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Pricing Carbon

Abstract

We study the variation of global and unilateral carbon price recommendations and their determinants. To this end, we provide survey evidence on carbon pricing from more than 400 experts across almost 40 countries. We quantify the extent of (dis-)agreement and reveal that a majority of experts can agree on some short- and medium-term global carbon price levels, and on unilateral carbon price levels in most countries. We find little evidence for free-riding. Indeed, experts' unilateral carbon price recommendations with border carbon adjustment are, on average, higher than global recommendations. Furthermore, border carbon adjustment facilitates higher price recommendations and tends to foster agreement among experts on carbon price levels. We analyze how experts' recommendations vary with additional survey data on key policy design issues, such as instrument choice, other likely determinants of carbon price recommendations as well as country characteristics and observable expert characteristics.

JEL-Codes: Q540, H430.

Keywords: carbon pricing, expert survey, carbon tax, emission trading, border carbon adjustment, climate policy.

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“[A]ll of the answers are grounded at least as much in fact-based intuition as in formal modeling, as I'm not sure how far formal modeling gets us to any of them”.

[quote from an expert respondent]

1. Introduction

A carbon price is widely seen as a key ingredient of any effective climate policy mix. This is highlighted by recent high-level statements, such as the “Economists’ Statement on Carbon Dividends” (Wall Street Journal, 2019) and the “Economists’ Statement on Carbon Pricing” (EAERE, 2019), signed by more than 5000 economists in combination. According to the World Bank (2020), carbon prices—by means of a carbon tax or a cap-and-trade scheme—have been implemented or are scheduled to be in 46 national jurisdictions covering around 20 percent of global CO_2 emissions, with prices ranging from a few cents to more than 100 US dollars per (metric) ton of CO_2. This large variety in implemented carbon prices mirrors a heated academic debate over the appropriate level of carbon prices, with suggestions ranging from negative values to several hundred dollars per ton of CO_2 (e.g. Dietz and Stern, 2015; Hänsel et al., 2020; Nordhaus, 2019; Pindyck, 2019; Ricke et al., 2018; Tol, 2018, 2021a,b). While numerous political obstacles stand in the way of enacting stringent carbon pricing policies, the seemingly substantial disagreement among experts on an appropriate level of carbon prices is often regarded as an impediment to climate policy in itself.

Determining appropriate carbon prices is a difficult task that is often informed by integrated climate-economy assessment models (IAM), such as the DICE model by Nobel laureate Nordhaus (2019). IAMs are criticized as being very sensitive to crucial modeling and parameter choices, such as on climate damages and discount rates, some of which are left to judgement calls by the modelers (e.g., Pindyck, 2013; Stern and Stiglitz, 2022).[1] Crucially, there is no way to judge whether an expert holding a specific view on input parameters, such as on discount rates (e.g., Hänsel et al., 2020; Pindyck, 2019), would also find optimal carbon prices that result from an IAM run agreeable. The crucial policy question of how representative, and thus robust to alternative well-founded views, carbon price recommendations derived from IAMs are of the views of a broader expert population on carbon pricing remains unanswered.

To fill this gap and uncover a more precise and more representative understanding of the range of appropriate carbon prices, our approach is to ask experts directly for their recommendations on carbon prices. Expert elicitation has become more common to inform climate policy and its determinants (e.g., Christensen et al., 2018; Drupp et al., 2018; Howard and Sylvain, 2020; Kornek et al., 2020; Nordhaus, 1994; Pindyck, 2019) and in eliciting information on key economic aspects (e.g., Andre et al., 2022; DellaVigna and Pope, 2018; Sapienza and Zingales, 2013), but has not been comprehensively applied to carbon pricing.[2]

[1] A number of recent studies aim at putting estimates of the economic damages from climate change on firmer empirical ground (e.g., Carleton and Greenstone, 2021; Moore and Diaz, 2015; Hsiang et al., 2017). Other studies translate a range of expert views on key parameters, such as on discount rates, into optimal carbon prices within specific models (e.g., Drupp and Hänsel, 2021; Hänsel et al., 2020; Howard and Sylvain, 2020; Jaakkola and Millner, 2022; Pindyck, 2019). This, however, does not solve the issue that expert views on input parameters are channeled through a corset of functional form assumptions that underlie IAMs (e.g., Weitzman, 2010).

[2] Two previous surveys concern carbon pricing directly. Schauer (1995) interviewed 16 experts on determinants of carbon prices to calibrate a pre-curser to recent analytic IAMs. Nine experts provided a direct estimate of the social cost of carbon (SCC). While the calibration of the analytic model produced a mean SCC of $8 per ton of CO_2, the mean recommendation was $113, showcasing a substantial gap. Howard and Sylvain (2015) surveyed economists who published on climate change. As one of 16 questions, they elicited views on whether a SCC of $37 is a likely estimate, too high or too low. They find that 55 percent of respondents think that the SCC should be higher, while only 8.6 percent think it should be lower. The expert survey by Pindyck (2019) does not elicit recommendations on carbon prices directly, but elicits inputs to calibrate an analytic IAM to compute the SCC.

Instead of relying on a specific model, or assuming a specific definition of social welfare, our approach gives experts full flexibility in determining carbon price recommendations, based on their own perspectives on the various related complexities. Our approach has the considerable benefit that experts are not confined to a certain IAM structure and can build on their own "mental model" of the climate-economy, which may be informed by a mix of quantitative modelling and fact-based intuition, as exemplified in the opening quote. This flexibility is important as subjective models of the macroeconomy are very heterogeneous (Andre et al., 2022). That respondents have full flexibility with regard to their own conceptualization of how the climate and the economy interact enables a more direct and comprehensive overview of experts' views on carbon pricing than previous studies. Our data further allows us to test a number of potential determinants of carbon price recommendations.

Our sample includes 445 responses on carbon price recommendations from a population of 2106 invited scholars, who are defined as (potential) experts on carbon pricing by their pertinent publications. Our survey includes questions on the recommended level of carbon prices, on crucial policy design issues and other potential determinants of carbon prices. We elicited recommendations on carbon prices across three hypothetical scenarios that are stylized to capture key features of the academic and policy debate on carbon prices and allow us to test key hypotheses on carbon pricing from the literature. In the first scenario, experts were asked to give a recommendation to a hypothetical world government that plans to implement a uniform carbon price globally. This is most closely related to results from IAMs that estimate a global social cost of carbon (SCC). In the second scenario, each expert was asked to give a recommendation to the government in his or her country, if the government were to implement a carbon price unilaterally, under the assumption that competitiveness concerns can be addressed with the help of a border carbon adjustment (BCA) scheme.[3] A sizable literature suggests that unilateral carbon prices with BCA would be lower than global carbon price recommendations due to free-riding (e.g., Barrett 1994). In the third scenario, we again asked for the unilateral carbon price, but without BCA. The difference between unilateral carbon prices with and without BCA provides an indication of competitiveness concerns hampering carbon pricing. In each scenario, we asked for experts' recommendations on carbon prices for the short-term (2020) and for the medium-term (2030). In the global scenario, we also asked for a long-term price recommendation (2050). Furthermore, we asked for *ranges* of carbon prices that respondents would still feel comfortable with recommending to examine spaces for agreement among experts on global and on unilateral carbon prices.

Besides carbon price recommendations, we also elicit recommendations on key policy design issues, such as on instrument choice, revenue use, and support for BCA, which we present and analyze in a companion paper (Nesje et al., 2022). Here, the focus is on experts' carbon price recommendations, for which responses to the policy design questions serve as explanatory variables. To uncover further potential drivers of carbon price recommendations, we also use survey questions to elicit each expert's view on global emission reduction targets, their assessment of climate risks, mitigation costs, and discounting. We further use additionally gathered data on characteristics of the country of each expert as elicited in the survey, and on observable characteristics of experts who revealed their identity when participating.

We find that the distributions of carbon price recommendations are highly dispersed and skewed towards high prices in all our scenarios. In Section 3, we first scrutinize global carbon price recommendations. We find average (median) global carbon prices of \$50 (\$40) in 2020, \$92 (\$70) in 2030, and \$224 (\$100) in 2050 per ton of CO_2. The interquartile ranges are

[3] The EU uses the term "Carbon border adjustment mechanism" (CBAM). While there are other ways to mitigate competitiveness concerns, we focused on BCA to ensure that respondents have the same scenario in mind. See Böhringer et al. (2022) for a recent review on potential impacts and challenges of BCA.

$25 to $50 in 2020, $50 to $100 in 2030, and $75 to $250 in 2050.[4] Our *first result* is, thus, that there is a strong consensus among experts that a uniform global carbon price should be higher than the existing global average price, which was recently estimated to be less than $3 (Dolphin, 2022). CO_2 prices of $3 (or lower) are recommended by fewer than two percent of experts and are, furthermore, contained in the acceptable ranges of fewer than four percent of experts. Based on the ranges that experts find acceptable, we find that a majority can agree on global carbon price levels of $30-35, $40, or $50 in 2020, and $50 or $60 in 2030. While no single price is supported by a majority in 2050, almost half of the experts (48 percent) can agree on the median price of $100. Our *second result* summarizes that—despite sizeable heterogeneity in point recommendations—a majority of experts can agree on some specific short- and medium-term global carbon price levels.

Regarding experts' unilateral carbon price recommendations, we find that these vary substantially across countries, such as from $13 ($41) in India to $99 ($171) in Switzerland in 2020 (2030) for the case without BCA. Comparing recommendations across scenarios, we find that unilateral carbon price recommendations with BCA are, on average, significantly higher than global carbon price recommendations. Hence, on aggregate, we do *not* find evidence supporting the well-known free-rider hypothesis (e.g. Barrett 1994) in our data, establishing our *third result*. If free-riding were a main driver of experts' recommendations, we would expect global price recommendations to exceed unilateral prices with BCA, as a global carbon price triggers abatement efforts by all countries, whereas a unilateral price only triggers (direct) abatement efforts in one country, which however bears the costs of these efforts. We find evidence of free-riding, i.e. unilateral carbon prices with BCA falling short of global prices, only in 16 percent of experts' price recommendations. Twice as many expert responses instead exhibit what one may call "ride-sharing", i.e. unilateral carbon price recommendations with BCA exceeding the global ones. Yet, there is a clear income-dependency of this effect, as the "ride-sharing" effect is strongest for experts from the richest countries, and insignificant for those from the poorest countries in our sample. One explanation for the lack of free-riding is that many experts exhibit empathy (Heal, 2021) and have global social welfare in mind also when providing unilateral price recommendations.[5] Other explanations include the role of co-benefits of emission reductions, such as improved health due to reduced air pollution, which is typically valued more highly in richer countries.

Moreover, we compare unilateral price recommendations with and without BCA and find that price recommendations without BCA are lower than those with BCA across almost all countries. The average difference across these two scenarios ("BCA-wedge") of around $15 ($25) in 2020 (2030) points towards non-negligible competitiveness and leakage concerns. Our data suggest that the introduction of a BCA scheme would facilitate unilateral carbon prices that are around 30 percent higher than without BCA. Our *fourth result*, thus, establishes that the introduction of BCA facilitates higher unilateral carbon price recommendations. We further study the space for agreement on unilateral carbon prices based on the price ranges that experts indicated. At the country level, we find larger spaces for agreement and more majority agreement on unilateral carbon prices with BCA as compared to without BCA. Our *fifth result* summarizes that the introduction of BCA tends to facilitate higher agreement among experts on unilateral carbon prices. Furthermore, we find that 94 (89) percent of experts' 2020 unilateral carbon price recommendations with (without) BCA are larger than the weighted

[4] These recommendations are broadly in line with results from IAMs studies (e.g., Nordhaus, 2019; Tol, 2021) and with the price ranges that have been suggested by the High-Level Commission on Carbon Prices (Stiglitz et al., 2017) of $40-80 by 2020 and $50-100 by 2030, which start higher but have an identical range in 2030.

[5] In a related paper (Schmidt et al., 2022), we show that global welfare considerations in conjunction with convex climate damages can help to rationalize our "ride-sharing" result.

existing carbon prices (in 2018) in their respective countries, while 90 (86) percent of experts' acceptable ranges lie strictly above. This mirrors our first result at the country level.

In Section 4, we move on to a more detailed analysis of our data with the goal to uncover determinants of experts' price recommendations. To this end, we draw on four pillars of additional data: survey questions on key policy design issues related with carbon pricing (e.g., experts' preference for carbon taxes vs. cap-and-trade), survey questions on other likely "determinants" of experts' recommendations (e.g., their views on utility discounting), observable characteristics of the country that an expert indicated that she feels most comfortable with advising on carbon pricing, and observable characteristics of experts. We analyze the relation of each of these potential drivers with carbon price recommendations in isolation, and in various multivariate specifications.

We find that experts who favor carbon taxes over cap-and-trade recommend carbon prices that are more than 30 percent higher than those recommended by experts who prefer cap-and-trade, in all of our scenarios. Furthermore, experts supporting BCA tend to recommend global carbon prices that are around 35 (20) percent higher in 2020 (2030) than those recommended by experts not supporting BCA. Relatedly, the average BCA-wedge is higher for those experts who strongly support the introduction of BCA, suggesting that these experts are likely more concerned about competitiveness issues. Our analysis of experts' recommendations regarding the usage of revenues from carbon pricing further reveals that experts who suggest using parts of the revenue for international transfers tend to recommend higher carbon prices, while experts who recommend using revenues for transfers to firms or tax reductions recommend lower carbon prices. Regarding other determinants, we find that a majority of experts recommend that global emissions be reduced by at least 80 percent by 2050, and that those recommending more stringent reduction targets also recommend significantly higher carbon prices. While higher utility discounting is associated with lower carbon price recommendations, carbon prices are far less sensitive to utility discounting than in standard IAMs (e.g., Emmerling et al., 2019; Hänsel et al., 2020; Nordhaus, 2019; Traeger, 2021).

Moving on to the analysis of country characteristics, we find that experts from Europe, from countries with higher GDP per capita, with higher mean world governance indicator rank score, or more knowledge on about climate change, tend to recommend higher global carbon prices. By contrast, experts from Asia and from countries with a higher share of fossil fuel energy consumption tend to recommend lower global carbon prices. Overall, experts' unilateral carbon price recommendations are affected by various country characteristics by and large in line with what has been found for existing carbon pricing schemes (e.g., Levi et al., 2020; Best and Zhang, 2020; Levi, 2021). Regarding experts' observable characteristics, we find that those who have published on cap-and-trade recommend lower global carbon prices for 2030 and 2050 than those who published on carbon taxes. Various combinations of potential determinants from these four pillars of data suggest a major share of unexplained heterogeneity in terms of expert recommendations for global and unilateral carbon prices, pointing at strong idiosyncratic or subjective components in experts' views on carbon pricing.

Section 5 provides a discussion of our results. First, we compare our results with those from prominent IAMs. We find that global carbon price recommendations and growth rates of carbon prices are, on aggregate, in line with IAM results, but that recommendations are less dispersed, and that carbon price recommendations by experts whom we identified as working with IAMs do not significantly differ from recommendations by experts who do not publish on IAMs. Section 5 furthermore discusses issues pertaining to potential non-response bias, using the population of potential experts as the comparison group, and non-representation bias, using various measures of global averages, such as in terms of GDP per capita, as the comparison group. We conclude by discussing implications for interpreting and using our survey data and by summarizing key takeaways for policy and further research.

2. Survey design and data

2.1 Conceptual background and survey design

In the following, we motivate and present the survey design. The key feature of our approach is to give experts full flexibility in determining carbon price recommendations based on their own perspectives on the various complexities of how the economy, the climate system, and climate policy interact. We call these perspectives that may draw on different levels of formalization *mental models of the climate-economy*. These can come in stylized forms, such as a specific IAM like the DICE model (Nordhaus 2019) that some experts may rely on when forming their own views on carbon prices. Yet, they can also be based on a more intuitive understanding of climate-economy interactions, or be grounded in political economy or other feasibility considerations that are not typically part of a formal IAM. As argued elsewhere (e.g., Pindyck, 2013; Stern and Stiglitz, 2022), disagreements on carbon pricing extend beyond mere parameter sensitivities. This may relate to differences in a descriptive understanding of the climate-economy, just like subjective models of the macroeconomy have been shown to be very heterogeneous (Andre et al., 2022). Or there can be disagreements on prescriptive issues, for example on how to balance the well-being of current and future generations (e.g., Arrow et al., 2013; Drupp et al., 2018; Freeman and Groom, 2015; Heal and Millner, 2014). That various descriptive and prescriptive aspects likely inform carbon pricing recommendations is a further justification for the flexibility that our expert survey approach allows.

It is widely accepted that market failures based on externalities can be addressed with the help of prices that signal to economic actors the true (social) costs of their activities. Accordingly, the climate change externality can be corrected with the help of a price on emissions. Theoretically, the carbon price should be identical across all sectors, and across countries, in order to achieve a cost-efficient outcome. The marginal abatement costs are, then, equalized across all emitters, so that emissions are reduced where it is cheapest. In stylized climate-economy models, the appropriate global carbon price is closely tied to the *"the most important single economic concept in the economics of climate change"* (Nordhaus, 2017, p. 1518): the social cost of carbon (SCC). The SCC is defined as the change in the discounted value of global social welfare from emitting an additional unit of CO_2 (or its equivalent for other greenhouse gases). An optimal global carbon price should, thus, reflect the (discounted) net damages that result from the emission of an additional ton of CO_2 that accrue both today and in the future, evaluated along an optimal path. This depends, among other things, on physical aspects of the climate system and on economic issues that determine how climate change impacts the world economy and the well-being of people. The aggregation of damages across time also necessitates a decision on what weights to put on the welfare of people living at different points in time, including the discounting of future utilities.

As pointed out above, we can think of an individual expert having some *mental model of the climate-economy* for determining carbon price recommendations. Such a mental model may be based on an expert's theoretical and empirical considerations on, among others, climate damages, abatement options and their costs, views on discounting, political contexts and agency structures, etc. Some experts may be informed by a particular IAM (e.g., DICE, FUND or PAGE, all of which underpin governmental guidance on the SCC in the United States) or an analytic IAM that provides closed-form solutions for the SCC or a carbon price (see, e.g., Dietz and Venmans, 2019; Gerlagh and Liski, 2018; Golosov et al., 2014; Iverson and Karp, 2021; Rezai and van der Ploeg, 2016; Traeger, 2021; van den Bijgaart et al., 2016). Global carbon prices estimated according to standard cost-benefit IAMs depend, among other things, on expected climate damages, mitigation costs, and utility discount rates. Each expert may rely on different calibrations of input parameters or functional forms for key drivers. The exact mapping of input parameters and functional forms differs across IAMs (e.g., Gillingham et al., 2018). Other examples include cost-effectiveness IAMs to model pathways that achieve certain emission reduction targets, or target-constrained IAMs that trade-off mitigation costs and climate damages within the bounds of reaching a pre-specified climate target (e.g., Schultes et al., 2021; Stern and Stiglitz, 2022). Such formalized models provide examples of plausible determinants of global carbon price levels and paths. Yet, experts may also formally or intuitively consider various extensions or alternatives approaches, such as a number of real-world constraints, for instance relating to international re-distribution or a limited internalization of other externalities such as relating to innovation (e.g., Acemoglu et al., 2012; Barrage, 2018; Fischer et al., 2021; Kornek et al., 2021).

Based on these considerations, our survey (the full survey text is available in Appendix A.1.3) instructs experts to have in mind a setting where they give advice on hypothetical new carbon pricing policies for CO_2 emissions covering all sectors of the economy. We first ask for recommendations on global uniform carbon pricing, a natural point of comparison for IAM studies that seek to determine optimal global carbon price paths.[6] Precisely, we ask them to 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 CO_2). We ask each expert for a recommended global carbon price for the years 2020, 2030, and 2050. Furthermore, to quantify the scope for agreement among experts on appropriate carbon price levels, we additionally asked for the range of global carbon prices that each expert would still feel comfortable with recommending.

While a uniform global carbon price may be required to achieve a (theoretical) first best outcome, such a unified and fully cooperative approach to climate policy may not be feasible for various political reasons in practice.[7] Reflecting these real-world constraints on countries' climate policy, we asked each expert to provide carbon price recommendations also at the unilateral (rather than the global) level. We, therefore, also included a question that elicits which country each expert would feel most ready to advice on carbon pricing. To facilitate a comparison across the different scenarios that we consider, the questions on unilateral carbon pricing are structured in the same way as the question on global carbon pricing. However, we restricted them to the years 2020 and 2030 to reduce the total number of survey items.

Unilateral carbon pricing comes with a number of additional challenges. First of all, when each country sets its own climate policy targets, the free-rider problem that is well-known from public goods games in economics can have a detrimental effect upon countries' ambitions (e.g., Barrett, 1994; Nordhaus, 2015). Since climate stabilization is a *global public good*, but individual countries are facing the costs of contributing to this public good, the incentives are such that the public good is under-provided. In other words, due to free-riding, unilateral carbon prices may be lower, and emissions higher than under a global carbon price.[8] Furthermore, competitiveness concerns can play a major role under unilateral carbon pricing. If a country behaves altruistically or empathically (cf., Heal, 2021) and establishes a higher price unilaterally as compared to other countries, firms located in this country may suffer from a loss in international competitiveness. Apart from potential job losses (e.g., due to firm relocation), this may also lead to a leakage of emissions to other countries with less stringent environmental policies, also known as "carbon leakage".

[6] Note that carbon prices are often close in magnitude but may not be equated to SCC estimates. For example, SCCs are often not evaluated along an optimal but along a business-as-usual path (e.g., Nordhaus, 2019; Tol, 2013). Furthermore, carbon price recommendations by experts may account for co-benefits of emission reductions, e.g. due to reduced air pollution, or real world constraints, while SCC estimates typically do not.

[7] This is mirrored by countries' efforts to cooperate internationally, which has switched from strict emission reduction targets to a "pledge-and-review process" (e.g., Barrett and Dannenberg, 2016; Harstad, 2020, 2021).

[8] See our companion paper (Schmidt et al., 2022) for an analysis of free-riding among asymmetric countries.

Taking these issues into consideration, we asked experts to provide their recommendations on unilateral carbon pricing as well as acceptable ranges of carbon prices across two different scenarios. In the first scenario (*"unilateral with BCA"*), we asked each expert to assume 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". The idea is that with the help of this BCA-scenario, we are able to disentangle any effects that are related with competitiveness concerns from other concerns that may determine experts' views on unilateral carbon prices. In the second scenario (*"unilateral without BCA"*), we asked each expert to consider the same case without BCA.

When analyzing and interpreting the results from the different scenarios, we compare the experts' recommendations across these three scenarios (global, unilateral with BCA, and unilateral without BCA). The difference in the price recommendation of an expert between the global and the unilateral ("local") scenario with BCA *("Glocal-wedge")* serves as a proxy for the expert's view on the issue of free-riding, where the term "Glocal" captures "both local and global considerations" (Lexico, 2021). Similarly, the difference between the price recommendation of an expert in the unilateral scenario with BCA and the unilateral scenario without BCA (*"BCA-wedge"*) helps us to quantify each expert's views on competitiveness and leakage concerns. If such concerns play a major role, then we would expect that carbon prices in the unilateral scenario with BCA are substantially higher than in the scenario without BCA.

Apart from describing and comparing the carbon price recommendations that we obtain in these scenarios, we also analyze possible determinants of the variation of expert recommendations by drawing on four types of additional data. First, we elicit experts' recommendations on key carbon pricing policy design issues. This includes a question on instrument choice, i.e. whether a (new) unilateral carbon price should be implemented with the help of a carbon tax, or via a cap-and-trade scheme, or some other (mix of) instrument(s). Furthermore, we asked each expert if she would strongly recommend introducing a BCA scheme, and we also elicited experts' recommendations regarding the usage of the revenue from carbon pricing, a key determinant of carbon pricing acceptance (Carratini et al., 2019; Klenert et al., 2018). Second, we included a question that elicits each expert's (rough) views on likely "determinants" of carbon pricing that are typically featured in IAMs. This includes the expert's view on global emission reduction targets, reduction costs, expected damages from climate change, and discounting. These determinants are plausible "ingredients" that each expert may utilize when forming her views on appropriate (global) carbon prices with the help of her own mental model of the climate-economy. Third, we gather country-level information, such as GDP per capita, "good governance" indicators, and existing carbon prices, among other things, based on the countries experts indicated to feel most comfortable with recommending on carbon pricing. A number of these (potential) explanatory variables have been shown to correlate with existing (weighted) carbon prices at the national level (e.g., Levi et al., 2020; Best and Zhang, 2020; Levi, 2021).[9] Fourth, as these mental models likely have a strong subjective component (cf. Andre et al., 2022), we further asked each expert if she is willing to provide her name to us at the end of the survey. For those experts who provided their identity to us when answering our survey, we gathered additional available information.[10] This includes a number of measures available through SCOPUS, such as the number of publications, the number of citations and the number of publications in SCOPUS's economics category as well

[9] Furthermore, theoretical work suggests links between such determinants and unilateral carbon prices. For instance, Hambel et al. (2021) show that unilateral carbon prices should increase in proportion to GDP.

[10] To preserve the anonymity of our respondents, we only report results of aggregated data that makes use of these expert characteristics and we will *not* provide this data linked to individual survey responses. Furthermore, for linked country-level data, we set the threshold such that we require a minimum of 5 potential experts from a given country within the full population of more than 2000 potential experts whom we identified.

as data on whether an expert's publications are concerned with the SCC, IAMs, or different carbon pricing instruments that we obtained via a keyword-based analysis of the abstracts. We further gathered data on an expert's country of main affiliation and gender via online search.

2.2 Expert Selection, Survey Dissemination, Data

Determining carbon prices is a complex matter that requires a mix of expertise, from techno-economic knowledge about abatement options and their costs, to knowledge about the climate system and likely climate damages, and all the way to socio-economic, political, and philosophical considerations on intergenerational distribution. In recognition of this, we restricted our sample to scholars who are involved with these complex issues and who have, as judged by colleagues via cited publications, made relevant contributions to pricing carbon. For the purposes of this paper, a scholar is deemed to be a potential expert if they are a (co-) author of at least *two pertinent and cited publications* on the topic since the year 2000.

We constructed our sample of experts by first defining keywords that are often used in the literature on the topic, including "carbon tax", "cap-and-trade", and a number of equivalent terms and combinations of terms (Appendix A.1 provides the full search-string).[11] With these keywords, we conducted an automated search in the literature database SCOPUS to identify authors of pertinent papers, published in scientific journals (many but not all of them in economics journals). To define a potential "expert" on carbon pricing, we narrowed down this pool to those authors who had at least two publications since the year 2000 matching our keywords criteria that had been *cited at least once*, and for whom we could obtain a workable e-mail address. This search strategy provides us with a population of 2106 potential experts around the globe and allows us to compare respondents and non-respondents along additional information provided via SCOPUS, such as their country of main affiliation, number of pertinent papers, and main keywords appearing in their abstracts.

Starting in June 2019, we sent out a link to the online survey (implemented in SoSci Survey) via email to all potential publication-based experts. We used four general rounds of reminders until we closed the survey at the end of November 2019, each time slightly varying the subject line and motivation, such as providing the number of experts that had already previously responded, for answering the survey (Appendix A.1.2 provides the initial invitation e-mail). By the end of November 2019, we received 574 responses out of a pool of 2106 potential experts, with 445 experts providing carbon price recommendations.[12] The response rate is around 25 percent, which compares well with other large-scale online surveys with experts or economists (e.g., Drupp et al., 2018; Howard and Sylvain, 2015, 2020; Necker, 2014; Pindyck, 2019). Our sample contains responses from all major continents, and the represented countries cover more than 80 percent of global CO2 emissions. Table A.2.2 in Appendix A.2 provides an overview of key descriptive statistics on the number of responses, carbon price recommendations, and determinants.[13]

[11] For refining the search string, we consulted colleagues and surveys by Drupp et al. (2018) and Pindyck (2019).

[12] More than 90 percent of the 97 who responded to our invitation but did not provide carbon price recommendations stated that they did not perceive themselves as an expert. We compare these "no expert" non-participants with our respondents that provided recommendations and the non-responders in Section 5.

[13] Throughout, we winsorize the carbon price data to deal with extreme outliers by replacing the highest two price recommendations by the third highest recommendation for each carbon price question, including their ranges, and follow the same procedure for the lowest prices. See Appendix A.2 for details on data cleaning and winsorizing.

3. Survey results

3.1 Global carbon price recommendations

Figure 1 shows raincloud plots (combining violin plots with box plots and individual observations) for our first survey question where we asked experts to provide global price recommendations for the years 2020, 2030 and 2050, in a scenario with a hypothetical world government that implements a uniform carbon price around the world.

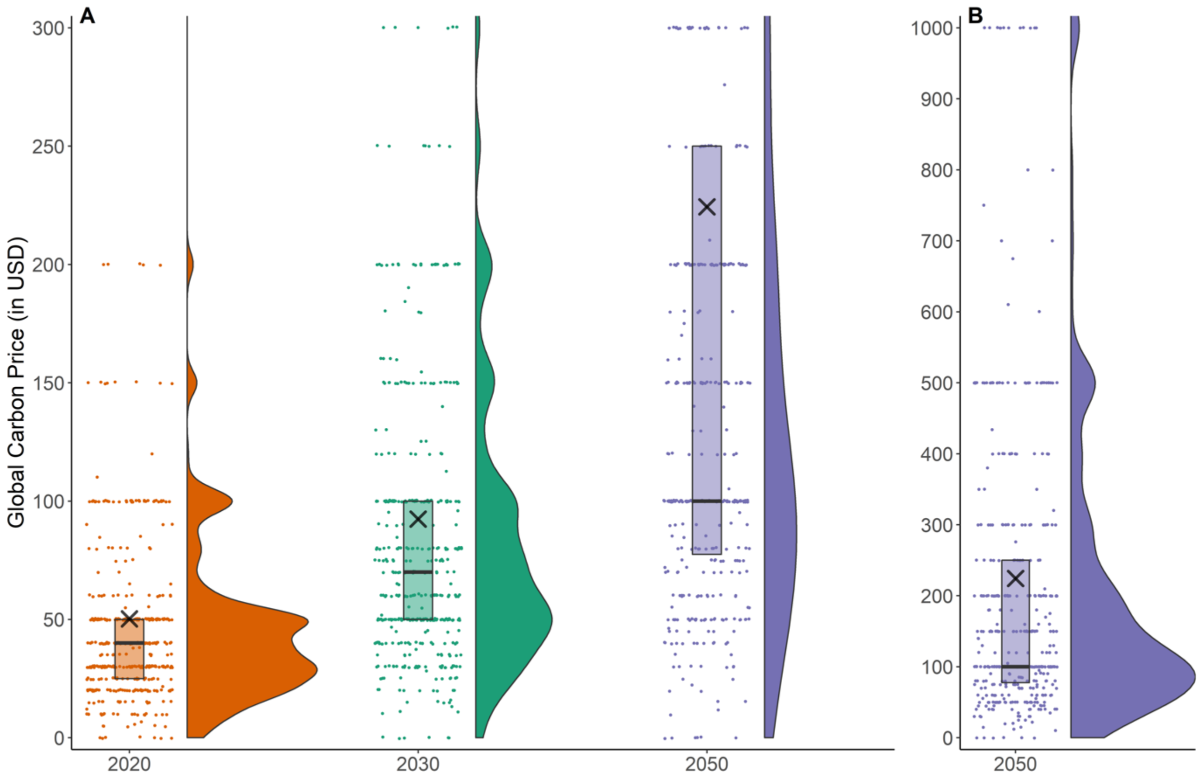

Figure 1: Global carbon price recommendations

Notes: Raincloud plots of global carbon price recommendations for the years 2020 (orange), 2030 (green), and 2050 (velvet), cropped at \$300, and raincloud plot for 2050, cropped at \$1000. Raincloud plots include kernel density plot violin and box plots, in which the black line represents the median recommendation, the multiplier sign the mean, and the boxes interquartile ranges. Visually cropped values in the raincloud plots in Panel A are the 1.1 (1.8) [16.6] percent highest prices for 2020 (2030) [2050], and 0.7 percent in Panel B.

Figure 1 showcases substantial heterogeneity in experts' price recommendations as well as skewness towards higher carbon prices. Recommendations range from \$0 to \$500 in 2020 and 2030, and up to \$4000 in 2050, with considerable bunching at focal points at \$10 or \$50 step-intervals. We capped Panel A of Figure 1 at a price of \$300 for expositional purposes, and show the results for 2050 again in Panel B (capped at \$1000) to illustrate the wide dispersion especially of longer-term price recommendations. The mean (median) recommended carbon prices at the global level, indicated by a cross (respectively by a horizontal line), are \$50 (\$40) for a ton of CO_2 in 2020, and increase over time to \$92 (\$70) in 2030, respectively \$224 (\$100) in 2050. The interquartile ranges, i.e. the range of carbon prices that the middle 50 percent of experts recommend, extend from \$25 to \$50 for 2020, from \$50 to \$100 in 2030, and from \$75 to \$250 in 2050, and 90 percent of recommendations range from \$10 to \$100 in 2020 and \$20 to \$250 in 2030, for instance. Overall, we find that more than 98 percent of experts recommend a 2020 global carbon price that exceeds the globally prevailing emission-weighted carbon price in 2020, estimated at below $3 (cf., Dolphin, 2022), suggesting a strong consensus within this expert sample on more ambitious carbon pricing. We summarize this finding as:

Result 1: *There is a strong consensus among experts that a uniform global carbon price should be higher than the existing global average carbon price.*

This result is further strengthened by our data on ranges of prices that experts would feel comfortable with recommending. This allows us to quantify the potential degree of agreement among experts on carbon price levels. It is natural to assume that those experts who indicated ranges that comprise a given price (for a given year) could jointly agree on such a price recommendation. Figure 2 quantifies this "space for agreement", i.e. the fraction of all experts whose price ranges comprise a given price level (displayed on the horizontal axis). When examining the overlap in experts' acceptable price ranges for 2020 (orange bars, Panel A), we find that 96.39 percent of experts recommend carbon prices for 2020 that lie strictly above the existing emissions-weighted global carbon price of (around) $3.

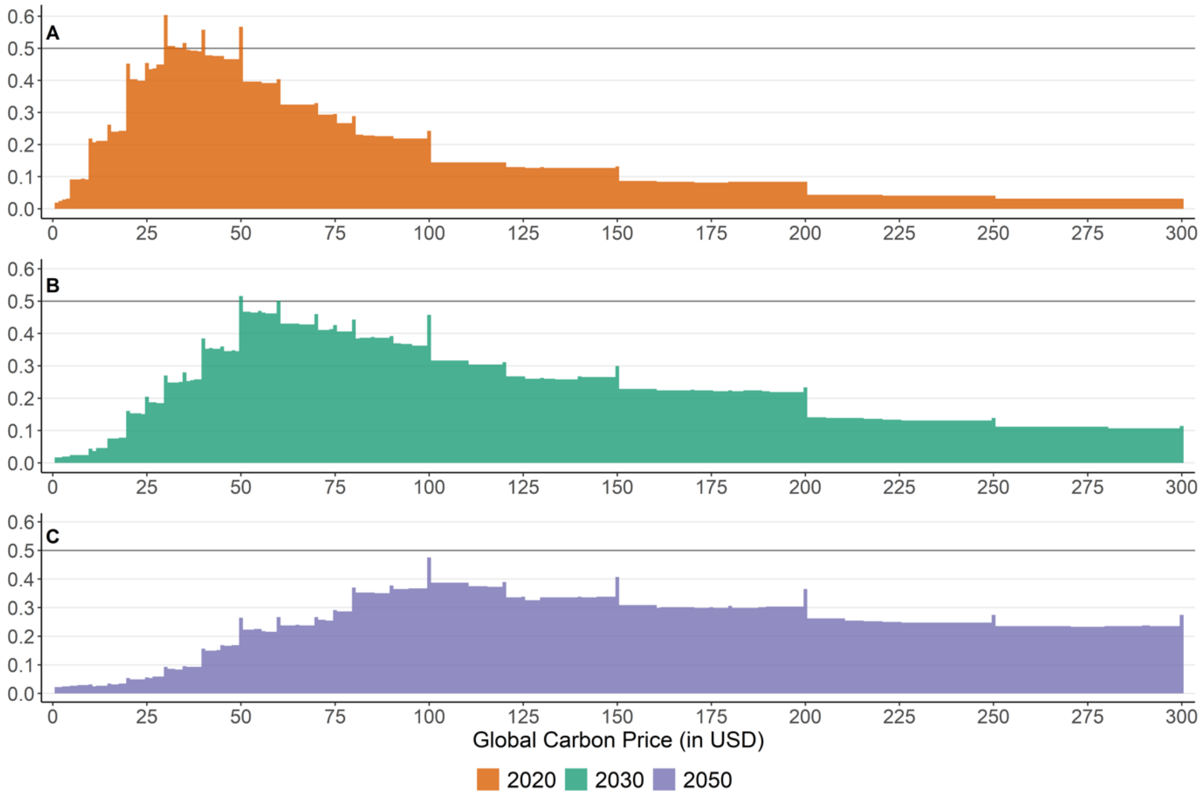

Figure 2: Spaces for agreement on global carbon prices

Notes: Proportion of experts for whom a certain carbon price level, varied on the horizontal axis, is contained within their acceptable range of global carbon prices for 2020 (orange, panel A), 2030 (green, Panel B), and 2050 (velvet, Panel C). For instance, a global carbon price of $150 per ton of CO_2 in 2020 (2030) [2050] is contained in the acceptable ranges of 13% (30%) [41%] of experts. Carbon prices are capped at $300 for expositional purposes. No carbon price beyond $300 yields support of more than 25 percent of experts.

By contrast, a majority of all experts (more than 60 percent) indicated ranges that comprise a carbon price of $30 for 2020. Carbon prices of $40 and of $50 as well as all prices between $30 and $35 can also gain a majority support. Hence, despite the large variation in experts' price recommendations, our data suggests that there is nevertheless space for majority agreement on certain price levels among experts. Also for the year 2030 (Panel B in Figure 2), we find that majority support for certain global carbon price levels is possible, since at least half of all experts indicate ranges that comprise carbon prices of $50 and $60 per ton of CO_2, while still around 48 percent of experts could agree on a price level of $100. Only for 2050 (Panel C), we find that experts' price recommendations and the acceptable ranges are so divergent that no single carbon price level is supported by a majority. Still, 47.65 percent of experts could agree on a price of $100, and more than 40 percent of experts could agree on a price of $150. We summarize these findings as:

Result 2: *Despite substantial heterogeneity in recommendations, experts can agree on some short- and medium-term global carbon prices.*

3.2 Unilateral carbon price recommendations

Moving from the global to the unilateral level, we next investigate experts' carbon price recommendations to individual governments. Each expert was asked to give a price recommendation to the government in her country, assuming that the government plans to implement a carbon price unilaterally, thereby considering a scenario with and another one without BCA. These two scenarios can be thought of as stylized opposing ends of a reasonable situation faced by policy-makers. In practice, governments enact some measures to address competitiveness concerns, such as allocating part of their allowances in emissions trading schemes for free (e.g., Schmidt and Heitzig, 2014), or partially exempting certain industries, but these measures may be insufficient to fully eliminate competitiveness concerns. BCA is also gaining prominence in climate policy discussions. Apart from the direct (policy) relevance of individual country-level results, we use our data for the three different scenarios to elicit insights on the issue of free-riding and domestic versus global welfare concerns as considered by experts, by comparing unilateral with BCA and global price recommendations (*"Glocal-wedge"*). Furthermore, we measure competitiveness or leakage concerns by comparing unilateral carbon price recommendations in the scenarios with and without BCA (*"BCA-wedge"*). To study aggregate differences across scenarios, in the following, we examine country-level data and all recommendations pooled.

We first examine differences between global and unilateral carbon price recommendations in the scenario with BCA of all experts (see top row 'All' and Panel A of Figure 3) and compute the difference as the *"Glocal-wedge"* (Panel B). We find that, on average, unilateral price recommendations with BCA are *higher* than global price recommendations, with means of $54.53 versus $49.58 for 2020, and $104.44 versus $91.71 for 2030 (two-sided t-tests: $p<0.000$ and $p<0.000$).[14] This contrasts sharply with the ubiquitous notion of *"free-riding"* (e.g., Barrett, 1994), according to which one would expect unilateral prices (with BCA) to be lower than the global carbon price. Overall, we find evidence for free-riding, i.e. unilateral carbon prices with BCA falling short of global prices, in only 16 percent of experts' price recommendations. In contrast, twice as many expert responses exhibit what may be called *"ride-sharing"* (32 percent for 2020 carbon prices, and 34 percent for 2030). This finding is summarized as:

Result 3: *The majority of experts' carbon price recommendations do not support the notion of free-riding. Instead, we find that unilateral price recommendations with BCA are, on average, higher than global price recommendations.*

[14] Throughout the paper, we report two-sided tests and therefore omit this qualification in the following.

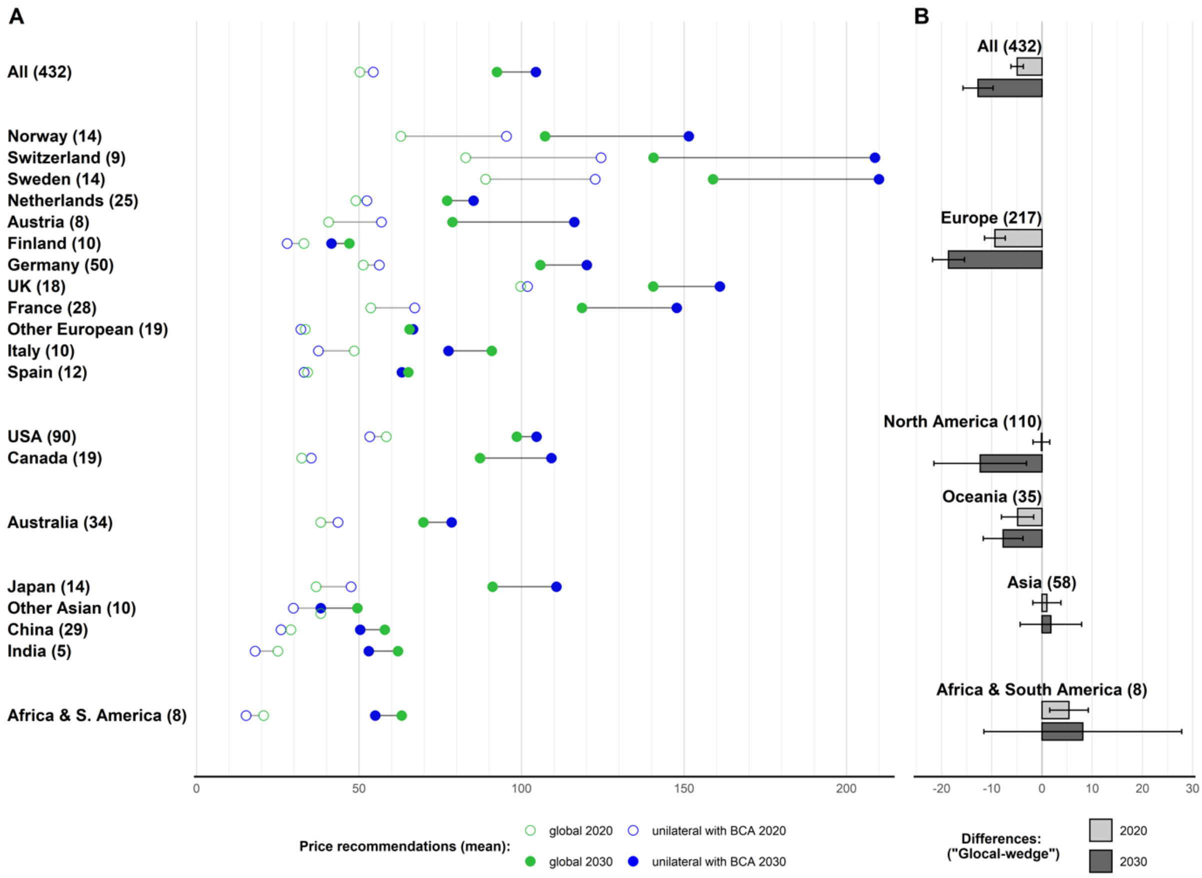

Figure 3: Unilateral and global carbon pricing and *"Glocal-wedge"* in carbon prices

Notes: Panel A shows mean *unilateral with border carbon adjustment (BCA)* (in blue) and *global* (green) carbon price recommendations for 2020 (transparent circle) and 2030 (dot), for all countries or groups of countries with at least five observations. Within each continental group, countries are ordered by their rank in terms of GDP per capita. Panel B shows bar plot with differences in means for 2020 and 2030 between *global* and *unilateral with BCA* carbon price recommendations *("Glocal-wedge"*), with standard errors.

We, next, examine how Result 3 varies across countries. Panel A of Figure 3 shows average *unilateral with BCA* (in blue) and *global* carbon price recommendations (in green) for 2020 (circles) and 2030 (dots) also at a country or country-group-level. Individual countries per continental group are ordered in terms of GDP per capita. We only consider countries (or groups) with at least five observations for both scenarios, and keep these 20 "countries" depicted in Figure 3 also for the subsequent analyses.[15] Panel B of Figure 3 also highlights the difference between *global* and *unilateral with BCA* carbon price recommendations ("*Glocal-wedge"*) at a continental level with bar plots, where the bar size depicts the mean difference. The first observation is that effects for the difference between *global* and *unilateral with BCA* carbon price recommendations are heterogeneous across countries and continents: While the *Glocal-wedge* for 2030 is positive but insignificant for Africa and South America ($8.13; t-test: p=0.205) and Asia ($1.78; t-test: p=0.773), it is significantly negative for Europe (-$18.53; t-test: p<0.000) and Oceania (-$7.74; t-test: p=0.059) and insignificantly so for experts from

[15] We set this threshold here to preserve anonymity of our respondents, such that it carries through to yield at least three observations for all countries for all of our analyses. Besides individual countries, we consider "Other European", "Other Asian", and "Africa and South America" (pooled, due to a low number of observations).

North America (-$12.29; t-test: p=0.185).[16] Within each continental group, unilateral carbon prices in the scenario with BCA tend to increase with GDP per capita as compared to global carbon prices. Within Europe, for instance, the average 2020 (2030) difference between global and unilateral with BCA carbon prices in the three richest countries shown in Panel A of Figure 3 is -$35.19 (-$52.19), as compared to $3.61 ($3.34) in the three poorest countries or country groups (t-tests: p<0.000). Alternatively, if we split the sample at global average GDP per capita, this gap tends to be (insignificantly) positive in the countries below ($9.44 in 2030; t-test: p=0.132) and negative in the countries above this level (-$15.32; t-test: p<0.000). As experts are sourced disproportionally from countries in the richer half of the global income distribution, this helps to explain why, on average, *unilateral with BCA* carbon price recommendations are higher than the global ones in our sample. It does not answer the question why this is the case.

There are different potential explanations for why *unilateral with BCA* carbon prices may be higher (or lower) than the *global* average ones, some of which would be positively associated with GDP as depicted in Figure 3. First, experts who expect their fellow citizens to exhibit empathy may recommend internalizing parts of the global climate externality unilaterally (e.g., Heal 2021). Further, due to global welfare considerations, experts may prefer richer countries to shoulder a higher relative abatement burden. Hambel et al. (2021), for instance, suggest that country-level carbon prices should be proportional to GDP. Along these lines, experts from richer countries may be reluctant to recommend a very high global carbon price, as compared to carbon prices they recommend to their own government, as this may impose an overly high burden on poorer countries.[17] In a companion paper (Schmidt et al., 2022), we show that a unique fingerprint of free-riding—that countries with a larger global population share have a stronger unilateral incentive to contribute to the global public good—can also not be supported empirically when considering weighted nationally implemented carbon prices across countries, thus pointing in a similar direction as our survey data.[18]

Second, there are a number of local co-pollutants discharged in combination with CO_2. These co-pollutants and associated detrimental health consequences caused by air pollution can be a considerable independent determinant of carbon pricing (e.g., Parry et al., 2021; Stiglitz et al., 2017). Due to a positive income elasticity of the value of a statistical life (e.g. Viscusi and Masterman, 2017), these co-benefit related price justifications are very likely valued differently across countries. Accordingly, to the extent that carbon prices can be rationalized by their local co-benefits, we would expect higher unilateral carbon prices aimed at reducing not only CO_2 but also its co-pollutants in richer countries.

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[16] While one may argue that differences in how experts converted local currencies into US dollars may confound our finding on the absence of free-riding in the aggregate, it is reassuring that we find the same for US respondents, where the mean 2030 Glocal-wedge is -$10.4 (which does not significantly differ from zero; t-test: p=0.330).

[17] One respondent, e.g., remarked: *"The first question suggests a universal global tax. The tax that would be suitable in a fully developed country would seem inhumane in many countries with substantially lower per capita income. Hence, I do not agree to any such global tax without clearly specified compensating mechanisms."* In this spirit, we find that the 2030 *Glocal-wedge* for those experts recommending to use carbon pricing revenue for international transfers is substantially larger in absolute size (-$20.42 vs. -$8.99; t-test: p=0.073). Relatedly, one would expect the *Glocal-wedge* to depend on an expert's perceived international carbon price heterogeneity, which we approximate by the *BCA-wedge*. We find that the 2030 *Glocal-wedge* increases (in absolute terms) by 0.62 units for each unit increase in the 2030 *BCA-wedge*—with or without controlling for GDP per capita (linear regressions, p<0.000). The *Glocal-wedge* amounts to, e.g., -$32.94 at the 90th percentile of the *BCA-wedge*. See Bauer et al. (2020) for a discussion on trade-offs between uniformity of carbon prices and international transfers.

[18] We find that the 2020 *Glocal-wedge* increases (in absolute terms) with a country's share of the global population, with or without controlling for GDP per capita (linear regressions: p<0.000 and p=0.051). For 2030, we find similar results, while the effect turns insignificant when controlling for GDP (p=0.003 and p=0.374). In Schmidt et al. (2022), we show theoretically that "ride-sharing" may be consistent with experts who focus on global social welfare also under unilateral carbon pricing, but who expect other countries to behave non-cooperatively and expect convex climate damages in countries' aggregated emissions.

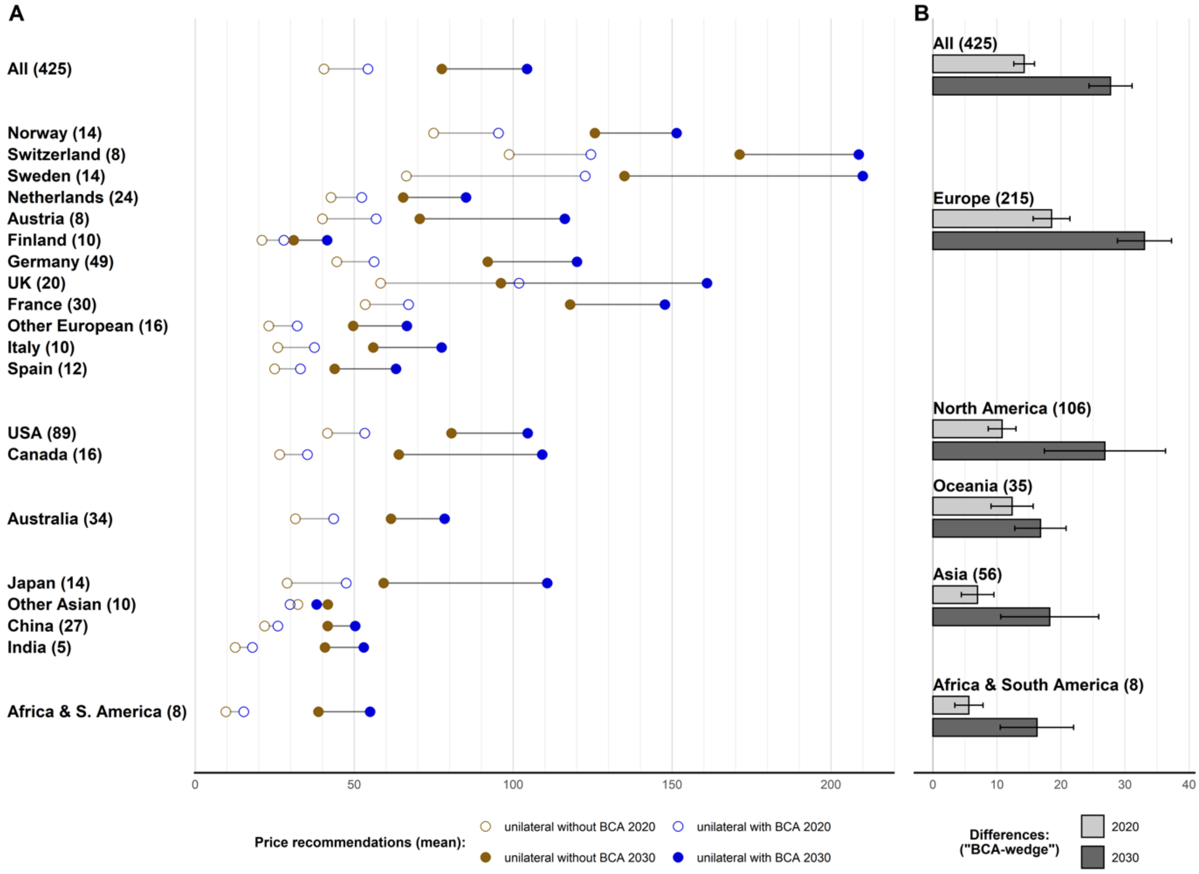

Figure 4: Unilateral carbon pricing and the Border Carbon Adjustment (BCA) wedge
Notes: Panel A shows the mean *unilateral carbon price recommendations with* (in blue) and *without* (brown) *border carbon adjustment (BCA)* for 2020 (transparent circle) and 2030 (dot), for all countries or groups of countries with at least five observations. Within each continental group, countries are ordered by their rank in terms of GDP per capita. Panel B shows bar plots with differences in means for 2020 and 2030 between *unilateral with BCA* and *without BCA* carbon price recommendations *("BCA-wedge")*, with standard errors.

Other arguments may relate to differences in mitigation costs,[19] or to mechanism design approaches in the face of relocation risk (e.g., Ahlvik and Liski, 2022). These considerations can rationalize our finding that *unilateral with BCA* recommendations are higher than *global* carbon price recommendations in higher income countries and—given the skewed distribution of academic experts towards higher-income countries—the aggregate Result 3, which summarized the predominant absence of free-riding in experts' carbon price recommendations.

Next, we examine unilateral carbon price recommendations with and without BCA to shed light on the size of competitiveness or leakage concerns. Panel A of Figure 4 depicts unilateral carbon price recommendations for the years 2020 and 2030 across countries, while Panel B depicts the *BCA-wedge* on a continental level. When considering all responses (see top row `All' of Figure 4), we observe that unilateral price recommendations without BCA are lower than those with BCA for 2020, with means of \$54.53 versus \$40.57, and for 2030, with means of \$104.44 versus \$77.68 (t-tests: $p<0.000$ and $p<0.000$). The BCA-wedge roughly doubles within the decade, amounting to \$13.96 in 2020 and \$26.76 in 2030 in absolute terms.

Focusing on the country-level (Panel A of Figure 4), we observe that the aggregate finding of sizable competitiveness concerns qualitatively generalizes across almost all

[19] One respondent from a rich country, e.g., remarked: *"I recommend slightly higher prices as the unilateral targets that they are bound to are more costly than those required by a global carbon reduction effort."*

countries, with the exception of "Other Asian". Quantitatively, we observe substantial differences. Unilateral carbon price recommendations in 2020 (2030) without BCA vary from \$9.63 (\$38.75) in "Africa and South America" to \$98.75 (\$171.25) in Switzerland, with carbon prices in the scenario with BCA varying from \$15.25 (\$55.00) to \$124.44 (\$208.75).

We also find considerably higher *BCA-wedges* in Europe as compared to Asia. For instance, while 2020 (2030) unilateral carbon prices without BCA are only lower than unilateral carbon prices with BCA by \$4.78 (\$10.22) in China, the *BCA-wedge* amounts to \$56.21 (\$75.00) in Sweden. In relative terms, the introduction of BCA increases 2030 unilateral carbon prices by 20 percent in China and by 56 percent in Sweden. For our aggregate data, BCA increases unilateral carbon prices in 2020 (2030) by 34 (35) percent. This indicates that competitiveness concerns matter for unilateral carbon pricing,[20] underscoring the importance of establishing BCA schemes for implementing stringent carbon prices. We summarize:

Result 4: *The introduction of border carbon adjustment facilitates higher unilateral carbon price recommendations.*

We next focus on the ranges that experts feel comfortable with recommending. We first quantify this "space for agreement", i.e. the fraction of experts whose price ranges comprise a given price, for the three most represented continents for 2030 unilateral carbon price recommendations with (blue) and without BCA (brown) in Figure 5, while Figure A.4.1 in Appendix A.4 provides the analogue for 2020 prices.

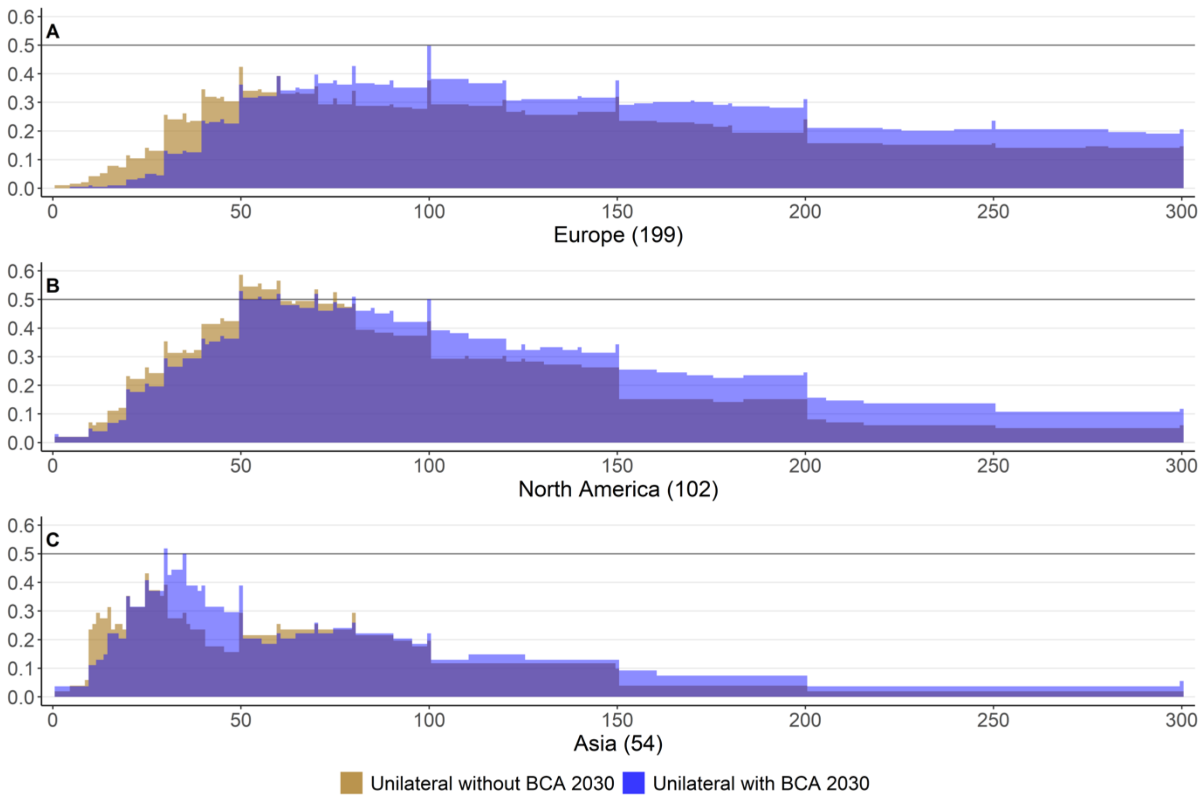

Figure 5: Spaces for agreement on unilateral carbon prices at a continental-level
Notes: Proportion of experts for whom a certain carbon price, varied on the horizontal axis, is contained within their acceptable range of *unilateral carbon prices with* (in blue) and *without* (brown) *border carbon adjustment (BCA)* in 2030 for Europe, North America and Asia. Carbon prices at \$300 for expositional purposes.

[20] Recall that our unilateral scenarios did not provide details on other country's policies. The *BCA-wedge*, thus, is also indicative of an expert's expectation that other countries will not match her own country's carbon price.

When examining the overlap in experts' acceptable ranges for 2030, we observe that BCA tends to facilitate reaching higher agreement among experts on unilateral carbon pricing: Without BCA, we find that no single carbon price is supported by a majority both in Europe and in Asia. In Europe, the carbon prices with the highest agreement among experts in the case without BCA are \$50 and \$100, contained respectively in 42.41 and 37.70percent of experts' acceptable price ranges for 2030. In Asia, a unilateral carbon price of \$25 receives the highest support in the scenario without BCA, and is acceptable for 43.14 percent of the experts. By contrast, in the unilateral scenario with BCA, experts in Asia can achieve majority support for some carbon prices: prices of \$30 (\$35) are supported by 51.85 (50.00) percent. Furthermore, a 2030 carbon price of \$100 in Europe achieves support by 49.75 percent of experts. North American experts can agree on unilateral carbon prices in both scenarios, with a carbon price of \$50 receiving most support. In terms of the integral of overlapping ranges in blue and brown, we find that BCA increases the overall space for agreement on unilateral carbon prices by more than 40 percent in all three continents.

Figure 6 depicts the “space for agreement” for 2030 unilateral carbon price recommendations with (blue) and without BCA (brown) for the 20 countries (and groups of countries) covered previously. Figure A.4.2 in Appendix A.4 provides the analogue for 2020 prices. Examining these country-level spaces for agreement, we find that majority agreement on some unilateral carbon price with BCA is possible for 18 (15) out of 20 of the countries in 2020 (2030) shown in Figure 6, while these frequencies are reduced to 16 (11) out of 20 cases without BCA. Thus, in the case with BCA, agreement on the country-level tends to occur more frequently (t-tests: $p=0.163$ for 2020 and $p=0.010$ for 2030). Considering the integral of the level of agreement (in percent) above the 50 percent lines, we also find that this space for majority agreement tends to be larger in the case with BCA as compared to the case without BCA (t-tests: $p=0.059$ for 2020 and $p=0.056$ for 2030). We also consider the whole space for agreement also below the majority threshold line, by computing the interval covered by all overlapping ranges (i.e. the full blue or brown shaded areas in Figure 6 and those beyond \$300 not depicted here). According to this criterion, we find substantially larger spaces for agreement on unilateral carbon prices with BCA as compared to without BCA for both 2020 (t-test: $p<0.000$) and 2030 ($p<0.000$). Taken together, we find the introduction of BCA leads to higher levels of (majority) agreement on unilateral carbon prices. We summarize:

Result 5: *The introduction of border carbon adjustment tends to facilitate higher levels of agreement on unilateral carbon prices.*

Finally, we find that 94.24 (89.36) percent of experts’ 2020 unilateral carbon price recommendations with (without) BCA are larger than the weighted existing carbon prices in their respective countries, while 90.40 (85.75) percent of experts’ acceptable ranges lie strictly above. This mirrors our results from the global level and suggests a strong consensus for unilateral carbon prices that exceed prevailing emission-weighted unilateral carbon prices.[21]

[21] Figure A.4.3 in Appendix A.4 illustrates this unilateral carbon pricing gap using mean values across countries, while A.4.4 illustrates the percentage share of experts within individual countries whose acceptable ranges for unilateral carbon prices in 2020 lie strictly above the existing emission-weighted prices. Across all countries—expect for Sweden and Finland which already have very high prices—we find that a majority of acceptable ranges for 2020 unilateral carbon prices with and without BCA lie above existing carbon prices.

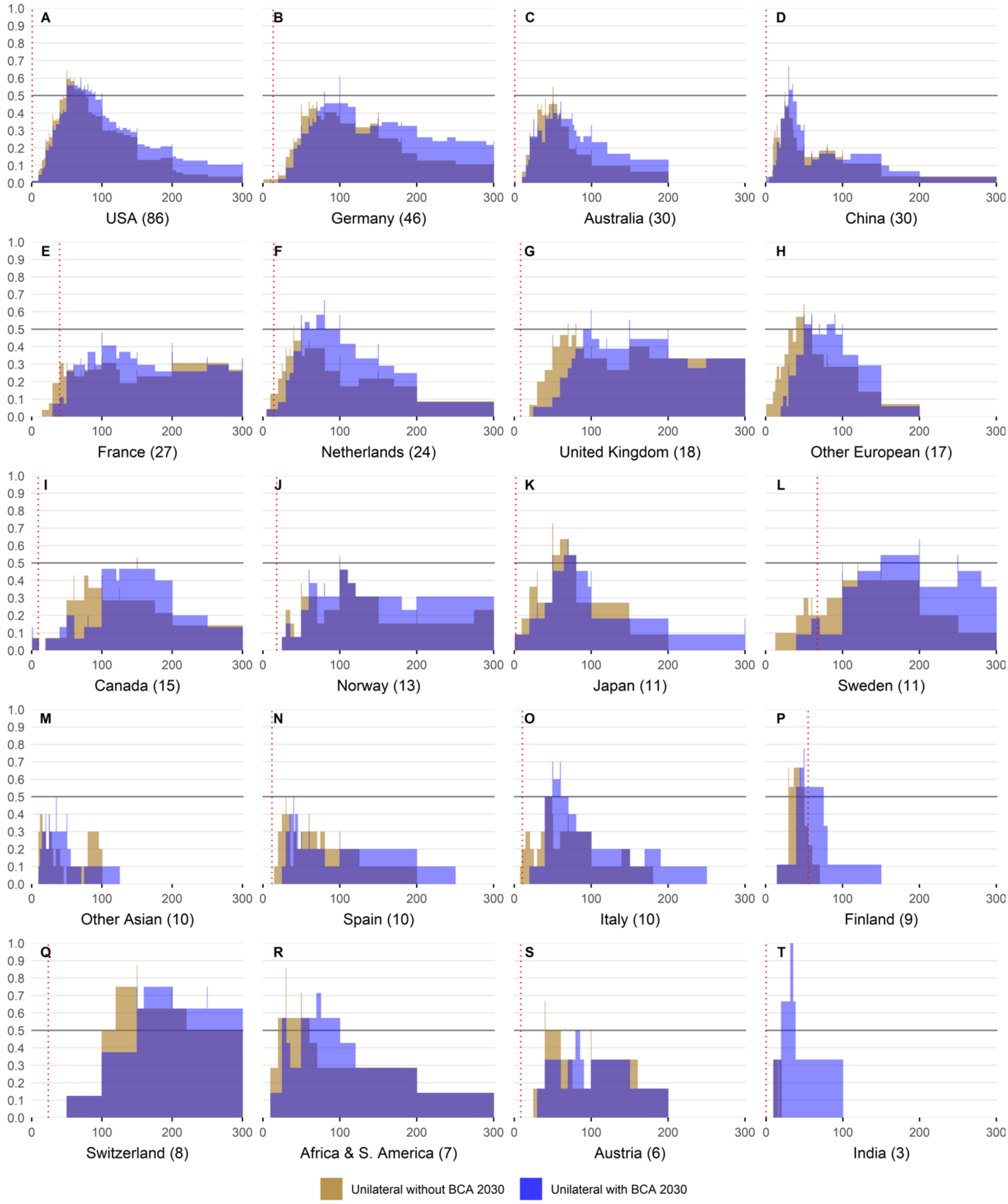

Figure 6: Spaces for agreement on unilateral carbon prices at a country-level

Notes: Proportion of experts for whom a certain carbon price level, varied on the horizontal axis, is contained within their acceptable range of 2030 *unilateral carbon prices with* (in blue) and *without* (brown) *border carbon adjustment (BCA)*. The red dotted line plots existing emission-weighted unilateral carbon price. Carbon prices are capped at $300 for expositional purposes as there is no price level of majority support beyond.

4. Analysis: Determinants of expert recommendations

We now move to an analysis of potential determinants of carbon price recommendations with the aim of obtaining a better understanding of the underlying reasons for the substantial variation in carbon price recommendations documented above. To this end, we utilize four pillars of additional data sources (see Figure 7) in univariate and multivariate regressions. We summarize our main findings along these four pillars and consider them in combination.

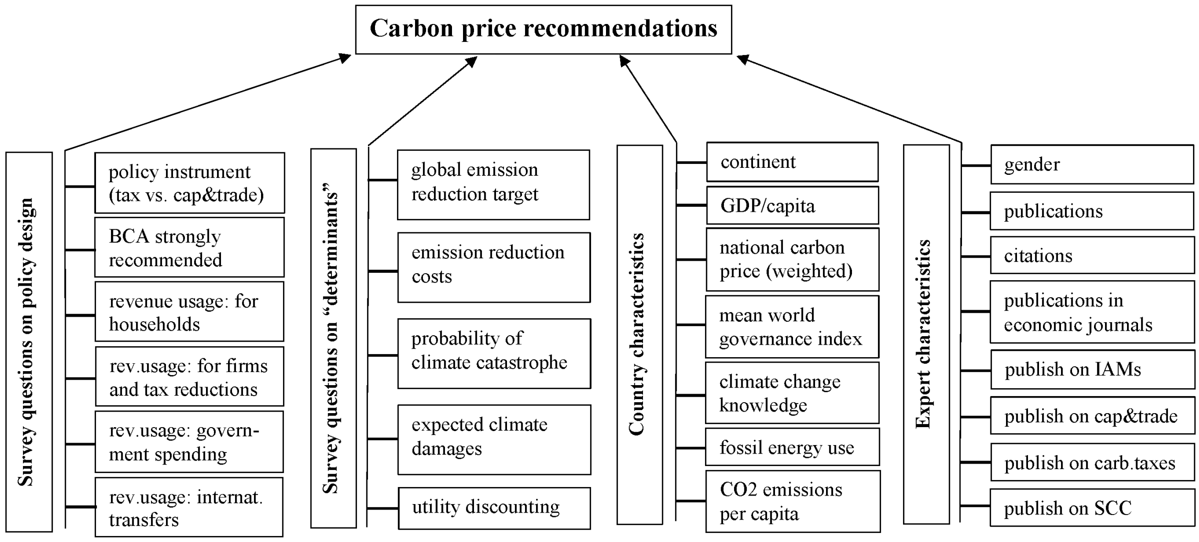

Figure 7: Explanatory variables used for analyzing carbon price recommendations

4.1 Survey questions on policy design issues

We examine possible relations between experts' carbon price recommendations and their views on key policy design issues. Here, we find that almost twice as many experts favor a carbon tax compared to some cap-and-trade scheme, with almost 20 percent of experts favoring some "other instrument or mix of instruments"; Furthermore, around three-quarters of all experts strongly recommend the usage of BCA, while views on revenue use are very heterogeneous (see Nesje et al., 2022). Regarding experts' recommendations on instrument choice, we find that experts who prefer carbon taxes recommend global carbon prices that on average exceed those by experts who prefer cap-and-trade by 33 percent in 2020 (\$53.15 versus \$40.08; t-test: p=0.015), by 37 percent in 2030 (\$99.69 vs. \$72.54; t-test: p=0.002) and by 60 percent in 2050 (\$235.86 vs. \$147.75; t-test: p=0.007). The results for 2030 are illustrated in Panel A of Figure 8, and Appendix A.5 contains the results for 2020. We find qualitatively the same for univariate analyses on unilateral carbon prices (with and without BCA),[22] and in multivariate analyses for both global and unilateral carbon prices (Table A.5.1 in Appendix A.5).[23]

[22] For instance, experts who recommend the use of carbon taxes recommend carbon prices that on average exceed those recommended by experts who prefer cap-and-trade by between 37 and 47 percent in 2030 (\$113.52 vs. \$77.31 with BCA; t-test: p=0.001, and \$83.24 vs. \$60.03 without BCA; t-test: p=0.004).

[23] Furthermore, the *BCA-wedge* is larger for those recommending carbon taxes as opposed to cap-and-trade schemes (\$30.86 vs. \$17.66 in 2030; t-test: p=0.074) while this is only tentatively the case for the *Glocal-wedge* (\$15.19 vs. \$4.99 in 2030; t-test: p=0.158). An explanation may be that carbon tax proponents have more heterogeneous unilateral climate policies in mind as compared to cap-and-trade proponents, who may assume variants of linked cap-and-trade schemes that lead to more international harmonization of carbon prices. Another explanation may be that experts preferring carbon taxes to cap-and-trade are more worried about competitiveness effects per se. However, we do not find that the effect of recommending a carbon tax versus cap-and-trade schemes

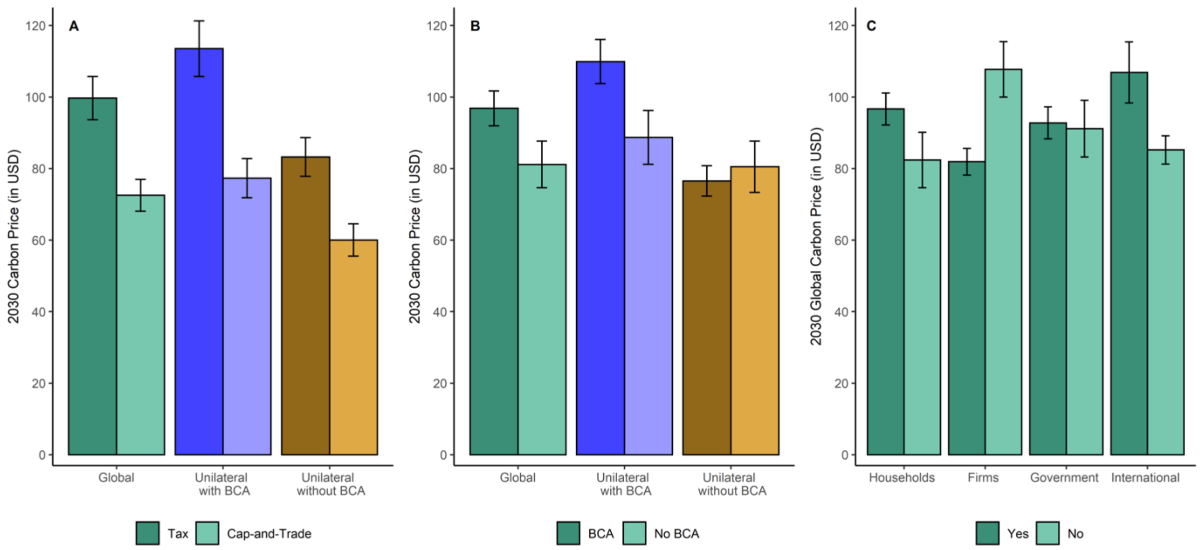

Figure 8: Relation between carbon prices and policy design recommendations
Notes: All panels depict relations of policy design recommendations and 2030 carbon prices, with means and standard errors. Panel A depicts how 2030 carbon price recommendations across all three scenarios—*global* (green) as well as *unilateral with* (blue) and *without* (brown) *border carbon adjustment (BCA)*—vary between those recommending the use of a carbon tax versus a cap-and-trade scheme (in more transparent bars). Panel B shows the equivalent for those that strongly recommend the use of BCA or not, and Panel C depicts how 2030 global carbon price recommendations vary with recommendations on revenue use.

It is intriguing why carbon price recommendations differ so much between experts favoring carbon taxes versus cap-and-trade. Consistent with lower carbon price recommendations, those who recommend using cap-and-trade also recommend a less stringent global emission reduction target, and they are different along a number of other observable characteristics. However, even when we control for these significant explanatory variables of cap-and-trade support in multivariate regressions, we still find a significant effect of recommending cap-and-trade on lower carbon price recommendations.[24] Experts recommending cap-and-trade thus seem to differ from those recommending the use of carbon taxes in more fundamental ways than we are able to explain with our data.

Also regarding experts' views on BCA, we find that experts who strongly support the introduction of BCA recommend higher global carbon prices in 2020 ($54.12; t-test vs. $40.68: p=0.029) and in 2030 ($96.83 vs. $81.15; t-test: p=0.085). For 2030, this is illustrated in Panel B of Figure 8. We find qualitatively the same for unilateral carbon price recommendations with BCA (e.g., $109.89 vs. $88.70 in 2030; t-test: p=0.066), but find no difference in recommendations on unilateral carbon prices without BCA for those who strongly support the introduction of BCA or not ($76.53 vs. $80.49 in 2030; t-test: p=0.635). This is also supported qualitatively by multivariate analyses (Table A.5.1 in Appendix A.5). Relatedly, we find that the *BCA-wedge* is substantially larger for those who strongly recommend the usage of BCA as compared to those who do not (34.04$ vs. 9.50$ in 2030; t-test: p=0.002).[25] This is indeed expected, because experts who express a strong preference for implementing BCA are probably more concerned about competitiveness issues and, thus, less likely to recommend high carbon

on a larger 2030 BCA-wedge is much affected when we control for BCA support and use of revenues to compensate firms (univariate regression: $13.20; p=0.030; multivariate regression: $12.01; p=0.036).

[24] Recommending cap-and-trade remains a significant explanatory variable of global carbon prices across all years in multivariate linear regressions that additionally considers its significant covariates.

[25] Again, we find no significant difference for the Glocal-wedge (-$13.94 vs. -$8.76; t-test: p=0.459).

prices in a unilateral scenario without BCA relative to the case with BCA. Overall, our results point towards an important role of BCA for shaping experts' carbon price recommendations.

We further investigate the relation between experts' recommendations regarding the usage of the revenues generated by carbon pricing and their carbon price recommendations. Based on frequencies of eleven pre-specified revenue usage options (see Appendix A.1.3) where each expert could select several types of usage, we group responses in four categories to facilitate the analysis: Using the revenues for (1) transfers to households, (2) transfers to firms or tax reductions, (3) governmental spending, and (4) international transfers.[26] Panel C of Figure 8 depicts how 2030 global carbon price recommendations vary with recommendations on revenue use along these four categories. Figure A.5.1 in Appendix A.5 shows the equivalent for the two unilateral cases that provide qualitatively similar insights. We find that experts who recommend using part of the revenue for transfers to households tend to recommend somewhat higher 2030 global carbon prices compared to all other experts ($96.66 vs. $82.53, p=0.102). Experts who recommend using part of the revenue for transfers to firms or tax reductions recommend considerably lower carbon prices ($81.91 vs. $108.42; p<0.001), while those who recommend using part of the revenue for international transfers recommend considerably higher carbon prices ($106.88 vs. $85.32; p=0.009), and there are no differences in carbon price recommendation between those recommending the usage of revenues for governmental spending or not ($92.77 vs. $91.71; t-test: p=0.911). A possible interpretation of these results is that experts who are concerned about distributional issues within (recommending transfers to households) and across countries (recommending international transfers) also tend to favor more ambitious climate policy.[27] By contrast, experts who place a greater weight on firms and profits are likely more "laissez-faire" oriented, and tend to recommend lower carbon prices. The category "Governmental spending" constitutes the largest group (N=334) and forms the middle ground in terms of carbon price recommendations.

4.2 Survey questions on "determinants"

Our final survey question asked for experts' (rough) views on other likely determinants of experts' price recommendations, such as climate damages, emission reduction targets, and discounting, using five-ordered categorical steps. We find that more than half of the experts expect catastrophic damages of at least 20 percent of GDP by 2070 to occur with a probability of at least 20 percent under business-as-usual, while more than half expect mitigation costs to be less than one percent of GDP annually for an 80 percent global emission reduction by 2050 (see Table 1). These two observations already point towards a majority view among experts

[26] The four grouping are: "Households": equal lump-sum transfers to households OR transfers to particularly affected households; "Firms and tax reductions": reduction of distortionary taxes OR grandfathering or tax cuts for firms OR transfers to particularly affected firms; "Governmental spending": general government spending OR spending on environmental public goods OR green R&D OR subsidies for renewable energy; "International transfers": international transfers to countries particularly affected by climate change OR international transfers to support climate policy in other countries. In addition, experts could tick an "Other" category and provide further explanations. We do not classify these here, but include those experts in the respective control groups. Appendix A.5 contains all associations with individual pre-specified options and the "Other" option (Table A.5.2).

[27] We also find that that those recommending transfers to households or international transfers tend to exhibit a larger 2030 Glocal-wedge in their carbon price recommendations (Household transfers: -$15.87 vs. -$5.39; t-test: p=0.114; International transfers: -$20.42 vs. -$8.99; t-test: p=0.073). We observe a similar effect for intergenerational distribution: Experts recommending the two most stringent emission reduction target (ERT) options or the two highest options on the utility weight to be put on future generations exhibit larger 2030 Glocal-wedges (ERT: -$20.36 vs. -$2.91; t-test: p=0.004; Utility discounting: -$19.09 vs. -$7.49; t-test: p=0.071).

regarding the need of stringent climate policy, and we indeed find that a majority of experts (57 percent) recommend global emission reductions of at least 80 percent by 2050.[28]

Table 1: Global carbon price recommendations and determinants

	(1) ERT	(2) Global price 2020	(3) Global price 2020	(4) Global price 2030	(5) Global price 2050
Emission reduction target (ERT)			0.54*** (0.13)	0.75*** (0.12)	0.85*** (0.12)
Abatement cost	-0.66*** (0.12)	-0.14 (0.11)	-0.02 (0.11)	-0.06 (0.10)	-0.13 (0.09)
Probability of 20% of GDP damages	0.16* (0.11)	0.11 (0.09)	0.07 (0.09)	0.09 (0.09)	0.07 (0.08)
Mean damages	0.42*** (0.12)	-0.11 (0.11)	-0.21* (0.11)	-0.20* (0.11)	-0.13 (0.10)
Utility discount factor	0.18** (0.08)	0.27*** (0.07)	0.24*** (0.07)	0.25*** (0.07)	0.25*** (0.07)
Observations	399	388	388	388	387
Pseudo R-squared	0.09	0.01	0.02	0.03	0.04

Notes: Robust standard errors in parentheses. $* \ p < 0.1$, $** \ p < 0.05$, $*** \ p < 0.01$. The multivariate regressions are estimated by ordered logit to account for categorical dependent variables.

We first examine how the estimates of abatement costs, damages, and views on discounting are associated with the overall emission reduction target indicated by the experts. Then, we examine how all of these "determinants" are associated with global carbon price recommendations. Table 1 shows the results by means of ordered logit regressions. We find that abatement costs, climate damages, and the utility discount factor correlate with the overall emission reduction target (ERT) in expected ways: Both higher damages and a higher discount factor are positively correlated with ERT, while higher abatement costs are associated with a less stringent ERT. Disregarding the ERT, only the utility discount factor is significantly positively associated with global carbon price recommendations in 2020. When we consider all five determinants together, we find that only ERT and the utility discount factor are consistently significant (positive) correlating variables of global carbon prices across all years considered (columns 3-5 in Table 1). This is in line with the importance of utility discount rates in both cost-benefit analyses and in cost-effectiveness frameworks (e.g. Emmerling et al. 2019; Hänsel et al. 2020; Nordhaus 2019; Traeger 2021). Furthermore, this suggests that the variation in expert recommendations may be driven more strongly by differences in determinants that likely exhibit a considerable degree of normative content (ERT and utility discounting) and less so by differences in those determinants that relate to expectations (mitigation costs and economic damages from climate change).[29]

[28] This finding is broadly similar to results from Howard and Sylvain (2021), who found that among researchers who have published broadly on climate economics, around two-thirds suggest that it is at least likely that expected benefits of mid-century net-zero greenhouse gas emission targets outweigh the expected costs.
[29] For the example of global carbon price recommendations for the year 2030, we find that the pseudo R2 for an ordered logit regressions with ERT and utility discounting amounts to 0.029, while it is only 0.005 for an ordered logit regressions with mitigation costs and the two climate damage variants.

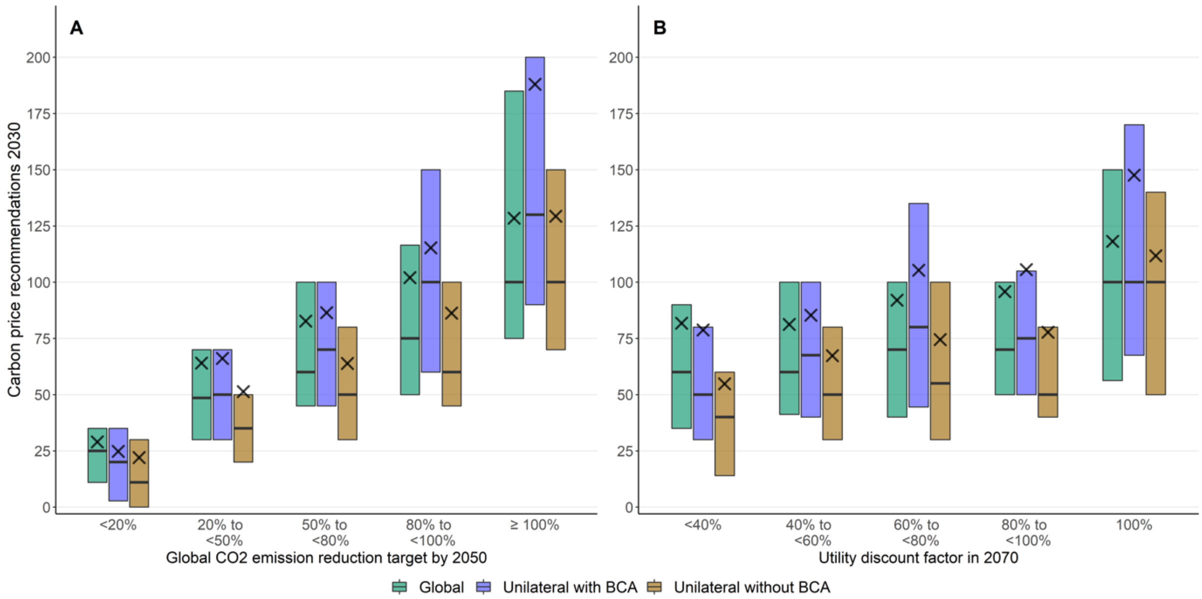

Figure 9: Key determinants and carbon price recommendations
Notes: Boxplots of 2030 carbon price recommendations for the *global* (green) as well as *unilateral with* (blue) and *without* (brown) *border carbon adjustment (BCA)* scenarios. Boxes represent interquartile ranges, the black horizontal lines represent median recommendations and the multiplier signs depict mean carbon prices.

Figure 9 illustrates 2030 carbon price recommendations across scenarios for subgroups of experts who selected the same global emission reduction target (ERT) by 2050 (Panel A), and for the utility discount factor in 2070 (Panel B). We only report here the results on global carbon prices as the unilateral results are qualitatively similar. We find that carbon price recommendations increase strongly with the stringency of the ERT (also when controlling for answers to the other "determinants" survey questions, cf. Table A.5.3 in Appendix A.5). For instance, 2030 global carbon price recommendations are considerably lower (higher) for those who recommend the lowest (highest) emission reduction target ($29.00 vs. $128.46; t-test: p<0.000). The views on abatement costs, damages, and the utility discount factor also correlate with the carbon price recommendations in expected ways. On utility discounting, we find that 2030 global carbon price recommendations are considerably lower for those recommending the lowest weight on the utility of future generations as compared to the highest weight ($81.76 vs. $118.17; t-test: p=0.028). Interestingly, we find that carbon price recommendations are considerably less sensitive to utility discount rate ranges as compared to what is suggested by findings from prominent IAMs. For instance, while carbon price recommendations for the utility discount ranges that encompass the prominent focal assumption on the utility discount rate by Nordhaus (2007) are lower as compared to the one by Stern (2007), we do not find that these differences are statistically significant ($81.21 versus $95.83 in 2030; t-test: p=0.196).[30] In contrast, using the 2016 version of the DICE models would suggest 2030 global carbon prices according to the utility discount rates by Nordhaus and Stern of $49 and $382 (Nordhaus, 2018). For 2050 global carbon prices, this relative insensitivity to utility discounting as compared to ERT becomes even more striking: While there is a large difference in terms of carbon price recommendations between those recommending less than 20 percent (equal to 100 percent or more) global emission reductions by 2050 ($43.46 vs. $289.32; t-test: p<0.000), 2050 global carbon recommendations do not differ significantly among those recommending the end points in the range of utility discount factors ($272.91 vs. $307.65; t-test: p=0.733).

[30] Nordhaus' (2007) choice of a utility discount rate of 1.5% yields a utility discount factor for utility in the year 2070 of 47%, Stern's choice of 0.1% yields a utility discount factor of 95%.

4.3 Country characteristics

We now investigate how carbon price recommendations relate to country-level information, for the country that experts indicated in our survey. Previous research by Best and Zhang (2020), Levi et al. (2020), and Levi (2021) has shown that existing carbon prices are associated with country-level characteristics: For instance, regulatory control, public belief in climate change, government effectiveness, and corruption control are positively associated with higher prices, while the share of oil and coal in electricity production, fossil reserves, and per-capita CO_2-emissions are negatively associated. Yet, countries that have already implemented carbon prices are likely systematically different. Our data allows testing how country characteristics are related to carbon price recommendations for countries that have not yet implemented carbon pricing schemes, and how implemented schemes relate to recommendations.[31]

Figure 10 depicts plots with linearly fitted lines for *unilateral with* (blue) and *without* (dashed brown) *BCA* as well as global (thin green) carbon price recommendations for the year 2030 based on key country characteristics that have been explored in the extant literature. Green spikes represent the 95 percent confidence level for global carbon prices and vertical lines the mean sample values of the country characteristics. We find that GDP per capita, emission-weighted nationally implemented carbon prices, mean world governance indicator rank scores, and knowledge about climate change are significantly positively correlated (at the 1 percent level) with 2030 carbon price recommendations across all scenarios. For instance, an increase in GDP per capita by $1000 is associated with a linearly predicted increase in the recommended *unilateral with (without) BCA* carbon price in 2030 of $1.27 ($1.08), and an increase in the nationally implemented carbon prices (in 2018) by $1 is associated with an increase in the recommended *unilateral with (without) BCA* carbon price of $1.32 ($0.90), and with an increase in the 2030 *global* carbon price recommendation of $0.76." In contrast, the share of fossil fuels in energy consumption is significantly negatively associated with recommended unilateral carbon prices, while the association with CO_2 emissions per capita is insignificant. These findings are qualitatively similar for 2020 carbon price recommendations,[32] and are broadly in line with the literature relating *existing* carbon prices in different countries and country characteristics (e.g., Levi et al., 2020). These country-level insights are difficult to disentangle in multivariate analysis mainly because much of the country-level information is highly correlated with GDP per capita (see Tables A.5.4 and A.5.7 in Appendix A.5).

[31] For the level of implemented carbon prices, we use the emission-weighted average of sector(-fuel) prices (ECP) data from Dolphin (2022). The prices are the existing total prices including any potential rebate and are expressed in 2019USD/tCO2e. Dolphin (2022) uses verified emissions data to calculate the shares of sector (or sector-fuel)-level in total jurisdiction (national or subnational) CO2 emissions. Additionally, the ECP is calculated separately for carbon taxes and ETSs and the combination of both. We use the national CO_2 prices for 2018 (as a pre-survey covariate) and 2020 (as a comparison point for the 2020 price recommendations) for the combination of carbon taxes and ETSs, as multiple jurisdictions covered contain both kind of instruments. For subnational jurisdictions, Dolphin (2022) calculates the share of emissions of each sector in total emissions of the relevant national jurisdiction to calculate national coverage and average price figures arising from subnational pricing mechanisms.

[32] The sole exceptions are that the share of fossil fuel energy consumption and nationally implemented carbon prices are insignificantly correlated with global carbon price recommendations in 2020 (Linear regressions: $p=0.149$ and $p=0.137$), while they remains strongly correlated with both unilateral carbon price recommendations in both cases (Linear regression: $p<0.000$ in all four cases).

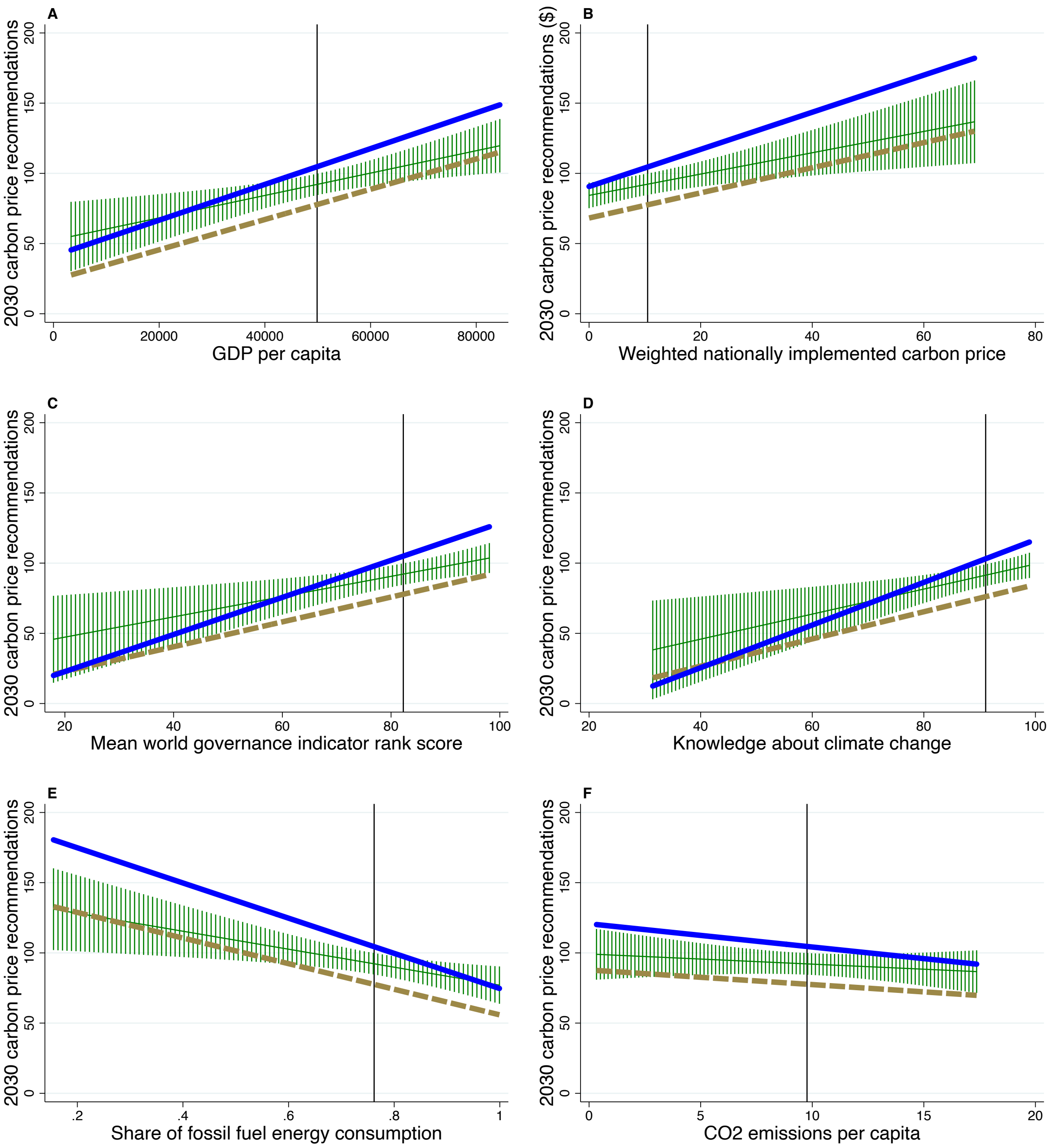

Figure 10: Unilateral and global carbon price recommendations and country characteristics

Notes: Linearly fitted *global* (green line), *unilateral with* (blue line) and *without* (dashed brown line*) border carbon adjustment (BCA)* carbon price recommendations for the year 2030, with green spikes representing 95 percent confidence levels for global prices, based on country characteristics—from upper left to lower right: GDP per capita (Panel A), weighted nationally implemented carbon prices (B), mean world governance indicator rank scores (C), knowledge about climate change (D), fossil fuel energy consumption (E), and CO2 emissions per capita (F). The vertical black lines represent mean characteristic values in our sample.

Furthermore, we find that none of the six country characteristics is significantly correlated (at the 1 percent level) with the 2030 *BCA-wedge*, which contrasts with findings for the Glocal-wedge. We have already discussed in Section 3 that the Glocal-wedge becomes negative and larger (in absolute terms) with increasing GDP per capita (linear regression, p=0.003), which is illustrated in Panel A of Figure 11. We have demonstrated a substantial Glocal-wedge with higher unilateral as compared to global carbon price recommendations, i.e. the opposite of free-riding on unilateral carbon prices. Indeed, we only find insigificant effects of free-riding for the bottom 10 percent of the sample in terms of GDP per capita (\$9.44; t-test: p=0.132). We now examine other country characteristics besides GDP and find that weighted nationally implemented carbon prices (Panel B of Figure 11), mean world governance indicator rank scores (Panel C), and knowledge about climate change (Panel D) are negatively correlated with the absolute value of the 2030 *Glocal-wedge*, while the share of fossil fuel energy consumption (Panel E) is positively correlated (linear regressions, p<0.000 in all cases). Solely CO_2 emissions per capita are not significantly correlated with the 2030 Glocal-wedge.

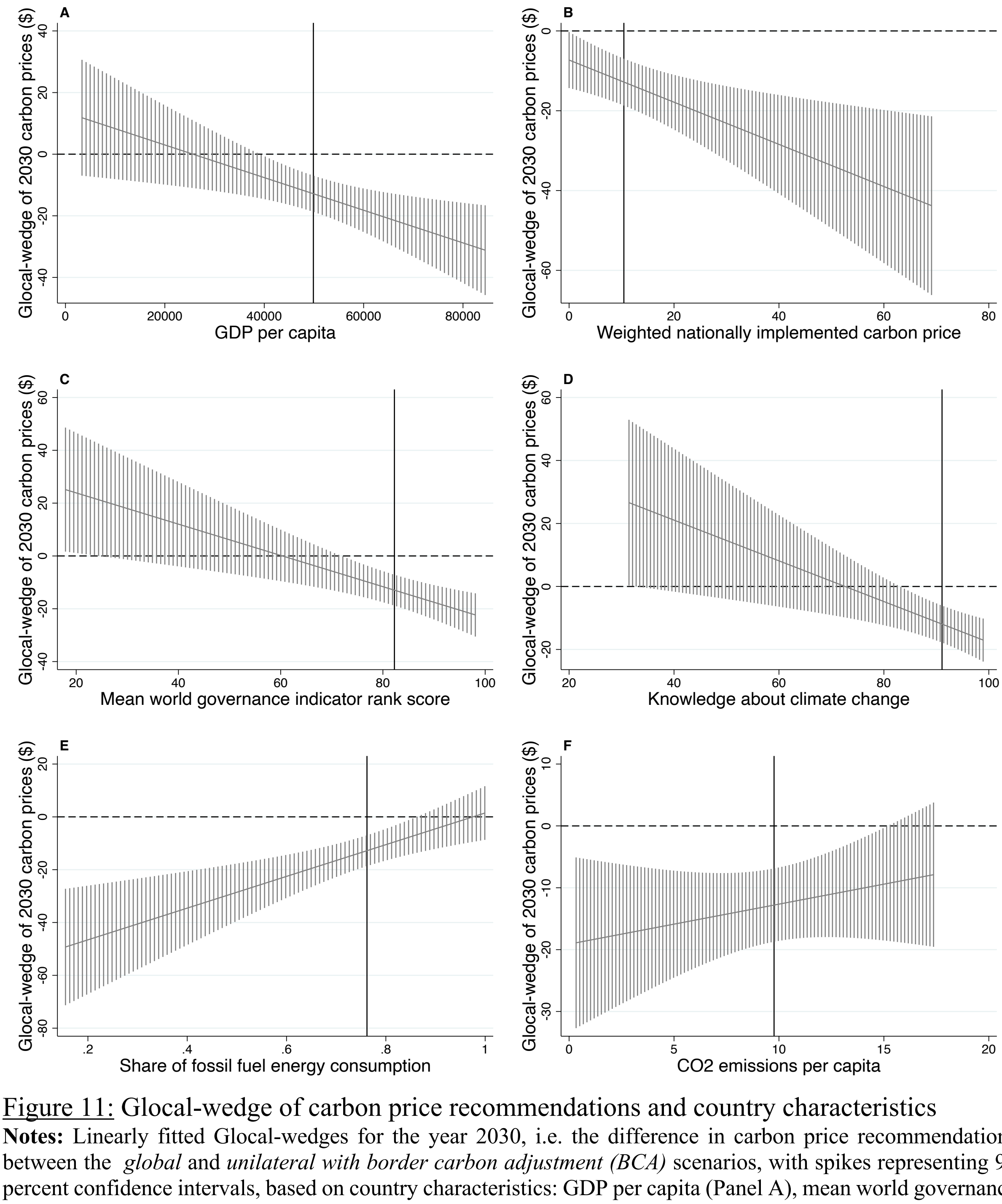

Figure 11: Glocal-wedge of carbon price recommendations and country characteristics

Notes: Linearly fitted Glocal-wedges for the year 2030, i.e. the difference in carbon price recommendations between the *global* and *unilateral with border carbon adjustment (BCA)* scenarios, with spikes representing 95 percent confidence intervals, based on country characteristics: GDP per capita (Panel A), mean world governance indicator rank score (Panel B), knowledge about climate change (Panel C), fossil fuel energy consumption (Panel D). The vertical black lines represent mean characteristic values in our sample.

Also when examining subgroups along these other country characteristics, we only find limited evidence for free-riding in our data, with the bottom 25 percent of experts in terms of mean world governance indicator rank scores ($7.45; t-test: p=0.078) and the bottom 5 percent in terms of knowledge about climate change ($17.86; t-test: p=0.081) forming the exception. For example, even among experts whose countries have not implemented any carbon price do we find a Glocal-wedge in 2030 that does not significantly differ from zero (-$0.29; t-test: p=0.943). Results for 2020, illustrated in Figure A.5.6 in Appendix A.5.3, are qualitatively similar and overall add to suggesting that there is little evidence for free-riding on unilateral carbon prices evident in the expert recommendations.

To compare results with the previous literature, we also consider the continental level. Pindyck (2019) computed an average SCC based on an analytic IAM and expert elicitation and reports this average SCC separately for experts from Europe, North America, and Developing Countries (with a residual category of Asia and Latin America). Pindyck (2019) finds similar average SCCs for experts from North America and Europe of $263 to $301, depending on distributional assumptions, and for those from the residual category, but that experts from Developing Countries recommend average SCC that are around 30 percent higher. We also find no significant differences in 2030 global carbon price recommendations of European and North American experts ($101.95 vs. $95.92; t-test: p=0.542). Yet we obtain the opposite result concerning recommendations by experts from Developing Countries as well as from the rest of the world in that experts who are not from Europe and North America recommend global carbon prices that are around 30 percent lower ($67.09 vs. $99.95; t-test: p<0.000).[33]

4.4 Observable expert characteristics

We further utilize a number of experts' observable characteristics to study carbon price recommendations. These include the number of relevant publications, the number of citations of these publications, whether and how many articles an expert has published in economics journals, as well as an expert's gender. In addition, we categorize experts based on whether their publications relate to topics such as carbon taxes and cap-and-trade or whether they have published on IAMs and the SCC, based on keywords used in their abstracts.

Figure 12 depicts results for all three carbon pricing scenarios for selected observable expert characteristics. Panel A shows a split across whether experts have published on carbon taxes or cap-and-trade schemes. Experts publishing on cap-and-trade tend to recommend lower carbon prices across all three scenarios, but insignificantly so. For instance, 2030 global carbon price recommendations for those publishing on carbon taxes are around $20 higher on average ($95.26 vs. $73.93; t-test: p=0.202). This tentatively echoes our finding from Section 4.1 based on survey results that suggested considerable differences in terms of carbon prices across those recommending the *usage* of carbon taxes versus cap-and-trade schemes for carbon pricing.

[33] Average recommended global carbon prices in Asia, South America and Africa as well as Oceania are $64.83, $63.12 as well as $71.37, respectively.

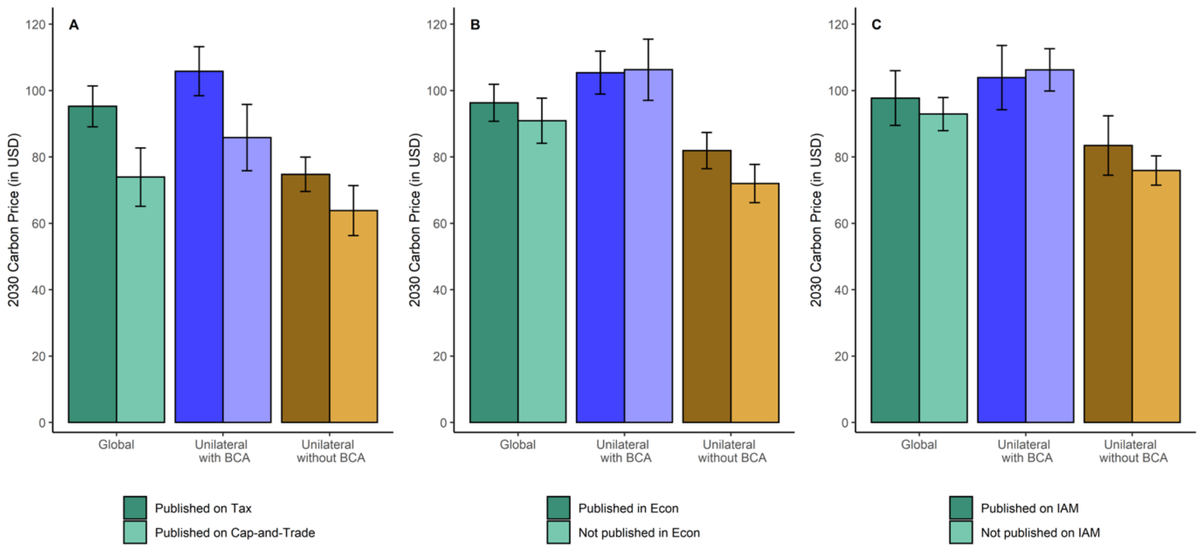

Figure 12: Carbon price recommendations and selected observable expert characteristics
Notes: All panels depict relations of policy design recommendations and 2030 carbon prices, with means and standard errors. Panel A depicts how 2030 carbon price recommendations across all three scenarios—*global* (green) as well as *unilateral with* (blue) and *without* (brown) *border carbon adjustment (BCA)*—vary between those publishing on the use of a carbon tax versus a cap-and-trade scheme (in lighter or more transparent bars). Panel B shows the equivalent for those that publish in economics journals and not, and Panel C depicts how 2030 carbon price recommendations vary between those publishing on IAMs and not.

Panel B of Figure 12 shows carbon price recommendations split across whether experts have published in economics journals or not. While Pindyck (2019) found that the imputed average SCC of economists is around 50 percent lower than that of non-economists, we find no considerable differences in terms of carbon price recommendations. For instance, 2030 global carbon price recommendations for those who published in economics journals are just \$5 higher on average (\$96.32 vs. \$90.95; t-test: p=0.539). We only find that experts who have published in economics journals recommend slightly higher 2020 unilateral carbon prices without BCA (\$43.66 vs. \$37.13; t-test: p=0.0848). Panel C of Figure 12 shows recommendations split across whether experts have published on IAMs or not. Again, we find no significant differences for these subgroups. This is also the case for count variables not depicted in Figure 12 such as the number of publications and number of citations. For gender, we also find no significant differences, while female experts tend to recommend higher carbon prices, for example 2030 global carbon prices are more than \$15 higher on average (\$107.35 vs. \$91.67; t-test: p=0.205), and 2030 unilateral carbon prices without BCA are almost \$20 higher (\$92.18 vs. \$74.81; t-test: p=0.122). Overall, we find that expert characteristics exhibit only a rather limited correlation with experts' carbon price recommendations.

4.5 The data in combination

We finally consider the multivariate regressions where we combine all four pillars of explanatory variables (see Figure 7). As a first step, we summarize how much of the variation in carbon price recommendations each of these four pillars of data can explain individually. The explanatory variables related to experts' recommendations on key policy design issues, when combined in multivariate analysis, can explain up to 6.62 (8.64) percent of the variation in global (unilateral) carbon price recommendations, depending on the year (and unilateral scenario) (Table A.5.1 in Appendix A.5). The survey questions on "determinants" can only explain a slightly lower amount of total variation in carbon price recommendations of up to 3.88 percent at the global level (see Table 1), and up to 4.26 percent of the variation in unilateral carbon price recommendations (Table A.5.3 in Appendix A.5). Considering the continent and country characteristics combined, we can explain up to 4.45 (9.68) percent of the variation in the global (unilateral) price recommendations (Tables A.5.4-6 in Appendix A.5), while observable expert characteristics can explain only up to 1.33 (2.76) percent of the variation in global (unilateral) carbon price recommendations (Table A.5.8 in Appendix A.5).

When we consider all four pillars of explanatory variables together, we explain more of the variation in the price recommendations. One such combination is to consider all the data. We find that in combination, the additional data sources can explain up to 18.72 (25.26) percent of the variation in the global (unilateral) carbon price recommendations (Tables A.5.9-10 in Appendix A.5). These numbers can be compared to the variation explained when studying these data pillars through model selection. One such combination of the data results from considering only those explanatory variables that are significantly correlated with carbon price recommendations in systematic ways. This can then explain up to 14.32 (20.07) percent of the variation in global (unilateral) carbon price recommendations (Tables A.5.11-17 in Appendix A.5). This is lower than when considering all data together, but clearly higher than when considering each type of data in isolation. Closer inspection of the combined data when keeping only those explanatory variables that we have found to be significantly correlated with carbon price recommendations in systematic ways is reassuring in that it also confirms that the main findings from the univariate analysis presented in the preceding subsections carries over (see Appendix A.5 for details). Yet, while several of the explanatory variables have some predictive power on experts' price recommendations, and many consistently so across different regression models, at least around 75 percent of the variation in the data remain unexplained. In contrast, we find that carbon price recommendations are strongly correlated across scenarios. Unilateral carbon price recommendations with (without) BCA can explain 63.83 (59.70) percent of the variation in global price recommendations in 2030. This points at strong idiosyncratic or subjective elements in the mental climate-economy models used by experts to arrive at their carbon price recommendations beyond what we are able to capture here.

5. Discussion

This section contrasts and compares our survey results with results from IAM studies and discusses a number of considerations that may limit the conclusions one can draw from our survey results. As with any survey, standard concerns include population selection (external validity), sample response bias (internal validity) and potential strategic or protest response behavior. We address these concerns in detail below.

5.1 Relation to IAM estimates

We start by investigating if our results on global carbon price recommendations are broadly consistent with the literature on integrated assessment models (IAMs). We do this in several steps, examining the relation in terms of (1) absolute numbers, (2) growth rates, (3) determinants, (4) how survey responses differ by IAM experts.

First, recall that the mean (median) recommended carbon prices at the global level are \$50 (\$40) for a ton of CO_2 in 2020, with a modal recommendation of \$50. This encompasses the focal prices of Nordhaus (2019) of \$43-\$45 for a ton of CO_2. A recent meta-study by Tol (2021a) on the SCC reports that the mode from published studies lies in the range \$0 to \$50 per ton of carbon, i.e. \$0 to \$13.64 per ton of CO_2, and that the distribution is highly dispersed and skewed towards high prices, with a sample mean of €42 (\$47) per ton of CO_2. While our 90 percentile range for 2020 global carbon prices extends from \$10 to \$100, Tol (2021a) reports an upper 95 percentile value of \$800 (\$218) per ton of carbon (CO_2). Furthermore, a recent analytic paper on the SCC (Traeger, 2021) illustrates a sensitivity range from \$10 to \$2330. Thus, in comparison, the responses to our survey point towards somewhat less dispersed recommendations than SCC estimates from the literature, with higher values for the central moments. The latter are still well below some recent estimates (e.g. Hänsel et al., 2020).

Second, in terms of growth rates of carbon prices, we find that more than 95 percent of all price paths increase over time. This is in line with most theoretical work on the topic.[34] For instance, Smulders et al. (2014: 435), referering to Golosov et al. (2014), state that "*as a rule of thumb, the optimal carbon tax grows at approximately the same rate as GDP*". There are a number of extensions to this rule of thumb (e.g. Bretschger and Karydas, 2019). For instance, some authors consider more general cases of isoelastic utility (Quaas and Broecker, 2016) or other approaches to deriving optimal growth rates of carbon prices. Based on the price recommendations for 2020 and 2050, we compute exponential growth rates and find an interquartile range of 2.56 to 5.51 percent and a mean (median) growth rate of global carbon prices of 4.42 percent (4.10 percent) from 2020 to 2050; Figure A.6.3 in Appendix A.6 illustrates the distribution of these growth rates.[35] This is around twice as high as forecasts of long-term global economic growth rates, which tend to be around 2 percent (Christensen et al., 2018; Drupp et al., 2018), and higher than meta-analytic estimates of the mean growth rate of Pigouvian climate taxes or the SCC (Tol, 2013). It is slightly higher as compared to some prominent estimates derived from IAMs, cf. 3.5 percent (Nordhaus, 2018), or from stylized models, but considerably lower than carbon price growth rates as used in cost-efficiency IAMs featured in the IPCC, which Gollier (2021) reports to exhibit mean (median) growth rates of almost 6 (8) percent.

Third, we have illustrated in Section 4.2 that global carbon price recommendations are affected in expected ways by key determinants from the IAM literature, including discount rates, damages and the emission reduction target. Yet, while higher utility discounting is associated with lower carbon price recommendations, carbon prices are far less sensitive to utility discounting in our survey data than as suggested by standard IAMs (e.g., Emmerling et al., 2019; Hänsel et al., 2020; Nordhaus, 2019; Traeger, 2021).

Fourth, we have shown in Section 4.4 that global carbon price recommendations do not differ significantly between the subgroup of expert that we have identified as publishing on IAMs based on their paper's abstracts (N=67) and the other experts (t-tests: p-values>0.65 for all three years). In terms of the qualitative direction, carbon price recommendations for the IAM subsample tend to be a little higher for 2020 (\$52.82 vs. \$50.61) and 2030 (\$97.75 vs. \$92.92) and a little smaller for 2050 (\$212.46 vs. \$235.25) for the IAM subsample. Additionally, we investigate differences regarding views on determinants between the IAM-subgroup and other respondents. Here we find no differences in ERT, utility discounting and mitigation costs (ranksum tests: p>0.25 in all cases), but IAM experts expect lower damages (mean damages and catastrophic damages; ranksum tests: p=0.002 and p=0.0495).

These analyses suggest that our survey results are broadly comparable with standard IAM results but tend to be less dispersed and less sensitive to controversial input assumptions.

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[34] Besides this standard case, carbon price recommendations of 14 experts do not grow over time, six of which stay zero at all times, while some others stay constant at rather high values of \$500, which may be interpreted as the price of a backstop technology. In addition, four experts recommend carbon price schedules that exhibit negative growth rates between 2020 and 2050, as suggested i.a. by Daniel et al. (2019).

[35] If we split the time frame into two periods, we find mean (median) growth rates of global carbon prices of 6.53 (5.54) percent per year from 2020 to 2030, and 3.19 (3.41) percent per year from 2030 to 2050. This slowing growth rate of carbon prices in later periods is more pronounced than in standard IAMs. Compare for instance the optimal run by Nordhaus (2018) with a growth rate of the global carbon price of 3.37 percent per year from 2020 to 2030 and 3.07 percent per year from 2030 to 2050.

5.2 Non-Response Bias

Among the potential biases, we first consider *non-response bias*, which relates to a biased selection of specific experts from our population of experts into responding. Allowing respondents to reveal their identity, permits us to examine which experts respond to our study, and then to re-weight responses according to potentially biased sample characteristics. To some extent, such response bias would be desirable because our population selection yields publication-based *potential experts*, as co-authors of two pertinent papers. Some co-authors may not be experts (or may not sufficiently perceive themselves as experts) on carbon pricing, and if these select out of responding, this may not be a problem per se. For instance, we find that the probability of being a respondent is higher for those with more than the median number of publications (24.79 percent versus 18.87 percent; t-test: p=0.001).

We investigate how systematically these expert characteristics are related to experts' price recommendations. To this end, we use the information on those experts who revealed their identity to us to test for potential self-selection and response bias effects and compare respondents and non-respondents based on observable characteristics. We consider one such approach to see how the carbon price recommendations differ between the full dataset (Table A.2.2 in Appendix A.2) and matching models that allow price recommendations to be re-weighted based on the characteristics of the respondents and non-respondents.[36] For the purpose of this exercise, we define as respondents or non-respondents those that are neither explained non-respondents nor in the "missing" group (e.g. potential experts for whom we could not obtain a workable e-mail address). Respondents for whom we cannot identify characteristics are dropped from these models. We generate a constant broad notion of "treatment" (i.e. response), interpreted as the remaining respondents, who responded to the relevant question. We consider non-respondents as the "control" group. The matching procedure is done by propensity scores and outlined in Appendix A.6.

Table 2: Re-weighting global price recommendations

	Global 2020	Global 2030	Global 2050	Unilateral 2020 with BCA	Unilateral 2030 with BCA	Unilateral 2020 w/o BCA	Unilateral 2030 w/o BCA
Full dataset	50.26	92.40	224.36	54.34	104.39	40.47	77.54
Unweighted	51.35	94.43	233.56	55.51	106.63	40.69	77.69
Weighted	52.33	95.07	247.38	55.41	107.70	39.77	78.28

Notes: The model consists of the following characteristics: Whether the expert is based in Europe, Oceania, Asia or the category of Africa and Latin 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.

The unweighted model in Table 2 presents the mean recommendations before matching. It differs from the full dataset since the number of respondents is slightly lower. This is because we can only obtain the characteristics for some respondents. The weighted model presents the mean response after the matching procedure. We consider a model that is broadly in line with the setups considered in Sections 4.3 and 4.4, in that it builds on the data types concerning continent of main affiliation and observable expert characteristics.[37] This allows us to focus on demographics as well as information related to the pertinent publications.

[36] Another approach is detailed in Dutz et al. (2021), showing how standard approaches to deal with this can be improved by modeling non-respondents, as some may decline to participate and others may not see the survey invitation. With our design, we identified 97 explained non-respondents, mitigating some of these concerns.

[37] We here focus on continent of main affiliation instead of continent implied by the answer to the survey, to obtain comparable information also for the non-respondents.

We explain the matching and estimation procedure in detail in Appendix A.6. To start with, we estimate the propensity to respond by a probit regression to obtain the propensity score. We then use these scores to reweight the sample of respondents. Tables A.6.2 and A.6.3 in Appendix A.6 show the balancing test before and after reweighting for the global carbon price in 2030. After reweighting, characteristics are relatively balanced between respondents and non-respondents. While expert characteristics have predictive power regarding who responded to our survey, the effects on global price recommendations seem to decline in the aggregate, and in some cases cancel out. For the full dataset (see Table 2), we obtain mean global prices of \$50.26, \$92.40, and \$224.36 for the years 2020, 2030, and 2050, respectively. The matching models present both mean responses before and after re-weighting by propensity scores. The unweighted responses are \$51.35, \$94.43, and \$233.56 for 2020, 2030, and 2050, respectively, and should be used for comparison. The re-weighed responses are \$52.33, \$95.07, and \$247.37. While there is some effect on 2050 global carbon price recommendations when correcting for potential self-selection and response bias, the effect is not stable when considering other model specifications. The continent of affiliation has some predictive power in line with the analysis above, but we interpret these results broadly as evidence against systematic self-selection and response biases. The same can be said for information related to the relevant publications.

We also undertook this non-response bias analysis for the unilateral prices with and without BCA. The unweighted and weighted recommendations are \$106.63 and \$107.70 for the 2030 unilateral carbon price with BCA, and \$77.69 and \$78.28 for the 2030 unilateral carbon price without BCA. These exercises point in the same direction, as recommendations seem relatively unaffected by reweighting.

5.3 Non-Representation Bias

Our survey seeks recommendations on global carbon prices based on a population of experts that is itself not globally representative since a disproportionate fraction of academic experts are located in higher-income countries. We investigate this potential *non-representation bias* by exploring how country-level characteristics, in particular GDP per capita, is associated with carbon price recommendations and then perform a re-weighting of responses according to the global average of these country-level characteristics.

Panel A of Figure 13 shows that recommendations on the appropriate global carbon price for 2030 vary significantly across the income distribution within our sample (the same holds for 2020 and 2050 prices). Using this observed relationship to re-weight the global carbon price recommendation according to the global average GDP per capita instead of the mean value from our sample leads to a reduction in the 2030 carbon price from the sample mean of \$92.40 to \$65.63. For 2020 (2050) the re-weighting for global representativity would result in a mean carbon price of \$30.83 (\$137.15) as compared to \$50.26 (\$224.36) in 2020 (2050) in our sample. This indicates a potentially sizable non-representation bias of around 29 to 39 percent. To investigate effects across subgroups, we split the sample by the median number of publications, for those who have published or not in economics journals, and for experts who have or have not published on IAMs or the SCC. Figure A.6.3 in Appendix A.6 illustrates that for those who have published in economics journals, on IAMs or the SCC, and who have more than the median number of publications, we do not find a significantly positive relationship between GDP per capita and global carbon price recommendations in 2030.[38]

[38] If we split at the median number of citations, we find a significant positive relationship between GDP per capita and global carbon price recommendations in 2030 for both subgroups, with p=0.001 and 0.016 respectively, in a linear regression with robust standard errors. Furthermore, we do find a number of significantly positive relationships for the above median sub-groups for 2020 global carbon prices but not for 2050 recommendations.

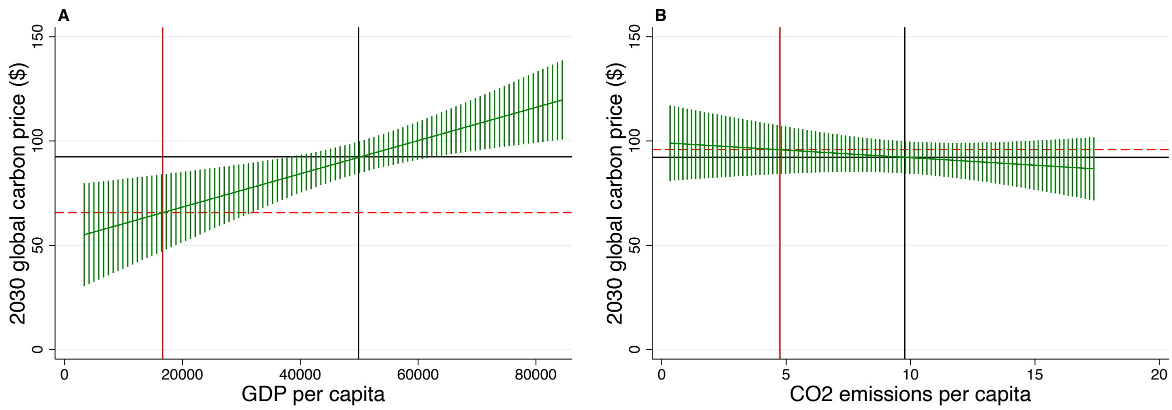


Figure 13: Re-weighting global carbon prices for non-representation bias

Notes: Plot of 2030 global carbon price recommendations and GDP per capita (Panel A) as well as a CO_2 emissions per capita (Panel B), with linear fit (green line) and 95 percent confidence interval (green spikes). The black lines show mean characteristic values and mean 2030 global carbon price recommendations in our sample. The solid red lines show global GDP per capita (Panel A) and the global average CO_2 emissions per capita (Panel B) and the red dashed lines show the corresponding predicted (re-weighted) 2030 global carbon prices.

Furthermore, in the Panel B of Figure 13, we consider global re-weighting also for a CO_2 emissions per capita, with emissions being a potentially more important metric for addressing the global climate externality. Here, we find no significant relationship, suggesting no indication for non-representation bias. This highlights that one would likely need to construct some multi-dimensional measure of "global representativity", with appropriate indicator-weights, to clearly identify the extent of non-representation bias. In Figure A.6.4 in Appendix A.6, we further consider similar re-weighting exercises for the 2030 Glocal-wedge. While re-weighting according to global GDP per capita would predict a positive but insignificant Glocal-wedge, thus not detecting a clear free-riding signal, re-weighting according to CO_2 emissions per capita would lead to a somewhat larger Glocal-wedge.

5.4 Strategic Response Bias

A standard concern with expert elicitation is strategic response bias to tilt the resulting distribution according to one's own preferences. We account for strategic response bias in different ways. First, we communicate median values besides mean values, which may be prone to strategic response bias. Second, we winsorize the data to deal with two extreme outliers, which may be regarded as either strategic or protest responses. Third, we test for remaining strategic response bias in two ways: Comparing anonymous and non-anonymous responses as well as comparing early and late respondents. The hypothesis is that strategic responders respond anonymously and early (Armstrong and Overton, 1977; Necker, 2014).

In our first test on strategic response bias, we compare early versus late responses across two measures. One measure is based on whether responses came to the initial e-mail invitation or to any of the reminders. We interpret respondents to the invitation e-mail as early respondents. In general, there is no predictive power of being an early respondent on global and unilateral prices for any years. With one exception, there are no differences between early and late respondents in terms of country-level information and experts' characteristics: The share of respondents from Asia is lower in early respondents as compared to the later rounds (9.47 versus 16.52; t-test: p=0.042). But this is mitigated by the responses to the first reminder (20.00 versus 11.51: t-test: p=0.035). The other measure is based on the respondent ID (as recorded by SoSci Survey) as proxy for the time of response. We distinguish between early and late responses through a median split value interpretation of the respondent ID. We confirm the observations made above for the price levels. In terms of country-level information, we see effects for experts being from Asia (consistent with above and mitigated in the first round of reminders), South America and Africa (for the opposite reason, although not statistically significant when comparing respondents that reply to different rounds) and in terms of fossil fuel energy consumption (74.54 versus 77.96; t-test: $p=0.028$). There are no differences in terms of experts' characteristics.

In our second test on strategic response bias, we compare anonymous and non-anonymous responses. The vast majority of our responses were non-anonymous, yet our preceding analysis has included also 57 responses that were provided anonymously. For these, we can still leverage their responses on the relevant country from the survey itself to investigate whether observable country-characteristics differ across these two sub-samples. We neither find that anonymous respondents make recommendations more often to countries on particular continents (chi squared tests: $p>0.25$ in all cases), nor that their GDP per capita is statistically distinguishable (\$51000.56 versus \$49727.62; t-test: $p=0.550$). Furthermore, we find that mean carbon price recommendations by anonymous respondents tend to be slightly lower but not significantly so as compared to non-anonymous respondents (t-tests: $p>0.3$ in all three years), with the same median values in 2020 and 2030.

6. Conclusion

Implementing carbon prices that reflect the true social costs of CO_2 emissions remains a key challenge for policy makers around the globe. Our paper provides the first of its kind global expert survey on carbon pricing. Building on survey evidence on carbon pricing from more than 400 publication-based experts across almost 40 countries, we study the variation of global and unilateral carbon pricing recommendations and their determinants. We further quantify the extent of (dis-)agreement on carbon prices and analyze how recommendations vary with additional survey data, country characteristics, and observable expert characteristics.

Our study reveals that, first, there is a strong consensus among experts that a uniform global carbon price should be higher than the existing global average carbon price, which was recently estimated at \$3 per ton of CO_2; Second, experts can agree on some short- and medium-term global carbon prices despite substantial heterogeneity in point recommendations; Third, expert recommendations on carbon prices do not, on aggregate, support the notion of free-riding; Fourth, the introduction of border carbon adjustment (BCA) facilitates higher unilateral carbon price recommendations; Fifth, the introduction of BCA tends to facilitate higher levels of agreement on carbon prices.

The first result provides a clear message for climate policy to build (more) strongly on the steering effect of carbon prices in order to achieve more ambitious emission reduction targets. Specifically, we find that the mean (median) recommended global carbon prices are \$50 (\$40) for a ton of CO_2 in 2020, and increase over time to \$92 (\$70) in 2030, respectively \$224 (\$100) in 2050. Moreover, 98.43 percent of experts recommend carbon prices that exceed the globally prevailing emission-weighted carbon price, and the acceptable ranges of carbon prices of 96.39 percent of experts lie strictly above the prevailing emission-weighted carbon price. The second result shows that—despite substantial heterogeneity in recommendations—a majority of experts can indeed agree on specific carbon price levels at the global level for the short- and medium term (2020 and 2030). Carbon prices between \$30 and \$50 receive majority support in 2020, and carbon prices of \$50 and \$60 receive majority support in 2030. We thereby provide data-driven focal points on carbon prices that are complementary to those informed by theoretical approaches, such as the non-dogmatic approach of reducing disagreement on the SCC by Jaakkola and Millner (2022).

The third result reveals that—contrary to the standard hypothesis from stylized theoretical work—expert recommendations provide no evidence for free-riding under unilateral carbon pricing, except for special subgroups. Indeed, we find the opposite on aggregate: experts' unilateral carbon price recommendations under BCA exceed the global ones—a result that may be interpreted as "ride-sharing" as opposed to "free-riding". We show that the extent of "ride-sharing" increases with the level of a country's GDP per capita and vanishes for the poorest countries. The variation of the extent of free-riding or ride-sharing along different income levels can be rationalized by global welfare considerations as well as by a consideration of local health co-benefits of the reductions of (air) co-pollutants that come along with pricing carbon. Furthermore, the fourth and fifth results show that an introduction of the much discussed border carbon adjustment could facilitate both higher unilateral carbon prices as well as higher levels of agreement on carbon prices. We also find that most experts recommend unilateral carbon prices that are considerably higher than their country's emissions-weighted existing carbon prices, and that there is also majority agreement on some higher unilateral carbon price level in most countries.

Further analysis of the variation of global and unilateral carbon pricing recommendations drawing on additional survey data, country characteristics, and observable expert characteristics provides the following insights: (i) Experts who recommend the use of carbon taxes over cap-and-trade, and those who strongly support BCA, tend to recommend substantially higher global carbon prices. The same holds for experts who have published on carbon taxes compared to those experts who have published on cap-and-trade; (ii) Expert's (unilateral) carbon price recommendations are correlated with observable country characteristics in ways that would be expected from the previous literature: Specifically, we find that experts from countries with higher GDP per capita, higher weighted nationally implemented carbon prices, higher mean world governance indicator rank score, or more knowledge about climate change, tend to recommend higher carbon prices; (iii) despite making use of a large number of additional data sources, our explanatory variables are only able to explain up to around 25 percent of the variation in individual carbon price recommendations. This points towards a strong idiosyncratic or subjective component in experts' mental models of the climate-economy and their respective views on the issue of carbon pricing; (iv) across a number of measures we find that expert recommendations are broadly consistent with but less dispersed than carbon price estimates from the integrated assessment modelling literature. This is true for absolute levels of carbon prices, carbon price growth rates as well as key determinants, and we also find that carbon price recommendations by integrated assessment modelling experts are statistically indistinguishable from the rest of all experts; (v) we find no or only minor evidence for strategic biases or non-response bias, yet, we show that—depending on the metric chosen—there can be a substantial non-representation bias in global carbon price recommendations, as experts are unequally sourced from countries across the globe, predominantly from Europe and North America, and global carbon price recommendations tend to increase with the GDP per capita of an expert's country. We perform re-weighting exercises to provide estimates of the extent of this non-representation bias and find that re-weighting according to the global average GDP per capita would entail reducing the 2030 mean global carbon price recommendation by almost 30 percent, from around \$92 to \$66. Thus, while our data do not allow us to test how representative experts are of the general population, our approach of asking experts directly also sheds light on the (non-)inclusiveness of views that are considered when determining carbon prices (e.g., Wagner et al., 2021).

Besides contributing to a better understanding of carbon prices that are deemed appropriate by experts in the field along with potential determinants of experts' carbon price recommendations, our paper provides useful data for researchers and practitioners alike. Our data on the distribution of carbon price recommendations may be used in scenario analyses of climate-economy models. Experts' price recommendations on the country level may also directly inform policy-makers about appropriate carbon price levels (as recommended by experts who associate themselves with this country). Future research may also relate our data to further country characteristics of interest. It will be particularly interesting to further investigate to what extent our finding of "ride-sharing" as opposed to "free-riding" on unilateral carbon prices can be explained by co-benefits of emission reductions, by global welfare considerations, or by strategic considerations or other explanations. Likewise it will be interesting to investigate to what extent views of academic experts in a given country are representative of the general population on carbon prices. Future studies may also target a broader population of experts (or non-experts), with the goal of obtaining more responses from under-represented countries. This can also help to shed more light on issues such as non-representation bias, and to investigate possible drivers of the considerable heterogeneity in experts' views on the issue of carbon pricing that we have identified.

References

Acemoglu, D., Aghion, P., Bursztyn, L., & Hemous, D. (2012). The environment and directed technical change. *American Economic Review*, 102(1), 131-66.

Ahlvik, L., & Liski, M. (2022). Global Externalities, Local Policies, and Firm Selection. Forthcoming, *Journal of the European Economic Association*.

Andre, P., Pizzinelli, C., Roth, C., & Wohlfart, J. (2022). Subjective models of the macroeconomy: Evidence from experts and representative samples. Forthcoming, *Review of Economic Studies*.

Armstrong, J. & Overton, T. (1977). Estimating nonresponse bias in mail surveys. *Journal of Marketing Research*, 14, 396-402.

Arrow, K., Cropper, M., Gollier, C., Groom, B., Heal, G., Newell, R., ... & Weitzman, M. (2013). Determining benefits and costs for future generations. *Science*, *341*(6144), 349-350.

Barrett, S. (1994). Self-enforcing international environmental agreements. *Oxford Economic Papers* 46, 878-894.

Barrett, S., & Dannenberg, A. (2016). An experimental investigation into 'pledge and review' in climate negotiations. *Climatic Change*, 138(1), 339-351.

Barrage, L. (2018). Be careful what you calibrate for: social discounting in general equilibrium. *Journal of Public Economics*, 160, 33-49.

Bauer, N., Bertram, C., Schultes, A., Klein, D., Luderer, G., Kriegler, E., ... & Edenhofer, O. (2020). Quantification of an efficiency–sovereignty trade-off in climate policy. *Nature*, *588*(7837), 261-266.

Best, R., & Zhang, Q. Y. (2020). What explains carbon-pricing variation between countries?. *Energy Policy*, 143, 111541.

Böhringer, C., Fischer, C., Rosendahl, K. E., & Rutherford, T. F. (2022). Potential impacts and challenges of border carbon adjustments. *Nature Climate Change*, 1-8. https://doi.org/10.1038/s41558-021-01250-z.

Bretschger, L., & Karydas, C. (2019). Economics of climate change: introducing the Basic Climate Economic (BCE) model. *Environment and Development Economics*, 24(6), 560-582.

Carattini, S., Kallbekken, S., & Orlov, A. (2019). How to win public support for a global carbon tax. *Nature* 565, 289-291.

Carleton, T., & Greenstone, M. (2021). Updating the United States Government's Social Cost of Carbon. *University of Chicago, Becker Friedman Institute for Economics Working Paper*, (2021-04).

Christensen, P., Gillingham, K., & Nordhaus, W. (2018). Uncertainty in forecasts of long-run economic growth. *Proceedings of the National Academy of Sciences*, *115*(21), 5409-5414.

Daniel, K. D., Litterman, R. B., & Wagner, G. (2019). Declining CO2 price paths. *Proceedings of the National Academy of Sciences*, 116(42), 20886-20891.

DellaVigna, S., & Pope, D. (2018). What motivates effort? Evidence and expert forecasts. *The Review of Economic Studies*, 85(2), 1029-1069.

Moore, F. C., & Diaz, D. B. (2015). Temperature impacts on economic growth warrant stringent mitigation policy. *Nature Climate Change*, *5*(2), 127-131.

Dietz, S., & Stern, N. (2015). Endogenous growth, convexity of damage and climate risk: how Nordhaus' framework supports deep cuts in carbon emissions. *The Economic Journal*, 125(583), 574-620.

Dietz, S., & Venmans, F. (2019). Cumulative carbon emissions and economic policy: in search of general principles. *Journal of Environmental Economics and Management*, 96, 108-129.

Dolphin, G. (2022). Evaluating National and Subnational Carbon Prices: A Harmonized Approach. RFF Working Paper 22-4.

Drupp, M.A., Freeman, M. C., Groom, B., & Nesje, F. (2018). Discounting disentangled. *American Economic Journal: Economic Policy*, 10(4), 109-34.

Drupp, M.A., & Hänsel, M. C. (2021). Relative Prices and Climate Policy: How the Scarcity of Non-Market Goods Drives Policy Evaluation. *American Economic Journal: Economic Policy* 13(1), 168-201.

Dutz, D., Huitfeldt, I., Lacouture, S., Mogstad, M., Torgovitsky, A., & van Dijk, W. (2021). Selection in Surveys. Becker-Freidman Institute Working Paper No. 2021-141.

[EAERE 2019]. Economists' Statement on Carbon Pricing, https://www.eaere.org/statement/ (visited 11/11/2019).

Emmerling, J., Drouet, L., van der Wijst, K. I., Van Vuuren, D., Bosetti, V., & Tavoni, M. (2019). The role of the discount rate for emission pathways and negative emissions. *Environmental Research Letters*, *14*(10), 104008.

Fischer, C., Hübler, M., & Schenker, O. (2021). More birds than stones–A framework for second-best energy and climate policy adjustments. *Journal of Public Economics*, *203*, 104515.

Freeman, M. C., & Groom, B. (2015). Positively gamma discounting: combining the opinions of experts on the social discount rate. *The Economic Journal*, 125(585), 1015-1024.

Gerlagh, R., & Liski, M. (2018). Consistent climate policies. *Journal of the European Economic Association*, 16(1), 1-44.

Gillingham, K., Nordhaus, W., Anthoff, D., Blanford, G., Bosetti, V., Christensen, P., ... & Reilly, J. (2018). Modeling uncertainty in integrated assessment of climate change: A multimodel comparison. *Journal of the Association of Environmental and Resource Economists*, 5(4), 791-826.

Gollier, C. (2021). The cost-efficiency carbon pricing puzzle. CEPR Discussion Paper No. DP15919.

Golosov, M., Hassler, J., Krusell, P., & Tsyvinski, A. (2014). Optimal taxes on fossil fuel in general equilibrium. *Econometrica*, 82(1), 41-88.

Hambel, C., Kraft, H., & Schwartz, E. (2021). The social cost of carbon in a non-cooperative world. *Journal of International Economics*, 131, 103490.

Hänsel, M. C., Drupp, M. A., Johansson, D. J., Nesje, F., Azar, C., Freeman, M. C., Groom, B. & Sterner, T. (2020). Climate economics support for the UN climate targets. *Nature Climate Change*, 10(8), 781-789.

Harstad, B. (2020). Pledge-and-review bargaining: From Kyoto to Paris. Mimeo, University of Oslo.

Harstad, B. (2021). A Theory of Pledge-and-Review Bargaining. Mimeo, University of Oslo.

Heal, G. M., & Millner, A. (2014). Agreeing to disagree on climate policy. *Proceedings of the National Academy of Sciences*, 111(10), 3695-3698.

Heal, G. M. (2021). Empathy and the Efficient Provision of Public Goods. *NBER Working Paper* No. w29255.

Hsiang, S., Kopp, R., Jina, A., Rising, J., Delgado, M., Mohan, S., ... & Houser, T. (2017). Estimating economic damage from climate change in the United States. *Science*, *356*(6345), 1362-1369.

Howard, P.H., & Sylvan, D. (2015). The Economic Climate: Establishing Expert Consensus on the Economics of Climate Change. Institute for Policy Integrity, 438-441.

Howard, P.H., & Sylvan, D. (2020). Wisdom of the experts: Using survey responses to address positive and normative uncertainties in climate-economic models. *Climatic Change*, *162*(2), 213-232.

Howard, P.H., & Sylvan, D. (2021). Gauging Economic Consensus on Climate Change. Institute for Policy Integrity, 438-441.

Iverson, T., & Karp, L. (2021). Carbon taxes and climate commitment with non-constant time preference. *The Review of Economic Studies*, 88(2), 764-799.

Jaakkola, N., & Millner, A. (2022). Non-dogmatic Climate Policy. *Journal of the Association of Environmental and Resource Economists*, accepted.

Klenert, D., Mattauch, L., Combet, E., Edenhofer, O., Hepburn, C., Rafaty, R. & Stern, N. Making carbon pricing work for citizens. *Nature Climate Change* 8, 669-677 (2018).

Kornek, U., Flachsland, C., Kardish, C., Levi, S., & Edenhofer, O. (2020). What is important for achieving 2° C? UNFCCC and IPCC expert perceptions on obstacles and response options for climate change mitigation. *Environmental Research Letters*, *15*(2), 024005.

Kornek, U., Klenert, D., Edenhofer, O., & Fleurbaey, M. (2021). The social cost of carbon and inequality: when local redistribution shapes global carbon prices. *Journal of Environmental Economics and Management*, 107, 102450.

Levi, S., Flachsland, C., & Jakob, M. (2020). Political Economy Determinants of Carbon Pricing. *Global Environmental Politics*, *20*(2), 128-156.

Levi, S. (2021). Why hate carbon taxes? Machine learning evidence on the roles of personal responsibility, trust, revenue recycling, and other factors across 23 European countries. *Energy Research & Social Science*, *73*, 101883.

Lexico (2021). https://www.lexico.com/definition/glocal. Lexico.com is a collaboration between Dictionary.com and Oxford University Press. Last accessed: 01.12.2021.

Necker, S. (2014). Scientific misbehavior in economics. *Research Policy*, 43(10), 1747-1759.

Nesje, F., Schmidt, R.C., & Drupp, M.A. (2022). Designing Carbon Pricing Policies. Mimeo, University of Hamburg.

Nordhaus, W. D. (1994). Expert opinion on climatic change. *American Scientist*, 82(1), 45-51.

Nordhaus, W. D. (2007). The Stern Review on the economics of climate change. *Journal of Economic Literature*, 45(3), 686-702.

Nordhaus, W.D. (2015). Climate Clubs: Overcoming Free-riding in International Climate Policy. *American Economic Review*, 105, 1339-1370.

Nordhaus, W. D. (2017). Revisiting the social cost of carbon. *Proceedings of the National Academy of Sciences*, 114(7), 1518-1523.

Nordhaus, W. (2018). Projections and uncertainties about climate change in an era of minimal climate policies. *American Economic Journal: Economic Policy*, 10(3), 333-60.

Nordhaus, W. (2019). Climate change: The ultimate challenge for Economics. *American Economic Review*, 109(6), 1991-2014.

Parry, I., Mylonas, V. & Vernon, N. (2021) Mitigation Policies for the Paris Agreement: An Assessment for G20 Countries. *Journal of the Association of Environmental and Resource Economists*, 8(4), 797-823.

Pindyck, R. S. (2013). Climate change policy: what do the models tell us? *Journal of Economic Literature* 51, 860-72.

Pindyck, R. S. (2019). The social cost of carbon revisited. *Journal of Environmental Economics and Management*, 94, 140-160.

Quaas, M.F. & Bröcker, J. (2016). Substitutability and the social cost of carbon in a solvable growth model with irreversible climate change, Economics Working Papers 2016-09, Christian-Albrechts-University of Kiel, Department of Economics.

Rezai, A., & Van der Ploeg, F. (2016). Intergenerational inequality aversion, growth, and the role of damages: Occam's rule for the global carbon tax. *Journal of the Association of Environmental and Resource Economists*, 3(2), 493-522.

Ricke, K., Drouet, L., Caldeira, K., & Tavoni, M. (2018). Country-level social cost of carbon. *Nature Climate Change*, 8(10), 895-900.

Sapienza, P., & Zingales, L. (2013). Economic experts versus average Americans. *American Economic Review*, 103(3), 636-42.

Schauer, M. J. (1995). Estimation of the greenhouse gas externality with uncertainty. *Environmental and Resource Economics*, 5(1), 71-82.

Schmidt, R.C., Drupp, M.A., & Nesje, F. (2022). Testing the free-rider hypothesis in climate policy. Mimeo, University of Hamburg.

Schmidt, R.C. & Heitzig, J. (2014) Carbon leakage: Grandfathering as an incentive device to avert firm relocation. *Journal of Environmental Economics and Management* 67, 209-223.

Schultes, A., Piontek, F., Soergel, B., Rogelj, J., Baumstark, L., Kriegler, E., ... & Luderer, G. (2021). Economic damages from on-going climate change imply deeper near-term emission cuts. *Environmental Research Letters*.

Smulders, S., Toman, M., & Withagen, C. (2014). Growth theory and 'green growth'. *Oxford Review of Economic Policy*, 30, 3, 423-446.

Stern, N. (2007). The Economics of Climate Change: The Stern Review. (Cambridge University Press).

Stern, N., & Stiglitz, J.E. (2022). The economics of immense risk, urgent action and radical change: towards new approaches to the economics of climate change. *Journal of Economic Methodology*, 1-36.

Stiglitz, J.E., Stern, N., Duan, M., Edenhofer, O., Giraud, G., Heal, G.M., la Rovere, E.L., Morris, A., Moyer, E., Pangestu, M., Shukla, P.R., Sokona, Y. & Winkler, H. (2017) Report of the High-Level Commission on Carbon Prices. World Bank, Washington D.C..

Tol, R. S. (2013). Targets for global climate policy: An overview. *Journal of Economic Dynamics and Control*, *37*(5), 911-928.

Tol, R. S. (2018). The Economic Impacts of Climate Change. *Review of Environmental Economics and Policy*, *12*(1), 4-25.

Tol, R. S. (2021a). Estimates of the social cost of carbon have increased over time. *arXiv preprint https://arxiv.org/abs/2105.03656*.

Tol, R. S. (2021b). Europe's Climate Target for 2050: An Assessment. *Intereconomics* 56(6): 330–335

Traeger, C.P. (2021), ACE – Analytic Climate Economy, *SSRN Working Paper*. Available at: https://ssrn.com/abstract=3832722.

van den Bijgaart, I., Gerlagh, R., & Liski, M. (2016). A simple formula for the social cost of carbon. *Journal of Environmental Economics and Management*, 77, 75-94.

Viscusi, W. K., & Masterman, C. J. (2017). Income elasticities and global values of a statistical life. *Journal of Benefit-Cost Analysis*, *8*(2), 226-250.

Wagner, G., Anthoff, D., Cropper, M., Dietz, S., Gillingham, K. T., Groom, B., Kelleher, J.P., Moore, F.C., & Stock, J. H. (2021). Eight priorities for calculating the social cost of carbon. *Nature*, 590(7847), 548-550.

Weitzman, M. L. (2010). What Is The" Damages Function" For Global Warming—And What Difference Might It Make?. *Climate Change Economics*, 1(01), 57-69.

World Bank (2020), Carbon Pricing Dashboard, https://carbonpricingdashboard.worldbank.org [accessed: 26.01.2020].

[WSJ (2019)]. Economists' Statement on Carbon Dividends, *The Wall Street Journal*, Thursday, January 17, 2019.

Appendix

A.1 Details on Expert Selection and Survey Dissemination

A.1.1 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))

A.1.2 Text of the initial e-mail invitation

Dear NN,

We conduct an expert survey on carbon pricing and related policy design issues, such as instrument choice and distribution of revenues. We invite you to participate, as we have identified you as a potential expert based on your publications using a keywords search strategy.

Carbon pricing is key to tackling climate change. Determining appropriate carbon prices is a difficult task that is often informed by large-scale models. These are sensitive to crucial modeling and parameter choices, which are typically based on expert views. Yet, we lack a clear and representative understanding of which carbon prices experts – who may or may not work with numerical models – would indeed feel comfortable with recommending. The aim of our survey is to fill this gap by asking experts directly.

We would be most grateful if you could complete the short survey (9 questions with some sub-questions) appended in the link below:

www.soscisurvey.de/carbon-pricing-survey

Results will be published in a way that no individual participant can be identified. As two of us have demonstrated in a previous expert survey (Drupp et al. 2018, *American Economic Journal: Economic Policy*), we take greatest care in protecting personalized data.

Many thanks in advance for your valuable contribution.

Best regards,
Moritz Drupp (Hamburg), Frikk Nesje (Heidelberg and Oslo) and Robert Schmidt (Hagen)

\- - -
Frikk Nesje
www.frikknesje.com

A.1.3 The Survey

The survey asked publication-based experts about recommended carbon prices and a number of related policy design issues.[39] We also asked for the names of participants and explained in the invitation e-mail that we would protect their anonymity by publishing results only is such a way that no individual participant could be identified. The survey began with the following contextual preamble, followed by eight quantitative and qualitative questions as well as an optional comments section for additional qualitative responses:

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].

[39] We piloted different versions of the survey with a number of selected experts to determine whether the survey was understandable and to strike a balance between completeness and parsimony.

(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: [___].

A.2 Details on data and data cleaning (Section 2.2)

We conducted a number of survey response data cleaning steps, for example correcting or dropping a few implausible answers and swapping the responses to the price ranges questions where these were obviously reversed. A brief overview of these changes is provided below. We also show the actual changes in the price recommendations that our winsorization procedure led to.

- 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.

- Inconsistent responses: We followed up and changed twelve responses in cases where there were obvious typos. We were also in touch with three respondents who wanted to stick with their original response. In three cases we did not adjust the responses as respondents did not reply to our follow-up or were not contactable. We deleted one response that was clearly inconsistent and where the respondent was not possible to follow up.

- 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 adjusted the quantitative survey responses based on respondents' own additional qualitative responses in three cases. Finally, we also corrected the country for one respondent and did some imputation of recommended revenue use from the remaining survey data.

Table A.2.1: Descriptive overview without winsorizing

Carbon prices *(in US$)*							
	Mean	*Median*	*Mode*	*Std.*	*Min*	*Max*	*Obs.*
Global 2020	50.26	40	50	55.22	0	500	445
Global 2030	114.98	70	50	478.95	0	10000	443
Global 2050	2495.43	100	100	47718.31	0	1000000	439
Unilateral with BCA 2020	54.72	40	50	55.39	0	500	439
Unilateral with BCA 2030	106.22	75	100	114.50	0	1000	437
Unilateral w/o BCA 2020	40.94	30	30	39.24	0	400	428
Unilateral w/o BCA 2030	77.54	50.50	50	74.17	0	500	428

Winsorizing: We winsorized 16 survey responses by replacing the two most extreme observations with the third most extreme observation, at the lower and higher end of each question related to the price level. Table A.2.2 contains the descriptive overview for the point recommendations after our winsorization procedure. In comparison, Table A.2.1 shows that the means, standard deviations and maximum values are higher before winsorization.

Table A.2.2: Descriptive overview

***Carbon prices** (in US$)*	*Mean*	*Median*	*Mode*	*Std.*	*Min*	*Max*	*Obs.*
Global 2020	50.26	40	50	55.22	0	500	445
Global 2030	92.40	70	50	81.94	0	500	443
Global 2050	224.36	100	100	372.85	0	4000	439
Unilateral with BCA 2020	54.34	40	50	52.55	0	417	439
Unilateral with BCA 2030	104.39	75	100	102.77	0	1000	437
Unilateral w/o BCA 2020	40.47	30	30	35.84	0	250	428
Unilateral w/o BCA 2030	77.54	50.50	50	74.17	0	500	428

***Determinants** (in % of respondents per response bin)*						
Global CO2 emission reduction target by 2050	*<20%*	*20 to <50%*	*50 to <80%*	*80 to <100%*	*≥100%*	
	3.25	11.28	28.85	47.29	9.33	461
Mitigation costs (for 80% reduction in 2050)	*<0.25%*	*.25 to <.5%*	*.5 to <1%*	*1 to <3%*	*≥3%*	
	4.92	16.78	44.74	22.15	11.41	447
Probability: 2070 damages under BAU ≥20% of GDP	*<5%*	*5 to <10%*	*10 to <20%*	*20 to <50%*	*≥50%*	
	9.77	14.09	18.18	30.91	27.05	440
Expected damages for 3°C warming in % of GDP	*<2%*	*2 to <5%*	*5 to <8%*	*8 to <12%*	*≥12%*	
	3.94	18.52	28.47	23.38%	25.69	432
Utility discount factor (weight on 2070 utility)	*<40%*	*40 to <60%*	*60 to <80%*	*80 to <100%*	*100%*	
	13.65	21.88	19.29	24.24	20.94	425

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

A.3 Additional material on global carbon prices (Section 3.1)

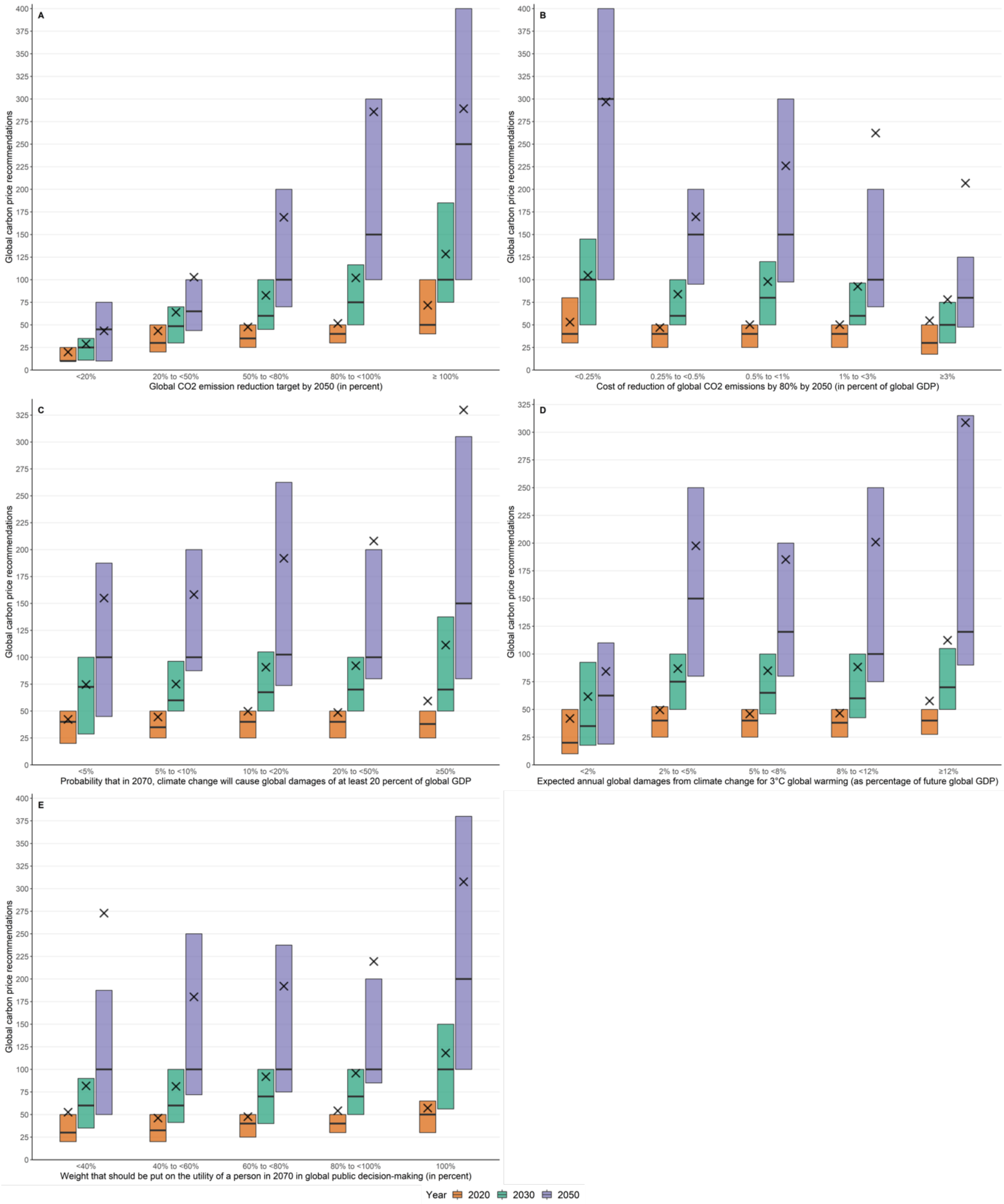


Figure A.3.1: Global carbon price determinants elicited as part of the survey

Notes: Boxplots of global carbon price recommendations by year. Boxes represent interquartile ranges, the black horizontal lines represent median recommendations and the multiplier signs depict mean carbon prices. Panels A – E correspond to parts (a) – (e) of survey Question 8 on "determinants". Panel A: (a) global emission reduction target for 2050, B: emission reduction costs, C: probability of catastrophic climate change, D: damages for 3 degree warming, E: utility discount factor.

A.4 Additional material on unilateral carbon prices (Section 3.2)

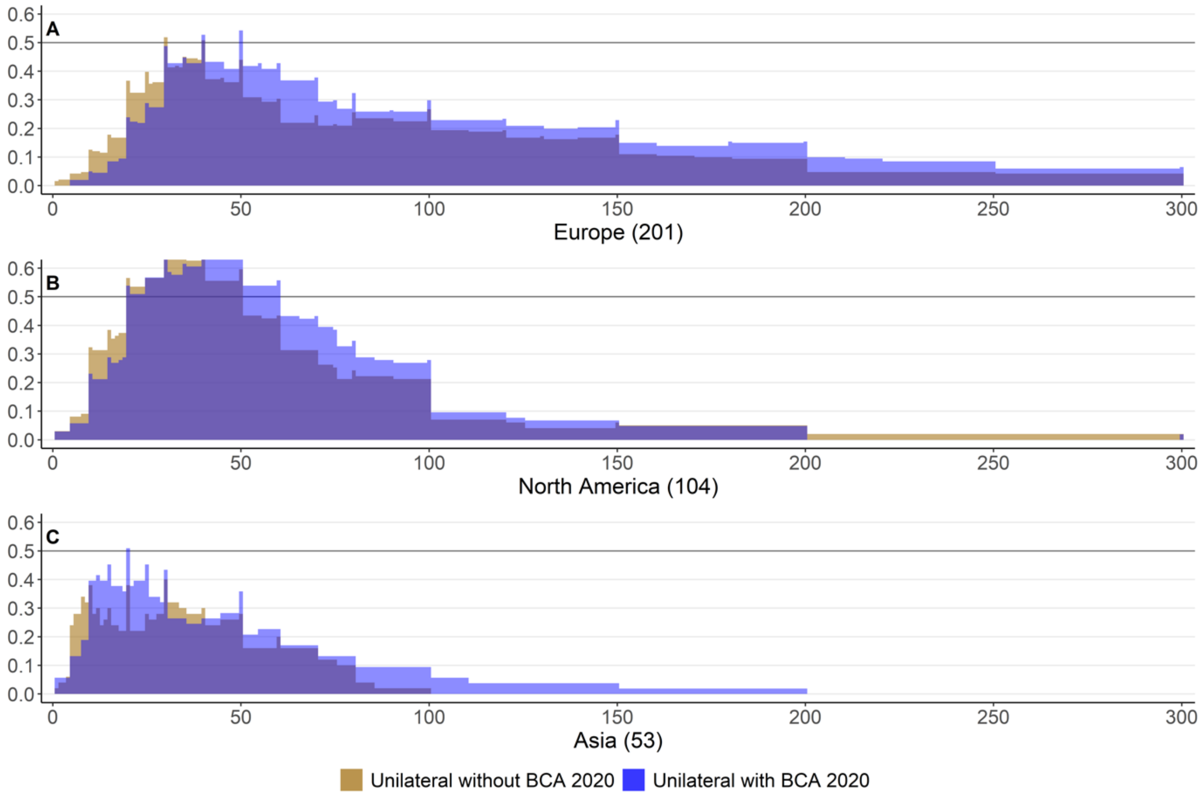


Figure A.4.1: Spaces for agreement on 2020 unilateral carbon prices at a continental-level

Notes: Proportion of experts for whom a certain carbon price level, varied on the horizontal axis, is contained within their acceptable range of unilateral carbon prices with BCA (blue) and without BCA (brown) in 2020 for the three continental blocks with more than 50 responses (Europe, North America and Asia). We have capped carbon prices at $300 for expositional purposes.

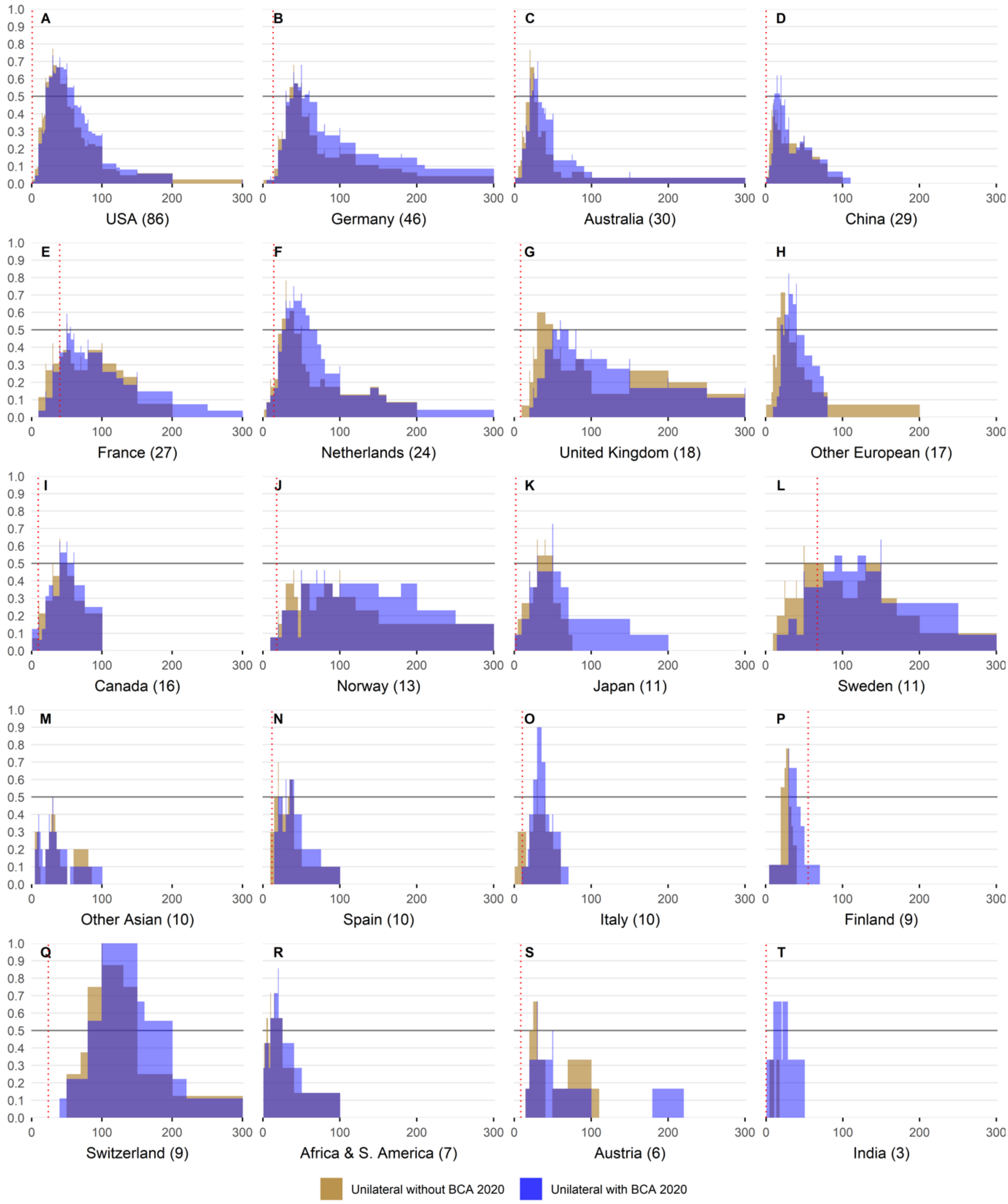


Figure A.4.2: Spaces for agreement on 2020 unilateral carbon prices at a country-level

Notes: Proportion of experts for whom a certain carbon price level, varied on the horizontal axis, is contained within their acceptable range of unilateral carbon prices with BCA (blue) and without BCA (brown) in 2020, for all countries or groups of countries covered in previous Figures. The red dotted line plots the existing emission-weighted unilateral carbon price in 2020. Carbon prices are capped at $300 for expositional purposes as there is no price level of majority support beyond.

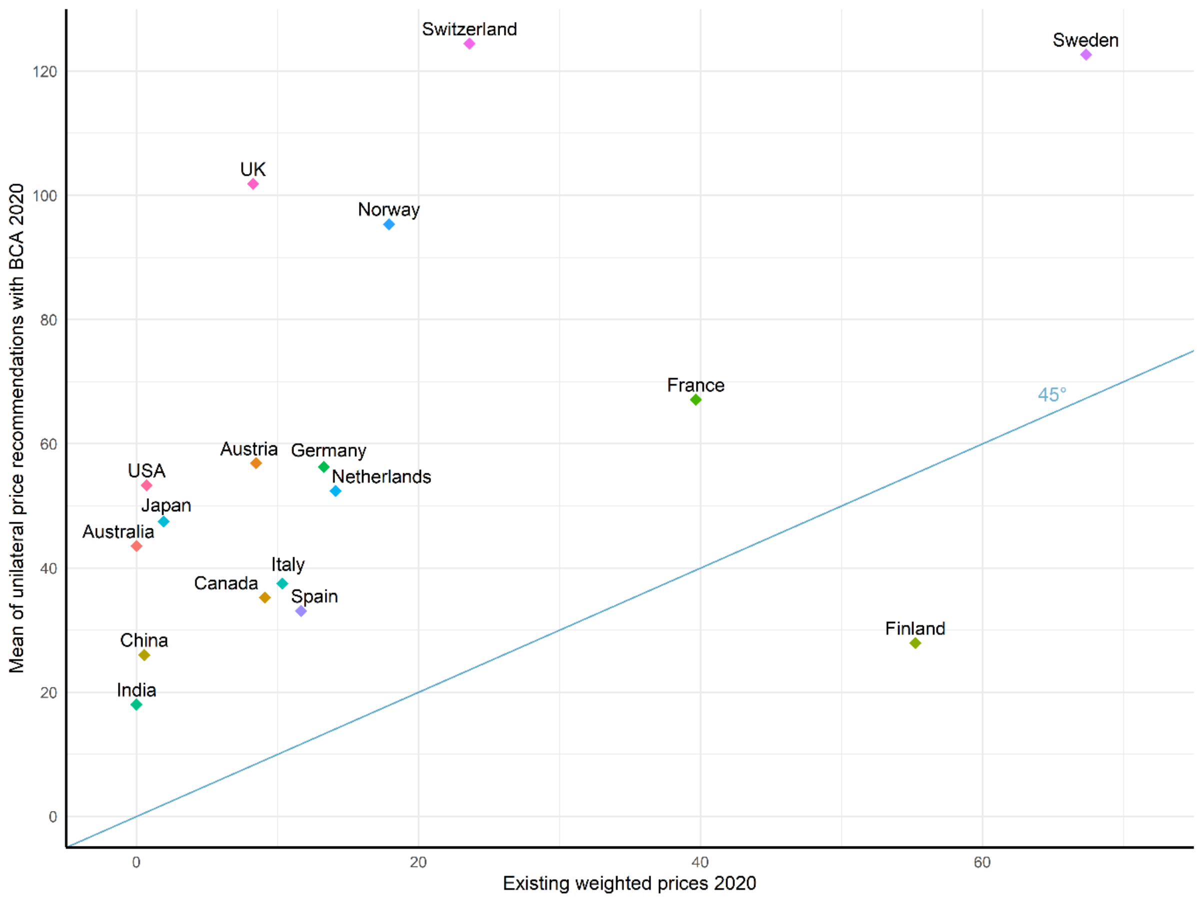
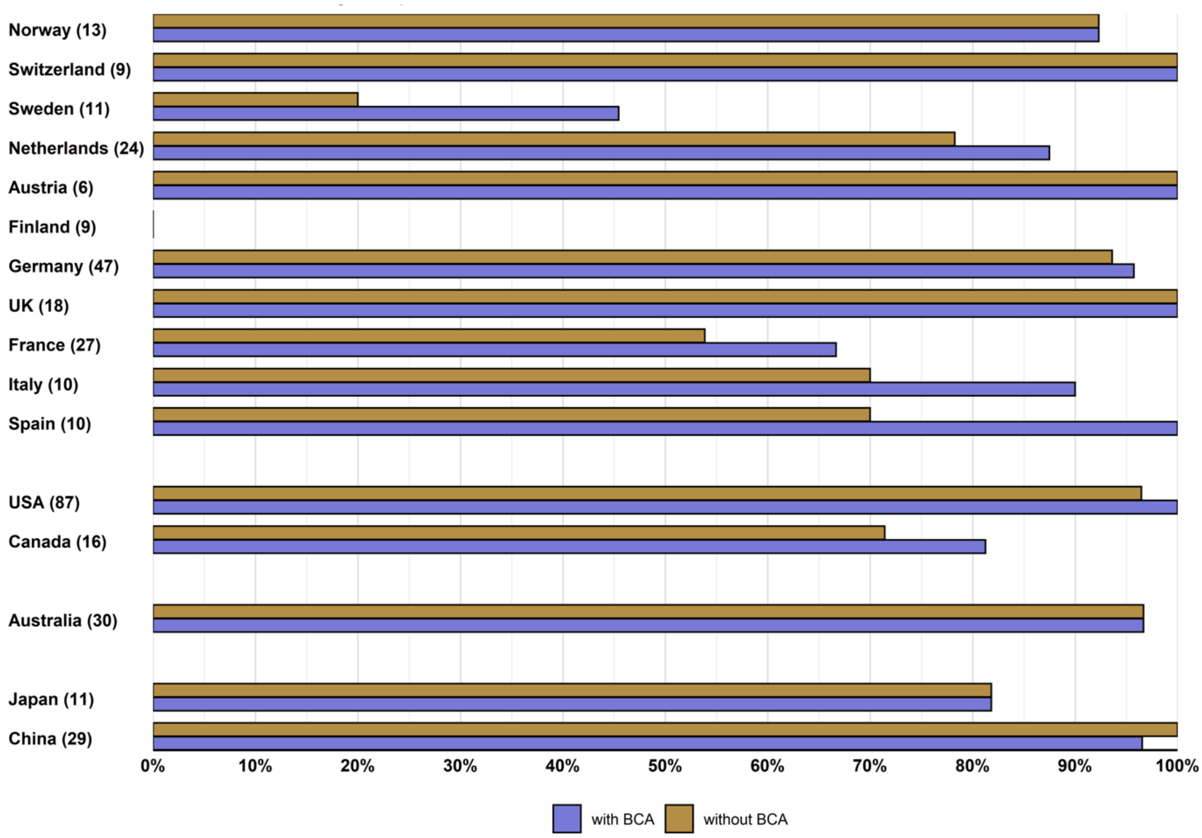


Figure A.4.3: Mean price recommendations by country vs. weighted implemented prices

Notes: Mean of unilateral price recommendations with BCA for 2020 (vertical axis) and existing weighted carbon prices in 2020 (horizontal axis). The vertical difference between each diamond and the 45°-line may be interpreted as the "gap" between the mean recommended and the weighted existing price for the respective country.



<u>Figure A.4.4:</u> Acceptable ranges of 2020 unilateral carbon prices vs. weighted implemented prices at a country-level

Notes: Share of experts whose ranges for 2020 unilateral price recommendations with BCA (blue) and without BCA (brown) lie strictly above the existing weighted carbon prices in 2020.

A.5 Details on predictors of global price recommendations (Section 4)

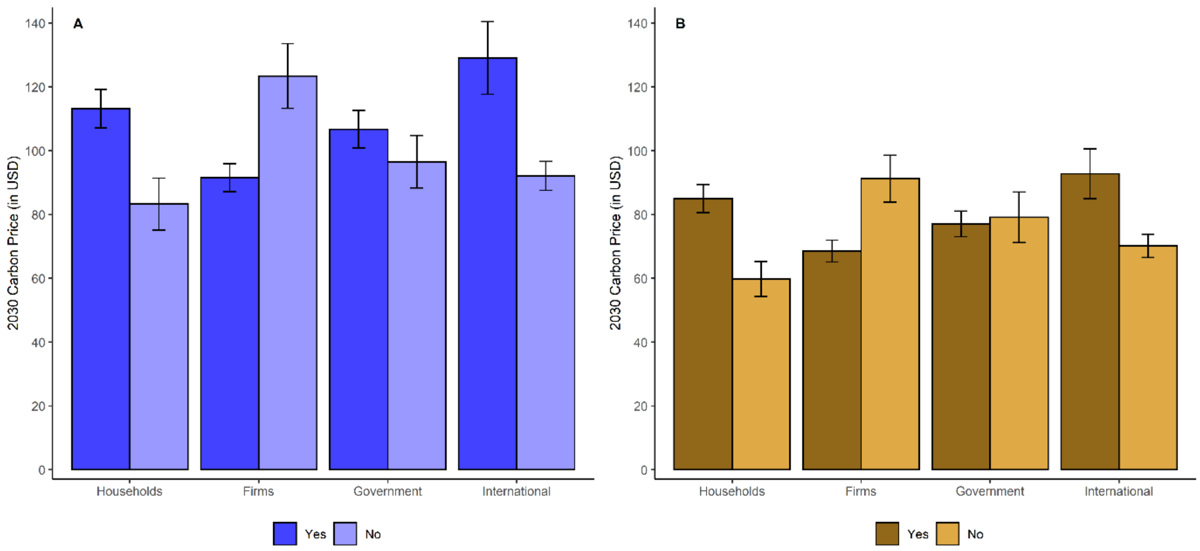
A.5.1 Survey questions on policy design issues

Table A.5.1: Multivariate analysis of carbon price recommendations and survey questions on policy design issues

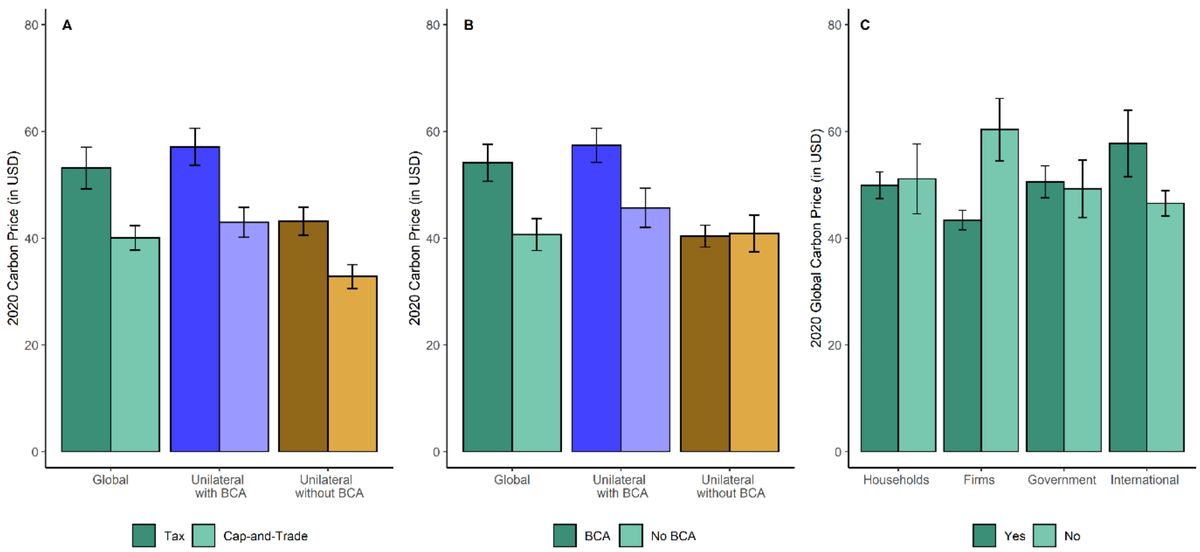
	(1) Global price 2020	(2) Global price 2030	(3) Global price 2050	(4) Unilateral 2020 with BCA	(5) Unilateral 2030 with BCA	(6) Unilateral 2020 w/o BCA	(7) Unilateral 2030 w/o BCA
Instrument: tax	6.15	16.64**	28.78	6.33	21.07**	6.68*	14.74**
(vs. not tax)	(5.21)	(7.70)	(31.96)	(5.08)	(9.81)	(3.58)	(7.04)
BCA strongly	13.45**	13.43*	30.43	10.13**	15.36*	-2.80	-8.20
recommended	(5.21)	(7.77)	(41.34)	(4.99)	(8.82)	(3.95)	(7.49)
Revenue usage:	-2.29	13.62	-18.23	8.20	28.96***	12.56***	27.02***
households	(7.54)	(9.47)	(57.86)	(6.13)	(10.55)	(3.40)	(7.54)
Revenue usage:	-17.79***	-29.24***	-113.47***	-15.20***	-36.68***	-9.91**	-26.70***
firms	(6.00)	(8.83)	(41.66)	(5.72)	(11.22)	(3.94)	(8.26)
Revenue usage:	-5.01	-5.98	-90.94	-1.21	-1.23	0.48	-6.53
government	(6.62)	(10.16)	(71.65)	(4.55)	(10.43)	(3.89)	(9.50)
Revenue usage:	13.18**	23.98**	100.71**	14.63**	36.53***	8.52**	23.64***
international	(6.68)	(10.00)	(50.00)	(6.48)	(12.61)	(3.96)	(9.06)
Constant	49.42***	79.12***	305.84**	43.29***	73.19***	33.28***	70.86***
	(10.26)	(16.63)	(119.18)	(7.92)	(17.56)	(5.53)	(15.00)
Observations	426	425	421	425	424	418	418
R-squared	0.049	0.066	0.041	0.052	0.086	0.060	0.082

Notes: Robust standard errors in parentheses. ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$. The multivariate regressions are estimated by ordinary least squares.

Table A.5.1 reports the multivariate associations between carbon price recommendations and survey questions on policy design issues in the form of ordinary least squares regressions. The results are discussed in Sections 4.1 and 4.5.



<u>Figure A.5.1:</u> Relation between carbon prices and policy design recommendations
Notes: All panels depict relations of policy design recommendations and 2030 carbon prices, with means and standard errors. Panel A depicts how 2030 unilateral carbon price recommendations with BCA vary with recommendations on revenue use. Panel B depicts how 2030 unilateral carbon price recommendations without BCA vary with recommendations on revenue use.



<u>Figure A.5.2:</u> Relation between carbon prices and policy design recommendations
Notes: All panels depict relations of policy design recommendations and 2020 carbon prices, with means and standard errors. Panel A depicts how 2020 carbon price recommendations across all three scenarios vary between those recommending the use of a carbon tax versus a cap-and-trade scheme (in more transparent bars). Panel B shows the equivalent for those that strongly recommend the use of border carbon adjustment (BCA) or not, and Panel C depicts how 2020 global carbon price recommendations vary with recommendations on revenue use.

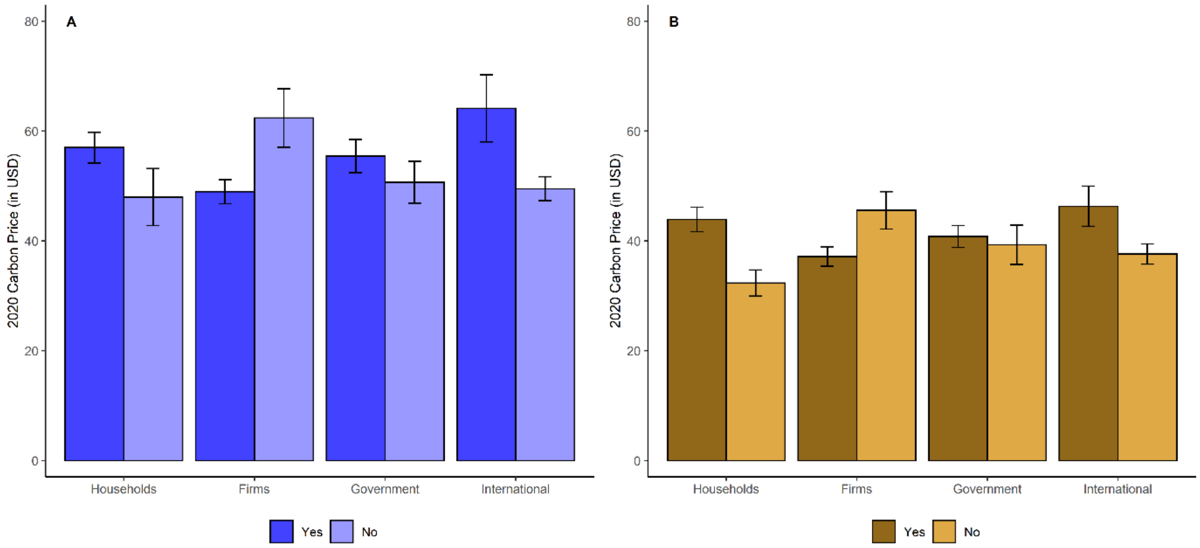


Figure A.5.3: Relation between carbon prices and policy design recommendations

Notes: All panels depict relations of policy design recommendations and 2020 carbon prices, with means and standard errors. Panel A depicts how 2020 unilateral carbon price recommendations with BCA vary with recommendations on revenue use. Panel B depicts how 2020 unilateral carbon price recommendations without BCA vary with recommendations on revenue use.

Table A.5.2: Correlation matrix of recommendations on revenue use

	Global price 2020	Global price 2030	Global price 2050	Unilateral 2020 with BCA	Unilateral 2030 with BCA	Unilateral 2020 w/o BCA	Unilateral 2030 w/o BCA
Government spending	0	-0.004	-0.048	0.029	0.017	0.042	0.011
Lump-sum transf. to households	-0.018	0.018	0.016	0.021	0.047	0.095**	0.102**
Transf. affected households	0.009	0.090*	0.001	0.065	0.120**	0.099**	0.119**
Reduction of distort. taxes	-0.106**	-0.117**	-0.108**	-0.077	-0.107**	-0.048	-0.086*
Grandf. or tax cuts for firms	-0.056	-0.083*	-0.071	-0.075	-0.082*	-0.073	-0.073
Transf. particul. affected firms	-0.066	-0.076	-0.061	-0.07	-0.092*	-0.091*	-0.114**
Spending on env. public goods	-0.015	0.047	-0.015	0.014	0.091*	0.044	0.101**
Green R&D	0.055	0.008	-0.053	0.044	0.004	-0.003	-0.066
Subsidies for renew. energy	-0.085*	-0.071	-0.074	-0.085*	-0.056	-0.049	-0.063
Internat.transf. affected countries	0.012	0.077	0.05	0.06	0.155***	0.101**	0.139***
Internat.transf. climate policy	0.097**	0.090*	0.109**	0.086*	0.113**	0.03	0.068
Other	0.175***	0.150***	0.279***	0.115**	0.096**	0.110**	0.130***

Notes: $* \, p < 0.1$, $** \, p < 0.05$, $*** \, p < 0.01$.

A.5.2 Survey questions on “determinants”

Table A.5.3: Multivariate analysis of carbon price recommendations and survey questions on “determinants”

	(1) Global price 2020	(2) Global price 2030	(3) Global price 2050	(4) Unilateral 2020 with BCA	(5) Unilateral 2030 with BCA	(6) Unilateral 2020 w/o BCA	(7) Unilateral 2030 w/o BCA
Emission reduction target	0.54*** (0.13)	0.75*** (0.12)	0.85*** (0.12)	0.71*** (0.13)	0.87*** (0.12)	0.61*** (0.13)	0.79*** (0.12)
Abatement cost	-0.02 (0.11)	-0.06 (0.10)	-0.13 (0.09)	-0.03 (0.10)	-0.10 (0.10)	-0.07 (0.10)	-0.11 (0.10)
Probability of 20% damages	0.07 (0.09)	0.09 (0.09)	0.07 (0.08)	0.02 (0.09)	0.05 (0.09)	-0.01 (0.10)	-0.05 (0.09)
Mean damages	-0.21* (0.11)	-0.20* (0.11)	-0.13 (0.10)	-0.18 (0.11)	-0.10 (0.11)	-0.04 (0.12)	0.04 (0.12)
Utility discount factor	0.24*** (0.07)	0.25*** (0.07)	0.25*** (0.07)	0.30*** (0.07)	0.32*** (0.07)	0.31*** (0.08)	0.28*** (0.08)
Observations	388	388	387	386	385	380	379
Pseudo R-squared	0.0218	0.0313	0.0388	0.0325	0.0426	0.0293	0.0369

Notes: Robust standard errors in parentheses. ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$. The multivariate regressions are estimated by ordered logit to account for categorical dependent variables.

Table A.5.3 reports the multivariate associations between carbon price recommendations and survey questions on “determinants” in the form of ordered logit regressions. The results are discussed in Sections 4.2 and 4.5.

A.5.3 Country characteristics

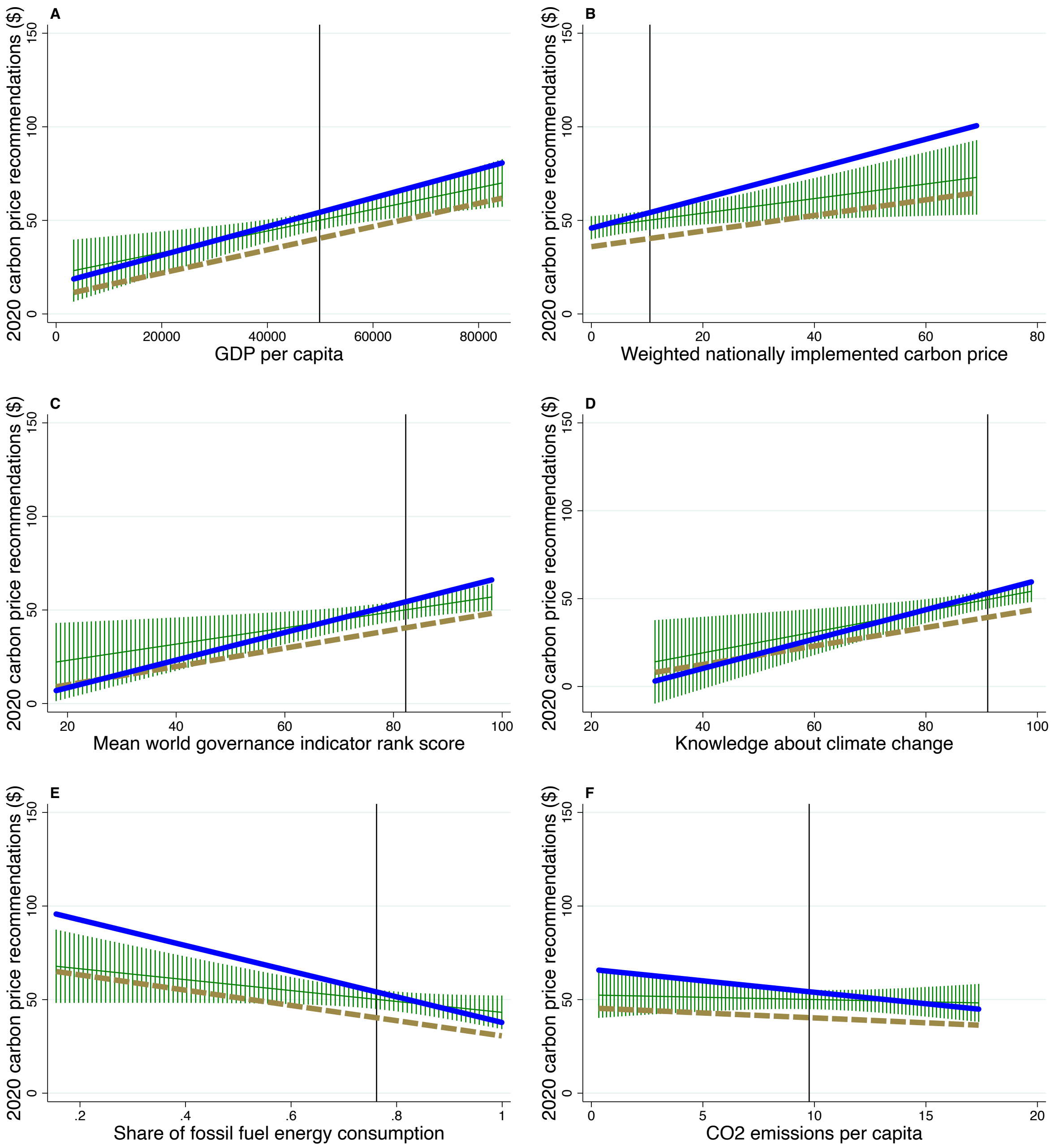


Figure A.5.5: Unilateral and global carbon price recommendations and country characteristics

Notes: Linearly fitted *global* (green line), *unilateral with BCA* (blue line) and *unilateral without BCA* (dashed brown line) carbon price recommendations for the year 2020, with green spikes representing 95 percent confidence levels for global prices, based on country characteristics—from upper left to lower right: GDP per capita (Panel A), weighted nationally implemented carbon prices (B), mean world governance indicator rank scores (C), knowledge about climate change (D), fossil fuel energy consumption (E), and CO_2 emissions per capita (F). The vertical black lines represent mean characteristic values in our sample.

Table A.5.4: Multivariate analysis of carbon price recommendations and country characteristics

	(1) Global price 2020	(2) Global price 2030	(3) Global price 2050	(4) Unilateral 2020 with BCA	(5) Unilateral 2030 with BCA	(6) Unilateral 2020 w/o BCA	(7) Unilateral 2030 w/o BCA
CC: GDP per capita	0.00**	0.00	0.00*	0.00*	0.00	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CC: Weighted carbon price	0.47	0.55	0.01	0.53	0.32	0.19	0.26
	(0.39)	(0.55)	(1.41)	(0.38)	(0.66)	(0.24)	(0.50)
CC: Governance index	-0.52**	-0.40	-1.35	-0.14	0.08	-0.15	-0.31
	(0.26)	(0.45)	(2.04)	(0.26)	(0.54)	(0.18)	(0.39)
CC: Climate change knowledge	0.50*	0.69	0.45	0.57**	1.16**	0.05	0.26
	(0.29)	(0.48)	(2.64)	(0.28)	(0.50)	(0.20)	(0.37)
CC: Fossil energy usage	26.86	4.94	7.70	12.76	-49.94	1.16	-35.95
	(23.74)	(37.03)	(167.40)	(26.93)	(49.82)	(20.90)	(36.68)
CC: CO2 emissions per capita	-0.88	-1.14	-6.79	-1.61*	-1.91	-1.17*	-1.41
	(0.93)	(1.28)	(6.81)	(0.90)	(1.67)	(0.62)	(1.17)
Constant	-4.19	29.64	138.12	-13.90	22.99	16.55	57.22
	(23.48)	(37.75)	(176.12)	(25.64)	(49.16)	(19.36)	(35.27)
Observations	427	426	422	422	421	412	412
R-squared	0.037	0.039	0.015	0.095	0.073	0.088	0.072

Notes: Robust standard errors in parentheses. $*$ $p < 0.1$, $**$ $p < 0.05$, $***$ $p < 0.01$. The multivariate regressions are estimated by ordinary least squares.

Table A.5.4 reports the multivariate associations between carbon price recommendations and country characteristics in the form of ordinary least squares regressions. The results are discussed in Sections 4.3 and 4.5.

Table A.5.5: Multivariate analysis of carbon price recommendations and continent of affiliation

	(1) Global price 2020	(2) Global price 2030	(3) Global price 2050	(4) Unilateral 2020 with BCA	(5) Unilateral 2030 with BCA	(6) Unilateral 2020 w/o BCA	(7) Unilateral 2030 w/o BCA
Europe	2.51	6.03	-6.65	15.62**	16.74	8.45*	12.32
	(7.59)	(10.38)	(57.04)	(6.22)	(13.55)	(4.36)	(9.54)
Oceania	-14.68*	-24.55	-106.38*	-5.39	-24.76	-7.02	-14.92
	(8.47)	(15.45)	(59.27)	(9.58)	(20.22)	(6.59)	(15.55)
Asia	-21.39***	-31.09***	-119.68**	-18.66***	-41.51***	-14.41***	-31.57***
	(7.22)	(11.84)	(55.58)	(5.95)	(15.20)	(4.25)	(9.44)
South America or Africa	-32.90***	-32.79*	-26.04	-34.57***	-49.56***	-29.45***	-38.81***
	(7.78)	(18.69)	(107.73)	(5.98)	(15.63)	(4.01)	(12.30)
Constant	53.53***	95.92***	253.54***	49.82***	104.56***	39.07***	77.56***
	(6.60)	(8.84)	(52.32)	(4.91)	(11.86)	(3.53)	(8.09)
Observations	440	438	434	434	432	423	423
R-squared	0.030	0.030	0.015	0.064	0.044	0.066	0.047

Notes: Robust standard errors in parentheses. ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$. The multivariate regressions are estimated by ordinary least squares.

Table A.5.5 reports the multivariate associations between carbon price recommendations and the continent of affiliation in the form of ordinary least squares regressions.

Table A.5.6: Multivariate analysis of carbon price recommendations and country characteristics as well as continent of affiliation

	(1) Global price 2020	(2) Global price 2030	(3) Global price 2050	(4) Unilateral 2020 with BCA	(5) Unilateral 2030 with BCA	(6) Unilateral 2020 w/o BCA	(7) Unilateral 2030 w/o BCA
Europe	-19.51	-24.48	-126.58	-11.38	-28.04	3.50	-4.73
	(15.12)	(21.58)	(88.23)	(13.80)	(25.86)	(9.65)	(19.37)
Oceania	-14.40	-27.58	-106.43	-0.94	-22.35	3.88	5.00
	(9.997)	(18.02)	(69.57)	(11.74)	(23.91)	(8.58)	(18.09)
Asia	-23.87	-29.54	-148.10	-4.78	-17.10	8.72	5.35
	(17.26)	(25.59)	(113.01)	(16.98)	(32.11)	(12.49)	(21.52)
South America or Africa	-26.63*	-22.19	-20.95	-15.79	-24.32	-5.26	-4.66
	(15.76)	(29.17)	(135.66)	(15.34)	(31.51)	(10.92)	(22.27)
CC: GDP per capita	0.000505	0.00	0.00	0.00	0.00	0.00***	0.00**
	(0.000393)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CC: Weighted carbon price	0.655	0.84	1.80	0.58	0.56	0.10	0.25
	(0.484)	(0.66)	(1.79)	(0.47)	(0.80)	(0.30)	(0.62)
CC: Governance index	-0.273	0.01	0.32	-0.08	0.43	-0.21	-0.35
	(0.219)	(0.42)	(1.88)	(0.25)	(0.56)	(0.15)	(0.35)
CC: Climate change knowledge	0.370	0.56	-0.15	0.55**	1.12**	0.10	0.30
	(0.240)	(0.46)	(2.21)	(0.24)	(0.54)	(0.16)	(0.35)
CC: Fossil energy usage	59.35	53.00	277.80	20.94	-12.11	-12.69	-39.40
	(40.02)	(54.47)	(253.40)	(43.71)	(71.17)	(32.55)	(55.64)
CC: CO2 emissions per capita	-2.656	-3.09	-17.90	-2.86*	-4.44	-0.90	-2.12
	(1.736)	(2.37)	(11.48)	(1.64)	(2.82)	(1.07)	(2.01)
Constant	1.913	23.44	83.26	-9.44	13.08	18.96	57.99
	(22.23)	(40.36)	(146.04)	(24.11)	(57.78)	(18.67)	(35.84)
Observations	427	426	422	422	421	412	412
R-squared	0.042	0.045	0.021	0.097	0.076	0.092	0.073

Notes: Robust standard errors in parentheses. ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$. The multivariate regressions are estimated by ordinary least squares.

Table A.5.6 reports the multivariate associations between carbon price recommendations and country characteristics as well as the continent of affiliation in the form of ordinary least squares regressions.

Table A.5.7: Correlation matrix of country-level information

	CC: GDP per capita	CC: Weigthed carbon price	CC: Governance index	CC: Climate change knowledge	CC: Fossil energy usage	CC: CO2 emissions per capita
CC: GDP per capita	1					
CC: Weigthed carbon price	0.103**	1				
CC: Governance index	0.827***	0.258***	1			
CC: Climate change knowledge	0.835***	0.178***	0.865***	1		
CC: Fossil energy usage	-0.059	-0.850***	-0.138***	-0.071	1	
CC: CO2 emissions per capita	0.458***	-0.490***	0.342***	0.389***	0.543***	1

Notes: ∗ p < 0.1, ∗∗ p < 0.05, ∗∗∗ p < 0.01.

There is a caveat to Table A.5.3, however, illustrated in Table A.5.7. The correlation matrix establishes that the country-level information remains highly correlated, meaning – as discussed in Section 4.3 – that it is difficult to disentangle the effects of the global carbon price recommendation of the various sources of country-level information.

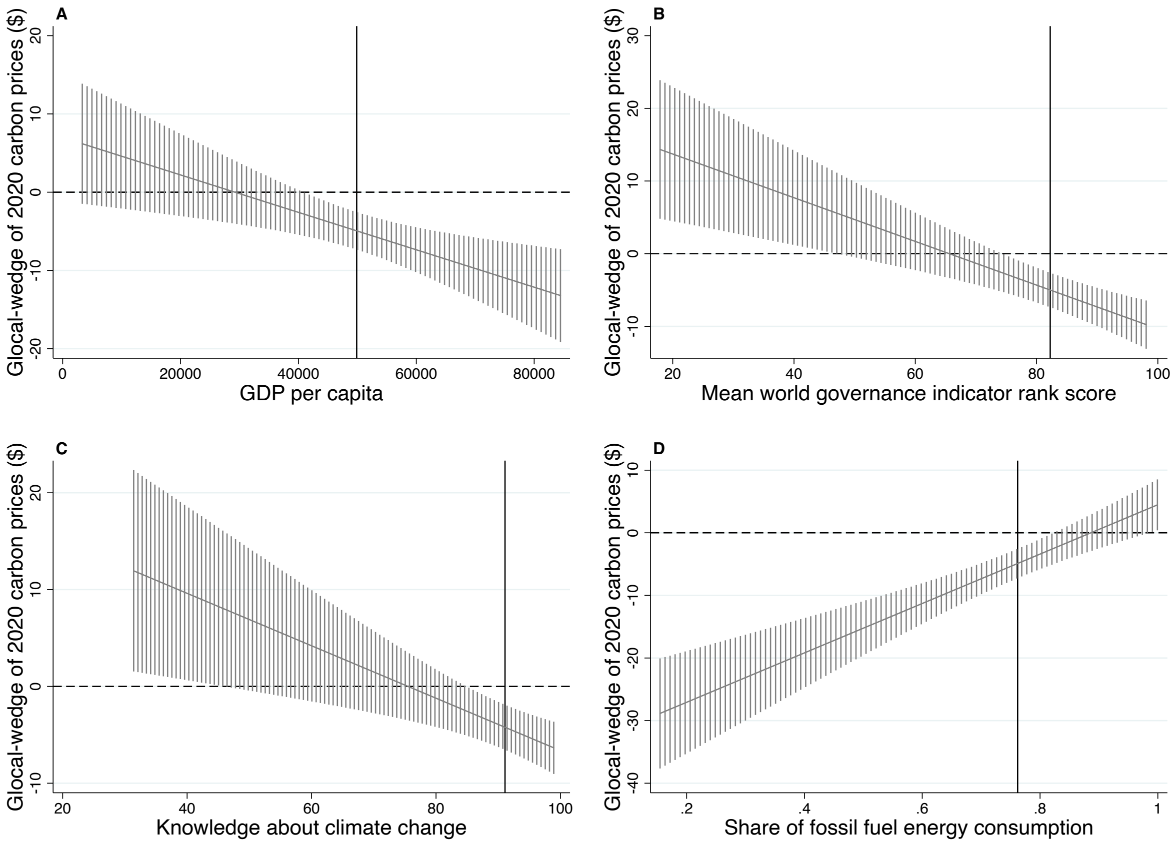


Figure A.5.6: Glocal-wedge of carbon price recommendations and country characteristics

Notes: Linearly fitted Glocal-wedges for the year 2020, i.e. the difference in carbon price recommendations between the *global* and *unilateral with border carbon adjustment* scenarios, with spikes representing 95 percent confidence intervals, based on country characteristics: GDP per capita (Panel A), mean world governance indicator rank score (Panel B), knowledge about climate change (Panel C), fossil fuel energy consumption (Panel D). The vertical black lines represent mean characteristic values in our sample.

A.5.4 Observable expert characteristics

Table A.5.8: Multivariate analysis of carbon price recommendations and observable expert characteristics

	(1) Global price 2020	(2) Global price 2030	(3) Global price 2050	(4) Unilateral 2020 with BCA	(5) Unilateral 2030 with BCA	(6) Unilateral 2020 w/o BCA	(7) Unilateral 2030 w/o BCA
EC: Male	-9.58	-16.39	-32.41	-9.49	-8.72	-0.93	-17.22
	(11.27)	(15.68)	(73.02)	(10.89)	(17.19)	(5.29)	(13.73)
EC: Nb. of publications	-2.40	-1.88	-9.16	-2.70	-3.46	-1.84	-3.49
	(2.06)	(2.86)	(9.53)	(2.18)	(2.93)	(1.52)	(2.82)
EC: Nb. of citations	0.04	0.03	0.16	0.04	0.02	0.02	0.05
	(0.05)	(0.06)	(0.21)	(0.05)	(0.07)	(0.03)	(0.06)
EC: Published in econ	-5.44	3.33	-32.83	-1.57	0.63	4.04	11.24
	(6.80)	(11.60)	(48.15)	(6.70)	(14.89)	(4.61)	(10.32)
EC: Nb. of econ publicat.	3.41**	2.36	4.21	3.08*	1.42	1.76	1.53
	(1.62)	(3.12)	(8.88)	(1.76)	(3.55)	(1.53)	(2.84)
EC: Published on IAM	1.46	7.04	-7.76	1.28	1.88	6.19	7.83
	(6.40)	(10.67)	(29.04)	(8.22)	(13.42)	(6.90)	(11.80)
EC: Published on SCC	1.35	-11.86	-54.51*	5.55	-4.81	5.83	-1.14
	(7.57)	(11.82)	(31.93)	(9.00)	(14.00)	(8.65)	(13.57)
EC: Published on cap-and-tr.	-0.71	-20.92*	-118.29***	1.38	-30.52*	-0.50	-20.63*
	(7.72)	(11.99)	(39.48)	(8.22)	(16.11)	(6.63)	(11.14)
EC: Published on tax	2.61	0.04	-12.08	2.94	-9.56	-3.85	-10.45
	(6.78)	(10.44)	(46.39)	(6.50)	(14.17)	(4.62)	(10.01)
Constant	61.10***	109.01***	315.19***	64.78***	130.72***	42.67***	98.92***
	(13.78)	(20.64)	(109.79)	(13.87)	(23.57)	(8.40)	(20.71)
Observations	382	380	378	378	376	370	369
R-squared	0.013	0.013	0.012	0.016	0.010	0.027	0.025

Notes: Robust standard errors in parentheses. ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$. The multivariate regressions are estimated by ordinary least squares.

Table A.5.8 reports the multivariate associations between carbon price recommendations and observable expert characteristics in the form of ordinary least squares regressions. The results are discussed in Sections 4.3 and 4.5.

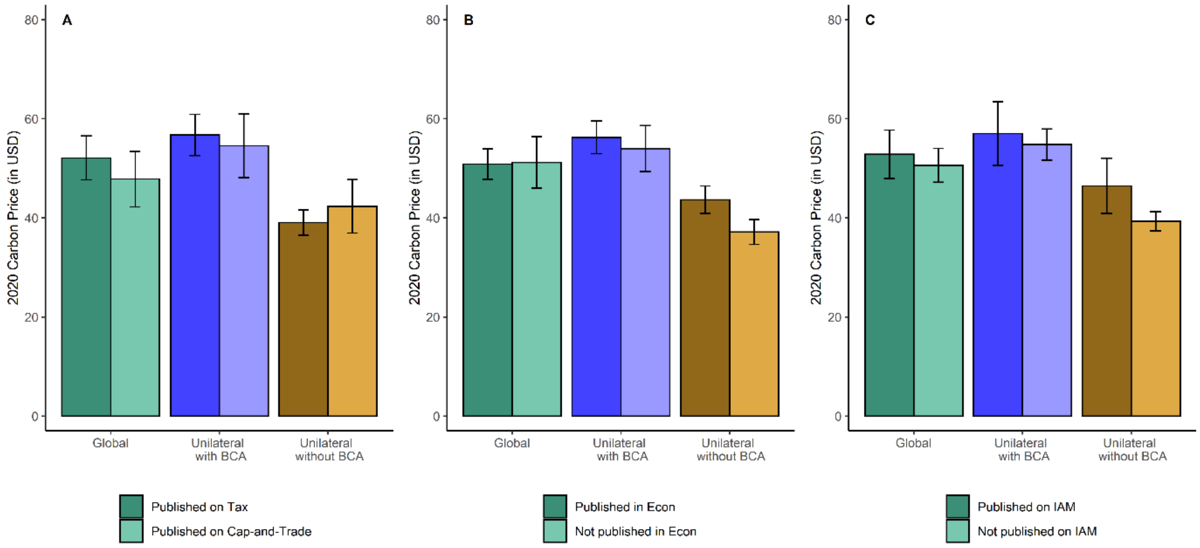


Figure A.5.7: Carbon price recommendations and selected observable expert characteristics
Notes: All panels depict relations of policy design recommendations and 2020 carbon prices, with means and standard errors. Panel A depicts how 2020 carbon price recommendations across all three scenarios, global (green) as well as unilateral with (blue) and without (brown) BCA, vary between those publishing on the use of a carbon tax versus a cap-and-trade scheme (in more transparent bars). Panel B shows the equivalent for those that publish in economics journals and not, and Panel C depicts how 2020 carbon price recommendations vary between those publishing on IAMs and not.

A.5.5 The data in combination

The remaining tables report the multivariate analysis when considering all four additional data sources. In addition to results discussed in Section 4.5, we provide a more detailed account of the multivariate analysis here, focusing first on global carbon price recommendations and subsequently on unilateral carbon price recommendations.

Regarding experts' recommendations for the 2020 global carbon price, we find that these variables have the expected predictive power (Table A.5.11). More precisely, across many specifications we see higher recommended prices from those experts supporting the introduction of BCA, recommending using part of the revenue for international transfers, providing higher ERT and discount factors, or with a home country with more knowledge about climate change. Experts who recommend using part of the revenue for transfers to firms and those who have Oceania as the continent of affiliation, on average, recommend lower 2020 carbon prices. We see, however, that whether an expert prefers carbon taxes, recommends using part of the revenue for transfers for government spending, or has published on cap-and-trade do not generally explain the mean 2020 carbon price recommendations. The same conclusions hold qualitatively for the global carbon price in 2030 – with the additions that in several specifications supporting the introduction of BCA is not always a significant predictor and that a home country with more knowledge about climate change loses explanatory power (Table A.5.12). For 2030, we also find that preferring a carbon tax over alternatives becomes a positive predictor and publishing on cap-and-trade a negative predictor. Further, experts' support for BCA has no explanatory power for the 2050 carbon price recommendations (Table A.5.13). Yet, whether an expert prefers carbon taxes over alternatives or publishes on cap-and-trade has predictive power. For global carbon price recommendations, these findings support what we established above. In this model, we confirm the results for the survey questions on policy design issues and "determinants" and also country-information. The picture is less clear for the survey questions on observable expert characteristics, but—whenever statistically significant—results align with what we discussed in Sections 4.1 and 4.4.

We also consider the same model specifications for the unilateral price recommendations, with and without BCA. For the 2020 and 2030 carbon price recommendations with BCA, we find that recommending using part of the revenue for transfers for government spending and having published on cap-and-trade do not have any predictive power (Tables A.5.14-15). The other variables related to survey questions on policy design issues and "determinants", and also country-information give the expected results. Without BCA, we qualitatively confirm many of the insights (Tables A.5.16-17). Here, experts' preference for BCA are generally less predictive of price recommendations in 2020 or 2030.

Table A.5.9: Multivariate analysis of carbon price recommendations using all four additional data sources

	(1) Global price 2020	(2) Global price 2030	(3) Global price 2050	(4) Unilateral 2020 with BCA	(5) Unilateral 2030 with BCA	(6) Unilateral 2020 w/o BCA	(7) Unilateral 2030 w/o BCA
Instrument: tax	4.05	12.74	36.43	2.39	13.10	1.89	7.37
(vs. not tax)	(6.84)	(10.15)	(33.03)	(6.57)	(11.37)	(4.38)	(8.91)
BCA strongly	10.60*	7.16	-14.93	6.68	7.71	-3.95	-13.61
recommended	(5.71)	(9.93)	(54.82)	(5.26)	(10.65)	(4.32)	(9.37)
Revenue usage:	-1.63	13.10	-37.84	11.27*	25.73**	12.25***	22.50**
households	(9.79)	(12.42)	(80.79)	(6.63)	(12.15)	(4.02)	(10.29)
Revenue usage:	-21.72***	-34.77***	-109.73***	-20.49***	-41.69***	-13.35***	-34.24***
firms	(6.88)	(10.68)	(35.66)	(6.83)	(12.11)	(4.84)	(10.31)
Revenue usage:	-12.03	-19.86	-166.76	-1.77	-5.92	0.71	-9.37
government	(11.65)	(15.12)	(119.07)	(6.23)	(13.52)	(5.21)	(13.10)
Revenue usage:	14.76*	26.04**	83.79	18.05**	35.95**	11.72**	27.25**
international	(8.42)	(12.51)	(53.31)	(8.04)	(14.65)	(4.92)	(11.33)
Emission	3.08	12.95*	66.32**	6.05	21.82***	5.61*	14.20**
reduction target	(5.16)	(6.79)	(26.95)	(4.62)	(8.13)	(3.04)	(6.15)
Abatement cost	1.31	0.83	7.88	0.99	-1.41	-0.31	-0.41
	(2.95)	(4.51)	(17.01)	(2.53)	(5.11)	(1.74)	(3.76)
Probability of	5.02	7.50	33.81	0.32	3.01	-2.05	-0.57
20% damages	(3.30)	(5.14)	(21.83)	(3.26)	(5.36)	(2.72)	(4.85)
Mean damages	-2.47	-0.95	11.88	-2.41	1.58	1.14	4.56
	(3.84)	(5.87)	(22.75)	(3.36)	(6.09)	(2.75)	(5.18)
Utility discount	2.04	5.74	14.19	3.44	10.62**	2.98*	5.98*
factor	(3.09)	(3.97)	(23.35)	(2.40)	(4.61)	(1.60)	(3.53)
Europe	-4.41	-1.93	-74.06	1.84	-3.19	8.85	4.04
	(16.87)	(24.35)	(95.53)	(16.74)	(31.01)	(11.23)	(22.53)
Oceania	-10.34	-24.09	-99.91	7.51	-22.73	7.31	9.85
	(12.04)	(20.51)	(92.56)	(12.30)	(26.89)	(9.16)	(19.76)
Asia	-2.39	13.81	30.96	19.53	40.40	18.59	29.42
	(15.69)	(25.07)	(86.59)	(17.41)	(34.42)	(14.23)	(23.34)
South America	-13.15	4.30	78.60	6.13	9.58	0.64	-1.43

or Africa	(16.24)	(31.21)	(140.75)	(16.12)	(36.28)	(13.95)	(26.26)
CC: GDP per capita	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)	0.00* (0.00)	0.00 (0.00)	0.00** (0.00)	0.00* (0.00)
CC: Weigthed carbon price	0.29 (0.58)	0.29 (0.74)	-0.19 (1.97)	0.25 (0.56)	-0.02 (0.94)	-0.24 (0.34)	-0.19 (0.69)
CC: Governance index	-0.24 (0.30)	0.14 (0.55)	-0.43 (2.07)	0.02 (0.35)	0.53 (0.72)	-0.07 (0.21)	-0.25 (0.42)
CC: Climate change knowledge	0.03 (0.28)	0.09 (0.54)	-2.08 (2.18)	0.09 (0.31)	0.39 (0.62)	-0.09 (0.23)	-0.00 (0.44)
CC: Fossil energy usage	-3.12 (39.33)	-46.90 (56.22)	-192.36 (231.04)	-29.55 (45.20)	-126.70 (78.93)	-41.22 (34.72)	-94.31 (59.49)
CC: CO2 emissions per capita	-0.17 (1.85)	1.14 (2.87)	0.28 (10.98)	-1.54 (2.00)	0.74 (3.91)	-0.60 (1.41)	-0.59 (2.60)
EC: Male	-17.30 (11.84)	-29.23 (17.95)	-98.31 (85.33)	-16.16 (11.27)	-19.89 (17.87)	-3.43 (6.20)	-23.48 (15.80)
EC: Nb. of publications	-1.71 (2.42)	-1.64 (2.98)	-5.38 (11.53)	-1.91 (2.41)	-1.50 (2.86)	-1.18 (1.62)	-2.59 (2.85)
EC: Nb. of citations	0.05 (0.06)	0.06 (0.07)	0.29 (0.29)	0.04 (0.06)	0.03 (0.07)	0.02 (0.04)	0.06 (0.07)
EC: Published in econ	3.90 (8.40)	17.51 (12.51)	24.54 (41.75)	8.00 (7.43)	17.73 (13.40)	10.68** (5.36)	22.84** (11.01)
EC: Nb. of econ publications	1.32 (1.74)	-0.44 (3.07)	-7.43 (9.89)	0.20 (1.65)	-4.15 (3.37)	-1.02 (1.38)	-2.55 (2.66)
EC: Published on IAM	6.00 (7.30)	8.11 (12.44)	-17.79 (38.24)	2.14 (7.66)	-1.49 (12.98)	5.83 (6.42)	5.30 (11.07)
EC: Published on SCC	-1.10 (8.93)	-12.70 (13.80)	-49.12 (51.07)	11.93 (8.78)	8.44 (14.28)	8.23 (7.73)	3.98 (12.65)
EC: Published on cap-and-trade	5.19 (9.48)	-10.00 (13.94)	-76.13 (47.19)	9.45 (8.75)	-16.40 (18.66)	2.63 (6.73)	-10.70 (13.04)
EC: Published on tax	5.44 (8.49)	4.49 (11.53)	10.93 (46.59)	5.58 (7.28)	-2.76 (14.31)	-1.35 (4.98)	-6.38 (10.09)
Constant	29.65 (33.92)	13.64 (59.59)	204.53 (251.87)	1.38 (35.05)	-35.67 (77.30)	16.58 (27.55)	51.16 (52.90)
Observations	319	320	319	320	320	317	316
R-squared	0.131	0.187	0.155	0.221	0.252	0.240	0.253

Notes: Robust standard errors in parentheses. ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$. The multivariate regressions are estimated by ordinary least squares.

Table A.5.10: Multivariate analysis of carbon price recommendations using all four additional data sources

	(1) Global price 2020	(2) Global price 2030	(3) Global price 2050	(4) Unilateral 2020 with BCA	(5) Unilateral 2030 with BCA	(6) Unilateral 2020 w/o BCA	(7) Unilateral 2030 w/o BCA
Instrument: tax (vs. not tax)	-0.05	0.01	0.24	0.11	0.19	-0.15	0.05
	(0.22)	(0.23)	(0.22)	(0.21)	(0.21)	(0.22)	(0.23)
BCA strongly recommended	0.38	0.03	-0.22	0.26	0.08	-0.22	-0.46*
	(0.25)	(0.25)	(0.24)	(0.25)	(0.26)	(0.26)	(0.26)
Revenue usage: households	0.33	0.60**	0.72***	0.57**	0.82***	0.51**	0.76***
	(0.26)	(0.25)	(0.26)	(0.25)	(0.26)	(0.24)	(0.26)
Revenue usage: firms	-0.62**	-0.63***	-0.72***	-0.49**	-0.66***	-0.55**	-0.71***
	(0.25)	(0.24)	(0.23)	(0.24)	(0.23)	(0.25)	(0.26)
Revenue usage: government	-0.04	-0.07	-0.05	0.07	0.23	0.21	0.19
	(0.29)	(0.30)	(0.31)	(0.26)	(0.29)	(0.29)	(0.31)
Revenue usage: international	0.09	0.26	0.42*	0.24	0.41	0.40	0.48*
	(0.27)	(0.27)	(0.24)	(0.25)	(0.26)	(0.24)	(0.25)
Emission reduct. target	0.38**	0.58***	0.75***	0.45***	0.61***	0.47***	0.65***
	(0.15)	(0.14)	(0.15)	(0.16)	(0.15)	(0.16)	(0.15)
Abatement cost	-0.04	-0.04	-0.14	-0.03	-0.09	0.01	-0.04
	(0.12)	(0.12)	(0.10)	(0.12)	(0.12)	(0.12)	(0.12)
Probability of 20% damages	0.16	0.14	0.11	0.05	0.07	-0.04	-0.05
	(0.12)	(0.11)	(0.10)	(0.11)	(0.11)	(0.12)	(0.11)
Mean damages	-0.27*	-0.22*	-0.11	-0.14	-0.07	-0.01	0.05
	(0.14)	(0.13)	(0.12)	(0.13)	(0.12)	(0.15)	(0.14)
Utility discount factor	0.21**	0.21***	0.18**	0.19**	0.21**	0.25***	0.20**
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)	(0.09)
Europe	1.19*	0.38	0.05	0.57	0.11	0.76	0.28
	(0.64)	(0.93)	(0.98)	(0.73)	(0.84)	(0.71)	(0.89)
Oceania	-0.31	-0.89*	-0.42	-0.13	-0.61	-0.06	-0.09
	(0.54)	(0.54)	(0.56)	(0.52)	(0.56)	(0.54)	(0.55)
Asia	0.74	0.16	0.56	0.73	0.12	1.47*	1.10
	(0.85)	(1.06)	(1.07)	(0.81)	(0.84)	(0.87)	(0.84)
South America or Africa	0.19	0.71	1.39	-0.06	0.51	0.35	0.78
	(0.88)	(1.24)	(1.68)	(0.89)	(1.11)	(1.01)	(1.18)
CC: GDP per capita	0.00	0.00	0.00*	0.00	0.00	0.00**	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CC: Weighted carbon price	0.00	0.01	0.01	0.02	0.02	0.01	0.01
	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
CC: Governance index	-0.02	0.00	0.01	-0.01	0.00	-0.01	-0.01
	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
CC: Climate							

change knowledge	0.01 (0.02)	-0.00 (0.02)	-0.01 (0.03)	0.04** (0.02)	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)
CC: Fossil energy usage	0.08 (1.40)	0.75 (1.62)	1.62 (1.66)	-0.45 (1.49)	0.67 (1.45)	-1.11 (1.36)	-0.21 (1.34)
CC: CO2 emissions per capita	0.06 (0.09)	0.01 (0.12)	-0.06 (0.13)	-0.05 (0.11)	-0.06 (0.12)	-0.02 (0.10)	-0.04 (0.12)
EC: Male	-0.34 (0.33)	-0.46 (0.35)	-0.54 (0.33)	-0.38 (0.32)	-0.60* (0.33)	-0.12 (0.29)	-0.42 (0.32)
EC: Nb. of publications	-0.07 (0.07)	-0.07 (0.06)	-0.07 (0.06)	-0.02 (0.06)	-0.05 (0.06)	-0.06 (0.05)	-0.05 (0.06)
EC: Nb. of citations	0.00 (0.00)	0.00 (0.00)	0.00* (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
EC: Published in econ	0.27 (0.29)	0.24 (0.28)	0.41 (0.27)	0.22 (0.28)	0.24 (0.27)	0.31 (0.30)	0.34 (0.29)
EC: Nb. of econ publications	0.10 (0.08)	0.08 (0.08)	0.02 (0.07)	0.04 (0.08)	0.04 (0.07)	-0.01 (0.08)	0.02 (0.08)
EC: Published on IAM	0.25 (0.36)	0.38 (0.31)	0.32 (0.30)	-0.07 (0.32)	0.16 (0.29)	-0.11 (0.38)	0.08 (0.33)
EC: Published on SCC	0.48 (0.42)	0.11 (0.38)	-0.08 (0.38)	0.80* (0.42)	0.41 (0.39)	0.70 (0.43)	0.42 (0.40)
EC: Published on cap-and-trade	0.35 (0.41)	-0.06 (0.39)	-0.46 (0.38)	0.66* (0.38)	0.06 (0.39)	0.36 (0.42)	-0.02 (0.40)
EC: Published on tax	0.05 (0.25)	0.07 (0.26)	-0.09 (0.24)	0.02 (0.24)	-0.08 (0.26)	-0.10 (0.24)	-0.09 (0.25)
Observations	319	320	319	320	320	317	316
Pseudo R-squared	0.0537	0.0527	0.0640	0.0847	0.0811	0.0772	0.0741

Notes: Robust standard errors in parentheses. ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$. The multivariate regressions are estimated by ordered logit to account for categorical dependent variables.

Table A.5.11: Multivariate analysis of the 2020 global carbon price recommendations using all four additional data sources

	(1) Global price 2020	(2) Global price 2020	(3) Global price 2020	(4) Global price 2020	(5) Global price 2020	(6) Global price 2020	(7) Global price 2020
Instrument: tax	6.15	6.11	0.28	2.57	0.11	3.40	0.07
(vs. not tax)	(5.21)	(5.60)	(0.19)	(5.50)	(0.19)	(6.12)	(0.20)
BCA strongly	13.45**	12.98**	0.33	14.41**	0.41*	13.72**	0.34
recommended	(5.21)	(5.58)	(0.21)	(5.68)	(0.21)	(6.16)	(0.22)
Revenue usage:	-2.29	-5.82	0.06	-6.24	0.15	-6.17	0.21
households	(7.54)	(8.27)	(0.22)	(8.77)	(0.23)	(9.73)	(0.24)
Revenue usage:	-17.79***	-20.26***	-0.44**	-20.11***	-0.42*	-21.78***	-0.40*
firms	(6.00)	(6.89)	(0.20)	(6.66)	(0.21)	(7.39)	(0.23)
Revenue usage:	-5.01	-7.91	-0.24	-4.87	-0.11	-6.85	-0.16
government	(6.62)	(7.05)	(0.22)	(7.49)	(0.22)	(8.79)	(0.24)
Revenue usage:	13.18**	12.42*	0.00	13.18*	-0.03	15.21*	-0.02
international	(6.68)	(7.36)	(0.20)	(7.66)	(0.21)	(8.29)	(0.22)
Emission		7.72**	0.49***	5.50	0.39***	4.81	0.33**
reduction target		(3.66)	(0.12)	(3.96)	(0.14)	(4.67)	(0.14)
Utility discount		0.34	0.17**	-0.64	0.10	-0.07	0.15*
factor		(2.72)	(0.07)	(2.77)	(0.07)	(3.14)	(0.08)
Europe				2.96	0.36	0.98	0.31
				(7.81)	(0.24)	(8.92)	(0.26)
Oceania				-14.49*	-0.64*	-20.21**	-0.99**
				(8.75)	(0.39)	(9.81)	(0.39)
Asia				-7.71	-0.03	-11.22	-0.24
				(9.14)	(0.51)	(9.71)	(0.53)
South America or				-14.13	-0.77	-16.38	-0.80
Africa				(10.60)	(0.57)	(11.60)	(0.59)
CC: Climate				0.30*	0.02*	0.29	0.02*
change knowledge				(0.17)	(0.01)	(0.18)	(0.01)
EC: Published on						-1.79	0.24
cap-and-trade						(6.51)	(0.37)
Constant	49.42***	29.90**		12.40		18.78	
	(10.26)	(12.56)		(21.08)		(22.99)	
Observations	426	396	396	380	380	339	339
R-squared	0.049	0.070		0.093		0.099	
Pseudo R-squared			0.0230		0.0338		0.0387

Notes: Robust standard errors in parentheses. ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$. Columns (1), (2), (4) and (6) are multivariate regressions estimated by ordinary least squares. Columns (3), (5) and (7) are multivariate regressions estimated by ordered logit to account for categorical dependent variables.

Table A.5.12: Multivariate analysis of the 2030 global carbon price recommendations using all four additional data sources

	(1) Global price 2030	(2) Global price 2030	(3) Global price 2030	(4) Global price 2030	(5) Global price 2030	(6) Global price 2030	(7) Global price 2030
Instrument: tax (vs. not tax)	16.64** (7.70)	17.25** (8.13)	0.39** (0.19)	11.44 (8.43)	0.19 (0.19)	11.14 (9.27)	0.12 (0.20)
BCA strongly recommended	13.43* (7.77)	10.56 (8.06)	0.03 (0.20)	13.02 (8.32)	0.10 (0.21)	10.54 (9.27)	0.01 (0.22)
Revenue usage: households	13.62 (9.47)	5.33 (10.29)	0.34 (0.21)	7.75 (11.19)	0.43* (0.22)	8.31 (12.11)	0.47** (0.23)
Revenue usage: firms	-29.24*** (8.83)	-31.78*** (9.53)	-0.52*** (0.20)	-31.02*** (9.66)	-0.46** (0.21)	-33.48*** (10.65)	-0.47** (0.23)
Revenue usage: government	-5.98 (10.16)	-12.30 (10.57)	-0.23 (0.22)	-9.29 (11.16)	-0.17 (0.23)	-11.01 (12.75)	-0.16 (0.26)
Revenue usage: international	23.98** (10.00)	21.66** (10.50)	0.19 (0.21)	23.89** (10.92)	0.20 (0.21)	26.90** (11.87)	0.22 (0.23)
Emission reduction target		18.24*** (4.61)	0.69*** (0.12)	15.90*** (5.03)	0.62*** (0.13)	15.16** (5.90)	0.56*** (0.13)
Utility discount factor		4.77 (3.28)	0.18*** (0.07)	3.13 (3.43)	0.14* (0.07)	4.13 (3.83)	0.17** (0.08)
Europe				5.33 (11.62)	0.14 (0.24)	2.22 (13.24)	0.09 (0.26)
Oceania				-24.04 (16.66)	-0.86** (0.36)	-32.30* (18.61)	-1.13*** (0.39)
Asia				0.90 (17.95)	-0.17 (0.53)	-4.22 (18.80)	-0.34 (0.54)
South America or Africa				5.41 (24.90)	0.21 (0.82)	1.79 (26.17)	0.22 (0.87)
CC: Climate change knowledge				0.47 (0.35)	0.01 (0.01)	0.50 (0.37)	0.02 (0.01)
EC: Published on cap-and-trade						-17.59* (10.05)	-0.16 (0.35)
Constant	79.12*** (16.63)	17.98 (17.98)		-17.68 (39.80)		-10.50 (42.13)	
Observations	425	396	396	381	381	340	340
R-squared	0.066	0.121		0.132		0.143	
Pseudo R-squared			0.0339		0.0392		0.0422

Notes: Robust standard errors in parentheses. ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$. Columns (1), (2), (4) and (6) are multivariate regressions estimated by ordinary least squares. Columns (3), (5) and (7) are multivariate regressions estimated by ordered logit to account for categorical dependent variables.

Table A.5.13: Multivariate analysis of the 2050 global carbon price recommendations using all four additional data sources

	(1) Global price 2050	(2) Global price 2050	(3) Global price 2050	(4) Global price 2050	(5) Global price 2050	(6) Global price 2050	(7) Global price 2050
Instrument: tax (vs. not tax)	28.78 (31.96)	31.20 (32.80)	0.48*** (0.18)	20.55 (35.10)	0.36* (0.18)	15.18 (38.72)	0.30 (0.20)
BCA strongly recommended	30.43 (41.34)	14.31 (42.38)	-0.18 (0.21)	16.36 (45.79)	-0.15 (0.22)	3.50 (51.86)	-0.30 (0.23)
Revenue usage: households	-18.23 (57.86)	-49.31 (63.25)	0.42** (0.20)	-59.17 (74.40)	0.52** (0.22)	-74.27 (82.48)	0.53** (0.23)
Revenue usage: firms	-113.47*** (41.66)	-130.40*** (46.41)	-0.58*** (0.19)	-124.47*** (43.91)	-0.54** (0.21)	-135.44*** (48.68)	-0.58*** (0.22)
Revenue usage: government	-90.94 (71.65)	-115.16 (78.09)	-0.21 (0.23)	-109.01 (82.49)	-0.10 (0.25)	-124.81 (96.38)	-0.08 (0.28)
Revenue usage: international	100.71** (50.00)	91.75* (50.33)	0.29 (0.19)	105.54* (54.10)	0.37* (0.20)	117.24** (58.17)	0.42** (0.21)
Emission reduction target		84.74*** (21.44)	0.85*** (0.12)	83.51*** (25.47)	0.77*** (0.13)	93.50*** (31.26)	0.76*** (0.14)
Utility discount factor		1.12 (20.43)	0.21*** (0.07)	1.96 (22.18)	0.18** (0.07)	-0.24 (25.57)	0.17** (0.08)
Europe				-34.13 (73.14)	0.25 (0.23)	-47.77 (85.63)	0.25 (0.24)
Oceania				-118.21* (68.63)	-0.65* (0.35)	-151.33* (83.06)	-0.76** (0.37)
Asia				-61.17 (64.11)	0.11 (0.53)	-76.30 (72.63)	0.03 (0.55)
South America or Africa				55.67 (114.00)	0.83 (1.24)	30.57 (123.60)	0.91 (1.27)
CC: Climate ch. knowledge				0.11 (1.15)	0.02 (0.01)	0.01 (1.29)	0.02 (0.01)
EC: Published on cap-and-trade						-91.56** (38.23)	-0.46 (0.34)
Constant	305.84** (119.18)	80.72 (95.01)		104.99 (160.86)		153.88 (186.30)	
Observations	421	394	394	379	379	339	339
R-squared	0.041	0.086		0.093		0.107	
Pseudo R-squared			0.0441		0.0477		0.0513

Notes: Robust standard errors in parentheses. ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$. Columns (1), (2), (4) and (6) are multivariate regressions estimated by ordinary least squares. Columns (3), (5) and (7) are multivariate regressions estimated by ordered logit to account for categorical dependent variables.

Table A.5.14: Multivariate analysis of the 2020 unilateral carbon price recommendations with BCA using all four additional data sources

	(1) Unilateral 2020 with BCA	(2) Unilateral 2020 with BCA	(3) Unilateral 2020 with BCA	(4) Unilateral 2020 with BCA	(5) Unilateral 2020 with BCA	(6) Unilateral 2020 with BCA	(7) Unilateral 2020 with BCA
Instrument: tax (vs. not tax)	6.33 (5.08)	6.14 (5.41)	0.37** (0.18)	3.65 (5.36)	0.26 (0.19)	3.82 (5.97)	0.20 (0.20)
BCA strongly recommended	10.13** (4.99)	9.58* (5.23)	0.27 (0.23)	10.03* (5.11)	0.34 (0.22)	9.48* (5.52)	0.33 (0.23)
Revenue usage: households	8.20 (6.13)	3.13 (6.75)	0.38* (0.22)	4.86 (6.55)	0.45** (0.23)	4.82 (7.16)	0.43* (0.23)
Revenue usage: firms	-15.20*** (5.72)	-15.67** (6.24)	-0.28 (0.20)	-17.41*** (6.15)	-0.36* (0.21)	-18.39*** (6.86)	-0.34 (0.22)
Revenue usage: government	-1.21 (4.55)	-4.68 (4.70)	-0.19 (0.21)	0.87 (4.43)	0.07 (0.21)	0.74 (5.07)	0.07 (0.23)
Revenue usage: international	14.63** (6.48)	12.31* (7.01)	0.08 (0.19)	13.79* (7.10)	0.09 (0.19)	15.39** (7.69)	0.08 (0.20)
Emission reduction target		10.74*** (3.38)	0.60*** (0.12)	6.68** (3.32)	0.46*** (0.13)	5.93 (3.87)	0.40*** (0.13)
Utility discount factor		2.55 (2.28)	0.22*** (0.07)	0.96 (2.30)	0.14** (0.07)	1.18 (2.59)	0.15* (0.08)
Europe				15.36** (6.01)	0.74*** (0.23)	15.88** (6.69)	0.80*** (0.24)
Oceania				-6.69 (9.67)	-0.60 (0.37)	-10.07 (10.62)	-0.86** (0.36)
Asia				8.80 (8.54)	0.45 (0.52)	6.01 (8.82)	0.29 (0.53)
South America or Africa				-1.69 (10.28)	-0.65 (0.64)	-1.93 (10.58)	-0.57 (0.68)
CC: Climate ch. knowledge				0.67*** (0.17)	0.05*** (0.01)	0.68*** (0.17)	0.05*** (0.01)
EC: Published on cap-and-tr.						1.61 (6.11)	0.44 (0.34)
Constant	43.29*** (7.92)	7.14 (10.66)		-48.19** (18.83)		-45.37** (19.79)	
Observations	425	398	398	382	382	341	341
R-squared	0.052	0.093		0.144		0.149	
Pseudo R-squared			0.0328		0.0623		0.0701

Notes: Robust standard errors in parentheses. ∗ p < 0.1, ∗∗ p < 0.05, ∗∗∗ p < 0.01. Columns (1), (2), (4) and (6) are multivariate regressions estimated by ordinary least squares. Columns (3), (5) and (7) are multivariate regressions estimated by ordered logit to account for categorical dependent variables.

Table A.5.15: Multivariate analysis of the 2030 unilateral carbon price recommendations with BCA using all four additional data sources

	(1) Unilateral 2030 with BCA	(2) Unilateral 2030 with BCA	(3) Unilateral 2030 with BCA	(4) Unilateral 2030 with BCA	(5) Unilateral 2030 with BCA	(6) Unilateral 2030 with BCA	(7) Unilateral 2030 with BCA
Instrument: tax	21.07**	20.98**	0.45**	16.42	0.33*	14.49	0.28
(vs. not tax)	(9.81)	(10.25)	(0.19)	(10.30)	(0.19)	(11.16)	(0.21)
BCA strongly	15.36*	13.37	0.13	13.64	0.18	11.12	0.12
recommended	(8.82)	(8.93)	(0.22)	(9.11)	(0.23)	(10.06)	(0.24)
Revenue usage:	28.96***	14.41	0.53**	16.23	0.64***	16.20	0.63***
households	(10.55)	(10.90)	(0.22)	(11.31)	(0.23)	(12.22)	(0.23)
Revenue usage:	-36.68***	-37.47***	-0.45**	-37.98***	-0.46**	-40.80***	-0.48**
firms	(11.22)	(11.58)	(0.20)	(11.46)	(0.21)	(12.68)	(0.22)
Revenue usage:	-1.23	-9.97	-0.10	-2.09	0.15	-1.40	0.20
government	(10.43)	(10.44)	(0.23)	(10.63)	(0.24)	(11.82)	(0.26)
Revenue usage:	36.53***	30.99**	0.32	34.31**	0.34	35.99**	0.32
international	(12.61)	(12.84)	(0.20)	(13.34)	(0.21)	(14.54)	(0.22)
Emission		28.17***	0.80***	23.96***	0.66***	24.01***	0.62***
reduction target		(5.71)	(0.12)	(6.38)	(0.12)	(7.53)	(0.13)
Utility discount		9.02**	0.26***	7.40*	0.19***	7.56	0.18**
factor		(3.82)	(0.07)	(4.13)	(0.07)	(4.67)	(0.08)
Europe				10.90	0.52**	8.69	0.59**
				(15.23)	(0.24)	(17.91)	(0.26)
Oceania				-29.25	-0.77**	-37.01	-0.95**
				(20.33)	(0.38)	(23.26)	(0.43)
Asia				15.06	0.07	9.55	-0.05
				(24.86)	(0.45)	(26.26)	(0.46)
South America				-0.61	0.14	-2.68	0.33
or Africa				(28.58)	(0.86)	(30.80)	(0.95)
CC: Climate				1.09**	0.03***	1.17**	0.04***
change knowledge				(0.49)	(0.01)	(0.51)	(0.01)
EC: Published						-16.25	-0.01
on cap-and-tr.						(11.85)	(0.35)
Constant	73.19***	-30.08		-121.59**		-120.24**	
	(17.56)	(23.30)		(53.87)		(55.81)	
Observations	424	397	397	382	382	341	341

R-squared	0.086	0.169		0.194		0.201	
Pseudo R-squared			0.0470		0.0625		0.0687

Notes: Robust standard errors in parentheses. ∗ p < 0.1, ∗∗ p < 0.05, ∗∗∗ p < 0.01. Columns (1), (2), (4) and (6) are multivariate regressions estimated by ordinary least squares. Columns (3), (5) and (7) are multivariate regressions estimated by ordered logit to account for categorical dependent variables.

Table A.5.16: Multivariate analysis of the 2020 unilateral carbon price recommendations without BCA using all four additional data sources

	(1) Unilateral 2020 w/o BCA	(2) Unilateral 2020 w/o BCA	(3) Unilateral 2020 w/o BCA	(4) Unilateral 2020 w/o BCA	(5) Unilateral 2020 w/o BCA	(6) Unilateral 2020 w/o BCA	(7) Unilateral 2020 w/o BCA
Instrument: tax (vs. not tax)	6.68* (3.58)	6.37* (3.81)	0.32* (0.19)	4.20 (3.74)	0.14 (0.20)	4.29 (4.11)	0.08 (0.21)
BCA strongly recommended	-2.80 (3.95)	-3.90 (4.05)	-0.21 (0.22)	-3.62 (3.83)	-0.20 (0.22)	-5.37 (4.12)	-0.28 (0.22)
Revenue usage: households	12.56*** (3.40)	8.94** (3.71)	0.46** (0.21)	9.76*** (3.48)	0.46** (0.22)	10.49*** (3.58)	0.42* (0.22)
Revenue usage: firms	-9.91** (3.94)	-9.56** (4.23)	-0.31 (0.20)	-10.69** (4.21)	-0.34 (0.21)	-10.73** (4.60)	-0.32 (0.22)
Revenue usage: government	0.48 (3.89)	-1.72 (4.00)	-0.04 (0.23)	1.20 (3.87)	0.14 (0.23)	-0.26 (4.52)	0.08 (0.25)
Revenue usage: international	8.52** (3.96)	6.12 (4.29)	0.22 (0.19)	7.54* (4.29)	0.24 (0.19)	9.00* (4.66)	0.26 (0.21)
Emission reduction target		7.70*** (2.31)	0.54*** (0.13)	5.62** (2.28)	0.46*** (0.14)	4.99* (2.54)	0.40*** (0.15)
Utility discount factor		3.23** (1.35)	0.25*** (0.08)	2.20* (1.32)	0.20** (0.08)	2.99** (1.38)	0.23*** (0.08)
Europe				5.71 (4.13)	0.33 (0.22)	6.05 (4.54)	0.48** (0.24)
Oceania				-7.61 (6.63)	-0.84** (0.35)	-9.81 (7.22)	-1.04*** (0.34)
Asia				0.52 (5.82)	0.11 (0.43)	-1.72 (5.85)	0.02 (0.45)
South America or Africa				-13.59* (7.05)	-1.26** (0.57)	-13.52* (7.34)	-1.14* (0.63)
CC: Climate change knowledge				0.29** (0.13)	0.03*** (0.01)	0.27** (0.13)	0.04*** (0.01)
EC: Published on cap-and-trade						3.03 (5.32)	0.35 (0.37)

Constant	33.28*** (5.53)	3.03 (7.57)		-17.36 (14.67)		-14.65 (15.21)	
Observations	418	390	390	375	375	335	335
R-squared	0.060	0.117		0.156		0.171	
Pseudo R-squared			0.0321		0.0508		0.0597

Notes: Robust standard errors in parentheses. ∗ p < 0.1, ∗∗ p < 0.05, ∗∗∗ p < 0.01. Columns (1), (2), (4) and (6) are multivariate regressions estimated by ordinary least squares. Columns (3), (5) and (7) are multivariate regressions estimated by ordered logit to account for categorical dependent variables.

Table A.5.17: Multivariate analysis of the 2030 unilateral carbon price recommendations without BCA using all four additional data sources

	(1) Unilateral 2030 w/o BCA	(2) Unilateral 2030 w/o BCA	(3) Unilateral 2030 w/o BCA	(4) Unilateral 2030 w/o BCA	(5) Unilateral 2030 w/o BCA	(6) Unilateral 2030 w/o BCA	(7) Unilateral 2030 w/o BCA
Instrument: tax (vs. not tax)	14.74** (7.04)	14.02* (7.52)	0.45** (0.19)	10.79 (7.70)	0.31 (0.20)	9.14 (8.49)	0.26 (0.22)
BCA strongly recommended	-8.20 (7.49)	-9.42 (7.52)	-0.38* (0.22)	-10.56 (7.53)	-0.41* (0.23)	-14.31* (8.31)	-0.52** (0.23)
Revenue usage: households	27.02*** (7.54)	17.55** (8.30)	0.56*** (0.22)	18.65** (8.76)	0.62*** (0.23)	20.21** (9.37)	0.63*** (0.23)
Revenue usage: firms	-26.70*** (8.26)	-27.62*** (8.91)	-0.46** (0.20)	-28.32*** (9.03)	-0.46** (0.21)	-30.44*** (10.00)	-0.47** (0.23)
Revenue usage: government	-6.53 (9.50)	-13.17 (9.78)	-0.10 (0.25)	-6.24 (10.05)	0.08 (0.25)	-6.12 (11.33)	0.09 (0.28)
Revenue usage: international	23.64*** (9.06)	20.20** (9.59)	0.37* (0.20)	23.00** (10.03)	0.41** (0.20)	24.37** (11.06)	0.41* (0.22)
Emission reduction target		19.01*** (4.31)	0.75*** (0.12)	16.03*** (4.53)	0.66*** (0.13)	14.57*** (5.20)	0.59*** (0.14)
Utility discount factor		7.43*** (2.77)	0.25*** (0.08)	6.29** (2.91)	0.21*** (0.08)	6.87** (3.21)	0.22*** (0.08)
Europe				4.04 (10.22)	0.15 (0.23)	4.86 (11.75)	0.28 (0.25)
Oceania				-16.99 (16.33)	-0.77** (0.35)	-20.32 (18.39)	-0.94** (0.37)
Asia				-5.34 (11.36)	-0.02 (0.41)	-8.05 (12.19)	-0.10 (0.43)
South America or Africa				-24.24 (15.49)	-0.57 (0.74)	-22.24 (16.61)	-0.35 (0.82)
CC: Climate change				0.31 (0.22)	0.03** (0.01)	0.38* (0.23)	0.03*** (0.01)

knowledge							
EC: Published on cap-and-trade						-10.51 (9.02)	-0.02 (0.36)
Constant	70.86*** (15.00)	-2.43 (16.65)		-21.69 (27.72)		-20.12 (29.76)	
Observations	418	389	389	374	374	334	334
R-squared	0.082	0.164		0.183		0.193	
Pseudo R-squared			0.0445		0.0544		0.0607

Notes: Robust standard errors in parentheses. ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$. Columns (1), (2), (4) and (6) are multivariate regressions estimated by ordinary least squares. Columns (3), (5) and (7) are multivariate regressions estimated by ordered logit to account for categorical dependent variables.

A.6 Details on Section 5

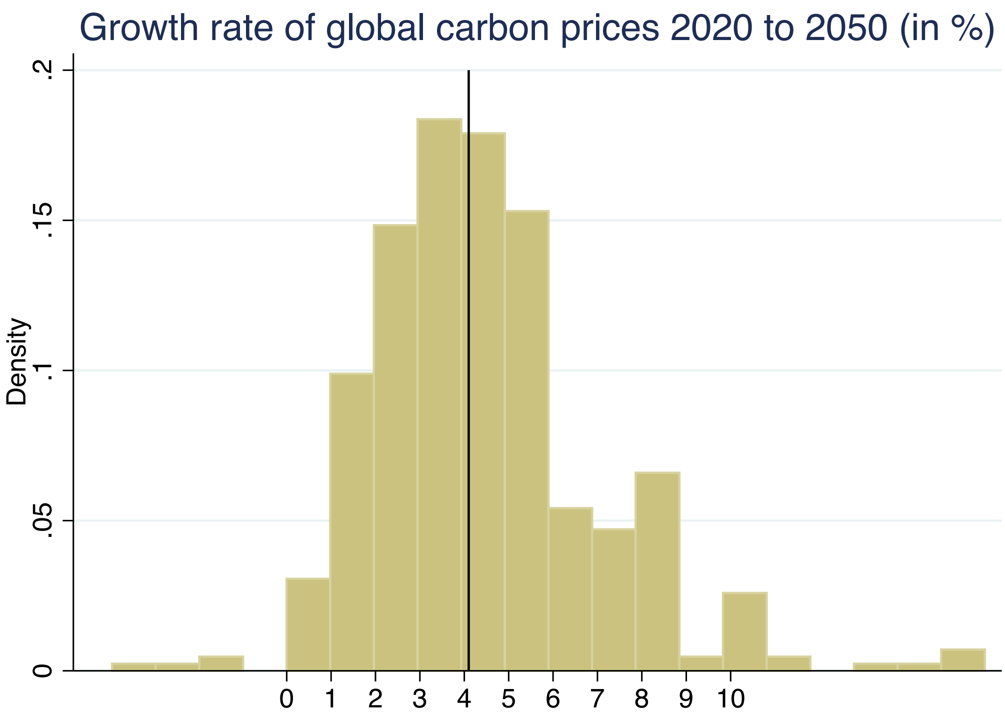


Figure A.6.1: Growth rates of global carbon price recommendations, 2020-2050

Notes: The figure shows a histogram of (exponential) real growth rates global carbon price recommendations from 2020 to 2050. The vertical black line depicts the median growth rate of 4.09 percent per year.

Table A.6.1: Estimation of propensity score for global price recommendation

	(1) Response Global price 2020	(2) Response Global price 2030	(3) Response Global price 2050	(4) Response Unilateral 2020 w/ BCA	(5) Response Unilateral 2030 w/ BCA	(6) Response Unilateral 2020 w/o BCA	(7) Response Unilateral 2030 w/o BCA
Europe	0.24***	0.25***	0.25***	0.25***	0.25***	0.24***	0.25***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Oceania	0.08	0.07	0.08	0.03	0.04	0.04	0.05
	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)
Asia	-0.17	-0.16	-0.16	-0.17	-0.16	-0.16	-0.16
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
South America or Africa	-0.08	-0.07	-0.06	-0.08	-0.07	-0.06	-0.06
	(0.28)	(0.28)	(0.28)	(0.28)	(0.28)	(0.28)	(0.28)
EC: Male	0.15	0.14	0.14	0.16*	0.15	0.14	0.14
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
EC: Nb. of publications	0.05**	0.04**	0.04**	0.05**	0.04**	0.04**	0.04**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
EC: Nb. of citations	-0.00**	-0.00**	-0.00**	-0.00***	-0.00***	-0.00**	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
EC: Published in econ	0.14	0.14	0.13	0.15	0.14	0.15	0.15*
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
EC: Nb. of econ publications	0.04	0.04	0.04	0.05	0.05	0.04	0.04
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
EC: Published on IAM	0.30***	0.29***	0.28**	0.31***	0.31***	0.30***	0.30***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
EC: Published on SCC	-0.04	-0.03	-0.02	-0.06	-0.05	-0.04	-0.04
	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
EC: Published on cap-and-trade	0.02	0.02	0.02	0.02	0.02	0.03	0.03
	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
EC: Published on tax	0.21***	0.20***	0.20***	0.20***	0.19**	0.19**	0.19**
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Constant	-1.32***	-1.33***	-1.32***	-1.33***	-1.33***	-1.33***	-1.33***
	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
Observations	1,730	1,728	1,726	1,727	1,725	1,719	1,718
Pseudo R-squared	0.0393	0.0393	0.0386	0.0411	0.0407	0.0392	0.0395

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Weights are estimated by propensity score matching according to a probit model.

Next, we show the balancing tests before and after matching alongside a standard graphical evaluation of matching quality for the 2030 global price recommendation.

Table A.6.2: Balancing test for global price recommendation for 2030 – before matching

	Response	Nonresponse	t	p>|t|
Europe	0.55	0.43	4.05	0.000
Oceania	0.08	0.09	-0.43	0.666
Asia	0.11	0.18	-3.23	0.001
South America or Africa	0.02	0.02	-0.24	0.808
EC: Male	0.85	0.81	1.70	0.089
EC: Nb. of publications	4.07	3.38	3.93	0.000
EC: Nb. of citations	104.66	94.86	1.14	0.255
EC: Published in econ	0.53	0.40	4.55	0.000
EC: Nb. of econ publications	1.34	0.83	5.33	0.000
EC: Published on IAM	0.18	0.10	3.88	0.000
EC: Published on SCC	0.10	0.08	1.23	0.220
EC: Published on cap-and-trade	0.08	0.11	-1.50	0.133
EC: Published on tax	0.55	0.48	2.34	0.020

Notes: Balancing of characteristics by respondents and non-respondents before matching. t is the t-test and p>|t| the corresponding p-value.

Table A.6.3: Balancing test for global price recommendation for 2030 – after matching

	Response	Nonresponse	t	p>|t|
Europe	0.55	0.55	-0.15	0.884
Oceania	0.08	0.08	0.00	1.000
Asia	0.11	0.13	-0.67	0.501
South America or Africa	0.02	0.01	0.30	0.762
EC: Male	0.85	0.83	0.70	0.458
EC: Nb. of publications	4.07	3.59	2.07	0.039
EC: Nb. of citations	104.66	93.15	1.09	0.276
EC: Published in econ	0.53	0.56	-0.80	0.422
EC: Nb. of econ publications	1.33	1.21	1.03	0.302
EC: Published on IAM	0.18	0.21	-1.19	0.233
EC: Published on SCC	0.10	0.09	0.25	0.808
EC: Published on cap-and-trade	0.08	0.07	0.70	0.484
EC: Published on tax	0.55	0.57	-0.59	0.558

Notes: Balancing of characteristics by respondents and non-respondents after matching. t is the t-test and p>|t| the corresponding p-value.

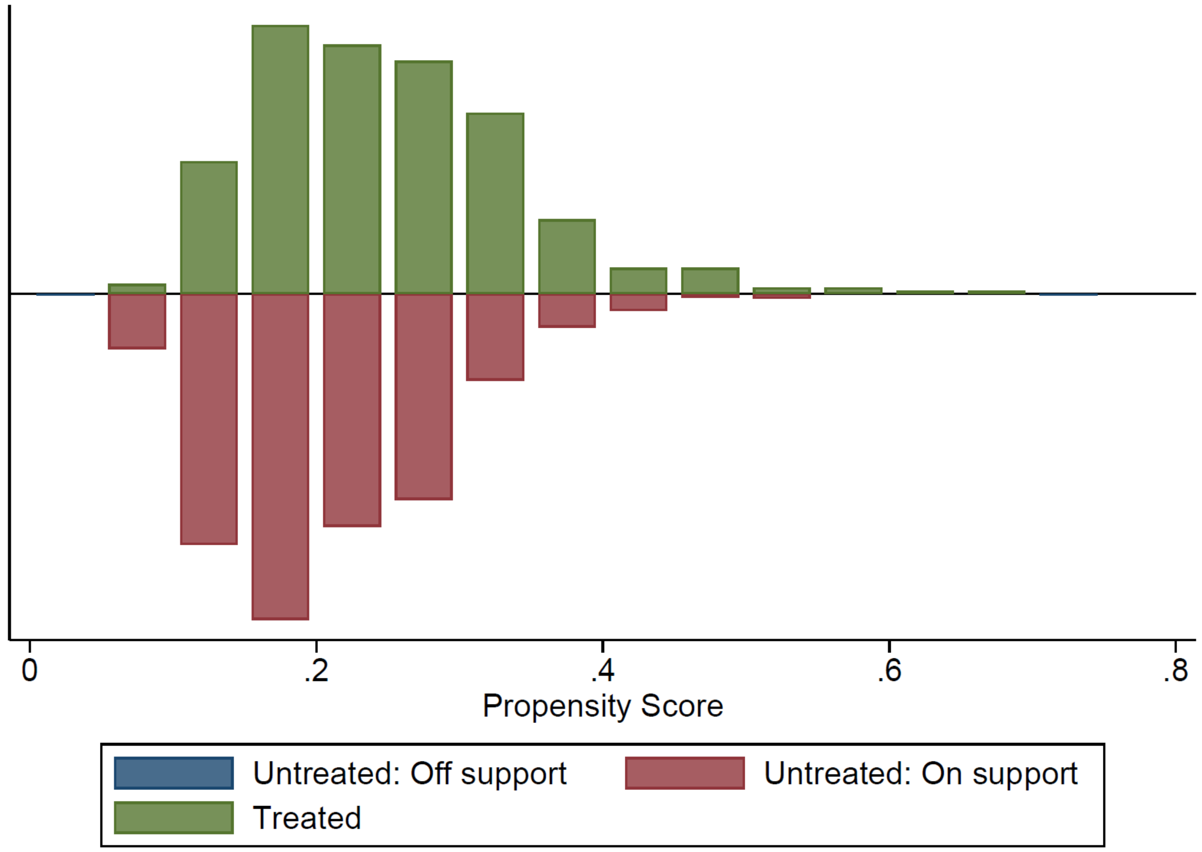


Figure A.6.2: Graphical evaluation of matching quality for 2030 global price recommendation

Notes: The figure shows the distribution of propensity scores for the treatment and control groups (i.e., respondents and non-respondents). It also illustrates where parts of the control group that is off support and thus not utilized in the matching procedure.

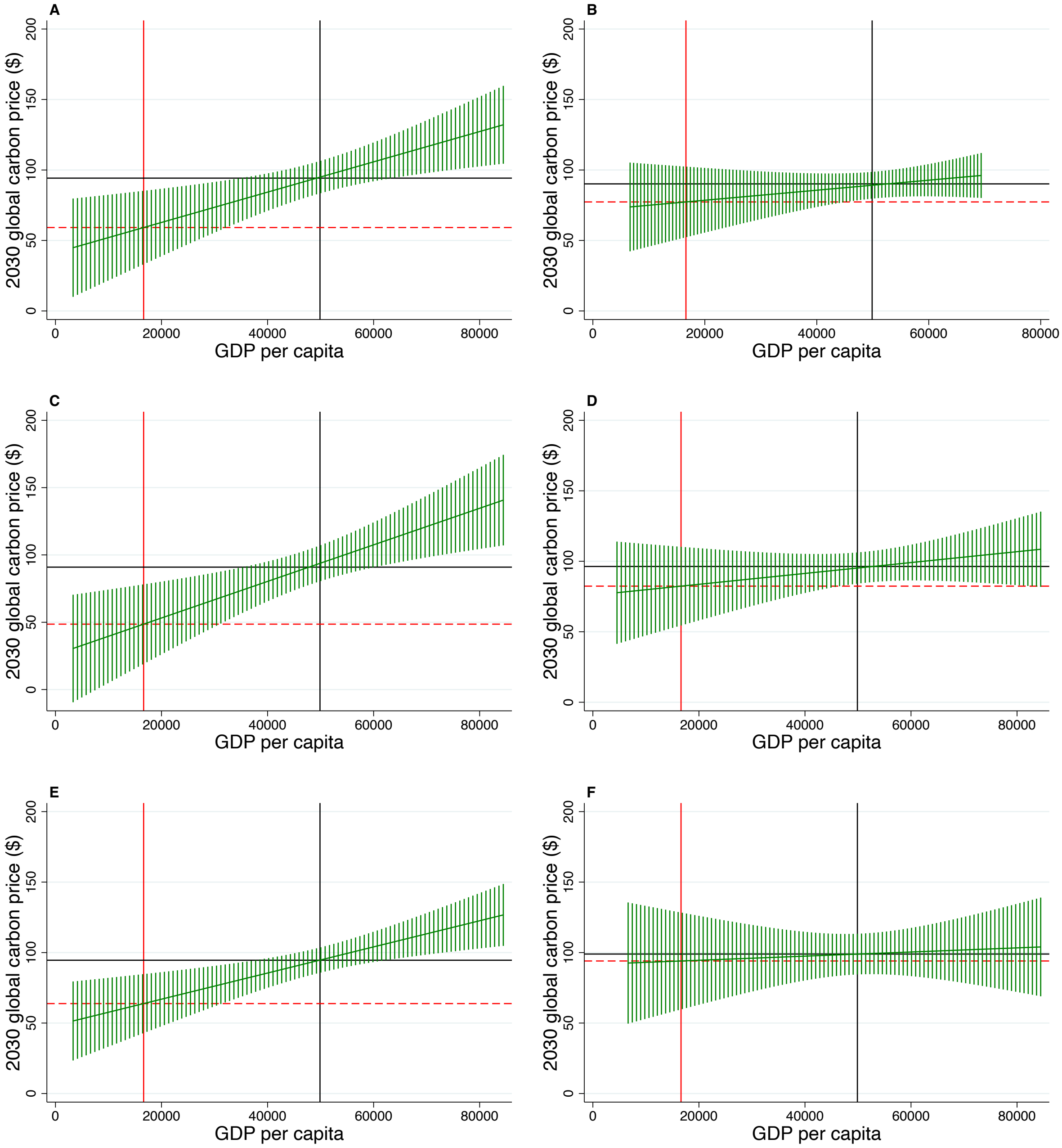


Figure A.6.3: Re-weighting global carbon prices for global GDP per capita across sub-groups

Notes: Plot of 2030 global carbon price recommendations and GDP per capita, with linear fit (green line) and 95 percent confidence interval (green spikes). The black lines show mean GDP per capita and mean global carbon price recommendations for 2030 in our full sample. The solid red line shows global GDP per capita and the red dashed line shows the corresponding predicted (re-weighted) 2030 global carbon price. Panel A (B) shows results for at or below (above) the median number of publications of experts, Panel C (D) shows results for experts who have not published (have published) in economics journals, while Panel E (F) shows results for experts from whose paper abstracts it is apparent that they have not published (published) on IAMs or the SCC.

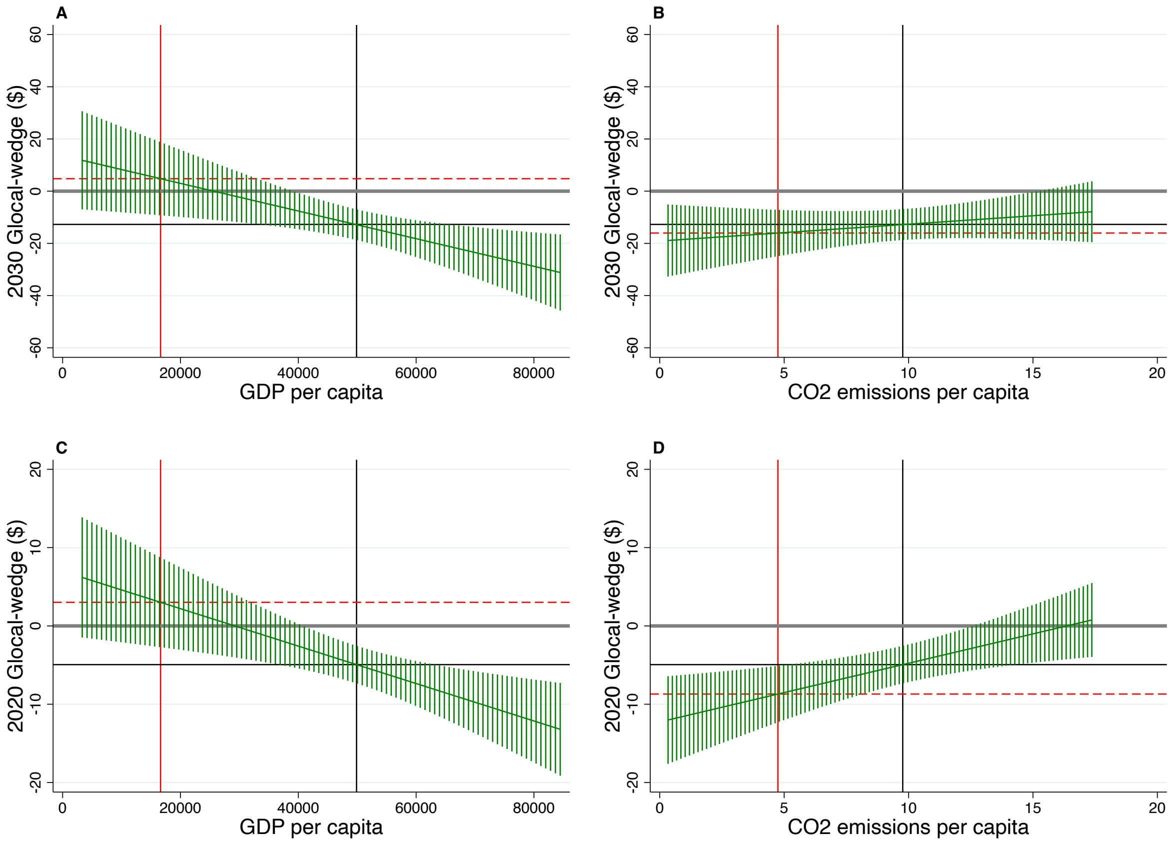


Figure A.6.4: Re-weighting the Glocal-wedge for global GDP and CO2 emissions per capita
Notes: Plots of 2030 and 2020 Glocal-wedges, i.e. the difference between global and unilateral with BCA carbon price recommendations, along GDP per capita (Panels A and C) and CO2 emissions per capita (Panels B and D), with linear fit (green line) and 95 percent confidence interval (green spikes). The black lines show mean GDP (or CO2 emissions) per capita and mean global carbon price recommendations. The solid red line shows global GDP (or CO2 emissions) per capita and the red dashed line shows the corresponding predicted (re-weighted) global carbon prices for 2030 and 2020.