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Heterogeneity in Expert Recommendations for Designing Carbon Pricing Policies across the Globe

Abstract

Pricing the emissions of greenhouse gases is widely considered as key to tackling climate change. While carbon pricing schemes are proliferating, the vast majority of emissions is not yet covered. Designing carbon pricing policies requires navigating crucial design choices, such as addressing distributional and competitiveness concerns. Here, we present recommendations from a global survey of more than 400 experts to inform key design issues for carbon pricing policies. We find that almost twice as many experts favor a carbon tax over a cap-and-trade scheme for unilateral carbon pricing, and three-quarters strongly recommend using border carbon adjustment to address competitiveness concerns. Recommendations on the usage of revenues from carbon pricing exhibit a substantial degree of heterogeneity. While transfers to particularly affected households and equal lump sum transfers are among the options most favored, these account for only around 40 percent of recommendations. In terms of country and observable expert characteristics, we find that experts from countries with a higher GDP per capita recommend equal lump sum transfers to households more often, and that the clear preference for carbon taxes only exists in richer countries. While economists recommend lump-sum transfers to households and reducing distortionary taxes more often, non-economic experts rather recommend using revenue for governmental spending, such as on environmental public goods or renewable energy subsidies. Our results provide insights for science and policy to improve the design of unilateral carbon pricing policies.

JEL-Codes: Q540, H230.

Keywords: carbon pricing, expert survey, carbon tax versus emission trading, border carbon adjustment, revenue recycling.

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Introduction

There is a broad consensus among economists that pricing greenhouse gas emissions is a key building block of an effective climate policy mix. Carbon pricing has proliferated in recent decades, partly due to policy diffusion from an early adopter to neighboring countries (Linsenmeier et al. 2023). To date, 39 national jurisdictions have implemented carbon pricing schemes that collectively cover around 23 percent of global greenhouse gas emissions (World Bank 2023a). These existing schemes exhibit considerable heterogeneity in terms of institutional design, including instrument choice and its stringency as well as the use of revenue from carbon pricing (World Bank 2023b). Recent debates regarding implementation have been informed by surveys of the population at large (e.g., Carattini et al. 2019; Douenne and Fabre 2022; Dechezleprêtre et al. 2022) and distilled in panels of and petitions by general economists in North America (e.g., IGM 2018; Wall Street Journal 2019) and in Europe (EAERE, 2019, 2022). With 77 percent greenhouse gas emissions across the globe currently unregulated by explicit carbon pricing and a number of countries working towards putting climate policy in place (World Bank 2023b), however, obtaining a representative account of expert views on how to design carbon pricing policy, especially beyond solely economic experts, is crucial to inform the scientific and public debate.

The question if a carbon price should be implemented as a carbon tax, via cap-and-trade, or some mix of instruments has occupied scholars in the field for decades (e.g. Weitzman 1974; Karp and Traeger 2019; Stavins 2022), without a clear resolution from a theoretical perspective. Furthermore, border carbon adjustment (BCA), as a means to protect the competitiveness of domestic industries under unilateral carbon pricing, has been controversially discussed as a potential barrier to trade (e.g., Böhringer et al. 2022; Cosbey et al. 2019). Yet, BCA may be amenable to establishing effective carbon prices unilaterally in a non-cooperative world (e.g., Böhringer et al. 2022), or for fostering cooperation on climate policy among countries (Helm and Schmidt 2015, Al Khourdajie and Finus 2020), and has gained substantial prominence, as exemplified by the CBAM mechanism proposed for the EU (European Commission 2021). Similarly, the use of revenues from carbon pricing is subject to intensive debate, not least due to its potential effects on public acceptance of carbon pricing and its political feasibility (e.g., Carratini et al. 2019; Klenert et al. 2018; Douenne and Fabre 2022), and its relation to the instrument choice (e.g., Fischer 2001). There are also a number of disciplinary differences in views on the role of carbon pricing more generally, as illustrated by the recent debate between economists and other climate policy experts in *PNAS* that pointed to important areas of disagreement (Rosenbloom 2020a, 2020b; Van den Bergh and Botzen 2020). So far, however, no consensus view among scholars or policy makers has emerged on any of these key policy design issues, leaving practitioners in lack of guidance and researchers in the field without a representative account of their fellow researchers' views.

We address this important gap by eliciting expert recommendations on key policy design issues related to carbon pricing. Expert elicitation, complementing other sources of evidence such as surveys of the general population, has gained prominence in the past few years as a way to inform different stakeholders about complex issues in climate science and economics (e.g., Christensen et al. 2018; Dannenberg et al. 2017; Dannenberg and Zitzelsberger 2019; Drupp et al. 2018; Howard and Sylvain 2020; Kornek et al. 2020; Meng et al. 2021; Otto et al. 2020; Pindyck 2019; Victor et al. 2022; Zickfeld et al. 2007).

Our study targets a broad population of academics sourced as (potential) experts on carbon pricing by virtue of their pertinent and cited publications. The systematic search process reveals 2106 authors on this topic around the globe, of which 467 participated in our survey (Materials and Methods provides details). The survey combines two main modules. A module on policy design issues (summarized in Table 1; the full survey text is in the SI Appendix) that

focuses on three key and contentious carbon pricing design questions of interest to a general scientific and policy audience, and a module on carbon price levels that is analyzed in a more specialized companion paper (Drupp et al. forthcoming). Both were included in the same survey due to concerns about the limited attention of experts to voluntarily engage with complex surveys. The survey closed with a question on potential determinants of experts' recommendations (such as global emission reduction targets or expected climate damages) and an option to provide qualitative remarks. In addition to the primary survey data, we further draw on country-level data gathered subsequently (e.g., GDP per capita), and on observable individual expert characteristics, such as publication record or gender, to shed light on possible determinants of heterogeneities.

Table 1. Summary of survey questions on policy design issues

Country	*Please specify the country you would feel most comfortable advising on carbon pricing (below, we will refer to this as "your country").*
Instrument choice	*Assuming that no carbon pricing scheme has been implemented in your country yet, which instrument would you recommend?* *Carbon tax, cap-and-trade with price collar (price floor and price cap), cap-and-trade without price collar, other (please specify).*
Border carbon adjustment	*If your country implements a carbon pricing scheme unilaterally, would you strongly recommend introducing a border carbon adjustment scheme (if that is possible)?*
Revenue usage	*How should your government use the revenues raised by carbon pricing? (Multiple answers are possible)* *a) General government spending* *b) Equal lump-sum transfers to households* *c) Transfers to particularly affected households* *d) Reduction of distortionary taxes* *e) Grandfathering or tax cuts for firms* *f) Transfers to particularly affected firms* *g) Spending on environmental public goods* *h) Green R&D* *i) Subsidies for renewable energy* *j) International transfers to countries particularly affected* *k) International transfers to support climate policy in other countries* *l) Other.* *If you suggest more than one use, please indicate your most recommended option.*

Notes: The table provides a summary of the survey questions (shortened) related with key policy design issues. The full survey text, including additional questions (on carbon price recommendations and likely determinants such as experts' views on emission reduction targets and abatement costs) is provided in the SI Appendix.

We document carbon pricing policy design recommendations, both in the aggregate as well as across countries before analyzing possible determinants. Our data shows that experts' views are substantially more nuanced than previously acknowledged by the limited evidence available. The IGM Economic Experts Panels, for example, were conducted among a small set of general economists, most without special climate policy expertise. In the US IGM (2018), 66 percent of the panel members agreed to the statement that "Carbon taxes are a better way to implement climate policy than cap-and-trade", 29 percent were uncertain. No single IGM (2018) member expressed disagreement. In the European IGM (2020), which asked the same question, 53 percent of the panel members agreed and 35 percent were uncertain. However, 11 percent expressed disagreement, preferring, for instance, emissions trading. Our data allows us to investigate whether these differences carry over to experts on carbon pricing both within and beyond economics, and whether policy preferences by US and European experts are

representative of expert views in other parts of the world. A representative account of expert views on support for BCA and on the usage of revenues from carbon pricing is also lacking. Carattini et al. (2019) survey citizens in several countries and highlight that returning the revenues to citizens is crucial for winning public support for a carbon pricing scheme. Mildenberger et al. (2022), by contrast, present empirical evidence suggesting that existing rebate programs in Canada and Switzerland had only limited effects on public support of carbon pricing policies in these countries.

Results

Instrument choice

We find that almost twice as many experts recommend using a carbon tax (49 percent) as compared to cap-and-trade with (23 percent) or without (6 percent) a price collar. A carbon tax is thus clearly preferred over cap-and-trade schemes (two-sided t-test: $p<0.000$). While 4 percent of experts selected "no clear recommendation" regarding instrument choice, 18 percent recommend some "other instrument or mix of instruments". These were then asked to specify what other instrument or mix of instruments they had in mind. The majority of these responses also contain some variant of "carbon tax" or "cap-and-trade" in combination or in conjunction with other instruments or additional measures. The ratio of recommendations of "tax" vs. "cap-and-trade" in these qualitative responses is very similar to the one in the overall sample. Around 10 percent of these experts recommend cap-and-trade specifically for larger emitters or energy intensive industries, and a carbon tax for smaller emitters or other sectors, such as for agriculture or small and medium-sized firms (see Table S1 in the SI Appendix for details).

Figure 1 shows recommendations on instrument choice on aggregate and split by continents and countries. A carbon tax is most strongly preferred over other instruments in North America (two-sided t-test: $p<0.000$), followed by Africa & South America. The share of European experts who prefer a carbon tax (49 percent) coincides with the share of experts who prefer a tax in the overall sample. There are some notable exceptions within Europe, though. For instance, experts from Germany and Spain recommend cap-and-trade more often relative to carbon taxes (see Figure 1 Panel A). Furthermore, 50 percent of the experts from Oceania recommend cap-and-trade, whereas Asian experts are almost equally split in their preference for tax vs. cap-and-trade (48 vs. 52 percent). Among Asian experts, those from China exhibit a clear preference for cap-and-trade with a price collar.

When using data on potential determinants we find that experts recommending more stringent global emission reduction targets tend to recommend carbon taxes as opposed to cap-and-trade schemes; this also holds when controlling for a country's GDP per capita, whether experts published in economics and their gender (univariate and multivariate logistic regression: $p=0.012$ and $p=0.015$). When drawing on the additionally gathered data outside of our survey, such as country-level data for the country indicated by an expert, we find that support for carbon taxes tends to increase in GDP per capita in the expert's country (linear regression: $p=0.002$) and that a clear recommendation for carbon taxes as opposed to cap-and-trade exists only in richer countries—both when splitting our sample at the sample mean GDP per capita as well as when splitting it at global GDP per capita (two-sided t-tests: $p=0.000$). In contrast, experts in the bottom half of the global income distribution, with a 2020 GDP per capita below $16626, tend to recommend cap-and-trade more frequently, yet insignificantly so (two-sided t-test: $p=0.163$). The SI Appendix contains a discussion on how limited global representation of expertise, which we dub "non-representation bias", affects instrument recommendations. We further find that the existence of a carbon tax in an expert's country is also associated with higher support for carbon taxes (58 vs. 45 percent; t-test: $p=0.011$). In terms of observable expert characteristics, we find no differences in recommending carbon

taxes relative to other instruments for economists and non-economists (chi-squared test: p=0.573), whereas female researchers recommend carbon taxes less often than male experts (chi-squared test: 38 vs. 52 percent; p=0.058), and recommend a mix of instruments more often (30 vs. 16 percent; p=0.008). The higher aggregate recommendation for instruments other than a carbon tax in our expert sample compared with the IGM Economic Experts Panels (IGM 2018; European IGM 2020) is likely also due to the limited geographical coverage and the gender imbalance of the IGM Panels. In sum, our findings suggest a clear recommendation for a carbon tax in the overall sample of experts, and especially in the US, with more nuanced views within Europe and elsewhere. This clear finding in support of carbon taxes, however, does not generalize to a hypothetical population of experts that would be globally representative (see also Figure S1).

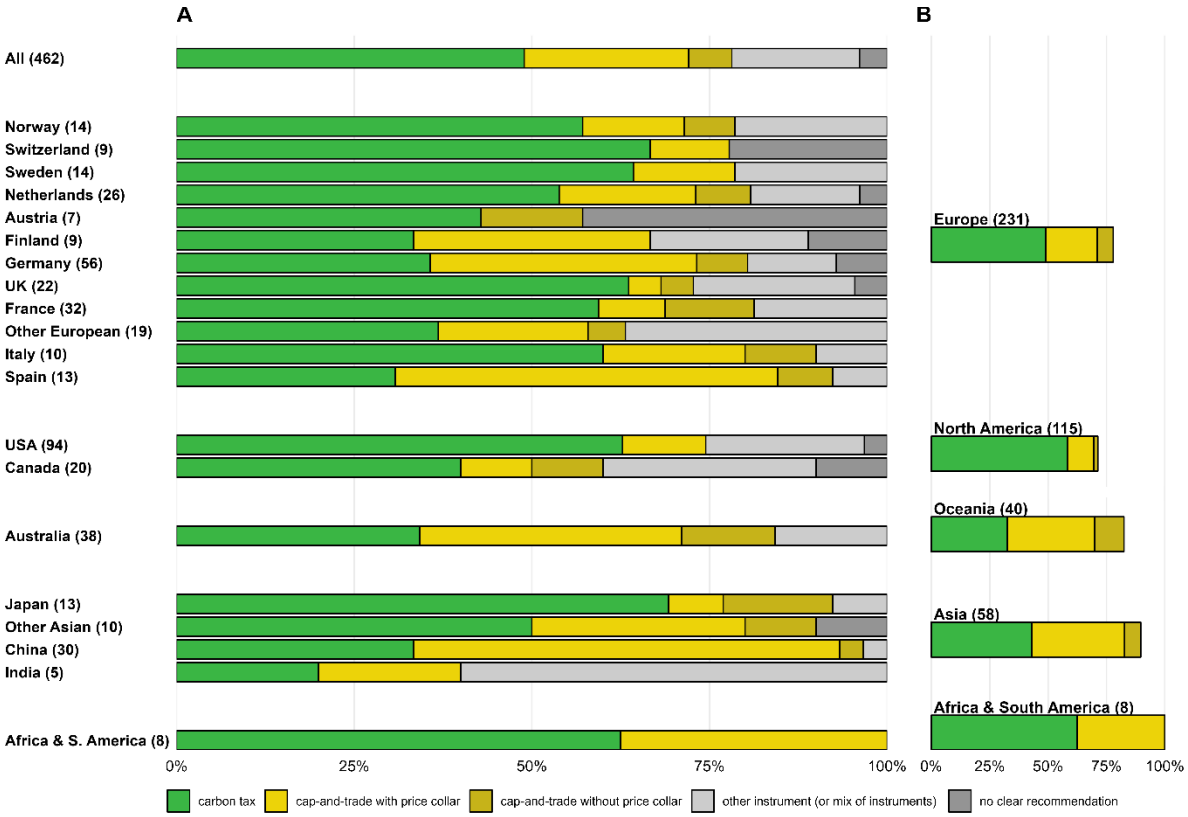

Fig. 1. Carbon pricing instruments. The shares of experts recommending the use of certain carbon pricing instruments, by experts' countries (Panel A), and continental groups of countries (Panel B), with carbon tax (green), cap-and-trade with price collar (yellow), cap-and-trade without price collar (dark yellow), other instrument or mix of instrument (light gray), and no clear recommendation (dark gray). Countries are ordered by continental group and along GDP per capita within a continent. (Number of observations in parentheses.)

Border Carbon Adjustment (BCA)

Regarding experts' views on BCA, we find that 74 percent of all respondents *strongly* recommend its usage (if that is possible), assuming that their country plans to implement a (new) carbon pricing scheme unilaterally (see Fig. 2). We find that this strong recommendation for BCA is consistent across all continents and virtually all countries. Among the countries with at least five observations, only experts from Norway are split equally between a strong recommendation on BCA or not (see Fig. 2 Panel A). On the other end, all experts from Switzerland strongly recommend the usage of BCA. In terms of the survey data on potential determinants, we solely find that experts who expect a higher probability of severe climate damages tend to strongly recommend BCA more often (logistic regression: p=0.035). Overall,

though, our analysis reveals that support for BCA is widespread without much heterogeneity across various country and expert characteristics. Interestingly, experts who publish in economics journals tend to recommend the use of BCA less often compared to those who do not (70 vs. 80 percent; chi-squared t-test: p=0.032). Still, there is an overwhelming majority favoring BCA. The overall widespread support for BCA we document also aligns well with wording in the "Economists' Statement on Carbon Pricing" (EAERE 2019) which suggests BCA as a potential solution in the multilateral context. Although its implementation may involve considerable bureaucratic costs as well as legal challenges (Böhringer et al. 2022; Dominioni and Esty 2022), our findings suggest that the benefits could outweigh those costs. Particularly for higher carbon prices, the risks of carbon leakage, competitiveness losses, and firm relocation may be substantial (e.g., Nachtigall 2019).

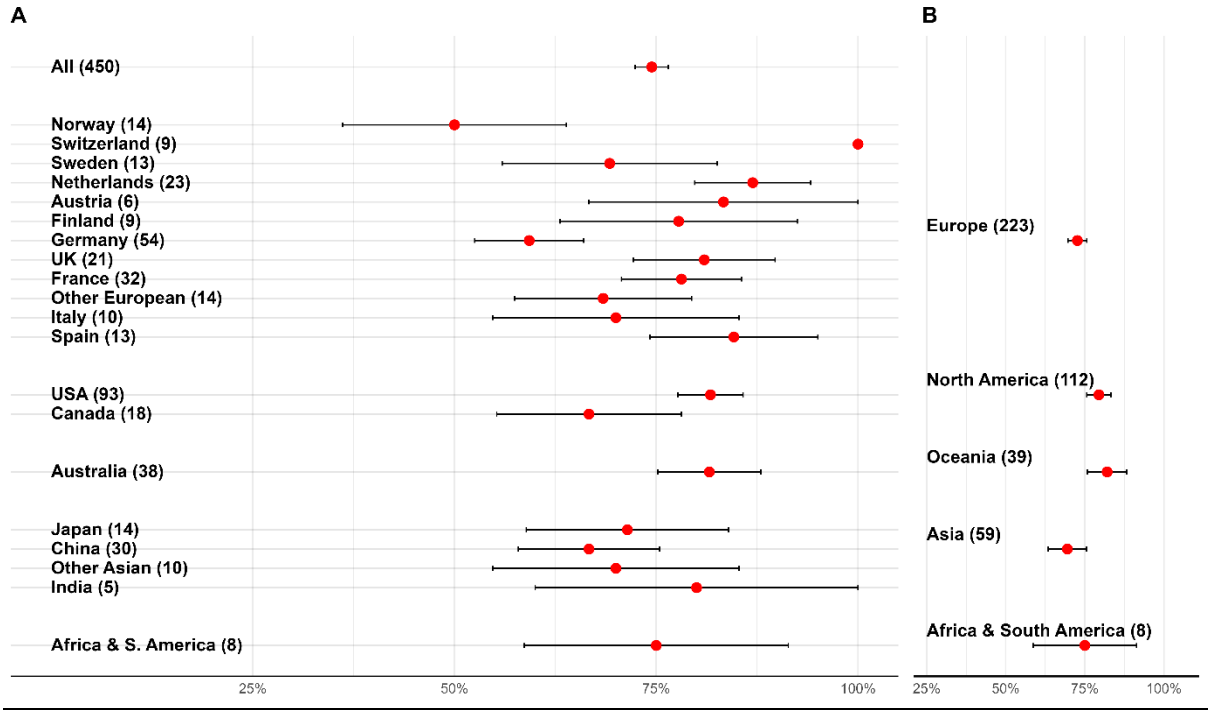

Fig. 2. Border carbon adjustment. Bars show mean *strong recommendation for BCA* (in percent) for countries (Panel A) and continental groups of countries (Panel B) (respectively for all respondents), with standard errors. (Number of observations in parentheses.)

Revenue Use

Experts' recommendations on the use of revenues from carbon pricing display substantial heterogeneities. We first asked respondents to choose one or several among *multiple options* for the recommended usage of the revenues (see Table S2 in the SI Appendix). Here, we find the strongest support for green R&D: 59 percent of the respondents who answered the question chose this option (among others). The second most frequently suggested usage is "transfers to particularly affected households" (56 percent), followed by a reduction in distortionary taxes (43 percent). Interestingly, the option "equal lump-sum transfers to households" was chosen only by 25 percent of the respondents. This contrasts with the "Economists' Statement on Carbon Dividends" (Wall Street Journal 2019) that explicitly recommended (only) lump-sum transfers. Some of the detailed responses also contain other ways to use the revenues than our specified options. Examples include "climate adaptation", "dealing with the regressive impacts on poorer households … in order to mitigate political resistance", "green infrastructure

investments", "international transfers to support carbon sinks in other countries", and "transfers to low-income households" (see Table S3 in the SI Appendix).

We additionally allowed respondents to indicate one "most recommended option" in case they selected several options for the usage of revenues from carbon pricing, and to indicate the fraction of revenues to be used for that option. Fig. 3 shows the most recommended revenue use options. We observe that the option "transfers to particularly affected households" is most favored by experts, i.e., indicated by respondents as their most preferred option most frequently (24 percent). The option "equal lump-sum transfers to households" now ranks second (15 percent), followed by "reduction of distortionary taxes" (15 percent). The option "green R&D" that ranked first among all options selected when multiple options are possible, only ranks fourth among the experts' most recommended options (11 percent).

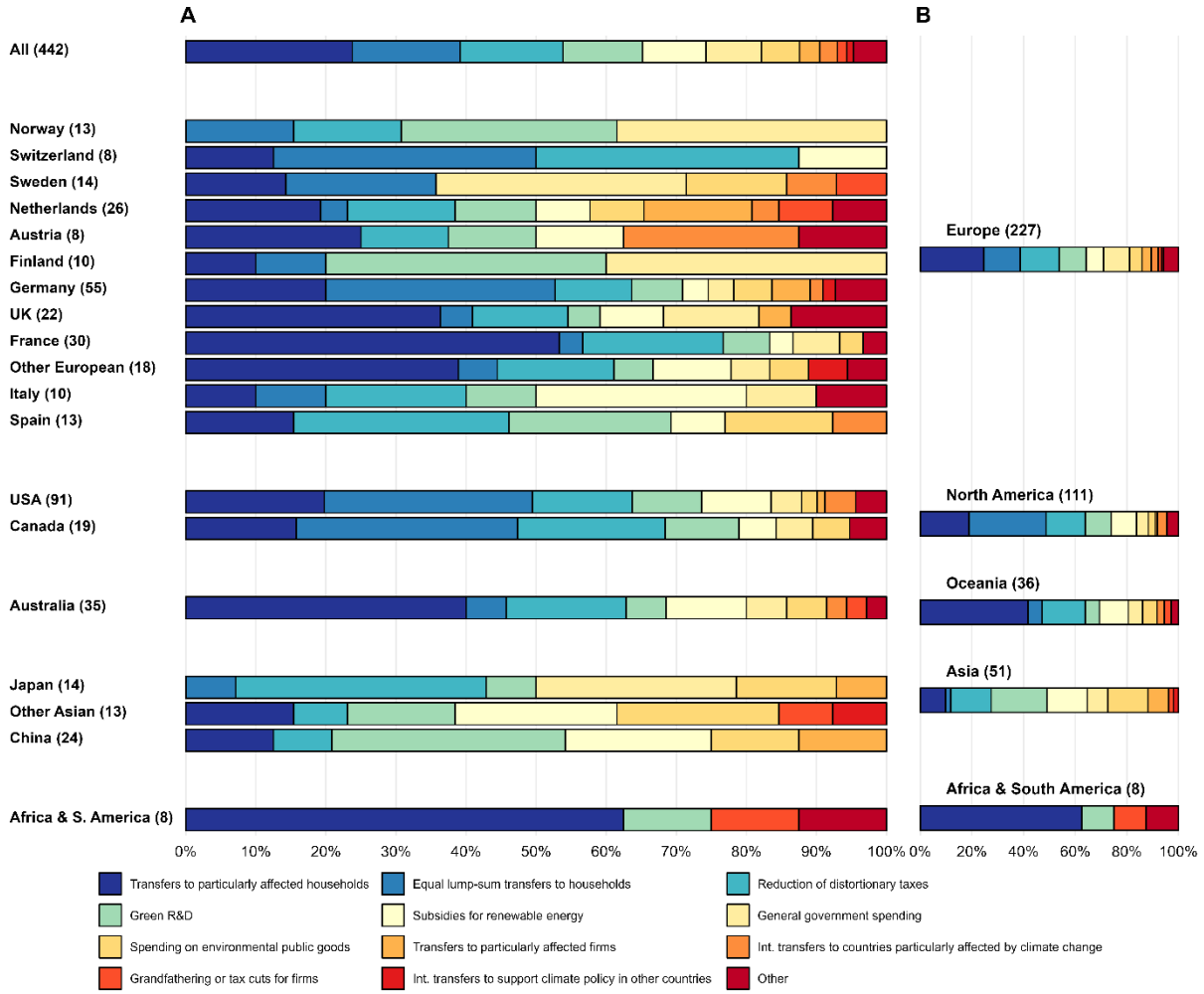

Fig. 3. Carbon pricing revenue use – most recommended option (in percent). Fraction of experts that indicate each of the options for revenue usage as "most recommended" for countries (Panel A) and continental groups of countries (Panel B). The option chosen by any expert who selected only a single option when several options are possible is also counted as this expert's most recommended option. (Number of observations in parentheses.)

There are also some clear differences across continents and countries. Regarding experts' most recommended options for revenue usage, we observe that "equal lump sum transfers to households" ranks first among North American experts (30 percent), whereas this option was indicated as the most preferred one by only 2 percent of Asian experts. Among the Asian experts, the strongest support is for the option "green R&D" (indicated as most

recommended by 22 percent of Asian experts), followed by "reduction of distortionary taxes", "spending on environmental public goods", and "subsidies for renewable energy" (16 percent for each of these three options). Among European experts, by contrast, the option "transfers to particularly affected households" is indicated as "most recommended" most frequently (25 percent). Across Europe, however, there are notable heterogeneities. This is perhaps most striking for France, where political feasibility constraints due to distributional issues and inequality are very salient in public discourse. In contrast, experts from Norway, which exhibits a comparatively lower degree of income inequality, do not at all recommend relying on transfers to particularly affected households (see Panel A in Figure 3).

When using data on potential determinants for the case when respondents could choose multiple options, we find that those who expect a higher probability of severe climate damages tend to recommend a "reduction of distortionary taxes" less frequently (logistic regression: $p=0.018$) but to more often suggest using the revenue for environmental purposes, including "green R&D" and "subsidies for renewable energy" (logistic regressions: all $p<0.01$). Furthermore, experts recommending more stringent global emission reductions recommend "equal lump-sum transfers to households" more often as well as supporting particularly affected households—both domestically and abroad—and climate policy in other countries (logistic regressions: all $p<0.05$). Experts who suggest placing more weight on the well-being of future generations also tend to more often recommend supporting particularly affected households—both domestically and abroad—and climate policy in other countries (logistic regressions: all $p<0.05$).

Using the additional data gathered, we are able to shed light on some of the heterogeneities reported above. For example, support for "equal lump-sum transfers to households" tends to increase along GDP per capita in the expert's country, while the support for "spending on environmental public goods" and a number of other targeted options decrease with it (these options are "grandfathering or tax cuts for firms", "green R&D" and "subsidies for renewable energy"). We also observe that experts who have published in economics journals recommend "reduction of distortionary taxes" and "equal lump-sum transfers to households" more often than non-economists (chi-squared tests: $p=0.000$ and $p=0.035$), while they recommend targeted options such as "subsidies for renewable energy" or "spending on environmental public goods" less frequently (chi-squared tests: $p=0.000$ and $p=0.043$). Economists thus generally recommend options more in line with efficiency considerations, while non-economic experts tend to recommend options that have been shown to raise public support for climate policies more often (e.g., Douenne and Fabre 2022). Non-economic experts also recommend using parts of the revenue for "international transfers to countries particularly affected by climate change" more frequently (chi-squared tests: $p=0.007$).

Discussion

Tackling climate change requires an effective design of climate policy. Building on a rich dataset from a global survey of academic experts, we investigate recommendations on key policy design issues related to carbon pricing. While we document strong and general support for the use of border carbon adjustment mechanisms, our results also highlight important heterogeneities in recommendations. Notably, while prior surveys on carbon pricing, such as the IGM Panel (2018), have often focused on general economists from North America (with similar results as our survey shows for the US), we find much more heterogeneity in the recommendations when considering climate policy experts in the rest of the world as well as non-economists. For instance, the option "equal lump sum transfers to households", which corresponds to the only revenue usage emphasized prominently in the US "Economists' Statement on Carbon Dividends" (Wall Street Journal 2019), is recommended only by a quarter

of all experts (when multiple usage options can be selected), thus ranking fourth among all options in our survey. While the option is recommended by 42 percent of experts in North America, it is only recommended by 21 percent in the rest of the world. Relatedly, while compensating particularly affected households is frequently recommended to governments in poorer and richer countries alike, recommendations for equal lump-sum transfers increase with a country's GDP per capita. In contrast, experts from poorer countries recommend governmental spending on subsidies for renewable energy or environmental public goods much more frequently. We also find that the clear and significant support for carbon taxes over cap-and-trade only exists in countries with a high GDP per capita. A potential explanations for this finding could be implicit transfers to poorer countries that cap-and-trade might lead to (Keen and Kotsogiannis 2014; Bauer et al. 2020). Furthermore, we document that while economists recommend lump-sum transfers and reductions in distortionary taxation more often, in line with efficiency considerations, non-economists rather recommend revenue-use options via governmental spending that have been shown to be more effective in raising public support for climate policies. Furthermore, we find that experts who support more stringent global climate policy and suggest placing greater weight on the well-being of future generations consistently suggest using recycle revenue from carbon pricing to support particularly affected households—both domestically and abroad—and to support climate policy in other countries. The considerable heterogeneities in recommendations we document here suggest that climate policy mixes may need substantial tailoring to local circumstances and objectives. Our results can serve as important inputs for climate policy modeling, and can help inform policy-makers and researchers in the search for suitable policies that balance efficiency, distributional and political acceptability considerations in addressing the climate challenge.

Materials and Methods

To identify experts, we ran an automated keywords search in SCOPUS, and defined a potential expert as a (co-)author of at least two publications matching our keywords criteria since the year 2000, that have been cited at least once. The search string contained "carbon tax", "cap-and-trade", and various variations of these and equivalent terms. We narrowed our sample to those experts for whom we could find a workable e-mail address. This way, we identified 2106 potential experts on carbon pricing around the globe.

Among these experts, we conducted an online survey on carbon pricing. Invitations to the survey were sent out by e-mail. The survey took place from June to November 2019, with three rounds of reminders. By the end of November 2019, we received 574 responses (including 97 explained non-responses), amounting to a response rate of around 25 percent. A complete description of our research methodology, including the search string, and other details of our approach, including data cleaning, are provided in the Supplementary Text in the SI Appendix. Here, we briefly summarize our methodology.

In the survey, we included three questions on key policy design issues that are analyzed in the present paper. Furthermore, we asked each expert three questions on their recommended level of carbon prices in different scenarios that we analyze in a companion paper (Drupp et al., forthcoming), which solely uses recommendations for policy design at a more aggregated level alongside other covariates to explain the variation in recommended carbon price levels. Additionally, we included one question on potential determinants of experts' recommendations (such as global emission reduction targets, or expected climate damages). The full survey text (including the preamble) is in the Supplementary Text in the SI Appendix.

Outside of the survey, we used further data sources in order to analyze possible drivers of experts' recommendations. Based on their country as revealed in the survey, we collected country-level data including GDP per capita, existing carbon prices in the country (if any), as well as governance indicators. We have also collected publicly observable information on the experts who provided their name to us at the end of our survey. These measures were collected from SCOPUS, for example the expert's number of publications, number of citations, and whether the expert has published on topics related to the social cost of carbon or integrated assessment models, among other things.

In the Supplementary Text in the SI Appendix, we discuss standard concerns with surveys, related to non-response bias, non-representation bias, and strategic response bias. We do not find evidence for non-response bias and strategic response bias in our survey. There is some evidence of non-representation bias, but this is to be expected as the population of experts is not globally representative. Table S4 in the SI Appendix gives a descriptive overview.

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Supplementary Information for

Heterogeneity in expert recommendations for designing carbon pricing policies across the globe

Frikk Nesje, Robert C. Schmidt and Moritz A. Drupp

This PDF includes:

- Supplementary Text.
- Supplementary Figures.
- Supplementary Tables.

Supplementary Text

Full survey text, including the preamble

We seek your advice on hypothetical new carbon pricing policies for CO2 emissions covering all sectors of the economy. We first ask for your recommendations on global uniform carbon pricing. We then move to a national level and seek recommendations on unilateral carbon pricing. This includes questions regarding policy design issues. These include the use of revenues from carbon pricing as well as instrument choice, that is whether carbon pricing should be implemented in the form of a tax, a cap-and-trade scheme or some other instrument.

(Q1) Suppose that a "world government" exists, which seeks to maximize the well-being of all present and future people and plans to implement a uniform global carbon price (measured in real US dollars per ton of CO2). Which carbon price would you recommend to the "world government" for the years 2020 [X], 2030 [X], and 2050 [X]? Which range of carbon prices would you still be comfortable with recommending for the years 2020 [X] – [X], 2030 [X] – [X], and 2050 [X] – [X]?

(Q2) Please specify the country you are most familiar with or that you would feel most comfortable advising on carbon pricing (below, we will refer to this as "your country"): [___].

(Q3) Suppose that your country unilaterally introduces a carbon price. Suppose further that any competitive disadvantages are neutralized by border carbon adjustment, exempting exports from the carbon price and pricing the carbon content of imports at the domestic rate. In this case, which carbon price would you recommend to your government for 2020 [X] and 2030 [X], and which range of carbon prices would you still be comfortable with recommending for 2020 [X] – [X] and 2030 [X] – [X]?

(Q4) Suppose that your country unilaterally introduces a carbon price without border carbon adjustment. In this case, which carbon price would you recommend to your government for the years 2020 [X] and 2030 [X]? Which range of carbon prices would you still be comfortable with recommending for the years 2020 [X] – [X] and 2030 [X] – [X]?

(Q5) If your country implements a carbon pricing scheme unilaterally, would you strongly recommend introducing a border carbon adjustment scheme (if that is possible)? Yes [x], No [x].

(Q6) Assuming that no carbon pricing scheme has been implemented in your country yet, which instrument would you recommend using for it to be implemented? Carbon tax [x], cap-and-trade with price collar (price floor and price cap) [x], cap-and-trade without price collar [x], other instrument (or mix of instruments), please specify [___], no clear recommendation [x].

(Q7) Considering the case of unilateral carbon pricing without border carbon adjustments, how should your government use the revenues raised by carbon pricing? (Multiple answers are possible.)
a) General government spending [x]
b) Equal lump-sum transfers to households [x]
c) Transfers to particularly affected households [x]
d) Reduction of distortionary taxes [x]
e) Grandfathering or tax cuts for firms [x]
f) Transfers to particularly affected firms [x]
g) Spending on environmental public goods [x]
h) Green R&D [x]
i) Subsidies for renewable energy [x]
j) International transfers to countries particularly affected by climate change [x]
k) International transfers to support climate policy in other countries [x]
l) Other, please specify [___].
If you suggest more than one use, please indicate your most recommended option by its letter [___]. Please also specify which percentage of total revenues should (roughly) be allocated to it [X].

(Q8) Please also provide your (very rough) views on the following issues:

(a) By what percentage should global CO2 emissions be reduced by 2050 as compared to today?
<20% [x], 20% to <50% [x], 50% to <80% [x], 80% to <100%, [x] ≥100% [x];

(b) How costly would it be to reduce global CO2 emissions by 80% by 2050 (average abatement cost per year as percentage of global GDP until 2050)?
<0.25% [x], 0.25% to <0.5% [x], 0.5% to <1% [x], 1% to <3%, [x] ≥3% [x];

(c) In the absence of effective climate policy (beyond current policies), what is the probability that in 2070, climate change will cause global damages, comprising both market and non-market impacts, of at least 20 percent of global GDP?
<5% [x], 5% to <10% [x], 10% to <20% [x], 20% to <50% [x], ≥50% [x];

(d) How large are the expected annual global damages from climate change, measured as a percentage of future global GDP and comprising both market and non-market damages, for 3°C global warming (in the absence of effective climate policy beyond current policies we may reach 3°C by around 2070)?
<2% [x], 2% to <5% [x], 5% to <8% [x], 8% to <12% [x], ≥12% [x];

(e) As compared to the utility of a person today, what is the weight (measured in percent) that should be put on the utility of a person in 2070 in global public decision-making?
<40% [x], 40% to <60% [x], 60% to <80% [x], 80% to <100% [x], 100% [x].

Feel free to provide us with any additional comments or feedback: [___].

Search string (used in SCOPUS)

TITLE-ABS-KEY ("carbon pric*" OR "carbon-pric*" OR "CO2 pric*" OR "carbon tax*" OR " tax on carbon" OR "CO2 tax*" OR "carbon trad*" OR "carbon-trad*" OR "price on carbon" OR "price on CO2" OR "price per ton of carbon" OR "price per ton of CO2" OR "social cost of carbon" OR "social cost of CO2"
OR ("cap and trade" AND ("carbon" OR "CO2" OR "climate change" OR "climate policy"))
OR ("cap-and-trade" AND ("carbon" OR "CO2" OR "climate change" OR "climate policy"))
OR ("permit pric*" AND ("carbon" OR "CO2" OR "climate change" OR "climate policy"))
OR ("permit trad*" AND ("carbon" OR "CO2" OR "climate change" OR "climate policy"))
OR ("permit-trad*" AND ("carbon" OR "CO2" OR "climate change" OR "climate policy"))
OR ("emission* tax" AND ("carbon" OR "CO2" OR "climate change" OR "climate policy"))
OR ("emission* pric*" AND ("carbon" OR "CO2" OR "climate change" OR "climate policy")) OR ("emission-pricing" AND ("carbon" OR "CO2")) OR ("emission* trad*" AND ("carbon" OR "CO2" OR "climate change" OR "climate policy")) OR ("emission* permit*" AND ("carbon" OR "CO2" OR "climate change" OR "climate policy")) OR ("tax on emission*" AND ("carbon" OR "CO2" OR "climate change" OR "climate policy")))
AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-TO (PUBYEAR , 2007) OR LIMIT-TO (PUBYEAR , 2006) OR LIMIT-TO (PUBYEAR , 2005) OR LIMIT-TO (PUBYEAR , 2004) OR LIMIT-TO (PUBYEAR , 2003) OR LIMIT-TO (PUBYEAR , 2002) OR LIMIT-TO (PUBYEAR , 2001) OR LIMIT-TO (PUBYEAR , 2000))

Details on data and data cleaning

We conducted a number of survey response data cleaning steps. A brief overview of these changes is provided below:

- Double responses: We kept the first and more complete response in two cases where we had two responses from the same respondents.
- Discretion: We deleted six unfinished responses and two responses that contained clear mistakes.
- Unrelatable names: We deleted eight responses with unrelatable names. In five cases we also imputed or removed the names of respondents based on information provided to us in the survey.
- Other adjustments: We also corrected the country for one respondent and did some imputation of recommended revenue use from the remaining survey data.

Supplementary discussion of materials and methods

We conduct standard tests for non-response and other biases (cf. Armstrong and Overton 1977; Necker 2014; Johnson and Wislar 2012). As we write in the Materials and Methods, we do not find evidence for non-response bias and strategic response bias in our survey. There is some evidence of non-representation bias, but this is to be expected as the population of experts is not globally representative.

Non-response bias: We reweight the recommendations on carbon taxes versus other instruments, BCA, and revenue use options by the characteristics of both respondents and non-respondents. Table S5 in the SI Appendix shows the full dataset for each of these variables, as well as the unweighted and weighted data. The unweighted data is the raw data for respondents that reveal their identity and is used for comparison to the weighted data. For the weighted data, we rebalance recommendations by propensity score matching using the following characteristics: Whether the expert is based in Europe, Oceania, Asia or the category of Africa & South America, is a male, as well as number of publications and citations, whether the publications are in economics journals and if so how many, and consider issues like integrated assessment models (IAMs), the social cost of carbon (SCC), carbon taxes or cap-and-trade. It is clear from Table S5 that there is no systematic change in recommendations by weighting. Moreover, quantitative implications are also negligible. We can rule out other concerns related to non-response bias by design as we are able to identify 97 explained non-respondents (Dutz et al. 2021).

Non-representation bias: Our survey seeks recommendations on designing carbon pricing policies based on a population of experts that is itself not globally representative, as a disproportionate fraction of academic experts are located in higher-income countries. Here, we investigate this potential non-representation bias by exploring how country and observable expert characteristics are associated with recommendations and then perform a re-weighting of responses according to the global average of these country-level characteristics. We hereby focus on GDP per capita as well as the share of experts with an economics publication and the share of female experts. For the share of female experts, we take 50 percent as the representative share. The latter is not clear cut for the share of economists; for illustrative purposes, we vary it to a very low share. Figure S1 shows that recommendations for a carbon tax versus cap-and-trade are far less frequent for global average GDP per capita compared to the average in our sample (Panel A), but not differing along the other dimensions (Panels B and C). The strong support for BCA is consistently high along GDP per capita (see Fig. S2, Panel A). However, this support is lower for respondents with an economics publication, and comparably higher for experts without (Panel B of Fig. S2). According to Figure S3, recommendations for the use of revenue for lump-sum transfers are far less frequent at global average GDP per capita, and only slightly less likely for non-economic experts (Panels A and B). Our non-representation bias analysis also reveals that recommendations for the use of revenue for transfers to particularly affected households are not affected by the three country characteristics (Panels D-F). Recommendations for the use of revenue for renewable energy subsides are, on the other hand, much more frequent at a global average GDP per capita, and somewhat more likely among non-economists (Panels G and H). Finally, the use of revenue for reductions in distortionary taxes are recommended less often at global average GDP per capita and at a much lower share of economic experts (Panels J and K). We do not find any gender effects in the exemplary revenue use categories (see Panels C, F, I and L in Fig. S3); Below a 5 percent significance level, female experts only recommend "green R&D" much more often than males (chi-squared test: $p=0.006$), leading to an adjustment from a share of 61 percent of experts recommending "green R&D" (among other options) in the sample to a share of 67 percent in the hypothetical population.

Strategic response bias: We conduct two tests. First, we compare experts revealing their identity to us to experts who do not, to see if anonymous experts give systematically different recommendations as this has been a concern in the literature. Here, we find that experts who do not reveal their identity give similar recommendations in favor of carbon taxes versus other instruments, BCA, as well as for most revenue use categories compared to those revealing their

identity (all t-tests: p>0.250). These respondents are, however, less likely to recommend transfers to particularly affected firms (14 vs. 25 percent; t-test: p=0.050), spending on environmental public goods (24 vs. 36 percent; t-test: p=0.057) and green R&D (46 vs. 61 percent; t-test: p=0.025).

Second, we compare experts replying early to those replying late, e.g. to a reminder instead of the initial invitation to participate, to check if those replying early differ in their recommendations. We do not find that experts replying to the initial invitation give different recommendations, on average, for carbon taxes versus other instruments, BCA, or any of the revenue uses than those who replied to a reminder (t-tests: p>0.140). This holds also, on average, for those who replied to the second, third as well as fourth (and final) invitation to participate (t-test: p=0.271, p=0.260, p=0.283), when not considering strong support for BCA or recommending international transfers to support climate policy in other countries. For BCA, we find that experts replying to the second invitation were less likely to support its introduction (66 vs. 78 percent; t-test: p=0.020), while those replying to the final invitation did so more frequently (85 vs. 72 percent; t-test: p=0.023). Yet, this is not worrying as strategic response bias concerns only those replying early on, and – if it were a concern – would bias our results in the more conservative direction. For international transfers to support climate policy in other countries, we pick up an effect only for the second round (31 vs. 21 percent; t-test: p=0.042). Finally, we split the sample in two equal parts based on the order of responses by calendar time. Also here the results are reassuring since early respondents give similar recommendations for carbon taxes versus other instruments, BCA and most revenue uses compared to late respondents (t-test: p=0.110). The only exception is subsidies for renewable energy, which were recommended less frequently by experts filling out the survey early on (30 vs. 39 percent; t-test: p=0.046). If this was a concern, it would bias our results in a conservative direction.

Supplementary Figures

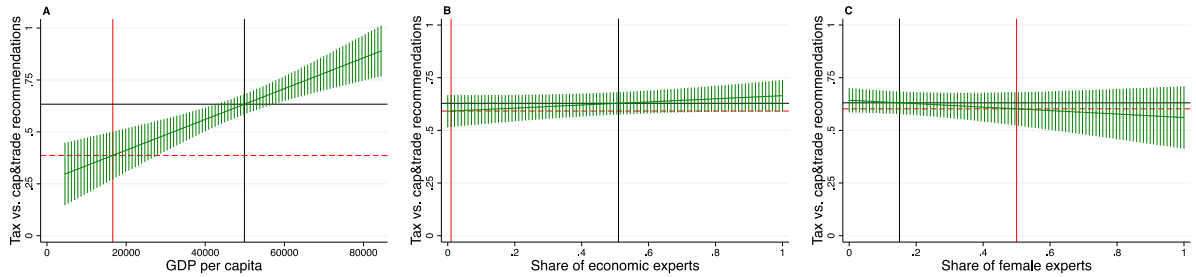

Fig. S1. Re-weighting recommendations on carbon pricing instruments. The shares of experts recommending the use of a carbon tax versus cap-and-trade with and without price collar along GDP per capita (Panel A), from the sample mean GDP per capita to the global mean GDP per capita, as well as the share of experts with an economics publication (Panel B) in the sample relative to a marginal 1 percent, and the share of female experts (Panel C) in the sample relative to a 50-50 share.

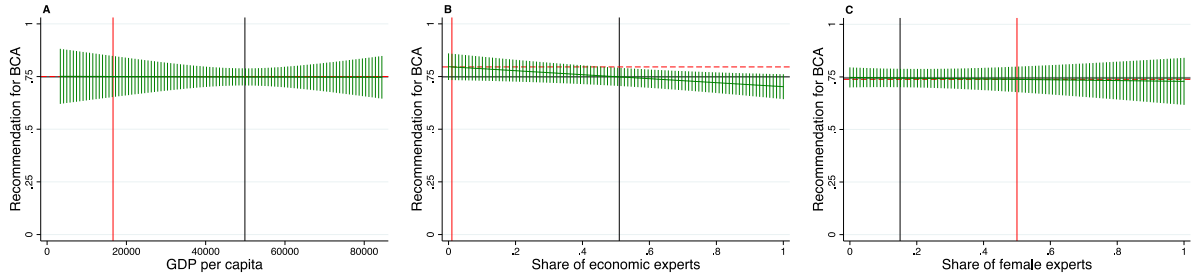

Fig. S2. Re-weighting recommendations on border carbon adjustment (BCA). The shares of experts recommending the use of revenue for lump-sum transfers to household along GDP per capita (Panel A), from the sample mean GDP per capita to the global mean GDP per capita, as well as the share of experts with an economics publication (Panel B) in the sample relative to a marginal 1 percent, and the share of female experts (Panel C) in the sample relative to a 50-50 share.

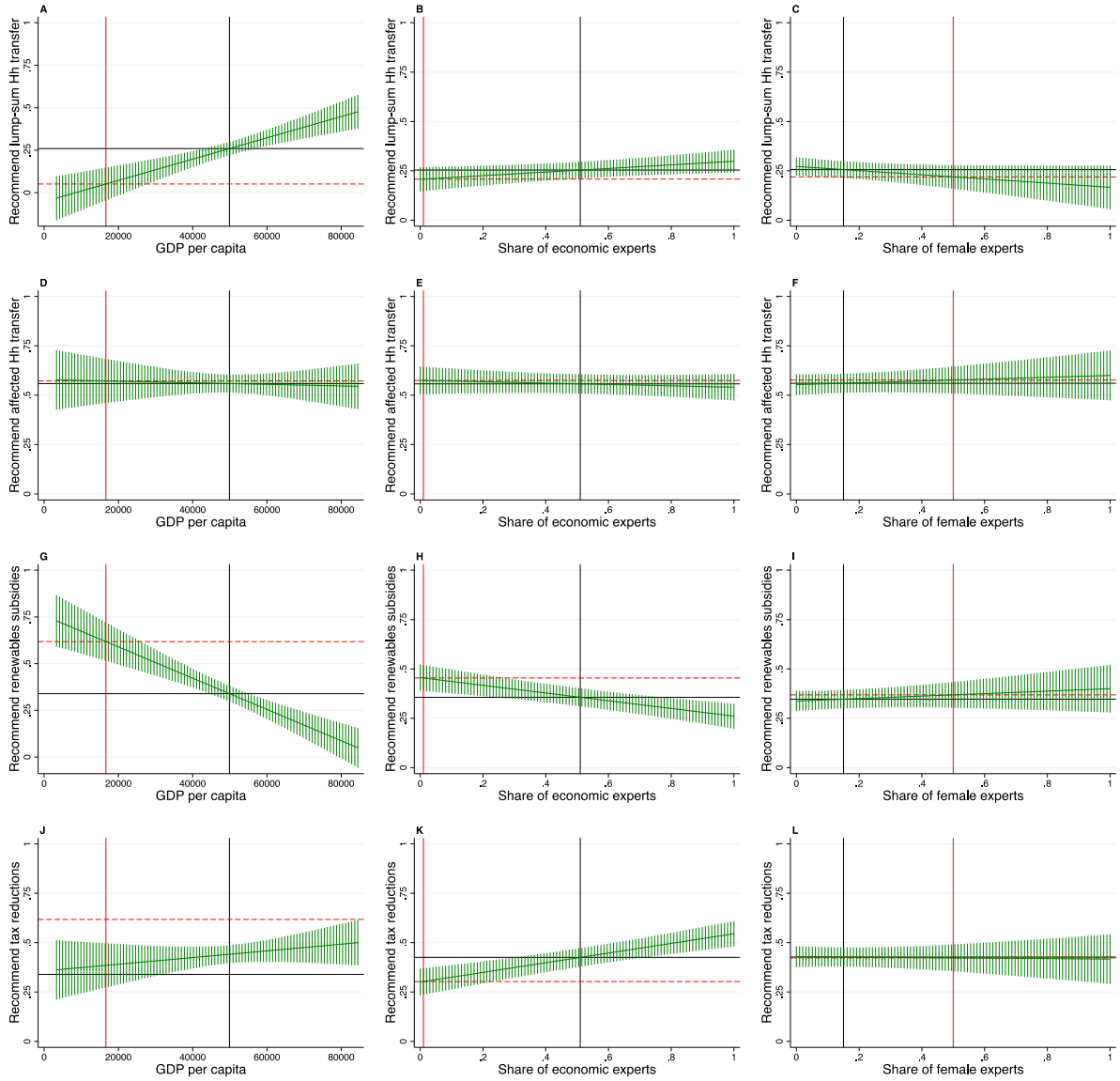

Fig. S3. Re-weighting revenue use recommendations. The shares of experts recommending the use of revenue for lump-sum transfers to household along GDP per capita (Panel A), from the sample mean GDP per capita to the global mean GDP per capita, as well as the share of experts with an economics publication (Panel B) in the sample relative to a marginal 1 percent, and the share of female experts (Panel C) in the sample relative to a 50-50 share. We illustrate the corresponding analyses for transfers to particularly affected households in Panels D-F, for subsidies for renewable energy in Panels G-I, and for reductions in distortionary taxes in Panels J-L.

Supplementary Tables

Table S1. Other instrument (or mix of instruments)

a combination of policies, **ETS** for energy intensive industries, *tax* for others, revenue recycling used to investment in renewables and energy efficiency
a mix of instruments depending on who the regulatory object is
ambivalent between cap-and-trade with price collar and prescriptive sectoral policies - efficiency gains of c&t may be outweighed by political/distributional benefits of other policies
base-line and credit trading to connect with Kyoto CDM
border carbon tax and green procurement
budget/tax reforms which quantitative impact is measured yearly with four numbers; the sum of the four numbers allows to judge progress
cap and trade with a price floor and price cap and also renewable energy targets
cap and trade with collars and multiple steps to achieve a price-responsive allowance supply
cap and trade with continuously lowering the cap.
cap and trade with price collar + renewable energy subsidies
cap and trade with series of price steps in allowance supply
cap-and-trade (EU ETS) + *carbon tax* for non ETS sectors (agriculture, households, ...)
cap-and-trade at the EU level (not single member country)
cap-and-trade with a 'carbon central bank' (more flexible approach to price collar)
cap-and-trade with price collar, but with clearly-defined rebate or reduction in other taxes
cap-and-trade with price floor
cap-and-trade with price floor and border tax adjustments
capital grants to increase low carbon technology deployment along with *carbon tax* to give proper signal to market and society
carbon dividends
carbon dividends
carbon fee and dividend (i.e. *carbon tax* paid back to tax payers)
carbon pricing in combination with RES policy instruments and instruments that create markets for low-carbon products (e.g. via public procurement)
carbon tax (for sectors that are not directly subject to international competition), some sort of **cap and trade** with price collar for e.g. manufacturing industry combined with subsidies to renewables and technology development in the harder to abate sectors (e.g. aviation, shipping or industry).
carbon tax (with socially balanced dividend); subsidies for low carbon (and other GHGs) development
carbon tax + **cap and trade** depending on point and non-point sources
carbon tax + energy efficiency standards + reverse auctions for large-scale renewable energy
carbon tax + prices adjustment for other externalities
carbon tax + regulation
carbon tax and **cap-and-trade**
carbon tax and regulations
carbon tax combined with command-and-control / regulatory instruments
carbon tax for intermediate, feebate for final goods
carbon tax for private consumption, with redistribution. **Cap and trade** for industry.
carbon tax for small fossil fuel users, and **emission trading** scheme for larger emitters
carbon tax in combination with strong R&D policies, investment support (e.g. for households), information policies (e.g. for craftsmen) and standards (to prevent investment into carbon-intensive technologies)
carbon tax plus investment incentives plus energy efficiency measures
carbon tax with 75% to 100% per-person refund
carbon tax with a tax adjustment mechanism

carbon tax with complementary sectoral policies, increase in RD&D funding (with innovation policies)
carbon tax with differentiation across sectors; depends on international context
carbon tax, and R&D subsidies directed at new zero carbon tech
carbon tax, **cap-and-trade** for electricity, strong regulations for vehicles and buildings
carbon tax, feebate
carbon tax, green tax reform, subsidies for new technologies
carbon tax, subsidies to green transition, infrastructure investments, host of measures to address resulting inequalities/fairness/poverty.
carbon taxes + a wide range of other measures
contracts for difference
distinction btw carbon tax and cap-and-trade less important than price, signal and plans to tie price to emission reductions. A C&T can be designed to look very similar to a carbon tax and vice-versa. The distinctions are more political than functional, one may have more political feasibility and durability than the other or public acceptance. These are more important than the functional distinctions.
emission trading with carbon-content certification of imports
energy efficiency standard, carbon disclosure etc.
escalating *carbon tax* (for certainty) with dividend to offset some financial hardship
ETS with price collar plus (higher) *carbon tax* in difficult sectors such as transport
I am fine with both cap-and-trade with price collar and carbon tax
information, restrictions, subsidies for renewables, green R&D
many instruments including a carbon price
mix of *carbon tax* and **cap-and-trade** with price collar
mix of *carbon tax*, and **cap and trade** with high price floor, and many policy and measures (standards, infrastructures program, financing arrangements)
mix of consumer (households) and EITE industry output based pricing
mix of different *tax* and incentive programs
mix of instruments **cap and trade** with collar for industry plus *carbon tax* for other users
mix of *tax*, norms, subsidies
one (*tax*) for fossil carbon, one for biogenic methane, a tax for N2O.
output-based performance system, fuel charge and mix of incentives and regulations
output-based pricing system for large emitters; *carbon tax* for small emitters
output-based rebate with *carbon tax*
prioritization of GHG mitigation measures which maximize the benefits across SDGs
really carbon tax is cap and trade just with 0 cap before a penalty - not really a difference.
regulation: cap with NO trading or offsetting
rental price for carbon sequestration in biomass, land or atmosphere
repeal of existing regulations followed by *carbon tax*
revenue neutral *carbon tax* with cut on labour taxation
sector specific polices including **cap-and-trade** with a collar
sector-specific flex-regulations (RPS, LCFS, ZEV, OBPS, etc.)
smart cap, i.e., a **cap and trade** system where the equilibrium certificate price (co-)determines the cap
stringent **cap and trade** for heavy polluters (where quantitative limits are key and abatement costs are heterogeneous), *carbon tax* elsewhere.
tax and dividend
tax and technology and emission standards as well as subsidies for lead abaters in each industry and government-funded carbon entrepreneurs for each industries
tax and vat
tax combined with support for critical measures and technologies

tax with accompanying measures (spatial planning, infrastructure roadmap, social protection, regulation on existing polluting sources)
tax with subsidy scheme
taxation for households and SME, **trading** with collar for large companies

Qualitative responses (corrected for typos, etc.) to survey question on instrument choice for unilateral carbon pricing: "other instrument (or mix of instruments), please specify". There are 82 such qualitative responses; out of these, 27 responses were interpreted as clear recommendations for variants of "cap-and-trade" (here: highlighted in **bold** letters), and 48 responses as recommendations for variants of "carbon tax" (*italics*). Hence, the ratio of recommendations of carbon tax vs. cap-and-trade is very similar to the one in the overall sample. Furthermore, 8 respondents recommend cap-and-trade for larger emitters / energy intensive / trade exposed industries, and a carbon tax for smaller emitters or other sectors.

Table S2. Carbon pricing revenue use (multiple options possible)

Revenue use (multiple options possible)	All	EU	North America	Asia
a) General government spending	17%	19%	13%	21%
b) Equal lump-sum transfers to households	25%	25%	42%	9%
c) Transfers to particularly affected households	56%	57%	54%	45%
d) Reduction of distortionary taxes	43%	44%	44%	38%
e) Grandfathering or tax cuts for firms	7%	6%	4%	16%
f) Transfers to particularly affected firms	24%	28%	15%	26%
g) Spending on environmental public goods	35%	32%	24%	48%
h) Green R&D	59%	55%	56%	79%
i) Subsidies for renewable energy	35%	29%	25%	66%
j) International transfers to countries particularly affected by climate change	23%	22%	23%	22%
k) International transfers to support climate policy in other countries	23%	24%	22%	16%
l) Other	11%	13%	12%	0%

Fraction of experts who recommend different options for revenue usage, for continental groups of countries.

Table S3. Other revenue use for carbon pricing

"green spending", that is finance low-carbon local infrastructure -- I am not sure you mean that by (g)
Although unilateral carbon pricing has no effect on total climate change, the allocation of any revenues is an issue related to current policies of any government. Consequently there is not reliable forecasts.
anything that is not too distortionary and will garner sufficient support by the public that allow such carbon pricing to be implemented
Basic Income Grant
budget deficit reduction -- some might interpret (a) this way, but there's a difference
building resilience to climate change via adaptation
buying off political resistance from industry (possibly f but this is not quite the same point)
climate adaptation
Dealing with the regressive impacts on poorer households is important in order to mitigate political resistance (but exactly how that should be done is a tricky question). In addition one would have to deal with the situation for carbon intensive companies exposed to international competition by exempting them from the tax or by pricing imports (for steel etc. it is not point having a high carbon tax if their competitors do not face a similar tax). However, I am not sure that transfers is the best way to deal with it. Also, I think that support to green tech development as well as support for adaption and mitigation in very developing countries is needed too, but the carbon tax cannot provide funds for every warranted measure...
debt reduction
Earmarking is often really inefficient, but subsidising affected firms would be perverse. Fairness towards poor households is key for political acceptability. Then, coherent international development policy funded by general budget.

for a cap and trade government doesn't get any revenue, unless the permits are auctioned off, or some tax on earning from permit sales
Funds should go to supporting actions that reduce emissions. Public transit, renewable energy etc. cannot happen at individual scale, funds need to be pooled and dedicated to {Category:} to reduce emissions.
green industrial policy for low-carbon cleantech sectors
green infrastructure investments
I'd prefer a lump-sum per capita instead of per household
in short term - access to investment finance for particularly affected firms and individuals
infrastructure (preferably clean or low-carbon)
Infrastructure for large-scale renewable energy -- e.g. new and upgraded transmission lines; the creation of Renewable Energy Zones -- and new institutions (e.g. structure and rules of the electricity market).
international transfers conditional on carbon pricing introduction & increase of prices in other countries
international transfers to support carbon sinks in other countries
invest in renewable energy
invest in the Hydrogen Economy and invest in carbon sinks
investing in energy efficiency
local government spending by locality where tax is raised
NB UK issues its own currency so does not need to balance budgets
no revenue use
part to government budget, part to poorer country mitigation and adaptation
Payments for Ecosystem Services
Policies to foster regional economic development in areas negatively affected.
public development of renewable energy and transportation infrastructure (not just subsidies for private firms, but investment)
R&D and investment support for low-carbon technologies, particularly in industry
raising tax free threshold
reduce tax on labour to encourage employment and maintain competitiveness
reduction of labour tax
reduction of payroll taxes and social security contributions
spending on climate adaptation, particularly for infrastructure
stopping natural native forest usage, reforestation, renewables investment, education
subsidies to energy efficiency, to lower the energy bill being mindful of income classes
subsidies/tax cuts for GHG efficient behaviour/consumption/products
support Indigenous engagement in carbon and ES industry
supporting workers in particularly affected firms
taxes reductions combined with income based lump sum payments
temporary tax cuts for EITE firms for first 10 years; schedule announced ahead of time
the budget/tax reform instrument includes the marked categories
there would be no revenue except from fines. Revenue from higher income and wealth taxes must be spent on g, h, j, k
transfer to low income households without linking it to affected households
transfers to export sectors during some transition
transfers to low-income households
whatever turns out to be least cost for this country plus funding to make transition to renewables possible

Qualitative responses (corrected for typos, etc.) to survey question on revenue usage (“Other, please specify.”).

Table S4. Descriptive overview

Border Carbon Adjustment (BCA)	*Yes, strongly support BCA*		*No*	*N*
	74%		26%	450
Instrument choice	*Carbon tax*	*Cap & trade*	*Other instruments*	
	49%	29%	18%	462
Revenue usage (the three most preferred options)	*Transfers to particularly affected households*	*Equal lump-sum transfers to households*	*Reduction in distortionary taxes*	
	24%	16%	15%	442
Response categories				
Quantitative responses				468
Quantitative responses (non-anonymous/verified identity)				406
Qualitative responses				176
Explained non-responses				97
Total responses				574
Expert population				2106

Table S5. Re-weighting policy design recommendations

	Carbon tax vs. other instruments	Border Carbon Adjustment	General government spending	Equal lump-sum transfers to households	Transfers to particularly affected households	Reduction of distortionary taxes	Grandfathering or tax cuts for firms
Full dataset	49%	74%	17%	25%	56%	43%	7%
Unweighted	50%	74%	16%	26%	56%	43%	7%
Weighted	50%	75%	15%	25%	55%	40%	7%

Continued.

	Transfers to particularly affected firms	Spending on environmental public goods	Green R&D	Subsidies for renewable energy	International transfers to countries particularly affected	International transfers to support climate policy in other countries	Other
Full dataset	24%	35%	59%	35%	23%	23%	11%
Unweighted	26%	36%	60%	35%	24%	23%	12%
Weighted	26%	39%	62%	38%	26%	24%	12%

The model consists of the following characteristics as described in the Supplementary Text: Whether the expert is based in Europe, Oceania, Asia or the category of Africa & South America, is a male, as well as number of publications and citations, whether the publications are in economics journals and if so how many, and consider issues like IAMs, the SCC, carbon taxes or cap-and trade. Weights are estimated by propensity score matching.

Supplementary References

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