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Citizens ditching cars: How do assessments of SDG interactions predict a modal shift towards low-carbon urban transport choices?

Myriam Pham-Truffert[1,2], Mario Angst[2], Thomas Breu[1,3] and Maria J. Santos[4]

[1] Centre for Development and Environment, University of Bern, Switzerland
[2] Digital Society Initiative, University of Zurich, Switzerland
[3] Institute of Geography, University of Bern, Switzerland
[4] Earth System Science, Department of Geography, University of Zurich, Switzerland

E-mail: myriam.pham-truffert@dsi.uzh.ch

Abstract.

In light of climate change, urbanization and worldwide mobility trends, the requirements for transforming urban transport systems towards the Sustainable Development Goals (SDGs) are twofold. First, understanding the systemic interactions underlying sustainable development as envisioned in the UN 2030 Agenda for Sustainable Development is key. In the context of urban transport systems, this includes understanding what hinders or fosters reduced carbon emissions. Second, systemic knowledge must be coupled with a strong societal and political engagement. This study analyses whether citizen assessments of key SDG interactions in urban transport systems play a role in predicting individual transport mode choices. Normatively, changes in individually held systemic perspectives could encourage greater use of low-carbon transport modes in urban and peri-urban areas, which would be an essential step toward climate change mitigation. We use survey data ($n = 822$) to measure citizens' perspectives on the urban transport system and their transportation habits in terms of car driving, cycling, or public transport. We use a Bayesian multilevel regression model to investigate "How do citizen assessments of SDG interactions influence transport mode choices?". We find that negative citizen assessments of the influence of car-related (1) infrastructure and (2) transport affordability on reduced carbon emissions are associated with reduced frequency of car-driving. Conversely, we find that positive citizen assessments of the influence of (3) road safety for cyclists and (4) public transport affordability on reduced carbon emissions are associated with increased frequency of cycling and public transport use, respectively.

Keywords— Urban transport system; Citizen; Modal shift; Inclusive urban planning; SDG interactions; Climate mitigation; Bayesian analysis

1. Introduction

A transformation of urban transport systems is needed to achieve a deep reduction of carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions to mitigate climate change (Creutzig, Jochem, et al. 2015; IPCC 2023; Iwasa et al. 2022). The urban share of global consumption-based GHG emissions increased from 62% in 2015 to 67–72% in 2020 (Iwasa et al. 2022). Urban transport is one of the most emitting sectors and cities can significantly reduce their fuel use by encouraging dense communities and building infrastructure that promotes options like walking, biking, and the utilization of public transport (Jaramillo et al. 2022). A modal shift strategy toward low-carbon urban transportation has been identified as an especially key puzzle piece in a transition toward sustainability (Batty, Palacin, and González-Gil 2015; Kuss and Nicholas 2022; Müller and Reutter 2022).

The Sustainable Development Goals (SDGs) offer a framework for ”Transforming our world” (UN 2015) while navigating potential conflicts among social, economic and environmental objectives. Yet achieving this transformation is far from trivial in the case of urban transport and mobility, as it affects the daily lives of large urban and peri-urban populations. At the political level, sustainability transformations require not only significant investments in infrastructure and attention to temporal dynamics, but also consideration of often-conflicting perceptions, needs, and visions for change of various stakeholders. As such, transformations are not only occurring at the policy level, but also at the individual level, with each citizen playing their part in the system.

In this study, we aim to assess how willing citizens might be to shift transport modes towards being in line with sustainability transformations within urban transport systems, depending on their perceptions of the system. We use survey data ($n = 822$) on citizens' mobility habits and perceptions of urban multi-modal transport systems in municipalities within Switzerland's five designated metropolitan regions (Zurich, Geneva, Basel, Lausanne, and Bern). We investigate the influence of citizen assessments of key SDG interactions (T. Bennich et al. 2023; Therese Bennich, Weitz, and Carlsen 2020; Pham-Truffert et al. 2020; Soest et al. 2019) on citizens' transport mode choice in terms of car driving, cycling, or using public transportation. Figure 1 illustrates the three specific influence pathways we formulate testable hypotheses for. We utilize Bayesian regression models to test a set of four hypotheses on whether qualitative differences in citizen assessments can potentially induce a modal shift toward less car use and a more mainstream use of bicycles or public transportation as low-carbon transportation alternatives. Specifically, we ask ”How do citizen assessments of SDG interactions influence transport mode choices?”. To answer this research question, we formulate and test the following hypotheses.

Individuals who believe that:

- **(H1)** *better transport infrastructure for car drivers would increase emissions are less likely to drive cars regularly.*
- **(H2)** *improved road safety for cyclists would reduce emissions are more likely to cycle more often.*
- **(H3.a)** *more affordable public transport would reduce emissions are more likely to use public transport regularly.*
- **(H3.b)** *more affordable car driving would increase emissions are less likely to drive cars regularly.*

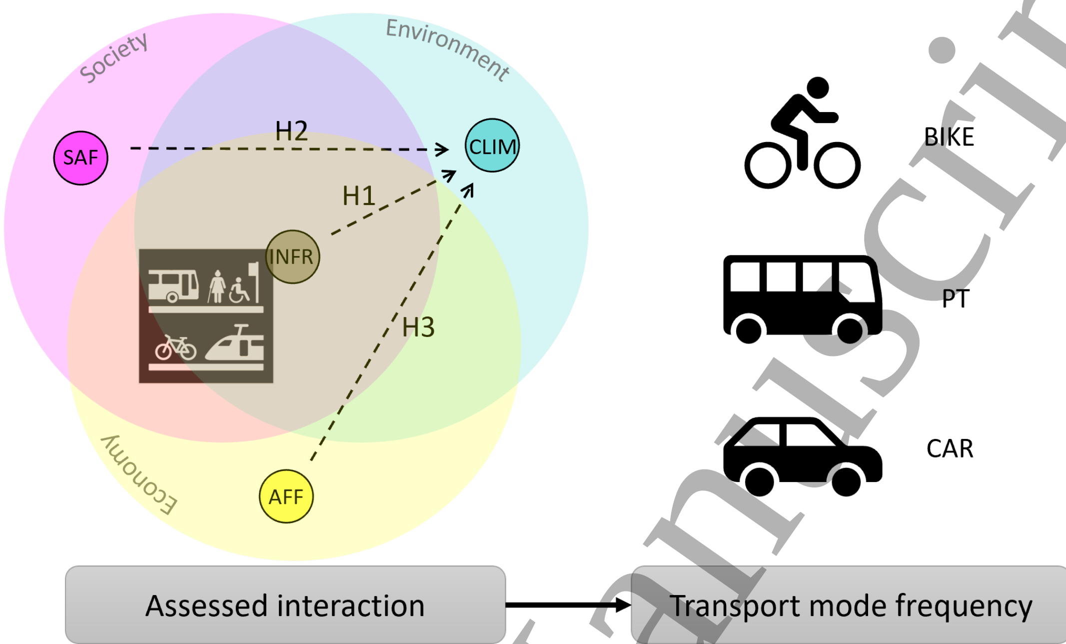

Figure 1. Simplified model on which the hypotheses tested are based: Different citizen assessments of relevant interactions within the urban transport system should influence citizen transport mode choices. Objectives within the urban transport systems underlie social, economic and environmental objectives such as road safety (SAF), transport infrastructure (INFR) and affordability (AFF), and the climate action objective of reducing CO_2 emissions (CLIM). The transport options compared are bikes or e-bikes, public transport (PT) and cars.

2. Literature review

2.1. The 2030 Agenda in urban transport systems

Our study breaks down the components of the urban transport system into four objectives (road safety, transport affordability, transport infrastructure, and reduced CO_2 emissions) as a way to reflect an integrated vision of sustainable (urban transport) development as envisioned in target 11.2 of the 2030 Agenda (UN 2015):

> By 2030, provide access to **safe, affordable, accessible and sustainable** transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.

To address the "sustainable" aspect, we focus on the major environmental issue of climate change in the context of the urban transport systems, namely CO_2 emissions. The definition of SDG target 11.2 conveys furthermore that transport systems should be inclusive and for all. The survey data used in our study enables us to incorporate demographic and social aspects relevant to the urban transport context, such as gender (Goel et al. 2023; Priya Uteng 2021), age (Nissen et al. 2020; Remillard et al. 2022), disabilities or other special conditions (Shen et al. 2023).

To conceptualize interactions within the urban transport systems, we build on a stream of research investigating the indivisible nature of the 2030 Agenda and its 17 interconnected SDGs to gain insights for practitioners and policymakers to steer society towards more sustainability. Namely, an ever-growing body of literature identifies *SDG interactions*, that is, synergies or trade-offs that are inherent in the implementation of the 2030 Agenda, as progress towards its different components can foster or hinder one another (Kroll, Warchold, and Pradhan 2019; Pham-Truffert et al. 2020).

2.2. Modal shift

Our first hypothesis directly builds on the literature on car dependence (Mattioli et al. 2020; Newman and Kenworthy 2015; Sierra Muñoz et al. 2024), indicating the historical expansion of the automotive industry, urban sprawl and the related, still ongoing development centred on car use (Miner et al. 2024) and how it complicates urban planning that would aim to give space to alternative transport modes that need to coexist. Specifically, road development is primarily pursued to meet the demand of car drivers for smooth traffic flow from point A to point B, directly constraining the infrastructure of the other transport modes (e.g., cycling lanes). In most cities, car users benefit from far more space than other transport modes (Creutzig, Javaid, et al. 2020). Good coverage of bus and light and heavy rail transit (Ingvardson and Nielsen 2018) is key to modern transport system development. Yet, it would require large investments to compete with the advantages of individual car use in more peripheral areas (Batty, Palacin, and González-Gil 2015). Given this *by default* car-related infrastructure and traffic growth, we assume citizen assessments of the interaction from car-related infrastructure to reduced emissions would be good predictors of modal transport choices (H1).

Another predictor of transport choices could be linked to social valuation and perception of the different modes. As shifting toward *active transport* modes such as walking and cycling effectively mitigates climate change (Brand et al. 2021), the promotion of active travel is a key strategy and includes addressing special hurdles related to cycling. In their literature review on the effect of the built environment on cycling, Fraser and Lock (2011) identify perceived and objective insecurity, long distances, steep topographies, and lack of bike lanes as typical factors hindering cycling. Yet overcoming these issues preventing people from using alternative, often multi-modal transport options could truly bring about effective climate change mitigation, with multiple co-benefits expected (e.g., many studies have stressed the health benefits related to active mobility (Nazelle et al. 2011; Pucher et al. 2010; Scrivano et al. 2024; Voss 2018)). Another, unsuspected benefit of using active mobility is better accessibility, as a case study in Sweden seems to suggest that the perceived accessibility is greater among cyclists compared to car drivers or public transport users (Lättman, Olsson, and Friman 2018). Long and steep routes are issues that the development of electric bicycles (e-bikes) has contributed to mitigate (Rérat 2021). However, the perceived vulnerability of bike users in the transport system might be long-lasting. In particular, perceived safety and comfort while using active mobility transport modes vary across gender and age (Akgün-Tanbay et al. 2022). As such, perceived road safety for cyclists could promote a bike culture and encourage a greater use of bikes and e-bikes. Citizen assessments of the interaction from road safety for cyclists to reduced emissions could be good predictors of cycling frequency (H2).

Finally, our last hypotheses relate to transport costs, as we assume that making transport more affordable for public transport users (or less affordable for car drivers) may help promote low-carbon transport mode choices. The assumed link between a perceived interaction between transport affordability and reduced emissions on different transport mode use frequencies is based on the literature investigating existing policy instruments to nudge behaviors with financial incentives toward modal shift (e.g., "carrot-and-stick" transport policies like public transport subsidies and carbon tax). In particular, public transport subsidies are targeting the lower-income population, who tends to represent a larger share of the users (Guzman and Hessel 2022), whereas, carbon taxes are targeting by definition the population owning cars. Citizen assessments of the interaction from public transport (or car-related) affordability to reduced (or increased) emissions are also expected to predict different uses of these means of transport (H3.a and H3.b).

3. Methods

3.1. Study system

Transportation is the sector emitting the most GHG emissions in Switzerland (15.02 million tonnes of CO_2-equivalent emitted in 2021, see supplementary appendix A), contributing to over 30% of national emissions. These transportation numbers do not include fossil fuel combustion from international aviation.

More than two-thirds of the average daily 30 km per person is travelled by car (FSO 2025; Niroomand and Bach 2024). Thalmann and Vielle (2019) stressed that despite a general reduction of GHG emissions observed in Switzerland for the other sectors, those from the transport sector keep on increasing. This points to systemic barriers to the adoption of sustainable modes of transportation and makes clear that, apart from the climate aspect, other socio-economic aspects need to be considered and cautiously addressed. The public resistance towards carbon taxes (Mus, Mercier, and Chevallier 2023) has been illustrated in many countries (e.g., backlash of the yellow vests in France or political opposition in several United States).

Our study system comprises the five largest agglomerations in Switzerland, namely Zurich, Geneva and Basel (within national borders), Lausanne and Bern. Together, the agglomerations comprise 520 potential Swiss municipalities within 11 German- and French-speaking cantons, for a total of permanently residing populations of close to 3.5 million (see Table 1), representing therefore almost 40% of the total population of Switzerland. We screened out respondents who were not living in any of these municipalities and set quotas based on age and gender to ensure that the sample was representative of the Swiss population based on these two criteria, enabling a good gender balance and a representation of three age group categories from 18 to 79 years old.

3.2. Survey and measurement

We surveyed ($n = 822$) citizens in the five aforementioned agglomerations to measure socio-demographic characteristics, transport habits, and perceptions and assessments of urban transport systems concerning cycling, car driving, and public transportation. The survey was carried out in late Summer 2024, between August 27 and September 2.

The most challenging aspect of survey design was finding a valid measurement for people's assessments of interactions within the urban transport system, while considering different transport modes. To achieve this, we measured individual assessments of all the potential 36 directed interactions – that is, $(4 \times 4 - 4 \text{ objectives}) \times 3$ transport modes. This was made possible by opting for a series of array types of questions where we had the respondents select answers on a 5-point Likert scale [very negative, negative, no impact, positive, very positive]

Table 1. Overview of the permanently residing population and number of Swiss municipalities within the 5 agglomerations. Geneva and Basel are transnational agglomerations and in the table, we only indicate the population living in Switzerland (CH); the total population (including in France and Germany) of the Geneva and Basel agglomerations, is 994'957 and 875'147 respectively (Data source: Office fédéral de la statistique 2024).

Agglomeration	Population in 2022	Number of Swiss municipalities
Zurich	1'450'724	148
Geneva (CH)	606'779	86
Basel (CH)	561'983	111
Lausanne	443'445	107
Bern	433'138	68

referring to complete sentences. For instance, a "Negative" individual answer to the sub-question to complete the sentence that an *Easier physical access for car drivers would have an impact on a reduction in CO_2 emissions* was translated as a negative directed interaction from transport infrastructure for car drivers to reduced CO_2 emissions. We also included the options for respondents to indicate either "It doesn't make sense" or "I don't know", given the large number of interactions we assessed.

3.3. Variables in causal model

We present in Figure 2 our theoretical causal model as a Directed Acyclic Graph (DAG), where variables are displayed as nodes (circles in the figure), and direct causal influences as directed edges (arrows in the figure) (see McElreath (2020, pp 128-144) and Pearl (2009)). The DAG formalization enables us to be explicit about the causal model informing our statistical modeling. First, the DAG delineates causal model components considered (arrows and blue, green, white and red nodes in Figure 2) and external or latent factors (e.g. grey nodes in Figure 2). Second, the DAG formalizes the variables examined and their expected role in the system, based on current state of scientific knowledge, to correctly identify their effect and adjust for potential confounding or indirect effects on outcomes of interest(Cunningham 2021). For example, we expect an influence of *age* on both the *assessed interaction* and the *transport mode frequency*.

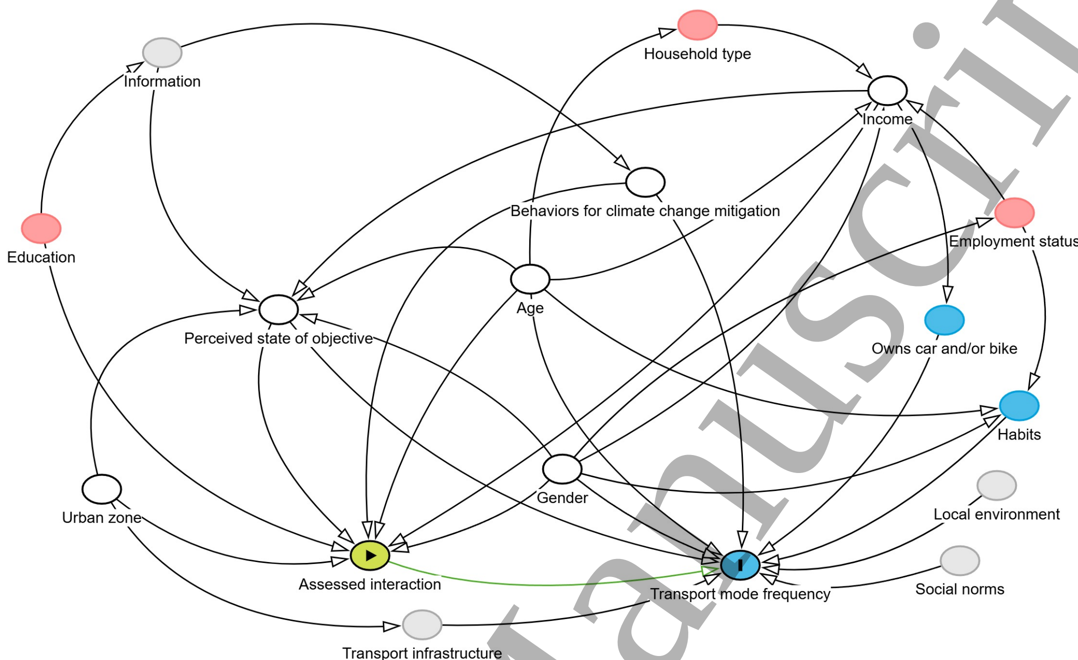

Figure 2. DAG specifiying the causal model used for informing the statistical model, as well as illustrating adjustments undertaken in statistical modeling. Nodes represent variables as follows: The outcome variable (*blue with the letter I*) is the transport mode frequency, the exposure variable (*green*) is the assessed interaction; six variables are adjusted (*white*) to close biasing paths. The remaining variables are ancestors of the outcome variable (*blue*) or of both the outcome and exposure variables (*red*) but are not adjusted to avoid overfitting. Some variables in the model are unobserved (*light gray*) in our data. Figure produced with the web application `www.DAGitty.net` (see also Textor et al. 2016).

The theoretical foundations for our DAG are as follows. An interdisciplinary meta-analysis from Javaid, Creutzig, and Bamberg (2020) provided evidence on the factors influencing transport mode choice, which are mostly individual, social, and infrastructure factors. The individual factors include habit formation processes, socio-demographic factors and behavioral and cognitive factors, which stress the role of attitudes, beliefs, personal norms, and awareness on individual decision-making. The social factors entail social influences, social norms, social identity and social practices (e.g., injunctive norms to use eco-friendly transport modes). Finally, the infrastructure factors imply the built environment and all transport system infrastructure and characteristics (e.g., coverage or quality). The authors stress that infrastructure factors, such as bike lanes, public transportation or walkability, are the most promising ones in terms of impact, but that addressing individual and social level factors as well would be synergetic, in particular, to address the intention-behavior gap (Javaid, Creutzig, and Bamberg 2020).

3.3.1. Observed variables Our DAG (Figure 2) displays the effect we are examining, which goes from a given exposure variable (*assessed interaction*) to a given outcome variable (*transport mode frequency*).

Most of the variables identified in our DAG can be observed in our survey data and were indeed collected at the household level (*household type*, *owns car and/or bike*, range of *income*) or at the individual level (*education*, *age*, *gender*, *employment status*), covering the main potential socio-demographic factors.

Among the variables in our DAG, we assume the prevalence of many confounding factors at the individual level that may drive both individual beliefs and related modal use. Gender is illustrative of this, as we know that women tend to perceive road safety as an issue more than their male counterparts, and they also tend to drive and cycle less than men (Priya Uteng 2021).

At an individual level, accepting the scientific consensus that human activities are causing climate change is influenced by cognitive factors (e.g., understanding scientific concepts such as the greenhouse effect, critical thinking, ability to evaluate the validity of information), so that *education* level might be a proxy to consider. However, in Switzerland, the high literacy level is a given privilege and potential disinformation might be more strongly explained by factors such as social media and/or social isolation. Instead, a useful proxy for our model might be the number of climate change mitigation behaviors an individual has been willing to do. We argue that it is a proxy for both awareness of human-made climate change and related personal norms or political orientation. To capture this, the variable *behaviors for climate change mitigation* is a composite variable summing up a maximum of six consuming behaviors derived from Ivanova et al. (2020) that help mitigate climate change at the individual level.

Javaid, Creutzig, and Bamberg (2020) distinguish between transport mode choices and transport habits: Over time, daily travel behaviors can form "automatic" habits involving no particular reflection. In both our DAG and survey data, we distinguished in a similar manner *transport mode frequency* and *habits*. For instance, a change in *employment status* could mark the beginning of a new habit formation, which could lead to new multi-modal transport choices. This distinction is of special relevance when using a DAG notation, as the graph must be *acyclic*, that is, the influence of a variable cannot loop back on itself.

Finally, we assume that living in different *urban zones* might imply access to differentiated built environments and modal infrastructure (e.g., public transport coverage is expected to be better within the city centers).

3.3.2. Unobserved variables The social and infrastructure-related factors are variables that directly influence transport mode choices (Javaid, Creutzig, and Bamberg 2020). We propose that they are mostly encapsulated in the unobserved variables *social norms* and *transport infrastructure* (e.g., bike lanes and public transport quality or coverage).

Other unobserved variables undeniably play a role in the causal model. The *local environment* can encourage or discourage certain transport modes. For instance, the local climate and its related weather (e.g., cold and rainy days), or temporal circumstances such as those caused by the commuters' "rush hour" (e.g., public transport crowding or road traffic congestion) may also play a non-negligible role in individual transport mode choice. Further, access to different types of *information* plays an increasingly important role as Information and Communication Technology (ICT) develops – from simple access to public transit information to promotion of new forms of shared mobility or multi-modal and eco-friendly travel alternatives.

3.4. Statistical tests

To test our hypotheses, we model the variable Y, i.e., the frequency of using a transport mode, in cumulative ordinal regression models (Bürkner and Vuorre 2019), where we assume the latent continuous variable $\tilde{Y}$ to be normally distributed with a standard deviation of 1. The probabilities of Y being equal to the ordinal category k, given a linear predictor η, are:

$$Pr(Y = k|\eta) = F(\tau_k - \eta) - F(\tau_{k-1} - \eta) \tag{1}$$

where F is the cumulative distribution function and τ_k indicates one of $K = 4$ thresholds (the five levels being (1) "Never", (2) "A few days a year", (3) "A few days a month", (4) "1 to 3 days a week" and (5) "At least 4 days a week"), partitioning $\tilde{Y}$ into $K + 1$, namely $k = 5$ response categories of Y.

Accordingly, we use equation 2 to define the linear predictor η as a function of the citizen assessment of the interaction at scrutiny and further co-variates following the minimal adjustment set we chose to implement to fit the model adequately (i.e., variables in white in our DAG, see Figure 2):

$$\begin{aligned} &y_{[mode\_frequency]} \sim \eta + \epsilon \\ &\eta = \beta_{[mode\_interaction]} \\ &\quad + \beta_{[mode\_objective]} \\ &\quad + \beta_{[pro\_climate\_behaviour]} \\ &\quad + \beta_{[urban\_zone]} \\ &\quad + \beta_{[income]} \\ &\quad + \beta_{[age]} \\ &\quad + \beta_{[gender]} \end{aligned} \tag{2}$$

where $y_{[mode-frequency]}$ is the dependent response variable, multi-level β parameters are all the independent variables whose effects we are accounting for in our model, and ϵ is the error, i.e., the remaining unexplained variation. Specifically, $\beta_{[mode-interaction]}$ is the independent variable whose predicting effect we are trying to grasp. The remaining variables are co-variates we chose to adjust for according to our DAG, namely the perceived state of objective at the source of the interaction, behaviors for climate change mitigation, the type of urban zone where the respondent is living, the income range of their household, and finally the respondent's age and gender. Apart from gender, all these categorical variables are ordinal and cumulative ((Bürkner and Vuorre 2019); see Supplementary Material B): we use a monotonic effect on them to account for this specificity correctly (Bürkner and Charpentier 2020). We use weakly informative Normal(0,5) priors for all β parameters and Normal(0,10) parameters for the intercept parameters. For monotonic effects, we relied on the brms default dirichlet(1) prior, which a priori assumes equal probability of increases in categories for all categories.

We fit models in R using Bayesian Regression Models using Stan, specifically the `brms` package (Bürkner 2017). We fit models using Markov chain Monte Carlo with 4 chains with a total of 2000 iterations, including a burn-in of 1000 iterations. R̂ scores were consistently 1 for all parameters, indicating good convergence. Based on guidelines by Kruschke (2021), we report further key points in any Bayesian analysis (prior and posterior predictive checks, as well as posterior summaries) in Supplementary Material C.

For readability, we convey the results of the four statistical tests by plotting them grouped and colored by assessed interactions for each specific mode use frequency level.

4. Results

4.1. Transport infrastructure for car drivers

Figure 3 displays the predicted probabilities of car-driving frequency levels depending on the assessed interaction. It shows that citizens who believe that facilitated access for car drivers leads to more emissions tend to drive less, thus validating our first hypothesis. In particular, negative assessments predict the probability of ”never” driving cars better than positive ones. Conversely, positive assessments of the interaction can better predict occasional or regular car driving than negative ones.

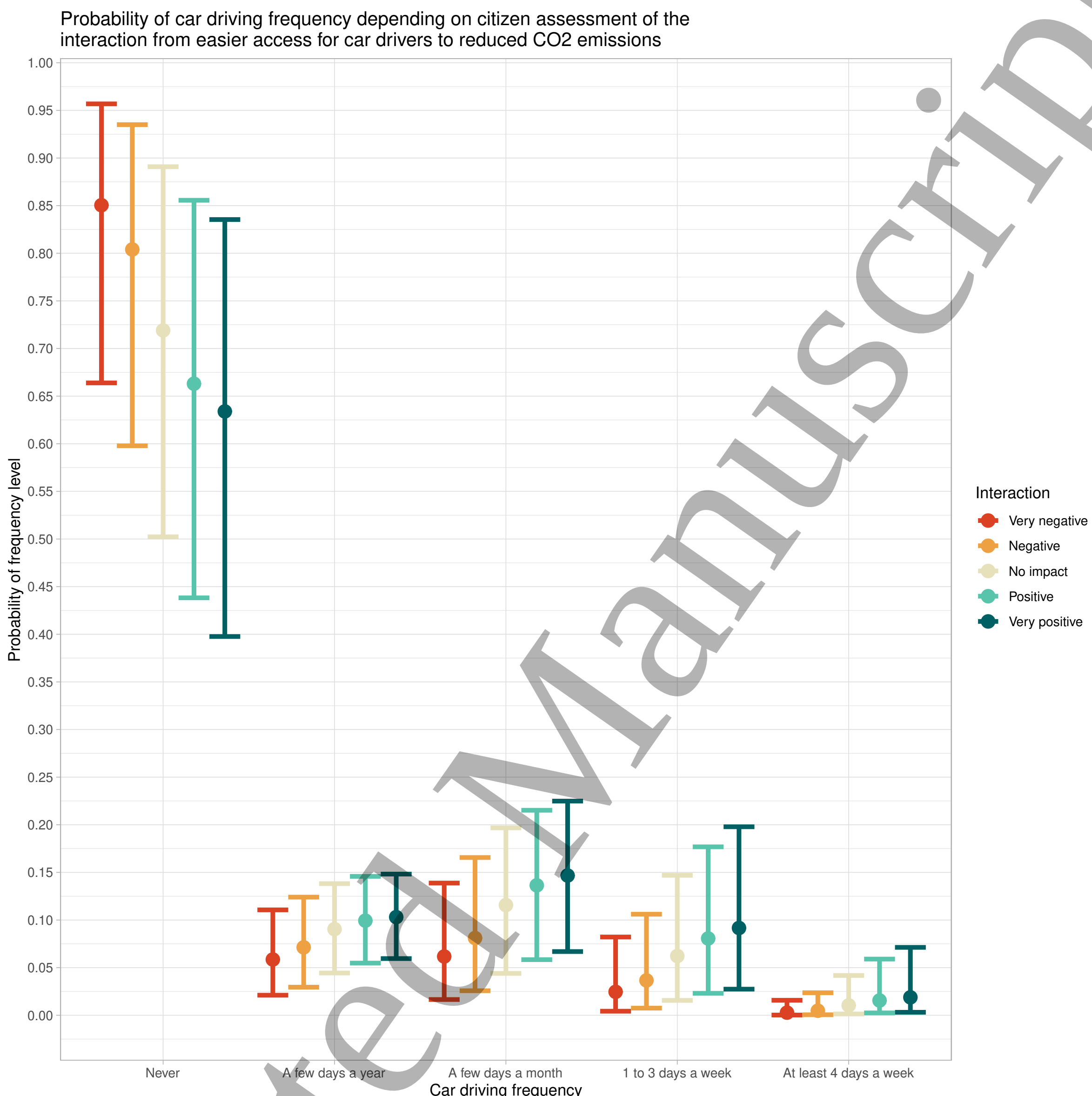

Figure 3. Predicted probabilities of different car driving frequencies depending on how individuals assess the interaction (from very negative to very positive) between easier access for car drivers and reduced CO_2 emissions in the urban transport system. Predicted probabilities are based on the posterior distribution of the fitted model, holding all other model variables besides assessment of the interaction and car driving frequency constant at their mean or reference category. Points indicate the median of the posterior distribution and bars indicate the 95% credible interval.

4.2. Road safety for cyclists

Figure 4 displays the predicted probabilities of cycling frequency levels depending on the assessed interaction. Positive assessments of the interaction going from safer roads for cyclists to reduced emissions are better associated with more cycling frequency among occasional cyclists (citizens who cycle "a few days a year" or "a few days a month") than negative assessments. Among the overwhelming majority of citizens who "never" cycle, we observe the reverse trend: negative assessments predict the transport mode frequency better than positive ones. As for the effect among the very regular cyclists, it is either marginal or non-existent.

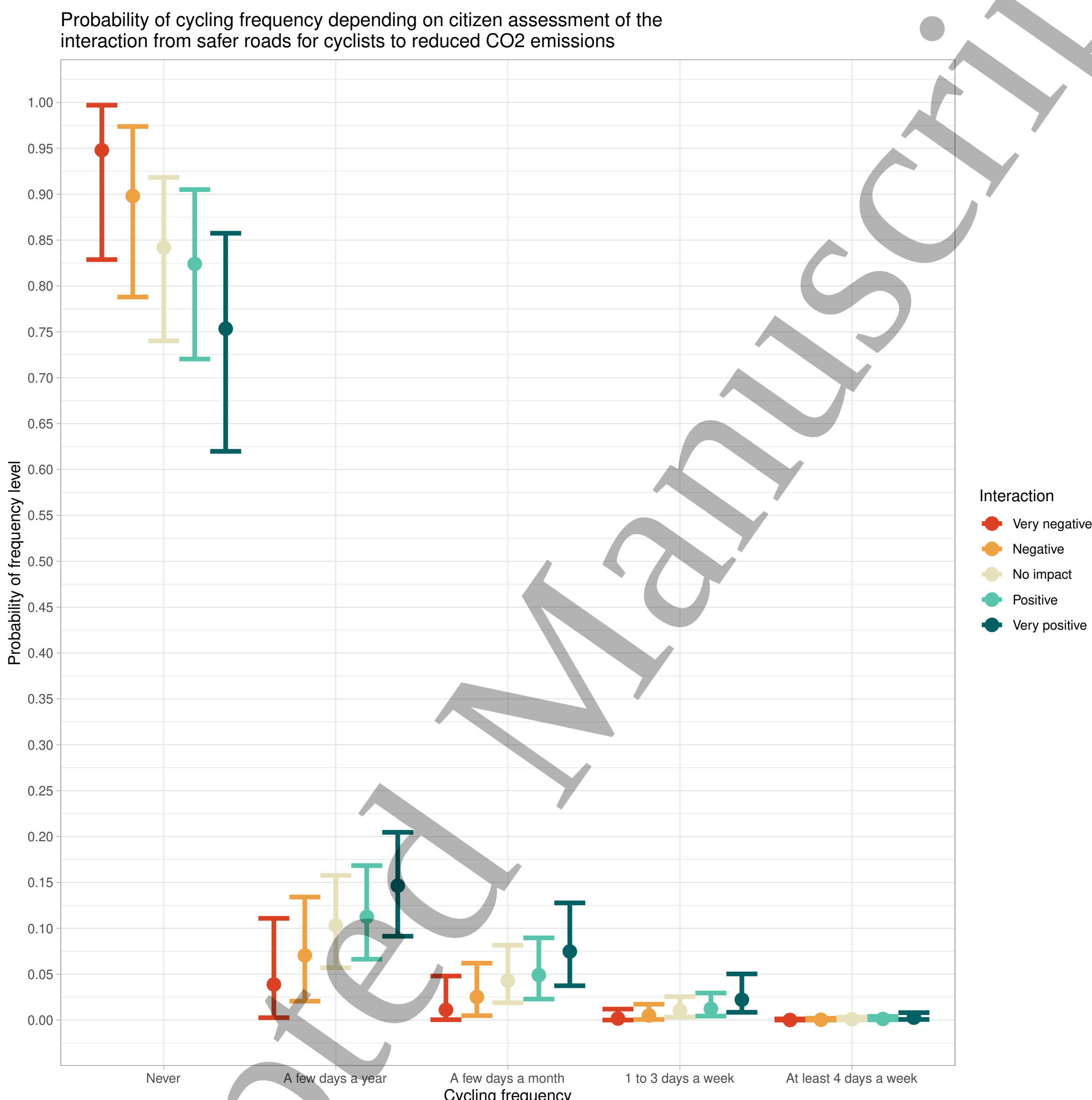

Figure 4. Predicted probabilities of different cycling frequencies depending on how individuals assess the interaction (from very negative to very positive) between improved road safety for cyclists and reduced CO_2 emissions in the urban transport system. Predicted probabilities are based on the posterior distribution of the fitted model, holding all other model variables besides assessment of the interaction and car driving frequency constant at their mean or reference category. Points indicate the median of the posterior distribution and bars indicate the 95% credible interval.

4.3. Affordability by transport mode

Figure 5 displays the predicted probabilities of car driving and public transport use frequencies, respectively, depending on the assessed interaction. Just like the findings on infrastructure for car drivers, panel A shows that people who believe cheaper car driving leads to more emissions tend to drive less. For car driving (panel A in Figure 5), the probability of "never" driving decreases substantially with increasing positive perception of the interaction. Conversely, more positive assessments of the interaction can predict occasional or regular car use ("a few days a year", "a few days a month", and "a to 3 days a week"). The large uncertainty range for the probability of never using public transport given a very negative assessment of the interaction between affordable public transport and reduced emissions displayed in panel B is due to limited data points on this specific combination and should not be substantively interpreted.

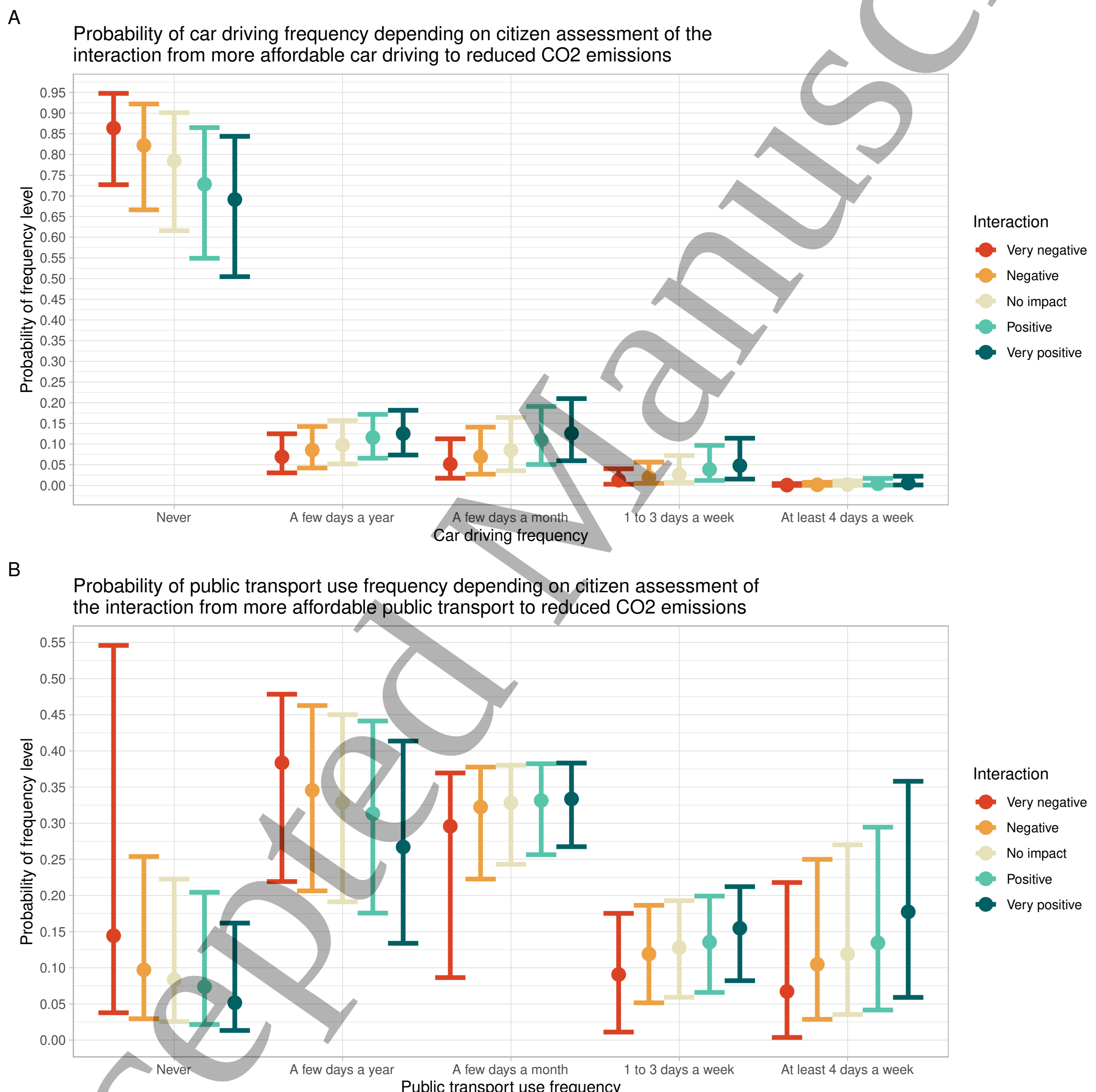

Figure 5. Predicted probabilities of car driving frequencies (A) and public transport use frequencies (B) depending on how individuals assess the interaction (from very negative to very positive) between affordability of car (A) or public (B) transport and reduced CO_2 emissions in the urban transport system. Predicted probabilities are based on the posterior distribution of the fitted model, holding all other model variables besides assessment of the interaction and car driving frequency constant at their mean or reference category. Points indicate the median of the posterior distribution and bars indicate the 95% credible interval.

A similar, though less pronounced trend is observed for public transport use (panel B in Figure 5). Negative assessments predict better no or rare public transport use ("never", "a few days a year") than positive ones; and positive assessments predict better regular use than negative ones.

5. Discussion

5.1. Shifting transport modes

Urban sustainability hinges on its citizens; understanding their choices between sustainable and unsustainable options is crucial (Stieninger Hurtado 2018). Furthermore, peri-urban dynamics and their rapid pace of change are often missed in policy and planning because these processes rely on top-down expertise and coarse, aggregated data, leading to a neglect of important trade-offs (Dolley et al. 2020). The present findings contribute to the body of evidence surrounding these studies by demonstrating that understanding citizens' perceptions of environmental consequences can influence a modal shift in mobility behaviour. Specifically, negative citizen assessments of the environmental impact of car-related infrastructure and affordability are associated with lower car-driving frequency, indicating a potential openness to modal shift. Conversely, positive citizen assessments of the environmental benefits of improved road safety for cyclists and affordable public transport are associated with increased frequency of cycling and public transport use, respectively. These insights emphasise the necessity of incorporating citizens' perceptions into planning for more effective transformation towards sustainable urban transport.

5.2. Study limitations

Some of the study's limitations may stem from the challenging survey design. We needed to ensure clarity and ease of use for respondents while collecting extensive data on SDG interactions. The large number of interactions may have included irrelevant or unclear ones, which could have led to fatigue and reduced quality. While we can relate respondent assessments and mode use frequency in this article, we have limited ability to understand the causal mechanisms behind the links found at the individual level.

5.3. Future research

Including citizen perspectives is increasingly recognized as key for more legitimate societal transformations (Poelsma et al. 2024). Specifically, the use of surveys holds the potential to consider a larger range of perspectives, enabling the assessment of preferences and willingness to support policy measures (Alonso et al. 2023; Ogunkunbi and Meszaros 2023) or modify consumption patterns (Semenza et al. 2008).

Further research is needed to understand the systemic role of the remaining key factors we identified in our DAG but didn't address in this study such as social norms across societal groups, concrete transport infrastructure (e.g., charging stations for the expansion of e-mobility (Mastoi et al. 2022; Singh et al. 2024)), local environment, and transport-related ICTs and information systems in smart cities (promoting for instance mobility-as-a-service (Hoerler et al. 2020; Krauss, Reck, and Axhausen 2023; Mustapha, Ozkan, and Turetken 2024), such as ride-hailing (Olayode et al. 2023; Xie et al. 2019).

6. Conclusion

The study's results show the significance of subjective perceptions in influencing mobility behaviour, thereby supporting the notion that more citizen-centred approaches are required in urban planning. From methodological point of view, this study makes a novel contribution and shows the potential of using a Bayesian approach to investigate how a change of perspective might change habits.

Data availability statement

The script and data to reproduce this study are available under:
`https://doi.org/10.5281/zenodo.14900322`

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