

Comparing advice on climate policy between academic experts and ChatGPT

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ABSTRACT

We compare the results from a recent global expert survey on climate policy with answers to the same survey by the online artificial-intelligence chatbot *ChatGPT*. Such a study is timely and relevant as many people around the world are likely to use ChatGPT and similar language models to inquire about climate solutions, which in turn might influence public opinion. The comparison provides insights about performance criteria, policy instruments, and use of information from distinct academic disciplines. With a few exceptions, responses by ChatGPT are informative and of high quality. We find that ChatGPT answers questions with less bias than experts from various scientific disciplines. The latter may also be a disadvantage as it seems to weight all the information available equally without accounting well for relevance, which arguably may require human rather than artificial intelligence. On the other hand, experts from distinct disciplines show difference in average responses, with some even expressing opinions inconsistent with objective evidence, meaning there is no consistent and unbiased expert opinion on climate policy. As a new way of synthesizing large amounts of academic and grey literature, ChatGPT can serve policymaking. However, since the procedure that it follows for collecting and summarizing information remains a black box, it is best regarded as a complement rather than a substitute to traditional literature reviews and expert surveys.

1. Introduction

The quantity of academic publications on climate policy is rapidly expanding. New journals have appeared over the last decade, many behavioral and social sciences contribute to it, and the number of climate researchers is growing. How can we make sense of all the associated information? This is a pertinent question as debate about suitable climate-policy instruments is ongoing while disciplines do not entirely agree on the best choice. One way to make progress is undertaking systematic reviews while another is surveying academic experts. In the last decade, a potential third option has become available, namely artificial intelligence (AI). One application is in the form of machine learning to integrate big data, including linguistic excerpts from publications (Griffith and Steyvers, 2004; Lüdering and Winker, 2016; Savin and van den Bergh, 2021; Creutzig et al., 2021). Another is the recent option of aggregating or summarizing (mostly online) information using

artificial-intelligence (AI) chatbots (Fergus et al., 2023; Temsah et al., 2023).

We recently undertook an expert survey on climate policy covering many disciplines (Drews et al., 2024), including computational linguistic analysis of answers to open-ended questions (Savin et al., 2024), and think it is timely to undertake a comparison with the currently most used AI chatbot, namely ChatGPT. This allows us to test the contents and quality of its responses, as well as examine the role of disciplinary information and differences. We therefore presented to ChatGPT a selection of the questions from our original survey as well as some follow-up questions to clarify some of the responses and identify the sources of information, including the contribution of distinct disciplines. This was done as the expert survey covered many disciplines and as some instruments tend to be studied more in specific disciplines. In doing this, we paid particular attention to providing clear instructions (i.e. prompt engineering) to ChatGPT on the context and purpose of our questions in

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order to get as clear answers as possible (Lee et al., 2023). We compare the answers between ChatGPT and experts both qualitatively and quantitatively.

Our research question is whether evaluation of climate-policy instruments by ChatGPT systematically differs from that by scientific experts? This is not a trivial question as differences between ChatGPT and experts could easily arise for at least two reasons: they may not have access to the same bodies of information (e.g., as not all historical textbooks and grey literature are online), and they may differently weight information obtained from distinct sources.

We provide a timely and relevant study given that many people around the world are likely to use ChatGPT and similar language models in the near future with the purpose to obtain information about climate solutions. This, in turn, may influence opinion formation about climate policies and strategies. While there are already some studies investigating the quality of ChatGPT responses on the topic of climate change (Bergener et al., 2023; Sommer and von Querfurth, 2024) or more broadly environment (Zhu et al., 2023), our study is the first that studies ChatGPT in the context of climate change mitigation policies. Moreover, ours are the first study that compares responses from ChatGPT with those from a global expert survey.

The reminder of this paper is organised as follows. Section 2 presents the responses to the survey from ChatGPT in a summary way. Next, Section 3 compares these with the earlier replies from academic experts. Section 4 then reports responses to additional questions we posed to ChatGPT with the purpose to resolve apparent inconsistencies between certain responses as well as to inquire about the sources of information and the role of distinct academic disciplines. Finally, Section 5 concludes.

2. Responses from ChatGPT

2.1. Policy performance criteria

We presented to ChatGPT all substantial questions from our original survey, omitting the ones relating to professional and personal features of the experts since these are irrelevant to the chatbot. The full questionnaire with answer options is presented in Section A.2.1 of the Appendix.

2.2. Policy criteria

Regarding question 1, “How important do you consider the following criteria for evaluating climate policy instruments?”, ChatGPT gave a maximum score to the criteria effectiveness, efficiency, equity, feasibility. It added that “Each of these criteria is interconnected, and a holistic approach is required for effective climate policy evaluation. For instance, a highly effective policy that lacks equity or feasibility might not be sustainable in the long term. Similarly, an efficient policy that fails to substantially reduce emissions would not be serving its primary purpose. Therefore, a balanced consideration of all these factors is essential in climate policy assessment.”

2.3. Policy instruments

Regarding question 2 about rating the following instruments of climate policy in terms of their performance on each of the four mentioned criteria, ChatGPT responded as in Table 1 below.

ChatGPT added the provision that “These ratings are inherently subjective and can vary depending on specific policy designs, local contexts, and changes in technology or market conditions. Additionally, policy instruments are often used in combination to leverage their strengths and mitigate their weaknesses.”. Since it did not provide other

Table 1
ChatGPT on performance of instruments of climate policy in terms of four key criteria.

Instrument	Effectiveness (i.e. certainty and degree of realization of the emissions-reduction objective)	Efficiency (i.e. achieving the objective at the lowest economic costs or welfare sacrifice)	Equity (i.e. avoiding regressive distributional effects)	Feasibility (i.e. taking into account public and political support for, and opposition to, a policy)
<i>Direct regulation (e.g. technical standards, quotas)</i>	High – Direct regulation can be very effective because it mandates specific limits or standards that must be met.	Low to Moderate – These can be economically inefficient as they don’t allow for flexibility or market mechanisms to find the cheapest solutions.	Moderate – The impact on equity depends on how the regulations are structured and can vary widely.	Moderate – While direct regulations can be straightforward to implement, they often face significant political resistance from regulated industries.
<i>Carbon tax</i>	Moderate to High – Taxes create a clear financial incentive for emission reductions but depend on the tax rate for their overall effectiveness.	High – Taxes are generally considered economically efficient as they allow entities to find cost-effective ways to reduce emissions.	Low to Moderate – A carbon tax can be regressive, impacting lower-income groups more unless measures are taken to redistribute the revenues.	Low to Moderate – Taxes are often unpopular and can face significant opposition, although they can be more acceptable if coupled with revenue recycling to the public.
<i>Cap-and-trade</i>	High – If the cap is set appropriately, it guarantees a certain level of emission reductions.	High – It allows for emissions reductions to occur where they are most economical due to the trading mechanism.	Moderate – The impact on equity depends on the allocation of allowances and use of revenues.	Moderate – These systems can be complex to design and require buy-in from various stakeholders but have been successfully implemented in multiple jurisdictions.
<i>Adoption subsidies</i>	Moderate – Subsidies encourage adoption of clean technologies but may not always lead to the most cost-effective emission reductions.	Low – They can lead to market distortions and may not always be allocated to the best technologies.	High – If well-designed, they can be directed to benefit lower-income groups specifically.	High – Subsidies are generally politically popular as they are seen as a positive incentive rather than a penalty.
<i>Innovation support (e.g. R&D subsidies)</i>	Moderate – Supports the development of new technologies but doesn’t guarantee their adoption or direct emission reductions.	Moderate – Can be efficient if they accelerate cost-effective technologies but also risk supporting technologies that aren’t market-viable.	Moderate – Can be structured to be equitable but doesn’t inherently address equity.	High – R&D support is generally viewed positively and can gain broad support.
<i>Information provision (e.g. education or ecolabels)</i>	Low to Moderate – Depends greatly on public response and behavior change, which can be uncertain.	High – Relatively low-cost ways to potentially influence behavior.	High – Accessible to all and can be particularly empowering for consumers.	High – Information campaigns are generally easy to implement and face little opposition.
<i>Other, please specify (optional)</i>	–	–	–	–

instruments, we asked a separate question about this later (see [Section 2.2](#)).

Next, question 3 asked how important do you consider each of these instruments in the climate policy mix of a country? The answer is presented in [Table 2](#).

ChatGPT mentioned in addition that “Other instruments might be crucial depending on the specific context of a country, such as public investment in infrastructure, legal frameworks for climate liability, etc.” and “Each instrument plays a unique role and their importance can vary depending on a country’s specific economic structure, existing legal frameworks, and environmental targets. Moreover, the effectiveness of each tool can be enhanced when used as part of a comprehensive strategy that employs multiple instruments in tandem.”

Note that despite the response scale (1 = unimportant; 2 = somewhat important; 3 = important; 4 = very important; 5 = extremely important) no instrument was rated as extremely important. Surprisingly, cap-and-trade was rated lower than carbon tax, despite the most successful carbon pricing system being the EU-ETS, i.e. cap-and-trade.

2.4. Carbon pricing

Next, we asked an open question (4): “There is considerable debate about the specific role of carbon pricing (carbon tax or cap-and-trade) in the climate policy mix. What do you think are the main strength(s) and weakness(es) of carbon pricing compared with other instruments?” The responses were:

- Strength(s) of Carbon Pricing: Carbon pricing, which encompasses both carbon taxes and cap-and-trade systems, is lauded for its economic efficiency. The primary strength of carbon pricing is its ability to internalize the external cost of carbon emissions, effectively making it more expensive to pollute. This incentivizes businesses and consumers to reduce emissions and invest in cleaner technologies. It’s a market-based mechanism that encourages innovation and provides flexibility, allowing emitters to decide the most cost-effective way to reduce their carbon footprint. Carbon pricing can also generate significant government revenue, which can be reinvested in green technologies or offset elsewhere in the budget, potentially reducing other taxes. By providing a predictable and scalable method of reducing emissions, it can drive long-term

investments in low-carbon infrastructure and research and development.

- Weakness(es) of Carbon Pricing: Despite its strengths, carbon pricing is not without criticism. One of the main weaknesses is the challenge of setting the correct price. If the price is too low, it won’t lead to significant emission reductions; if it’s too high, it can be economically disruptive. The social and political acceptability of carbon pricing is often low due to its direct impact on energy prices, which can be regressive, affecting lower-income households disproportionately unless mitigating measures are taken. Furthermore, carbon pricing alone may not be enough to address all sources of emissions effectively, particularly in sectors where alternatives to fossil fuels are not readily available or where significant technological change is required. It also does not directly address other market failures, such as the under-provision of R&D for new technologies or the need for adaptation measures. Another challenge is the potential for carbon leakage, where emissions are effectively outsourced to countries with less stringent or no carbon pricing, thereby undermining global emission reduction efforts.

As a fifth question we asked whether ChatGPT agrees or disagrees with ten statements. The responses are in [Table 3](#).

ChatGPT adds to this the comment “These responses reflect the complex interplay between carbon pricing and the broader climate policy landscape, highlighting the importance of integrating carbon pricing with other policy instruments to achieve comprehensive and effective climate action.”

While we could add nuances to some of these responses, generally the arguments for the ratings sound well-informed. Note that in view of the response scale (1 = strongly disagree to 5 = strongly agree; don’t know), ChatGPT never responded with a 1 (“strongly disagree”) or with a “don’t know”.

Next, question 6 asked in an open question form about knowledge gaps regarding carbon pricing that deserve attention in research. Here ChatGPT offered a list of ten suggestions:

1. Optimal pricing strategies: Determining the most effective carbon price levels to balance economic growth with significant emissions reductions remains a challenge. Research into dynamic pricing models that respond to market signals and environmental targets could be beneficial.
2. Distributional impacts: More detailed studies are needed to understand the regressive effects of carbon pricing and how to mitigate them through revenue recycling or other policy measures to ensure social equity.
3. Behavioral responses: While economic theory predicts how consumers and firms should respond to carbon pricing, empirical research on actual behavior is less conclusive. Understanding the psychological and social factors that influence the response to carbon pricing could help in designing more effective policies.
4. Technology innovation and diffusion: It’s important to investigate how carbon pricing stimulates innovation and the adoption of new technologies across different sectors and economies, and whether it can be effective in promoting breakthrough technologies, not just incremental improvements.
5. Global coordination and linkage: Research on how different carbon pricing systems can be linked effectively to form a coherent global system would be valuable, considering issues of competitiveness, carbon leakage, and harmonization of pricing mechanisms.
6. Long-term transformational change: How carbon pricing can contribute to the long-term transformational change required to achieve net-zero emissions, beyond short-term marginal abatement, is an area needing further exploration.
7. Complementary policies: Identifying the most effective mix of carbon pricing and complementary policies, such as regulations

Table 2
ChatGPT rating importance of instruments in a climate policy mix.

Instrument	Rating	Argument
Direct regulation (e.g., technical standards, quotas)	4	Direct regulation ensures compliance and can rapidly shift industry standards, making it a critical tool for achieving immediate environmental objectives.
Carbon tax	4	It provides a clear economic signal to reduce emissions and can be adjusted to balance environmental goals with economic considerations.
Cap-and-trade	3	It establishes a market for carbon emissions and can be an effective way to reduce emissions if the cap is set ambitiously.
Adoption subsidies	3	Subsidies encourage the uptake of green technology and can accelerate the transition to a low-carbon economy, especially in the early stages of technology development.
Innovation support (e.g., R&D subsidies)	4	Long-term solutions to climate change rely on innovation, and R&D support is critical for developing new technologies that can later be deployed at scale.
Information provision (e.g. education or ecolabels)	2	While not as directly impactful as regulatory or financial instruments, information provision can change consumer behavior and support a cultural shift towards sustainability.

Table 3
Agreement/disagreement of ChatGPT with ten statements about carbon pricing.

Statement	Rating	Comment
a) Since carbon pricing alters relative prices, firms and consumers automatically account for climate-change effects of their decisions.	4 (strongly agree)	Carbon pricing effectively integrates the social cost of carbon emissions into the economic decision-making process for both firms and consumers, promoting more environmentally conscious behavior.
b) Carbon pricing has little impact on the speed of low-carbon innovation.	2 (disagree)	By creating a consistent financial incentive to reduce emissions, carbon pricing can indeed accelerate innovation in low-carbon technologies as firms seek cost-effective ways to minimize their tax burden or capitalize on trading schemes.
c) Carbon pricing is the most effective instrument to limit energy/carbon rebound. An example of rebound is driving more kilometers after buying a more fuel-efficient car.	3 (neutral/agree)	While carbon pricing can mitigate some rebound effects by maintaining an economic disincentive for increased consumption, it is not always the most effective instrument on its own, as rebound effects are complex and can be influenced by behavioral factors.
D) Carbon pricing promotes emissions reduction at the margin but cannot stimulate major changes necessary for achieving zero carbon emissions.	3 (neutral/agree)	Carbon pricing is effective for incremental improvements but may not be sufficient to drive the systemic changes required for full decarbonization without complementary policies.
e) Carbon pricing decentralizes policy, thus reducing regulators' need for information.	4 (strongly agree)	By leveraging market mechanisms, carbon pricing reduces the need for regulators to collect detailed information for policy enforcement, as the market naturally adjusts to the price signals.
f) Contextual, sector-specific climate policies are more effective in terms of overall emissions reduction than economy-wide carbon pricing.	3 (neutral/agree)	Sector-specific policies can address unique challenges and opportunities within different sectors more effectively than a broad-based pricing mechanism, which may not capture sector-specific nuances.
g) Carbon pricing takes into account that in making purchasing decisions, most consumers are more influenced by prices than by environmental concerns.	5 (strongly agree)	Carbon pricing capitalizes on economic self-interest to drive behavior change, which is typically more influential on consumer behavior than voluntary environmental considerations.
h) Carbon pricing can be more easily up-scaled and harmonized globally than other instruments.	4 (strongly agree)	Carbon pricing mechanisms, especially cap-and-trade systems, have the potential for integration across borders, providing a scalable approach to global emissions reduction.
i) Carbon pricing functions worse than other instruments when consumers and firms do not make rational choices.	2 (disagree)	While true that carbon pricing relies on rational decision-making, it is also the case for most other policy instruments; moreover, the clear price signal helps guide decisions even if they are not entirely rational.
j) A unique advantage of carbon pricing over other instruments is that it generates public revenues which can be used for multiple purposes.	5 (strongly agree)	Revenue generation is a significant advantage of carbon pricing, providing funds that can be used for tax cuts, investment in clean energy, or to offset impacts on vulnerable populations.

or subsidies, could help to maximize the overall effectiveness of climate policy.

8. Market mechanisms and alternatives: The development of alternative market mechanisms, such as carbon offset markets, and their interactions with direct carbon pricing need more attention to assess their validity and integrity.
9. Economic and environmental outcomes: Further studies are needed to empirically assess the long-term economic and environmental outcomes of carbon pricing policies in various contexts and to compare them with the outcomes of other climate policy instruments.
10. Policy implementation: Research on the barriers to the implementation and public acceptance of carbon pricing, including political economy aspects, can provide insights into how to overcome obstacles to policy enactment and enforcement.

We would say that suggestions 5 and 9 are possibly the most innovative elements, whereas the remaining ones really have already received considerable attention in the literature. Nevertheless, it is interesting to see that ChatGPT is able to cover a wide range of relevant topics, including key ones, while also helping the reader by offering a brief title for each.

2.5. General closing questions

In response to question 7 “How worried are you about climate change and its societal consequences?” ChatGPT did not provide a rating (1 = Not at all worried, 3 = A bit worried, 5 = Somewhat worried, 7 = Very worried, 9 = Extremely worried, Don't know). Instead, it noted that “As an AI, I don't have personal feelings or worries, so I cannot provide a personal response to how worried I might be about climate change and its societal consequences.”¹ However, I can provide information and perspectives based on the consensus of the scientific community and public opinion ...” This complete response (see Appendix A.2.1) reflects that ChatGPT is up-to-date with most recent developments in the literature (Dechezleprêtre et al., 2022; Andre et al., 2024).

Subsequently, we asked question 8 about agreement or not with three statements about economic (GDP) growth in relation to progress and environment. The response was that “As an artificial intelligence, I don't hold personal opinions or beliefs, so I can't agree or disagree with statements.” However, it provided “an analysis based on prevailing economic theories and social perspectives”, shown in Table 4.

ChatGPT ended with the comment “These are complex issues with varying opinions among economists, policymakers, and the public, reflecting the ongoing debate about the role of GDP growth in society and its relationship with environmental sustainability and human well-being.”

3. Comparison with academic experts

Here we compare the findings of the previous section with a global survey among almost 800 scientists who published on climate policy, various fields across the social and natural sciences. Details of this are reported in Drews et al. (2024) while a computational linguistic analysis of answers to open-ended questions was performed by Savin et al. (2024). The results provide insight into (dis)agreements about the six main types of instruments of climate policy.

¹ A colleague suggested to ask ChatGPT to answer all questions as if it was an expert in climate policy. This led to small differences in some answers, which indicates that prompting matters.

Table 4
Response by ChatGPT to three statements about economic growth.

Statement	"Analysis"
Continued economic growth is essential for improving people's life satisfaction	Prevailing View: This statement is often associated with traditional economic perspectives that correlate higher GDP with better standards of living, including access to goods, services, and infrastructure that can improve life satisfaction. Critics argue that beyond a certain point, the correlation between GDP growth and life satisfaction weakens, and other factors like income distribution, environmental quality, and work-life balance become more significant.
In view of limited natural resources, rich countries may have to give up their economic growth to assure that all poor people in the world can reach a fair standard of living	Prevailing View: This perspective is grounded in the concept of sustainable development and global equity. It suggests that in a world with finite resources, the continued growth of high-income countries could compromise the ability of low-income countries to meet their basic needs. Proponents of sustainable growth advocate for a more equitable distribution of resources and growth opportunities, while some argue for a complete reevaluation of what constitutes growth and progress.
Economic growth is necessary to finance environmental protection	Prevailing View: The argument here is that wealth generation provides the resources needed for investments in environmental protection and sustainable technologies. Higher GDP can mean more funding for research, innovation, and implementation of environmental measures. However, some environmentalists and economists contend that reliance on GDP growth can lead to environmental degradation and that alternative measures of progress may be needed to truly protect the environment.

3.1. Policy performance criteria

First, we compare the importance given to each of the four criteria - effectiveness, efficiency, equity, and feasibility - in evaluating climate policy instruments (question 1). Whereas ChatGPT assigns identical

significance (5 out of 5, i.e. "extremely important") to each of the criteria, the results of the survey show that experts find effectiveness by far the most important criterion (varying between "very important" and "extremely important", depending on the discipline), followed by equity and feasibility (mostly "very important") and efficiency ranked as last (mostly between "important" and "very important"). Fig. 1 illustrates these ratings. We also checked how many of our respondents selected all four criteria as "extremely important" and the total equals 52 (i.e. 6.5%, which is small fraction). So, ChatGPT presents a minority opinion in this regard. For comparison, the number of respondents who rated only one of the criteria as extremely important (while others lower) is 260 (i.e. 33%). This shows, that unlike ChatGPT, experts make clear choices in favor of certain criteria over others.

3.2. Policy instruments

Next, we compare the rating of climate policies based on their performance in relation to the four evaluation criteria (question 2). Fig. 2 shows the differences between ChatGPT's assessment and experts' opinions. In assessing effectiveness, ChatGPT rates cap-and-trade as a highly effective tool while experts assign it as moderately effective. Incidentally, we personally would agree more with ChatGPT given the experiences with cap-and-trade in reality (Finch and van den Bergh, 2022). In contrast, subsidies and information provision are rated by ChatGPT as less effective compared to experts.

Concerning efficiency, ChatGPT identifies information provision next to two forms of carbon pricing as the most efficient tools, whereas experts rated information provision substantially lower. Also, we observe that ChatGPT considers adoption subsidies as well as direct regulation as inefficient while experts rate them much higher. Here again, based on recent evidence from Gugler et al. (2021), we tend to agree rather with ChatGPT than the experts.

As for assessing equity and feasibility of the instruments, ChatGPT attributes lower scores (than experts) to carbon pricing and direct regulation and higher scores to adoption subsidies and information provision. The ranking of the instruments remains though rather stable. This shows that ChatGPT is ready to demonstrate bigger differences in evaluating instruments while experts are more cautious in giving extreme evaluations.

Let us now compare the assessment of the significance of the instruments in a climate policy mix to address the climate change (question 3). As depicted in Fig. 3, despite both ChatGPT and experts

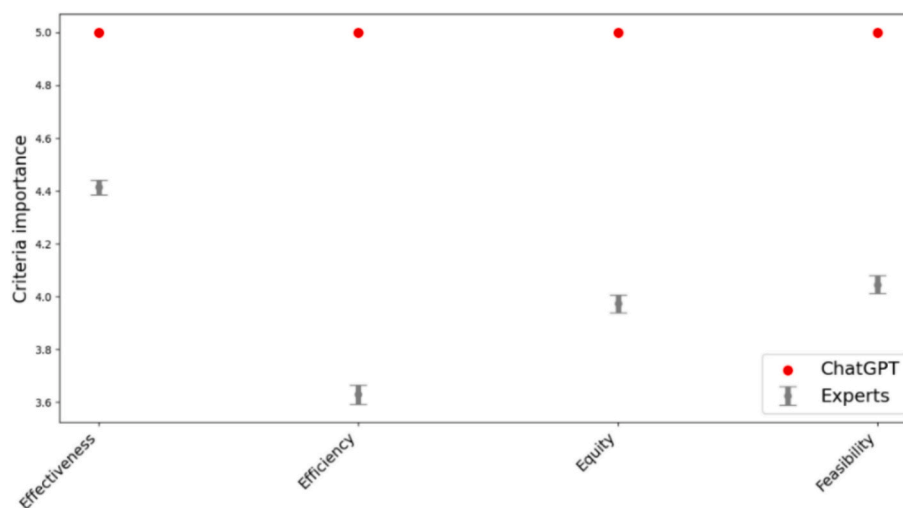


Fig. 1. Importance of policy evaluation criteria as rated by ChatGPT (red) and experts (black). The results for experts represent mean values with error bars indicating ± 2 standard errors. The scale on the Y-axis ranges from 1 (unimportant) to 5 (extremely important). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

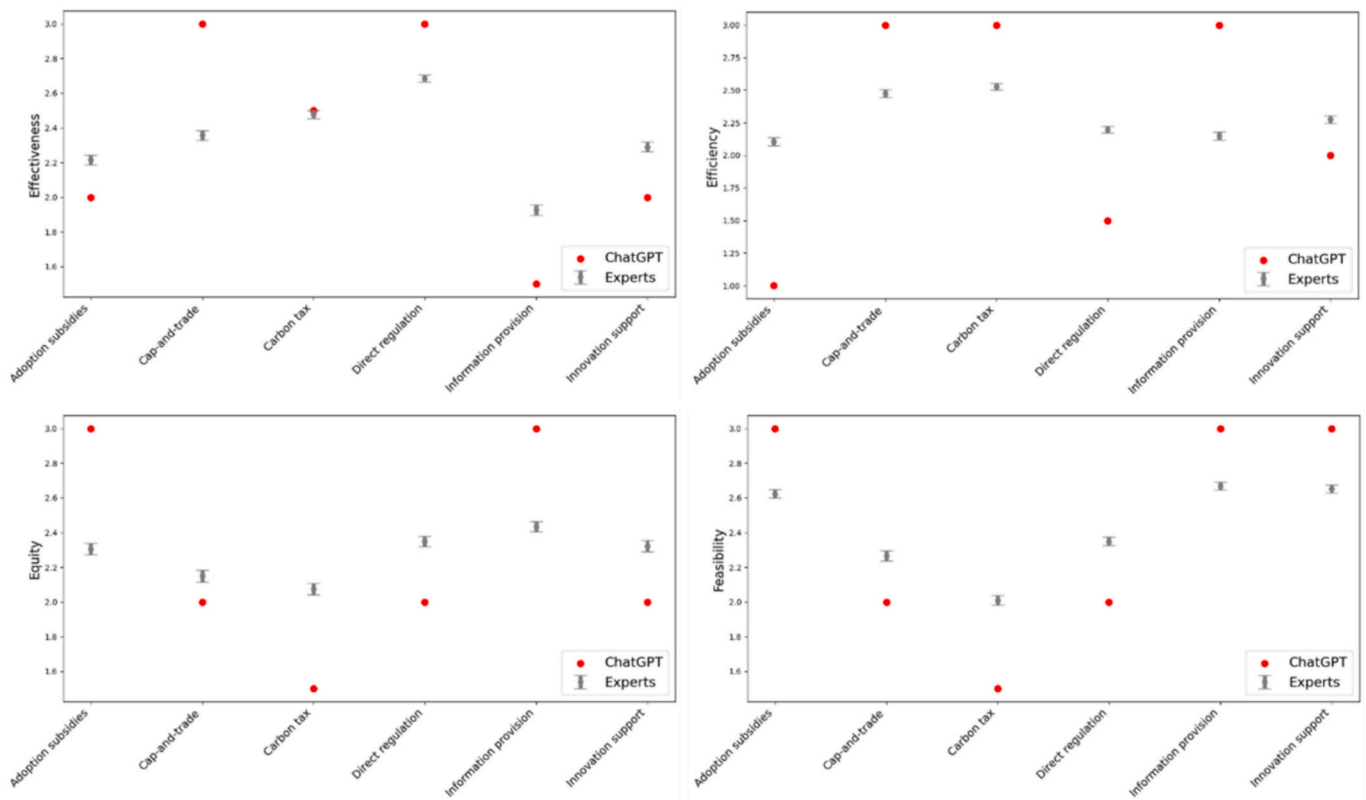


Fig. 2. Evaluation of instruments performance across the four criteria: effectiveness, efficiency, equity and feasibility, rated by ChatGPT (red) and experts (black). The results for experts represent mean values with error bars indicating ± 2 standard errors. The scale on the Y-axis ranges from 1 (low performance) to 3 (high performance). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

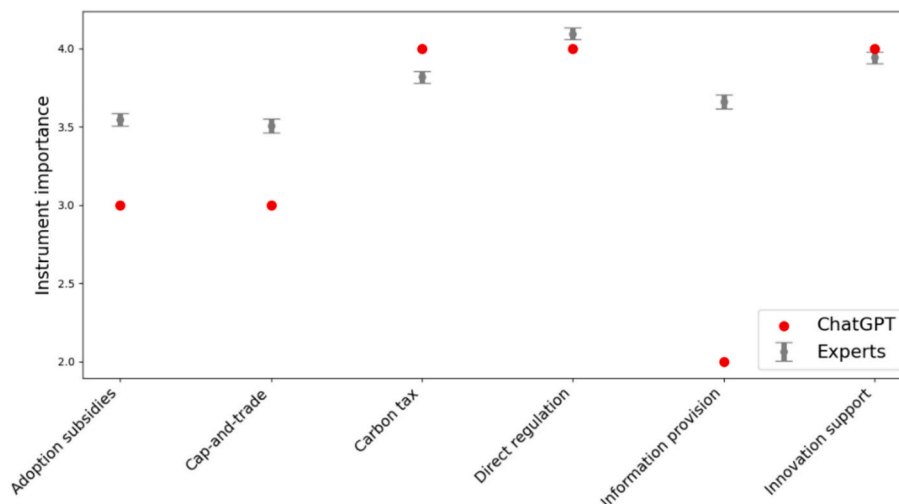


Fig. 3. Importance of instruments rated by ChatGPT (red) and experts (black). The results for experts represent mean values with error bars indicating ± 2 standard errors. The scale on the Y-axis ranges from 1 (unimportant) to 5 (extremely important). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

recognize direct regulation, innovation support and carbon taxation as very important climate policy instruments (each assigning a rating of approximately 4 out of 5), their perspectives differ drastically regarding the importance of information provision. ChatGPT ranks it only as “somewhat important” tool (score of 2 out of 5), whereas experts position it between important and very important (score 3.7). Also, ChatGPT tends to rate importance of adoption subsidies and cap-and-trade lower than experts.

3.3. Carbon pricing

Next, we compare the main strength(s) and weakness(es) of carbon pricing relative to other instruments (question 4). ChatGPT’s responses align with the answers of experts. ChatGPT’s mentions the potential of carbon taxation to generate government revenue which can be invested in low-carbon infrastructure (Topic 1 T1 in Table 1 from Savin et al., 2024, representing 12% of expert responses), the ability of the price to

give right incentives (1 T3, 1 T4 and 1 T5, in total 46% of responses), flexibility (1 T6, 12%), effectiveness (1 T2, 17%) and efficiency (1 T7, also 12%). The only issue stressed more by ChatGPT than the experts is the role of carbon price in driving “long-term investments in low-carbon infrastructure and research and development”.

As for perceived weaknesses of carbon pricing, the overlap between ChatGPT and academic experts is smaller. Both stress its low feasibility (topics 2 T4 and 2 T5 in Table 2, 35% of responses; Savin et al., 2024) and regressive effects (2 T1 and 2 T3, 34%). What ChatGPT stresses more than experts is the difficulty to determine the right carbon price, the need to complement with other instruments (e.g. R&D subsidies) and carbon leakage. Unlike ChatGPT, experts highlight the amenability of carbon pricing to manipulation and difficulty to implement it globally. Interestingly, these distinctions relate to issues that economists would disagree with: e.g., there is no need to determine the right carbon price – instead one should either over time gradually increase a carbon tax or lower the cap of an emissions trading system until emissions reduction is as desired (Baranzini et al., 2017).

Subsequently, we compare viewpoints of ChatGPT and experts regarding the functionality and impact of carbon pricing using ten statements presented earlier (question 5). On most of the statements (8 out of 10) the judgement of the experts and ChatGPT coincided, i.e. ChatGPT chose a response in line with the majority of experts. There is some disagreement about the remaining two statements:

- Statement 5 on policy decentralization: while ChatGPT strongly agreed with this statement, experts showed a variety of opinions in this regard.
- Statement 9 on worse performance of carbon pricing under boundedly rational behavior of firms and consumers: while experts again show a variety of opinions on this issue with over 15% of experts finding it difficult to give any response, ChatGPT clearly disagreed with this statement.

Regarding perceived knowledge gaps (question 6), ChatGPT provided a list of ten open issues, some of which were also mentioned by experts in our survey. Below we indicate which of these issues were mentioned also by the experts and under which topic (in brackets we report the % of the responses):

1. Optimal pricing strategies – covered by 3 T1 (13% of responses)
2. Distributional impacts – mostly overlooked, mentioned only by a few individuals, as reported in Table 4 in Savin et al. (2024).
3. Behavioral responses – mostly overlooked, mentioned only by a few individuals in Table 4 in Savin et al., 2024.
4. Technology innovation and diffusion – not covered.
5. Global coordination and linkage – covered by 3 T5 (9% of responses)
6. Long-term transformational change– covered by 3 T9 (10% of responses)
7. Complementary policies – covered by 3 T2 (13% of responses)
8. Market mechanisms and alternatives – not covered.
9. Economic and environmental outcomes – covered by 3 T8 (8% of responses)
10. Policy implementation – covered by 3 T3, 3 T4 and 3 T7 (38% of responses)

In addition to the research directions provided by ChatGPT, experts stressed that we need better (e.g., more empirically-grounded) models of carbon pricing (9% of responses).

3.4. General closing questions

ChatGPT is also presented with a question about concerns regarding climate change (question 7). It rates the public concerns about climate change as ranging between “somewhat worried” to “extremely worried”.

Experts in our survey agree with this estimation as indicated by the distribution of responses in Fig. 4.

Finally, we compare responses to question 8 about (dis)agreement with three statements about economic (GDP) growth in relation to progress and environment that predict the position of a respondent in the growth-vs environment debate (Savin et al., 2021). Although ChatGPT said it does not “hold personal opinions or beliefs, so I can’t agree or disagree with statements” it nevertheless provided some responses (Table 4 in Section 2). The response by ChatGPT to the first statement indicates it is in favor of green growth, while the second suggests support of degrowth, and the third is close to ‘agrowth’. Hence, it is not easy to classify ChatGPT in terms of a growth position, and one could even say it expresses inconsistent views. This is perhaps not surprising given that (as it often states in its opening of a response) it has no opinions. In fact, some of the responses breathe a kind of political correctness, which may be due to weighing distinct literatures and disciplines equally. The expert survey instead found that 27% of scientists hold a green growth position, 28% a degrowth position, and 45% an ‘agrowth’ position (King et al., 2023). Interestingly, the opinions vary with the respondent’s country and discipline: stronger green growth views are found for researchers from developing countries and from the field of economics, while more critical views about green growth are common among researchers in OECD countries and from the social sciences.

4. Additional questions to ChatGPT for deeper understanding of responses

As we noted an apparent inconsistency between some responses, we asked ChatGPT several additional questions. In addition, we inquired about the sources of information it used, including academic versus other literature and the role of distinct academic disciplines. These questions and associated responses can be found in Section A.2.2 of the Appendix.

4.1. About consistency of responses

Since we noted that ChatGPT did not score instruments (response to question 3) consistent with the importance assigned to criteria (response to question 2), we asked an additional question (10 in Appendix A.2.2) about which are the main performance criteria for evaluating instruments of climate policy and how important it regards these. As the first three it mentioned three of the four above ones (efficiency, equity and feasibility). Surprisingly, it did not mention effectiveness, which we would regard as the most important. And this time it rated feasibility as 4 out of 5, so not the maximum as under the response to question 2. Other criteria it mentioned are: flexibility (the ability of the policy to

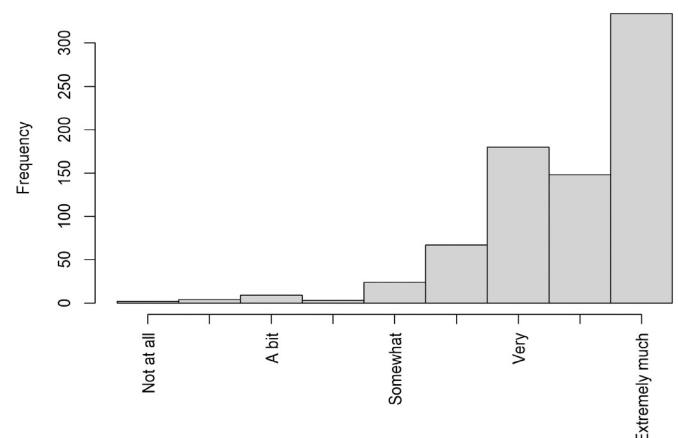


Fig. 4. Distribution of responses to the question about climate concern.

adapt to changing circumstances or information), transparency (how clearly and understandably the policy is communicated and its results measured) and durability (the extent to which a policy can sustain its effectiveness over time despite changing political and economic conditions). All these were rated just below the maximum, i.e. 4. The criterion of “durability” is not well known and hence came as a surprise to us; on the other hand, it might be considered as an extended interpretation of effectiveness, also given that it mentions this term in its definition; it might also be seen as relating to continued political support over a long time.

To check on a particular potential inconsistency we noted in the responses to questions 2 and 3, we asked question 11, which was rather long to assure it had all the relevant information from the original questions (see Section A.2.2 in the Appendix). The response from ChatGPT was: “The discrepancy between the rating of cap-and-trade and carbon tax in terms of their performance on the four mentioned criteria versus their overall importance in the climate policy mix could stem from additional factors considered in determining their broader role in policy. While cap-and-trade might score equally or higher on the criteria of effectiveness, efficiency, equity, and feasibility, the following additional considerations could explain why a carbon tax might be rated higher in overall importance:

- Simplicity and Transparency: ...
- Stability and Predictability: ...
- Administrative Ease: ...
- Economic Certainty: ...
- Global Harmonization: ...
- Political Viability: ...
- Revenue Generation: ...

In summary, the rating for overall importance may consider not only the four criteria but also practical considerations about the implementation and operation of these instruments within the broader socio-political context.”

Our impression is that this is a very nuanced and rich response, which shows that there are many considerations in the literature (or on the Internet) which ChatGPT draws from. One could disagree with some points in the above list, but most of them are quite reasonable.

4.2. About information sources

Here we discuss responses to questions about information sources, in terms of disciplines and academic versus grey literature. This is relevant as the expert survey covered experts from many different disciplines (see Section 3).

Question 12 asked about clarification and quantification of information used by ChatGPT. The response was: “In answering questions about instruments of climate policy and their performance on key criteria, my responses are based on a synthesis of widely accepted principles from environmental economics, public policy analysis, and climate science. I do not use quantifiable data such as percentages because I do not have access to current databases or statistical models in this environment. Instead, my responses draw upon general knowledge up to my last update in April 2023, which includes:

- Published Research and Literature: ...
- Expert Consensus and Analysis: ...
- Historical Precedents and Case Studies: ...
- Policy Evaluations and Reviews: ...

While specific percentages or precise quantitative data are not used in my responses, the general trends, comparisons, and performance evaluations are grounded in the qualitative synthesis of the above types of information. The aim is to reflect the broad consensus and the range of considerations that experts in the field would typically make when

assessing climate policy instruments.”

This response sounds reasonable but is not very informative as what matters is the details about which sources and disciplines dominate. We therefore asked additional questions. One (13) as what type of information it uses in terms of academic versus other (grey) publications. It answered: “When providing information on the performance of climate policy instruments against key criteria, my responses are derived from a mixture of academic and grey literature encompassed in my training data.” It then continued with a long response defining the two sources (see Section A.2.2 in the Appendix). In addition, it noted that “While academic publications tend to be more methodologically rigorous and are peer-reviewed, grey literature can offer more up-to-date information on policy date information on policy implementation and can be more accessible to a wider audience, including policymakers and the general public. Quantification in terms of percentages (e.g., ‘60% academic and 40% grey literature’) is not possible because my responses synthesize information from a large, diverse set of not possible because my responses synthesize information from a large, diverse set of sources without a strict quantitative division. The information from both types of sources is integrated to provide a comprehensive overview of the topic, with the intent to balance the depth and rigor of academic research with the practical insights from grey literature. The emphasis on one type of source over another can vary depending on the specific question at hand. For example, questions about the theoretical underpinnings of climate question at hand. For example, questions about the theoretical underpinnings of climate policy might lean more heavily on academic sources, while questions about the practical application of a policy might draw more from grey literature.”

4.3. About disciplinary sources

Regarding question 14 about what disciplinary information ChatGPT uses to answer questions about climate policy instruments and their performance based on key criteria (effectiveness, efficiency, equity, and feasibility), it answers that it draws “from a multidisciplinary academic perspective” and “cannot provide a quantitative breakdown” (which we asked). But it makes interesting connections between the criteria and disciplines:

- “Environmental Economics provides a framework for understanding the economic impact of environmental policies, including the principles of externalities, market failures, and the cost-benefit analysis of different policy instruments.
- Insights from political science are crucial for evaluating the feasibility and political acceptability of various climate policies, as well as their governance structures.
- The field of public policy offers models and case studies on policy design, implementation, and evaluation. It also contributes to understanding regulatory implementation, and evaluation, as well as regulatory approaches and the role of public institutions.
- The fields of Environmental Science and Engineering contribute knowledge on the technical aspects of pollution control, the effectiveness of various mitigation technologies, and the scientific basis for setting environmental standards.
- The disciplines of Sociology and Social Policy provide perspectives on the social implications of climate policies, particularly equity and distributional effects, and how policies affect different groups within society.
- Law or Legal scholarship offers insights into the regulatory frameworks that underpin policy instruments and the enforceability of environmental legislation.
- Climate Science: Fundamental to all discussions on climate policy, this discipline informs the necessity, urgency, and objectives of climate action.

- Business and Management: This area provides perspectives on how climate policies affect corporate behavior, innovation, and competitiveness.”

ChatGPT adds that “These disciplines often overlap and inform each other, creating a comprehensive body of knowledge from which I synthesize responses. The integration of these disciplines enables a holistic view of climate policy instruments that considers scientific, economic, social, and practical dimensions.

Next, question 15 asked which disciplines dominate if ChatGPT is asked to answer questions about instruments of climate policy, and questions 16 to 21 asked this about specific instruments of climate policy. The results are summarized in Table 5. What is noticeable is that Environmental Economics is the first mentioned in all cases except for direct regulation and information provision. In these latter cases Environmental Economics is not even mentioned. For direct regulation Law is mentioned first while Economics (in general) is still mentioned as third discipline; for information provision Environmental Communication is mentioned first. One must assume that this overlaps with environmental psychology as this discipline is, surprisingly, not mentioned anywhere in the answers from ChatGPT (unlike social psychology, which is mentioned once). The second field listed in all cases is Public policy and administration, while Political science is often mentioned as third or fourth discipline, except for information provision (where it is in sixth place). Interestingly, these two disciplines are along with Sociology (and social policy) the only disciplines that are mentioned for all instruments. On the other end of the spectrum are, with one mention, next to Environmental Communication, Environmental Education and Marketing and Consumer Behavior for information provision, and Science and Technology Studies for innovation support. All these results make much sense. In addition, climate science is mentioned once for Climate policy instruments in general.

Regarding disciplines in the expert survey, Fig. 5 shows that disciplines are not equally represented, resulting in some having a larger impact on the average outcomes. Differences with ChatGPT might be due to it weighing information from disciplines in a way that assumes more or less equal relevance.

Finally, we asked which instruments other than the ones listed in previous questions ChatGPT considered essential for effective climate policy, and which disciplines dominate the information about these (question 22). The answer was: “Other than the instruments listed (direct regulation, carbon tax, cap-and-trade, adoption subsidies, trade, adoption subsidies, innovation support, information provision), the following are also considered essential for an innovation support, information provision), the following are also considered essential for an effective climate policy²:

1. Public Investment in Clean Infrastructure: ...
2. Green Public Procurement: ...
3. Voluntary Agreements: ...
4. International Climate Agreements: ...”

Interestingly, none of the above represents a genuine policy instrument: 1 and 2 are government activities, while 3 and 4 are agreements instead of policies. This response of ChatGPT indicates that our questions covered all relevant instruments.

Regarding the disciplines that dominate the information about these additional instruments ChatGPT responded with:

² Note this response is strangely formulated and resembles a bit repetition. In fact, in the full responses (in the appendix) there were considerable literal repetitions of phrases (immediately following the original phrase) which we removed. This seems to be a frequent error of machine-generated responses.

Table 5
Disciplinary information used by ChatGPT for responses to questions about instruments of climate policy. Numbers indicate average ranking by the respective scientific discipline of the respective climate policy instrument.

Discipline Instrument	Business and finance/ management	Climate science	Economics	Environmental communication	Environmental economics	Environmental education	Environmental science and engineering	Law (environmental law and policy)	Marketing and consumer behavior	Political science	Public policy and administration	Science and technology studies	Sociology and social policy
Climate policy instruments (in general)		4			1			6		3	2		5
Direct regulation (e.g., technical standards, quotas)			3				5	1		4	2		6
Carbon tax	7		5		1		5	3		4	2		6
Cap-and-trade			6		1		5	4		3	2		7
Adoption subsidies	5				1		6	7		3	2		4
Innovation support (e.g., R&D subsidies)	5				1		7			3	2	4	6
Information provision (e. g., education or ecolabels)				1		5	7		4	6	2		3

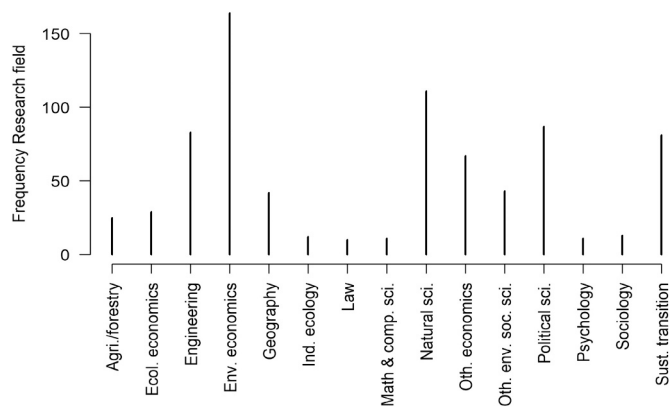


Fig. 5. Frequency of research fields or disciplines among respondents in the expert survey.

- “Environmental Economics: For analyzing the cost-effectiveness and market impact of public effectiveness and market impact of public investments and green procurement.
- Public Policy and Administration: For insights into the design, implementation, and management of public investment projects and procurement strategies.
- International Relations: Particularly relevant for international climate agreements, as it provides an understanding of the dynamics of international cooperation and policy-making.
- Business and Management: For understanding the strategic implications and responses of firms to voluntary agreements and green procurement policies.
- Law and Environmental Policy: For legal frameworks that govern international agreements, public investments, and procurement practices.

These disciplines help to evaluate the broader economic, legal, political, and social dimensions of these additional climate policy instruments.” Environmental Economics is mentioned first, which is consistent with the responses to questions 14 to 21. What is noticeable in comparison with earlier lists is that the above list is shorter, and notably that Political Science is missing (although mentioned for all instruments in Table 5), while International Relations is added.

5. Conclusions

Exploring the implications and limitations of comparing AI-generated content with human expert opinions can contribute to a better understanding of the potential benefits and challenges associated with AI-driven analyses in policymaking and public engagement. To this end, we have compared the results from a previous global expert survey on climate policy with answers from the online artificial-intelligence chatbot ChatGPT. The comparison provides insights about performance criteria, policy instruments, and use of information from distinct academic disciplines.

We find that ChatGPT answered the expert survey very well. Its responses were very consistent with the range of answers by experts from different disciplines. Altogether, ChatGPT might well survive a Turing test on climate-policy expertise. Indeed, on many issues the responses from ChatGPT are in line with the opinion of expert majority. Nevertheless, a few notable differences emerge. First, ChatGPT considers all performance criteria of climate policies as equally important while experts tend to give a larger weight to some over others, or even concentrate on one (notably effectiveness). Second, ChatGPT tends to rate carbon pricing instruments (tax and cap-and-trade) as more effective and efficient than experts, but as less equitable and politically feasible. While experts give a slight preference to direct regulation over

innovation subsidies and carbon taxation in a climate policy mix, ChatGPT rates the three instruments equally high. Also, unlike experts rating information provision as very important, ChatGPT finds this instrument only somewhat important, which may be due to empirical estimates showing its low effectiveness. In stating weaknesses of carbon pricing, ChatGPT stresses the difficulty to find an adequate price level and complement it with other policy instruments, while experts instead stress the amenability of the instrument to manipulation (we would argue neither are so relevant). Finally, ChatGPT did not express a preference for one of three views on growth-vs-environment debate (i.e. pro-, anti- or indifferent regarding growth) while majority of experts opted for an ‘agrowth’ (agnostic) perspective.

In terms of directions for future research, ChatGPT highlighted behavioral responses, technological innovation and market mechanisms, while experts stressed the need for better calibrated and realistic models of carbon pricing. Experts did not provide a unified answer on whether carbon pricing is a more decentralized instrument than others, nor whether it performs worse under boundedly rational behavior of economic agents. On the other hand, ChatGPT replied positively on the first point and negatively on the second.

In addition to comparing the responses, we asked ChatGPT a series of additional questions to clarify some discrepancies in its replies and to understand the sources of its information. Among others, we found that: ChatGPT prefers carbon tax over carbon markets based on additional considerations such as policy simplicity and predictability; and similar to our survey, ChatGPT is basing its responses predominantly on insights from such disciplines like Environmental Economics and Political Science. Only for the instrument of direct regulation Law is mentioned first while for information provision Environmental Communication is mentioned first. One must assume that the latter covers environmental psychology as this discipline is not mentioned anywhere in the answers from ChatGPT. Indeed, environmental psychology is a mature sub-discipline within the broader fields of psychology and environmental/climate studies. Environmental psychologists publish regularly on climate policy and, in line with this, participated well in the expert survey that serves as the basis for the current comparison with ChatGPT (Drews et al., 2024; Savin et al., 2024).

Finally, we noted a lack of systemic perspective on policy assessment. For example, in the case of direct regulation, such as technical standards or quotas, there is mention of only regulating purchase and not of use, which links to the risk of rebound. On the other hand, this partial perspective is rather consistent with the majority of replies by experts.

Our conclusions are in line with, though perhaps a little more positive, than a previous study which examined how ChatGPT explains the topic of climate change in a broad sense (Sommer and von Querfurth, 2024). It concluded that “Generally, the narrative is in line with scientific knowledge on climate change; the stories convey no significant misinformation. However, specific topics in current debates on global warming are conspicuously missing.”

ChatGPT provides a new way of synthesizing large amounts of academic and grey literature. Our study suggests that it performs quite well in this sense. However, since the procedure that ChatGPT follows for collecting and summarizing information remains a black box, it is best seen as a complement rather than a substitute to traditional literature reviews and expert surveys. This is further supported by lack of stability in responses from ChatGPT depending on how one prompts it. On the other hand, ChatGPT seems to show less bias than experts. But this has a downside: a tendency for political correctness of answers results in giving equal weight to all information, whereas experts would better separate highly from less relevant material. To put this in context, experts from distinct disciplines show difference in average responses meaning there is no overall consistent expert opinion on climate policy. In our original expert survey, we noted that a fair number of responses – particularly in some disciplines – were not consistent with objective evidence in the literature. This indicates the need for an approach that

can separate well-founded from other opinions of experts. Future research might examine whether ChatGPT is able to contribute to this or how it can be improved to do so. It could also assess the consistency with expert surveys for other themes than climate policy.

CRediT authorship contribution statement

Foroogh Salekpay: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Jeroen van den Bergh:** Writing – review & editing, Writing – original draft, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Ivan Savin:** Writing – review & editing, Writing – original draft, Formal analysis.

Appendix A. Appendix

A.1. Software versions and dates of questioning

The questions were posed to ChatGPT-4, a large language model developed by OpenAI, from 1 to 4 December 2023. We sequentially submitted the individual questions from the questionnaire within a single ChatGPT-4 session. Given its expansive context window – amount of text that it can consider at one time while generating a response – ChatGPT-4 is able to utilize the context of a series of prior interactions, including both questions (prompts) and their corresponding responses. This allows for a coherent conversation, where each response is informed by the entirety of the dialogue history in the session.

A.2. Questions posed to, and answers by, ChatGPT

We presented to ChatGPT a selection of the questions of our original survey, deleting the ones relating to professional and personal features of the experts since these are irrelevant to the chatbot. In addition, we asked some follow-up questions to clarify some of the unclear responses and identify the sources of information and contribution of distinct disciplines. Questions are formulated in *Italics* and answers in normal letter. In total we asked 22 questions.

A.2.1. Questions from the survey

We presented to ChatGPT a selection of the questions of our original survey (Drews et al., 2024; and Savin et al., 2024), deleting the ones relating to professions and personal features of the experts (like age, gender, main discipline etc.) since these are irrelevant to the chatbot.

1. How important do you consider the following criteria for evaluating climate policy instruments?

(Response scale: 1 = unimportant; 2 = somewhat important; 3 = important; 4 = very important; 5 = extremely important)

- *Effectiveness, i.e. certainty and degree of realization of the emissions-reduction objective.*
- *Efficiency, i.e. achieving the objective at the lowest economic costs or welfare sacrifice.*
- *Equity, i.e. avoiding regressive distributional effects.*
- *Feasibility, i.e. taking into account public and political support for, and opposition to, a policy.*
- *Other, please specify (optional): [_____ open text field_____].*

Here you can optionally add comments related to the question above: [__ open text field__].

Evaluating climate policy instruments requires considering various criteria that are crucial for ensuring that the policies are not only effective in reducing emissions but also socially and economically sustainable. Here's a rating of the importance of each criterion on a scale of 1 (unimportant) to 5 (extremely important), along with brief comments on each:

Effectiveness (5/5): This is paramount as the primary goal of climate policy is to reduce emissions. Policies must be judged on their actual impact in achieving this goal. If a policy fails to effectively reduce emissions, it fails in its fundamental purpose, regardless of its performance in other criteria.

Efficiency (5/5): High efficiency ensures that the objectives are met at the lowest possible economic cost or welfare sacrifice. This is crucial for maintaining economic stability and ensuring that the transition to a low-carbon economy is sustainable and does not place undue burden on the economy.

Equity (5/5): Policies must avoid regressive effects where the less affluent bear disproportionate costs. Equity is essential for social acceptability and justice. Unequitable policies risk resistance and can undermine the public's willingness to support necessary changes.

Feasibility (5/5): This reflects the practicality of implementing and sustaining a policy. Public and political support are critical for the longevity and effectiveness of climate policies. Policies that lack feasibility might be theoretically sound but fail in practice due to opposition or lack of support.

Other (optional): [Open text field for additional criteria like adaptability, transparency, or compatibility with existing laws and international commitments.]

Comments: Each of these criteria is interconnected, and a holistic approach is required for effective climate policy evaluation. For instance, a highly effective policy that lacks equity or feasibility might not be sustainable in the long term. Similarly, an efficient policy that fails to substantially reduce emissions would not be serving its primary purpose. Therefore, a balanced consideration of all these factors is essential in climate policy assessment.

2. Can you please rate the following instruments of climate policy in terms of their performance on each of the four mentioned criteria? We are aware that this is a challenging task, so we are mainly interested in your expert intuition (or 'gut feeling'). (response scale: Low, moderate, high)

	Effectiveness (i.e. certainty and degree of realization of the emissions-reduction objective)	Efficiency (i.e. achieving the objective at the lowest economic costs or welfare sacrifice)	Equity (i.e. avoiding regressive distributional effects)	Feasibility (i.e. taking into account public and political support for, and opposition to, a policy)
Direct regulation (e.g. technical standards, quotas) Carbon tax Cap-and-trade Adoption subsidies Innovation support (e.g. R&D subsidies) Information provision (e.g. education or ecolabels) Other, please specify (optional)				

Here you can optionally add comments related to the question above: [open text field].

Evaluating the performance of various climate policy instruments based on the criteria of effectiveness, efficiency, equity, and feasibility involves a nuanced understanding of how each instrument functions and its real-world impacts. Here are my ratings, based on expert intuition:

Direct regulation (e.g., technical standards, quotas).

Effectiveness: High - Direct regulation can be very effective because it mandates specific limits or standards that must be met.

Efficiency: Low to Moderate - These can be economically inefficient as they don't allow for flexibility or market mechanisms to find the cheapest solutions.

Equity: Moderate - The impact on equity depends on how the regulations are structured and can vary widely.

Feasibility: Moderate - While direct regulations can be straightforward to implement, they often face significant political resistance from regulated industries.

Carbon tax.

Effectiveness: Moderate to High - Taxes create a clear financial incentive for emission reductions but depend on the tax rate for their overall effectiveness.

Efficiency: High - Taxes are generally considered economically efficient as they allow entities to find cost-effective ways to reduce emissions.

Equity: Low to Moderate - A carbon tax can be regressive, impacting lower-income groups more unless measures are taken to redistribute the revenues.

Feasibility: Low to Moderate - Taxes are often unpopular and can face significant opposition, although they can be more acceptable if coupled with revenue recycling to the public.

Cap-and-trade.

Effectiveness: High - If the cap is set appropriately, it guarantees a certain level of emission reductions.

Efficiency: High - It allows for emissions reductions to occur where they are most economical due to the trading mechanism.

Equity: Moderate - The impact on equity depends on the allocation of allowances and use of revenues.

Feasibility: Moderate - These systems can be complex to design and require buy-in from various stakeholders but have been successfully implemented in multiple jurisdictions.

Adoption subsidies.

Effectiveness: Moderate - Subsidies encourage adoption of clean technologies but may not always lead to the most cost-effective emission reductions.

Efficiency: Low - They can lead to market distortions and may not always be allocated to the best technologies.

Equity: High - If well-designed, they can be directed to benefit lower-income groups specifically.

Feasibility: High - Subsidies are generally politically popular as they are seen as a positive incentive rather than a penalty.

Innovation support (e.g., R&D subsidies).

Effectiveness: Moderate - Supports the development of new technologies but doesn't guarantee their adoption or direct emission reductions.

Efficiency: Moderate - Can be efficient if they accelerate cost-effective technologies but also risk supporting technologies that aren't market-viable.

Equity: Moderate - Can be structured to be equitable but doesn't inherently address equity.

Feasibility: High - R&D support is generally viewed positively and can gain broad support.

Information provision (e.g., education or ecolabels).

Effectiveness: Low to Moderate - Depends greatly on public response and behavior change, which can be uncertain.

Efficiency: High - Relatively low-cost ways to potentially influence behavior.

Equity: High - Accessible to all and can be particularly empowering for consumers.

Feasibility: High - Information campaigns are generally easy to implement and face little opposition.

These ratings are inherently subjective and can vary depending on specific policy designs, local contexts, and changes in technology or market conditions. Additionally, policy instruments are often used in combination to leverage their strengths and mitigate their weaknesses.

3. Overall, how important do you consider each of these instruments in the climate policy mix of a country? (response scale: 1 = unimportant; 2 = somewhat important; 3 = important; 4 = very important; 5 = extremely important)

direct regulation (e.g., technical standards, quotas)
carbon tax
cap-and-trade
adoption subsidies
innovation support (e.g., R&D subsidies)
information provision (e.g. education or ecolabels)
other (please specify):

Here you can optionally add comments related to the question above: [__open text field__].

The importance of each instrument in the climate policy mix of a country can be rated as follows:

Direct regulation (e.g., technical standards, quotas).

Rating: 4 (Very Important).

Rationale: Direct regulation ensures compliance and can rapidly shift industry standards, making it a critical tool for achieving immediate environmental objectives.

Carbon tax.

Rating: 4 (Very Important).

Rationale: It provides a clear economic signal to reduce emissions and can be adjusted to balance environmental goals with economic considerations.

Cap-and-trade.

Rating: 3 (Important).

Rationale: It establishes a market for carbon emissions and can be an effective way to reduce emissions if the cap is set ambitiously.

Adoption subsidies.

Rating: 3 (Important).

Rationale: Subsidies encourage the uptake of green technology and can accelerate the transition to a low-carbon economy, especially in the early stages of technology development.

Innovation support (e.g., R&D subsidies).

Rating: 4 (Very Important).

Rationale: Long-term solutions to climate change rely on innovation, and R&D support is critical for developing new technologies that can later be deployed at scale.

Information provision (e.g., education or ecolabels).

Rating: 2 (Somewhat Important).

Rationale: While not as directly impactful as regulatory or financial instruments, information provision can change consumer behavior and support a cultural shift towards sustainability.

Other (please specify).

Rating: [Open for specific context].

Rationale: Other instruments might be crucial depending on the specific context of a country, such as public investment in infrastructure, legal frameworks for climate liability, etc.

Each instrument plays a unique role and their importance can vary depending on a country's specific economic structure, existing legal frameworks, and environmental targets. Moreover, the effectiveness of each tool can be enhanced when used as part of a comprehensive strategy that employs multiple instruments in tandem.

4. *There is considerable debate about the specific role of carbon pricing (carbon tax or cap-and-trade) in the climate policy mix. What do you think are the main strength(s) and weakness(es) of carbon pricing compared with other instruments?*

We would like that you take your time to answer this question and, if possible, write some sentences. All kinds of answers are welcome.

Strength(s): [__open text field__].

Weakness(es): [__open text field__].

Strength(s) of Carbon Pricing:

Carbon pricing, which encompasses both carbon taxes and cap-and-trade systems, is lauded for its economic efficiency. The primary strength of carbon pricing is its ability to internalize the external cost of carbon emissions, effectively making it more expensive to pollute. This incentivizes businesses and consumers to reduce emissions and invest in cleaner technologies. It's a market-based mechanism that encourages innovation and provides flexibility, allowing emitters to decide the most cost-effective way to reduce their carbon footprint. Carbon pricing can also generate significant government revenue, which can be reinvested in green technologies or offset elsewhere in the budget, potentially reducing other taxes. By providing a predictable and scalable method of reducing emissions, it can drive long-term investments in low-carbon infrastructure and research and development.

Weakness(es) of Carbon Pricing:

Despite its strengths, carbon pricing is not without criticism. One of the main weaknesses is the challenge of setting the correct price. If the price is too low, it won't lead to significant emission reductions; if it's too high, it can be economically disruptive. The social and political acceptability of carbon pricing is often low due to its direct impact on energy prices, which can be regressive, affecting lower-income households disproportionately unless mitigating measures are taken. Furthermore, carbon pricing alone may not be enough to address all sources of emissions effectively, particularly in sectors where alternatives to fossil fuels are not readily available or where significant technological change is required. It also does not directly address other market failures, such as the under-provision of R&D for new technologies or the need for adaptation measures. Another challenge is the potential for carbon leakage, where emissions are effectively outsourced to countries with less stringent or no carbon pricing, thereby undermining global emission reduction efforts.

5. *Please indicate whether you agree or disagree with the following statements (response scale: 1 = strongly disagree to 5 = strongly agree; don't know)*

- a) Since carbon pricing alters relative prices, firms and consumers automatically account for climate-change effects of their decisions.
- b) Carbon pricing has little impact on the speed of low-carbon innovation.
- c) Carbon pricing is the most effective instrument to limit energy/carbon rebound. An example of rebound is driving more kilometers after buying a more fuel-efficient car.
- d) Carbon pricing promotes emissions reduction at the margin but cannot stimulate major changes necessary for achieving zero carbon emissions.
- e) Carbon pricing decentralizes policy, thus reducing regulators' need for information.
- f) Contextual, sector-specific climate policies are more effective in terms of overall emissions reduction than economy-wide carbon pricing.
- g) Carbon pricing takes into account that in making purchasing decisions, most consumers are more influenced by prices than by environmental concerns.
- h) Carbon pricing can be more easily up-scaled and harmonized globally than other instruments.
- i) Carbon pricing functions worse than other instruments when consumers and firms do not make rational choices.
- j) A unique advantage of carbon pricing over other instruments is that it generates public revenues which can be used for multiple purposes.

Here you can optionally add comments related to the question above: [open text field].

- a) Rating: 4 (Strongly Agree).

Comment: Carbon pricing effectively integrates the social cost of carbon emissions into the economic decision-making process for both firms and consumers, promoting more environmentally conscious behavior.

- b) Rating: 2 (Disagree).

Comment: By creating a consistent financial incentive to reduce emissions, carbon pricing can indeed accelerate innovation in low-carbon technologies as firms seek cost-effective ways to minimize their tax burden or capitalize on trading schemes.

- c) Rating: 3 (Neutral/Agree).

Comment: While carbon pricing can mitigate some rebound effects by maintaining an economic disincentive for increased consumption, it is not always the most effective instrument on its own, as rebound effects are complex and can be influenced by behavioral factors.

- d) Rating: 3 (Neutral/Agree).

Comment: Carbon pricing is effective for incremental improvements but may not be sufficient to drive the systemic changes required for full decarbonization without complementary policies.

- e) Rating: 4 (Strongly Agree).

Comment: By leveraging market mechanisms, carbon pricing reduces the need for regulators to collect detailed information for policy enforcement, as the market naturally adjusts to the price signals.

- f) Rating: 3 (Neutral/Agree).

Comment: Sector-specific policies can address unique challenges and opportunities within different sectors more effectively than a broad-based pricing mechanism, which may not capture sector-specific nuances.

- g) Rating: 5 (Strongly Agree).

Comment: Carbon pricing capitalizes on economic self-interest to drive behavior change, which is typically more influential on consumer behavior than voluntary environmental considerations.

- h) Rating: 4 (Strongly Agree).

Comment: Carbon pricing mechanisms, especially cap-and-trade systems, have the potential for integration across borders, providing a scalable approach to global emissions reduction.

- i) Rating: 2 (Disagree).

Comment: While true that carbon pricing relies on rational decision-making, it is also the case for most other policy instruments; moreover, the clear price signal helps guide decisions even if they are not entirely rational.

- j) Rating: 5 (Strongly Agree).

Comment: Revenue generation is a significant advantage of carbon pricing, providing funds that can be used for tax cuts, investment in clean energy, or to offset impacts on vulnerable populations.

These responses reflect the complex interplay between carbon pricing and the broader climate policy landscape, highlighting the importance of integrating carbon pricing with other policy instruments to achieve comprehensive and effective climate action.

6. Can you indicate knowledge gaps about carbon pricing that deserve attention in research?

We would like that you take your time to answer this question and, if possible, write some sentences. All kinds of answers are welcome.

[____open text field____].

Knowledge gaps about carbon pricing that merit further research include:

Optimal Pricing Strategies: Determining the most effective carbon price levels to balance economic growth with significant emissions reductions remains a challenge. Research into dynamic pricing models that respond to market signals and environmental targets could be beneficial.

Distributional Impacts: More detailed studies are needed to understand the regressive effects of carbon pricing and how to mitigate them through revenue recycling or other policy measures to ensure social equity.

Behavioral Responses: While economic theory predicts how consumers and firms should respond to carbon pricing, empirical research on actual behavior is less conclusive. Understanding the psychological and social factors that influence the response to carbon pricing could help in designing more effective policies.

Technology Innovation and Diffusion: It's important to investigate how carbon pricing stimulates innovation and the adoption of new technologies across different sectors and economies, and whether it can be effective in promoting breakthrough technologies, not just incremental improvements.

Global Coordination and Linkage: Research on how different carbon pricing systems can be linked effectively to form a coherent global system would be valuable, considering issues of competitiveness, carbon leakage, and harmonization of pricing mechanisms.

Long-term Transformational Change: How carbon pricing can contribute to the long-term transformational change required to achieve net-zero emissions, beyond short-term marginal abatement, is an area needing further exploration.

Complementary Policies: Identifying the most effective mix of carbon pricing and complementary policies, such as regulations or subsidies, could help to maximize the overall effectiveness of climate policy.

Market Mechanisms and Alternatives: The development of alternative market mechanisms, such as carbon offset markets, and their interactions with direct carbon pricing need more attention to assess their validity and integrity.

Economic and Environmental Outcomes: Further studies are needed to empirically assess the long-term economic and environmental outcomes of carbon pricing policies in various contexts and to compare them with the outcomes of other climate policy instruments.

Policy Implementation: Research on the barriers to the implementation and public acceptance of carbon pricing, including political economy aspects, can provide insights into how to overcome obstacles to policy enactment and enforcement.

Addressing these gaps can enhance the design and implementation of carbon pricing mechanisms, making them more effective and acceptable to stakeholders.

7. How worried are you about climate change and its societal consequences? (1 = Not at all worried, 3 = A bit worried, 5 = Somewhat worried, 7 = Very worried, 9 = Extremely worried, Don't know)

As an AI, I don't have personal feelings or worries, so I cannot provide a personal response to how worried I might be about climate change and its societal consequences. However, I can provide information and perspectives based on the consensus of the scientific community and public opinion:

The scientific consensus is clear that climate change is a significant global challenge that poses extensive risks to natural and human systems. The potential consequences include more frequent and severe weather events, loss of biodiversity, sea-level rise, and various socio-economic impacts, particularly for the most vulnerable populations. These realities are prompting governments, organizations, and individuals to express increasing levels of concern and to take action to mitigate and adapt to climate change. Public opinion surveys across various regions tend to show that a majority of people are somewhere between "somewhat worried" to "extremely worried" about climate change, reflecting the growing awareness and concern about this issue globally.

8. Please indicate whether you agree or disagree with the following statements about economic (GDP) growth (response scale: 1 = strongly disagree to 7 = strongly agree; don't know)

- a. Continued economic growth is essential for improving people's life satisfaction.
- b. In view of limited natural resources, rich countries may have to give up their economic growth to assure that all poor people in the world can reach a fair standard of living. Economic growth is necessary to finance environmental protection.

As an artificial intelligence, I don't hold personal opinions or beliefs, so I can't agree or disagree with statements. However, I can provide an analysis based on prevailing economic theories and social perspectives:

- a. Continued economic growth is essential for improving people's life satisfaction.

Prevailing View: This statement is often associated with traditional economic perspectives that correlate higher GDP with better standards of living, including access to goods, services, and infrastructure that can improve life satisfaction. Critics argue that beyond a certain point, the correlation between GDP growth and life satisfaction weakens, and other factors like income distribution, environmental quality, and work-life balance become more significant.

- b. In view of limited natural resources, rich countries may have to give up their economic growth to assure that all poor people in the world can reach a fair standard of living.

Prevailing View: This perspective is grounded in the concept of sustainable development and global equity. It suggests that in a world with finite resources, the continued growth of high-income countries could compromise the ability of low-income countries to meet their basic needs. Proponents of sustainable growth advocate for a more equitable distribution of resources and growth opportunities, while some argue for a complete reevaluation of what constitutes growth and progress.

c. Economic growth is necessary to finance environmental protection.

Prevailing View: The argument here is that wealth generation provides the resources needed for investments in environmental protection and sustainable technologies. Higher GDP can mean more funding for research, innovation, and implementation of environmental measures. However, some environmentalists and economists contend that reliance on GDP growth can lead to environmental degradation and that alternative measures of progress may be needed to truly protect the environment.

These are complex issues with varying opinions among economists, policymakers, and the public, reflecting the ongoing debate about the role of GDP growth in society and its relationship with environmental sustainability and human well-being.

9. Do you have any comments about this survey? [____open text field____]

As an AI, I don't have personal experiences or opinions to provide comments on the survey. However, I can offer some general observations that could be applicable:

The survey tackles critical and complex issues surrounding climate policy, economic growth, and societal well-being. Its focus on carbon pricing reflects a nuanced understanding of the policy tools available to address climate change. The questions are designed to elicit responses that can provide insights into public opinion and understanding of these issues.

From a design perspective, the survey could benefit from including more nuanced response options or scales to capture a wider range of opinions and the intensity of respondents' views. Additionally, providing definitions or explanations for technical terms could help ensure that respondents have a clear understanding of the questions, leading to more informed responses.

The survey also appears to recognize the interdisciplinary nature of climate change, touching on economic, social, and environmental aspects. This holistic approach is crucial for developing effective climate policies. Finally, allowing open-ended feedback gives respondents the opportunity to express detailed thoughts or concerns that might not be fully captured by the structured response options.

A.2.2. Additional questions to assess potential inconsistencies

We noted an apparent inconsistency in the response to the question about the four criteria vs instruments where cap-and-trade was judged as performing equal and sometimes better than a carbon tax. We therefore asked whether ChatGPT used additional criteria, and we asked more generally which criteria it thinks should be used to evaluate instruments of climate policy.

10. Which are the main performance criteria for evaluating instruments of climate policy? How would you rate these on the following response scale: 1 = unimportant; 2 = somewhat important; 3 = important; 4 = very important; 5 = extremely important?

The main performance criteria for evaluating instruments of climate policy typically include:

Effectiveness: This measures the degree to which the policy instrument achieves its stated emissions-reduction objectives. Rating: 5 (Extremely Important).

Efficiency: This pertains to how cost-effectively the policy instrument achieves its goals, minimizing economic and welfare losses. Rating: 5 (Extremely Important).

Equity: This considers the fairness of the policy instrument, particularly in its distributional impacts across different societal groups. Rating: 5 (Extremely Important).

Feasibility: This evaluates the practicality of implementing the policy instrument, including political acceptability and administrative ease. Rating: 4 (Very Important).

Other criteria that could be considered include:

Flexibility: The ability of the policy to adapt to changing circumstances or information. Rating: 4 (Very Important).

Transparency: How clearly and understandably the policy is communicated and its results measured. Rating: 4 (Very Important).

Durability: The extent to which a policy can sustain its effectiveness over time despite changing political and economic conditions. Rating: 4 (Very Important).

These ratings reflect the notion that for a climate policy to be successful, it must be effective in reducing emissions, do so at a reasonable cost, distribute its effects fairly, and be politically and administratively viable. The exact ratings might vary based on specific policy contexts and priorities.

11. By considering the following instruments of climate policy direct regulation (e.g., technical standards, quotas), carbon tax, cap-and-trade, adoption subsidies, innovation support (e.g., R&D subsidies), and information provision (e.g. education or ecolabels),

and by considering the following four criteria: Effectiveness (i.e. certainty and degree of realization of the emissions-reduction objective), Efficiency (i.e. achieving the objective at the lowest economic costs or welfare sacrifice), Equity (i.e. avoiding regressive distributional effects), Feasibility (i.e. taking into account public and political support for, and opposition to, a policy),

We asked you before "Can you please rate the instruments of climate policy in terms of their performance on each of the four mentioned criteria. (response scale: low, moderate, high).

Your answer indicated that you scored cap-and-trade equal or higher than carbon tax on each criterion. However, subsequently we asked you: "Overall, how important do you consider each of these instruments in the climate policy mix of a country? (response scale: 1 = unimportant; 2 = somewhat important; 3 = important; 4 = very important; 5 = extremely important).

Your answer indicated that you rated carbon tax higher (4) than cap-and-trade (3). Why is that? Did you use other criteria than the four above? If so, which one(s)?

The discrepancy between the rating of cap-and-trade and carbon tax in terms of their performance on the four mentioned criteria versus their overall importance in the climate policy mix could stem from additional factors considered in determining their broader role in policy. While cap-and-trade might score equally or higher on the criteria of effectiveness, efficiency, equity, and feasibility, the following additional considerations could explain why a carbon tax might be rated higher in overall importance:

Simplicity and Transparency: A carbon tax is often simpler and more transparent than cap-and-trade systems, which can involve complex market mechanisms that are difficult for the public to understand.

Stability and Predictability: Carbon taxes provide more predictable and stable price signals, which can be crucial for businesses and consumers in planning and investing in long-term emission reduction strategies.

Administrative Ease: Implementing and managing a carbon tax can be administratively easier than a cap-and-trade system, which requires the creation of markets, monitoring trades, and ensuring compliance.

Economic Certainty: A carbon tax ensures a consistent cost for carbon emissions, which can be preferable for economic planning over the potential volatility of cap-and-trade market prices.

Global Harmonization: It may be perceived that carbon taxes could be more easily standardized or harmonized internationally than cap-and-trade systems, which can vary greatly in design and operation.

Political Viability: In some political contexts, a carbon tax, particularly if revenue-neutral, could be more viable and have greater chances of being implemented and sustained over time.

Revenue Generation: Carbon taxes have a clear mechanism for revenue generation, which governments can use to fund other climate initiatives or offset impacts on vulnerable populations.

In summary, the rating for overall importance may consider not only the four criteria but also practical considerations about the implementation and operation of these instruments within the broader socio-political context.

A.2.3. Additional questions about information use

The following questions were used to assess if academic or grey literature was used and information from which discipline influenced the response from ChatGPT. The discipline was asked in general and for specific policy instruments, as some instruments tend to be studied more in specific disciplines. This attention for disciplines was motivated by the expert survey covering many disciplines.

12. In answering questions about instruments of climate policy and their performance on key criteria, can you clarify and if possible quantify (e.g., percent wise) what type of information you are using?

In answering questions about instruments of climate policy and their performance on key criteria, my responses are based on a synthesis of widely accepted principles from environmental economics, public policy analysis, and climate science. I do not use quantifiable data such as percentages because I do not have access to current databases or statistical models in this environment. Instead, my responses draw upon general knowledge up to my last update in April 2023, which includes:

Published Research and Literature:

This includes peer reviewed journal articles, reports from climate policy think tanks, and academic textbooks that outline the theory and empirical findings related to climate policy instruments.

Expert Consensus and Analysis:

Information from the Intergovernmental Panel on Climate Change (IPCC) reports, insights from economists specializing in environmental policy, and synthesis reports from various environmental agencies provide a consensus viewpoint on the effectiveness of policy instruments.

Historical Precedents and Case Studies:

Past and current examples of climate policy implementation in various countries, along with their outcomes, inform an understanding of how these instruments perform in real world settings.

Policy Evaluations and Reviews:

Assessments and evaluations from organizations such as the International Energy Agency (IEA) and the World Bank, which periodically review the performance of different climate policy instruments across countries.

While specific percentages or precise quantitative data are not used in my responses, the general trends, comparisons, and performance evaluations are grounded in the qualitative synthesis of the above types of information. The aim is to reflect the broad consensus and the range of considerations that experts in the field would typically make when assessing climate policy instruments.

13. In answering questions about instruments of climate policy and their performance on key criteria, can you clarify and if possible quantify (e.g., percent wise) what type of information you are using in terms of academic versus other (grey) publications

When providing information on the performance of climate policy instruments against key criteria, my responses are derived from a mixture of academic and “grey” literature encompassed in my training data. Here’s a qualitative breakdown of these sources:

Academic Publications:

These include peer-reviewed journal articles, academic conference papers, and reviewed journal articles, academic conference papers, and research from university-affiliated institutions. Such sources are highly credible affiliated institutions. Such sources are highly credible and often provide empirical data, theoretical models, and rigorous analysis and often provide empirical data, theoretical models, and rigorous analysis.

Academic sources form a substantial basis of the information I provide, especially for detailed descriptions of policy mechanisms and evidence especially for detailed descriptions of policy mechanisms and evidence-based assessments of effectiveness, efficiency, equity, and feasibility assessments of effectiveness, efficiency, equity, and feasibility.

Grey Literature:

Grey literature refers to materials and research produced by grey literature refers to materials and research produced by organizations outside of the traditional commercial or academic publishing and distribution outside of the traditional commercial or academic publishing and distribution channels. This includes reports by government agencies, international channels. This includes reports by government agencies, international organizations (like the IPCC, IEA, or UN agencies), policy think tanks, and industry organizations (like the IPCC, IEA, or UN agencies), policy think tanks, and industry groups.

These sources are particularly useful for current policy reviews, implementation case studies, and practical considerations in policy effectiveness. They often case studies, and practical considerations in policy effectiveness. They often provide broader overviews and are valuable for insights into real-world applications and policy applications and policy recommendations.

While academic publications tend to be more methodologically rigorous and are peer-reviewed, grey literature can offer more up-to-date information on policy implementation and can be more accessible to a wider audience, including policymakers and the general public.

Quantification in terms of percentages (e.g., “60% academic and 40% grey literature”) is not possible because my responses synthesize information from a large, diverse set of sources without a strict quantitative division. The information from both types of sources is integrated to provide a comprehensive overview of the topic, with the intent to balance the depth and rigor of academic research with the practical insights from grey literature.

The emphasis on one type of source over another can vary depending on the specific question at hand. For example, questions about the theoretical underpinnings of climate policy might lean more heavily on academic sources, while questions about the practical application of a policy might draw more from grey literature.

14. *In answering questions about instruments of climate policy and their performance on key criteria, can you clarify — And if possible quantify (e.g., percent wise) — What type of what type of information you are using in terms of academic disciplines?*

When addressing questions about climate policy instruments and their performance based on effectiveness, efficiency, equity, and feasibility, I draw from a multidisciplinary academic perspective. Although I cannot provide a quantitative breakdown, the types of academic disciplines that inform my responses include:

Environmental Economics: This discipline provides a framework for understanding the economic impact of environmental policies, including the principles of externalities, market failures, and the cost-benefit analysis of different policy instruments.

Political Science: Insights from political science are crucial for evaluating the feasibility and political acceptability of various climate policies, as well as their governance and political acceptability of various climate policies, as well as their governance structures.

Public Policy: The field of public policy offers models and case studies on policy design, implementation, and evaluation. It also contributes to understanding regulatory approaches and the role of public institutions.

Environmental Science and Engineering: These fields contribute knowledge on the technical aspects of pollution control, the effectiveness of various mitigation technologies, and the scientific basis for setting environmental standards.

Sociology and Social Policy: These disciplines provide perspectives on the social implications of climate policies, particularly equity and distributional effects, and how policies affect different groups within society.

Law: Legal scholarship offers insights into the regulatory frameworks that underpin policy instruments and the enforceability of environmental legislation.

Climate Science: Fundamental to all discussions on climate policy, this discipline informs the necessity, urgency, and objectives of climate action.

Business and Management: This area provides perspectives on how climate policies affect corporate behavior, innovation, and competitiveness.

These disciplines often overlap and inform each other, creating a comprehensive body of knowledge from which I synthesize responses. The integration of these disciplines enables a holistic view of climate policy instruments that considers scientific, economic, social, and practical dimensions.

15. *If you answer questions about instruments of climate policy, which disciplines dominate the information that you make use of?*

When answering questions about instruments of climate policy, the information I utilize is predominantly influenced by the following disciplines: Environmental Economics.

Environmental Economics: This discipline is often dominant as it provides the core principles for evaluating the cost-effectiveness and efficiency of climate policy instruments. It also offers insights into the market-based mechanisms like carbon pricing.

Public Policy and Administration: This field is crucial for understanding the design, implementation, and feasibility of climate policies. It contributes to the discussion of how policies are received by the public and policymakers.

Political Science: It contributes significantly, particularly in the analysis of the feasibility criterion, by examining the political dynamics that affect the adoption and sustainability criterion, by examining the political dynamics that affect the adoption and sustainability of climate policies.

Climate Science: The fundamental data and rationale for climate policies come from climate science, which informs the climate science, which informs the effectiveness criterion by providing the goals and effectiveness criterion by providing the goals and benchmarks for emissions reductions.

Sociology: This discipline informs the equity aspect, exploring how different climate policies impact various societal groups and contribute to social justice.

Law: Legal frameworks are essential for understanding the enforceability of climate policies and the compliance mechanisms that underpin them.

These disciplines collectively form a comprehensive base from which I draw to provide nuanced and informed responses about climate policy instruments. The interplay between these disciplines reflects the multifaceted nature of climate policy, which encompasses scientific, economic, social, legal, and political considerations.

16. *If you answer questions about direct regulation (e.g., technical standards, quotas) in climate policy, which disciplines dominate the information that you make use of?*

When addressing questions about direct regulation in climate policy, such as technical standards and quotas, the standards and quotas, the information I utilize is heavily influenced by the following information I utilize is heavily influenced by the following disciplines:

Environmental Law and Policy: This discipline is central to understanding the legal basis and framework for direct regulation, including how laws are crafted, enforced, and interpreted. It addresses the structure and enforceability of regulations.

Public Administration: This field provides insight into how regulations are implemented and managed by government agencies. It informs the practical aspects of enforcing and managed by government agencies. It informs the practical aspects of enforcing standards and managing quota systems.

Economics, particularly environmental economics, plays a role in analyzing the cost-effectiveness of direct regulations and their impact on economic behavior.

Political Science: The political acceptability, policy design, and legislative process behind direct regulation are informed by political science. It helps understand the dynamics that direct regulation are informed by political science. It helps understand the dynamics that influence policy adoption and reform. Reform.

Engineering and Environmental Science: These disciplines are significant for setting technical standards and quotas as they provide the necessary data on emissions, technical standards and quotas as they provide the necessary data on emissions, technology performance, and environmental impact assessments.

Sociology: This discipline is relevant when considering the social implications and equity of direct regulations, including how they affect different groups and how compliance of direct regulations, including how they affect different groups and how compliance burdens are distributed.

These disciplines intersect to provide a multidimensional view of direct regulation, ensuring that responses are well-rounded and consider the legal, administrative, rounded and consider the legal, administrative, economic, technological, political, and social aspects of policy implementation.

17. If you answer questions about carbon taxation, which disciplines dominate the information that you make use of?

In responding to questions about carbon taxation, the information I use is primarily drawn from the following disciplines:

Environmental Economics: This is the leading discipline as it provides the foundation for understanding how carbon taxes work as a market-based mechanism to internalize the based mechanism to internalize the external costs of carbon emissions. It addresses the efficiency and effectiveness of external costs of carbon emissions. It addresses the efficiency and effectiveness of carbon taxes in reducing emissions.

Public Policy: Public policy is crucial for exploring how carbon taxes are designed, the political processes involved in their implementation, and their broader impact on public political processes involved in their implementation, and their broader impact on public initiatives and governmental agendas.

Law: Legal frameworks are essential for structuring and enforcing carbon taxation. This discipline outlines the statutory requirements and ensures that tax measures comply discipline outlines the statutory requirements and ensures that tax measures comply with broader legal standards and principles.

Political Science: This field examines the political feasibility of implementing a carbon tax, including public and political support, opposition, and the strategies for navigating tax, including public and political support, opposition, and the strategies for navigating the political landscape.

Economics: Beyond environmental economics, general economics contributes to environmental economics, general economics contributes to understanding the broader fiscal implications of carbon taxation, including its impact on understanding the broader fiscal implications of carbon taxation, including its impact on the economy, labor markets, and distribution of wealth.

Sociology and Social Policy: These disciplines provide insight into the social dimensions of carbon taxation, particularly its equity impacts and distributional effects across of carbon taxation, particularly its equity impacts and distributional effects across different demographic groups.

Business and Finance: Insights into how carbon taxation affects corporate behavior, investment decisions, and the overall market are informed by these disciplines.

Together, these disciplines form a comprehensive basis for understanding and discussing the multifaceted aspects of carbon taxation within the context of climate policy. They the multifaceted aspects of carbon taxation within the context of climate policy. They provide a holistic view that includes theoretical foundations, practical implications, legal constraints, political dynamics, and social impacts.

18. If you answer questions about cap-and-trade in climate policy, which disciplines trade in climate policy, which disciplines dominate the information that you make use of?

In addressing questions about cap-and-trade systems in climate policy, the information trade systems in climate policy, the information primarily comes from a combination of the following academic disciplines:

Environmental Economics: This discipline is critical in analyzing the market-based approach of cap-and-trade, assessing its efficiency in reducing emissions, and discussing trade, and discussing the cost implications for businesses and consumers.

Public Policy: It provides insights into how cap-and-trade policies are designed, the trade policies are designed, the mechanisms for policy mechanisms for policy implementation, and the overall governance of such systems.

Political Science: This field contributes an understanding of the political feasibility of cap-and-trade systems, including stakeholder engagement, legislative processes, and trade systems, including stakeholder engagement, legislative processes, and policy negotiations.

Law: Legal perspectives are essential for understanding the regulatory frameworks that Legal perspectives are essential for understanding the regulatory frameworks that enable the establishment and enforcement of cap-and-trade systems, including trade systems, including compliance mechanisms and penalties.

Environmental Science: Scientific data on emission levels, environmental impacts, and the effectiveness of cap-and-trade systems in achieving desired environmental outcomes trade systems in achieving desired environmental outcomes are based on this discipline.

Economics: Beyond environmental economics, the broader field of economics provides Beyond environmental economics, the broader field of economics provides an understanding of how cap-and-trade systems affect economic activities, market trade systems affect economic activities, market behavior, and innovation incentives.

Sociology: This discipline looks at the social implications of cap-and-trade, particularly trade, particularly how such policies affect different communities and their perceptions of fairness and how such policies affect different communities and their perceptions of fairness and equity.

Each of these disciplines plays a role in providing a nuanced understanding of cap-and-trade systems. The interdisciplinary nature of the information reflects the complexity of trade systems. The interdisciplinary nature of the information reflects the complexity of designing and implementing climate policies that designing and implementing climate policies that are not only environmentally effective are not only environmentally effective but also economically viable and socially equitable.

19. *If you answer questions about adoption subsidies in climate policy, which disciplines if you answer questions about adoption subsidies in climate policy, which disciplines dominate the information that you make use of?*

In addressing questions about adoption subsidies in climate policy, my responses are informed predominantly by the following academic disciplines:

Environmental Economics: This discipline is essential in evaluating the cost-effectiveness effectiveness of subsidies, understanding how they incentivize behavioral changes, and assessing their of subsidies, understanding how they incentivize behavioral changes, and assessing their impact on market dynamics.

Public Policy: Public policy analysis is crucial for understanding the design, Public policy analysis is crucial for understanding the design, implementation, and evaluation of subsidy programs, including policy goals, target implementation, and evaluation of subsidy programs, including policy goals, target groups, and measures of success.

Political Science: It provides insights into the political processes and dynamics involved in enacting subsidy policies, including stakeholder engagement and public support.

Sociology and Social Policy: These fields offer perspectives on the social impacts of adoption subsidies, including their effects on equity, accessibility, and the distribution of adoption subsidies, including their effects on equity, accessibility, and the distribution of benefits across different societal groups.

Business and Management: Insights from these disciplines are important for understanding how subsidies influence corporate decision-making, technological making, technological innovation, and competitiveness in the market.

Environmental Science and Engineering: Knowledge from these areas helps assess the technological feasibility and environmental effectiveness of the technologies and technological feasibility and environmental effectiveness of the technologies and practices that subsidies aim to promote.

Law: Legal perspectives are relevant in framing the regulatory context within which subsidy programs operate, including compliance with international trade and subsidy programs operate, including compliance with international trade and environmental agreements.

These disciplines collectively contribute to a comprehensive understanding of adoption subsidies in climate policy, encompassing economic, social, legal, and technological subsidies in climate policy, encompassing economic, social, legal, and technological aspects. This multidisciplinary approach ensures that the varied impacts and implications of subsidy policies are thoroughly considered.

20. *If you answer questions about innovation support (e.g., R&D subsidies) in climate policy, if you answer questions about innovation support (e.g., R&D subsidies) in climate policy, which disciplines dominate the information that you make use of?*

In responding to questions about innovation support, such as research and development (R&D) subsidies, in climate policy, the information I use is primarily influenced by the (R&D) subsidies, in climate policy, the information I use is primarily influenced by the following academic disciplines:

Environmental Economics: This discipline is crucial for understanding how R&D subsidies can can incentivize innovation in climate technology and for evaluating the cost-effectiveness of these subsidies.

Public Policy: Insights from public policy are key to understanding the design, implementation, and effectiveness of R&D subsidy programs, including how they align implementation, and effectiveness of R&D subsidy programs, including how they align with broader climate policy goals.

Political Science: This field provides an understanding of the political dynamics and processes involved in the allocation of R&D subsidies, including stakeholder engagement processes involved in the allocation of R&D subsidies, including stakeholder engagement and legislative considerations.

Science and Technology Studies: This interdisciplinary field helps in assessing the impact of R&D subsidies on technological innovation, including the development and diffusion of R&D subsidies on technological innovation, including the development and diffusion of new climate technologies.

Business and Management: Perspectives from these disciplines are important for understanding how R&D subsidies affect corporate strategies, especially in terms of understanding how R&D subsidies affect corporate strategies, especially in terms of investment in new technologies and innovation management.

Sociology: Sociological perspectives are relevant for examining the social implications of R&D subsidies, such as their impact on workforce development and societal acceptance R&D subsidies, such as their impact on workforce development and societal acceptance of new technologies..

Environmental Science and Engineering: These fields provide the technical background necessary to understand the potential necessary to understand the potential effectiveness and feasibility of the technologies effectiveness and feasibility of the technologies being developed through subsidized R&D.

These disciplines collectively contribute to a comprehensive understanding of R&D subsidies in climate policy, encompassing their economic, political, social, and subsidies in climate policy, encompassing their economic, political, social, and technological aspects. This multidisciplinary approach is essential for appreciating the technological aspects. This multidisciplinary approach is essential for appreciating the complexity and potential impacts of innovation support mechanisms in the context of climate change mitigation and adaptation.

21. *If you answer questions about information provision (e.g. education or ecolabels) in climate policy, which disciplines dominate the information that you make use of?*

In responding to questions about information provision in climate policy, such as education initiatives or eco-labeling, the information I utilize is predominantly influenced by the following academic disciplines:

Environmental Communication: This discipline is central to understanding how information about climate change and sustainability is conveyed to the public and the information about climate change and sustainability is conveyed to the public and the effectiveness of different communication strategies, including ecoeffectiveness of different communication strategies, including eco-labeling and educational campaigns.

Public Policy: Public policy analysis provides insights into the design and implementation of information provision programs, policy objectives, and measures of success.

Sociology and Social Psychology: These fields offer perspectives on how individuals and communities perceive, process, and react to environmental information, and how this influences behavior change.

Marketing and Consumer Behavior: Insights from these areas are crucial in understanding how eco-labels influence consumer choices and the effectiveness of labels influence consumer choices and the effectiveness of marketing strategies in promoting sustainable products and practices.

Environmental Education: This discipline focuses specifically on educational approaches to raise awareness and understanding of environmental issues, and on developing to raise awareness and understanding of environmental issues, and on developing educational content and programs.

Political Science: It contributes to understanding the political aspects of information provision, including how environmental information is used in political discourse and provision, including how environmental information is used in political discourse and policy advocacy.

Environmental Science: A technical understanding of environmental issues, which is foundational to creating accurate and effective informational content, comes from this foundational to creating accurate and effective informational content, comes from this discipline.

These disciplines collectively form a comprehensive basis for understanding and discussing the multifaceted aspects of information provision in climate policy. They provide a holistic view that includes communication strategies, psychological and social provide a holistic view that includes communication strategies, psychological and social dynamics, marketing principles, educational methodologies, and political and scientific contexts.

22. Which instruments other than the ones listed below do you consider essential for which instruments other than the ones listed below do you consider essential for effective climate policy, and which disciplines dominate the information about these effective climate policy, and which disciplines dominate the information about these which you make use of?

direct regulation (e.g., technical standards, quotas)
carbon tax
cap-and-trade
adoption subsidies
innovation support (e.g., R&D subsidies)
information provision (e.g. education or ecolabels)
other (please specify):

Other than the instruments listed (direct regulation, carbon tax, cap-and-trade, adoption subsidies, trade, adoption subsidies, innovation support, information provision), the following are also considered essential for an innovation support, information provision), the following are also considered essential for an effective climate policy:

Public Investment in Clean Infrastructure: This involves government spending on infrastructure that supports a low-carbon economy, such as renewable energy facilities, public transportation, and energy-efficient buildings.

Green Public Procurement: Governments can use their purchasing power to buy environmentally friendly products and services, driving market demand and fostering sustainability-friendly products and services, driving market demand and fostering sustainability.

Voluntary Agreements: These are partnerships between government and industry to achieve environmental goals, which can sometimes lead to innovation faster than regulatory approaches.

International Climate Agreements: Participation in global efforts like the Paris Agreement can be critical for setting international targets and facilitating cooperation.

Disciplines that dominate the information about these additional instruments include:

Environmental Economics: For analyzing the cost-effectiveness and market impact of public effectiveness and market impact of public investments and green procurement.

Public Policy and Administration: For insights into the design, implementation, and management of public investment projects and procurement strategies.

International Relations: Particularly relevant for international climate agreements, as it provides an understanding of the dynamics of international cooperation and policy-making.

Business and Management: For understanding the strategic implications and responses of firms to voluntary agreements and green procurement policies.

Law and Environmental Policy: For legal frameworks that govern international agreements, public investments, and procurement practices.

These disciplines help to evaluate the broader economic, legal, political, and social dimensions of these additional climate policy instruments.

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