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Mind the gap: A comparative study of low-car policy acceptance

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ABSTRACT

The introduction or even consideration of low-car interventions may spark a heated debate amongst residents as well as between local authorities and residents. We investigate residents' and stakeholders' views towards different types of low-car city interventions, using Amsterdam as a case study. We compile a list of 28 low-car measures and identify the most and least favorable measures. In particular, we conduct a comparative analysis thereby contrasting the residents' own views, stakeholders' own views as representatives of their organization and stakeholders' expectations of the residents' views. Exploratory factor analysis is employed as a data reduction technique, followed by the application of a latent class cluster analysis, which reveals three clusters of Amsterdam residents which can be broadly labelled as supporters, skeptics and the ones with mixed attitude towards the low-car concept. Moreover, our findings show that stakeholders tend to express more support than residents towards low-car policy interventions as well as often over-estimate residents' support, highlighting the need for improving bi-directional communication.

1. Introduction

A transition towards a less car-oriented urban mobility system is an essential, although highly challenging task that cities around the world are facing, amidst an era of severe uncertainties caused by factors relayed to climate change and technological developments (Gall et al., 2023) such as electric and autonomous vehicles (EVs and AVs), artificial intelligence (AI), big data analytics, digital twins and digital mobility platforms to name just a few - all of which are reshaping how urban mobility is planned and experienced. Decreasing the number of cars in cities has become a key objective for policy-makers in recent decades, as it has proven to be one of the most efficient ways to limit the negative impact associated with its use, on different aspects of urban life (Kuss and Nicholas, 2022). Such negative impacts that can cause severe risks for the urban residents' health include air pollution (Adams and Requia, 2017; Degraeuwe et al., 2017), congestion (Struyf et al., 2022; Fan and Harper, 2022), urban fragmentation (Delclos-Alio et al., 2023), excessive land consumption (Guzman et al., 2021), noise (EEA, 2020) and visual pollution (Anciaes, 2021). Aiming at changing this status quo, many cities have started experimenting with different interventions revolving around the concept of the so-called "low-car city". These interventions aim at promoting a modal shift from private car to alternative, more sustainable modes of transport.

The introduction or even consideration of low-car interventions may spark a heated debate amongst residents and between local authorities and residents. A drastic and novel change, such as taking away the ability to access by car a specific area, that has been taken for granted so far, can prompt a negative response by some of the inhabitants. This became clearly evident when for instance, in 2023 the City of Amsterdam implemented different mobility experiments which included the closing of an urban arterial street (Weesperstraat) for car traffic between 6 am and 11 pm for a period of 6 weeks, with the intention to make the closure permanent as of 2025. Throughout its application, the measure has proved to be controversial and met by opposition from part of the area's residents and businesses, leading the city to withdraw its original plan. Residents' acceptance has been proven to be a key factor to consider prior to the implementation of different mobility-related measures, such as congestion charging (Schaller, 2010; Li and Hensher, 2012).

Past research on congestion charging for example suggests that residents' views might become more favorable following the implementation of such measures, presumably due to the status quo bias (Schuitema et al., 2010). When sufficient information is available regarding the measure and the full range of benefits that are expected from its

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implementation, the level of acceptance tends to increase (Noordegraaf et al., 2014), even more so when the aforementioned benefits start to be tangible and the residents can experience an improvement in their everyday lives (Tvinnereim et al., 2020; Eliason and Jonsson, 2011). In this research, we adopt the definition of acceptance suggested by Marcheschi et al. (2022) who studied the residents' acceptance towards car-free street experiments, and according to whom "acceptance refers to "the degree to which residents are supportive of car – free interventions occurring in their residential neighbourhood setting" (previously also used in Küller and Laike (1992). Adapting it to the context of the present study, acceptance can be defined as the degree to which residents are supportive towards low-car interventions occurring in their city or/and neighbourhood. Other researchers have used the term "acceptability" (e.g. see Marquet et al., 2024).

The significance of timely engagement and participation of the public in the urban transport planning process has been the topic of numerous studies (e.g. see Kyriakidis et al., 2023) and public acceptance has often emerged as a" break-or-make" determinant for the success and longevity of new transport policies (Lambert, 2012). Amidst the discussion of transforming cities into spaces much less dependent on the private car in the years to come and the inconvenience that this idea seems to be causing to (at least a part of) their residents, the following question arises: what do residents actually think about different low-car urban interventions? There is a risk that a divergence between planning visions and residents' perceptions may lead to growing resistance.

The objectives of this research are thus twofold; we aim to examine the perceptions and views of residents and those of different stakeholders regarding the low-car city strategic vision. By perceptions we refer herein to individuals' subjective interpretations, beliefs and evaluations regarding a measure or policy, including its fairness, feasibility and anticipated outcomes (Steg and Vlek, 2009; Schuitema et al., 2010). These perceptions can shape attitudes and therefore influence acceptance and response to different urban interventions. In particular we attempt to dive into the residents' (lack of) acceptance of this vision and the related measures that are already being implemented and/or might be implemented in the future as part of this vision.

By doing so we address the following research questions:

- What are the acceptance levels amongst residents towards different concepts and measures related to the low-car city?
- Are there latent groups of residents with distinct characteristics with regard to their view towards the low-car city concept and do these groups differ in terms of their socio-demographic characteristics?
- Is there a unanimous view on this topic amongst local planners/stakeholders and are there systemic discrepancies between the views of residents and those held by local planners?

Our research approach includes the design, implementation and analysis of the results of two surveys, one addressed to residents of the Greater Amsterdam Region and one to various stakeholders which are part of the local planners' community. Although The Netherlands is often taken as a bright example of a cycling – friendly country, at the same 42 % of urban trips (based on 2018 data) are made by car (Soza-Parra et al., 2022). Working towards a transition to a low-car city, the City of Amsterdam introduced in 2018 the "Amsterdam Agenda Autoluw" program, i.e. Autoluw can be roughly translated to 'low-car'. According to it, low-car does not imply banning all car traffic from the city but rather carefully and gradually reducing car traffic, ensuring that accessibility is guaranteed through other means of transport.

The remainder of the article is structured as follows: Initially a literature review is conducted, comprising two parts; in the first, an inventory and categorization of various interventions/policy/measures aiming at reducing dependence on cars is presented. It is worth mentioning at this point that according to Van Eenoo (2025), "car dependence" is a multifaceted concept, often reflecting not only the high ownership percentage of private vehicles and the extended usage of those, but also other factors such as societal perceptions about the role of the car and policy decisions that have an impact on car reliance, with land use patterns and existing transportation infrastructure also potentially influencing the way we interpret the term. In the present study, reducing car dependence refers to limiting car use, while taking into account the aforementioned societal and political considerations regarding the role of car would be out of scope of this work.

The second part focuses on studies which employed surveys to investigate public perceptions of topics related to transport and mobility. The following section details the survey design and content of both surveys that this study entails (Section 3). Next, the analysis of the collected data is presented and discussed (Section 4). We conclude with discussing the implications of our findings and ideas/perspectives for future research (Section 5).

2. Literature review

2.1. Urban interventions towards a low-car city: inventory and categorization

Urban mobility interventions which aim at reducing car usage are often divided into two broad categories: on one hand the "push" measures, which comprise restrictions or disincentives to achieve that, and on the other hand the "pull" measures, which offer attractive alternatives and incentives to get people out of their cars. Some measures that classify as push and have already been applied in Amsterdam, including cutting off traffic in certain streets, removing parking spaces in and around the city centre, reducing the maximum speed allowed to 30 km/h (from 50 km/h which was the pre-existing limit), and increasing parking fees. Pull measures implemented in Amsterdam include, among others, improved pedestrian facilities, a high-frequency metro service, dedicated bus and tram lanes and shared mobility hubs. Note that certain interventions combine attributes of both approaches, such as the transformation of prior parking spaces to green areas, "pocket parks" or playgrounds, which at the same time take something from urban residents (in this example, parking space) but give something back in return which can benefit their health and improve their quality of life. Traditionally, pull measures, such as expanded and high quality public transport services and provision of shared mobility, tend to be more welcome by the public whereas push measures such as increased parking fees often encounter resistance. A detailed inventory and categorization of urban interventions and international case studies of different kinds found in the literature (scientific papers and grey literature, see sources therein), which are aimed at reducing the presence of cars is presented in the Appendix (Table A1).

For this categorization, the comprehensive classification suggested by the recent meta-analysis study of Kuss and Nicholas (2022) was used as a point of departure. The main categories of interventions were adapted and new ones were added, leading to the following eight *Intervention categories* of: 1. Charging and pricing, 2. Access limitations, 3. Parking management, 4. Improvement of public transport/active modes infrastructure/mobility services, 5. Shared mobility, 6. Travel planning, 7. Gamification, and 8. Public space (urban planning/mobility). It should be highlighted that this inventory of urban interventions is not meant to be by any means exhaustive, but rather used as a basis for a selection of interventions to be included in our study.

Within each of these categories an inventory of *Intervention types* is created, and the *Main measures* of which are identified. In addition, the following four *Policy instruments* used in Kuss and Nicholas (2022): "regulatory, economic, information and education, public goods and services" are used to characterize all interventions, as well as the "push or pull" (or a combination thereof) label for describing the *Intervention approach*. Finally, *Case studies* where some of these measures have been applied are also mentioned in Table A1. Please note that the *Case studies* column includes actual application cases, and not cities for which studies regarding the potential application of specific measures were performed.As can be observed from Table A1, policies vary from more established measures that have already been tried out in many cities - such as congestion charging and low emission zones - to more pioneering or emerging ideas with which there is insofar limited experience, such as intelligent access and some measures of the gamification category. Mixed results are reported from the implementation of different policies, with some measures being (far) more successful and effective than others. Moreover, the reported impact may vary across urban contexts for the same policy whereas for others policies, for example the decreasing of car speed to 30 km/h, the impact of which has been unanimously positive. The main takeaway from the table is the diversity of existing approaches that can be considered under the umbrella objective of limiting high car use in a city. This underlines the importance of understanding the views of urban dwellers towards all these different possible paths which policy-makers may undertake in their efforts to achieve a low-car vision.

2.2. Public acceptance towards low-car interventions

For a review of the topic of public acceptance towards urban interventions of different kinds, including transport, see e.g. Banerjee et al. (2021), Pridmore and Miola (2011), Kresnanto (2024). In the following we focus on related work which shed light on the complex topic of public acceptance of urban mobility interventions directed at low-car developments.

A few studies have identified factors that can influence how the public perceives different mobility-related policy and measures that have as a common denominator the intention to reduce high car use. Different levels of acceptance towards diverse types of measures were identified in past studies and some of these differences could be attributed to differences amongst population groups and having different mobility characteristics. Marcheschi et al. (2022) investigated experts and residents views concerning four car-free street urban experiments in several Swedish cities, through observations in place, walk-through and bike-through interviews and with the aid of an environmental audit tool. The study concluded that quality of life, as well as inhabitants' affinity with the area they live, can have a significant impact on the acceptance levels of such experiments. For instance, Lanzendorf et al. (2023) investigated whether the residents of Frankfurt, Germany, were in favor of parking management, car lane conversion and road closures, and found that younger people tend to be more receptive to this type of measures, while older residents did not appear so inclined to change their daily car habits. The study also concluded that noteworthy differences can be found in relation to different measures, with residents tending to welcome more the "pull" measures rather than the "push" ones.

Also focusing on factors that can influence acceptance, Goetting and Jarass (2023) used regression analysis to analyze the results of their survey and found that respondents appeared divided in terms of their degree of acceptance of a temporary urban experiment, during which a street in Berlin became car-free for a month. The survey was conducted after the intervention; perceived fairness has proven to be a crucial determining factor of acceptability, and the authors noted differences among different age groups. Kyriakidis et al. (2023) assessed the viability, from the users' perspective, of a set of measures implemented in Athens during the period of the Covid-19 pandemic using descriptive statistics and Markov Chain Model analysis. The results showed a reverse correlation with car ownership, with the majority of participants and especially car-owners disapproving the interventions. Kresnanto (2024), investigated the public acceptance towards transportation demand management measures such as road pricing and license plate restriction and found that the acceptance was influenced by underlying factors such as the personal existing (un)willingness to reduce car use.

Other studies focused on circumstances under which a low-car vision could be more easily accepted by the local population. For instance, Gundlach et al. (2018) used a stated-preferences choice experiment and found that approximately 60 % of the survey participants appeared positive towards the idea of a car-free city center in Berlin, Germany, especially in case this would be accompanied with improved cycling infrastructure and/or a denser network of bus stops and train stations. There are also studies that are conducted after the implementation of certain low-car measures, that show that even if there was the possibility to return to the previous, pro-interventions state, the public would not opt for that. Szarata et al. (2017) evaluated the implementation of traffic and parking restrictions introduced over a period of 10 years in Cracow, Poland, by using a survey addressed to a part of the directly affected inhabitants. The great majority of respondents (75 %) said that they would not want to return to the previous situation, prior to the urban interventions and an even higher percentage (83 %) replied that they are happy with the quality of public space created by those interventions.

The results of these studies highlight the essential role of taking into account the perceptions of people who live in the city in the decision-making processes prior to the introduction of measures or/and experiments which aim at decreasing car usage. Using surveys as their starting point, past studies employed different methods and techniques to dive into the complex topic of public acceptance and identify the underlying drivers and patterns. The research presented herein contributes to this direction and adds a novel perspective to it, which is the comparative analysis of the views of stakeholders' own views as well as regarding the expected public acceptance of various measures versus the actual acceptance, as indicated by the residents themselves.

3. Survey design and analysis

3.1. Residents' survey

The survey addressed to residents of Amsterdam, comprises four parts; Part A aims at capturing the views of residents regarding the role of private cars in the city in general. Moreover, the participants are asked to answer whether they live in the centre of Amsterdam (District "Centrum"), in another district of the Amsterdam Municipality or outside it. In case they live in a district within the Municipality but outside centre, they are also asked to indicate this district on a map that is displayed to them. Part B, includes questions that attempt to examine the general degree of support of Amsterdammers for different interventions towards the low-car city concept, assuming that these would be implemented in the city centre, while Part C is focused on capturing the residents' views on the same measures, but this time under the assumption that they would be implemented in their own district/neighbourhood. This part is shown only to those who have replied that they live in another district except for the centre, within the Amsterdam Municipality. The fourth and last part of the survey, Part D, aims at collecting socio-demographic data as well as some information regarding the travel habits of the participants.

The survey consists primarily of closed type questions; there is only one open question, before the last part of the survey, which asks to mention any thoughts or/and concerns that the participants may have about the possibility of living in a neighbourhood without cars. The closed type questions require their answers to be expressed in a Likert 7-point scale (from 1 "I absolutely do not support this" to 7 "I fully support this"), which is a scale very widely used in such type of surveys, in the field of transportation and beyond. Table 1 presents the statements regarding the role of the car in Amsterdam, which were presented to the participants in Part A of the survey, asking them to rate each one according to their degree of support.

The interventions/measures included in Parts B and C of the survey are an adapted selection from the inventory of measures that have been discussed earlier in this paper and are summarized in Table A1. A conscious choice was made to include only the first five out of the total eight main categories of interventions. As one of the objectives of the survey is to investigate the existence of potential discrepancies between what inhabitants think about implementing low-car measures in the city

Table 1
Statements about the role of the car in Amsterdam which comprise Part A of the survey.

S1	Car is an essential part of my lifestyle.
S2	I think that the presence of cars in Amsterdam intervenes in a negative way with the urban scenery.
S3	I do not feel safe while walking or/and cycling in the city because of the number of cars in the streets.
S4	If I am not able to drive from A to B within Amsterdam, I will feel frustrated.
S5	I think that cars make the life of Amsterdammers easier.
S6	I consider the space allocated to on-street parking "lost space" - I would rather see another use of it.
S7	I think that the air-pollution levels in the city should be reduced.
S8	Amsterdam is already a city with a decreased number of cars when compared to other European capitals - no further decrease is required.
S9	There are sufficient alternative travel options available if a person does not want to travel by private car.
S10	Cars do not have a place in the city centre of Amsterdam.

centre versus what they think when the exact same measures are to be implemented in the district/neighbourhood where they live, the categories “travel planning” and “gamification” were not relevant, in the sense that they include measures that are typically not confined to a part of the city. The last category, “Public space (urban planning/mobility)” was merged for the purposes of the survey with the third one, resulting to the new category “Improvement of public transport and active modes' infrastructure/mobility services/public space”.

The selection of which measures to include from each category in the questionnaire was made based on the following three criteria: success, controversy and innovation. Hence, three types of measures were included: a. Measures that have been applied to other cities and have been considered successful, b. Measures that have been proven to be controversial (caused reaction from residents/debates with the City) when applied to other cities and c. Innovative measures that have not been applied elsewhere yet. The full set of the 28 measures that were included in the questionnaire can be found in Tables A2a to A2e of the Appendix.

The questionnaire was programmed in the Qualtrics platform and was translated to the local language (Dutch). In some instances, AI images that were created using the ChatGPT Dalle-3 tool were used to help the participants understand better the concepts that are being described. The entire survey required approximately 10 min to complete.

The survey was distributed online with the aid of a professional panel company. The sample size was determined using Fisher’s formula for large populations over 10,000, for a confidence level of 95 % and margin of error 5 %. According to it, for the total population of the Greater Amsterdam Region, 2.48million (2020), the target sample size is: 385. We therefore aimed at collecting 400 questionnaires from residents of the Greater Amsterdam Region.

3.2. Stakeholders’ survey

The second survey is addressed to stakeholders: professionals and policy-makers working at organizations such as the City of Amsterdam (Gemeente Amsterdam), Amsterdam Metropolitan Area (Metropoolregio Amsterdam – MRA), Transport Authority Amsterdam (Vervoerregio) and the Province of North Holland (Provincie Noord-Holland). In this survey, exactly the same measures that were selected for the survey addressed to residents are included, in order to be able to observe and identify similarities and differences between the two different angles. The part that in the previous survey focuses on specific measures at the neighbourhood scale (Part C), is in this survey replaced by a part in which stakeholders are asked to provide their expectation regarding residents’ perceptions. The answers will be then compared and contrasted with the actual answers of inhabitants.

The structure of this survey is as follows: In Part A the participants are asked to provide their opinion on various interventions towards decreasing the number of cars in the city. Following that, in Part B, they are asked what they think residents of Amsterdam would opt for when faced with the same dilemmas. The questions in both parts A and B are closed-type and require their answers given in a 7-point Likert scale, exactly as in the case of the first survey. In the next part of the survey, Part C, some open questions regarding stakeholders’ views towards the low-car concept and the role of citizens’ acceptance in general are posed. The last part of the survey, Part D, asks for the organization and role of the participants.

3.3. Analysis approach

After the data from the two surveys are collected, a data cleaning process is followed for both datasets. Following that, an exploratory factor analysis (EFA) is applied to the 28 Likert scale questions about different low-car policies and measures from the residents’ survey to reduce the number of variables. The resulting factors are then used as input indicators when performing a subsequent Latent Class Cluster Analysis (LCCA) to identify latent groups of residents. LCCA is a probabilistic model-based clustering method which has seen its use in transport and mobility-related studies growing in the past few years (e.g. see Alonso-González at al, 2020; van ’t Veer et al., 2023; Soza-Parra and Cats, 2024; Lin and Fan, 2021; Pantelaki et al., 2022; Salehian et al., 2023; Khan et al., 2023, Rasca et al., 2023; Ghasri et al., 2024). LCCA is used to uncover heterogeneity that is not otherwise obvious (McCutcheon, 2002). We included participants’ socio-economic characteristics, travel behaviour and attitudes towards the role of car in Amsterdam in our LCCA. This allowed us to explore which factors might help explain differences in how residents view the low-car city concept.

The mathematical formulation of the model with continuous indicators (as in our case the EFA resulting factors are) is the following (Alonso-González et al., 2020; Molin et al., 2016; van ‘t Veer et al., 2023):

$$f(y_i|z_i^{cov}) = \sum_{(x=1)}^{K} P(x|z_i^{cov}) * \prod_{(m=1)}^{M} (f(y_i m|x) \qquad (1)$$

where x is the latent variable, in our case the residents’ views towards the low-car city concept. K are the different categories (clusters) which residents are probabilistically assigned to. The model is based on the assumption that each individual i has a certain probability to belong to each of these K clusters, and Z_i^{cov} is individual’s i set of covariates and y_m individual’s i value of indicator m, with M being the number of indicators included in the model (Alonso-González et al., 2020; van ’t Veer et al., 2023). The structure of our LCCA model is presented in Fig. 1.

4. Results and discussion

4.1. Residents’ survey results

The residents’ survey ran between December 2023 and February 2024, following a pilot that lasted for a few days before the official launch and which was used for refining the final survey text. Responses from 458 participants were collected, 419 of which were fully completed, and were considered for further analysis. Initially, the process of data cleaning took place, to check whether some of these complete questionnaires needed to be excluded from the analysis. This decision was based on either patterns of completion that indicated that the questionnaire was completed without the necessary attention or eye for detail (e.g. “straight lines” consisting of the same number in more than one Likert scale questions) or on extremely low or high amount of time from the start of the filling-in process until the questionnaire was submitted. The final clean dataset consists of 400 entries.

4.1.1. Sample characteristics

An overview of the socio-demographics, household and travel behaviour characteristics of the sample is presented in Table 2.

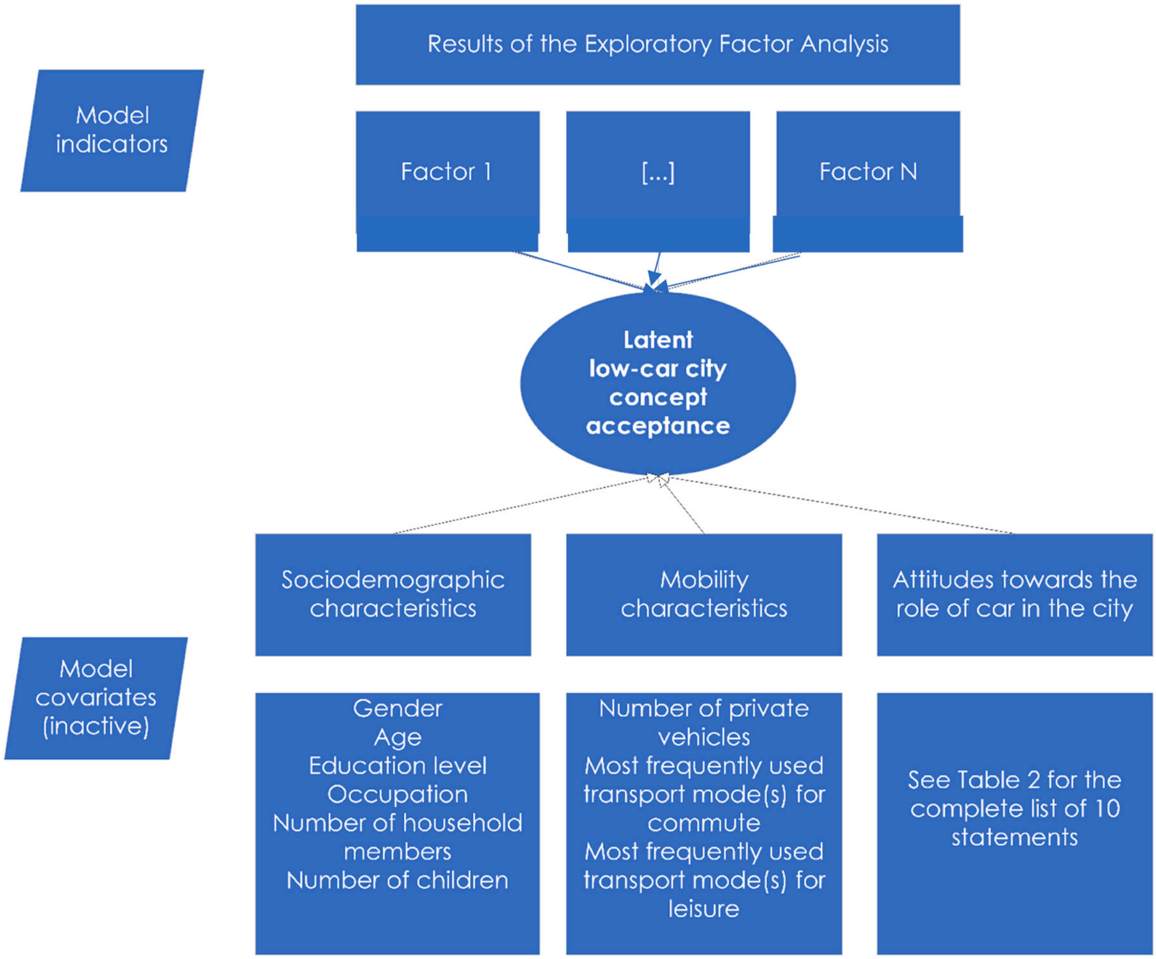

Fig. 1. The Latent Class Cluster Analysis model.

The sample consists of more male (55 %) than female (45 %). The age distribution reveals an over-representation of the older age groups, with 41.5 % of the sample being 65 years old or older. In the following, this is taken into account throughout the analysis by assigning the appropriate weights for all age groups. The high share of retired individuals and the majority of the sample having no children in their household can be attributed to the over-representation of older individuals in our sample. The number of private vehicles in the household reported is well-aligned with the available data on car ownership available from the Central Bureau of Statistics of the Netherlands. Moreover, according to the Central Bureau of Statistics, in 2023, 36 % of people aged 15 to 74 had a Bachelor diploma or higher. In our sample, if we combine the Bachelor graduates with the Master/PhD holders, 39 % of the survey participants hold a higher education degree, which is very close to the aforementioned Dutch average (CBS, 2024).

Respondents were also inquired about the most frequently used modes of transport for daily commute and for leisure trips (allowing for multiple options). Private car was indicated as the most commonly used mode for both commute (57 %) and leisure (68 %) purposes, followed by the bicycle which was indicated by 42 % and 39 % of the respondents for commute and leisure purposes, respectively. A very small part of the sample replied that they regularly use shared mobility to reach their workplace (2.5 %), with this number increasing slightly to 4.8 % when inquiring about leisure activities.

4.1.2. Exploratory Factor Analysis (EFA)

In order to prepare our dataset for subsequent Latent Class Cluster Analysis, we first perform Exploratory Factor Analysis (EFA) to reduce the number of dimensions (variables). The EFA is conducted using Principal Axis Factoring as an extraction method and oblimin oblique as a rotation method, since it is effective in taking into account the existence of potential correlations among factors (Alonso-González et al., 2020). The input variables are the answers in the 28 Likert scale questions that comprise the third part of the questionnaire, i.e. a series of potential interventions that aim at decreasing the number of cars in the city centre of Amsterdam.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was calculated to check the suitability of the dataset, yielding a value of 0.937, which shows very good sample adequacy (Kaiser, 1974). The Bartlett's test of sphericity tests the null hypothesis that the original correlation matrix is an identity matrix, which would indicate that the variables are unrelated (Bartlett, 1950). The significance level in our sample is 0.000, therefore the test is significant and the null hypothesis can be rejected, justifying the use of a factor analysis. The analysis identifies five factors which all have eigenvalues equal to 1 or higher, accounting for 53 % of the variance, as Table 3 shows.

To facilitate the interpretation and focus on meaningful factor loadings only, all coefficients smaller than 0.5 were suppressed and do not appear in the pattern matrix (Table 4). Only the first four factors have factor loadings higher than the predefined threshold. In addition, an inspection of the scree plot revealed that based on the so-called "elbow rule" – a criterion based on visual inspection of the point at which the plot shows a sharp change in the slope of the curve ("elbow"), i.e. a point beyond which additional factors explain substantially less variance – there is a negligible value in considering more than four factors. Therefore, it is decided to retain the first four factors, which

Table 2
Socio-demographics and household characteristics of the sample.

Variable	Category	Frequency (%)
Gender	Male	54.8
	Female	44.8
	Non-binary/third gender	0.5
	Prefer not to say	0.0
Age	18–24	3.3
	25–34	11.5
	35–44	12.0
	45–54	13.5
	55–64	18.3
	>65	41.5
	Prefer not to say	0.0
Education level	No formal school or primary school	1.0
	Secondary (middle) school	32.3
	Vocational education[a]	27.3
	University degree	22.0
	Master/PhD	17.0
	Prefer not to say	0.5
Occupation	Student	3.3
	With professional occupation	49.8
	Unemployed	6.5
	Retired	39.8
	Prefer not to say	0.8
Number of household members	1	31.0
	2	42.3
	3–5	25.8
	5–7	1.0
	7+	0.0
Number of children in the household	0	71.0
	1	14.0
	2	11.3
	3	3.0
	4+	0.8
Number of private vehicles in the household	0	19.3
	1	57.5
	2	18.8
	3+	4.5

[a] Also refer to as "technical/professional" education. For more information regarding vocational education in the Netherlands please see De Bruijn et al. (2017).

explain 51.2 % of the total variance.

Table 4 presents the complete set of variables that comprise each factor with their respective loadings. The factors represent comprehensive and distinct aspects of urban interventions towards decreasing the number of cars in cities and the classification of measures are in line with the questionnaire's initial categorization. The four factors can be described as follows:

- **Factor 1: Resident – priority access**
  This factor is characterized by measures aiming at regulating access to the city centre through different restrictions, while having special exemptions for the residents.
- **Factor 2: Shared mobility integration**
  This factor comprises measures and policies that focus on boosting the use of shared mobility services through various options and plans, for residents as well as visitors.
- **Factor 3: Public transport enhancement**
  This factor includes measures that place public transport in their core and aim at enhancing its attractiveness and usage.
- **Factor 4: Urban space reclamation**

This factor involves measures that aim at introducing car-free zones and reclaim the urban space back from cars, by reducing parking supply and re-purposing parking spaces.

4.1.3. Latent class cluster analysis (LCCA)

Next, the output of the EFA is used as input for performing a Latent Class Cluster Analysis (LCCA). The analysis is conducted using the Latent GOLD Software (6.0) (Vermunt and Magidson, 2021). The four factors described previously, the scores of which were calculated using the Bartlett method, play the role of indicators in our model, while the socio-demographic, household and travel behaviour characteristics of participants are not utilized in the cluster formation process. The same applies for respondents' perceptions of the general role of private car in the city of Amsterdam (see Section 3 for a detailed description).

As mentioned above, we apply weights to address the over-representation of the older age group in our sample. The weights were calculated using the latest (2022) age distribution dataset of the Amsterdam Metropolitan Area (Metropoolregio Amsterdam, 2023). Some age groups had to be merged because the dataset that was available used a different classification system.

We tested for nine different models ranging from 2 clusters to 10 clusters, a summary of key statistics per model is presented in Table 5. The criteria we evaluate are the Log-likelihood (LL), the Bayesian Information Criterion (BIC) the Akaike's Information Criterion (AIC) and Classification Error (Class.Err.). Based on these criteria as well as on our judgment of the distinctiveness of each cluster and on the meaningfulness of the proposed clusters in each model, the 3-cluster model is selected for further analysis.

The profile of the 3-cluster model is presented in Table 6. The full profile description including all the covariates can be found in the Appendix (Table A3).

In the following, we describe the characteristics of each of the clusters.

4.1.3.1. Cluster 1: low-car policy supporters (39 % of the sample). Factors (indicators): Members of this cluster are positive towards all four factors, with almost equal mean scores for the first three ones. A negative score towards factor 4: urban space reclamation can be observed - however, this factor had negative factor loadings in the pattern matrix of factor analysis, that means that as the factor scores increase, the observed variables score decreases and vice versa. Therefore, the members of this group can be described as supportive of urban space reclamation as well, showing that they would like to see the city-centre becoming more car-free and that they are comfortable with parking spaces being repurposed.

Characteristics (covariates): The probability of being of older age

Table 3
Total variance explained, EFA.

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	11.097	39.632	39.632	10.668	38.1	38.1	7.598
2	2.333	8.332	47.965	1.862	6.649	44.749	6.919
3	1.578	5.637	53.601	1.086	3.878	48.627	3.344
4	1.123	4.011	57.612	0.716	2.558	51.186	7.593
5	1	3.572	61.184	0.513	1.833	53.019	3.564

Table 4
Pattern matrix with explanation of all variables.

Pattern Matrix

		Factor			
		1	2	3	4
Q3	Everyone except for residents of the City of Amsterdam required to pay a daily fee to access the city centre by car, while the residents' cars are able to enter for free.	0.755			
Q4	Access allowed only to residents' cars by charging an annual fee that would depend on the type of car and the household's annual income.	0.614			
Q5	Introduction of a "green city tax" to all car owners. If you travel to and from the city centre more than a specific number of times per year (which will be measured by sensors installed at the edges of the area) you are ought to pay the tax.	0.502			
Q1	Charging cars for entering the city centre during specific days and times (for example during the busiest hours of morning and evening on weekdays).				
	Only cars of certain categories (emission standards) can enter the city centre, independently of the time or/and day.				
Q6	License plate control - only odd or even (ending) license plate numbers can enter the city centre on specific days.				
Q12	Cars above a certain weight (e.g. SUVs) are not allowed to enter the city centre.				
Q2	Stop of free parking provision at workplaces - a parking fee required if employees want to park their car at the parking facilities of their work.				
Q11	Dynamic access to (parts of) the city centre based on real-time information regarding traffic conditions (for example, if there is a traffic jam on a street, cars will be redirected to different paths until it is dissolved).				
Q27	Increase the number of available shared vehicles in the city centre (bikes, e-bikes and (e)cars).		0.829		
Q28	Having various shared mobility options made available at specific locations where other non-mobility services such as post and waste also exist.		0.812		
Q26	Car sharing scheme that involves a resident discount at an existing car sharing service, which nevertheless is used by residents and visitors all of the same. In this scheme, vehicle availability cannot be guaranteed.		0.774		
Q25	Car sharing plan that involves some cars parked in the city centre to be used only by residents when needed, upon reservation. This plan would entail a monthly fee.		0.718		
Q24	Introducing a system where each resident will be given a monthly mobility budget that can be spent as one sees fit with less socially desirable modes will involve using more of this budget. Trading mobility budget with others is allowed so that you can increase your mobility budget by paying for it or make money by selling unused mobility budget.				
Q18	Introducing/increasing the frequency of late evening/night and/or 24 h public transport services in the city centre.			0.589	
Q20	Make public transport free-of-charge for all.			0.548	
Q19	Reduced public transport fee for certain population groups such as students or the unemployed.			0.527	
Q22	Shuttle buses from companies in the city centre to/from P + R locations at the edge of the city.				
Q21	Development of cycle superhighways (dedicated fast cycle paths to eliminate interactions with cars and improve the cycling experience).				
Q23	Creating gradually multiple centers within the city centre so that in the future all residents will not have to travel more than 15 min on foot or by bike from home to reach their work/school, run errands or attend leisure activities.				
Q17	Decreasing the number of parking spaces in the city centre and transforming the space into alternative uses (green, bike parking, garbage containers, playgrounds, recreational spaces/street art exhibitions etc.).				−0.916
Q16	Reduction of parking spaces in the city centre and provision of reduced public transport fees for residents from/to P + R locations at the edge of the city.				−0.769
Q8	The city centre becomes completely car-free. No car is allowed to enter anymore.				−0.693
Q9	The city centre becomes completely car-free during the weekends. During the weekdays only certain streets become car-free, and these streets change every week. The rotation plan of the streets is announced beforehand to residents, visitors and tourists.				−0.539
Q13	Increasing the hourly parking fees of on-street parking in the city centre to discourage visitors and tourists to access the city centre by car.				
Q15	Reduction of number of resident parking permits for new building developments and an increase in the parking fee for visitors and tourists.				
Q14	Daily parking fee, regardless the duration that the car stays parked at the parking spot.				
Q10	Allow certain groups of people to access certain locations at certain times by car (e.g. ticket holders that want to approach a concert hall) and prohibit access to all other cars in the centre.				

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.
Rotation converged in 18 iterations.

Table 5
Latent class cluster analysis – models' comparative statistics.

	LL	BIC (LL)	AIC (LL)	AIC3 (LL)	Npar	Max. BVR	Class.Err.	Entropy R^2
2-Cluster	−1792.73	3683.699	3619.46	3636.46	17	21.9585	0.0267	0.8766
3-Cluster	−1722.82	3595.891	3497.643	3523.643	26	5.5699	0.1023	0.777
4-Cluster	−1682.46	3567.173	3434.916	3469.916	35	4.7742	0.1378	0.736
5-Cluster	−1668.33	3590.923	3424.657	3468.657	44	5.6853	0.1771	0.7048
6-Cluster	−1643.18	3592.644	3392.369	3445.369	53	3.2502	0.2021	0.7086
7-Cluster	−1633.53	3625.351	3391.067	3453.067	62	2.7289	0.1953	0.7323
8-Cluster	−1614.65	3639.598	3371.305	3442.305	71	1.4019	0.1918	0.7454
9-Cluster	−1603.54	3669.388	3367.086	3447.086	80	2.1208	0.1962	0.7499
10-Cluster	−1582.83	3679.972	3343.661	3432.661	89	2.3172	0.1509	0.806

Table 6
Three-cluster model profile description.

	Cluster1	Cluster2	Cluster3	Overall
Cluster Size	0.3863	0.346	0.2677	
Indicators				
Factor 1				
Mean	0.5593	−0.1995	−0.9538	−0.1083
Factor 2				
Mean	0.4945	0.1332	−0.7793	0.0284
Factor 3				
Mean	0.5218	−0.7382	−0.3407	−0.145
Factor 4				
Mean	−0.7255	−0.2136	1.3359	0.0035

We used the Wald test, a statistical test commonly used in LCCA analysis to determine whether an explanatory variable in the model significantly contributes to the prediction of the outcome. For Factor 1, Wald = 72.18 with $p < 0.001$, meaning that the differences among the three clusters are statistically significant. Similarly for Factor 2: Wald = 72.49 and $p < 0.001$, Factor 3: Wald = 89.12, $p < 0.001$, and Factor 4: 654.09, $p < 0.001$, providing evidence that the factor are differing across clusters; especially in the case of Factor 4, this evidence is really strong.

(65 +) is higher in this cluster (22 %) compared to the other two; and at the same time, it is the cluster where younger participants are least represented (3.5 %). The educational level of individuals belonging in this cluster is high, with 33 % having Bachelor degrees and 18 % Master and PhD degrees, while the first two educational level categories (no formal education and middle school) have the lowest shares among the three clusters. The cluster comprises a low number of students; the majority of cluster members have a professional occupation and there is an significant share of retired individuals as well (23 %). Plurality of the households consist of two members (38 %) with usually no children residing in the household (63.87 %). The great majority having 1 private vehicle per household (51 %), followed by no car (24 %). This makes this share of households who do not own a car the highest amongst the three clusters. Half of cluster members are likely to use their private car or/and their bicycle for their daily commute, while the use of public transport ranges between 20 % and 25 %, and walking reaches almost 30 %. When leisure is the trip purpose, the likelihood of using the car increases and the use of bike decreases. This cluster recognizes the benefits of cars but is concerned about safety and pollution, consequently showing strong support for alternative transportation.

The socio-demographic and mobility profile of Cluster 1 suggests that individuals who are members of this cluster are already using the private car less in their everyday life and they are more familiar with and supportive of alternatives to car use. Their openness to car-free zones and space reclamation may be linked to their current life phase (e.g. retirement) or/and prior positive experience with different transport modes. Since this cluster is likely to respond positively to more ambitious or radical urban interventions, it could be seen by policy-makers as 'early adopters' when a new policy is introduced. Understanding and giving visibility to their viewpoints could help in the wider adaptation of such policies.

4.1.3.2. Cluster 2: the individuals with a mixed attitude towards low-car (35 %). Factors (indicators): This group shows slightly negative acceptance scores towards factor 1: Resident – priority access and higher negative score towards factor 3: Public transport enhancement. Slightly positive scores are observed towards the other two factors. Overall, we could say that this cluster faces the "low-car" concept with what appears as a mixed attitude; they do not actively support the measures but they do not seem to be strongly against them either.

Characteristics (covariates): A relatively young cluster, with 41 % being between 25 and 34 years old, with either a Bachelor degree (including the highest share of Master of PhD degree holders amongst the three clusters) or middle school education and having a job. Larger households and the existence of one child is more common here compared to the other two clusters. Half of cluster members own at least one car, and almost 27 % own 2 cars, but at the same time almost 20 % do not have any. Notwithstanding, many of them are likely to use car for commute or leisure activities. Cluster 2 shows a high agreement on the negative impacts of cars in urban scenery and is more accepting towards the potential scenario of not being able to drive from A to B, compared to other clusters.

The mixed acceptance of this group may reflect a practical tension between sustainable values and the demands of daily life, e.g. for young professionals with children and more complex household mobility needs, who are most represented in this cluster. They own more cars than Cluster 1 and rely on them more heavily, yet they are open to the idea that car use should be restricted. This group represents a critical segment of residents – not fully opposed to change, but requiring tangible, trustworthy alternatives before shifting behaviour.

4.1.3.3. Cluster 3: low-car policy skeptics (27 %). Factors (indicators): This group appears to be the least supportive of all towards all categories of measures, with factor 1 and factor 4 being the ones where the lack of acceptance is the strongest.

Characteristics (covariates): The majority of individuals belonging to this group is of age 45–54 (28 %). Educational levels are mostly secondary (40 %) and vocational education (37 %), being the group with the lowest share of university or higher degree holders. The cluster mainly consists of households with 2 members, but many with 3–5 members as well (34 %) and no children. This group has the highest car ownership (71 % owning one and 14 % two cars) and the lowest zero-cars households among all three clusters. Remarkably, while this cluster is most skeptical towards urban interventions that promote the concept of low car, it is also the cluster that expresses the most concerns regarding safety and pollution and is dissatisfied with the presence of cars in the city centre – revealing a contradiction between what they believe in general and what they are willing to accept in terms of policy interventions.

Despite being the most car-oriented and least supportive group of the three, Cluster 3 shows a strong recognition of the negative externalities of car use, including safety risks and pollution, revealing a contradiction between what they value and how they act. This suggests that skepticism in this case may not have its roots solely in rejection based on attitudes but rather in structural dependencies and a perceived lack of viable alternatives. This group is likely to experience the highest transition resistance.

Our clustering results resonate with past results from the Netherlands (Alonso-González et al., 2020; Van't Veer et al., 2023; Soza-Parra and Cats, 2024) and Australia (Ghasri et al., 2024). Across these studies, the clusters that showed greater support for Mobility-as-a-Service (MaaS) (Alonso-González et al., 2020; van 't Veer et al., 2023), more openness to shared micromobility (Ghasri et al., 2024) and lesser attachment to car ownership (Soza-Parra and Cats, 2024), generally included a larger proportion of individuals with higher education levels and lower car ownership rates.

4.1.4. *Support for policies applied to city centre vs to the district one lives in*

From the total sample of 400 residents, in this section we consider responses from only the 180 who replied that they live within the limits of the Amsterdam municipality, but outside the city centre. We are interested in identifying whether there are discrepancies between the opinions related to the application of low-car policy measures in the city centre versus the application of those in their own district. In the following we perform a comparative analysis between the two sets of responses provided by this subset of respondents, see Fig. 2.

In general, across all categories of policies considered, there is a higher acceptance towards the application of low-car measures in the city centre than in the residential district in which one lives. While most discrepancies are in the range of 0.10 – 0.50 point in the Likert scale, larger discrepancies are observed for policies such as congestion charging (Q1) (*t*-test: 3.09, p: 0.0022), green city tax (Q5) (*t*-test: 2.84, p: 0.0047), making the whole area car-free every day (Q8) (*t*-test: 3.24, p: 0.0013) or only during weekends (Q9) (*t*-test: 2.48, p: 0.0137). Observed differences could be attributed to views on the impacts of such measures in different parts of the city and the suitability thereof as well as a NIMBY effect where one may in principle agree with a certain measure (e.g. reducing the number of parking places) but at the same time is not interested in experiencing the consequences thereof where one resides.

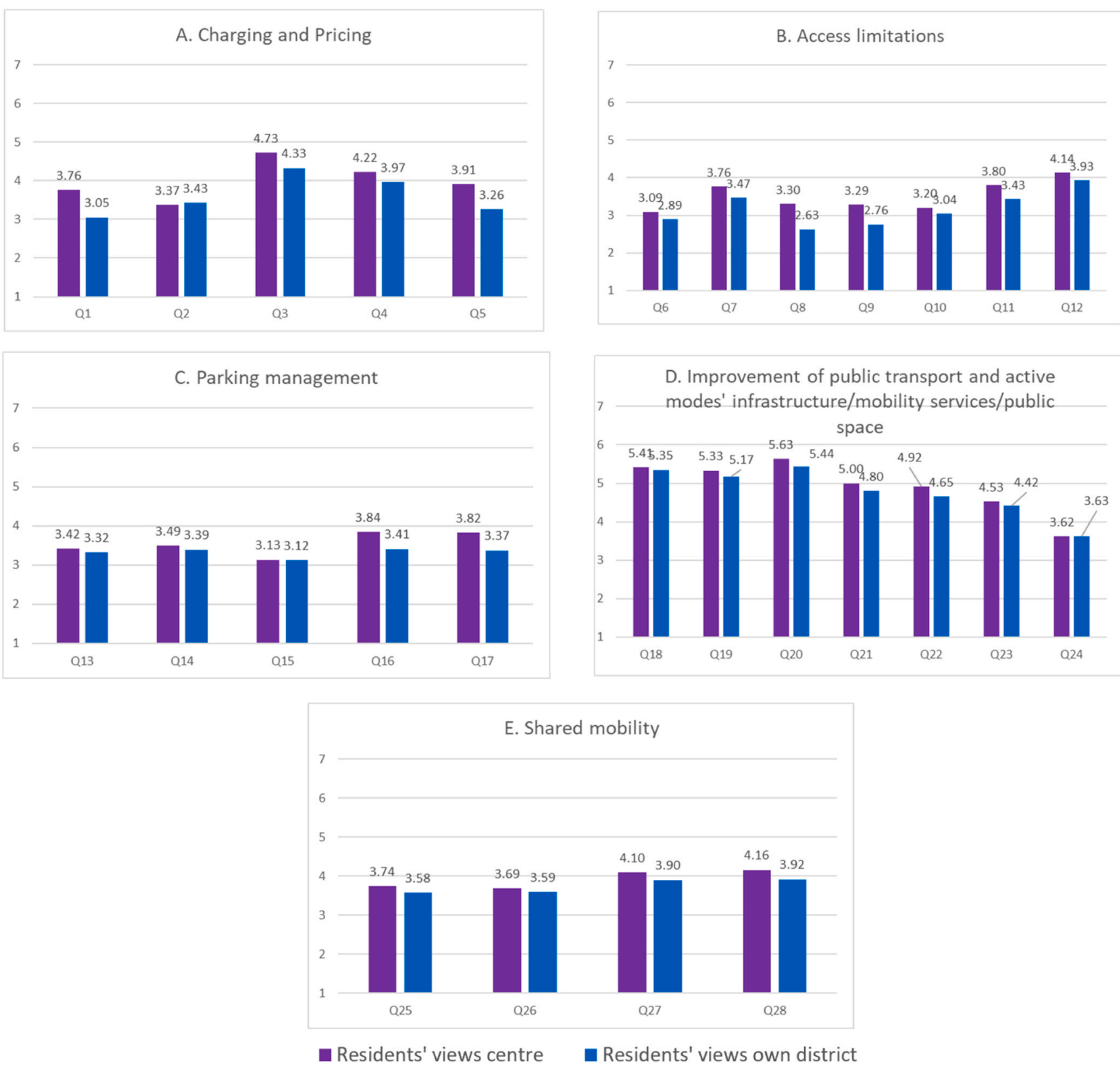

Fig. 2. Comparative analysis of the mean values of (i) residents' views about centre and (ii) their views about their own district with regard to the five different categories of urban interventions.

Notwithstanding, we find an overall good alignment for many of the measures, in particular "pull" measures and those which are likely to be applicable for travelers other than themselves - such as the stop of free parking provision at workplaces (Q2) (*t*-test: −0.45, p: 0.653), the reduction of number of resident parking permits for new building developments with a parallel increase in the parking fee for visitors and tourists (Q15) (*t*-test: 0.094, p: 0.925), and late night/24 h public transport provision (Q18) (*t*-test: 0.35, p: 0.726), but also towards for example mobility credits[1] (Q24) (*t*-test: −0.048, p: 0.961), indicating that respondents hold either positive or negative views towards some measures as a matter of principle, regardless of the area under consideration.

4.2. Stakeholders' survey results

The stakeholders survey (see Section 3 for details) was distributed between November 2023 and March 2024, resulting in 45 questionnaires, 32 of which were fully completed and were considered for further analysis. Most of the stakeholders who participated work at the City of Amsterdam (56 %), followed by the Amsterdam Regional Transport Authority (in Dutch: Vervoerregio Amsterdam) (25 %), while the rest of the participants work at the Ministry of Infrastructure and Water management (in Dutch: Rijkswaterstaat) (10 %), two participants work at the Provinces of North Holland (which includes Amsterdam) and Flevoland (adjacent province to the one of North Holland), and one participant works at another municipality within the MRA. The stakeholder sample is composed of (senior) policy officers/advisors, mobility and strategic advisors, project managers, directors, counselors and researchers in different policy areas such as: smart mobility, service design and public transport. A number of participants work as advisors at the low-car program of the City of Amsterdam (Programma Autoluw).

We compare and contrast the answers provided by stakeholders to those provided by (the complete sample of 400) residents with the goal of identifying potential similarities and discrepancies in relation to introducing low-car measures in the city center. Furthermore, we also contrast the views of (i) residents and (ii) stakeholders with (iii) stakeholders' expectations of residents' views.

The general trends can be summarized as follows. The most popular measures (with a mean favorable value of more than 5 on the 1–7 scale) amongst our group of stakeholders include congestion charging (Q1), banning SUVs (Q12), increased on-street parking fees (Q13), reducing parking availability (Q16, Q17), and residents' parking permits for new developments, having more shared micro-mobility (Q27) and mobility hubs (Q28), and all the measures in the fourth category expect for free-fare public transport (Q20), and introducing mobility credits (Q24). The least favorable measures (<3.5) amongst our stakeholders include license plate control (Q6) and daily parking fee (Q14).

It is important to acknowledge that the stakeholder sample may carry an inherent bias, as many of the respondents are professionally involved in the planning or implementation of sustainable mobility policies, and therefore also more likely to be regular cyclists of public transport users and more favourable towards car-restrictive measures.

4.3. A comparative analysis between residents and stakeholders

Among residents, only 5 measures received a mean value of more than 5 in the 1–7 scale, comparing to the aforementioned 13 that received an equivalent score by stakeholders. Remarkably they are all measures (Q20, Q18, Q19, Q22, Q21) which belong to the fourth category of measures "Improvement of public transport and active modes' infrastructure/mobility services/public space", in line with the results of previous studies which have shown that the "pull" measures aiming at decrease car use, tend to be more easily accepted in general amongst the inhabitants than the "push" ones (e.g. see Lanzendorf et al., 2023). Whereas only two measures received a mean score of < 3.5 by stakeholders, the following seven measures received low acceptance rates amongst residents: license plate control (Q6), reduction of parking permits (Q15), limited access (e.g. only ticket-holders for an event), completely car-free city-centre (Q8) or car-free during the weekends (Q9), stop of free parking provision at workplaces (Q2), increasing the hourly parking fees of on-street parking (Q13) and introducing a flat parking daily fee (Q14). Parking management measures appear to be favored by stakeholders but not so popular among residents.

Interestingly, several measures sparked quite polarized reactions from citizens, receiving an almost equal amount of strong disapproval and strong support. These measures include restrictions based on vehicle weight (Q12), where 16 % of residents replied with 1 out of 7 in the Likert scale and 17 % of residents opted for 7 out of 7Other measures for which this was the case are the following: reduction of parking spaces (Q16), (16,5 % replied "1" and almost 15 % replied "7"), access allowed only to residents' cars (15 % "1" and 16 % "7"), emissions standards' restrictions (Q7) (18,5 % "1" and 21 % "6" or "7") and daily parking fee (Q14) (21 % "1" and 20 % "6" or "7").

When comparing stakeholders' views with each one of the residents' clusters, it can be observed that the stakeholders' preferences are more closely aligned with those of Cluster 1 (supporters), particularly in the favourable views of some push measures such as parking space limitations or congestion charging. Large discrepancies are met between stakeholders and the "skeptics" (Cluster 3), especially on measures such as the introduction of daily parking fees or license plate control. The "mixed" cluster (Cluster 2) views often mirrors stakeholders' expectations, especially for more flexible or incentive based policies, such as shared mobility enhancement and mobility hubs.

It is worth mentioning at this point that residents of the central district (61 questionnaires in total in our sample), tend to view the measures considerably more favorably when compared to the total sample results, as interestingly, no measure receives a mean value of lower than 3.5, and with the exception of license plate control (Q6), completely car-free centre (Q8) and limited access to certain locations (Q10), all other measures achieve a mean score of 4 or higher, with the most popular measure among them (with 5.49 out of 7) being the application to a daily fee for accessing the city centre to everyone but residents (Q3).

Clearly, the observed trend is that stakeholders view much more favorably than residents the vast majority of the low-car measures. Fig. 3 presents an overview of the differences of the mean values (stakeholders' views – residents' views and stakeholders' views of residents' views – residents' views) for all the questions, per category of measures, using the complete sample of residents' answers as the basis (equal to 0 in our axis). The largest gaps in stakeholders viewing measures more favorably than residents (of more than one Likert scale point) are recorded for the following measures: time-dependent charging of cars entering the city center (Q1) (*t*-test: −6.37, p:0.00000143), charging for parking at one's workplace (Q2), banning SUVs from the city center (Q12), increased on-street parking fees (Q13), reducing parking norms in new buildings (Q15), moving parking spots from city-center to Park & Ride facilities in the edges of the city (Q16), transforming parking spots in the city centre into alternative uses (Q17), 15-min city land-use development (Q23), car sharing for residents with a monthly fee

[1] According to Tanner et al. (2024), (tradeable) mobility credits (TMC) are "market – based pricing instruments that are designed to reduced the externalities associated with motorized transport […] In such schemes, credits are allocated to citizens by a governmental institution. Citizens with a credit expenditure that exceeds the allocated credits can buy credits from citizens who do not use all their allocated credits. This trade happens in a centralized market. The price of the credit is therefore dynamic and is the outcome of the equilibrium value that emerges from the current relation between demand and supply." For more information see Tanner et al. (2024).

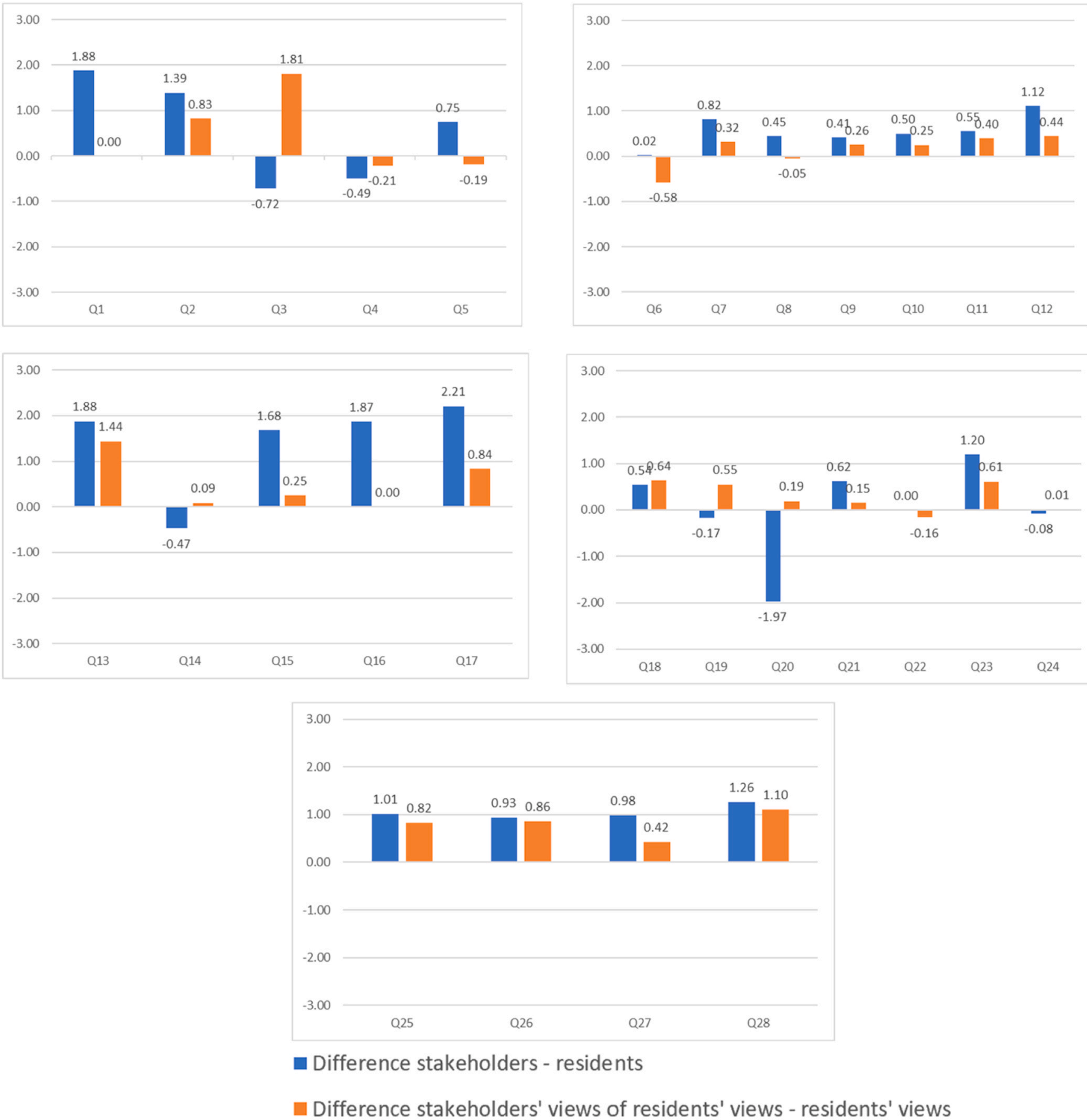

Fig. 3. Comparative analysis of the mean values of the differences between (ii) stakeholders with residents' views and (ii) stakeholders' expectations of residents' views and residents' views in the five different categories of urban interventions.

(Q25) and mobility hubs (Q28). Evidently, parking-related measures are often contested between residents and stakeholders. Notable exceptions to this trend - for which residents view a measure more favorably than stakeholders by at least 0.5 Likert scale difference - pertain to charging everyone who enters the city center by car except for residents (Q3) (*t*-test: 1.78, p: 0.083) and making public transport fare-free for all (Q20) (*t*-test: 5.97, p: 0.00000001).

Interestingly, measures for moving towards having a car-free city center (Q8-Q10) are received with skepticism and are not supported by neither most residents nor most stakeholders, with an overall mean support value of less than 4 (which represent 'Neutral' in our 1–7 Likert scale). Overall, pull measures (the fourth and fifth categories) are in general more popular among both residents and stakeholders than push measures (first three categories). Conscious of this, when asked to rank categories of measures in terms of likely level of public acceptance, stakeholders indicated that they expect the fourth (promoting public transport and active modes) category of measures to be most straightforward in implementing in terms of public acceptance whereas the third category of (parking-related push) measures was expected to receive most opposition.

Moreover, the stakeholder responders are generally aware that they tend to view low-car measures more positively than city residents do. Interestingly, their estimates of how residents would respond are more closely aligned with the residents actual views than their own personal opinions are. Notwithstanding, there is still an overall tendency to overestimate residents' support towards the proposed measures, as can be seen in Fig. 3. Examples of an overall correct perception of residents' views include congestion charging (Q1), increasing hourly parking fees (Q13), reduction of parking spaces (Q16) and mobility credits (Q24). However, for some measures stakeholders are mistaken to assume that they are much more popular among residents than they in fact are. This is particularly true for charging everyone who enters the city center by car except for residents (Q3), increased on-street parking fees (Q13) and mobility hubs (Q28). The only measure for which stakeholders thought would be even more unpopular among residents than it actually is license plate rationing (Q6).

5. Conclusions

We investigated residents' and stakeholders' views towards low-car city interventions, using Amsterdam as a case study. We compiled a list of 28 low-car measures and identified the most and least favorable measures for each, as well as conducted a comparative analysis in relation to three sets of answers: residents' own views, stakeholders' own views as representatives of their organization and stakeholders' expectations of the residents' views. Moreover, we employed exploratory factor analysis as a data reduction technique, followed by the application of a latent class cluster analysis, which revealed three clusters of Amsterdam residents with distinct characteristics with regard to the low-car city concept acceptance which can be broadly labelled as the supporters, the skeptics and the ones with mixed attitude. To the best of our knowledge, there are no other studies that attempt to investigate and contrast the public perception related to specific policy interventions versus those of stakeholders as well as the expectations of the latter in relation to the former, thereby allowing to highlight potential discrepancies.

The discussion revolving around low-car policies emerges as an engaging and even at times polarizing topic amongst residents, as there is a noteworthy share expressing either strong support or strong disagreement with some of the measures as described in section 4.4., also reflected in individuals expressing passionate arguments in favor or against the low-car city concept.

Several stakeholders pointed out that a potential reason for the experienced skepticism towards some measures such as the cut of through traffic in specific streets that sparked a debate which led to early abandonment of the measure, was that the introduction of the measure was done quite abruptly, without a proper preparation of the impacted population or a clear explanation of what the expected advantages for them, and for the city as a whole, would be, especially in the medium and long-term. This calls for better communication on behalf of city officials before each planned intervention, regarding the specific objectives as well as the expected effects (e.g. in terms of livability, health and safety impacts).

Nevertheless, although improved communication and awareness campaigns may help in clarifying the objectives and expected benefits of low-car interventions, it is important to recognize that resistance to certain measures cannot be justified solely due to lack of information. In many cases, structural constraints exist, such as caregiving responsibilities, remote job access or transporting dependents. For these individuals, alternative modes of transport may not currently meet their needs – an actual discrepancy between needs and offerings that improved information alone cannot resolve. Moreover, as highlighted also earlier herein, stakeholders are generally professionally more aligned with sustainable mobility goals, and therefore they are more likely to adopt a lifestyle that involves more sustainable travel options as well; plus, some of them can be responsible for designing and promoting such campaigns, and this introduces a potential stakeholder bias. This potential bias can also extend to researchers, especially in fields with a strong focus on sustainability goals, as this focus may unintentionally shape the interpretation of public resistance or the assumptions made about behavioural change.An interesting result that emerged from both surveys is that both residents and stakeholders do not seem to be excited about car-free scenarios in the city centre. Future research may investigate the potential root cause; are such scenarios perceived to be undesirable or rather unattainable? Do also stakeholders find them too radical or do they think that the current public sentiment will not permit it and therefore more incremental interventions to gradually achieve car-independency are needed?

Finally, the insights from the application of the latent class cluster analysis can be used by cities to obtain a better understanding of the potential profile of the supporters of low-car policy measures, the skeptics, as well as the indifferent ones.

The findings of this study can provide valuable insights for policymakers in the field of urban mobility. The observed gap between stakeholders' expectations and residents' actual views highlights the need for a more responsive and inclusive planning process. Cities should not assume that public resistance is triggered by lack of awareness or information; instead, they should invest in increasing their understanding of structural and social factors that shape people's travel behaviour. This way, policy design will not only be based on predefined, "by-the-book" sustainability goals, but also on lived realities – actual daily experiences and circumstances. The existence of clearly distinguishable resident clusters suggests that one-size-fits-all approach is unlikely to be effective. The use of more participatory planning tools, such as co-design workshops or citizen panels, may also help in bridging the gap between stakeholder assumptions and public preferences.

A limitation of this study is the number of collected questionnaires for the stakeholders' survey. Moreover, the overrepresentation of elderly individuals in our sample, which we controlled and corrected for by applying weights for the latent class cluster analysis is a shortcoming. Repeating the survey with residents and stakeholders of different cities will allow to compare and contrast the results and investigate the role of the local context in shaping the acceptance rates towards a low-car vision. Future research may also examine the impact of field implementations of low-car measures on public perceptions, for example by performing before-after studies.

CRediT authorship contribution statement

Anastasia Roukouni: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Oded Cats:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of Competing Interest

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

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Appendix

Table A1
Inventory of urban interventions aiming at achieving low-car cities.

	Intervention category	Intervention type	Intervention approach	Policy instrument (s)	Main measures	Case studies	References
1	**Charging and Pricing**	Congestion Charge	Push	Economic, Public Goods and Services	Daily/time-dependent charges for cars in defined charging zone(s)	Gothenburg and Stockholm (SE), London (UK), Bergen and Oslo (NO),Milan (IT), Singapore	Kristoffersson and Börjesson (2021), Tvinnereim et al. (2020), Boggio and Beria (2019), Metz (2018), Eliasson (2017), Beria (2016), Borjesson and Kristoffersson (2018)
		Workplace charge	Push	Economic, Public Goods and Services	Charges for car parking spaces at workplace Cash-out scheme for employees to use public transport	Nottingham (UK) Cardiff (IE) Dresden (DE)	Tscharaktschiew and Reimann (2021), Santos et al. (2020), Dale et al. (2019), Evangelinos et al. (2018), Rye and Ison (2005)
2	**Access Limitations**	Limited Traffic Zone	Push & Pull	Regulatory, Public Goods and Services	Time/day dependent access restrictions	Rome, Milan, Bologna, Genoa, Florence (IT)	Ricci et al. (2017)
		Access with a special permit	Push	Regulatory, Public Goods and Services	Access only with special entrance permit for residents/ access-only roads	Pontevedra (ES)	Hernandez-Morales (2022)
		Low/zero emissions zone (LEZ/ZEZ)	Push	Regulatory, Public Goods and Services	Only vehicles that belong to specific standards (emission levels) can enter part of the city centre (LEZ) or only active travel and emission-free vehicles	Amsterdam and Rotterdam (NL), Brussels (BE), Copenhagen (DE), Paris (FR), Barcelona and Madrid (ES)	Gonzalez et al. (2023), Gementee Amsterdam (2023), Azdad et al. (2022), Peters et al. (2021), Tarriño-Ortiz et al. (2022), Attia et al. (2023).
		Car-free settings or streets	Push & Pull	Regulatory, Public Goods and Services	Car-free street urban experiments, e.g. the Summer Streets and Piazza Zenetti experiments in Munich, the "living street" in Amsterdam	Malmo and Gothenburg (SE), Munich (DE), Amsterdam (NL)	Marcheschi et al. (2022), Kinigadner et al. (2024), Van Hoose (2023)
		Car-free city centre	Push & Pull	Regulatory, Public Goods and Services	Car-free city centre	Berlin (DE)	Gundlach et al. (2018)
		Car-reduced settings	Push & Pull	Regulatory, Public Goods and Services	Car-reduced housing developments	Darmstadt (DE)	Selzer (2021)
		Cut of traffic	Push	Regulatory, Public Goods and Services	(Pilot) Cut of traffic in specific streets	Amsterdam (NL)	Gemeente Amsterdam (2023)
		Intelligent access	Push & Pull	Regulatory, Public Goods and Services	Provide access in a smart way and manage traffic flows digitally to keep out unnecessary (through) traffic.	Groningen (NL)	Hive mobility (2023)
3	**Parking Management**	Parking spaces	Push & Pull	Regulatory, Public Goodsand Services	Removal of parking spaces in and around city centre	Amsterdam (NL)	Gemeente Amsterdam (2023)
		Parking regulations	Push	Regulatory	E.g. only residents can park in a street or within a specific area	Stockholm (SE), Barcelona (ES)	Cats et al. (2016), Albalate and Gragera (2020)
		Parking pricing	Push	Economy	Increase the price of parking for all or for specific categories of vehicles (e.g. SUVs)	Paris (FR), Several Dutch cities (NL)	EU Urban Mobility Observatory (2024), Mingardo et al. (2022)
		Parking min and max/permits	Push	Regulatory	Changing the parking requirements especially for new developments	56 municipalities in Sweden	McAslan and Sprei (2023)
		Parking supply cap	Push	Regulatory	Within specific zones, when a new space is built off-street, an on-street space has to be removed, so it can be repurposed for other needs like widened sidewalks or bikeways	Hamburg (DE), Zurich (CH)	Kodransky and Hermann (2011)
		From P + R to multi-purpose interchange: permitholders from city centre area on P + R	Push & Pull	Information and Education	Encouraging permit holders from the city centre area (and any other target groups) to park at the P + Rs.	Amsterdam (NL)	Gementee Amsterdam (2023)

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Table A1 (*continued*)

	Intervention category	Intervention type	Intervention approach	Policy instrument (s)	Main measures	Case studies	References
4	**Improvement of Public Transport/ Active modes Infrastructure/ Mobility Services**	Mobility services for commuters	Pull	Economic, Public Goods and Services, Information and Education	Free public transport pass foremployees- Private Shuttle Bus from local companies to P + R stations, train stations, etc.- Marketing of measures + communication plan	Utrecht (NL)	Stumpel-Vos et al. (2013)
		Mobility services for Universities	Pull	Economic, Public Goods and Services	Fare-free public transport for studentsand transfer to campus site	Catania (IT)	Inturri et al. (2020)
		Introducing timetable-free travel inurban public transport	Pull	Public Goods and Services	Increasing frequency on a number of public transport lines	Amsterdam (NL)	Gemeente Amsterdam (2023)
		Bicycle Infrastructure Improvements	Pull	Public Goods and Services	Cycle superhighways	Copenhagen (DE)	Hallberg et al. (2021)
		Public transport fare reduction	Pull	Economic	Based on age (children and/or elderly) Based on income (e.g. free for unemployed people)	Slovakia and Czech Republic	Tomeš et al. (2022)
		Free-fare public transport	Pull	Economic	Completely free public transport for all	Luxembourg, Tallin (EE), 93 municipalities in Poland	Štraub et al. (2023), Carr and Hesse (2020), Cats et al. (2017)
		Expanding public transport in the evening and night	Pull	Economic, Public Goods and Services	E.g. (pilot) night metro	London (UK); Frankfurt (DE)	Zhang et al. (2022), Chang et al. (2023)
		Bus and tram lanes	Pull	Public Goods and Services	Improving traffic flow for public transport by creating separate bus and tram lanes where possible	Amsterdam (NL), Clermont-Ferrand (FR)	Gemeente Amsterdam (2023), Taillandier et al. (2023)
		Improving pedestrian facilities	Pull	Public Goods and Services	Safeguarding space for pedestrians during refurbishments - Policy framework "Space for the Pedestrian"	Amsterdam (NL)	Gemeente Amsterdam (2023)
		30 km/h streets	Push	Public Goods and Services, Regulatory	Making all streets within residential areas 30 km/h streets.	Spain, Amsterdam (NL), Bristol (UK), Turin (IT)	Gonzalo-Orden et al. (2021), Gementee Amsterdam (2023), Bornioli et al. (2020)
5	**Shared mobility**	Car Sharing	Pull	Public Goods and Services, Information and Education	Increase of number of carsharing cars and stations- Introduction of car-sharing service for employees- Integration of car sharing into residential areas, public transport, bikeinfrastructure, parking spaces	Bremen (DE), Genoa (IT)	Glotz-Richter (2016), CIVITAS (2015)
			Pull	Public Goods and Services, Information and Education	Awareness-raising for carsharing services, One-stop shop for car-sharing initiatives, Lower rates for shared cars	Bremen (DE)	Glotz-Richter (2016)
		Shared Micromobility	Pull	Public Goods and Services, Information and Education	Increase the availability of vehicles (Bike sharing, e-bike sharing, (e)scooter sharing)	Boston (USA), Sacramento (California, USA)	Basu and Ferreira (2021), Fukushige et al. (2023)
6	**Travel Planning**	Workplace Travel Planning	Push & Pull	Information and Education, Regulatory, Economic, Public Goods and Services	Travel plans and advice for companies and employees	Brighton, Hove, Norwich and 20 other cities in UK, Graz (AUT), Nantes (FR), Finland	CIVITAS) (2013a, 2013b), Cairns et al. (2010), Isola et al. (2023)
		School Travel Planning	Pull	Information and Education, Public Goods and Services	Travel plans and advice for pupils and their parents	San Sebastian (ES), Several cities in Canada	CIVITAS (2013c), Mammen et al. (2014);Buttazzoni et al. (2019)
		University Travel Planning	Push & Pull	Information and Education, Regulatory, Economic, Public Goods and Services	Travel plans and advice for staff and students	Barcelona (ES); Turin and Roma (IT); Glasgow (UK); Bristol (UK); La Coruna (ES);	Brett (2016), Miralles-Guasch and Domene (2010), Papantoniou et al. (2020).
		Personalized Travel Planning	Pull	Information and Education, Economic	Personal travel analysis andplans for individuals	Sardinia (IT), Cities in Japan	Meloni et al. (2017),Fujii and Taniguchi (2006)

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Table A1 (*continued*)

	Intervention category	Intervention type	Intervention approach	Policy instrument (s)	Main measures	Case studies	References
		Multi-modal planners	Pull	Information and Education	MaaS app	Sydney (AUS), London, Birmingham and Huddersfield (UK)	Hensher et al. (2021), Alyavina et al. (2020)
7	**Gamification**	App for Sustainable Mobility	Pull	Information and Education, Economic	App for individual users in which they can collect points for sustainable mobility behaviour and receive rewards from local businesses	Bologna (IT)	Kassirer (2020)
		Smartphone-app-based mobility management	Pull	Information and Education	Gamified smartphone app that counts steps and provides "evaluation" through comments and images	Kumamoto (JP)	Nakashima et al. (2017)
		Apps for changing travel behaviour	Pull	Information and Education	Systematic review: 30 studies on different apps that aim at changing travel behaviour, improving driving behaviour and encouraging bicycle commuting	Different cities	Wang et al. (2022)
		App to encourage active travel	Pull	Information and Education	"Beat the street": physical Radio Frequency Identification (RFID) scanners called 'Beat Boxes' are placed on lampposts and in areas of blue and green space at roughly half-mile intervals throughout a town or city	London (UK) and 113 towns and cities worldwide	Harris and Crone (2021)
		Carpooling gamification app	Pull	Information and Education	Aiming at reducing energy emissions and optimizing the traffic flow by using gamification to stimulate carpooling.	Warsaw (PL)	Olszewski et al. (2018)
8	**Public space (urban planning/ mobility)**	X - minute city/ multiple centers	Push & Pull	Public Goods and Services	Having access to work, leisure and services within X min from home.	Paris (FR), Barcelona (ES) and many other cities	Moreno et al. (2021); Ferrer-Ortiz et al. (2022)
		Mobility hubs	Pull	Public Goods and Services	Gathering of various shared mobility options and potentially other non-mobility services at one location.	Bremen and Hamburg (DE), Amsterdam (NL) and many other cities	Czarnetzki and Siek (2022), Gemeente Amsterdam (2023), Hachette and L'Hostis (2023), Roukouni et al. (2023)

Table A1a
Charging and pricing.

Q1	Charging cars for entering the city centre during specific days and times (for example during the busiest hours of morning and evening on weekdays).
Q2	Stop of free parking provision at workplaces - a parking fee required if employees want to park their car at the parking facilities of their work.
Q3	Everyone except for residents of the City of Amsterdam required to pay a daily fee to access the city centre by car, while the residents; cars are able to enter for free.
Q4	Access allowed only to residents' cars by charging an annual fee that would depend on the type of car and the household's annual income.
Q5	Introduction of a "green city tax" to all car owners. If you travel to and from the city centre more than a specific number of times per year (which will be measured by sensors installed at the edges of the area) you are ought to pay the tax.

Table A1b
Access limitations.

Q6	License plate control - only odd or even (ending) license plate numbers can enter the city centre on specific days
Q7	Only cars of certain categories (emission standards) can enter the city centre, independently of the time or/and day.
Q8	The city centre becomes completely car-free. No car is allowed to enter anymore.
Q9	The city centre becomes completely car-free during the weekends. During the weekdays only certain streets become car-free, and these streets change every week. The rotation plan of the streets is announced beforehand to residents, visitors and tourists.
Q10	Allow certain groups of people to access certain locations at certain times by car (e.g. ticket holders that want to approach a concert hall) and prohibit access to all other cars in the centre.
Q11	Dynamic access to (parts of) the city centre based on real-time information regarding traffic conditions (for example, if there is a traffic jam on a street, cars will be redirected to different paths until it is dissolved).
Q12	Cars above a certain weight (e.g. SUVs) are not allowed to enter the city centre.

Table A1c
Parking management.

Q13	Increasing the hourly parking fees of on-street parking in the city centre to discourage visitors and tourists to access the city centre by car.
Q14	Daily parking fee, regardless the duration that the car stays parked at the parking spot.
Q15	Reduction of number of resident parking permits for new building developments and an increase in the parking fee for visitors and tourists.
Q16	Reduction of parking spaces in the city centre and provision of reduced public transport fees for residents from/to P + R locations at the edge of the city.
Q17	Decreasing the number of parking spaces in the city centre and transforming the space into alternative uses (green, bike parking, garbage containers, playgrounds, recreational spaces/street art exhibitions etc.).

Table A1d
Improvement of public transport and active modes' infrastructure/mobility services/public space.

Q18	Introducing/increasing the frequency of late evening/night and/or 24 h public transport services in the city centre.
Q19	Reduced public transport fee for certain population groups such as students or the unemployed.
Q20	Make public transport free-of-charge for all.
Q21	Development of cycle superhighways (elevated cycle paths to eliminate interactions with cars and improve the cycling experience).
Q22	Shuttle buses from companies in the city centre to/from P + R locations at the edge of the city.
Q23	Creating gradually multiple centers within the city centre so that in the future all residents will not have to travel more than 15 min on foot or by bike from home to reach their work/school, run errands or attend leisure activities.
Q24	Introducing a system where each resident will be given a monthly mobility budget that can be spent as one sees fit with less socially desirable modes will involve using more of this budget. Trading mobility budget with others is allowed so that you can increase your mobility budget by paying for it or make money by selling unused mobility budget.

Table A1e
Shared mobility.

Q25	Car sharing plan that involves some cars parked in the city centre to be used only by residents when needed, upon reservation. This plan would entail a monthly fee.
Q26	Car sharing scheme that involves a resident discount at an existing car sharing service, which nevertheless is used by residents and visitors all of the same. In this scheme, vehicle availability cannot be guaranteed.
Q27	Increase the number of available shared vehicles in the city centre (bikes, e-bikes and (e)cars).
Q28	Having various shared mobility options made available at specific locations where other non-mobility services such as post and waste also exist.

Table A2
Results of LCCA - 3-Cluster model full profile.

	Cluster1	Cluster2	Cluster3	Overall
Cluster Size	0.3863	0.346	0.2677	
Indicators				
Factor 1				
Mean	0.5593	−0.1995	−0.9538	−0.1083
Factor 2				
Mean	0.4945	0.1332	−0.7793	0.0284
Factor 3				
Mean	0.5218	−0.7382	−0.3407	−0.145
Factor 4				
Mean	−0.7255	−0.2136	1.3359	0.0035
Covariates				
Gender				
Male	0.5023	0.485	0.5079	0.4978
Female	0.4953	0.4998	0.4809	0.493
Prefer not to say	0.0024	0.0152	0.0112	0.0092
Age				
18 −24	0.0348	0.0861	0.1389	0.0804
25 −34	0.2524	0.41	0.1549	0.2808
35 −44	0.1273	0.1307	0.0965	0.1202
45 −54	0.1359	0.1225	0.1509	0.1353
55 −64	0.2289	0.1609	0.2798	0.219
> 65	0.2207	0.0898	0.179	0.1643
Education				
No formal school or primary school	0.0037	0.0094	0.0105	0.0075
Secondary (middle) school	0.2189	0.2744	0.2984	0.2594
Vocational education	0.2614	0.2126	0.3733	0.2745
Bachelor degree	0.3334	0.2921	0.1903	0.2808
Master/PhD	0.1825	0.2043	0.1239	0.1744
Prefer not to say	0.0001	0.0072	0.0036	0.0035
Occupation				
Student	0.0468	0.1107	0.0898	0.0804
With professional occupation	0.6644	0.667	0.6116	0.6512

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Table A2 (*continued*)

	Cluster1	Cluster2	Cluster3	Overall
Unemployed	0.0582	0.1186	0.067	0.0814
Retired	0.2306	0.0965	0.2166	0.1805
Prefer not to say	0	0.0072	0.0149	0.0065
Household members				
1	0.3009	0.2495	0.2023	0.2567
2	0.3803	0.3058	0.417	0.3643
3 −5	0.3122	0.4198	0.3714	0.3653
5 −7	0.0066	0.0249	0.0094	0.0137
Number of children				
0	0.6387	0.5328	0.682	0.6136
1	0.1576	0.2756	0.1336	0.192
2	0.1754	0.1445	0.111	0.1475
3	0.0283	0.0313	0.0641	0.0389
4 +	0.0001	0.0158	0.0094	0.008
Car ownership				
0	0.2385	0.1963	0.0822	0.182
1	0.5142	0.5083	0.6426	0.5465
2	0.1925	0.2675	0.2073	0.2224
3 +	0.0549	0.0279	0.0679	0.049
Dummy_Car_Commute				
0	0.5097	0.3426	0.3035	0.3967
1	0.4903	0.6574	0.6965	0.6033
Dummy_Bus_Commute				
0	0.7478	0.8154	0.8739	0.8049
1	0.2522	0.1846	0.1261	0.1951
Dummy_Metro_Commute				
0	0.8029	0.7375	0.8242	0.786
1	0.1971	0.2625	0.1758	0.214
Dummy_Tram_Commute				
0	0.7635	0.7653	0.8955	0.7995
1	0.2365	0.2347	0.1045	0.2005
Dummy_Train_Commute				
0	0.7428	0.7747	0.8874	0.7926
1	0.2572	0.2253	0.1126	0.2074
Dummy_Bicycle_Commute				
0	0.5097	0.6476	0.6533	0.5959
1	0.4903	0.3524	0.3467	0.4041
Dummy_Walking_Commute				
0	0.7039	0.8159	0.8566	0.7835
1	0.2961	0.1841	0.1434	0.2165
Dummy_Other_Commute				
0	0.9417	0.936	0.9336	0.9376
1	0.0583	0.064	0.0664	0.0624
Dummy_Sharedmobility_Commute				
0	0.9908	0.9721	0.9604	0.9762
1	0.0092	0.0279	0.0396	0.0238
Number of modes_Commute				
1	0.4108	0.4974	0.5514	0.4784
2	0.2683	0.1724	0.23	0.2249
3	0.1314	0.1749	0.1452	0.1501
4	0.0645	0.0599	0.0242	0.0521
5	0.0748	0.0353	0.0316	0.0495
6	0.0379	0.0111	0.0135	0.0221
7	0.0123	0.0491	0.0041	0.0229
Dummy_Car_Leisure				
0	0.4169	0.3508	0.1651	0.3266
1	0.5831	0.6492	0.8349	0.6734
Dummy_Bus_Leisure				
0	0.735	0.8189	0.8695	0.8001
1	0.265	0.1811	0.1305	0.1999
Dummy_Metro_Leisure				
0	0.7776	0.776	0.8905	0.8073
1	0.2224	0.224	0.1095	0.1927
Dummy_Tram_Leisure				
0	0.7912	0.7948	0.8534	0.8091
1	0.2088	0.2052	0.1466	0.1909
Dummy_Train_Leisure				
0	0.6364	0.7522	0.8579	0.7358
1	0.3636	0.2478	0.1421	0.2642
Dummy_Bicycle_Leisure				
0	0.5674	0.6485	0.6419	0.6154
1	0.4326	0.3515	0.3581	0.3846
Dummy_Walking_Leisure				
0	0.6807	0.8338	0.7691	0.7573
1	0.3193	0.1662	0.2309	0.2427
Dummy_Other_Leisure				

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Table A2 (*continued*)

	Cluster1	Cluster2	Cluster3	Overall
0	0.9576	0.9579	0.9258	0.9492
1	0.0424	0.0421	0.0742	0.0508
Dummy_Sharedmobility_Leisure				
0	0.966	0.984	0.9462	0.9669
1	0.034	0.016	0.0538	0.0331
Number of modes_Leisure				
1	0.3624	0.5016	0.5093	0.4499
2	0.1971	0.1832	0.1988	0.1928
3	0.1996	0.1581	0.161	0.1749
4	0.1408	0.072	0.0218	0.0851
5	0.0616	0.0699	0.0514	0.0618
6	0.0245	0.0035	0.0577	0.0261
7	0.0139	0.0118	0	0.0095
S1				
1	0.2318	0.1282	0.0313	0.1423
2	0.0899	0.0709	0.0113	0.0623
3	0.0705	0.0645	0.0241	0.056
4	0.1898	0.3228	0.1651	0.2292
5	0.1837	0.2044	0.1129	0.1719
6	0.1011	0.0714	0.2032	0.1182
7	0.1333	0.1379	0.4521	0.2202
S2				
1	0.0276	0.0495	0.3297	0.1161
2	0.0433	0.0471	0.1414	0.0709
3	0.0875	0.1799	0.0923	0.1207
4	0.2029	0.327	0.2914	0.2696
5	0.2393	0.2426	0.0689	0.1948
6	0.217	0.108	0.0636	0.1382
7	0.1824	0.0458	0.0126	0.0897
S3				
1	0.0881	0.1411	0.3153	0.1673
2	0.1077	0.0795	0.2479	0.1355
3	0.1153	0.2096	0.1975	0.1699
4	0.2199	0.3081	0.114	0.2221
5	0.2008	0.1211	0.0819	0.1414
6	0.1454	0.0847	0.0291	0.0932
7	0.1227	0.0559	0.0142	0.0705
S4				
1	0.3663	0.1786	0.0957	0.2289
2	0.1581	0.1256	0.079	0.1257
3	0.0837	0.1188	0.0244	0.08
4	0.1317	0.3113	0.2085	0.2144
5	0.087	0.142	0.1845	0.1322
6	0.1316	0.0939	0.1462	0.1225
7	0.0415	0.0298	0.2616	0.0964
S5				
1	0.1313	0.0508	0.0201	0.0737
2	0.1419	0.0732	0.0139	0.0839
3	0.0932	0.1394	0.0596	0.1002
4	0.2873	0.3025	0.2204	0.2746
5	0.1444	0.2722	0.2668	0.2214
6	0.139	0.1003	0.181	0.1369
7	0.0629	0.0616	0.2382	0.1094
S6				
1	0.0744	0.1112	0.4737	0.194
2	0.0888	0.14	0.2853	0.1591
3	0.0692	0.1172	0.1233	0.1003
4	0.2763	0.3935	0.0996	0.2695
5	0.2337	0.1614	0.001	0.1464
6	0.1294	0.0515	0.017	0.0723
7	0.1282	0.0252	0	0.0582
S7				
1	0.0051	0.0246	0.1339	0.0464
2	0.0059	0.0441	0.0724	0.0369
3	0.0385	0.0889	0.1718	0.0917
4	0.1526	0.2423	0.3682	0.2413
5	0.2019	0.2345	0.1239	0.1923
6	0.2257	0.2205	0.0641	0.1806
7	0.3702	0.1452	0.0657	0.2108
S8				
1	0.1248	0.022	0.0131	0.0593
2	0.1246	0.0718	0.0181	0.0778
3	0.2178	0.1096	0.0327	0.1308
4	0.235	0.4379	0.2385	0.3061
5	0.1239	0.2163	0.2265	0.1833
6	0.1265	0.072	0.174	0.1204

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Table A2 (*continued*)

	Cluster1	Cluster2	Cluster3	Overall
7	0.0475	0.0704	0.2971	0.1223
S9				
1	0.0243	0.0122	0.1364	0.0501
2	0.023	0.019	0.1163	0.0466
3	0.0359	0.0496	0.1081	0.06
4	0.0932	0.2816	0.2217	0.1927
5	0.2239	0.2838	0.18	0.2329
6	0.3308	0.2496	0.1048	0.2422
7	0.269	0.1042	0.1327	0.1755
S10				
1	0.0371	0.043	0.3496	0.1228
2	0.0359	0.0552	0.1448	0.0717
3	0.0594	0.112	0.188	0.1121
4	0.1813	0.3613	0.2191	0.2537
5	0.2691	0.2815	0.046	0.2136
6	0.1453	0.0824	0.043	0.0961
7	0.2719	0.0646	0.0095	0.1299

Data availability

Data will be made available on request.

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