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Public support for carbon pricing policies and revenue recycling options: a systematic review and meta-analysis of the survey literature



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Since public support is critical for implementing carbon pricing policies, we conduct a systematic review and meta-analysis to examine the survey-based literature on change in public support for direct and indirect carbon pricing policies with and without revenue recycling options. Following a comprehensive and transparent machine-learning assisted screening of the literature, our dataset comprises 35 studies containing 70 surveys across 26 countries with over 100,000 respondents. We find that the introduction of any type of revenue recycling option increases public support for carbon pricing. Results from our meta-regression indicate that green spending (i.e. using revenues for climate-friendly projects) is the only revenue recycling option associated with a statistically significant increase in public support. Our findings moreover suggest that the effects may depend on which region the survey was carried out, highlighting the need for additional research in countries in the regions of Africa and Latin America and the Caribbean.

To achieve ambitious climate change mitigation, it is crucial to address the current mispricing of fossil fuel based goods. This can be achieved by removing fossil fuel subsidies (i.e. indirect carbon pricing policy abolishing negative carbon prices) and by putting a price on carbon (i.e. direct carbon pricing policy introducing a positive price associated with carbon emissions)^{1–4}. Such policies result in salient price increases passed on to consumers which, without additional compensatory policies, could lead to strong public opposition. Recent examples of protests against fuel price increases include the ‘yellow vests’ in France in 2018, as well as protests in Nigeria in 2020, and in India in 2021. To address some of the public’s concerns and to increase support for carbon pricing, studies in economics, behavioural psychology and political science recommend policymakers to introduce complementary policies with clear benefits intended for their constituents^{3,5,6}. Such complementary policies are often referred to as revenue recycling schemes and can vary in design. For example, revenue recycling could reduce the financial impact of increased fossil fuel prices by redistributing some of the revenues back to all or a targeted segment of the population. Other types of revenue recycling include investing in low-carbon infrastructure projects, or agreeing to reduce other types of taxes.

Current survey-based evidence on the effect of revenue recycling on public support for direct and indirect carbon pricing policies is mostly comprised of ex-ante studies with scattered and at times contradictory results. These studies elicit attitudes for different types of direct and indirect carbon pricing policies (e.g. carbon tax, fossil fuel taxes, fossil fuel subsidy reform, environmental taxes, and congestion charges), vary by the type of revenue recycling presented to respondents, and are conducted in countries with diverse socio-economic and political contexts. Several studies find an overall tendency for respondents to prefer investing revenues towards climate-friendly activities, such as renewable energy projects, expanding public infrastructure, or further climate research^{7–9}. Some detect favourable responses for applying tax cuts for income or labour taxes to counterbalance the increase in costs^{10,11}. Yet other survey studies reveal that respondents prefer to compensate all households equally or specifically target low-income households and highly affected population groups, such as workers or the elderly, for financial compensation^{12,13}. Real-world examples of carbon pricing with complementary revenue recycling are limited¹⁴. Moreover, the ex-post survey-based literature is even smaller and also reveals some scepticism on the effects of revenue recycling to increase public support^{15,16}.

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Given the varying conclusions from the existing studies, this study aims to synthesise and reconcile the available knowledge from primary ex-ante survey literature in a systematic, transparent and rigorous way. Our aim is to understand the *change* in public attitude – and the determinants of this change – towards a direct or indirect carbon pricing policy after revenue recycling schemes are presented to survey respondents. By conducting a machine-learning assisted systematic review and meta-analysis, we provide robust evidence on how the levels of support vary systematically for different pricing policies, revenue recycling options, and sampling regions of the existing survey literature.

The results from our study indicate that the introduction of any type of revenue recycling scheme increases public support for carbon pricing. When comparing the different schemes to each other using a logistic meta-regression we find that only *green spending* increases public support at a statistically significant level for carbon pricing when compared to using revenues for *public finance*. The effect of other revenue recycling schemes on public support, including *uniform cash transfers*, remain statistically insignificant. Our meta-regression findings moreover suggest that the effect of revenue recycling on public support depends on the region in which the survey is conducted, and is stronger in Africa, Asia and Pacific, and Latin America and Caribbean than in the baseline region North America. However, the small sample size for studies on this topic conducted in regions from low- and middle-income countries urgently beckons for further research.

Results

Systematic review – data and sample

We perform a comprehensive machine-learning assisted search and selection strategy and identify a final data sample of 35 primary studies from a total of 3542 retrieved search records (Web of Science, Scopus, snowballing), which comprise 70 surveys representative at the general population level, with 113,356 respondents spanning 26 countries⁶ (see Supplementary Table 3 for an overview of all included studies). Surveys were conducted between 2005 and 2022 and 87% of the sample comes from surveys conducted after 2016. We note that 20 surveys (close to a third of our sample) come from one working paper published in 2022, which allowed to expand regional variations in Latin America and the Caribbean as well as in Africa¹⁷. Our complete review methodology is described in the Methods section.

We categorise the different revenue recycling schemes presented in the 70 surveys into seven categories (see Fig. 1), namely (1) uniform cash transfers; (2) targeted cash transfers; (3) green spending; (4) tax cuts; (5) corporate tax cuts; (6) public finance; and (7) miscellaneous. We classify any scheme as revenue recycling which specifies how revenues generated from a direct carbon price or saved from a fossil fuel subsidy reform would be explicitly used (or recycled) to benefit households or society as a whole. Although using revenue towards public finance does not directly benefit households, often surveys explicitly ask respondents their support for a carbon pricing policy when revenues would be used to manage government expenditures and debts.

In terms of regional distribution, 44% of surveys were sampled in Europe and West Asia, 24% in North America, 23% in Asia and Pacific, 6% in Latin America and the Caribbean, and 3% in Africa. Regarding country distribution, the majority of surveys were conducted in the USA (19%), followed by Switzerland (7%), Canada (6%), China (6%), and Spain (6%) (Fig. 2). The survey evidence for different revenue recycling schemes is scattered unevenly across surveys. 83% of surveys in our sample elicit responses for *green spending*, 68% for *tax cuts*, 58% for *targeted cash transfers*, 47% for *uniform cash transfers*, 35% for *corporate tax cuts*, 11% for *public finance*, and 16% for *miscellaneous*.

The type of carbon pricing policy elicited also varies across the surveys, whereby 67% of surveys elicit support for carbon taxes, 12% for fossil fuel taxes, 10% for fossil fuel subsidy reforms, and less than 10% for environmental taxes or congestion charges. Furthermore, we find that the majority of surveys (77%) specify that a carbon pricing policy is intended towards a specific fuel, specifically gasoline, whereas the rest did not specify.

Regarding the measure of public attitudes, 66% of papers focus on *support* while the rest use *acceptance*, *acceptability*, *willingness to pay*, or other measures, such as *preferences*. However, a clear definition of the attitude measurement is often not provided in the primary studies. Conceptually, the different attitude measures appear to be used interchangeably or as potentially equivalent terms in the identified studies. While the exact definitions of these public attitude terms have potential implications for decision-making based on their different meanings, we interpret them as an overarching measurement concept to reveal respondents' favour or disfavour for a certain policy in the primary study¹⁸.

Quantitative results

To ensure comparability between effect sizes, in our quantitative analysis we only include papers that provide effect sizes when the change of public support with a revenue recycling options is compared to a baseline of "unspecified revenue use" (i.e. when surveys do not initially specify how generated revenues would be used). Moreover, this allows us to rule out potential effects from respondents being primed or prompted to compare revenue recycling to different baselines. Due to wider availability and to ensure comparability of effect sizes, we use summary statistics rather than results from econometric analyses in the primary studies. For the quantitative analysis, since very few studies conducted econometric analyses on the impact of revenue recycling, we expanded our dataset by including those that provide summary statistics. This also reduces the risk of comparing results from econometric analyses that are of different quality and potentially subject to biases. Our sample for the meta-regression thus includes 259 effect sizes from nine studies, 36 surveys, 68,043 respondents, spanning 22 countries. The surveys in our sample use different support measures, such as Likert-scales (with different levels across the studies), binary scales (support-not support), or stated preferences among policy alternatives. Although we may lose some important information from binning scaled responses into a binary system, to harmonise the different scales across the primary studies we standardise the effects by testing for the direction of the aggregated effect found for each revenue recycling scheme (that is, increase vs. decrease in public support), similar to comparable meta-analyses^{19,20}.

Our descriptive analysis reveals that presenting revenue recycling to respondents increase support for a given carbon pricing policy when compared to "unspecified revenue use" (see Fig. 3a). Revenue recycling options for which at least 80% of the available effect sizes report an increase in support for carbon pricing policies include *green spending* (97%), *targeted cash transfers* (86%), and *corporate tax cuts* (80%). In contrast, for *uniform cash transfers* only about two thirds of available effect sizes reported an increase in support, and labour and consumptions *tax cuts* and *public finance* about 80% of the effect sizes report an increase in support when compared to our baseline.

Regionally (see Fig. 3b–f), we find that in North America the reported effect sizes for at least three out of six types of revenue recycling schemes result in an increase in public support for a given carbon pricing policy. With regards to Africa, we find that all effect sizes reported for revenue recycling options are positive. For Asia and Pacific, we find that the reported effect sizes for *public finance*, *targeted cash transfers*, and *green spending* are over 90% positive. The revenue recycling option with the lowest share of positive effects in the Asia and Pacific region is *uniform cash transfers* (67%). For Europe and West Asia, we find that all effect sizes for *green spending* are positive; *uniform cash transfers* seem to have the least positive impact with only 64% positive effect sizes. In Latin America and the Caribbean, we find that effect sizes for *uniform cash transfers*, *green spending*, and *corporate tax cuts*, and *public finance* are all positive. However, for *targeted cash transfers* to low-income households or disproportionately affected population segments shows lower positive effects sizes (88%) as well as for income and consumption *tax cuts* (75%), which indicate potentially lowest impact on public support in that region. The evidence base, however, is very limited for some regions such as Africa and Latin America and the Caribbean.

Next, we run a logistic meta-regression on the same sample to compare the different revenue recycling schemes with each other, taking the

Revenue recycling option	Description
1. Uniform cash transfers 	Redistribution of revenues generated via equal lump sum cash transfers to all households / entire population
2. Targeted cash transfers 	Redistribution of revenues generated via cash transfers to targeted population segments such as low-income households
	Redistribution to other types of disproportionately affected households or workers
	Progressive/proportional/inversely proportional to income
3. Green spending 	Infrastructure - general, buildings, renewable energy projects, transport, multiple sectors
	Measures to increase households energy efficiency
	Investments in general environment and climate change projects
	Subsidies for households for low-carbon appliances
	Cost reduction of public transport
	Measures for pollution reduction
4. Tax cuts 	Investment in research and development climate/tech
5. Corporate tax cuts 	Rebate on income / labour / consumption taxes
6. Public finance 	Cuts on corporate taxes
7. Miscellaneous 	General budget; budget deficit
	Mixed: green spending and direct transfers; foreign aid; welfare and social services; behaviour change

Fig. 1 | Classification of revenue recycling scheme into seven categories for this analysis. The category *green spending* captures all schemes that reference infrastructure, energy efficiency, research and development, and other types of environmental projects. *Cash transfers* – both *uniform* and *targeted* – refer to schemes that explicitly state a redistribution scheme to all or some portion of the population. *Tax cuts* refer to schemes whereby individual people would benefit, either through

income or labour tax cuts, consumption tax cuts, or a tax rebate. *Corporate tax cuts* refer to tax cuts that benefit companies. *Public finance* refers to schemes that explicitly state that revenues would go towards a general government budget or explicitly to reduce government debt/budget deficit. The category *miscellaneous* refers to revenue recycling schemes that were presented as a combination of two categories, or that were did not fit the other categories.

allocation of revenues to *public finance* as a baseline (see Table 1). We find that *targeted cash transfers* and *green spending* increase public support for carbon pricing, but only the latter is statistically significant at the 1% level (3.09; standard error 1.08; $p < 1\%$, two-tailed test). Our results suggest that redistributing revenues equally to all households via *uniform cash transfers* (−0.60; standard error 0.86; $p > 10\%$, two-tailed test) is associated with a decrease in public support. We also find that *corporate tax cuts* (−0.51; standards error 0.47; $p > 10\%$, two-tailed test) are associated with a decrease in support, but none of the effects is significant at conventional level.

We control for the type of policy, whether a direct carbon pricing policy was in place at the time of the survey, regional variation and study design, but find only few significant effects – probably related to the limited sample size, which is a common problem in meta-regression²¹ (see Supplementary Table 4 for details on variance inflation factors). Due to insufficient variation across observations, we did not control for other potentially interesting features, such as the year the sample was collected or the article was published, the gender of the lead author, the timing of the survey in relation to upcoming elections or a forthcoming introduction of a carbon pricing

policy, the type of rating scales used to measure support, or other elements of the survey, such as checking for communication effects.

Our regional dummies suggest that – compared to North America – increases in public support through revenue recycling are significantly higher in regions mainly composed out of developing countries, i.e. Africa (significant at the 1% level, two-tailed test), East Asia and Pacific (significant at the 5% level, two-tailed test), and Latin America and Caribbean (significant at the 1% level, two-tailed test). The reported effect is also nominally positive for Europe and West Asia and Asia and Pacific, but comparatively small and not statistically significant. Non-experimental surveys tend to inflate estimates when compared to surveys with an experimental component (significant at the 1% level, two-tailed test), highlighting the importance of the choice of survey design²². Applying revenue recycling to carbon and environmental taxes compared to fossil fuel subsidy removal policies shows to increase support, but the effect is not statistically significant at conventional level.

Since all surveys underlying our analysis are representative for the general population, we decided against the use of sample weights in our

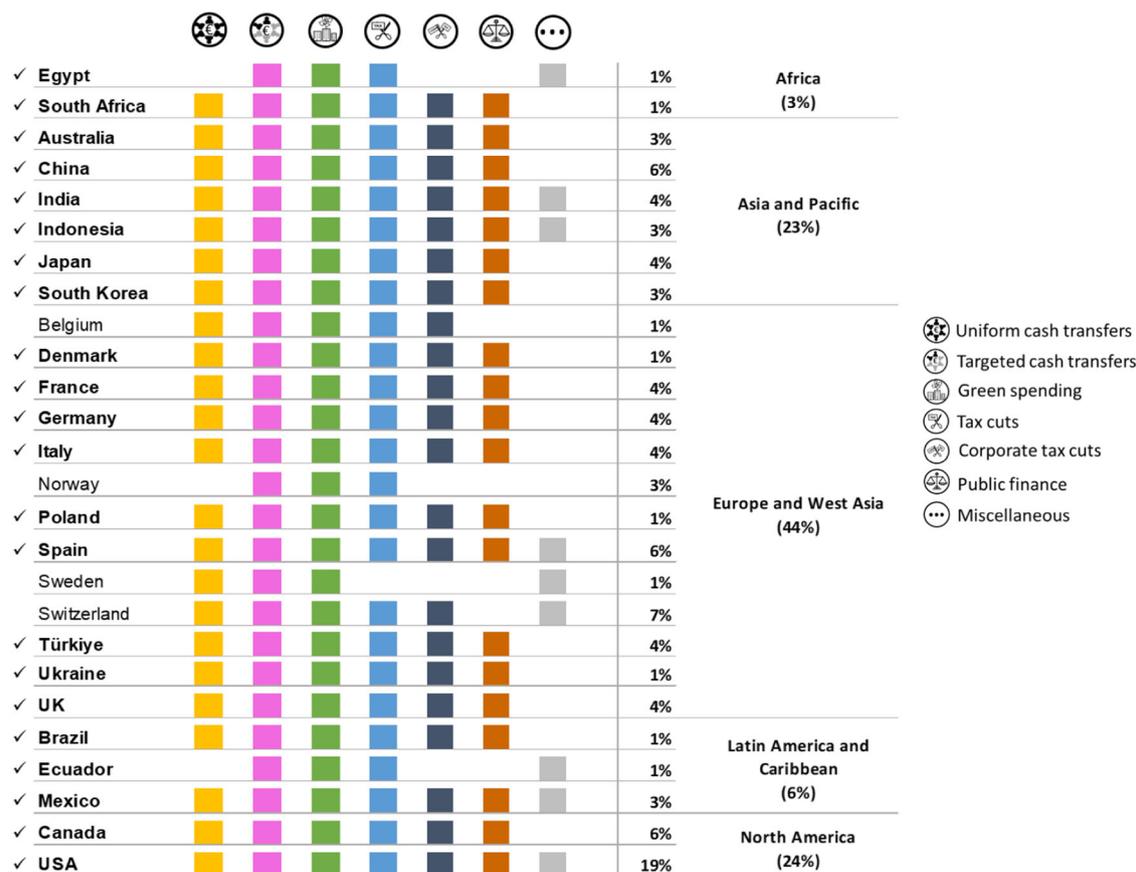


Fig. 2 | Overview of countries, regions, and revenue recycling options by country included in the systematic review and meta-analysis. This figure indicates which revenue recycling options are elicited by country and the country as well as regional shares represented in the final sample. In each country, one or more surveys elicited preferences for *green spending*, and *targeted cash transfers*. Surveys in all countries except for Norway and Ecuador elicited for *uniform cash transfers*. Surveys in all countries except for Norway elicit for *tax cuts*. Surveys elicit *corporate tax cuts* in all

countries except for Egypt, Norway, Sweden, and Ecuador. *Miscellaneous* types of revenue recycling options are elicited only in Egypt, India, Indonesia, Spain, Sweden Switzerland, Ecuador, Mexico, and USA. Countries marked in bold and with the check mark are represented in the quantitative analysis. This is because for those countries, our sample includes surveys that provide descriptive statistics and use an unspecified baseline before presenting respondents with revenue recycling options.

main regression. However, we provide results from a weighted regression in the Supplementary Information (see Supplementary Table 5). Additional robustness checks are also included in the Supplementary, such as an additional indicator variable (see Supplementary Table 6) to control for the influence of the working paper which provides our dataset with 20 surveys¹⁷ in our logit results, publication bias (see Supplementary Table 7) and a logit specification by OLS regressions (see Supplementary Table 8).

Discussion

The existing literature has identified various channels on how the use of revenues generated from indirect and direct carbon pricing policies could positively change public perception by highlighting the role of ‘perceived fairness’ and ‘effectiveness’^{6,20}. Specifically, questions of personal and distributional effects have shown to influence public perception of fairness and acceptability of carbon pricing policies. This is also why in theoretical analyses, *uniform cash transfers* are often touted as the optimal revenue recycling option with regards to the impact on acceptability, equity, and efficiency³. Regarding effectiveness, specifically effectiveness in reducing greenhouse gas emissions, using revenues to go towards climate-friendly and environmental purposes can also have positive effects on policy acceptability. Building on our systematic review and meta-analysis of the survey based literature, our regression results indicate that compared to using revenue towards *public finance*, only those schemes for environmental purposes (*green spending*) are associated with a statistically significant positive effect on public support.

While traditional economics as well as behavioural and political science suggest *uniform cash transfer* to increase public acceptability, our analysis of empirical studies indicate a decrease in support for this revenue recycling scheme when compared to *public finance*. One of the reasons why *uniform cash transfers* decrease support (if they have any effect) may be that respondents are averse to inequity and more concerned with distributional fairness^{23,24}. Thus, rather than providing all households with equal amount of compensation, respondents may prefer to target and compensate narrowly defined groups. Indeed, our analysis suggests that respondents systematically prefer *targeted cash transfers* when compared to revenue use for *public finance*, though none of the effects show statistical significance. This is well in-line with another recent meta-analysis, which finds that distributional fairness of climate change taxes and laws is the most important factor influencing public attitudes²⁰.

One way to interpret our findings for the substantial positive effect of *green spending* is that survey participants may not fully understand the incentive effects of Pigouvian taxes to reduce actions that have negative externalities, in this case change behaviour away from using fossil fuels to reduce greenhouse gas emissions²⁵. The concept of linking the ineffectiveness of carbon pricing policies with a preference for using revenues explicitly towards environmental purposes is known as ‘issue-linkage’²⁸. Thus, the perceived ineffectiveness of such pricing policies might be a driver in our findings of why the general public prefers revenues to be used for programs to improve the environment^{1,26}. The concept of issue-linkage also applies to other Pigouvian taxes, such as red meat taxes. For example, a survey in

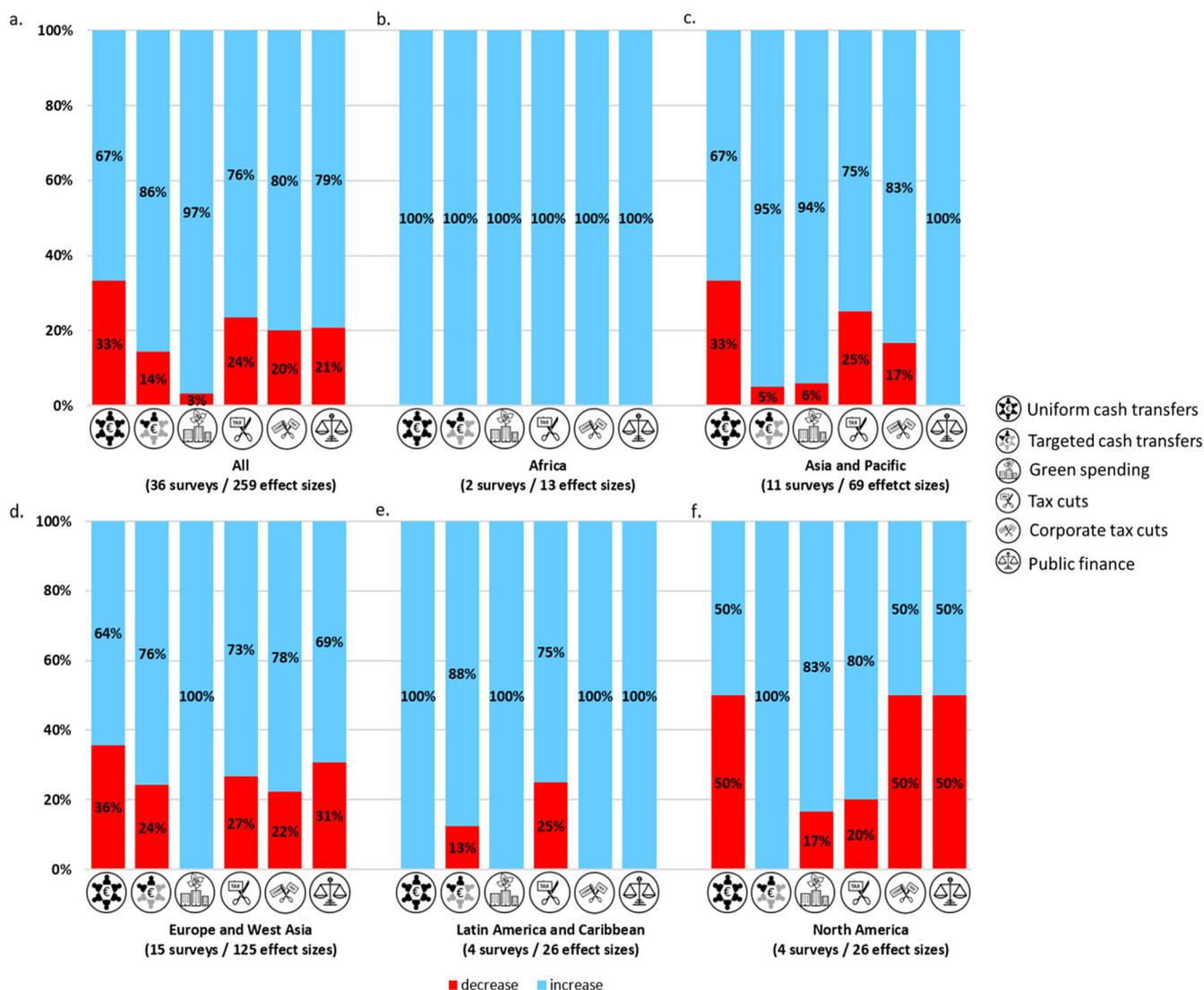


Fig. 3 | Increase or decrease in public support in shares of effect directions by revenue recycling option when compared to an ‘unspecified’ revenue use. This figure shows the share of positive and negative effect sizes for all regions and individually by each region. **a** For all surveys included in the quantitative analysis, the share of positive effect sizes is largest for *green spending* (97%) and lowest for *uniform cash* (67%). **b** In the Africa region, all effect sizes for all revenue recycling options are positive, but the sample is small. **c** In the Asia and Pacific region, effect sizes are positive for *public finance* (100%) followed by *targeted cash transfers* (95%). **d** In the

Europe and West Asia region, only for *green spending* (100%) show over 90% of effect sizes are positive. The lowest positive share is found for *uniform cash transfers* (64%). **e** In the Latin America and Caribbean region, all effect sizes are positive for *uniform cash transfers*, *green spending*, *corporate tax cuts* and *public finance*. The share of positive effect sizes is lowest for *tax cuts* (75%). **f** In the North America region, the effect of targeted cash transfers is always positive. For uniform cash transfers, corporate tax cuts and public finance half of the effect sizes are positive (50%), and more than 80% of the effect sizes are positive for green spending and tax cuts.

Norway found that earmarking revenues from a red meat tax for environmentally friendly technology increased public acceptability more than using revenues for income tax²⁷. Similarly for tobacco taxes, a study conducted in the US showed that public support for the tobacco increased when revenues were earmarked for health purposes²⁸. Both in the case of red meat and tobacco taxes, respondents favoured revenue recycling options which aimed to reduce the negative externality targeted by the policy to begin with.

Our analysis generally reveals a low amount of primary studies that analyse the relationship between public support for carbon pricing schemes and revenue recycling options. Despite statistically significant results that certain revenue recycling options increase public support for carbon pricing policies when compared to unspecified revenue use, the relatively small sample size makes it difficult to draw definitive conclusions for policy-making. For instance, uniform cash transfers has one of the lowest number of observations in our meta-analysis and we observe a high variability for support in the primary studies. To further illustrate,

uniform cash transfers are found to be the most popular revenue option in the studies by Nowlin et al.⁷ and Beiser-McGrath & Bernauer²⁹, while it is comparatively the least popular option identified in studies by Douenne & Fabre³⁰ and Ewald et al.³¹. This might underline the contextual importance of such research – depending on a country’s trust in institutions, recent economic history, regulatory traditions, political messaging and many other factors which we cannot control due to limited information in primary studies, certain revenue schemes might be more popular in one country and highly contested somewhere else. Moreover, unlike observational data or revealed preferences, a survey is an inherently controlled environment that identifies only the specified variations but cannot control for all potential biases and factors that may influence public opinion. This could also explain the perceived popularity of green spending as a potential artifact of surveys. When a survey intends to elicit support for green spending, the questions and information provided to respondents may create a more obvious link between carbon pricing

Table 1 | Logit Results

	Dependent variable: Change in public support		
	Parameter Estimate	Marginal effect at mean	Number of observations
Revenue recycling scheme:			
Uniform cash transfers (baseline: <i>Public finance</i>)	-0.60 (0.86)	-0.08	27 (24)
Targeted cash transfers (baseline: <i>Public finance</i>)	0.67 (0.46)	0.07	70 (24)
Green spending (baseline: <i>Public finance</i>)	3.09*** (1.08)	0.21	64 (24)
Tax cuts – income, labour, and consumption (baseline: <i>Public finance</i>)	0.69 (0.51)	0.08	34 (24)
Corporate tax cuts (baseline: <i>Public finance</i>)	-0.51 (0.47)	-0.07	40 (24)
Policy type:			
Carbon and environmental tax (baseline: <i>Fossil fuel subsidy reform</i>)	1.2 (1.12)	0.15	244 (15)
Carbon pricing policy in place:			
Yes (baseline: <i>No</i>)	0.73 (0.70)	0.08	194 (65)
Regions:			
Africa (baseline: <i>North America</i>)	17.85*** (1.34)	0.26	13 (26)
Asia and Pacific (baseline: <i>North America</i>)	1.34** (0.80)	0.14	69 (26)
Europe and West Asia (baseline: <i>North America</i>)	0.26 (0.69)	0.03	125 (26)
Latin America and Caribbean (baseline: <i>North America</i>)	2.67*** (1.01)	0.21	26 (26)
Survey type:			
Non-experimental (baseline: <i>experimental</i>)	2.55 *** (0.71)	0.35	213 (46)
Pseudo-R ²	0.29		

The table shows the baseline specification regression coefficients with standard errors in parentheses as well as the marginal effects at mean.

Dependent variable: change in public attitude with revenue recycling scheme.

**p* < 0.10, two-tailed test.

***p* < 0.05, two-tailed test.

****p* < 0.01, two-tailed test.

policies and their environmental purpose, thus influencing “issue-linkage”.

We tried to increase the sample size in several ways. First, we looked at other regional databases in other languages. For example, given by the large number of Spanish-speaking countries and their low representation in our data base, we conducted a search for relevant studies in a major Spanish-language database called “La Referencia”. We used the same policies and public attitude keywords as we did in the English-language query and translated it into Spanish (see Supplementary Table 2). We retrieved 535 articles; however, none fit our inclusion criteria. We would not expect that including search queries in additional languages would significantly increase our sample. Another way we increased our sample size is by including results from 20 surveys (close to a third of our sample) from one working paper published in 2022¹⁷. Our main results remain unaltered when including an additional indicator variable to control for the influence of this paper in our meta-regression (see Supplementary Table 6). Although we could have expanded our sample size for the meta-regression by assuming that respondents perceive “unspecified revenue use” to automatically imply *public finance*, we decided to treat those two concepts differently. We know from studies that wording and additional information can influence public support, for example when calling a policy a “carbon tax” or a “carbon contribution”¹. Since we did not find any study that analyses what respondents imagine revenues are used for when the survey does not specify

its usage, and to rule out any potential effects priming might have on respondents who receive information on how revenues are used (e.g., *public finance*) versus those that do not (e.g. “unspecified revenue use”), we decided to only included studies in our meta-regression which use a baseline without revenue recycling. This reveals a research gap on the cognitive-based effects of framing, additional information, political messaging and other priming methods on the responses from respondents.

Ultimately, our systematic review and meta-analysis show that the existing evidence on how revenue recycling influences public support for carbon pricing is relatively scarce. This points to a general gap in the empirical research of revenue recycling and public support for direct and indirect pricing policies. For example, the overwhelming majority of the surveys we identified are conducted ex-ante to introducing any type of carbon pricing policy. Although there is a limited number of countries and jurisdictions that have carbon pricing policies with revenue recycling, even fewer studies analyse ex-post the public support for these policies^{14–16}. Moreover, our overall sample elicits support for a carbon tax (67%) and only few analyse public attitudes for fossil fuel subsidy reform (10%). Since fossil fuel subsidy reforms also lead to highly visible price increases for consumers, our study reveals a gap in empirical understanding how revenue recycling could increase support for this indirect carbon pricing policies. Moreover, most empirical studies in our dataset have been conducted in North America, Europe and West Asia, and Asia and Pacific, revealing a lack of

research on how to increase support for carbon pricing policies with revenue recycling schemes in low-and middle-income countries in regions such as Latin America and the Caribbean and Africa. Given the number of countries in Latin America and the Caribbean which are implementing a direct and indirect carbon pricing policy and considering that protest responses are a form of active civic engagement in the region, additional empirical evidence could help inform policy-makers^{32,33}. Moreover, very few of the revenue recycling schemes in our dataset consider other types of socio-economic and welfare policies beyond *uniform- or targeted cash transfers*. This points to another gap in the empirical literature to consider what types of revenue recycling policies could increase public support specifically in low- and middle-income countries.

Methods

Literature search and data extraction

There is a large literature that discusses systematic reviews and meta-analyses and how to conduct them in a methodologically sound way in social sciences. This systematic review broadly follows the guidelines by the Collaboration for Environmental Evidence³⁴. We make use of machine-learning at the title and abstract screening stage to enable a comprehensive study identification. In particular, after screening a random sample of 100 publications, we train a support vector machine to rank the studies according to their probability of being relevant for our study. This is commonly known as “prioritised screening” that has been shown to substantially reduce workload without significant loss of recall^{35,36}. In fact, we argue that it enables the design of comprehensive search string with high-levels of recall that would not be feasible otherwise.

For the literature identification, we conducted a query search in February 2022 and 2023 in the Web of Science and the Scopus literature databases. We connect three groups of keywords with boolean operators filtering for research on (1) explicit carbon pricing policies (*carbon, CO₂, GHG, ecological, environmental AND pricing, tax, trading, market, certificate, levy, allowance*) and (2) implicit carbon pricing policies (*fuel, diesel, gas, oil, kerosene, energy, LPG AND subsidy reform, tax*) investigating (3) impacts on the general public attitudes (*people, public, social AND attitudes, response, perception, resistance, support, fair, fairness, acceptance, acceptability, opinion, belief, willingness, willing, opposition, willingness to pay*) (see Supplementary Table 1).

In order to ensure that our search query has a high recall of relevant research, we assembled a benchmark list of 53 studies of known relevance from a previous review which focuses more broadly on factors influencing public support of carbon pricing policies but does not focus on revenue recycling³⁷. Our final search string located 51 out of 53 benchmark studies. The searches were performed in Web of Science and Scopus identifying 3721 articles after correcting for duplicates. We also included all the references from the paper which were included by using citation chaser, which added an additional 1137 papers. All the results were exported and combined in the NACSOS review management tool³⁸ for screening. The NACSOS review tool automatically removes duplicate records using trigram similarity-based fuzzy title matching. The meta-data is automatically recorded from the bibliographic databases using the NACSOS software³⁸. A coding tool was used to systematically extract data from all eligible studies (codebook available upon request).

Records were screened at two levels (1) title and abstract, and (2) full-text. At an abstract-level, we screened all abstracts jointly by two people to minimise bias. When reviewing abstracts, all discrepancies between the two people were discussed and inclusion/exclusion criteria were further clarified prior to completing the screening. For the meta-analysis, we added additional inclusion criteria, that is we only included studies that also provided descriptive statistics and used the “unspecified” baseline before presenting respondents with revenue recycling options.

To screen the articles at an abstract level, the following eligibility criteria were followed by all reviewers:

Inclusion criteria.

1. Studies that conduct a public opinion survey towards different types of direct and indirect carbon pricing policies, e.g. Carbon -pricing, -tax, -trading, -levy, -allowance; or fuel -subsidy reform, -tax (including diesel, gas, oil, kerosene, energy, or LPG). Congestion and pollution pricing policies are also included if the study reference carbon emissions reductions.
2. Studies that are empirical, conducting surveys on a randomised set and representative sample of the general population.
3. Studies that include a specified a measure of public opinion toward accepting carbon pricing policies, such as acceptance, acceptability, support, and willingness to pay.
4. Studies that analyse some form of revenue recycling option as part of survey analysis using quantitative methods.
5. Studies that collect data from the population through primary survey or representative sample through secondary data.
6. Studies need either regression analyses and/or summary statistics indicating a change in public attitude.

Exclusion criteria.

1. Studies that assess unspecified tax or pricing policies (e.g. “Pigouvian taxes”) which do not reference carbon emissions. Studies were also excluded if they analysed public opinion on waste or water management, sulphur dioxide related policies, food, attitude toward specific technologies, housing, plastic tax, corporate social responsibility, reforestation, geoengineering, or personal and voluntary carbon trading.
2. Studies that present no revenue use options to survey respondents.
3. Studies using focus groups, in a laboratory setting, collecting responses from specific groups, such as farmers, policy makers, industry representatives, or students rather than the general population.

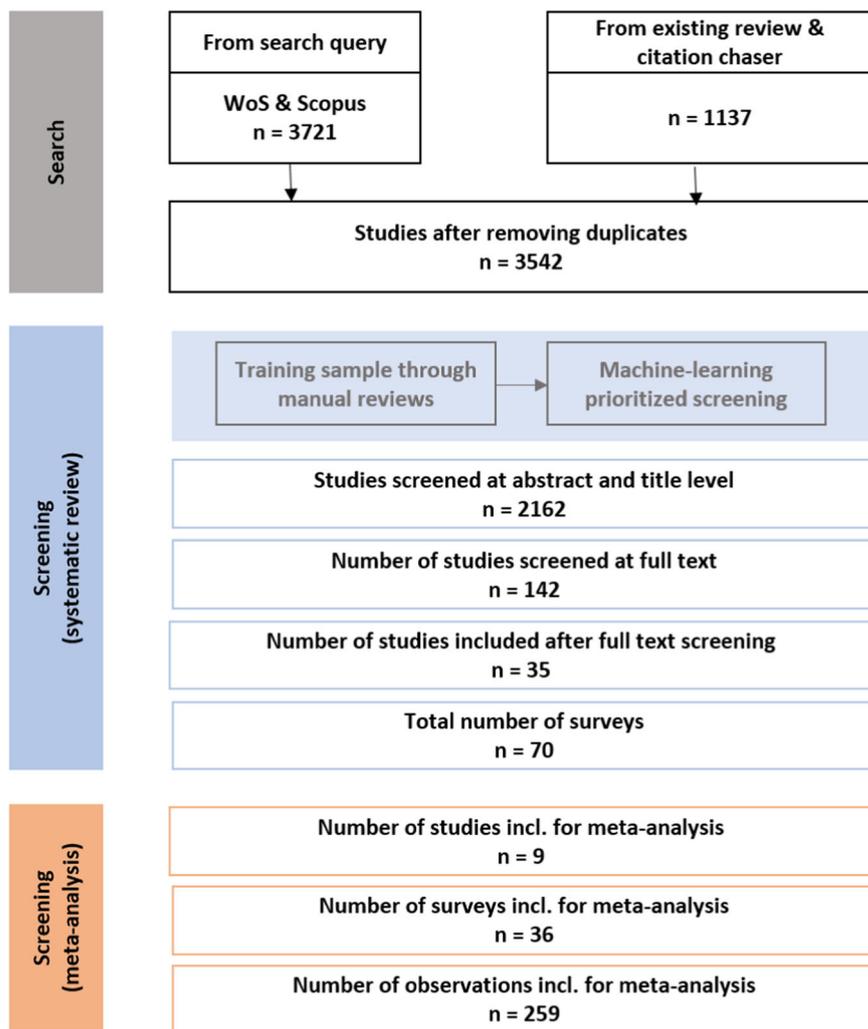
After the first screening of 200 random studies, we included 20 studies. These 20 studies plus the benchmark studies from prior literature searches are then used to train a machine learning classifier using terms from the titles, abstracts, and keywords. As a result, the remaining documents in the NACSOS management tool are ordered according to their predicted relevance based on the previous inclusion decisions. After each subsequent round of abstract screening, the machine learning classifier gets re-trained. As more documents are manually screened, the machine learning algorithm is updated using these additional labels, and the remaining documents are reordered by predicted relevance score. See Fig. 4 for an overview of the search and screening process.

Methods for meta-analysis

Dependent variable. The dependent variable of our econometric analysis is the change in public support of a carbon pricing policy following the introduction of a revenue recycling option. One main obstacle for the comparison of surveys is that they use different measures of public support. This results from the variety of rating scales such as Likert- scales (with different levels across the studies), binary scales (support-not support), or stated preferences among policy alternatives makes meaningful comparisons of the effect sizes found in different studies difficult. We therefore take the direction of the effect (that is, increase vs. decrease in public support) as the dependent variable in our regression analysis, similar to meta-analyses conducted by refs. 19,²⁰.

Moderator variables. Different moderator variables in our model account for the variation in the effects of revenue uses reported in our sample of studies. First, we create indicator variables, which capture the different survey designs that were presented to the respondents. For this, we include variables for the different revenue use options. We distinguish between redistribution schemes to the whole population or targeted to parts of it (*uniform cash transfers* and *targeted cash transfers*), infrastructure and other environmental and climate projects (*green spending*), tax-related relief mechanisms that could directly benefit populations

Fig. 4 | Flowchart for search and screening of the relevant literature – both for the qualitative and quantitative analysis. Adapted from the ROSES flow diagram for systematic reviews.⁴⁰



(income and consumption captured in *tax cuts*), and relief mechanisms for firms (*corporate tax cuts*). We use *public finance* as a reference category for the regression. Hence, this meta-regression allows us to make statements about the impact of different revenue use options on the observed changes in public support relative to the effect of transferring it to the government budget.

In addition to variables that account for the revenue recycling schemes tested, our specifications account for the design of the survey type (survey questionnaire or choice experiment). It also accounts for the type of policy respondents support (carbon tax, fuel tax, or fossil fuel subsidy reform policy). We also include a dummy that indicates whether a carbon policy was already in place in the country under study at the time of the survey, and region fixed effects. We assume fixed effects for country region groups instead of single countries to decrease the risk of multi-collinearity and imprecise results in our regression analysis. Other interesting aspects of the survey designs such as the mode of data collection or the different measures of acceptance do not show enough variation to be included in our analysis.

Logistic regression for meta-analysis. We run a logit regression to determine the relationship between the dependent variable and the moderator variables. Suppressing the observation-specific index, the logit model assumes a continuous latent variable y^* to measure the propensity for a study to find an increase in support caused by the introduction of a revenue recycling scheme. y^* is supposed to react continuously to the characteristics gathered in the vector of moderator variables x . However, we cannot observe y^* , but a binary variable y equal to 1 if the unobserved

latent variable y^* breaks a threshold θ , and 0 otherwise. Denoting α the constant and ε the normally distributed error term, the model we want to estimate can be expressed as follows:

$$y^* = \alpha + \beta x + \varepsilon$$

We can set $\theta = 0$ without a loss of generality. The resulting probability of a survey indicating a decrease in public support caused by the introduction of a revenue recycling scheme can be written as follows:

$$\pi = \Pr(y = 1|x) = \Pr(y^* = \alpha + \beta x + \varepsilon > \theta) = \Pr(\alpha + \beta x > -\varepsilon)$$

Using straightforward algebra, this equation can be transformed to:

$$\Pr(y = 1|x) = \Lambda(\alpha + \beta x) = e^{\beta x} / (1 + e^{\alpha + \beta x})$$

We cluster standard errors on survey level to account for non-independence of observations. We then estimate our model with the maximum likelihood method. The β -coefficients and their p -values provide the direction and the significance of the effects of the moderator variables: A positive β suggests that a moderator variable increases the probability of obtaining an increase in public support when introducing a revenue recycling mechanism $\Pr(y = 1)$. We provide marginal effects at mean, which show the magnitude of the probability change for the two possible outcomes induced by the moderator variables. We report the Pseudo R^2 as a measure of fit³⁹. We also test the validity of the logit specification by OLS regressions (see Supplementary Table 8).

Data availability

The data and codebook of this study are made available in a public repository and can be accessed here: https://github.com/farahmkv/PublicSupport_RR_CP.

Code availability

The code used for the meta-analysis can be accessed here: https://github.com/farahmkv/PublicSupport_RR_CP.

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Author contributions

F.M.V., J.C.S., J.C.M., and A.R. designed the research. F.M.V., A.R., and C.M. developed the literature screening strategy. F.M.V., C.M., A.R., and M.M. manually screened the literature and extracted the data. F.M.V. and A.R. performed the machine learning-enabled screening. C.M. and A.R. performed the meta-analysis. F.M.V., C.M., and J.C.S. analysed the results. F.M.V., C.M., and J.C.S. wrote the manuscript with contributions from all authors.

Competing interests

The authors declare no competing interests.

Additional information

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