Public Acceptability of Climate Change Mitigation Policies: Discrete Choice Experiments in Three European Countries

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Abstract

Our study examines public acceptability of the EU's future mitigation policies. Using the discrete choice experiment, we elicit the preferences of about 4,098 respondents from the Czech Republic, Poland, and the United Kingdom for the GHG emission reduction policies that differ in four attributes: emission reduction target, burden sharing across the EU Member States, the distribution of costs within each country, and cost. The three specific reduction targets we analysed correspond to the EU 2050 Roadmap and deep decarbonisation policy (80% target), the climate-energy 2014 targets (40% target), and the status quo policy (20% target); each will result in a specific emission trajectory by 2050. Our results reveal stark differences between the three countries. Czechs would be on average willing to pay around EUR 13 per household per month for the 40% GHG emission reductions by 2030 or EUR 17 for 80% reductions by 2050, and the citizens of the UK are willing to pay about EUR 45. Conversely, the mean willingness to pay of Polish households for achieving more stringent targets is not statistically different from zero. The willingness to pay for adopting policies to reach the 40% and 80% targets are not statistically different in any of the examined countries. However, we found that the preferences in all three countries are highly heterogeneous. In addition, we provide an insight into the preferred characteristics of the future GHG emission reduction policies.

Policy relevance

A detailed understanding of the acceptability of climate mitigation policies among the general public is crucial for identifying the potential for improvements in their design. Our study examines public acceptability of the EU's future mitigation policies. We elicit preferences of people from three EU countries for three different emission trajectories and reduction targets through policy packages that include several options to share the burden among the EU Member States and to distribute the costs among citizens of each country. We analyse preferences for each attribute and derive the willingness to pay values for several alternative policy packages. We believe that understanding public acceptability can help to successful implementation of climate mitigation policies.

Keywords

discrete choice experiments; climate change mitigation policy; consumer preferences; burden sharing; cost distribution; GHG emission targets

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1. Introduction

The Paris Agreement adopted on December 12, 2015 provides a framework for combating climate change worldwide, with the key objective of limiting the rise in global temperature to below 2°C by 2100. All countries should share responsibility, but in different proportions determined primarily by their historic level of responsibility and their current level of development.

Policies to comply with the Paris Agreement face the challenge of policy infeasibility. Decision-makers are usually reluctant to pursue policies which the public is not willing to endorse or accept. Understanding public acceptability can thus help to overcome a barrier to the successful implementation of policies.

The present study contributes to the recent debate by examining public acceptability of the EU's future mitigation policies yielding future benefits and costs, altogether with several options for burden sharing and cost distribution. Specifically, we elicit preferences and estimate willingness to pay (WTP) of the Czechs, the British, and the Poles for policies to reach three different EU emission reduction targets with no further reductions – 20% by 2020, 40% by 2030, and 80% by 2050 – and several options to share the burden among the EU countries and costs among citizens of each country.

The three GHG emission reduction targets present three different emission trajectories resulting in three different global temperature increases and likely impacts by 2100. More specifically, the status quo policy will result in a 20% reduction in EU emissions by 2020, as already committed to by the European Commission (Decision 406/2009/EC). According to data available at the time of our survey, total EU emissions were 19.8% below 1990 levels in 2013 and projected levels with existing measures were expected to be 24% below 1990 levels by 2020 (EEA, 2015)[1]. In case of the status quo policy, emissions remain in future more- or less as now. The 40% reduction by 2030 (on top of the 20% reduction by 2020) corresponds to the climate-energy integrated 40-27-27 target (EC, 2014) and submitted in March 2015 as the Intended Nationally Determined Contributions (INDC) to the UNFCCC before the

[1] This trend has been later confirmed by more recent estimates, as emissions decreased to 23 % below the 1990 levels in 2014 and the projections until 2020 stayed unchanged (EC, 2015b).

COP21 meeting in Paris (EC, 2015a). The 80% reduction target by 2050 corresponds to the EU's Roadmap for Moving to a Competitive Low-Carbon Economy in 2050 (EC, 2011) and to a pathway to achieve deeper emission cuts by 2050. These two targets require implementation of new policies.

There are several rules to allocate GHG emission reduction effort and related costs. Current EU policy requires the Member States will participate in this effort, balancing considerations of fairness and solidarity (EC 2014, 2016). Its burden sharing relies on a mix of allocation principles; it is based upon the proportionality either linked to verified historical emissions (ETS sectors) or GDP per capita (non ETS), with adjustments to reflect cost-effectiveness in a fair and balanced manner, reflecting the principle of progressivity.

This study uses the discrete choice experiments to provide an insight into the drivers of public acceptability of the EU's future mitigation policies, focusing specifically on preferences for various burden sharing and cost allocation options. Stated preference data from nationally representative samples of the Czech Republic, Poland and the UK are analysed.

Our results reveal stark differences among the three countries when preferences are analysed. The Czech households would be on average willing to pay around EUR 13 for 40% or EUR 17 for 80% GHG emission reductions per month and the UK households would be willing to pay EUR 46 for 40% and EUR 44 for 80% emission reductions. In contrast, the mean WTP of the Polish households for adopting policies delivering greater emission reductions is not statistically different from zero, with a preference for the status quo policy. Still, the preferences in all countries are highly heterogeneous. In each of the three countries, we identify three distinct classes of respondents who are against, modest and strongly in favour of more strict GHG emission reduction targets. In addition, there is a clear general preference for the polluter-pays principle at both national and EU levels, with the exception of Poland.

2. Literature review

In general, public acceptability of policies is influenced by at least two types of factors and their interactions[2]: **individual** characteristics and **characteristics of the policy**. Looking first at **individual characteristics**, social-psychological studies have identified the positive effect of biospheric and pro-environmental values and awareness of the consequences of climate change (e.g. Dietz, Dan, & Shwom, 2007; Leiserowitz, 2006; Poortinga, Spence, Demski, & Pidgeon, 2012; Steg, Dreijerink, & Abrahamse, 2005), personal and social norms (Cools et al., 2011; Harring & Jagers, 2013; Schade & Schlag, 2003), trust (Dietz et al., 2007; Harring & Jagers, 2013; Sælen & Kallbekken, 2011) and actual knowledge about climate change (Dietz, Dan, & Shwom, 2007; O'Connor, Bard, & Fisher, 1999). However, the evidence for the influence of several **socio-demographic characteristics** is not conclusive (Zvěřinová, Ščasný, & Kyselá, 2014).

Turning to the second type of factors, several policy characteristics have been studied as potentially influential. Studies aimed at specific policy instruments, such as permits versus taxes (Bristow et al., 2010) or forestry practices (Layton and Levine, 2003). Ancillary benefits of the climate change mitigation policy which might be quite substantial (Ščasný, Massetti, Melichar, Carrara, 2015) may also play quite a decisive role in respondents' decision making.

Three main categories of policy characteristics can be distinguished as important influences on public acceptability: perceived policy **effectiveness**, **fairness** linked either to distribution of costs or burden-sharing rules, and **use of revenues**. In this study, we further focus on effectiveness and fairness as attributes.

People are more likely to vote or willing to pay more for policies that they **perceive as effective**, i.e. that a policy will achieve its objectives. Overall, the price that people are willing to pay for improved environmental effectiveness is quite high. Dietz and Atkinson (2010) found that people from Southwark, UK, are willing to pay EUR 255 or EUR 548 per

[2] The effects of policy characteristics are interlinked with social-psychological variables mentioned above and hence the individual characteristics of the respondent (Kim, Schmöcker, Fujii, & Noland, 2013).

year (2014 Purchasing Power Standard) for medium and high improvement in national climate-change mitigation. Many people, however, do not know what consequences may be associated with a temperature increase of 2 °C (Reynolds, Bostrom, Read, & Morgan, 2010). One way to deal with this is to specify the effects in the questionnaire. Hence in our questionnaire, we provided information about the effects of climate change if not mitigated and if mitigated as corresponding to the three GHG emission reduction targets and the respective emission trajectories.

Perceived fairness of distribution of policy costs has been identified as another key factor influencing WTP for climate policy (Berrens et al. 2004 and Li et al. 2004; Wiser 2007 and 2003). While equity is based upon external ethical criteria, fairness is based upon the preferences of individuals and groups, and upon the ways in which they perceive themselves in relation to others. The fairest distributions are those in which there is little or no envy among parties (Fishburn and Sarin, 1994).

Four allocation principles to determine claimant's share in decisions can be distinguished according to Young (1994). The leading principle in fairness is proportionality; next include progressivity, parity, and priority. In environmental context, the allocation rule may be linked to the allocation of property rights that include polluter-pay and beneficiary-pays principle (see Dietz and Atkinson, 2010). Concern about regressive impact of a policy may involve introducing measures to mitigate social impact, following the ability-to-pay principle. Since a wide variety of distributive principles can be applied, it is difficult to identify the commonalities and put them to practical use (ibid.). Therefore it is important to know public preferences for the various allocation principles and/or the equity-efficiency trade-off.

The burden sharing rule among countries or regions may follow the same principles as described above. In the vast literature on burden-sharing rules, the most commonly rules are based on historical emissions or historical responsibility, current emissions (polluter-pays principle), carbon intensity, income level (ability to pay), per capita emissions (right to emit), or multi-criteria formulas (Brick & Visser, 2015; Carlsson et al., 2013; Ringius, Torvanger, & Underdal, 2002).

Studies assessing burden sharing at the country-level either analyse and rank implications of the respective burden sharing rules, or discuss rational behaviours in the game theory context

(Cazorla & Toman, 2010; Ringius et al., 2002; Rose, Stevens, Edmonds, & Wise, 1998). In the ranking by economic impact, developed countries are bearing higher costs under the historical polluter-pays and are relatively better off under the carbon intensity approach, and for developing countries historical polluter-pays and equal emissions per capita are the least costly (Brick & Visser, 2015; Miketa & Schrattenholzer, 2006).

Some studies found that citizens prefer the polluter-pays principle (Bechtel & Scheve, 2013; Schleich, Dütschke, Schwirplies, & Ziegler, 2016) and distribution based on ability to pay (Dietz & Atkinson, 2010) and progressive, rather than regressive, taxation (Brännlund & Persson, 2012; Cole & Brännlund, 2009). Bechtel and Scheve (2013) explored preferences for cost distribution within international mitigation agreements and their results suggest a preference for polluter-pays principle between French, German, UK, and US citizens over the principle that only rich countries should pay. That rich countries should pay more than poor, however, had a similar positive effect on willingness to pay, suggesting that the citizens of rich and emission-intensive economies are ready to accept larger shares of the costs. An empirical study conducted among students suggests that domestic distribution and payment vehicles are more important than international cost distribution and burden sharing (Cai, Cameron, & Gerdes, 2010). However, a study of the general public of the United States and China indicates that people can still consider international burden sharing rules and presumably prefer options which impose lower costs on their country (Carlsson et al., 2013).

Neither the study by Carlsson et al. (2013) nor the study by Bechtel and Scheve (2013) include domestic distribution as an attribute therefore it is not possible to evaluate which characteristics are more important for respondents. There is no current study on public acceptability of climate policy that examines the effects of both domestic cost distribution and burden sharing among the EU Member States simultaneously as two distinct attributes in the choice experiments. The present study aims to fill this research gap.

3. The survey and the study design

3.1. *Survey method and data*

Nationally representative samples of population aged 18 to 69 years in the Czech Republic, the United Kingdom and Poland were surveyed in September and October 2015 within the EU funded project CECILIA2050. The three countries were selected based on their different political stances in the European climate policy debate and distinct national contexts for the purpose of comparison.[3]

Data were collected using web-based questionnaires administered either by interviewers personally (CAPI) or by online access panels (CAWI).[4] The combination of the survey modes was chosen in order to alleviate possible generalizability issues caused by lower internet coverage rates in the Czech Republic and Poland (78% and 75% respectively of households in 2014; Eurostat, 2014). Since internet coverage reached 90% of British households in 2014 (*ibid.*), only CAWI questionnaires were distributed in the UK.

Web-based instruments were chosen, as they provide both the possibility for more complicated experimental designs and randomizations. In the self-administered mode some respondents may flip through the questions without properly reading them. Therefore, all cases with the overall time shorter than 48% of median specific for a given CAWI subsample were excluded from the final sample as speeders (see Supplemental online information, further SI Appendix).

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[3] The Czech Republic belongs to the medium-sized EU countries, while population of the UK and Poland is the third, or the sixth, respectively, largest among the 28 EU Member States. The UK economy produces the highest per capita GDP among the three analysed and 10th highest among the EU28. Czech and Polish economies are less productive, with per capita GDP ranked at 15th and 23rd. Poland and the Czech Republic belong to carbon-intensive economies, having third and fourth highest volume of GHG emissions per GDP (1.0 and 0.8 Mg per one billion EUR GDP). On the other hand, the UK economy belongs to one of the least carbon intensive countries with only 0.3 Mg GHG per billion euros, which is the sixth best performance in the EU28.

[4] CAWI and CAPI data yield the same results in the Czech Republic, however, two different survey modes result in differences in Poland (see SI Appendix). We highlight that due to our sampling strategy, the two sub-samples were not constructed in a way to allow analysing data separately.

In total, the interview was conducted with almost 5,500 respondents, including 680 respondents interviewed in the last pilot round. After excluding speeders from the CAWI sample and deleting the pilot data, the cleaned sample includes in total 4,098 valid observations (see Table 1).

< Table 1 around here >

The country subsamples are representative of national populations aged 18 to 69 years in terms of gender, age, region and education. The percentages in all categories are not statistically different from the quota set based on national statistics. Median household monthly income for the country samples correspond to national statistics as reported by Eurostat (see SI Appendix, Table S1).

3.2. *The instrument*

The questionnaire was tested and developed throughout qualitative pre-survey and several pilot rounds. The elaborated version was tested on a representative sample of the Czech adult population (N=727) by CAWI mode in September 2014. The last pilot round was carried out in summer 2015 in all of the surveyed countries (N=680).

The questionnaire is provided in Supplemental online material. It consisted of screening questions, two discrete choice experiments, several social-psychological constructs, respondents' environmentally significant behaviours and socio-demographic characteristics. Discrete choice experiments were accompanied by questions on perception of policy characteristics included in the experiments. Respondents could familiarize themselves with these characteristics before committing a decisive response in the choice experiments. While the first choice experiment is described and analysed in this paper, the second choice experiment targeted perceived effectiveness of the policy instruments and preferences for revenue use with the 80% reduction target set (not analysed here).

3.3. *The discrete choice experiment*

In order to explore public preferences for climate policies and their characteristics, we designed a choice experiment containing four attributes. The first three attributes described the policy: emissions reduction target for the European Union (20% by 2020, 40% by 2040, 80% by 2050), distribution of costs among the European Union countries, and cost distribution among the citizens of the given country, see the design in Table 2, and an example of the choice card in Figure 1.

< Table 2 around here >

< Figure 1 around here >

The three GHG emission reduction targets present three different emission trajectories and they correspond to the EU's Roadmap (by 80% by 2050), to the EU's 2014 integrated 40-27-27 targets (by 40% by 2030).[5] The status quo situation represents the current policy mix most certainly leading to 20% reduction by 2020 with both allocation rules based upon proportionality principle linked to wealth (GDP), or household income, respectively.

We informed our respondents that after achieving the two less stringent targets, emission volumes will remain stable or may even slightly increase at least until 2050. It implies that each stricter target includes all less stringent targets that are presented in our design. As a consequence of these emission trajectories, by 2100 global average temperature would increase much more due to the 20% mitigation policy than due to the 80% reduction policy, and would result in severe, moderate, or mild impacts, respectively (see Figure 2). In line with scientific knowledge, both the average temperature increase and the impacts are presented as uncertain, providing the temperature interval and a notion of likeliness.

< Figure 2 around here >

[5] Recall that preferences were elicited under the assumption that non-European countries 'comply equivalently'.

The remaining attribute was the increased monthly costs to the respondent's household, which allows us to estimate the WTP for each level of the policy attributes.[6] It was explained to respondents that introducing fees for polluting technology and supporting new (lower emission) technologies development would have to be financed mainly by businesses. These higher costs would be reflected in the prices of consumer goods. Therefore, all households would have less money for purchasing of other goods. The costs for a household varied between EUR 20 and EUR 150 a month and the nominal values were recalculated into national currencies using purchasing power standard. Both attributes and their levels were chosen based on the results of the literature review and the qualitative pre-survey.

In each choice situation, respondents were presented with three options, namely two proposed new policy options and a status quo option, that is, the continuation of the already implemented policies that will reach the 20% reduction target by 2020, but that will not reach the stricter target in later years.

The experimental design of our study consisted of 72 choice-tasks, blocked into twelve questionnaire versions with six choice tasks per respondent. The order of choice tasks in each version was randomized for each respondent, to mitigate potential anchoring or framing effects. The design was optimized for D-efficiency (Ferrini and Scarpa, 2007) of the multinomial logit model using Bayesian priors (Scarpa and Rose, 2008).

[6] Costs for a household are correlated with certain cost allocation rule, for instance, the proportional allocation linked to income will increase relative burden of a rich household, whereas lump sum allocation will be more penalizing poor. We therefore examined whether the respondents connect the own costs with some cost distribution rule in order to ensure that the attributes are uncorrelated. By interacting income with attributes, we find that deviations from mean income in the sample do not seem to significantly change the means of the parameter of cost distributions (the results are provided in SI Annex).

4. Modelling preference for climate change mitigation policies

4.1. Econometric model

In what follows we infer respondents' preferences and WTP for changes in the EU climate policy from the choices they made in the discrete choice experiments (Carson and Czajkowski, 2014). The state-of-practice in modelling consumers' preferences using discrete choice data is the mixed logit (MXL) model in which respondent *i*'s utility associated with choosing alternative *j* out of the *J* available alternatives in choice task *t* can be expressed as:

$$V_{ijt} = \mathbf{X}_{ijt}\mathbf{b}_i + p_{ijt}a_i + e_{ijt} \,, \tag{1}$$

where $\mathbf{X}$ represents a vector of alternative-specific attributes, p is an additively separable cost, and vector $\mathbf{b}$ and α are coefficients. Note that the coefficients are indexed by respondents – in the MXL model respondents' coefficients can differ and are assumed to follow an *a priori* specified multivariate parametric distribution.

Assuming the stochastic component *e* to be identically and independently, extreme value type 1 distributed leads to convenient expression of choice probabilities – an individual will choose alternative j if $V_{ijt} > V_{ikt}$ for all k and j, and the probability that alternative j is chosen from a set of J alternatives becomes

$$P\left(j|J\right) = \frac{\exp\left(\boldsymbol{X}_{ijt}\left(\sigma_i\mathbf{b}_i\right) + p_{ijt}\left(\sigma_i a_i\right)\right)}{\sum_{k=1}^{J}\exp\left(\boldsymbol{X}_{ikt}\left(\sigma_i\mathbf{b}_i\right) + p_{ikt}\left(\sigma_i a_i\right)\right)} \tag{2}$$

Given that we wish to estimate WTP for non-monetary attributes $\mathbf{X}$, it is convenient to introduce a modification which is equivalent to using a money-metric utility function (estimating preference parameters in WTP space, Train and Weeks, 2005):

$$U_{ijt} = \sigma_i a_i \left(\boldsymbol{X}_{ijt} \frac{\sigma_i \mathbf{b}_i}{\sigma_i a_i} + p_{ijt} \right) + \varepsilon_{ijt} = \sigma_i a_i \left(\boldsymbol{X}_{ijt} \boldsymbol{\beta}_i + p_{ijt} \right) + \varepsilon_{ijt} \,. \tag{3}$$

In this specification, the estimates obtained by a researcher are a product of the scale and marginal utility of income $\sigma_i a_i$ and the scale-free coefficients $\boldsymbol{\beta}_i$ corresponding to each of the choice attributes $\mathbf{X}$, which can be readily interpreted as respondents' marginal WTP for non-monetary attributes.

In the MXL models, all attribute coefficients are random and freely correlated; all coefficients are assumed to be normally distributed, with the exception of the coefficient representing the marginal utility of income $\sigma_i a_i$, which is assumed to follow lognormal distribution to constrain its sign. For the lognormally distributed coefficient, the estimated mean and standard deviation of the underlying normal distribution is reported. The cost enters the model with a negative sign and was scaled by a factor of 100 to facilitate convergence. Because the coefficients are assumed random variables following the specified probability distributions, the model is typically estimated using the maximum simulated likelihood method (Revelt and Train, 1998).

We estimate further a latent class (LC) model that tackles preference heterogeneity in a different way than MXL. LC model assumes that individuals who belong to the same class share the same preferences, whereas preferences between classes can considerably vary. These classes are latent and membership to any given class may be defined as a function of the respondent's characteristics. This approach might be here of particular interest, since some respondents may have strong preference and hence larger WTP for stringent emission reductions, while others could perceive them as not acceptable.

4.2. Marginal WTP for policy attributes

The discrete choice experiment data was used to model respondents' preferences using the approach outlined just above.[7] Table 3 presents the results of the MXL models for each of the countries. The models are estimated in WTP space and hence the coefficients of the non-monetary attributes can readily be interpreted as marginal WTP.[8] All WTP values are expressed in nominal 2014 EUR.

< Table 3 about here >

The results reveal stark differences between the countries. With respect to the preferences for more ambitious targets of the EU climate policies, while the Czech households would be on average willing to pay around EUR 13 each month for achieving 40% GHG emission reductions by 2030 with no further reductions or EUR 17 for 80% reductions by 2050, and the UK households would be willing to pay EUR 46 and EUR 44, respectively, the Polish households' mean WTP for adopting these targets vs. the current policy was not statistically different from zero. The mean WTP for adopting 40% and 80% targets are not statistically different from one another in any of the examined countries, indicating the utility change from adopting the 80% reduction vs. the 40% reduction is negligible. In line with these results, the citizens of the Czech Republic and the UK are generally supportive of the prospected climate policy, while the Poles prefer the status quo policy to any new policy option. However, the preferences in all countries are highly heterogeneous, as indicated by the estimates of the standard deviations of the WTP distributions relative to the means of these distributions.

Regarding the preferences for burden sharing rules among the EU countries, households from the Czech Republic and the UK significantly prefer the distribution of policy costs based on

[7] We examined whether results are affected by excluding respondents who protested against the contingent scenario, or who always chose stringent reduction targets but did not consider their costs. We found only a minor effect on WTP, thus we do not exclude neither group of respondents from the main analysis. These results are reported in SI Annex.

[8] The models were estimated using custom code developed in Matlab which is made available from github.com/czaj/DCE under Creative Commons by 4.0 license. The maximum likelihood function was simulated using 10,000 Sobol draws (Czajkowski and Budziński, 2015), using different starting points and optimization techniques, to make sure it reached the global optimum.

the GHG emissions of the EU countries to linear to wealth or per-capita based rules, for which they are statistically indifferent. The mean WTP for the burden sharing linked to GHG emission volumes is EUR 15 (s.d. EUR 22.1), and EUR 27 (s.d. EUR 47.4), respectively. In contrast, Polish households are not so eager to implement emission based burden sharing among countries – they are, on average, indifferent concerning different burden sharing rules.

Finally, with respect to the distribution of policy costs within a country, respondents from all surveyed countries are in favour of implementing the polluter-pays principle, i.e. cost distribution based on emissions, and disapprove of even lump sum distribution of the costs (per person). The estimated mean WTP for the most preferred option of this attribute is EUR 33 in the UK, EUR 21 in the Czech Republic, and EUR 13 in Poland. In the UK, progressive cost distribution (the richer should pay more) was preferred to the distribution proportional to income. However, the emission based option remained the best. Once again, the preferences for these attributes are highly heterogeneous, as indicated by the significant and relatively high estimates of the standard deviations of WTP distributions.

4.3. Total WTP for policy packages

Figure 4 reports the WTP simulation results using the parameter estimates obtained from the MXL model with correlated attributes levels.[9] The WTP values for 'a policy package' are simulated for overall eight different combinations of burden sharing and cost distribution for both 40% and 80% GHG mitigation policies.

At first, we found that the WTP values are very similar for 40% and 80% reduction targets for the same policy package in each country. The British households are willing to pay the most, followed by Czech households. The estimated mean WTP of the Polish households is negative for each policy package departing from the status quo, although the 95% confidence interval covers positive values for each package with costs proportional to their emission volumes.

The order of the eight policy packages is very similar in each of the three countries, with the policies that link the cost distribution to GHG emission volumes considered the best. The British and the Czech households similarly prefer the policy package that links burden sharing as well as cost distribution to emission volumes ("EU GHG-MS GHG"), and the estimated mean WTP per household is EUR 145 and EUR 62 respectively. The second most preferred policy package varies across the three countries. The British households prefer the "EU GHG-MS rich" package, followed by packages that either link cost distribution to emissions or progressively to household income. As the second most preferred, Czech households prefer a package that consists of some linking to emission volumes ("EU GHG-MS rich", "EU linear-MS GHG", or "EU person-MS GHG"), followed by policies based upon cost progressively linked to income. Polish households' WTP for the "EU GDP-MS GHG" package is similar to that of Czech and UK households. The least preferred package in all cases is the package that is based upon proportionality principle linked to the size of a country or a family, respectively ("EU person-MS_ person").

[9] SI Annex reports the WTP estimates using the parameter estimates from multinomial logit and mixed logit without correlated attributes.

4.4. WTP across segments

Most people are generally in favour of the emission reductions (65% of the Czechs, 58% of the Poles and 55% of the British are in favour of the 40% reduction target; see Figure S1 in SI Annex). As found in the MXL models, WTP for the stringent reductions varies considerably. This heterogeneity is also confirmed by the LC models. In each country, we identified three different classes that we may call *'against'*, *'modest'*, and *'green'*.

Respondents who are *'against'* strongly prefer the status quo policy and have negative or zero marginal WTP for stringent reductions. *'Modest'* are respondents who support stringent policies by modest WTP, but also have negative WTP for the status quo option. And *'green'* are willing to pay the largest amounts for the stringent reduction targets and have disutility from the status. While there are 44% and 39% *'green'* supporters in the UK and in the Czech Republic, respectively, there are only 25% respondents in '*green'* class in Poland, where *'against'* with 45% is the dominant class. Respondents in *'green'* class strongly prefer the proportional principle of distribution linked to emission volumes, but they dislike the lump sum cost allocation (see SI Annex for details).

< Table 4 about here >

Less educated respondents are more likely in '*against'* class in each country, although the effect of education is not consistent across various levels of education. The Czech males and older are more likely belong to class *'against'*. Males are also more likely to be members of *'green'* in the Czech Republic and in the UK, indicating that females are more likely to be *'modest'*. The Poles with lower education are more likely to be among *'greens'*, while respondents who completed a vocational school in the Czech Republic, or bachelor degree in the UK are less likely to be *'green'*. Effects of income, household size, or number of children in household are not significant.

If respondents think that it is very unlikely that other countries in the world will reduce their emissions adequately, they are WTP for the SQ option more in each country (EUR 36 in CZ, EUR 54 in UK, and EUR 39 in PL; see SI Annex). WTP is also larger for both stringent reductions in the Czech Republic (EUR 7 and EUR 10).

The share of respondents who believe that the stricter emission reduction policies will be implemented is largest among the Poles (23%), compared to the Czech (13%) and British (18%). The believers have a much stronger preference for policies with stricter reductions. WTP of Polish believers for policy package with stringent emission reductions is weakened by negative marginal WTP for 40% and 80% targets. On the contrary, respondents who do not think that stringent mitigation policy will be implemented strongly prefer the status quo hence they are willing to pay much less for the policy package with stringent reduction targets (see SI Annex).

5. Conclusions

Our study examines public acceptability of climate mitigation policy, focusing on various emission reductions and cost distributions. We conducted a questionnaire survey to elicit the preferences of Czechs, Poles and British aged 18 to 69 years for three different policy strategies differing in attained emission reduction targets: 20% reduction reached by 2020 with no further reductions, which reflects the current policy situation, 40% reduction by 2030 (on top of the 20% reduction by 2020) agreed by EU's Council (EC 2014) and submitted as INDC to the COP 21 Agreement, and a more stringent 80% reduction target by 2050 (in addition to the earlier reductions). We note that these three targets actually correspond to three different EU's GHG emission trajectories, and consequently lead to three different increases in global average temperature by 2100 and likely impacts. Preferences for reaching these three GHG reduction targets are elicited through a policy package that proposes several options to share the burden among EU Member States and to distribute the costs among citizens of the examined countries.

Specifically, we estimated the willingness to pay for each attribute of a policy package and also simulated the WTP for the whole policy package using discrete choice experiments and stated preference data. For the most preferred policy package that links burden sharing as well as cost distribution to emission volumes, households would be on average WTP almost EUR 62 a month in the Czech Republic and EUR 145 in the UK. For whole populations, these values can be translated into annual benefits of EUR 0.27 billion and EUR 2.72 billion, respectively for 40% reduction. Lower WTP values in the Czech Republic are understandable given the negative experience of the citizens with previous policy failures (Rais, 2014). It seems that the Poles are indifferent between the status quo (20% reduction) and the two more strict targets, implying that the Poles are not ready to pay for more strict GHG reducing policy, which corresponds to the lower share (55%) of Polish citizens in favour of the 40% reduction target.

The benefits that we estimated can be compared to costs of policies. According to EC (2016), the EU would need to invest a range of 1.5% to 3.5% of annual GDP to reach the 2050 target, the costs might be then around EUR 33-80 per month and household in Poland, EUR 40-110 in the Czech Republic, and EUR 120-280 in the UK. For most of the combinations of more strict policy packages (as reported in Figure 3), benefits exceed a lower bound of the costs in Czech Republic and UK, but benefits are not large enough to balance the costs, if the costs are close to the upper bound estimate or if mitigation policy uses less favoured cost allocation and/or burden sharing rule. The benefits do not exceed the costs in any case in Poland.

Still, how GHG emissions might be reduced is also a concern in Poland as well as in the other two countries. The WTP for climate policy depends on distribution of policy costs both among citizens of the country and among countries of the EU. There is a clear preference for distribution based on emissions in both instances in the UK and the Czech Republic, which lends support to previous conclusions about a preference for polluter-pays principle (Carlsson et al., 2013; S. Dietz & Atkinson, 2010; Schleich et al., 2016). The estimated values for the emission based distribution of costs are comparable to those estimated in previous studies: Carlsson and colleagues report EUR 16 (2014 PPP, survey in 2009) per month for U.S. households for international distribution based on current responsibility for emissions (compared to EUR 15 in the Czech Republic and EUR 27 in the UK reported here).

However, Polish citizens were indifferent between the different principles in the case of distribution among the EU countries, which can be indicative of self-serving bias (Carlsson et al., 2013) given the known high coal and emission intensity of the Polish industry. The preferences for cost distribution options were highly heterogeneous. Although the class of respondents who are 'against' stricter emission reductions is the dominant group in Poland (45%), there are also 25% of 'green' supporters and 29% of 'modest' respondents. The Polish 'green' class shared preference for the cost distribution linked to emission levels with 'green' supporters in other countries. The 'against' classes in Poland and UK were found to be indifferent with respect to the cost allocation rule, as they do not like the mitigation policy at all. Moreover, the 'against' class in Poland didn't care much about any policy attributes and strongly preferred the "current policy".

The reason for different WTP among examined countries might be different political and socioeconomic situation of the examined countries. Even though both Poland and the Czech Republic belong to post-communist countries and carbon-intensive economies (having third and fourth highest volume of GHG emissions per GDP in the EU), the Polish situation differs from the Czech context. Poland is much more dependent on hydrocarbon fuels, mostly coal. Energy security, stability of supply or employment arguments are often used by industry, the power lobby and labour unions to convince the Polish policy-makers to rely their power sector on domestic coal (Bukowski et al., 2015). Indeed, during the negotiations within the EU before COP21 in Paris, both Poland and the Czech Republic called for additional compensatory mechanism and opposed binding renewable and energy efficient target (Joint Statement, 2014), when Poland played a leading role in this opposition. Moreover, Poland declare upon signature of the Paris Agreement to remind that Poland is not obliged to provide financial resources to assist developing country Parties with respect to both mitigation and adaptation.

The Czech government seems to be more in favour of introducing measures to achieve more stringent emission reduction target. The State Energy Policy (2015) has already been expecting gradually decreasing ratio of fossil fuels to primary energy sources, from 77% in 2015 to 56 % in 2040. A new Climate Change Act that reflects the 80% reduction target by 2050 should be presented to the Government by September 2016. United Kingdom was the first EU MS that has approved Climate Change Act in 2008 that has set binding GHG emission reduction targets; 34% by 2020 and 80% by 2050, with a detailed five-year plan to prepare or implement specific measures.

Public acceptability of policies to reach the EU's GHG emission reduction targets may be raised by taking into account distributional consequences, especially introducing distribution of costs based on the people's individual emissions, i.e. implementing the polluter-pays principle (in all three surveyed countries) and of the EU Member States.

Special attention should be paid to the communication of climate change policy design to the Polish public, as the Poles are, contrary to the Czechs and the British, on average not willing to financially contribute to a stricter GHG reduction policy. People prefer the stricter emission targets more, if they believe that the policy is likely to be implemented. This suggests that measures such as providing clear information about the policy roadmap supported by a binding policy commitment may be effective at increasing public support for such policies.

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Tables

Table 1. National samples and identification of speeders

country	mode	N (completed)	% of speeders	**N valid**
Czech Republic	**CAWI**	1,270	9.4%	**1,150**
	CAPI	431	NA	**431**
Poland	**CAWI**	974	14.1%	**837**
	CAPI	429	NA	**429**
United Kingdom	**CAWI**	1,420	11.9%	**1,251**

Note: Here and in the following tables, "N" denotes number of observations.

Table 2. Design of the choice experiment for acceptability of policy instruments

Attribute	Levels
Emissions reduction target for the European Union (increase in global average temperature by 2100)	• **-20%** by 2020 (**+2.6–4.8°C** by 2100) • **-40%** by 2030 (**+1.2–2.8°C** by 2100) • **-80** by 2050 (**+0.7–2.2°C** by 2100)
	Status Quo: 20% reduction by 2020; current policy
Distribution of costs among the European Union countries *(EU)*	• richer states pay more *("GDP")* • states with higher population pay more *("person")* • higher emitting states pay more *("GHG")*
	Status Quo: richer states pay more
Distribution of costs among the citizens of *[member state](MS)*	• everyone pays the same amount *("person")* • everyone pays the same income percentage *("income")* • the rich pay a higher income percentage *("rich")* • those who emit more pay more *("GHG")*
	Status Quo: everyone pays the same amount
Increased monthly costs for your household	€20, €33, €65, €95, €130, €150
	Status Quo: €0

Note: In parentheses, we introduce abbreviations for attributes and levels that we use throughout this paper.

Table 3. The MXL model estimates of consumers' WTP based on the discrete choice experiment data

	Czech Republic		**United Kingdom**		**Poland**	
	means	**standard deviations**	**means**	**standard deviations**	**means**	**standard deviations**
	coefficient (s.e.)	**coefficient** (s.e.)	**coefficient** (s.e.)	**coefficient** (s.e.)	**coefficient** (s.e.)	**coefficient** (s.e.)
target = 20% (ref.)	0	0	0	0	0	0
target = 40%	13.19*** (2.78)	37.05*** (2.75)	45.79*** (6.26)	97.55*** (10.00)	-1.76 (2.53)	31.15*** (2.94)
target = 80%	17.04*** (3.02)	46.77*** (2.89)	43.57*** (8.36)	149.21*** (10.11)	-0.14 (2.57)	32.59*** (1.73)
burden sharing EU = GDP (ref.)	0	0	0	0	0	0
burden sharing EU = person	3.61 (2.56)	25.26*** (3.04)	-8.39 (5.43)	25.85*** (8.07)	-3.08 (2.16)	10.48*** (1.68)
burden sharing EU = GHG	14.98*** (2.56)	22.14*** (2.62)	27.13*** (6.21)	47.36*** (6.70)	-2.49 (2.33)	11.88*** (1.90)
cost distribution MS = income (ref.)	0	0	0	0	0	0
cost distribution MS = person	-12.78*** (2.96)	16.33*** (2.88)	-15.72** (7.49)	41.23*** (7.37)	-6.28** (3.05)	14.75*** (1.59)
cost distribution MS = rich	3.81 (3.09)	33.07*** (3.28)	23.21*** (8.02)	61.75*** (12.15)	4.47 (3.02)	22.23*** (2.32)
cost distribution MS = GHG	20.94*** (3.41)	49.10*** (4.01)	33.17*** (9.12)	81.69*** (8.65)	12.48*** (3.50)	24.31*** (3.17)
status quo (alternative specific constant)	-12.82*** (3.82)	81.80*** (5.44)	-39.07*** (8.82)	161.16*** (16.57)	15.95*** (3.03)	83.65*** (4.83)
-cost(100 EUR)*scale	1.39*** (0.07)	1.33*** (0.17)	0.58*** (0.08)	1.78*** (0.24)	2.02*** (0.16)	2.27*** (0.36)
Model diagnostics						
Log-likelihood (constant only)	-10,064.28		-7,933.06		-6,914.07	
Log-likelihood	-7,711.40		-6,014.17		-5,022.28	
McFadden's pseudo R^2	0.2338		0.2419		0.2736	
Ben-Akiva Lerman's pseudo R^2	0.4746		0.4846		0.5763	
AIC/*N*	1.6373		1.6170		1.3367	
N (observations)	9,486		7,506		7,596	
k (parameters)	54		54		54	

Table 4: Latent Class Model, summary of the results

	CZ			UK			PL		
	against	*modest*	*green*	*against*	*modest*	*green*	*against*	*modest*	*green*
SQ*	308	-24	-128	217	-27	-323	0	-8	-135
target = 40%*	-72	9	58	-32	44	139	0	4	26
target = 80%*	0	11	67	-34	45	215	0	2	24
burden sharing EU	GDP	GHG person	GHG	GHG	indiffer.	GHG	indiffer.	indiffer.	indiffer.
cost distribution MS	rich GHG	GHG person	GHG person	indiffer.	GHG income	GHG rich person	indiffer.	indiffer.	GHG rich person
class probability	33%	28%	39%	38%	18%	44%	45%	29%	25%

*Note: *Mean WTP in Euro; minus in cost distribution rule indicates the least preference for given option.*

Figures

Figure 1. Example of choice card

Policy characteristics	**Policy A**	**Policy B**	**Current policy**
Emissions reduction target for the European Union	**80%** reduction by 2050	**40%** reduction by 2030	**20%** reduction by 2020
Increase in global average temperature by 2100 if the rest of the world complies equivalently	**0.7 °C to 2.2 °C**	**1.2 °C to 2.8 °C**	**2.6 °C to 4.8 °C**
Likely impacts	Mild	Moderate	Severe
Distribution of costs among the European Union countries	states with higher population pay more	higher emitting states pay more	richer states pay more
Distribution of costs among the citizens of **[the UK]**	everyone pays the same income percentage	those who emit more pay more	everyone pays the same income percentage
Increased monthly costs for your household	£130	£130	£0
Which policy do you consider the best taking into account you and your household?	Policy A	Policy B	Current policy

Figure 2. Choice experiments design: Emissions reduction targets for the European Union

	20% reduction by 2020	**40% reduction by 2030**	**80% reduction by 2050**
Amount of greenhouse gas emissions	emissions remain more- or less as now, may slightly increase **(black dotted line)**	-20% by 2020 -40% by 2030 then, remain stable **(orange)**	-20% by 2020 -40% by 2030 -80% by 2050 **(dark red line)**
Policy status	policy that has been agreed at the EU and is currently being implemented	EU commitment, measures not implemented yet	EU commitment, measures not implemented yet
Increase in global average temperature by 2100 relative to 1986-2005 level - if the rest of the world adopts equivalent emission reduction targets	**2.6 ºC** to **4.8 ºC**	**1.2 ºC** to **2.8 ºC**	**0.7 ºC** to **2.2 ºC**
Likely impacts	**Severe** • **large** drop in agricultural production • loss of **most** coastal areas • **substantial threat** to human health caused by disease, malnutrition, heat waves, floods and droughts • **widespread** extinction of animal and plant species, loss of their habitats	**Moderate** • **moderate** drop in agricultural production • loss of **many** coastal areas • **some** threat to human health caused by disease, malnutrition, heat waves, floods and droughts • extinction of **some** animal and plant species and loss of their habitats (especially coral reefs, arctic animals)	**Mild** • **the most severe impacts** of climate change are prevented • some effects of global warming will be felt, however **not as severe** as in the other reduction scenarios

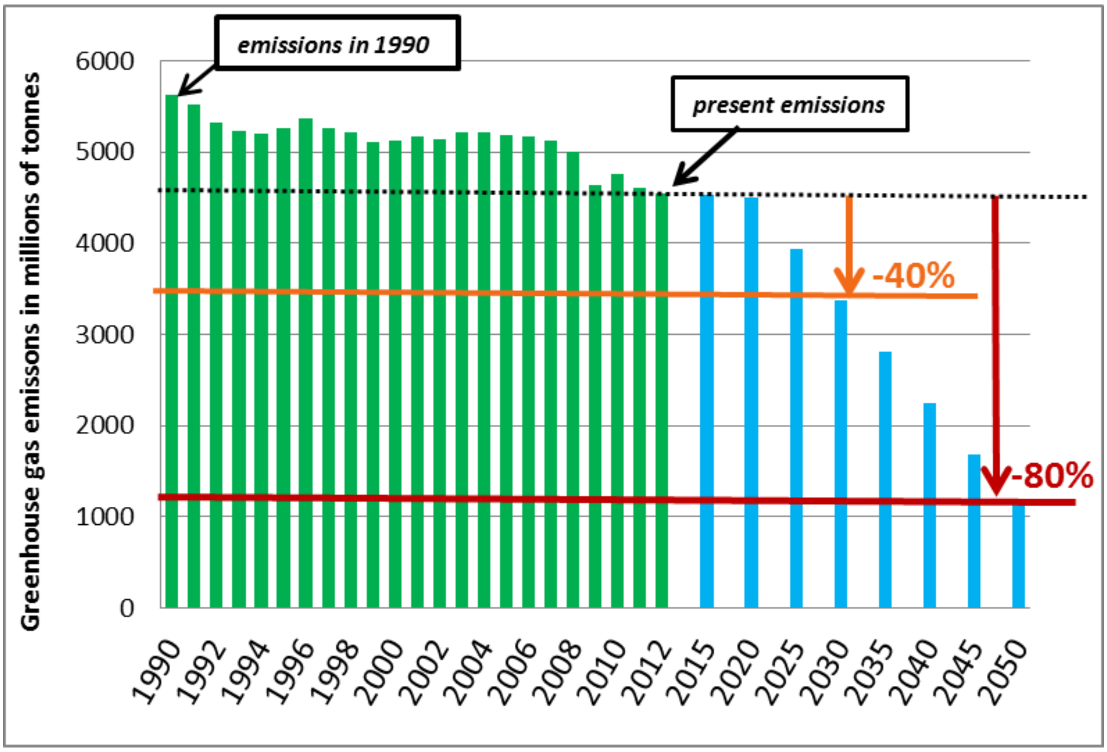
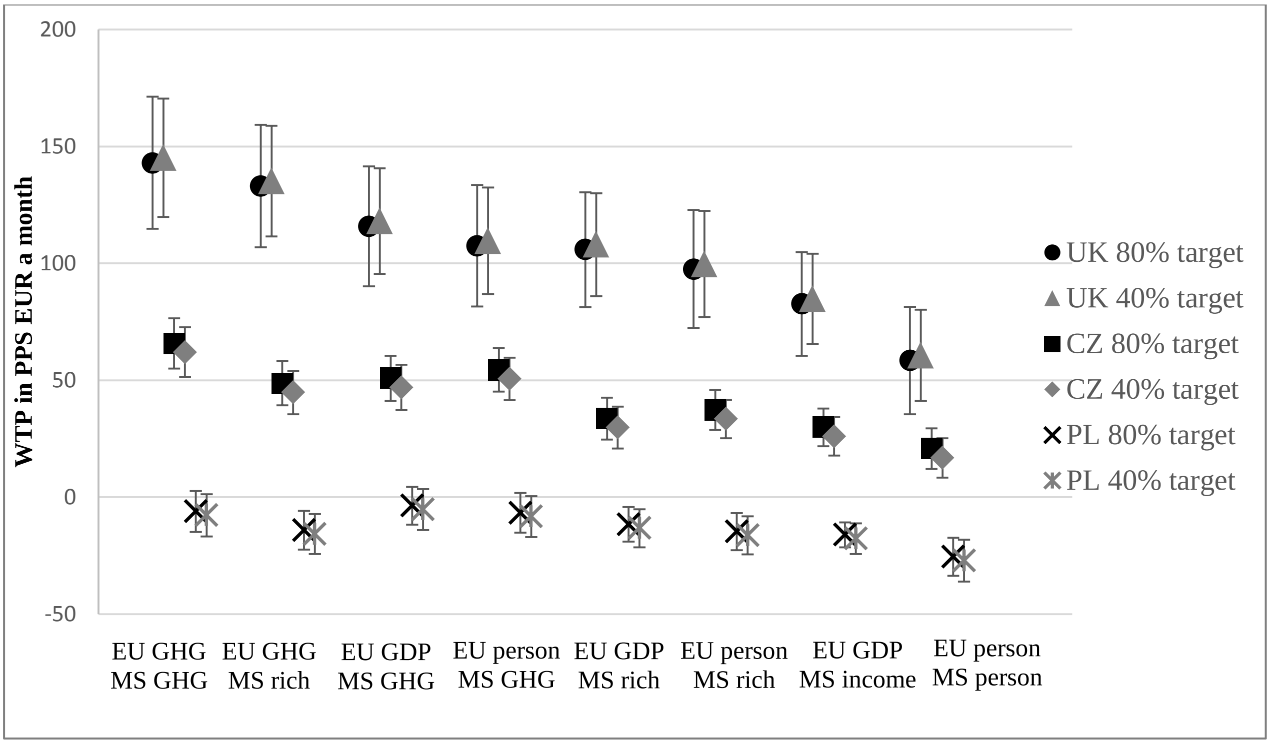


Figure 3. Estimates of implicit WTP for policy packages, in EUR per month and household.



Note: Burden sharing across the EU Member States (EU) and distribution of the cost within a member state (MS) is linked to greenhouse gas emissions released by a country or household respectively ("GHG"), to GDP or income, progressively to household income ("rich"), or is based on lump sum allocation ("person"). Estimates of means depicted as points and 95% confidence intervals as lines.