



OPEN

Meta-analyses of fifteen determinants of public opinion about climate change taxes and laws

Magnus Bergquist¹✉, Andreas Nilsson¹, Niklas Harring² and Sverker C. Jagers²

Public acceptance is a precondition for implementing taxes and laws aimed at mitigating climate change. However, it still remains challenging to understand its determinants for the climate community. Here, we use a meta-analytic approach to examine the role of public opinion about climate change taxes and laws. Fifteen variables were examined by synthesizing 89 datasets from 51 articles across 33 countries, with a total sample of 119,465 participants. Among all factors, perceived fairness and effectiveness were the most important determinants. Self-enhancement values and knowledge about climate change showed weak relationships and demographic variables showed only weak or close to zero effects. Our meta-analytic results provide useful insights and have the potential to inform climate change researchers, practitioners and policymakers to better design climate policy instruments.

Human activity has unequivocally caused a warmer climate^{1,2}. Taxes and laws aimed at mitigating climate change, such as fuel taxation, have been shown to efficiently reduce carbon emissions³. Importantly, public acceptance is crucial for implementing such policies successfully. Perceived risks of public resistance might cause reluctance among politicians to implement these policies because of both potential social unrest and policy evasion^{4,5}. To explore what determines public acceptance, we conduct a series of meta-analyses assessing determinants for public opinion about climate change taxes and laws covering market-based and legal policy instruments aimed at mitigating climate change.

Public opinions about climate change taxes and laws have attracted research across numerous academic disciplines^{6–10}. These substantial, yet diverse, fields of research, focus on different determinants of public opinion^{11–13}. Results, however, are inconclusive. Compelling evidence has been provided for perceived fairness and effectiveness. In contrast, weaker evidence has been reported for trust, values and demographic factors^{8,10}. Our goal is to provide a series of meta-analyses summarizing the relationship between determinants and public opinion.

In addition to identifying determinants of policy acceptance, an equally important task is assessing which ones work better. Identifying the important determinants would guide future research and assist decision-makers in designing policy instruments aimed at mitigating climate change. It should, however, be noted that any such analyses will be based on studies conducted in a biased set of countries and political contexts (Supplementary Fig. 1), as pointed out in several reviews^{14,15}.

In this article, we meta-analyse climate change taxes and law defined as existing or hypothetical instruments (for example, taxes and laws covering market-based and legal policy instruments) directed towards the public, rather than specific professions (for example, farmers, scientists or politicians) and with the explicit aim of mitigating climate change. It should be noted that we focus on policy instruments, restricting these meta-analyses to include taxes and laws, such as carbon taxes, while excluding broader policies and sustainable energy solutions, such as nuclear power, carbon capture and storage or geo-engineering.

On the basis of 89 eligible datasets, we investigate the importance of 15 determinants, central to past research. These determinants are organized into four categories: (1) policy-specific beliefs, (2) climate change evaluations, (3) psychological factors and (4) demographic factors. Explorative subgroup analyses tested if effects vary across (1) subtypes of determinants (for example, subjective versus objective knowledge), (2) policy domains (regulations versus economic policies) and (3) sampling regions (Asia, Europe, North America and Oceania).

Results

Final sample. The final sample includes 51 articles incorporating 89 datasets from 33 countries with a total of 119,465 participants. The final sample represents Africa, Asia, Europe, India, North America and Oceania. Europe represents 64% of the sample (Supplementary Fig. 1).

Assessing publication bias and heterogeneity. To assess publication bias, we conducted trim and fill analyses. One study was imputed for both fairness and education, resulting in minor adjustments of these effect sizes (from $r=0.65$ to 0.63 for fairness and from $r=0.132$ to 0.130 for education). Taken together, these analyses indicated that publication bias was not problematic.

We assessed dispersion for all determinants using Q statistics, P values for Q , I^2 , t^2 and 95% prediction intervals (PI). Q and I^2 suggest substantial heterogeneity. It should, however, be noted that Q increases with sample size and that I^2 is not an absolute measure of heterogeneity¹⁶. We were therefore encouraged to focus on t^2 and 95% PI. To further investigate the observed heterogeneity, we performed explorative subgroup analyses for categories where $k \geq 2$. These subgroup analyses assessed (1) construct subtype, (2) policy domain and (3) sampling region. We settled on $k \geq 2$ to increase power and decrease the risks of introducing confounds associated with $k=1$. Subgroup analyses were performed for construct measured by at least two subtypes of constructs by primary studies (for example, fairness was measured as either distributional or personal fairness, while values were measured as using single underlying constructs across primary studies; Supplementary Tables 2 and 3). For policy

¹Department of Psychology, University of Gothenburg, Gothenburg, Sweden. ²Department of Political Science, University of Gothenburg, Gothenburg, Sweden. ✉e-mail: magnus.bergquist@psy.gu.se

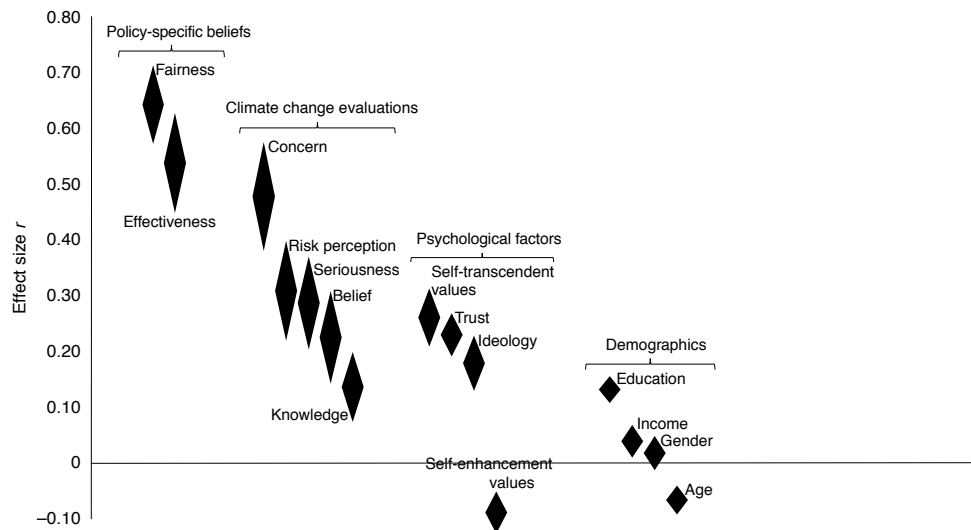


Fig. 1 | Visual summary of the relationship between determinants and public opinion about climate change taxes and laws. Higher levels of ideology represent identifying as left or liberal. Gender is coded 0, male; 1, female. Geometrical centres of the diamond shapes represent mean values and end-points represent $\pm 95\%$ CI.

domain, we compared studies assessing economic policies versus regulations (Supplementary Table 1). Economic or price-based policies are designed to act directly on prices (for example, taxes), while regulations directly control quantities of production or pollution¹⁷ by using, for example, bans to regulate unwanted behaviours. For regions, we compared studies sampling participants from Asia, Europe, North America and Oceania (see Supplementary Fig. 1 for distribution of regions). For trust, we performed subgroup analyses comparing trust in implementing institutions to trust in political or representational institutions. Implementing institutions refers to political institutions that implement policies in a non-partisan manner, such as the legal system or the public administration, while political institutions are based on different partisan interests, such as parties or the government¹⁸ (Supplementary Table 4).

Main analyses. We ran separate random-effects meta-analyses for each determinant using comprehensive meta-analysis, resulting in 15 meta-analyses (Table 1). Supplementary Table 5 and Fig. 2 provide a list of excluded determinants and forest plots for all 15 determinants.

Policy-specific beliefs. Among all determinants, fairness showed the strongest relationship with public opinion ($r=0.65$, 95% confidence interval (CI) (0.57, 0.71); Fig. 1). Importantly, fairness is a multicomponent construct referring to the extent that people, a process or a distribution, are treated or implemented equally or according to a criteria such as need or merit^{10,19}. When exploring subtypes of fairness, we found a strong effect for distributional fairness ($r=0.73$), measuring participants perceived fairness of policy distributions, for example how subsidies or taxes are distributed between or within specific groups. A weaker effect was found for personal fairness ($r=0.17$, $Q=26.87$, $P<0.001$; Fig. 2), measuring how fair a policy is perceived “for me”. Fairness was not moderated by sampling region ($Q=3.27$, $P=0.35$) but a stronger relationship was found for regulations ($r=0.78$) compared to economic policies ($r=0.57$, $Q=18.26$, $P<0.001$).

Effectiveness refers to people’s beliefs that a policy can fulfil a specific aim⁸. As an overall measure, we found effectiveness to be the second strongest determinant ($r=0.54$, 95% CI (0.45, 0.63)). Subgroup analyses found stronger relationships for taxes and laws aimed at mitigating climate change ($r=0.50$) than those aimed at

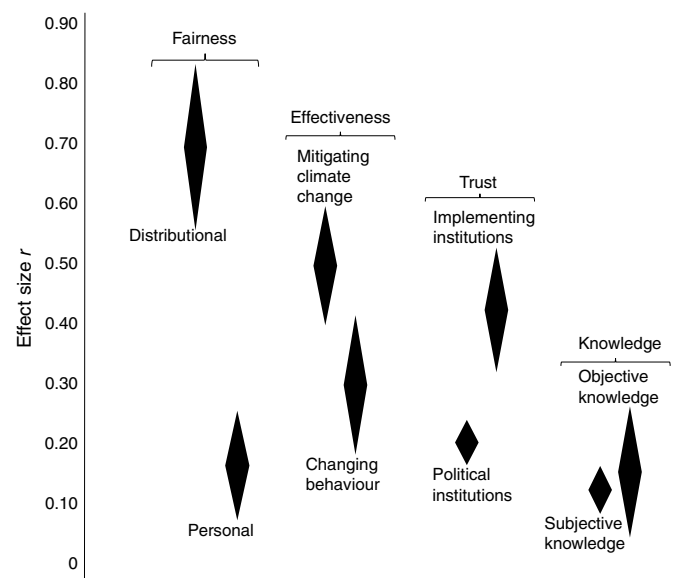


Fig. 2 | Visual summary of the relationship between subtypes of determinants and public opinion about climate change taxes and laws. Geometrical centres of the diamond shapes represent mean values and end-points represent $\pm 95\%$ CI.

changing behaviour ($r=0.30$, $Q=5.64$, $P=0.018$). In line with the results of fairness, effectiveness was not significantly moderated by sampling region ($Q=2.31$, $P=0.32$) but, again, a stronger relationship was found for regulations ($r=0.73$) compared to economic policies ($r=0.49$, $Q=14.11$, $P<0.001$).

In sum, perceived fairness was the strongest determinant for public opinions about climate change taxes and laws, which showed stronger relationships with public opinion than when perceived as personally fair. Policy effectiveness was also strongly associated with public opinion, specifically when a policy was perceived as effective in mitigating climate change. No support for variations across regions was found. Comparing between policy types, both fairness

Table 1 | Summary of relationships between determinants and public opinion about climate change taxes and laws

	<i>r</i>	95% CI	<i>P</i> for <i>r</i>	<i>n</i>	<i>k</i>	<i>Q</i>	<i>P</i> for <i>Q</i>	τ^2	τ^2	95% PI	Trim and fill
Policy-specific beliefs											
Fairness	0.65	0.57, 0.71	<0.001	13,915	27	1,941.54	<0.001	98.66	0.099	0.12, 0.89	1
Effectiveness	0.54	0.45, 0.63	<0.001	13,690	21	945.63	<0.001	97.89	0.080	-0.01, 0.83	0
Climate change evaluations											
Climate change concern	0.48	0.37, 0.58	<0.001	18,442	10	787.92	<0.001	98.86	0.049	-0.01, 0.79	0
Climate change risk perception	0.31	0.19, 0.41	<0.001	29,574	15	878.08	<0.001	98.41	0.055	-0.20, 0.69	0
Climate change seriousness	0.29	0.19, 0.38	<0.001	2,628	6	22.95	<0.001	78.21	0.011	-0.03, 0.55	0
Climate change belief	0.23	0.14, 0.31	<0.001	63,273	30	3,689.70	<0.001	99.21	0.066	-0.29, 0.65	0
Climate change knowledge	0.14	0.07, 0.20	<0.001	11,112	13	137.68	<0.001	92.28	0.013	-0.12, 0.38	0
Psychological factors											
Self-transcendent values	0.26	0.21, 0.31	<0.001	15,488	13	110.99	<0.001	89.19	0.008	0.06, 0.44	0
Trust	0.23	0.19, 0.27	<0.001	48,224	34	794.09	<0.001	95.84	0.017	-0.04, 0.46	0
Ideology (left-right)	-0.18	-0.24, 0.13	<0.001	81,025	40	2,418.52	<0.001	98.39	0.032	-0.18, 0.50	0
Self-enhancement values	-0.09	-0.12, -0.05	<0.001	11,490	10	20.56	0.015	56.26	0.001	-0.17, -0.01	0
Demographics											
Education	0.13	0.11, 0.16	<0.001	77,370	42	379.45	<0.001	91.45	0.006	-0.03, 0.28	1
Age	-0.07	-0.09, -0.05	<0.001	101,995	59	689.89	<0.001	91.88	0.007	-0.10, 0.23	0
Income	0.04	0.01, 0.07	0.006	68,386	41	514.03	<0.001	92.22	0.008	-0.14, 0.22	0
Gender (male-female)	0.02	-0.01, 0.05	0.09	97,740	56	745.56	<0.001	92.62	0.008	-0.16, 0.20	0

r, effect size; 95% CI, the mean effect size with a 95% CI; *P*, the probability of these or more extreme results given that the null hypothesis is true; *n*, number of participants; *k*, number of studies; *Q*, sum of weighted squared deviations from mean effect size; I^2 , ratio of true heterogeneity to total observed variation; τ^2 , variance of true effect; 95% PI, dispersion of effect size in 95% of all comparable populations; trim and fill, the number of estimated missing studies imputed.

and effectiveness showed stronger relationships for regulations than economic policies, in determining public opinion.

Climate change evaluations. Five types of climate change evaluations were assessed. Climate change concern can be defined as people's degree of concern or worry about climate change²⁰. Climate change risk perception measures perceived personal or societal threats to well-being that people associate with climate change²¹. Climate change seriousness refers to the extent that climate change is perceived as a serious problem¹¹. Climate change belief measures people's belief in anthropogenic climate change²². Finally, climate change knowledge assesses people's subjective or objective knowledge about climate change.

Climate change concern was strongly related to public opinion ($r=0.48$, 95% CI (0.37, 0.58)), while both climate change risk perception ($r=0.31$, 95% CI (0.19, 0.41)) and climate change seriousness ($r=0.29$, 95% CI (0.19, 0.38)) showed medium-sized effects. For region, no significant subgroup differences were found for either concern ($Q=0.17$, $P=0.92$), seriousness ($Q=2.58$, $P=0.11$) or climate change risk perception ($Q=2.05$, $P=0.36$).

Recent data suggest that the vast majority of Americans believe in climate change, while only 10% report denials²³. Importantly, denial has been reported in various cultures²⁴. This meta-analysis found a weak-to-medium-sized relationship between climate change belief and public opinion ($r=0.23$, 95% CI (0.14, 0.31)). This relationship was strong in North America ($r=0.61$), of medium size in Oceania ($r=0.36$) and weak in Europe ($r=0.17$, $Q=11.82$, $P=0.003$).

Making informed decisions about climate change mitigation is difficult if one has insufficient or incorrect knowledge²⁵. Although knowledge can be regarded as a necessary but not sufficient

precondition, past research confirms that knowledge is positively related to climate change risk perception and concern^{20,26}. One crucial limitation of measuring knowledge is the incongruence between what people think is true and the actual evidence for the specific issue²⁶. Consequently, past research has reported that objective knowledge is positively related to environmental issues, such as climate change belief and environmental risk perceptions, while smaller or even negative relationships have been reported for subjective knowledge^{21,22}. Our meta-analysis found knowledge to be weakly positively related to public opinion ($r=0.14$, 95% CI (0.07, 0.20)). Following up on this finding, we found no significant difference between objective knowledge ($r=0.16$) and subjective knowledge ($r=0.13$, $Q=0.23$, $P=0.63$).

In sum, knowledge about climate change was weakly positively related to public opinion. A weak-to-medium-sized relationship was found for climate change belief, while medium-sized relationships were found for climate change seriousness and risk perception. The strongest determinant among climate change evaluations was climate change concern, showing a strong positive relationship with public opinion. On the basis of effect sizes and 95% CI, these results indicate that 'problem-based' evaluations (climate change concern and climate change risk perception) are more strongly related to public opinion than 'knowledge-based' evaluations (knowledge and climate change belief).

Psychological factors. Values are defined as desirable goals serving as guiding principles in people's lives^{27,28}. Past studies differentiate between self-transcendent values and self-enhancement values. Self-transcendent values measure the extent to which people prioritize universalism or altruistic or biospheric values, such as a world

at peace, social justice, unity with nature and respecting the earth. Self-enhancement (or egoistic, hedonic) values measure the extent to which people prioritize authority, social power, wealth, ambition and influence. These values have been linked to accepting environmental policies such as congestion charge and energy policy^{12,29,30}. Our meta-analyses found that public opinion was positively related to self-transcendent values ($r=0.26$, 95% CI (0.21, 0.31)) and negatively related to self-enhancement values ($r=-0.09$, 95% CI (-0.12, -0.05)). Subgroup analyses across regions found weaker relationships for self-transcendent values in the Asian sample ($r=0.07$) compared to both Europe ($r=0.28$) and Oceania ($r=0.30$, $Q=12.60$, $P=0.002$). No significant subgroup effect was found for self-enhancement values ($Q=0.02$, $P=0.89$).

Trust can be defined as a “psychological state comprising the intention to accept vulnerability based on positive expectations of the intentions or behavior of another” (page 395, ref. ³¹). Past research shows that distrust is negatively linked to accepting both fuel taxes and road pricing^{32,33}. Results from our meta-analysis found a positive relationship for trust ($r=0.23$, 95% CI (0.19, 0.27)). Subgroup analyses found stronger effects for trust in implementing institutions ($r=0.43$) than trust in political institutions ($r=0.21$, $Q=13.56$, $P<0.001$). Stronger effects were also found in samples from Asia ($r=0.54$) and Oceania ($r=0.55$) compared to Europe ($r=0.19$, $Q=29.03$, $P<0.001$).

Meta-analytic results showed that identifying as politically right or conservative (versus left or liberal) was negatively associated with public opinion ($r=-0.18$, 95% CI (-0.24, -0.13)). While the overall effect was small-to-medium, we found a stronger relationship in North America ($r=-0.34$) than in both Europe ($r=-0.15$) and Oceania ($r=-0.09$, $Q=23.52$, $P<0.001$).

In sum, holding self-transcendent values, trusting institutions and identifying as political left or liberal were all positively related with public opinion. Overall, these effects were small-to-medium-sized. Nevertheless, ideology was strongly related to public opinion in the North American sample, a smaller effect for trust was found in the European sample and non-significant effects for self-transcendent values were found in the Asian sample. Interestingly, self-enhancement values showed only a weak negative relationship ($r=-0.09$), indicating that holding egocentric values is not a strong barrier for accepting policies aimed at mitigating climate change.

Demographics. Education was positively associated with public opinion ($r=0.13$, 95% CI (0.11, 0.15)). No significant subgroup difference was found for policy domain ($Q=0.04$, $P=0.84$), however, the association between education and public opinion was not significant in Oceania ($r=0.04$, $P=0.09$).

Both age and income showed small yet significant effects, showing that being younger ($r=-0.07$, 95% CI (-0.09, -0.04)) and having higher income ($r=0.04$, 95% CI (0.01, 0.07)) were both related to public opinion. The effect of age was statistically significant for economic policies ($r=-0.08$) but not for regulations ($r=-0.02$, $Q=4.42$, $P=0.04$), while no significant differences across regions were detected ($Q=4.56$, $P=0.18$).

Gender showed no significant overall effect ($r=0.02$, 95% CI (-0.01, 0.05)). No significant effects of either region ($Q=1.68$, $P=0.64$) or policy domain ($Q=0.80$, $P=0.37$) were found.

In sum, being younger, having higher income and higher education were weakly positively associated with public opinion. The effect of gender was non-significant and close to zero.

Discussion

In a series of meta-analyses, we assessed the relationships between 15 determinants and public opinion about climate change taxes and laws. These analyses were extracted from 89 datasets comprising a total of 119,465 participants from 33 countries. In line with past reviews^{8,10}, perceived fairness and effectiveness were the strongest

determinants. Importantly, distributional fairness was a stronger determinant than effectiveness, which in turn was stronger when measuring effectiveness in mitigating climate change. We have also seen strong public resistance against pursuit of pure economic efficiency, such as the Gilet Jaunes protests in France³⁴. In this light, it is noteworthy that our analyses showed a strong implication of fairness and effectiveness for regulations design and implementation.

For climate change evaluations, climate change concern was the strongest predictor, while medium-sized relationships were found for both climate change seriousness and risk perception. Results also found that climate change knowledge was only weakly related to public opinion. Past studies report inconclusive findings for determinants such as trust, values and demographic variables⁸. Here, we provide meta-analytic estimates reporting small-to-medium-sized effects of psychological variables. All demographic variables were small or close to zero. The generalizability of these findings is qualified by our subgroup analyses.

The meta-analyses showed substantial dispersion, calling for further analyses. Consequently, we conducted explorative subgroup analyses for (1) construct subtype, (2) region and (3) policy domain. When analysing construct subtypes for fairness and effectiveness we found strongest effects for distributional fairness and effectiveness in mitigation climate change. We also found stronger relationships for trust in implementing institutions compared to trust in political or representational institutions. Interestingly, we found no significant difference between objective and subjective knowledge.

Studies have reported polarization and politicization of climate change beliefs in North America (for example, refs. ³⁵). This could explain why subgroup analyses for ideology showed stronger effects on that continent. Furthermore, we found regional variation for self-transcendent values and trust, where the effect of self-transcendent values is weaker in Asia, while the effect of trust was weaker in Europe. While values have been claimed to be universal²⁷ we have reasons to believe that trust is dependent on political-institutional context³⁶.

When interpreting results from the subgroup analyses, we want to stress that these analyses were explorative and might have introduced confounders or biases, due to sample recruitment or intertwined methodological and procedural characteristics of studies. Being an observational method, this is a generic issue in meta-analytic work³⁷. We encourage future research to conduct in-depth analyses of regional or conceptual moderators, if possible, by using randomized controlled trials.

Past research has assessed a number of determinants not examined in the present meta-analysis, such as infringing on personal freedom of choice^{38,39}, emotions^{40,41} and pro-environmental identity^{42,43}. On the basis of methodological considerations⁴⁴, we did not analyse the full list of determinants (Supplementary Table 5). We encourage future research to further assess these determinants.

The goal of any meta-analysis is to include all eligible studies⁴⁵. Nevertheless, the final set of studies depends on a variety of methodological and practical considerations, such as searching literature (both search terms and search engines), developing and implementing eligibility criteria, extracting information from studies, identifying and accessing unpublished studies. All these limitations apply to our meta-analyses. More specifically, we would like to point out that our search terms were limited by including a selected list of survey methods, climate change mitigation policies and public opinion measures. This selective search strategy might have led to including studies biased towards carbon tax and congestion charge, while not identifying other policies. Importantly, any list of search terms must balance comprehensiveness and conceivability. Another limitation in these meta-analyses is the application of eligibility criteria. Developing and applying conceptual categories on the basis of such a diverse field as research on climate change mitigation policy instruments was challenging and we note that alternative

methods could have been used. The extent and impact of any such alternative methods are unclear. Meta-analytic statistics reported in Table 1 seek to inform about the robustness of results.

The effects reported in these meta-analyses are based on zero order correlations. It should be noted that interactions across determinants have been reported^{46–48}. For example, studies have found that trust is indirectly linked to acceptance via risk perception⁴⁹ and that climate change seriousness is indirectly linked via fairness and effectiveness⁵⁰.

Most of the included studies used data from the global north⁵¹. Africa and India are only represented with one study each, while South America is not represented. There is an empirical gap in the multidisciplinary research field of climate policy acceptance and we still do not know whether, or to what extent, the results are valid for the global south. For example, we have strong reasons to believe that the results may differ in contexts where the division between left and right is not the central political conflict line⁵². This, of course, limits the extent to which we can generalize the findings from this meta-analysis and calls for more and better studies based on samples in the global south. In further limiting generalizability, much past research has focused on fuel taxes. We encourage future research to conduct more studies within other areas of individual consumption.

Online content

Any methods, additional references, Nature Research reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at <https://doi.org/10.1038/s41558-022-01297-6>.

Received: 16 March 2021; Accepted: 21 January 2022;

Published online: 7 March 2022

References

- Summary for Policymakers in *Climate Change 2021: The Physical Science Basis* (eds Masson-Delmotte, V. et al.) (IPCC, Cambridge Univ. Press, 2021).
- Steffen, W., Broadgate, W., Deutch, L., Gaffney, O. & Ludwig, C. The trajectory of the Anthropocene: the great acceleration. *Anthropocene Rev.* **2**, 81–98 (2015).
- Sterner, T. Distributional effects of taxing transportation fuel. *Energy Policy* **41**, 75–83 (2012).
- Matti, S. in *Research Handbook on Climate Governance* (eds Bäckstrand, K. & Löfbrand, E.) 400–410 (Edward Elgar, 2015).
- Stern, M. J. Coercion, voluntary compliance, and protest: the role of trust and legitimacy in combating local opposition to protected areas. *Environ. Conserv.* **35**, 200–210 (2008).
- Alló, M. & Loureiro, M. L. The role of social norms on preferences towards climate change policies: a meta-analysis. *Energy Policy* **73**, 563–574 (2014).
- Cherry, T. L., Kallbekken, S. & Kroll, S. The acceptability of efficiency-enhancing environmental taxes, subsidies and regulation: an experimental investigation. *Environ. Sci. Policy* **16**, 90–96 (2012).
- Ejelöv, E. & Nilsson, A. Individual factors influencing acceptability for environmental policies: a review and research agenda. *Sustainability* **12**, 2404 (2020).
- Kyselá, E., Ščasný, M. & Zvěřinová, I. Attitudes toward climate change mitigation policies: a review of measures and a construct of policy attitudes. *Clim. Policy* **19**, 878–892 (2019).
- Maestre-Andrés, S., Drews, S. & van den Bergh, J. Perceived fairness and public acceptability of carbon pricing: a review of the literature. *Clim. Policy* **19**, 1186–1204 (2019).
- Nilsson, A., von Bergstede, C. & Biel, A. Willingness to accept climate change strategies: the effect of values and norms. *J. Environ. Psychol.* **24**, 267–277 (2004).
- Hiratsuka, J., Perlaviciute, G. & Steg, L. Testing VBN theory in Japan: relationships between values, beliefs, norms, and acceptability and expected effects of a car pricing policy. *Transp. Res. F* **53**, 74–83 (2018).
- Matthew, T. et al. Climate change in the American mind: data, tools, and trends. *Environ. Sci. Policy Sustain. Dev.* **61**, 4–18 (2019).
- Capstick, S., Whitmarsh, L., Poortinga, W., Pidgeon, N. & Upham, P. International trends in public perceptions of climate change over the past quarter century. *WIREs Clim. Change* **6**, 35–61 (2015).
- Drews, S. & Van den Bergh, J. C. What explains public support for climate policies? A review of empirical and experimental studies. *Clim. Policy* **16**, 855–876 (2016).
- Borenstein, M., Higgins, J. P. T., Hedges, L. V. & Rothstein, H. R. Basics of meta-analysis: *I* is not an absolute measure of heterogeneity. *Res. Synth. Methods* **8**, 5–18 (2017).
- Sterner, T. & Robinson, E. J. in *Handbook of Environmental Economics* (eds Dasgupta, P. et al.) 231–284 (Elsevier, 2018).
- Rothstein, B. & Stolle, D. The state and the social capital: an institutional theory of generalized trust. *Comp. Politics* **40**, 441–459 (2008).
- Jagers, C. S., Löfgren, Å. & Stripple, J. Attitudes to personal carbon allowances: political trust, fairness and ideology. *Clim. Policy* **10**, 410–431 (2010).
- Fransson, N. & Gärling, T. Environmental concern: conceptual definitions, measurement methods, and research findings. *J. Environ. Psychol.* **19**, 369–382 (1999).
- van der Linden, S. The social-psychological determinants of climate change risk perceptions: towards a comprehensive model. *J. Environ. Psychol.* **41**, 112–124 (2015).
- Hornsey, M. J., Harris, E. A., Bain, P. G. & Fielding, K. S. Meta-analysis of the determinants and outcomes of belief in climate change. *Nat. Clim. Change* **6**, 622–627 (2016).
- Leiserowitz, A. et al. *Climate Change in the American Mind: April 2019* (Yale Program on Climate Change Communication, 2019).
- Oreskes, N. & Conway, E. M. Defeating the merchants of doubt. *Nature* **465**, 686–687 (2010).
- Sarewitz, D. Does climate change knowledge really matter? *WIREs Clim. Change* **2**, 475–481 (2011).
- Shi, J. et al. Knowledge as a driver of public perceptions about climate change reassessed. *Nat. Clim. Change* **6**, 759–762 (2016).
- Schwartz, S. H. Universals in the content and structure of values: theoretical advances and empirical tests in 20 countries. *Adv. Exp. Social Psychol.* **25**, 1–65 (1992).
- Steg, L. & De Groot, J. I. M. in *The Oxford Handbook of Environmental and Conservation Psychology* (ed. Clayton, S.) 81–92 (Oxford Univ. Press, 2012).
- Steg, L., Dreijerink, L. & Abrahamse, W. Why are energy policies acceptable and effective? *Environ. Behav.* **38**, 92–111 (2006).
- Nilsson, A., Hansla, A., Heiling, J. M., Bergstad, C. J. & Martinsson, J. Public acceptability towards environmental policy measures: value-matching appeals. *Environ. Sci. Policy* **61**, 176–184 (2016).
- Rousseau, D. M., Sitkin, S. B., Burt, R. S. & Camerer, C. Not so different after all: a cross-discipline view of trust. *Acad. Manag. Rev.* **23**, 393–404 (1998).
- Kallbekken, S., Garcia, J. H. & Korneliusson, K. Determinants of public support for transport taxes. *Transp. Res. A* **58**, 67–78 (2013).
- Hammar, H. & Jagers, S. C. What is fair CO₂ tax increase? On fair emission reductions in the transport sector. *Ecol. Econ.* **61**, 337–387 (2007).
- Carattini, S., Kallbekken, S. & Orlov, A. How to win public support for a global carbon tax. *Nature* **565**, 289–291 (2019).
- McCright, A. M. & Dunlap, R. E. The politicization of climate change and polarization in the American public's views of global warming, 2001–2010. *Sociol. Q.* **52**, 155–194 (2011).
- Harring, N. Reward or punish? Understanding preferences toward economic or regulatory instruments in a cross-national perspective. *Political Stud.* **64**, 573–592 (2016).
- Lipsey, M. W. Those confounded moderators in meta-analysis: good, bad, and ugly. *Ann. Am. Acad. Polit. Soc. Sci.* **587**, 69–81 (2003).
- Bamberg, S. & Rölle, D. in *Acceptability of Transport Pricing Strategies* (eds Schade, J. & Schlag, B.) 235–248 (Elsevier, 2003).
- Fujii, A., Gärling, T. & Jakobsson, C. E. A cross-country study of fairness and infringement on freedom as determinants of car owners' acceptance of road pricing. *Transportation* **31**, 285–295 (2014).
- Goldberg, M. H., Gustafson, A., Ballew, M. T., Rosenthal, S. A. & Leiserowitz, A. Identifying the most important predictors of support for climate policy in the United States. *Behav. Public Policy* **5**, 480–502 (2021). <https://doi.org/10.1017/bpp.2020.39>
- Xi Xiao, C. & Dunlap, R. F. Validating a comprehensive model of environmental concern cross-nationally: a U.S.–Canadian comparison. *Social Sci. Q.* **88**, 471–493 (2007).
- Hine, D. W. et al. I. Identifying climate change interpretive communities in a large Australian sample. *J. Environ. Psychol.* **36**, 229–239 (2013).
- Owen, A. L., Conover, E., Videras, J. & Wu, S. Heat waves, droughts, and preference for environmental policy. *J. Policy Anal. Manag.* **31**, 556–557 (2012).
- Borenstein, M., Hedges, L. V., Higgins, J. P. & Rothstein, H. R. *Introduction to Meta-Analysis* (Wiley, 2011).
- Lipsey, W. L. & Wilson, D. B. *Practical Meta-analysis* (Sage Publications, 2001).
- Ballew, M. T., Pearson, A. R., Goldberg, M. H., Rosenthal, S. A. & Leiserowitz, A. Does socioeconomic status moderate the political divide on climate change? The roles of education, income, and individualism. *Glob. Environ. Change* **60**, 102024 (2020).

47. Czarnek, G., Kossowska, M. & Szwed, P. Right-wing ideology reduces the effects of education on climate change beliefs in more developed countries. *Nat. Clim. Change* **11**, 9–13 (2021).
48. Ehret, P. J., Sparks, A. C. & Sherman, D. K. Support for environmental protection: an integration of ideological-consistency and information-deficit models. *Environ. Politics* **26**, 253–277 (2017).
49. Bronfman, N. C., Jiménez, R. B., Arevalo, P. C. & Cifuentes, L. A. Understanding social acceptance of electricity generation sources. *Energy Policy* **46**, 246–252 (2012).
50. Kim, J., Schmöcker, J., Fujii, S. & Noland, R. B. Attitudes towards road pricing and environmental taxation among US and UK students. *Transp. Res. A* **48**, 50–62 (2013).
51. Jones, D. Psychology. A weird view of human nature skews psychologists' studies. *Science* **328**, 1627 (2010).
52. Fairbrother, M. Trust and public support for environmental protection in diverse national contexts. *Sociol. Sci.* **3**, 359–382 (2016).

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2022

Methods

Conceptual definitions. We define public opinion as measures of attitudes towards a specific policy (negative versus positive), direct measures of acceptance, acceptability or support for climate mitigation policies) or voting intentions or voting.

We define climate mitigation laws and regulations as existing or hypothetical policy instruments (for example, laws and taxes covering market-based and legal policy instruments) directed towards the public rather than specific professions (for example, farmers, scientists or politicians) with an explicit purpose of mitigating climate change.

We define determinants as any measure of policy-specific beliefs, climate change evaluations, psychological factors, demographic characteristics fulfilling statistical criteria for performing a correlational analysis.

Eligibility criteria. For inclusion, studies had to meet the following eligibility criteria:

- (1) Studies should have assessed policy-specific beliefs, climate change evaluations, psychological variables or demographic variables that could be correlated with public opinion about climate change policies. Studies were excluded if they did not assess such variables or did not fulfil statistical criteria for performing correlational analyses (for example, qualitative data such as employment type).
- (2) Studies were included that reported a measure of public opinion about laws or regulations aimed at mitigating climate change. Studies were excluded based on three criteria. (i) Measuring unspecific policies. We excluded studies measuring policies where the aims or means to mitigate climate change were unspecific. Two examples are “Government should do more to reduce greenhouse gas emissions and other potential sources of climate change”²⁵³ and “If other countries agreed in Copenhagen to limit GHG emissions their country also should do so”²⁵⁴. (ii) Measuring behaviours rather than policies. Studies were excluded when measuring a behaviour rather than a policy. Two examples are choosing a meat-free meal²⁵⁵ and “cut down on the amount you fly”²⁵⁶. (iii) Measuring support for a system rather than a policy regulation tool. Studies assessing support specific technological mitigation solutions such as carbon capture and storage, and nuclear power were excluded.
- (3) We included studies measuring attitudes or behavioural intentions toward accepting climate change policies (acceptance, acceptability, support, willingness to support, voting intention or voting for or against a specific climate change mitigation policy proposal). We excluded studies measuring willingness to pay and studies measuring pro-environmental behaviours (for example, willingness to act and self-reported pro-environmental behaviours) as these variables measure intended financial or behavioural propensities rather than public opinion.
- (4) Number of studies needed to perform a meta-analysis is related to (i) type of meta-analytic model, (ii) estimate of I^2 and (iii) statistical power. First, under the fixed-effects model two or more studies are sufficient, as the goal is to estimate one common true effect: θ (ref. 41). In this meta-analysis, the random-effects model was used to estimate the mean effect size from a universe of populations. Therefore, number of studies must be large enough to provide an acceptable estimate of I^2 and sufficient statistical power. To determine the least amount of studies for sufficient power in random-effects meta-analysis, statistical simulations have found that five or more studies are needed³⁷. Therefore, we set the cutoff for inclusion of a specific determinant to be represented by a minimum of five studies.
- (5) We included studies using survey methods, administering questionnaires for quantitative data, online, through the mail, face-to-face or in telephone interviews. We excluded studies manipulating an independent variable related to accepting climate change mitigation policies (for example, framing). Such study designs seek to assess the influence of acceptance between experimental conditions and thus induce between-group variance unrelated to the goal of the present meta-analysis. We included studies using within-group design. For these studies, we analysed data for the first measure only as later measures might have been affected by order effects.
- (6) Included studies must be reported in English.
- (7) We excluded studies assessing acceptance of environmental policies by specific professional groups (for example, farmers and policymakers) rather than the public. Although it could be argued that policies directed to specific groups will affect climate change mitigation and thus the public, the focus of this meta-analysis is on public opinion rather than the impact of climate change mitigation policies. It should be noted that, although some studies did not use representative samples, all included studies are aiming to assess public opinion.
- (8) Finally, adequate data extraction is necessary for inclusion. In cases of insufficiently reported data (not reporting zero order correlations), sufficient and unique data must be accessed either by the author(s) or a publicly available data source enabling us to retrieve at least one correlation coefficient. In cases of non-accessible data, we tried to contact the first or second author at least twice.

Search strategies. In searching for studies, we used four search strategies: (1) database search, (2) searching reference lists of reviews, (3) mailing lists and

(4) scanning conference programmes. In collaboration with librarians from the University of Gothenburg we choose to search the data bases EconLit, GreenFILE, International Political Science Abstracts, International Bibliography of Social Science, PsychINFO and ERIC to assess studies published in political science, psychology, economics and environmental science (Supplementary Table 6). The search terms were developed to match eligibility criteria in terms of (1) methods, (2) policy regulation tools and (3) public opinion measures. The search was developed to detect studies assessing climate change mitigation policy instruments based past research and literature reviews (for example, refs. 15,59). Importantly, although the goal of any meta-analysis is to “retrieve every study in a defined population”⁴² any list of search terms must balance an exhaustive yet feasible literature search. Lipsey and Wilson⁴⁵ suggest that a good literature search should “include every reference that has a reasonable prospect of being eligible but should exercise restraint in adding low probability prospects”. Guided by these suggestions, we performed a first database search in January 2020. After critically evaluating the search terms, we extended the list of search terms and performed a second search in May/June 2020 (search strategy 1 and search strategy 2, see below). The second search resulted in only minor improvements; therefore, we proceeded with our second search strategy. Second, to further refine our literature search in line with Lipsey and Wilson⁴⁵ recommendations, we searched the reference lists of four review articles related to climate change mitigation policy regulations^{8–10,20}. Third, we searched for unpublished studies by means of a call via the Environmental Psychology mailing list (December 2020), contacting authors via mailing lists from conferences and workshops (Centre for Collective Action Research Workshop on Environmental Policy Attitudes, 2019; Nordic Environmental Social Science Conference, 2019; Midwest Political Science Association). Finally, we searched for both published and unpublished studies by scanning conference programmes for relevant research (Biennial Conference on Environmental Psychology 8th–10th, 2009–2013; International Conference of Environmental Psychology 1st–2nd, 2017–19; Nordic Environmental Social Science Conference 6th and 14th, 2003 and 2019). Number of hits and the inclusion/exclusion process are visualized in a flow chart (Supplementary Fig. 3).

Search strategy 1. survey AND (“road pricing” OR “congestion charge” OR “environmental tax” OR “fuel tax” OR “carbon tax” OR “green deal” OR “water scheme” OR “carbon price” OR “climate policy” OR “climate change” OR “global warming” OR “CO₂ emissions reductions” OR “regulations” OR “mitigation policy” OR “adaptation policy” OR “climate change policy”) AND (“support” OR “accept” OR “public support” OR “policy support” OR “public accept” OR “policy accept” OR “public preferences” OR “policy preferences” OR “public attitudes” OR “policy attitudes” OR “public opinion” OR “willingness to act” OR “voting intention” OR “citizen support”)

Search strategy 2. survey AND (“road pricing” OR “congestion charge” OR “environmental tax” OR “fuel tax” OR “carbon tax” OR “green deal” OR “carbon price” OR “climate policy” OR “climate change” OR “global warming” OR “CO₂ emissions reductions” OR “regulations” OR “mitigation policy” OR “adaptation policy” OR “climate change policy” OR “greenhouse gas tax” OR “greenhouse gas” OR “CO₂-tax” OR “carbon dioxide tax”) AND (“support” OR “accept” OR “public support” OR “policy support” OR “public accept” OR “policy accept” OR “public preferences” OR “policy preferences” OR “public attitudes” OR “policy attitudes” OR “public opinion” OR “willingness to act” OR “voting intention” OR “citizen support”)

Data extraction and coding. For each included study, we coded basic descriptive information, effect size—Pearson product-moment correlation coefficients and information for explorative subgroup analyses: (1) construct subtypes, when determinants were assessed by different measures (for example, personal fairness versus distributional fairness); (2) policy domain—economic versus regulation; and (3) sampling region—North America, Europe, Oceania and Asia. For studies lacking sufficient information, we contacted the author(s) asking for specific information (for example, sampling method, statistics or raw data). For studies using multiple public opinion measures, we analysed average public opinion in index variables after excluding ineligible policies. Supplementary Tables 1–3 give study details and measurements of all included determinants.

Data availability

All data are available at <https://osf.io/q6r3a/>

Code availability

All analyses were performed using comprehensive meta-analysis. Outcomes are available at <https://osf.io/q6r3a/>

References

53. Arbuckle Jr, J. G., Morton, L. W. & Hobbs, J. Farmer beliefs and concerns about climate change and attitudes toward adaptation and mitigation: evidence from Iowa. *Climatic Change* **118**, 551–563 (2013).

54. Kim, S. Y. & Wolinsky-Nahmias, Y. Cross-national public opinion on climate change: the effects of affluence and vulnerability. *Glob. Environ. Politics* **14**, 79–106 (2014).
55. de Boer, J., Schösler, H. & Boersema, J. J. Climate change and meat eating: an inconvenient couple. *J. Environ. Psychol.* **33**, 1–8 (2013).
56. Whitmarsh, L. & O'Neill, S. Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. *J. Environ. Psychol.* **30**, 305–314 (2010).
57. Jackson, D. & Turner, R. Power analysis for random-effects meta-analysis. *Res. Synth. Methods* **8**, 290–302 (2017).
58. Sterner, T. *Policy Instruments for Environmental and Natural Resource Management* (Resources for the Future, 2003).

Acknowledgements

We would like to thank all authors who made this meta-analysis possible by providing raw data or summarizing their data. We thank P. Blumenschein, M. Helferich, P. Karinti, J. Köhler, K. Nnadi and M. Thiel for comments on the manuscript and for their work in the search process. We would also like to thank S. Gullstrand for assisting us during the literature search. We would like to thank T. Gärling and E. M. Giolla for providing valuable comments on the manuscript and both M. Borenstein and D. Wilson for provide feedback and recommendations on statistical considerations. This research was funded by the Kamprad Family Foundation, grant no. 20200135 received by M.B. and the Swedish Research Council Formas, grant no. 2019-02005 received by S.C.J.

Author contributions

S.C.J. conceived the idea. M.B., A.N., N.H and S.C.J. all contributed to developing the eligibility criteria and search strategies. M.B. led the literature search, developed the coding scheme and assessed eligibility of studies with assistance from acknowledged researchers' assistants. M.B. and N. H. extracted the data. M.B. performed the statistical analyses, wrote the first draft of the manuscript and made figures and tables. All authors contributed to revising the manuscript.

Funding

Open access funding provided by University of Gothenburg.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1038/s41558-022-01297-6>.

Correspondence and requests for materials should be addressed to Magnus Bergquist.

Peer review information *Nature Climate Change* thanks Gabriela Czarnek, Jiaying Zhao and the other, anonymous, reviewer(s) for their contribution to the peer review of this work.

Reprints and permissions information is available at www.nature.com/reprints.