for each product *not* purchased. Hence, the number of offsets was reduced by 60 kg of CO_2 each time a participant decided

to buy a product, effectively increasing total CO_2 emissions by this amount[41]. Participants were sent proof of purchase for the offsets after all data had been collected (Supplementary Methods).

Participants had been informed that they were part of a group of 50 individuals drawn from a representative sample of the German population and that the vote of one randomly selected group member determined which of the two purchase decisions would be implemented for the entire group. This procedure, called "random dictator" in the experimental economics literature, ensured that each participant had an equal probability of deciding the outcome of the vote for the whole group (including themselves). With this procedure, participants have an incentive to vote according to their true preferences (truth-telling is a dominant strategy).

At the voting stage, participants voted in five distinct conditions that differed in how the revenues from carbon pricing were used. Every participant encountered all conditions in random order, knowing that one of them would be randomly chosen to determine their payoffs (Supplementary Table 3). In the "State Budget" condition, the revenues went to the German federal government (via a payment to a bank account dedicated to reducing the federal debt). In the "Climate Projects" condition, the revenues were given to a German organisation supported by the German National Climate Protection Initiative (Nationale Klimaschutzinitiative; `https://www.klimaschutz.de`). In the "Redistribute All" condition, each group member received an equal share of the carbon price revenues. In the "Redistribute Poor" condition, revenues were evenly divided among group members with a monthly income below €2,100, the median income in our sample (this threshold was established by asking 250 participants of a pilot study recruited from the same subject pool about their monthly income). In both the Redistribute All and the Redistribute Poor conditions, the money was transferred to the participants two weeks after the completion of the experiment. In the "Climate Premium" condition, participants were given a fixed payment if the carbon price was implemented. These payments were made within two days of participation in the experiment. The payment was either €1.40 or €1.70 with 550 participants in each treatment. In the Climate Premium condition, the revenues from the carbon price that was not needed to pay the Climate Premium simply reduced the experiment cost. On the other hand, if the revenues from the carbon price had not been enough to pay for the Climate Premium, the cost of the experiment would have increased. The instructions did not inform the participants about these details.

Finally, the participants were asked to answer survey questions. First, they ranked the five different revenue recycling schemes. Then, they reported their beliefs about the purchasing and voting behaviour of the other group members. These belief elicitations were incentivised with €10 for the correct prediction of one randomly selected question, an incentive-compatible beliefs elicitation procedure[42]. Finally, participants answered questions about their time and risk preferences as well as their political preferences.

Expert survey. For the expert survey, we contacted 1,318 academic economists. Of those contacted, 481 began the survey, and 369 completed it and are included in our data. Experts were shown a simplified version of the instructions and asked to predict the purchase and voting decisions. They could earn €40 if their estimate in a randomly chosen prediction question was at most two percentage points below or above the actual percentage. The instructions are available in Supplementary Information C.

Further method details. Further details on methods can be found in the Supplementary Methods.

Ethical approval

This research was approved by the Ethics Commission of the Department of Economics at the University of Munich (Project No. 2022-10 and 2023-20).

Data availability

All data and materials are available at the project's OSF repository ([Link here]). [To the Editor: We will add link to the repository in case of AIP.]

Code availability

The code used for all analyses in the main manuscript and Supplementary Information is available at the project's OSF repository ([Link here]). [To the Editor: We will add link to the repository in case of AIP.]

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Contributions

All authors contributed equally to this research. A.W. and K.M.S. conceptualised the project. All authors designed the experiment and the expert survey. A.W. implemented the experiment and the expert survey. A.W., T.I. and D.D.P. conducted analyses. All authors discussed the results and wrote the paper.

Competing interests

The authors declare no competing interests.

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