Acceptance of car-reducing measures: observed factors and latent attitudes

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SHORT SUMMARY

Major cities are increasingly willing to reclaim public space from cars. This paper analyses the acceptance of car-reducing measures by different segments of the population. The respondents of a stated preference survey in Munich, Germany, were asked whether they accept one or more measures designed to decrease the ownership and use of private cars, and to state their opinion on theoretical statements regarding private cars and the environment. Factor analysis and binomial regression were employed to model the relationship between the established travel behaviour, socio-demographics and latent attitudinal constructs on the one side, with acceptance on the other. The results showed that age, education, occupation and income, as well as environmentally friendly travel behaviour and attitudes play a major role in acceptance, thus providing valuable policy recommendations.

Keywords: attitudes, factor analysis, socio-demographics, travel behaviour, transport policy

1. INTRODUCTION

Measures against private cars have the goal to reduce traffic congestion, to mitigate the external costs of transportation and to reclaim urban space for social, commercial and recreational activities. With this aim, many researchers proposed relevant measures such as road pricing, parking restrictions, improved infrastructure for active modes, incentives for public transport, within-neighbourhood mobility and concentration of land uses to reduce distances (Gärling, Gärling, & Johansson, 2000). However, the public acceptance of those measures varies and turns out to be a key issue for their success (Banister, 2008).

Such measures can be distinguished based on their coerciveness. According to Loukopoulos et al. (2005), coercive measures, also named hard or structural measures, are less acceptable by the public than noncoercive measures – an example of the former is the prohibition of car traffic in city centres. By contrast, noncoercive measures (e.g. reduced fares in public transport), also called soft or psychological measures, may be politically and socially more feasible (Friman, Larhult, & Gärling, 2013). Similarly, push measures are perceived as ineffective, unfair and not acceptable, whereas pull measures are perceived to be effective, fair and acceptable (Eriksson, Garvill, & Nordlund, 2008).

Another important factor is the effectiveness of those measures. Romero et al. (2019) investigated the influence of driving restrictions in Madrid and found the modal shift towards public transport to be modest, explained likely by the large number of cars driving into the city from the outskirts.

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Yan, Levine, & Marans (2019) investigated the responses of travellers to different parking attributes, e.g. search time and parking cost, and found that the primary response was changing parking location rather than shifting to another mode. In Gonzalez, Gomez, & Vassallo (2022) parking restrictions and low emission zones were found to encourage greener mobility, although owners of cleaner vehicles were unwilling towards shifting to public transport due to the perceived benefits stemming from their vehicles. Becker, Ciari, & Axhausen (2018) stated that free-floating car-sharing could reduce car ownership, however, there are differences compared to station-based schemes.

The objective of this study is to provide insight into the factors associated with the acceptability of measures against private cars. These factors can be related to the established travel behaviour, the socio-demographics and the underlying attitudes of individuals when concerned with questions about car ownership and the environment. More information about the dataset, the methodology, the results and the main findings are presented in the next sections.

2. METHODOLOGY

Data collection

The dataset was collected through an online panel (Schlesinger Group) as part of a stated preference mode choice survey in Munich, Germany. The survey includes four bundles of measures that aim to reduce the ownership and use of private cars and to encourage the use of active and environmentally friendly alternatives:

1. Extending the existing mobility hub network.
2. Removing on-street parking spots in favour of multipurpose garages.
3. Promoting neighbourhood mobility by creating attractive public spaces.
4. Facilitating active mobility and restricting motorised private transport.

The respondents could accept one or more bundles or to reject the measures altogether *(None of the above - everything should remain as it is)*. Furthermore, the survey included twelve attitudinal statements (Table 1) about car ownership and the environmental concerns of the individuals. The participants were asked to express their opinion about the statements in a five-level rating (Likert) scale from *Strongly disagree* to *Strongly agree*. Other collected data include information about their usual travel behaviour and socio-demographic questions.

Data analysis

Two modelling techniques were used in this study, namely factor analysis and binomial regression. Exploratory factor analysis (EFA) is a statistical technique that aims to explore the underlying correlations between measurable variables. The result of EFA is a latent construct *(factor)* and the association strength between the latent construct and the measured variables *(loadings)*. Confirmatory factor analysis (CFA) is a structural equation modelling technique that investigates relations between latent constructs and observed variables in an a priori specified theoretical model. Therefore, to apply CFA in this study, we assume that underlying attitudes that influence the acceptance of the bundles of measures exist. Further, we assume that the acceptance is influenced by the established travel behaviour and to the socio-demographics of the sample. The null hypothesis in factor analysis is that the correlation matrix of the assumed model does not differ from the one implied by the data.

To construct the models, we assume that pro-environmental attitudes are associated with the acceptance of measures, while attitudes in favour of cars contribute to the rejection of the measures. The structural models are estimated using the *R*-package *lavaan* (Rosseel, 2012). Between EFA and CFA we employ binomial regression in order to perform a first selection of the observed variables.

Table 1: Statements regarding car ownership and the environment

Statement	Variable
Car ownership	
A car is a symbol of social status for me.	Symbol
Having access to a car invokes to me a feeling of independence and freedom.	Independence
The brand/manufacturer is important to me when choosing to buy a car.	Brand
I deserve to own a good car because I have been successful in life.	Success
I feel accomplished and fulfilled after buying a car.	Accomplishment
A car is essential to my everyday mobility needs.	Essential
Environment	
The use of individual motorised transport threatens the environment	Threat
It is my obligation to protect the environment through my transportation mode choice.	Protection
The government should increase the price of fuel in order to invest in public transport.*	Fuel Price
A way to reduce congestion is to ban cars from city centres.	Carfree
I am concerned about the future of our planet.	Future
I have already moved towards a more environmentally friendly lifestyle.	Lifestyle Change

**Source:* Schmid, Schmutz, & Axhausen (2016)

3. RESULTS AND DISCUSSION

Established travel behaviour and socio-demographics

Some observations were filtered out of the initial sample, either because the respondents speeded through the questionnaire (completion time less than one third of the estimated time of 15 minutes), or because their socio-demographic category was underrepresented, e.g. gender *Diverse* or *I prefer not to say*. The resulting sample size was *N=1497*. At least one bundle was selected by 1230 respondents, whereas 267 respondents declined all measures. A comparison of the sample with the latest published census (Federal Statistical Office, 2011) can be seen in Table 2.

Table 2: Key characteristics of the respondents

Variable	**Answer**	**Sample (%)** *N=1497*	**Census (%)** *2011*
Gender	Female	46.8	51.7
	Male	53.2	48.3
Age	≤17	0	14.6
	18-29	18.0	17.2
	30-39	21.6	16.7
	40-49	18.7	16.2
	50-59	21.0	11.8
	60-69	14.8	10.7
	70-79	4.9	8.4
	≥80	0.8	4.4
Occupation	Full-time work	60.5	56.5
	Part-time work	16.2	
	Pupil, student or apprentice	6.5	4.5
	Retired	11.4	18.3
	Housewife/Househusband	1.9	2.9
	Other	2.4	17.8
	No answer	1.1	
Size of household (no. of people)	1	30.0	50.3
	2	37.3	28.8
	3	13.4	10.6
	≥4	18.9	10.3
Driving license	Yes	90.0	88.9*
	No	10.0	11.1*
Car ownership	0	29.8	44.0*
	1	52.0	49.0*
	≥2	18.2	7.0*

**Mobilität in Deutschland* (infas, DLR, IVT & infas 360, 2018)

Attitudes about car ownership and the environment

The answers to the attitudinal statements are summarised in Figure 1.

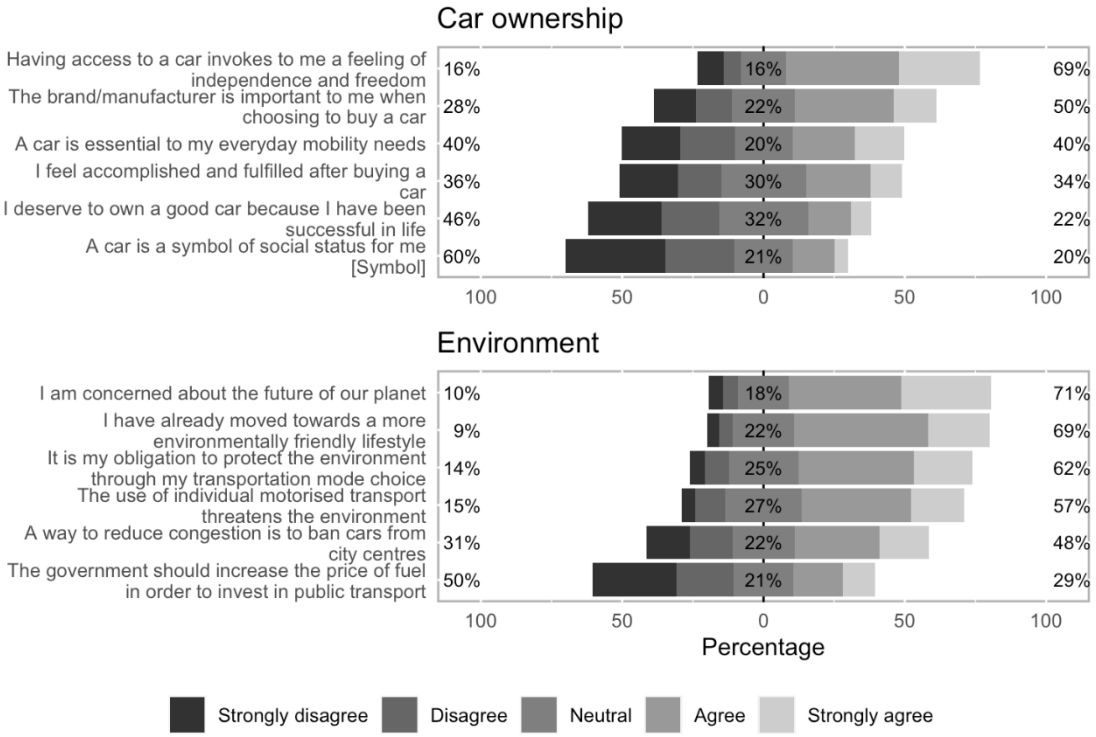

Figure 1: Responses to attitudinal questions

To check the conformity of the dataset with the assumptions of EFA, two inspection metrics are calculated. The χ^2-statistic with 66 df, calculated by Bartlett's test of sphericity, is close to 500, which indicates that the data are not an identity matrix at 95% confidence level. Furthermore, the Kaiser-Meyer-Olkin measure of sampling adequacy is 0.88, which suggests that the data are suitable for EFA (Howard, 2016). The eigenvalues of factors suggest empirically that between two and four factors should be retained in the model. Comparing the full model (four factors) with the parsimonious model of two factors results in a loss of explained variance of 0.05, while gaining in interpretation. Table 3 shows the factor loadings of the EFA model with two factors after oblique rotation, which results in an interpretable structure when the factors are correlated. It can be seen that:

1) All variables about environmentally friendly travel behaviour were associated with Factor 1 and
2) All variables related to car use and ownership were associated with Factor 2.

Therefore, Factor 1 is interpreted as "Pro-Environment" and Factor 2 as "Pro-Car" attitudes. We expect pro-environment attitudes to be associated with higher willingness to accept any of the measures, while attitudes in favour of cars are could be more resistant to changes.

Table 3: Factor loadings for attitudes towards car ownership and the environment (loadings ≤ 0.3 not presented, ≥ 0.7 highlighted)

Variable	Factor 1	Factor 2
Symbol		**0.718**
Independence		0.605
Brand		0.686
Success		**0.820**
Accomplishment		**0.828**
Essential		0.531
Threat	**0.741**	
Protection	**0.834**	
Fuel Price	0.647	
Carfree	**0.713**	
Future	**0.727**	
Lifestyle change	0.673	
Summary statistics		
Proportional variance	0.269	0.251
Cumulative variance		0.520
χ^2-statistic 644.12		
Factor interpretation	*Pro-Environment*	*Pro-Car*

Modelling the acceptance

First, we model the acceptance by binomial regression using as explanatory variables the measurable travel behaviour and the socio-demographics of the respondents. We check for separation effects in terms of the levels of the response variable and remove all instances with less than five occurrences in the sample. Non-significant variables with the appropriate sign are grouped with significant variables to enhance the interpretability of the model (*AIC* = 1170.9, McFadden pseudo-R^2 = 0.45*)*. The main findings are summarised below:

(1) Age: people 30-59 years old seem to disregard the measures, a possible explanation being that individuals in working age have less time to investigate alternatives and habitually select one mode of transport.
(2) Education: basic education (finished high school) and other types of education, e.g. professional training in Germany, are also connected with lower willingness to accept. Those education types are probably associated with out-of-office activities that require freedom of mobility.
(3) Occupation: students seem to accept the measures, while housewives and househusbands seem to disregard them. Students often use public transport, on the contrary, housewives and househusbands travel often for shopping trips, where avoiding the car is not always an alternative.
(4) Household income: medium to higher income households (4000-7000 € per month) tend to accept the measures; due to their financial flexibility, they are likely willing to try alternatives.
(5) Duration of residence: living in Munich for 1-3 years is associated with the adoption of measures, while other durations did not result in any significant relation.
(6) Subscription for public transport: regular users indicate their agreement with the measures, which also aim to shift much of the demand to public transport.

(7) Driving license: the positive association may relate to the fact that the vast majority of respondents hold a license. In contrast, people without a license are probably driven around by others or belong to a population segment that was not captured well by this survey.
(8) Home office: 2-5 days per week seems to contribute to the acceptance, because people do not have to change their commute patterns. By contrast, no conclusion can be drawn for those who work remotely one day per week or less.
(9) Modes of transport: active transportation, such as walking and bike, are associated positively with the measures. As expected, using a car for leisure trips relates to a negative impact. Furthermore, commuters to work with travel companions are also more likely to accept, possibly because they have a lower sensitivity to changes of travel time.
(10) Ownership of vehicles: bike owners are willing to accept the measures, which largely could improve the conditions for them, while no pattern could be identified for owners of other vehicles, including private cars, e-scooters and cargo bikes.
(11) Use of micromobility: respondents that indicated to use on-demand micromobility regularly stated that they will accept, as the measures aim to improve conditions for micromobility too.

No meaningful relation was found for *disabled* people, which were expected to vastly disregard the measures. Additionally, households *owning* or *planning to buy* a private vehicle were not related with the acceptance of the measures. The *household size* did not impact the acceptance of the models, despite our expectation that having children could impact the acceptance negatively.

The detailed results of the binomial model are not given. Instead, we add the latent factors Pro-Environment and Pro-Car and create a structural equation model to reveal the correlation between the underlying attitudes and the acceptance of the car-reducing measures. Although the coefficient estimates of the measurable characteristics change slightly in comparison to the binomial model, they remain consistent in sign and magnitude (Table 4).

Table 4: Structural modelling results

Indicator	Estimate	Std. Error	*t*-stat.
Regressions			
Age 30-59	-0.27	0.10	-2.85**
Education High School	-0.18	0.09	-1.95 .
Education Other	-0.72	0.27	-2.66**
Occupation Student	0.55	0.29	1.93 .
Occupation Housewife/husband	-0.53	0.25	-2.09**
Household income 4000-7000 €/month	0.21	0.10	2.12**
Home office 2-5 days	0.24	0.09	2.60**
Resident 1-3 years	0.60	0.28	2.13**
Subscription Public Transport	0.28	0.11	2.60**
Driving License	0.35	0.14	2.49**
Car to Leisure	-0.42	0.10	-4.26***
Public transport to work	0.43	0.12	3.76***
Bike to Work	0.47	0.17	2.82**
Bike to shopping	0.27	0.14	1.94 .
Walk to Shopping	0.22	0.10	2.15**
Car with companion to Work	0.94	0.29	3.29**
Own Bike	0.22	0.10	2.13**
Use micromobility	0.70	0.12	5.76***
Pro-Environment	*0.71*	*0.05*	*13.82****
Pro-Car	*0.08*	*0.06*	*1.32*
Covariances			
Pro-Environment ~ Pro-Car	*-0.17*	*0.01*	*-12.57****
Summary statistics			
R^2	0.537		
χ^2-statistic	2838.958 with 279 df		
CFI	0.904		
TLI	0.973		
RMSEA	0.078, 90% CI [0.076, 0.081]		

Significance: 0 '***' 0.001 '**' 0.05 '.' 0.1

The results suggest that pro-environmental attitudes partially explain the willingness to accept car-reducing measures. On the other hand, attitudes in favour of owning and using a private car do not necessarily associate with the rejection of the proposed measures. This is indicated by the *t*-statistic, which is large in the case of Pro-Environment, meaning that the null hypothesis of the coefficient estimate being equal to zero can be rejected, whereas it is low for Pro-Car, meaning that there is not enough evidence to reject the null hypothesis at a confidence level of 90% at least. Overall, the assumed model is valid as indicated by the Comparative Fit (CFI) and the Tucker-Lewis (TLI) indices being over 0.9.

4. CONCLUSIONS

In this short paper, citizens' acceptance of car-reducing measures is assessed using data from a survey. Through explanatory factor analysis, the responses of individuals to questions relating to

the environment and to private cars were clustered into latent attitudinal constructs. Subsequently, binomial regression and structural equation modelling reveal that pro-environmental attitudes are affiliated with a higher willingness to accept the measures, whereas attitudes associated with owning and using a car do not provide sufficient evidence against them. Other key factors include medium to high household income, possibility to work from home, public transport subscription, driving license and the habitual use of active modes of transport and micromobility.

A methodological limitation is that the presented models do not account for interactions between variables. Further, some answers in this study might be biased; the respondents were not aware of the goal of this project, which was to achieve modal shift towards alternative modes of transport but may have been able to infer this from the context and the formulations of the four bundles of measures. In the future, further effort should go into understanding which are the factors that influence each measure separately.

Overall, this work can be seen as a tool to target the relevant audiences when local authorities take decisions to curb motorised traffic. They can either target the mentioned population groups and maximise their acceptance of the measures or nudge the groups that would otherwise not accept the measures and shift their grounds.

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