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Why are carbon taxes unfair? Disentangling public perceptions of fairness

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ABSTRACT

In order to reach climate goals, governments need to gain support from their voters for the necessary policy interventions, such as carbon dioxide taxes. Previous research concludes that people often do not support and legitimize such taxes because they perceive them as unfair. However, the notion of fairness implies a multitude of factors and despite attempts of the previous research to further nuance people's fairness perceptions, we currently lack a more precise understanding of what people mean when they regard carbon taxes as unfair. In this article, we thoroughly investigate this problem by using original survey data from YouGov collected in the United States in 2018 and analyzing open-ended survey responses on why people think carbon taxes are unfair. Applying structural topic modeling, we unpack the multi-dimensional meaning of unfairness, as perceived by the US population. The results from our analysis show that people regard carbon taxes based on gas pricing as unfair because they perceive gas prices already being high, because of the need to drive, unfairness for the poor or rural population, lack of trust in government, or considerations that the purpose of the tax is unjustified. These findings help provide a more nuanced policy design to address fairness concerns related to carbon taxes.

1. Introduction

As governments around the world are struggling to reach the goals of the Paris agreement, one of the major obstacles to adopting effective and efficient policy measures is an unfavorable public opinion towards these measures (cf. Jagers, Martinsson, and Matti 2019). Although the support from a majority of the public is not necessary in all cases of policy implementation, and might not be enough if other powerful interests oppose a policy (e.g., Schneider and Ingram, 1993), a range of studies demonstrate how public opinion both constrains (Foyle, 2004; Sobel, 2001) and determines possible policy choices (Soroka and Wlezien, 2010; Stimson, 2007). This is due to the fact that elected decision-makers hold rational reasons for not straying too far from the majority opinion. The *gilet jaunes* protests in France is one prominent example of how surges in negative opinions affect policy choice; but the list of instances where plans for introducing carbon pricing measures have been scrapped due to low public acceptance is far more extensive, including examples from Canada (Harrison, 2012; Harrison, 2010), Australia (Crowley, 2017), and the US (Feldman and Hart, 2018; Shwom et al., 2010). Expanding our knowledge on the motives behind this public opposition is key for enabling governments to design policy measures that are both climate effective and politically feasible. This study aims to improve our understanding of public opposition to carbon dioxide (CO_2) taxes by focusing on why and in what aspects the public perceives them as unfair.

Carbon taxation is generally considered one the most cost-efficient ways of reducing greenhouse gas emissions (cf. Stiglitz et al. 2017) and is thus often advocated by, e.g., environmental economists and policy researchers (cf. Jagers et al., 2018; Sterner and Coria, 2012). Whereas piecemeal regulations can reduce emissions, they are difficult to administer properly and do little to reward technological development and innovation that go beyond regulatory minimums. Carbon taxation, on the other hand, encourages both consumers and businesses to reduce emissions at the lowest cost, and provides clear incentives for developing new ways to reduce emissions further. Moreover, apart from its cost effectiveness, putting a price on carbon can be considered a fair policy from a polluter-pays principle, since only those responsible for the emissions are affected by the increase in price (Cazorla and Toman, 2001; Rose et al., 1998).

At the same time, targeting the pricing of carbon through taxes only

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has been criticized for several reasons. Sterner et al. (2020) argue that the distributional effects of CO_2 taxes make them unpopular and thus unlikely to be implemented – at least unless they are combined with other (e.g., compensatory) measures. Patt and Lilliestam (2018) instead claim that carbon prices are outdated and that today, when our ambition is to eliminate CO_2 emissions from the economies completely, the price is not the greatest barrier, but rather infrastructure, institutions, and especially technology. They conclude that various forms of technology support instruments are considerably more effective. Still, although carbon taxes may not be the only solution to the emissions problem, they have been successfully implemented in several jurisdictions around the world, starting with the Nordic countries in the early 90′s (Finland 1990, Sweden and Norway 1991, and Denmark 1992), and most recently in Chile, Colombia, and by the Trudeau government in Canada in 2019. Moreover, numerous countries are currently considering implementing CO_2 taxes (see Coalition of Finance Ministers for Climate Action [WWW Document], 2021), thus making it increasingly important to investigate under what conditions their implementation becomes possible.

As several recent instances of public protests against governmental attempts to increase fossil fuel prices demonstrate, for example in France (Maestre-Andrés et al., 2019), Ecuador (Schaffitzel et al., 2020), and several Canadian provinces (De Cillia and McCurdy, 2020; Harrison and Peet, 2012), the effects of carbon pricing stretch beyond the immediate consequences for carbon emissions levels. Carbon tax also has tangible distributional effects, as it imposes a relatively larger direct burden as a share of income on lower-income than on higher-income households. Furthermore, it makes fossil fuels, and, as a consequence, goods and services made with them, more expensive, thereby reducing the purchasing power of workers and, in the long run, of individuals who receive government benefits linked to growth in real earnings (Brännlund and Nordström, 2004; Sterner et al., 2020; Sterner et al., 2019; Wier et al., 2005). The potential negative distributional effects of carbon taxation also stand out from a range of public opinion studies that report a strong link between a public opposition to CO_2 taxes and the perceptions of these taxes as being *unfair* (cf. Carattini et al., 2019; Drews and van den Bergh 2016; Johansson-Stenman and Konow 2010; Eriksson et al., 2006; Fujii et al. 2004; Schade and Schlag 2003; Jagers et al., 2018; Huber et al., 2020).

By now, the correlation between fairness perceptions and policy support is well documented (see Maestre-Andrés et al., 2019 for an overview). There are also several attempts to decompose what the perceptions of (un)fairness actually entail – information of utmost importance for policy-makers aiming at implementing such taxes, in different countries. For example, based on survey data, Hammar and Jagers (2007) make an early attempt to investigate how individuals' preferences for fair reductions of CO_2 emissions affect support for increases in the Swedish CO_2-tax on gasoline and diesel, primarily studying three key fairness principles: equity, equality, and need. Another example of survey-based studies is the one by Kim et al. (2013), exploring how, among other factors, different fairness conceptions, i.e., scenario fairness, distributional fairness, and procedural fairness, affect attitudes towards road pricing and environmental taxation. On the same theme, Gampfer (2014) uses lab experiments to explore how a set of normative criteria affect people's preferences for burden sharing related to climate change, i.e., ability to pay, vulnerability, and historical responsibility.

In addition to studies founded on pre-determined fairness principles, the literature also embraces a number of studies based on open-ended response designs, primarily interviews and focus groups. Such approaches enable even more nuanced images of what fairness means to people in relation to climate change policies, including CO_2 taxes (Dresner et al., 2006; Kallbekken and Aasen, 2010). With similar ambitions, much more recent research continues to disentangle the meaning of fairness using more quantitatively oriented methods (Carattini et al., 2019; Huber et al., 2020). For example, using data from about 44.000 respondents in 23 countries Levi (2021) applies machine learning methods to estimate the effects of 28 individual-level and country-level conditions on public resistance to carbon taxes. He finds that feeling of personal responsibility for reducing climate change, opinion about current carbon prices, and various aspects of political and institutional trust are the conditions primarily provoking public opposition to carbon taxes. As we see it, all of these conditions can be linked to the perceptions of fairness. Of particular interest for our study is a study by Savin et al. (2020) who use topic modelling when analyzing opinions of Spanish citizens about a policy proposal to introduce a carbon tax. They find that, compared to people accepting the carbon tax, those rejecting it show less trust in politicians, hold the opinion that the rich should pay more than the poor, and consider a specific CO_2 tax to be unfair.

In the present study, we largely build upon this research field, which is gradually moving towards more and more refined ways of detecting how people reason on the unfairness of carbon taxation. This development of the research field is most reasonable, since perceived unfairness is repeatedly proved to generate resistance against CO_2 taxes. Thus, it increasingly has the potential to generate significant input to future policy-making.

The overall question we ask in this paper is: *Why* do some people perceive an introduction of a CO_2 tax as unfair, and in *which aspects*? Compared to previous research, we thereby zoom in even more only studying those individuals who explicitly state that they have negative attitudes towards the introduction of a CO_2 tax and declare that they think that the tax is unfair. We do not study individuals that perceive the policy as fair, because fairness rarely lies behind public support for taxes - those who support the tax does not often do so because they believe it to be fair. Their main motivation is instead related to the tax being necessary for the climate or efficient. However, one of the main sources for opposition to carbon tax is the perception of the tax as unfair. Further scrutinizing the various dimensions underlying unfairness perceptions may provide us with insights into how to alleviate the negative attitudes originating from these perceptions. More specifically, we connect our results more explicitly to policy-making, by discussing how a CO_2 tax can be combined with other measures in order to increase the perceived fairness, depending on what underlying perceptions motivate the public resistance.

Furthermore, getting a sufficiently clear and more general understanding of what people mean by stating that a CO_2 tax is unfair, not only requires increasingly refined methods and a continuously narrowed focus. It also presupposes reiterated studies: For example, it needs to be ruled out whether or not unfairness perceptions are universal or if they are related to context. In this study we focus on US citizens. Thus, we focus on people living in the country that is the second largest CO_2 emitter in the world in absolute terms and the 16th largest per capita emitter. Moreover, it is a country that has a history of federal political administrations not agreeing to be an active party of most international agreements on reducing climate change. How does that potentially affect citizens' perceptions of unfairness and burden-sharing compared to more modest per-capita emitters such as Spain or Sweden, or even more so, to countries with low emission levels, such as most developing countries? Furthermore, as a range of previous studies demonstrates, political culture, ideological positions, and value orientations differ considerably across countries (Cherry et al., 2014; Inglehart and Baker, 2000; Schwartz, 2006). It is reasonable to assume that these more fundamental differences also affect how concepts like fairness are interpreted, and, consequently, which fairness perceptions dominate among the mass public. These considerations motivate conducting this type of studies in different political contexts.

In our study we use original data from a 2018 US survey (N = 3180) administered by YouGov, capturing both public attitudes towards a suggestion to introduce CO_2 tax on petrol as well as open-ended questions where respondents were asked to motivate and further explain why they considered the suggested policy (un)fair. The use of open-ended questions to get closer to people's understanding of the unfairness of the policy is an important advantage of this data. It allows us to explore

the political thinking of ordinary people without assuming they have very clear conceptions of fairness related to a CO_2 tax on petrol that conform to those commonly brought up in political philosophy that we elaborate on in our theory section. Relying only on closed-ended questions with various response options from a theoretical fairness framework would increase the risk of missing what are in reality important considerations for citizens when judging the unfairness of a CO_2 tax.

We apply Structural Topic Modeling (STM) to cluster the open-ended survey responses into themes based on word frequencies and word co-occurrence across responses, as suggested by Roberts et al. (2014) and implemented by Tvinnereim and Fløttum (2015) and by Tvinnereim et al. (2017). By identifying the most common themes raised in survey responses, we discover and analyze specific aspects of fairness raised by the respondents in their answers.

2. Theoretical perspectives on fairness

In this section we briefly disentangle what we, based on essential fairness theory (both normative and empirical), can expect fairness to mean when applied to the public opinion of CO_2 taxes. As we see it, it can both concern different types of fairness (distributional and procedural) but also be considered more or less fair, depending on what fairness principles a person has in mind or is guided by when expressing his or her opinion about the suggested CO_2 tax.

In the current literature, different conceptualisations of (un)fairness are based both on previous empirical findings as well as on normative theories concerning justice and fairness. Although the latter - for the most part - are theoretically derived, descriptions of what fairness entails might transfer to the real-world settings too. On the contrary, it is quite possible that explanations, definitions, and conceptualisations of fairness in the real world differ from the ones derived from established fairness theories. The unreflective assessment of empirical reality with theoretical models could lead to the nirvana fallacy (Carlsson, 1996; Cram, 2002), bound in criticism that the model lacks in realism or the reality is not as perfect as it theoretically could be. The theoretical fairness principles we introduce below, serve as a starting point and a structure for the empirical discussion; however, we neither aspire nor expect to fit our findings neatly into theoretical ideal fairness principles. Moreover, findings outside of what theories predict, if any, are still valuable for our ambition to better understand how people's (un)fairness perceptions may affect their opinion about climate policies.

2.1. Distributive and procedural fairness

Aristotle's seminal distinction between *retributive*, *corrective,* and *distributive* justice (as cited in Urmson, 1988) is still germane when characterizing justice. Retributive justice concerns punishment, that is how to sanction wrong-doing and how to establish what punishment is equivalent to the damage. Distributive justice serves to determine who should get what of a good (or a bad), which is to be distributed among a group. While Aristotle argued that retributive justice, i.e., the kind of justice practiced in the court, is rather simple and can mainly be upheld according to one principle (arithmetic equality where equal cases are treated equally), there is no such corresponding simple principle regarding the much more complex distributive justice. Thus, in some situations, arithmetic equality is applicable also to distributional matters, but more often, other forms of equality are more appropriate. In contrast to distributive justice, *procedural* justice concerns the fairness and the transparency of the *processes* by which decisions are made (Tyler and Degoey, 1995). Hearing all involved parties before a decision is made, is one example of a procedure which would be considered appropriate for a process to be characterized as procedurally fair. Some theories of procedural justice hold that fair procedure leads to equitable outcomes, whether or not the requirements of distributive or restorative justice are not met. In this case of so-called perfect procedural fairness (Rawls, 1999), the outcome of a distribution following from the adoption of a procedure is simply irrelevant: As long as the rules and procedures preceding the decision to adopt a particular distribution or allocation are considered fair and just, who will gain and lose from this allocation is simply extraneous.

Both opinions about distributional and procedural fairness can be expected to affect people's fairness perceptions related to the CO_2 tax: they may find it unfair because they assume that it will have unfair consequences (distributional fairness) or because they believe that something related to the procedures is considered unfair (e.g., that the decision about the tax has been taken without dialogue with affected actors).

2.2. Fairness principles

Empirical research on justice, and how people's perceptions of justice affect their views on politics and policy, is typically confined to a limited set of principles; *need*, *equality,* and *equity*. Some, however, also include others principles, in particular *utility* (e.g., Linneroth-Bayer 1999). The *need* principle is rather straightforward and refers to the ideal that what is to be distributed should be allocated in such a way that people's needs are fulfilled and especially not jeopardized. (Hammar & Jagers 2007). Applied on our particular case of CO_2 emissions, the need principle implies that the more CO_2 one needs to emit, the lesser one's obligation should be to lower emissions (or the converse). For example, people whose driving is a necessity, either for work-purposes such as taxi or truck drivers, or because of living in remote areas without public transport, should be obligated to lower their emissions to a *lesser* degree compared to those living in urban areas with well-functioning transport infrastructure or those who primarily drive for recreational purposes.

Although the *equality* principle can be philosophically intriguing, e.g., with the famous "equality of what" debate (Sen, 1992, p. 4), empirical research usually refers to equality either in procedures (i.e., *before* the distribution), or in outcome (i.e., *after* the distribution). Therefore, if someone argues that the burdens associated with reducing CO_2 emissions ought to be allocated or distributed equally, this can either mean that everyone in the group ought to have an equal share of the burden, or that the burden should be distributed so that everyone ends up more equal than they were before the distribution (Hammar and Jagers, 2007). Thus, the *equality* principle implies either that emission cuts should be distributed equally (e.g., each and every one should lower their emissions by the same amount or share), or that they should be distributed in such a way that the emissions end up more equally dispersed. In this paper it is the former interpretation we refer to when speaking about the equality principle.

If the need and equality principles are rather straightforward, the equity principle is not. Not only is equity, conceptually speaking, misleadingly similar to "equality" and therefore difficult to keep apart, we also found that the equity principle appears to have several different definitions. According to e.g., Young (1994) equity and equality are more or less synonymous – at least when it comes to burden-sharing: "Equity in taxation means that everyone should bear an equal burden" (Young, 1994, p. 105). This view is also shared by Kolm (2002, pp. 95–98) and the World Commission on Environment and Development (1987) who, when discussing distribution of welfare argue that "…sustainable development *requires* that societies meet human needs both by increasing productive potential and by ensuring *equitable* opportunities for all." (1987, p. 88 emphasis added). Eek (2001), on the other hand, builds his research on a much more procedural understanding of the equity principle establishing that a just distribution is one that is based on peoples' contribution to the good (or bad), which is to be distributed. That is, the more someone has contributed, the more he or she ought to receive of the cake or compensate for generated harm. This view is also supported by Wagstaff (1994; in Linneweber, 1999). Furthermore, this particular definition has great resemblances with merit and desert: i.e., one gets what one deserves in accordance with what one has contributed. Mainly because contribution is an important principle in

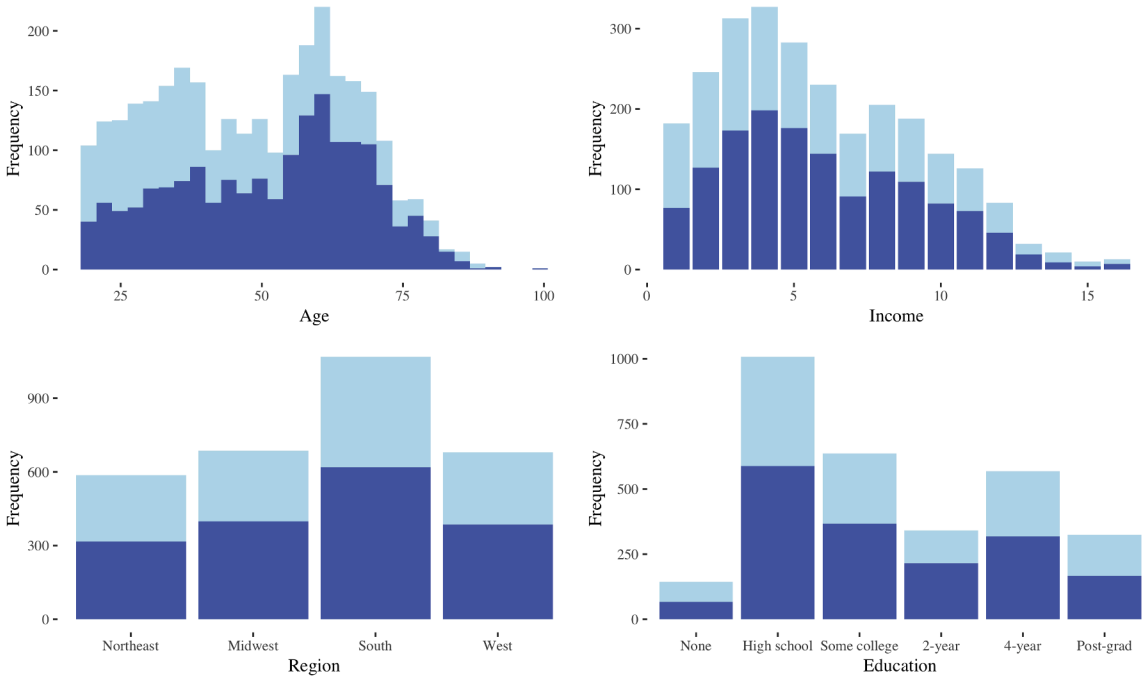

Fig. 1. Distribution of population by age, income, region, and education in the sample. *Note:* Frequencies in light blue are for the full sample of respondents; frequencies in dark blue are for the sample of respondents that ranked a proposed policy as "unfair" (0–4). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

environmental policy (cf. the polluter pays principle), we join the body of scholars holding that equity refers to contribution. Thus, we refer to equity as a principle dictating that social goods (and bads) ought to be distributed in proportion to how much each and every claimant has contributed to the good or bad to be distributed. For the specific case of distributing CO_2 emission reductions, this principle thus informs us that those who emit most, should also lower their emissions most.

Lastly, *utility*. The element that primarily unifies utilitarian theories of justice is that a distribution is just, if and only if it generates more utility than was available before the distribution. As society has become more 'economized', utilitarianism has commonly been equalised with economic utility (e.g., efficiency and Pareto optimality). Thus, a distribution is fair and just provided that it leads to additional aggregated economic utility. Transferred to the case of CO_2 taxes, such a tax would be considered fair if it contributes to the generation of more utility, either on its own account or compared to other policy measures, e.g., due to being more cost efficient than other alternatives, and unfair if someone is asserting that such a tax would decrease utility in society, e.g., due to negative consequences for the economy or for industry. However, someone guided by the utility principle could also have the benefits for the climate in mind when forming their opinion about the tax. In this case, utility is rather translated into "effectiveness", which has also been proved to be an important determinant for policy attitudes (Huber et al 2020).

3. Material and method

In our empirical analysis, we investigate what people mean by unfairness of CO_2 taxes. To get to the core of people's beliefs, we use an open-ended survey question asking people why they think a policy is unfair instead of restricting their answers to the categories in closed survey questions. Our strategy is inductive and we aim to be open to the topics brought up by the respondents, even if they do not match our theoretical expectations.

3.1. Data

We use unique original data from an internet-based survey conducted in the United States in 2018 by YouGov, an international survey data and analytics company. All participants were randomized in six groups and each of the groups was given a different vignette in order to trigger a larger universe of reactions and considerations related to unfairness or fairness of carbon taxes. All vignettes proposed an introduction of a carbon tax that would raise the price of gas:

> "In public debate, the negative effects of vehicle use on the climate and the environment have been discussed. One suggestion is to introduce a carbon tax that would raise the price of gasoline by 10 cents per gallon, in order to reduce the negative effects that vehicle use has on the climate and the environment."

The size of the increase was 10 or 40 cents, depending on a vignette. Some of the vignettes also introduced the possibility of a further compensation of this tax, either to all taxpayers, or personally to the respondent:

> "The revenues from this carbon tax will be used to simultaneously lower income tax for all taxpayers."
> "The revenues from this carbon tax will be used to simultaneously lower your personal income tax with the same amount as you pay in carbon tax (and similar for others that pays carbon tax)."

The use of different vignettes provided us with an opportunity to capture aspects of unfairness related to carbon taxes that are both compensated and not compensated and created a potential for broadening the range of detectable topics. In order to investigate whether the topics differ across vignettes, we also performed an analysis of topic prevalence by vignette, presented in Section 4.1.

The respondents were asked to evaluate their opinion about the proposal on a scale from 0 (very negative) to 10 (very positive) and answer whether they think the proposal was fair or unfair on the scale from 0 (very unfair) to 10 (very fair). Then the respondents were invited to provide justification to their rating and express their views on why

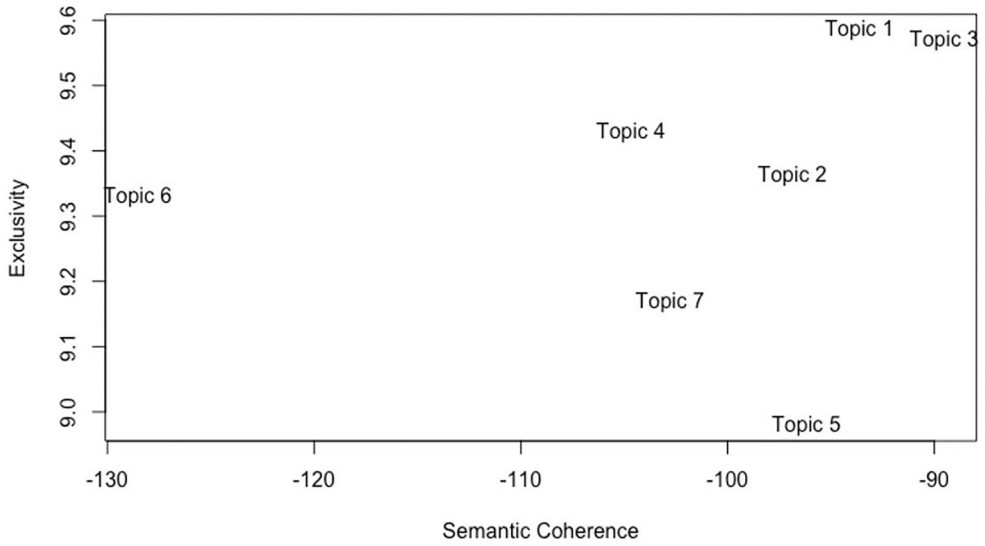

Fig. 2. Topic quality according to exclusivity and semantic coherence.

Table 1
Topic prevalence, word roots with highest probability, frequency, and exclusivity per topic.

Topic No	Topic title	Topic prevalence	Word roots with highest probability, frequency, and exclusivity (FREX)
1	Gas price too high	0.198	Highest Prob: gas, pay, alreadi, price, enough, rais, make FREX: gas, alreadi, price, enough, rais, high, expens
2	Trust in government	0.172	Highest Prob: tax, money, just, way, govern, use, environ FREX: money, just, anoth, help, anyth, pocket, taxpay
3	Need to drive	0.169	Highest Prob: peopl, work, get, need, afford, car, drive FREX: peopl, work, get, need, afford, cent, gallon
4	Unfair on middle class and poor	0.148	Highest Prob: tax, incom, lower, increas, poor, class, low FREX: incom, lower, class, low, hurt, middl, offset
5	No climate change	0.117	Highest Prob: chang, climat, global, warm, carbon, believ, made FREX: chang, climat, global, warm, made, man, liber
6	Corporations should pay	0.102	Highest Prob: carbon, fuel, consum, emiss, car, reduc, affect FREX: fuel, consum, electr, end, instead, manufactur, see
7	Unfair for rural pop	0.094	Highest Prob: vehicl, transport, live, use, public, everyon, drive FREX: transport, public, everyon, area, rural, commut, long

they find the proposal fair/unfair by answering the question "We would like you to explain why you find this proposal unfair/fair. Please enter your answer in your own words."

To capture what people mean by fairness when they rank a climate tax on the fairness criteria, we divided the sample of respondents into three groups. We separated those who ranked the fairness of the proposed policy from 6 to 10, which implies that they consider the policy fair; those who responded 5 on the question and are either neutral, cannot decide or see pros and cons with both; and those who placed the policy from 0 to 4 on the fairness scale, which implies that they consider the policy unfair. As the goal of our paper is to investigate the sources of opposition to carbon taxes, in our analysis we only stick to the analysis of open-ended survey responses of respondents who ranked the policy from 0 to 4 on the fairness criteria, believing that the policy is unfair. Although we might miss some points from people who ranked the policy as a 5 or higher on the fairness scale, who also expressed concerns regarding unfairness, despite the ranking, we have opted for limiting our analysis only to this group as their pool of replies is more coherent and is only related to why people think the policy is unfair, without hesitations. In the additional checks, we also performed the analysis for the full sample and, indeed, the test showed the lack of coherence between the new topics. Moreover, this analysis did not uncover any additional aspects of unfairness to those presented in the main analysis. We therefore opted for not including it in the paper; however, the results are available upon request.

Overall, the survey covered 3 questions related to the proposal, including open-ended responses, 4 questions on the importance of various societal problems to an individual, including environmental protection, economic development, reducing climate change or reducing unemployment. Additionally, the survey included questions on respondents' political views, asking for respondents' party affiliation and their positioning on the liberal-conservative scale, as well as background questions on age, gender, and education. The questionnaire gathered 3180 responses, among which 1728 respondents (54 per cent) ranked the policy from 0 to 4 on the fairness scale, indicating that they consider the suggested policy unfair. Response length varied from 1 to 1000 characters with the average of 107 characters. Fig. 1 presents our sample, which is representative of the US population, by age, income, region, and education.

Before conducting the analysis of the text responses, we cleaned the data by removing all empty responses, responses that are less than three words and all versions of "I don't know", "have no answer", "decline to answer", "I am not sure", and similar. This gave us 1609 responses total.

3.2. Method and models

In order to identify why respondents consider the suggested policy "unfair", we use quantitative text analysis technique called Structural Topic Modeling (STM). It is a machine-learning algorithm that allows for inductive search of distinct topics in a corpus of text. It specifically helps to "discover topics from the data, rather than assume them" (Roberts et al., 2014: 1066). STM clusters the words used by the respondents into themes (topics) based on word frequencies and word co-occurrence

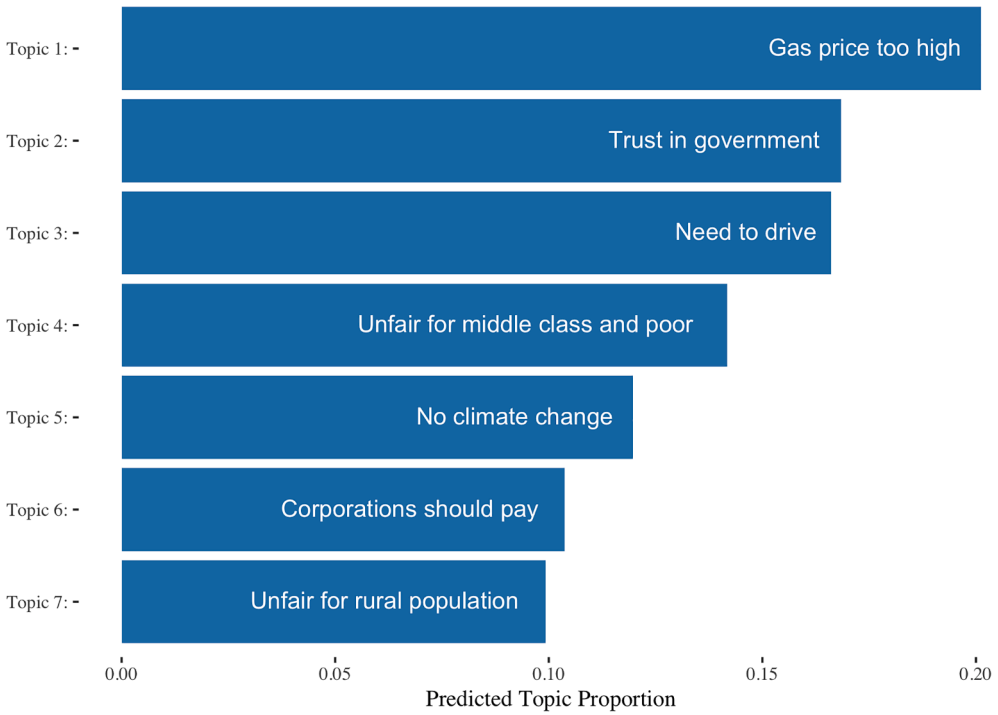

Fig. 3. Frequency of topics in the responses.

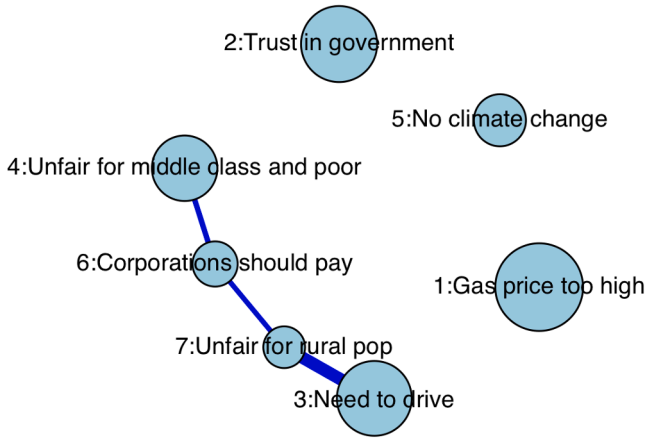

Fig. 4. Correlation between the topics. *Cluster sizes correspond to topic prevalence; line thickness corresponds to the correlation size between the topics.*

across responses (documents). The advantage with the STM is that it can match the respondents' background data to their free text responses and use it for identifying the main themes in the responses.

In order to initiate the model, we had to choose the total number of topics, usually denoted as *K*. STM assigns a vector with *K* values to every response, where every value is the degree to which a response belongs to topic *K*. All values within the K vector sum up to one. For example, if K = 5, each response can belong 10% to Topic 1, 10% to Topic 2, 50% to Topic 3, 10% to Topic 4, and 20% to Topic 5. Therefore, it is possible that the same response may belong to several topics with different degrees.

To identify the appropriate number of topics (K), we first made use of an algorithm—*SearchK* function in the *STM* package in R (Roberts et al., 2018) and ran it several hundred times with different topic prevalence functions, different seeds, tolerance levels, and numbers of iterations. Topic prevalence is a degree to which a particular response belongs to a given topic. We defined the topic prevalence as a function of a spline of age, the level of education, attitudes towards climate change (how important climate change issues are to the respondent), gender, attitudes towards unemployment, and political views on the liberal-conservative scale, in different combinations. We chose to omit income from the prevalence function because of the considerable amount of "prefer not to say" answers (>400), which would have complicated the search for the optimal number of topics.

We performed our search for both stemmed and non-stemmed data, reducing the words used in responses to their root form only. Stemming helps the algorithm to group words that have the same root into the same topic. The optimal number of topics identified by the *searchK* function varied from 6 to 11, depending on specification of the function, with most suggestions leaning towards 8 or 10 topics in the non-stemmed corpus and 6 or 8 topics in the stemmed corpus of text. Due the inconsistency of the *SearchK* results, we ran STM models for a range from 4 to 12 topics for both stemmed and non-stemmed text data and compared the results. In this range of topics, we performed STM runs for each K, choosing one best run per K automatically, based on the maximum likelihood estimation. The model selects such best run based on how exclusive the identified topics within the run are and how high the semantic coherence (coherence of responses) is within the identified topics.

We initiated multiple STM models for stemmed and non-stemmed data, performing from 100 to 300 runs per K, using different tolerance levels for convergence, different topic prevalence functions and different number of iterations for convergence. We defined the topic prevalence function similarly to how we did it in the *SearchK* function, that is in terms of a spline of age, the level of education, attitudes towards climate change, gender, attitudes towards unemployment, and political views on the liberal-conservative scale, in different combinations. We evaluated the automatically selected model outputs (runouts) for each number of topics (K) for each initiated model manually, comparing semantic coherence and exclusivity of each topic within each runout. Our evaluation revealed that topic modelling worked best on the stemmed text, as topics had on average higher semantic coherence and exclusivity.

After evaluating all model outputs, the best model outputs in terms of exclusivity and semantic coherence of topics was produced from 200

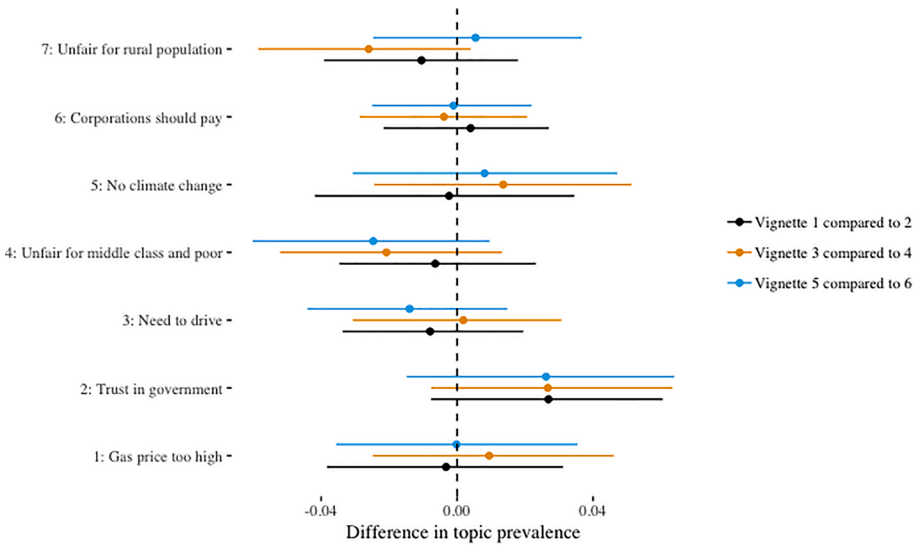

Fig. 5. Differences in topic prevalence across vignettes suggesting 10 cents (1, 3, 5) and 40 (2, 4, 6) cents gas price raise. Vignettes 1–2 are without a compensation condition; vignettes 3–4 suggest equal compensation; vignettes 5–6 suggest individual compensation.

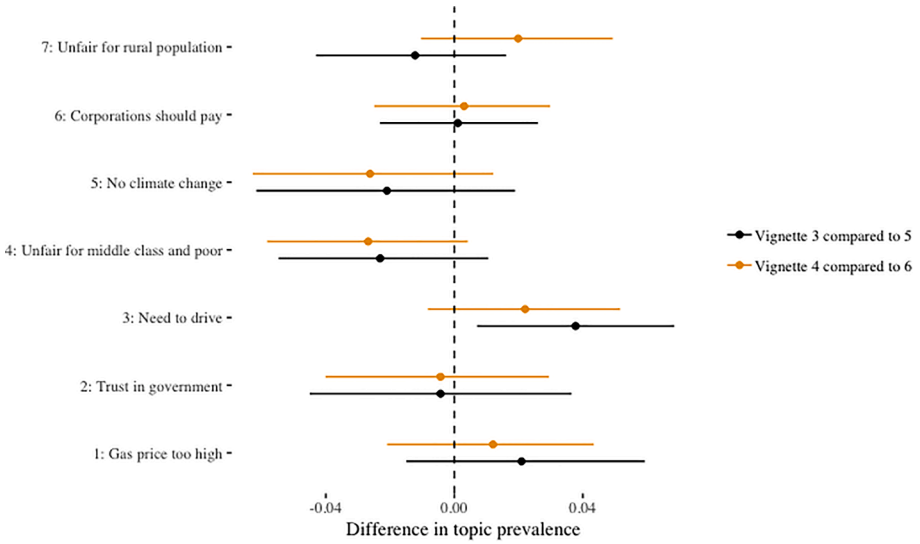

Fig. 6. Differences in topic prevalence across vignettes suggesting individual compensation (3, 4) and equal compensation (5, 6). Vignettes 3 and 5 suggest a 10-cent tax; Vignettes 4 and 6 suggest a 40-cent tax.

STM runs for each K in the range of 4–12 topics and the topic prevalence function defined as the spline of age, gender, climate attitudes, attitudes towards unemployment, political orientation and education for stemmed data. We carefully investigated most prevalent responses manually in each of the model outputs in all specifications. Both the model and manual investigations suggested that seven topics was an optimal number of clusters the responses could be summarized into (K = 7).

Fig. 2 places the topics within the model output along semantic coherence and exclusivity. While high scores on both are ideal, we are especially concerned with semantic coherence, as it shows the degree to which the responses within the topic are coherent with one another. If the topic is exclusive but not coherent, it is not of much substantive interest. In our case all topics score rather high on both semantic coherence and exclusivity.

4. Results

After analyzing the most frequent responses in each of the topics, we summarized them into representative titles. Table 1 presents the word roots with highest probability, frequency and exclusivity in each of the topics, while Fig. 3 illustrates the topic prevalence in our responses.

Our topic modeling algorithm showed that the most popular topic among the respondents, amounting to 21 per cent of the total topic prevalence, is that the CO_2 tax on petrol is unfair because gas prices are already too high. One of the representative replies is "The gas prices are high enough. The prices should not be raised" (for more citations on all topics, see Table A1 in Appendix A). Such replies can be related to several aspects of fairness, such as an unequal distribution of burden or the need to drive, implying that people think they spend too much on gas already since they spend a lot of time on the road.

The second most common argument why people think the CO_2 tax based on gas pricing is unfair is lack of trust in government (seventeen per cent of total topic prevalence). Responses that clustered into this topic indicate that government or politicians cannot be trusted to implement a carbon tax:

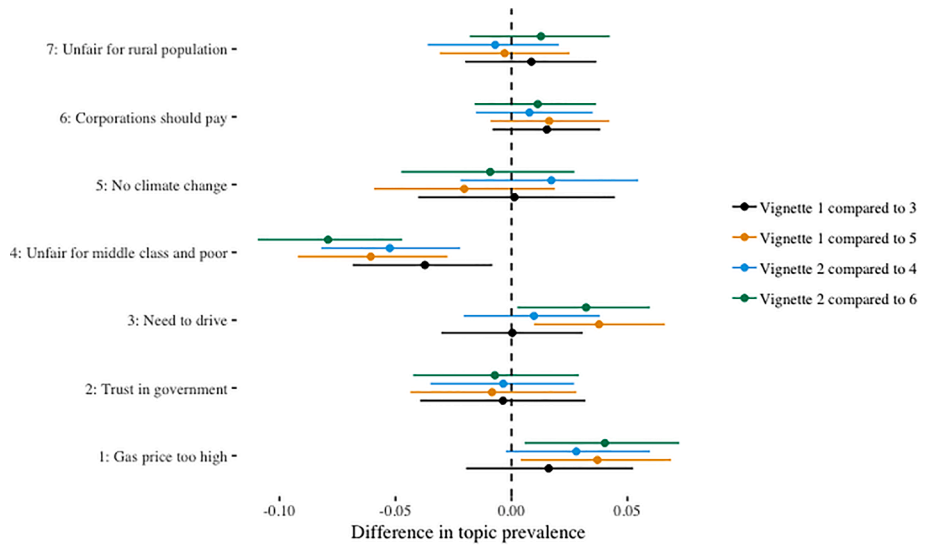

Fig. 7. Differences in topic prevalence across vignettes suggesting compensation (3, 4, 5, 6) and not suggesting compensation (1, 2). Vignettes 1, 3, and 5 suggest a 10-cent tax. Vignettes 2, 4, and 6 suggest a 40-cent tax.

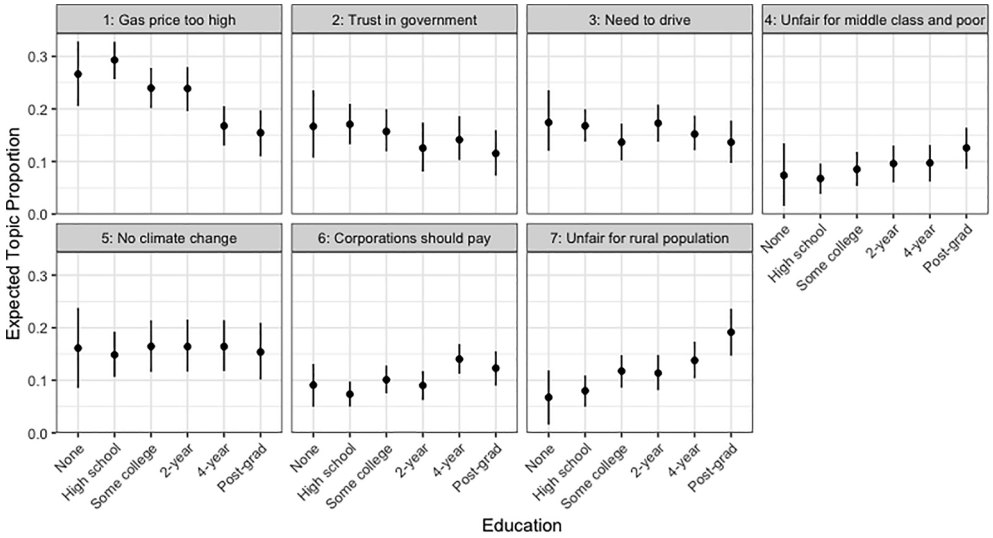

Fig. 8. Topic prevalence by education with 95% confidence intervals.

Table 2
Possible implications for policy design given different perceptions of unfairness.

Reasons for unfairness	Fairness principle	Examples of implications for policy design
Gas price too high	Equality, need	Tax together with a subsidy for green fuels and/or alternative vehicles
Lack of trust in government	Procedural justice	Transparency in the handling of carbon tax and tax revenues
Need to drive	Need	Tax together with infrastructure/ compensation/subsidies
Unfair for the middle class and poor	Equality	Targeted compensation/information
Corporations should pay	Equity	Tax on corporations
No climate change	Purpose not justified, utility	Information
Unfair for rural population	Equality, need	Infrastructure/targeted compensation

> "because the government always uses the excuse that it's to help something and wind up [sic] using the money to line their own pockets or some fat cat contractor"

This type of reaction is not at all related to any distributional effects of the tax, but is rather concerned with *procedural* aspects – in this case that the tax collecting authorities cannot be relied upon. Several responses also point to the fact that taxes can get and have been diverted from their original purpose, implying that the tax may lack effectiveness. Some people highlighted lack of transparency in the proposal, or that they do not know how the policy will be implemented and therefore they cannot be certain that the implementation will happen automatically. Others were against government intervention altogether, including those who do not support taxation system in principle. These ideas of fairness are also connected to procedural justice but have more to do with fairness and transparency of the decision-making and policy-implementation processes.

Another seventeen per cent of all concerns raised in the replies related to the *need* to drive. The respondents mentioned that public transportation is unreliable or non-existent or that infrastructure, such

Table A1
Examples of high probability responses in the topics. *Note:* The responses are printed in their original form without correction for errors.

Topic #	Three most probable replies
1	gasoline is already high enough as it is and I'm sure buy summer 2018 the price will be raised again The gas prices are high enough. The prices should not be raised gas prices are high enough
2	BECAUSE THE GOVERNMENT ALWAYS USES THE EXCUSE THAT IT'S TO HELP SOMETHING AND WIND UP USING THE MONEY TO LINE THEIR OWN POCKETS OR SOME FAT CAT CONTRACTOR Because it wouldn't help the environment at all. It is just a pointless way to try to convince people that the government is doing something about the environment, when in reality they're just moving the pieces on the board to try to catch tax breaks themselves. The money would just go to the general fund and we all know there will be no accountability. This is just another attempt by government to dream up new ways to drain money from the public for unrestricted government spending.
3	this would make it hard on people who do not run as much as people always on the go, a lot unnecessary going. take me for instance, when I worked I did errands on the way home. could not afford vacations. I also worked 2 jobs. one as a substitute teachers aide and the other in an after school program. cannot work anymore, get 840.00 a month to live on. I go to doctor appointments, grocery store. other shopping 3 to 4 times a year. etc sounds like a sob story but this is facts 40 cents per gallon is crazy. Who will b e able to afford this. Makje cars that work to take care of probkem.do not pass o t on to the poor world We need an infrastructure that works. I shouldn't penalize because of the fact my govt. can't or won't get its act together.
4	If you are low income you may not owe any tax and may not be able to offset the tax. In the first question the tax cut would be very short lived and the Congress would later re-raise it like all the other broken promises. Then we would have two large taxes. As far as the second question goes the carbon emissions aren't nearly as bad as the left wing nuts claim it is and is very overblown. It would really hurt the poor and the middle class. Because by lowering individual income tax it will only benefit the wealthy and hurt the middle class.
5	Contrary to what we have been told, there is absolutely no evidence of global warming. All predictions over the years have been proven to be false. […] There is no global warming. It is a hoax for the richer nations to give to the poorer nations. 20,000 yrs ago in ice core samples the CO2 levels were massively higher. Brain dead liberals are pushing a narrative to other brain dead liberals. Read some history man! Stop listening to your brain dead college professor. When the whole, global cooling-warming-don't know what it's doing, started in the 60′s we should be, right now in an ice age. What happened geniuses'? Oh, I'm not a lemming! Forgive me. The whole dialogue surrounding the dangers of carbon dioxide in the atmosphere are wholly formed for the purposes of justifying additional taxation and formulating new angles for the control of all peoples of the world. The true focus of the 'environmental issues leaders' is to dominate all of mankind and build a global dictatorship[…]
6	This proposal is punishing consumers for the actions of a few corporations. Those corporations should be held responsible directly. Also, compared to other sources such as agriculture and energy production, the pollution from vehicles is tiny. because legislation is biased towards gasoline industry funding should be shifted to support alternative energy and less incentives for automotive industry to continue business as usual The financial burden should not be on the consumer but on the production end. All fossil fuels that pollute should be phased out as soon a possible, and alternative renewable sources be funded privately but incentivized publicly.
7	Many people don't have the option of public transportation. Improvement in public transit would lead to less driving. Also, our passenger train system is sorely lacking. It is unfair because this is merely being used by the Left (ie socialism) to punish individuals for using a private vehicle even though there is no definitive proof that private vehicles contribute proportionally to environmental damage. Also, nothing is said about HOW these funds would be used. There is no "fix" these funds could be used towards. It could be that these monies could merely be spent at the whim of the bureaucrats. This, alone, is unfair. Government never considers how country folk have to drive. Imagine applying the grocery/food dessert rules to people who live in the rural areas. We must drive to everything we do. Stop passing laws for the city folk. We don't have buses, taxis, trains, etc.

as shopping areas or hospitals, is not easily available. The responses reflected that people must currently have a car to fulfill their needs for food and healthcare, as well as that people need to drive to work or need a car for work. The following reply, reproduced with its original errors, is representative of this topic:

> "this would make it hard on people who do not run as much as people always on the go, a lot unnecessary going. take me for instance, when I worked I did errands on the way home. could not afford vacations. I also worked 2 jobs. one as a substitute teachers aide and the other in an after school program. cannot work anymore, get 840.00 a month to live on. I go to doctor appointments, grocery store. other shopping 3 to 4 times a year. etc etc sounds like a sob story but this is facts"

The correlation analysis of the topics showed that Topic 3 "need to drive" is related to Topic 7 "Unfair to rural population", based on the words the respondents used in their replies (see Fig. 4). Responses in Topic 7 revolved around a similar "need to drive" but with a specific emphasis that people who live in the countryside lack access to alternatives, e.g., public transportations and will thus be most negatively affected since they have no choice but to use private vehicles:

> "Government never considers how country folk have to drive. Imagine applying the grocery/food dessert rules to people who live in the rural areas. We must drive to everything we do. Stop passing laws for the city folk. We don't have buses, taxis, trains, etc."

Fourteen per cent of issues brought up in the replies relates to the topic of *equality*, highlighting that CO_2 taxes are unfair to the poor or middle class but will benefit the rich. A representative reply in this theme is the following: "Because by lowering individual income tax it will only benefit the wealthy and hurt the middle class." Several replies explained that even a compensation scheme that could cover the cost of the CO_2 tax would be unfair to the poor because people with low income already have various tax deductions and will not be able to get the carbon tax back: "If you are low income you may not owe any tax and may not be able to offset the tax." Some replies in this topic also highlighted that the proposal was unfair to those who could not afford buying hybrid/electric vehicles.

Ten per cent of unfairness concerns related to the opinion that polluting corporations should be taxed rather than regular citizens, because they emit a larger share of CO_2 than private car owners. The replies also implied that it is automobile industry that should pay for producing fossil fuel-based cars rather than consumers of these cars. These replies rather speak to the *equity* or a polluter-pays principle, which states that those who emit most should pay:

> "This proposal is punishing consumers for the actions of a few corporations. Those corporations should be held responsible directly. Also, compared to other sources such as agriculture and energy production, the pollution from vehicles is tiny."

In addition, twelve per cent of unfairness concerns related to the sentiment that the whole *purpose* of carbon tax was not justified. The majority of these responses belong to climate change deniers or skeptics who do not agree with and do not accept the idea of climate change, and therefore disapprove of the tax:

> "Contrary to what we have been told, there is absolutely no evidence of global warming. All predictions over the years have been proven to be false. […]"

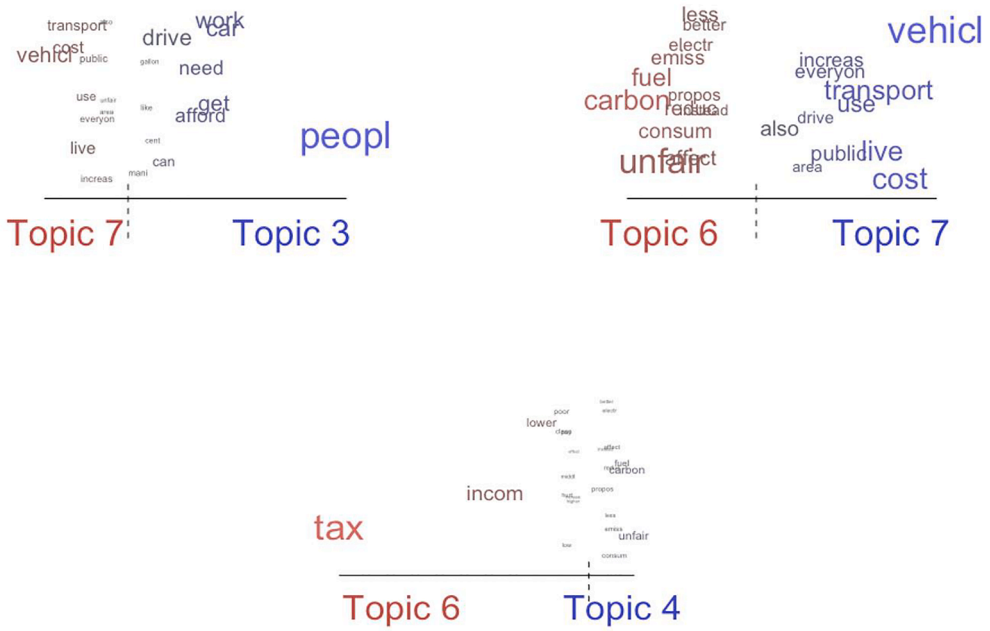

Fig. B1. Similarity of words between topics. *Size of the words corresponds to their frequency in responses.*

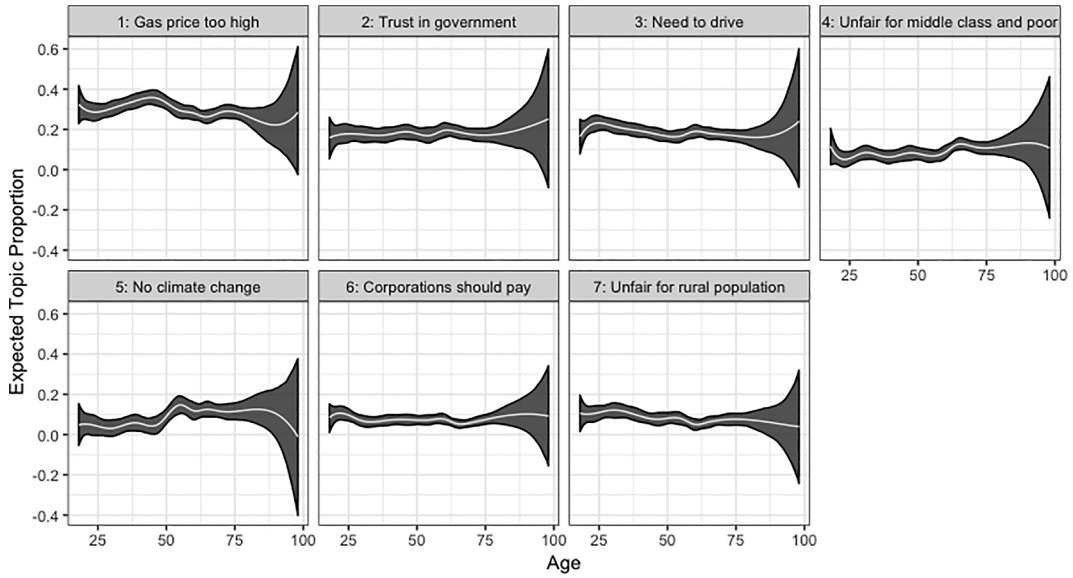

Fig. C1. Topic proportions by age with 95% confidence intervals.

There were also several responses in this theme, which signaled a lack of belief that a consumer tax can solve such large-scale problem as climate change, especially if compensated, which relates to the *utility* principle of fairness. These responses can also relate to the idea that the very purpose of the tax is not justified:

> "One volcano eruption outweighs 10 years of all automobile pollution ! Tax the volcano's [sic] before the automobile owners. Then we can talk!"

4.1. Topics by vignette

We further investigated whether the topics that people raised were influenced by the vignette people were assigned to. Vignettes 1 and 2 contain the proposal of the carbon tax without a compensation condition (see Data section). Vignettes 3–6 add a proposal of a compensation for the tax. More specifically, vignettes 3 and 4 suggest an equal compensation to all taxpayers, while vignettes 5 and 6 suggest individual compensation equal to the amount of tax an individual pays.

Figs. 5–7 show the difference in topic prevalence across the vignettes and reveal some clear trends. Fig. 5 shows that respondents who got a vignette suggesting a 10-cent tax rise tend to mention lack of trust in the government as a reason for why they consider the policy unfair more often than those who received a suggestion of the 40-cent raise, regardless of whether they were exposed to a compensation condition or not. This is an interesting trend that might indicate that people get more suspicious of government proposals to increase taxes when the increase is relatively small and therefore harder to trace or assign meaning to. Although the differences in this topic prevalence between the vignettes are not significant, the patterns appear consistent and clear, and deserve

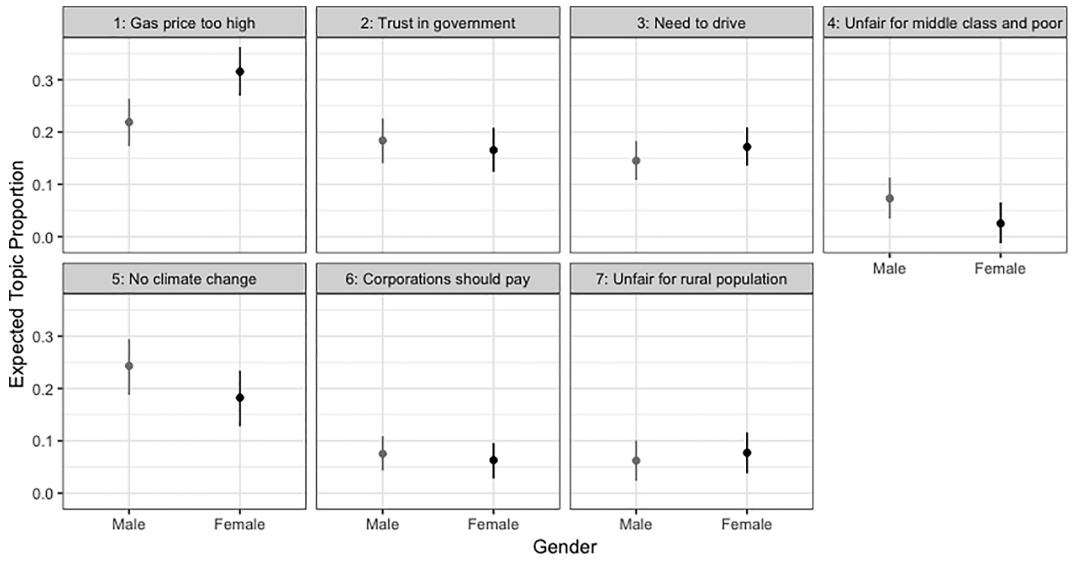

Fig. C2. Topic proportions by gender with 95% confidence intervals.

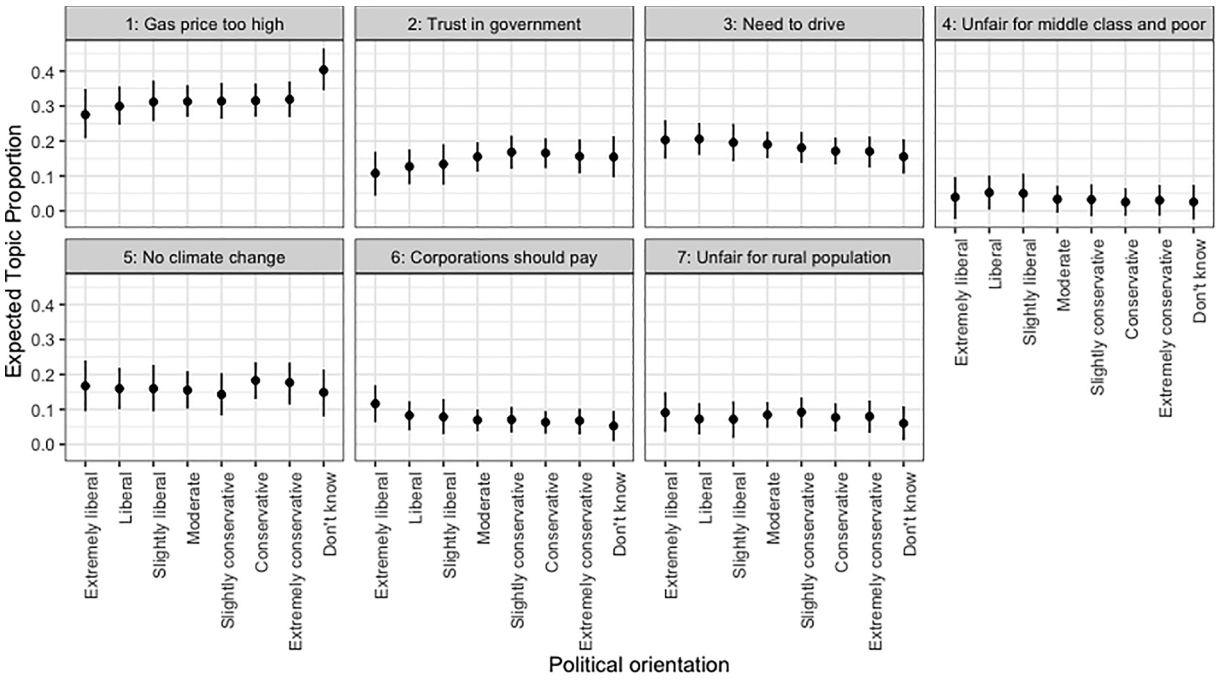

Fig. C3. Topic proportions by political orientation with 95% confidence intervals.

a closer attention in future research.

Figs. 6 and 7 show that respondents who received a suggestion of equal compensation to all taxpayers or did not receive a compensation suggestion mentioned the need to drive as the reason for unfairness more often than the respondents who received a suggestion of individual compensation equal to the paid tax. Similarly, Fig. 7 shows that people were significantly more likely to mention high gas prices as a reason for unfairness if they were not offered a compensation, in particular, individual compensation. This suggests that the individual compensation schemes might indeed have a potential to address some of the fairness concerns related to the individual need to drive and ability to pay. This potential of the compensation schemes, however, needs to be further studied before we can confirm this conclusion with certainty.

Another pattern that comes clear from Fig. 7 is that Topic 4 "Unfair for middle class and poor" is significantly less popular in replies by respondents who received vignettes without compensation schemes (or more popular in replies by respondents who received vignettes with compensation schemes). Careful investigation of the open-ended responses showed that respondents who received compensation vignettes were more prompted to mention the already existing tax reduction programs for the poor than respondents who received vignettes without compensation. More specifically, the replies indicated that due to the fact that individuals with low or no income already have low or no taxes, they will not benefit from the offered compensation scheme. This is noteworthy, as it indicates that respondents do not seem to consider middle class and the poor to be the most affected group but that the compensation is not devised in an optimal way to benefit the poor with the current compensation schemes in place.

Overall, using informational vignettes has proven to trigger a broader range of reactions; however, not much broader. The distribution

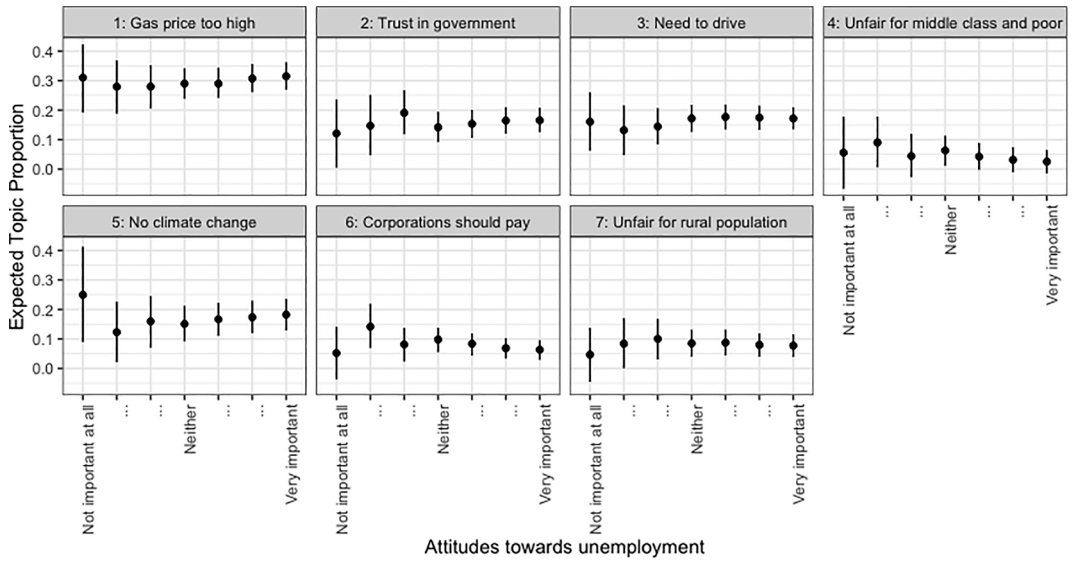

Fig. C4. Topic proportions by attitudes towards unemployment with 95% confidence intervals.

of topics across the vignettes shows that people were likely to bring up the detected aspects of fairness regardless of the vignette. The analysis of topics by vignette though hinted at the potential of tax price levels and compensation schemes mentioned in different vignettes to address some of the fairness concerns. This potential, however, needs to be further investigated in the future research.

4.2. Topics by socio-demographic factors

We also explore whether various socio-demographic factors influenced the topic prevalence among the respondents. Specifically, we investigate how the topic prevalence varies by age, gender, education, political orientation, and the attitudes towards unemployment. Although we find some variation, the differences between people of different age groups, gender, political orientation, and attitudes towards unemployment are rather minor. We did, however, find some interesting variation among people of different educational backgrounds. Fig. 8 presents the results and shows that people with higher education are less likely to mention already high gas prices as a reason for why they consider the suggested carbon tax to be unfair. People with higher education also tend to mention more than others that they consider the policy unfair for the middle class, the poor, and the rural population. More often than the rest, more educated respondents also emphasized that corporations should pay carbon taxes instead of consumers.

The figures plotting topic prevalence by other socio-demographic factors are included in Appendix C.

5. Discussion and conclusions

The reasons why people perceive carbon tax based on gas pricing to be unfair are diverse and range from arguments connected to theoretically established and expected fairness principles, such as need, equality, and equity, to quite different explanations, such as lack of trust in government and whether the purpose of the tax is justified. Thus, our findings add to the conclusions of previous studies attempting to reach a more specific understanding of the varying meaning of fairness through both qualitative and quantitative approaches. In line with, e.g., Savin et al. (2020) and Levi (2021), we conclude that statements of policy fairness are much more varied than is accounted for in studies only focusing on the fairness-policy acceptability link. This, in turn, suggests that there is likely no one policy instrument that will resolve *all* the public's objections to carbon tax related to fairness. For example, this questions the strife for fee-and-dividend systems as the panacea for alleviating negative public opinions over a carbon tax.

Rather, different perceptions of the reasons behind unfairness should also have different implications for policy design. For example, to address people's concerns regarding gas prices already being too high, alternative policy designs might combine the tax with a parallel subsidy for green fuels or alternative vehicles. To address people's lack of trust in government, on the other hand, a special emphasis on increasing transparency in how the government handles the tax and its revenues might be of greater importance. Finally, to appease the groups who find the tax unfair due to the uneven income effects, possible policy remedies include matching the tax with a relevant compensation scheme, for example, a fee-and-dividend system such as the one recently implemented in Canada. An alternative solution could be to combine the introduction of the tax with urban planning schemes and infrastructure investments reducing the need to drive. In Table 2, we link the reasons for unfairness found through our analyses with different fairness principles and provide some, although not conclusive, examples of possible implications for policy design.

Future research should conduct larger surveys enabling even more thorough disentangling of the motives behind peoples' fairness-related objections to carbon dioxide taxes. Furthermore, to become even more policy relevant, these studies should be conducted in different contexts in order to broaden the picture. For example, it is likely that public opinion will differ between countries with varying political systems and with different political cultures and also between countries with higher or lower trust in government and administrative systems. When it comes to objections related to distributional fairness more specifically, it is also likely that important differences exist between wealthy and less wealthy countries, as well as between countries that are currently large emitters and that have not yet reached high levels of emissions or have actively tried to limit their CO_2 emissions in more recent years. It is also possible that the public opinion about the introduction of a carbon tax will depend on the very design of the tax, such as the level of the tax, whether the tax is sudden or gradually implemented, and whether the use of the tax revenues is specified in advance. These more design-related matters invite for experimentally oriented studies, for example, conjoint or other choice-base experimental designs.

CRediT authorship contribution statement

Marina Povitkina: Conceptualization, Methodology, Formal analysis, Investigation, Visualization, Writing - original draft, Writing - review & editing. **Sverker Carlsson Jagers:** Conceptualization, Writing -

original draft, Writing - review & editing. **Simon Matti:** Conceptualization, Writing - original draft, Writing - review & editing. **Johan Martinsson:** Conceptualization, Investigation, Resources, Writing - review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendices

In the appendices we present the list the high-probability replies (A), do a correlation analysis between the topics (B), and perform an analysis of topic prevalence by socio-demographic factors (C).

Appendix A

Analysis of topic prevalence

Appendix B

Correlation between topics

Fig. 2 in the main analysis revealed that there is a correlation between Topics 3 "Need to drive" and 7 "Unfair for the rural population", a correlation between Topics 6 "Corporations should pay" and 7, as well as a correlation between Topics 6 and 4 "Unfair on middle class and poor". Fig. B.1 shows the nature of the correlations by plotting the common words within these pairs of topics. The further away the words are from the centerline, the more exclusive they are to the topic they were assigned to by the software. Although the correlated topics could be combined, having more topics allows us to obtain a more nuanced picture on the sources of unfairness.

Appendix C

Analysis of topic prevalence by socio-demographic factors

This appendix presents the analysis of topic prevalence by various socio-demographic factors, including age, gender, political orientation, and attitudes towards unemployment, Figs. C.1-C.4 respectively. Overall, the analysis did not reveal substantial differences between different population groups. Fig. C.1. shows that topic 'Gas price too high' is slightly more prevalent among ages between 30 and 50 than others, which is expected, as there are more people who drive cars in this age groups compared to others. Topic 'Need to drive' is slightly more prevalent amount the youth below 30 than among other age groups; however, the differences are very small. Topic 'No climate change' is substantially more prevalent among people over 50 years old, which is in line with studies on climate denialism.

Fig. C.2 shows that the differences in topic prevalence between genders are also not dramatic. Women mention that the price is too high significantly more often than men, they tend to mention that the tax proposal is unfair for the middle class and poor slightly less and they are also less prevalent among the climate change deniers.

Fig. C.3. shows that there are no substantial differences in the topic prevalence among people who place themselves on the liberal-conservative scale. There are, however, slight trends in the expected directions: people who consider themselves more conservative tend to bring up 'Trust in government' and 'No climate change' topics more often, while people who consider themselves more liberal tend to bring up 'Corporations should pay' topic more often. Notably, people who could not place themselves on the liberal-conservative scale commented on gas prices already being too high more often than others. This could indicate that either people who brought up 'Gas price too high' topic were either in rush and both did not want to elaborate on fairness in the open-ended response and did not think through their political orientation, or they are apolitical, which might also explain the response that is the least politically charged compared to the rest of the topics.

Fig. C.4 shows the expected topic proportions among people with different attitudes towards unemployment, ranging from unemployment issues not being important at all (left) to very important (right). There are some trends in responses; however, differences between different population groups are difficult to compare given that less than 2% of respondents replied that unemployment issues are not important to them, which is represented by large error bars. Interestingly, topic 'Corporations should pay' was somewhat more prevalent among people who did not consider unemployment as an important issue compared to the rest.

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