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Pushing low-carbon mobility: a survey experiment on the public acceptance of disruptive policy packages

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ABSTRACT
Disruptive policy packages that fundamentally change the current unsustainable passenger transport structures and enable low-carbon mobility transformation are inevitable. This implies the use of more stringent and multiple restrictive (i.e. push) measures. To enable successful implementation, public acceptance is critical, but what drives this acceptance? In this study, two main hypotheses were tested using survey methods that combined a two-group framing with a conjoint experiment: (1) The acceptance of push measures decreases as disruption increases; (2) disruptive push measures are less likely to be rejected when communicated as part of a policy package that included complementary pull measures (i.e. incentives). We conducted this survey with a quota-representative sample of 1,032 respondents from Austria. Two main findings emerge: First, we find low public acceptance of push measures, but observe differences based on the level of disruption (i.e. the measures’ intensity or rapidity of implementation). The more disruptive the measure (e.g. a fuel price increase), the more negatively these measures were evaluated by survey respondents. Interestingly, this trend was not seen for registration bans, where an earlier introduction is more acceptable than a later one. Second, our results indicate the need to communicate and implement high-impact, more restrictive push measures (e.g. car bans) as part of policy packages that include acceptance-boosting pull measures.

Key policy insights
- Acceptance levels of push measures are generally low, but acceptance differs depending on how disruptive the respective policy is, with the more disruptive policies being less well accepted.
- This does not hold true for a registration ban for cars with an internal combustion engine (ICEVs), where an earlier introduction is favoured.
- In addition to banning ICEV registration, acceptable combinations of push measures may include higher parking fees, car-free city centres, and street redesign to, e.g. prioritize non-motorized modes of transport.
- Successful and acceptable mitigation policies for low-carbon mobility require multiple push measures that are communicated in policy packages together with pull measures.
- Responses to the presented push measures vary across society, with frequent car users showing higher levels of rejection, underlining the need to tailor policies for specific contexts.

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1. Introduction

The current transport policies are not stringent enough to meet the emission reduction targets pledged in the fight against anthropogenic climate change. This lack of stringency is especially true for passenger road transport, where greenhouse gas (GHG) emissions are still increasing (Axsen et al., 2020; Brand et al., 2021), amounting to 45.1% of the total global transport CO2 emissions in 2018 (Ritchie, 2020). Regarding passenger inland transport (i.e. transport by road, rail, and inland waterways), cars with internal combustion engines are the dominant mode of travel. These accounted for 82.9% of such transport in the EU-27 in 2017 (Eurostat, 2020), underlining the prevalent consumer carbon lock-in (Ivanova et al., 2018; see also Unruh, 2000 for a general description of the carbon lock-in concept) and the need to implement demand-side measures. Therefore, radical or so-called ‘disruptive’ policy measures developed to overturn existing sectoral structures are needed to fundamentally change the current unsustainable passenger transport structures and enable a low-carbon mobility transformation (Axsen et al., 2020; Hamdi-Cherif et al., 2021; Thaller et al., 2021; Wicki et al., 2020). This proposal is based on Kivimaa et al.’s (2021) definition of disruption in a systematic review on disruption in sustainability transitions: ‘a high-intensity effect in the structure of the sociotechnical system(s), demonstrated as long-term change in more than one dimension or element, unlocking the stability and operation of incumbent technology and infrastructure, markets and business models, regulations and policy, actors, networks and ownership structures, and/or practices, behaviour and cultural models.’

Policies as a source of disruption are often restrictive in nature, such as potential registration bans for ICEVs or extensive fuel price increases, because they directly target emission reductions. Although these measures are necessary to effectively mitigate GHG emissions (Axsen et al., 2020), they are not favoured by policymakers or the public, in part due to the higher degree of coercion involved (Groot & Schuitema, 2012) to reduce car use by making motorized individual transport (MIT) less attractive (Ejelöv et al., 2022). Therefore, it is considered unlikely that these measures can be implemented without also using ancillary pull measures (Givoni, 2014; Givoni et al., 2013; Wicki et al., 2020). The latter are typically designed to make alternatives, such as non-motorized or public modes of transport, more attractive; one example is providing financial incentives for using public transport (Ejelöv et al., 2022). Thus, a more accurate term to use would be disruptive policy packages. These are needed to foster necessary systemic changes in the transport system, combining strong and effective push measures with pull measures to ensure public acceptance (Thaller et al., 2021). This packaging approach is especially relevant, since targeting MIT – a high-impact behaviour compared to GHG emissions and climate change mitigation (Whitmash et al., 2021) – is often associated with particularly high behavioural costs for the car user group (Groot & Schuitema, 2012). Several studies affirm that the proximity of the proposed policy can influence the level of public acceptance. For example, Long et al. (2021) showed that respondents who universally opposed several transport policy proposals (e.g. a carbon tax and a zero-emission vehicle (ZEV) mandate) commute more often daily with a vehicle. At the same time, possessing higher levels of environmental beliefs (Eriksson et al., 2008; Kitt et al., 2021; Levi, 2021) and climate change concern (Bergquist et al., 2022) were found to increase policy acceptance.

Another aspect influencing policy acceptance is the way policies are communicated. In this context, framing is a widely used, as well as heterogenous, approach (see Badullovich et al., 2020 for a systematic review of framing used as a tool in climate change communication). According to Chong and Druckman (2007), framing effects ‘occur when (often small) changes in the presentation of an issue or an event produce (sometimes large) changes of opinion.’ Framing is often used and studied in the context of so-called strategic issue framing, where different thematical frames (e.g. health or the local environment) are applied to see whether this can change the behavioural or policy responses (see, e.g. Bain et al., 2012; Hart & Feldman, 2018; Stevenson et al., 2018). However, this approach has been criticized. For example, Fesenfeld et al. (2021) surveyed a large sample that including respondents from China, Germany, and the United States and found that applying strategic issue framing in isolation is unlikely to effectively change behaviour or increase public support for demand-side policies. Existing values and social norms are further aspects that are often targeted in framing experiments. Several publications on communication in the climate and environmental area indicate that framing can effectively alter public support for specific policies and/or behavioural intentions across different population groups, where the frames align with the individuals’ existing values and prior beliefs.
(Bolderdijk et al., 2013; Boomsma & Steg, 2014; Graham & Abrahamse, 2017; Nilsson et al., 2016). In a recent study on food waste, Fesenfeld et al. (2022) showed that messages emphasizing national or international social norms could increase public support for stronger reduction targets.

In our study, we adopted a policy-package perspective by focusing on combinations of policies needed for climate change mitigation, namely, multiple push measures. Research on the public acceptance of policy packages has increased recently (cf. Brückmann & Bernauer, 2020; Wicki et al., 2019), and the literature indicates that policy packaging can increase acceptance for push measures in passenger transport (Fesenfeld, 2022; Wicki et al., 2020). However, the question of effective communication remains, and few studies have focused on how to frame disruptive policy packages to enhance acceptance by explicitly focusing and differentiating between multiple push measures. This study was performed for two reasons. First, we sought to define which kind of push measures have the highest levels of public acceptance. We hypothesized that higher levels of disruptions would lead to lower public acceptance, as suggested by Attari et al. (2009) and Wicki et al. (2019). Second, given the crucial but difficult role push measures play in mitigation, we asked whether including framing and communicating disruptive push measures in policy packages could increase their acceptance levels. We also examined two potential factors that have been shown to affect public acceptance, namely, car use and environmental awareness. Car use is an indicator for policy proximity, which has been shown to negatively affect support (Huber & Wicki, 2021). Environmental awareness represents personal ideology and beliefs, which has been found to positively influence acceptance (Eriksson et al., 2008; Kitt et al., 2021). Thus, we tested the following main and secondary hypotheses, derived from existing literature:

H1: The acceptance of push measures decreases with higher levels of disruption (main).

H2: Disruptive push measures are less likely rejected when communicated as part of a policy package that also includes complementary pull measures (main).

H3: Car users show lower acceptance levels for disruptive push measures (secondary).

H4: Respondents with high environmental awareness levels show higher acceptance levels for disruptive push measures (secondary).

To test these hypotheses, an experimental setting was implemented in an online survey that combined a conjoint experiment (H1) with a framing experiment (H2). In addition, we included the interaction effects of annual driving range (H3) and environmental awareness (H4) within a mixed-effects linear regression. We drew our quota-representative sample from the residential population of Austria, a Central European country. Transportation is one of the most pressing policy areas in Austria, as it is associated with high external costs of MIT (accidents, congestion, and environmental costs), which were estimated at 18.3 billion euros for road transport in 2016 (van Essen et al., 2020). Moreover, the Austrian transportation sector is responsible for around 30% of the GHG emissions (Umweltbundesamt, 2021). While some of the policies investigated already exist, albeit with substantially lower levels of disruption (e.g. level of fuel or parking prices), other policies (e.g. the ICEV registration and use ban or city tolls) are not yet in place in Austria.

2. Materials and methods

2.1. Questionnaire design and experimental settings

Figure 1 illustrates the overall survey design and highlights how the experimental settings were embedded in the survey. The framing experiment was carried out to assess whether the acceptance of push measures increases if they are communicated as part of a policy package together with pull measures. For this purpose, our sample was randomly split into two groups. Respondents of Group 1 (n = 537, 52%) and 2 (n = 495, 48%) received different instructions to fulfil the choice tasks. Both groups were asked to imagine that the federal government would implement policy measures to address challenges in passenger transport (e.g. GHG and particulate matter emissions, noise, poor air quality). Group 1 was then informed that a set of pull measures is combined with push measures into policy packages, but Group 2 was not notified about this joint implementation (see Supplement A.2 for the translated version of the information provided).
two groups were compared to assess differences in their response behaviour in the subsequent conjoint experiment. This conjoint experiment (with different framings for Groups 1 and 2) was performed to examine critical aspects in disruptive policy package design; therefore, the experiment only measured differences in push measure implementation.\(^1\) Survey respondents were first presented with an overview of the push measures, including a brief description of each policy to clarify its purpose (see Table 1 for a detailed overview). Before performing the choice tasks, Group 1 respondents again received information about the package design. They were then asked to compare two sets of eight push measures, respectively, and to indicate whether they preferred combination A or combination B (binary forced-choice). Overall, six choices with two combinations each (A and B) and randomly varied attribute levels were presented to each respondent. We assumed that all respondents would not be able to remember the descriptions in detail; therefore, an info button was provided for each choice task, allowing respondents to review the measure descriptions again if needed. After each task, respondents were asked to rate both combinations (A and B) separately on a seven-point scale, ranging from 1 (‘I strongly reject’) to 7 (‘I strongly support’). An example of a choice task, including the rating items, is provided in Supplement A.3.

After the conjoint experiment was conducted, the environmental awareness scale was included (H4), as this scale is recommended for German-speaking countries (Best, 2006). On this scale, nine items addressing three dimensions of environmental awareness – the respondents’ feelings about environmental problems, problem awareness, and their willingness to perform environmentally-friendly actions – were included using a five-point scale, ranging from 1 (‘strongly disagree’) to 5 (‘strongly agree’). The questionnaire also included a question on car use (i.e. kilometres driven in the previous year 2020, H3) and several items related to the respondents’ socio-demographic characteristics. Participants were asked to state their year of birth, gender, highest completed level of education, net monthly household income, and political orientation (ten-point left-to-right scale, whereby 1 was labelled ‘left’ and 10 ‘right’). With respect to the respondents’ residential location, they were asked whether they lived in a rural, rather rural, rather urban, or urban area.

### 2.2. Statistical analysis

To analyze the main results of the combined experimental design, the average marginal component effects (AMCEs) were estimated. These depict the marginal effect of a given attribute on the choice probability

\(^1\)For information on the assessment and description of the pull measures, see Supplement C.1.
Table 1. Push measures: attributes, descriptions, and levels.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ban on new/first registration of cars with internal combustion engines</td>
<td>The introduction of a new/first registration ban for cars with internal combustion engines means that no new cars of this type may be registered. Hybrids are also affected (i.e. time delay of two years). Lead time to prepare for the measure is provided.</td>
<td>(0) None (1) As of 2033 (2035 for hybrids) (2) As of 2025 (2027 for hybrids)</td>
</tr>
<tr>
<td>Ban on the use of cars with internal combustion engines</td>
<td>From this date and on, cars with internal combustion engines can no longer be used, and hybrid cars can only use the electric drive. Lead time to prepare for the measure is provided.</td>
<td>(0) None (1) As of 2043 (2) As of 2035</td>
</tr>
<tr>
<td>Increase in parking prices</td>
<td>The parking price increase applies to Austrian cities with more than 100,000 inhabitants (Vienna, Graz, Linz, Innsbruck, Salzburg, and Klagenfurt) for hourly tickets in the short-term parking zone.</td>
<td>(0) None (1) Doubling (2) Tripling</td>
</tr>
<tr>
<td>Annual mileage cap for private cars per household</td>
<td>The limit is calculated for a household and varies depending on the number of persons. For persons currently entitled to commuter allowance, this limit is higher. A year that has already passed before the introduction is used as the reference year.</td>
<td>(0) No reduction (1) Reduction by 1,500 km (2) Reduction by 3,000 km (individually adjusted)</td>
</tr>
<tr>
<td>Car-free city centres</td>
<td>The inner-city ban applies to all private cars in Austrian cities with more than 100,000 inhabitants (Vienna, Graz, Linz, Innsbruck, Salzburg, and Klagenfurt). Exceptions exist, e.g. for residents and loading activities.</td>
<td>(0) None (1) 3 days/week (2) 7 days/week</td>
</tr>
<tr>
<td>Reduction and redesign of street space</td>
<td>Change streetscape to favour bicyclists, pedestrians, and greening by reducing car lanes. This measure refers to Austrian cities with more than 100,000 inhabitants (Vienna, Graz, Linz, Innsbruck, Salzburg, and Klagenfurt).</td>
<td>(0) None (1) On busy multi-lane roads (2) On all multi-lane roads</td>
</tr>
<tr>
<td>Fuel price increase</td>
<td>The fuel price increase refers to the fuel gross price per litre and results from a corresponding increase in the mineral oil tax.</td>
<td>(0) None (1) From originally €1.20 to €2.40 (2) From originally €1.20 to €3.60</td>
</tr>
<tr>
<td>Introduction of a city toll</td>
<td>The individually determined entry toll is incurred when crossing the inner-city boundary with private cars. This measure applies to Austrian cities with more than 100,000 inhabitants (Vienna, Graz, Linz, Innsbruck, Salzburg, and Klagenfurt). Exemptions are planned, e.g. for residents and loading activities.</td>
<td>(0) None (1) E.g. €3/day in Graz or €5.50/day in Vienna (2) E.g. €8/day in Graz or €11/day in Vienna</td>
</tr>
</tbody>
</table>

Note: This table provides a comprehensive overview of attributes, attribute descriptions, and attribute levels. Respondents were presented with a table comprising attributes and descriptions only (before the conjoint experiment and optional for each choice task with the info button).

Across the joint distribution of all other attributes (Hainmueller et al., 2014). AMCEs were estimated separately for both the full sample and the two framing groups (package information for Group 1, no package information for Group 2). In practice, AMCEs are typically calculated by regressing a dummy variable to indicate whether a respondent preferred a particular combination of attributes and using cluster-robust standard errors to account for within-respondent clustering. In other words, the level of a specific attribute increases or decreases acceptance for the policy combination relative to the baseline level (in this study, indicating that the specific policy was not included) over all respondents and other policy attributes.

Moreover, marginal means (MM) were calculated as by Leeper et al. (2020), as conjoint experiment results are sensitive to baseline categories. This approach is critical to test hypotheses involving experimental interactions and heterogeneous treatment effects and, thus, was appropriate for identifying differences between the two framing groups. Marginal means can be interpreted as the probability of choosing packages with a particular attribute level, marginalizing across all other attributes. Thus, marginal means and AMCEs show the same results, but these are presented differently. If the AMCE of a value is added to the marginal mean of the baseline category, the marginal mean of this initial value is obtained. Calculating the ACMEs and marginal means allowed us to examine whether push measures were more socially acceptable when communicated as part of a policy package together with pull measures (H1) and to determine how the respondents evaluated the push measures differently, depending on their policy type and the extent of disruption (H2). We used a full factorial design with restricted randomization. For restriction (a), the ICEV use ban could only be introduced after the registration ban, if one was present in the combination, and for restriction (b), a city toll could only be installed if no permanent inner-city car ban was present in the same combination.
To additionally test for potential interaction effects, we predicted the acceptance of different attribute levels in the conjoint experiment by including interaction effects of an annual driving range (H3) and environmental awareness (H4) by performing a mixed-effects linear regression. The predicted acceptance level was calculated based on the seven-point scale to assess the acceptance of the individual proposals used in the conjoint task. We also log-transformed the annual driving range to control for large values and controlled for sociodemographic variables. All steps taken, ranging from data cleaning to the statistical analyses, were done in R (R Core Team, 2020, version 3.6.3). See Supplement D for a detailed overview of the used R packages.

3. Results

3.1. Sample description

The final sample (N = 1,032) is representative of Austria’s population in terms of age (16–69 years), gender, education, and size of residential area. The participants were between 16 and 81 years old, with an average age of 44.65 years. Regarding their income, the median income group was 2,201-3,000 euros per month. With respect to the respondents’ political orientation (n = 844), an overall tendency towards the middle could be observed, with an average of 5.2, a median of 5, and a mode of 5. Car users (n = 702) drove on average 19,996 (median = 15,000) kilometres by car in 2020, with a considerable range between 30 and 140,000 kilometres.2 Participants scored slightly positive (mean = 3.4) on the environmental awareness scale (α = 0.88). See Table 2 for an overview of the sociodemographic sample characteristics.

3.2. Overall conjoint effects: AMCEs and marginal means for rating (H1)

Findings from the rating tasks are presented below, whereas findings from the forced-choice task are provided in Supplement C.2 Overall, the marginal means for policy ratings ranged between 2.98 and 3.33 on the seven-point scale. Regulatory push measures (registration and use ban) were rejected least often, with a usage ban as of 2035 receiving the second highest marginal mean (MM = 3.29). Interestingly, respondents preferred implementing registration bans (MM = 3.23 for registration bans as of 2033 and MM = 3.33 for bans as of 2025) as compared to not having the measure as part of the policy package (MM = 3.07). Pricing mechanisms, however, had a predominantly negative effect on the rating of the overall combination of push measures. Increasing fuel prices had the most substantial effect, with an AMCE of −0.53 from no fuel price increase (baseline, MM = 3.51) to tripling prices (MM = 2.98). Similarly, increased parking prices and a toll in city centres showed significant adverse effects, but at smaller effect levels. This effect tendency is similar to that seen for a capacity-based measure: introducing a mileage cap on car use (AMCE = −0.22 for reduction by 3,000 km as compared to no mileage cap). The options of car-free city centres and street redesign, however, did not show any clear effect tendencies (AMCEs close to zero). Find an overview of the marginal means and AMCEs for both the forced-choice and the rating task for all respondents and per group in Supplement C.

3.3. Treatment effect (H2)

To determine whether the framing experiment (communicating push measures as part of a policy package together with pull measures vs. no information) influenced the average rating of push measure combinations per group, we calculated a two-sided t-test. We find a significant (p < 0.01) but negligible (Cohen’s d = 0.08) effect: Regarding the overall rating of policy combinations, Group 1 received a mean rating of 3.28, while the combinations in Group 2 were on average rated with 3.14 (mean rating overall: 3.21). Figure 2 shows both the marginal means and AMCEs of all attribute levels of policy options based on the rating task in the conjoint experiment per group (see Supplement C for general results for all respondents as well as results for the forced choice, which are similar). Regarding the marginal means, combinations from Group 1 on average received higher ratings than those from Group 2; for example, a registration ban as of 2025 received

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2Note: Cases further than 2.5 times the standard deviation from the mean were excluded from this variable for plausibility reasons.
Table 2. Sociodemographic sample characteristics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Categories</th>
<th>Shares in % and sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>n = 1,032</td>
<td></td>
</tr>
<tr>
<td>16–29</td>
<td></td>
<td>21.3 (n = 220)</td>
</tr>
<tr>
<td>30–39</td>
<td></td>
<td>18.4 (n = 190)</td>
</tr>
<tr>
<td>40–49</td>
<td></td>
<td>18.7 (n = 193)</td>
</tr>
<tr>
<td>50–59</td>
<td></td>
<td>21.5 (n = 222)</td>
</tr>
<tr>
<td>60+</td>
<td></td>
<td>20.1 (n = 207)</td>
</tr>
<tr>
<td>Gender</td>
<td>n = 1,030</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>49.2 (n = 507)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>50.8 (n = 523)</td>
</tr>
<tr>
<td>Education</td>
<td>n = 1,028</td>
<td></td>
</tr>
<tr>
<td>With ‘Matura’</td>
<td></td>
<td>31.8 (n = 327)</td>
</tr>
<tr>
<td>Without ‘Matura’</td>
<td></td>
<td>68.2 (n = 701)</td>
</tr>
<tr>
<td>Income</td>
<td>n = 911</td>
<td></td>
</tr>
<tr>
<td>max. €1,500/month</td>
<td></td>
<td>19.4 (n = 177)</td>
</tr>
<tr>
<td>€1,501-2,200/month</td>
<td></td>
<td>20.3 (n = 185)</td>
</tr>
<tr>
<td>€2,201-3,000/month</td>
<td></td>
<td>22.9 (n = 209)</td>
</tr>
<tr>
<td>€3,001-5,000/month</td>
<td></td>
<td>30.4 (n = 277)</td>
</tr>
<tr>
<td>More than 5,000/month</td>
<td></td>
<td>6.9 (n = 63)</td>
</tr>
<tr>
<td>Residential location</td>
<td>n = 1,032</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td></td>
<td>31.3 (n = 323)</td>
</tr>
<tr>
<td>Rather urban</td>
<td></td>
<td>17.6 (n = 182)</td>
</tr>
<tr>
<td>Rather rural</td>
<td></td>
<td>23.6 (n = 244)</td>
</tr>
<tr>
<td>Rural</td>
<td></td>
<td>27.4 (n = 283)</td>
</tr>
</tbody>
</table>

Note: For questions asked to determine the respondents’ gender, education, income, driven kilometres per year, and political orientation, one of the answer options ‘others’, ‘cannot choose’, ‘do not know’, or ‘no answer’ was included, which explains observations smaller than N = 1,032 for the respective questions.

Figure 2. Estimated marginal means and average marginal component effects (AMCE) of rating task by framing group. Error bars show 95% confidence intervals.
a MM = 3.41 for Group 1 and a MM = 3.25 for Group 2. These results reflect the t-test findings. Despite these differences in the overall ratings, no differences were found between the two groups regarding the mere direction of effects visible in the signs of the AMCEs. However, when looking at the changes in MMs represented through AMCEs, a fuel price increase more negatively affected Group 1 (AMCE = −0.62 for Group 1 and AMCE = −0.43 for Group 2, respectively, for a tripling of the fuel price), while the opposite was the case for the mileage cap (AMCE = −0.15 for Group 1 and AMCE = −0.30 for Group 2, respectively, for a reduction by 3,000 km).

3.4. Predicting acceptable push measure combinations (H1 and H2)

To identify combinations of push measures that were not strongly rejected, we predicted ratings for the 13,122 combinations generated by our conjoint design based on their distribution, including interactions among the single attributes (see Supplement C.2). We focused on the ratings instead of the forced choice results, as this enabled us to more clearly detect framing differences between groups and attributes regarding the general acceptance of the full policy package. Overall, we identified 102 policy combinations that attracted ratings of 4 or higher in their distribution (on a seven-point scale) for Group 1, and 7 for Group 2. Packages including a tripling of parking prices or generally increasing fuel prices did not on average receive ratings of 4 or higher in either of the groups. The two groups differed notably in several aspects: For example, doubling parking prices in Group 1 resulted in average acceptance levels above 4 for some of the included packages, while this was not the case in Group 2.

We also potentially identified the most effective policy combinations that imply higher behavioural costs due to their stringency and received the highest ratings from both framing groups. Various policy combinations are possible for Group 1 that receive ratings above 4, although none of these included increased fuel prices. Some of these combinations, however, included a doubling of parking prices together with registration bans, car-free city centres, and street redesigns. Such combinations could also receive ratings above 4 if – instead of a parking price increase – any two of the following three policies were included: a mileage reduction of 3,000 km, car-free city centres, or a mid-level city toll. In Group 2, the most stringent combination of push measures that received acceptance levels above 4 included a registration ban as of 2025, car-free city centres on seven days per week, and street redesign on all multi-lane roads.

3.5. Predicted average ratings by individual driving behaviour and environmental awareness (H3 and H4)

Overall, respondents with higher annual driving ranges displayed lower rating levels for the push measure combinations. A downward trend is observed in the predicted combination acceptance of all eight measures, which also results in statistically significantly lower average combination ratings (also see model 2.2 in Table C.2.2 and Figure B.3.1 in the Supplement). This finding supports H3, which states that car use negatively influences public acceptance of disruptive push measures. Regarding interaction effects with specific attribute levels, barely significant differences could be found. One notable exception is the fuel price increases, which received significantly lower acceptance levels from frequent drivers than from less frequent drivers. In contrast, frequent drivers were more likely to accept the rapid introduction of an ICEV registration and use ban.

In general, respondents with higher levels of environmental awareness showed significantly higher rating levels for combinations of policy measures (see model 2.2 in Table C.2.2 and Figure B.3.2 in the Supplement). This finding supports H4, which states that environmental awareness positively influences the public acceptance of disruptive push measures. Regarding interaction effects with specific attribute levels, however, different patterns were detected for some of the policies. While the introduction of city tolls (both stringency levels) was rated significantly higher for respondents with higher environmental awareness levels, the opposite was true for rapid introductions of an ICEV registration and use ban.
3.6. Sociodemographic differences in ratings

To test whether certain demographic traits affected the overall acceptance of push measure combinations, we also controlled for several demographic variables (age, gender, education, employment, political orientation, urban-rural differences, and income) and the primary outcome measures of rating preferences (see model 2.3 in Table C.2.2 in Supplement C). The results only indicate a statistically significant difference for respondents based on their political orientation, where a more right-wing political orientation was related to significantly lower ratings of the presented policy combinations.

4. Discussion

This study was carried out to answer two main questions, namely, which kind of push measures are the most publicly acceptable and whether framing and communicating disruptive push measures as part of policy packages could increase their acceptability. Regarding the first question, our results show that acceptance levels of most of the investigated push measures decreased as the disruption caused by introducing these measures increased. These results provide support for H1 (The acceptance of push measures decreases with higher levels of disruption). However, this relationship was not detected for the registration bans of ICEVs. In this case, respondents evaluated an earlier introduction of car bans over not including the policy in the package. These findings may indicate that the latest plans to effectively ban the sale of new petrol and diesel cars starting in 2035 at the EU level (EC, 2021) and in 2030 at the Austrian level (BMK, 2021) could be received positively, as could similar intentions for multiple other regions worldwide (Plötz et al., 2019). However, we also found differences in the acceptance rate of policy types. In general, regulatory measures (e.g. the registration and use ban) were less frequently rejected than economic measures (i.e. fuel price increases), a result that is also consistent with those of other studies (Kitt et al., 2021; Rhodes et al., 2017; Wicki et al., 2020).

Unlike the ban of ICEVs, fuel taxation was primarily viewed negatively. This result might be interpreted in the light of fairness considerations (Drews & van den Bergh, 2016): While a ban on certain technologies such as ICEVs affects everyone regardless of their income or wealth, an increase in the fuel price – as the current energy crisis illustrates – is felt much more strongly by low-income households than by wealthy households (Nikodinoska & Schröder, 2016; Wang et al., 2016). At the same time, switching to electric mobility, an option that is frequently discussed as the main alternative to ICEVs (Došak & Prakash, 2022), would be more affordable for wealthy households. However, this relationship may not be as prominent for respondents as the direct increase in fuel prices when they are confronted with policy proposals. In this context, it should be noted that the policy packages presented in our study did not explicitly mention any kind of monetary compensation measures for households that would be strongly affected by increases in the price of fossil fuels, an aspect that can influence the regressive nature of policies (Ohlendorf et al., 2021) and perhaps also their acceptance. We also did not address the issue of transparently using additional tax revenues, for example, by earmarking these for the expansion of public transport or infrastructure for active mobility (Creutzig et al., 2020). This could explain the fact that increasing parking fees (doubling or tripling) was rated lower than maintaining the current parking fee level.

Regarding our second question and H2 (Disruptive push measures are less likely rejected when communicated as part of a policy package that also includes complementary pull measures), the results show that negligible, but significant differences exist between the framing groups in terms of their public acceptance. Push measures in Group 1, where they were framed as part of a policy package together with pull measures, were less frequently rejected than in Group 2, where respondents did not receive any information regarding policy packaging. While we found combinations of push measures that were acceptable to both groups, clearly more combinations were acceptable to Group 1. This difference in options indicates that communicating them as part of a policy package to be implemented together with ancillary pull measures might indeed help increase the acceptance of the most restrictive measures. As some respondents might have even overlooked the relevant framing information, the effect might even be underestimated. At the same time, the used research design only allows
us to capture hypothetical policy preferences; we cannot guarantee that all respondents understood the proposals in the same way or as intended.

With regard to policy communication and framing, other research has shown that aligning presented policy information with individuals' beliefs can increase public acceptance (Bolderdijk et al., 2013; Boomsma & Steg, 2014; Nilsson et al., 2016), thus indicating that communication should emphasize pull measures that clearly benefit the respective population groups. This reveals an existing tension in communication: On the one hand, policymakers need to explain the framework in which push measures are embedded to make them more acceptable and, on the other hand, the explanations need to be short and simple, for example, to be disseminated via the media.

Like Kitt et al. (2021), we further found respondents with high levels of environmental awareness demonstrated significantly higher acceptance levels for all eight push measures and all intensity levels than respondents with lower levels of awareness, supporting H4. This is a particularly interesting result, as previous research indicated that environmental values apply only to low-cost behaviour change, resulting in the formulation of the so-called low-cost hypothesis (Diekmann & Preisendörfer, 2003). Our study findings, however, show that the push measures examined are highly disruptive and, therefore, costly. While our survey results do not directly reflect actual behaviour change – a common downside of empirical research on self-reported behavioural intentions – this still indicates that awareness-raising in public campaigns could play an important role as a complementary measure. In addition, we detected a significant correlation between respondents with comparably higher yearly driving ranges and those with lower levels of policy acceptance. These findings support H3. Furthermore, we found that frequent drivers rated combinations without fuel price increases significantly higher than infrequent drivers, with no differences seen across intensity levels. This result indicates that those most heavily affected by the proposed policy packages show the lowest acceptance levels for usage-dependent measures, as Huber and Wicki (2021) also showed. This may be due to the fact that the costs for such usage-dependent measures are more clearly visible and straightforward than for other measures, where such costs are only indirectly accessible. Regarding sociodemographic factors, we found a significant effect with respect to the respondents’ political orientation, with left-wing voters showing higher acceptance levels for the push measures, a result that agrees with that of Drews and van den Bergh (2016).

This study had certain limitations. First, the perceived policy fairness and effectiveness (see Bergquist et al., 2022, in their recent meta-analysis on public opinion of taxes and regulations) and the level of trust in the government (Kitt et al., 2021) are relevant factors for public acceptance; however, these factors were not included in the survey design. Furthermore, we focused on two relevant selection criteria for policies (i.e. mitigation effectiveness and resulting policy acceptance, see Axsen and Wolinetz (2021)), but did not consider other criteria such as cost effectiveness or environmental consequences. Regarding the framing experiment, we also cannot eliminate the possibility that experimenter demand effects potentially affect the results. In other words, respondents may have perceived the treatment as a cue regarding what constitutes appropriate behaviour. We attempted to reduce the possibility of eliciting this social desirability bias by not informing participants about the specific focus of the survey, e.g. by studying individual attitudes towards packaging policies (de Quidt et al., 2018; Mummolo & Peterson, 2019). Additionally, empirical evidence of framing effects is often generated through survey experiments, and these are seen as a gold standard for assessing the effectiveness of frames in altering public opinion (Badulovich et al., 2020; Druckman & McGrath, 2019). Regarding the hypothetical bias mentioned above, the annual mileage cap would particularly need to be individually designed in practice, and respondents may have found this hard to grasp when presented generically in the survey. In the selection of pull measures, one policy also dealt with reallocating more public space to alternative modes of transport, which is arguably overlapping (but not interchangeable) with the presented push measure on the reduction and redesign of street space. Finally, we conducted quota-representative research for the specific case of Austria. We believe, however, that our results are closely related to those from studies conducted in other industrialized European countries; thus, to a certain extent, they are generalizable and applicable for other countries as well.
5. Conclusions

Climate policy currently faces a dilemma around passenger transport. The climate crisis clearly indicates that a rapid and massive transition to climate neutrality is imperative, but significant changes in transport behaviour are difficult to achieve due to prevalent carbon lock-in dynamics. Furthermore, disruptive policy measures are failing to be implemented at the same time due to the fear of a lack of public acceptance. Our study highlights several relevant aspects that can help overcome the present inertia. First, we find differences in acceptability among push measures, both based on the levels of disruption and between different types of push measures, even though the public acceptance of push measures is often viewed as uniformly negative. While economic measures, such as making fuel more expensive by adding a carbon tax, are viewed particularly critically, regulatory measures – and especially those in the form of a registration ban on ICEVs – receive more public support. In addition to an ICEV ban, acceptable policy packages could also include higher parking fees, car-free city centres, and street redesign measures. Our study also indicates a potential for communicating these push measures as part of comprehensive demand-side policy packages, where they are embedded in a set of carefully selected pull measures to increase the attractiveness of climate-friendly alternatives. We also find that responses to these push measures vary across sectors of society, where the group of frequent car drivers is the most heavily affected by the proposed policy packages and shows the lowest acceptance for usage-dependent measures. These results underscore the need to tailor policies and communication efforts to reach different societal groups effectively, avert public resistance, and ensure a just mobility transition.

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Data availability statement

We preregistered the present study on the Open Science Framework (OSF) on May 11, 2021. The data set and the corresponding codes in R will be made available there after publication: https://osf.io/h34c7.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Ethics statement

This study was approved by the Ethics committee of the University of Graz in April 2021 (approval number: GZ. 39/92/63 ex 2020/21).

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