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Accessibility and time valuation in commuter mode choices: Evidence from European countries

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ABSTRACT

This paper examines how first- and last-mile access conditions influence commuter transport mode choice across four European urban contexts using a harmonised stated-preference experiment and Bayesian analysis. While access and egress conditions are widely recognised as important in mode choice, directly comparable cross-country evidence based on a common experimental design remains limited. We therefore focus on a deliberately controlled short-distance commuting setting to isolate and compare the role of access distance, access time, travel time, and cost.

The results show that access conditions materially affect stated mode choice, but their importance varies across modes and countries. In particular, improved access to public transport appears especially relevant in the Czech Republic and Poland, while the relative valuation of time and access differs across contexts. At the same time, some willingness-to-pay-based indicators could not be robustly derived for all cases, which limits full cross-country comparability.

The contribution of the paper is threefold: it provides a cross-country comparison under a harmonised stated-preference design, offers explicit valuation of access-related attributes, and identifies where comparative inference remains more or less stable across contexts. The findings support the inclusion of first- and last-mile conditions in sustainable transport planning, while also indicating that access improvements must be assessed together with broader network and operational trade-offs.

1. Introduction and state of the art

The access distances of the first and last-mile (or walking time) in transportation are closely intertwined with the concept of sustainable mobility, which aims to offer efficient, equitable and environmentally friendly transportation solutions: the closer the mass and shared modes are to the citizens, the higher the likelihood of a shift from personal cars (Núñez et al., 2024). Sustainable mobility seeks to balance the needs of individuals, communities, and the environment by promoting transport modes that minimise negative impacts on the planet while ensuring acceptable first- and last mile access for all. It is an alternative paradigm for investigating the complexity of cities and strengthening the links between land use and transport by addressing travel demand (Banister, 2008; Collins and Chambers, 2005).

Within the framework of this study, we refer to the access distance to the first and from the last-mile as the distance from/to the POI to/from shared modes, such as the walking distance to stops, multimodal hubs, or stations. This definition recognises that, while accessibility to opportunities and resources is broader, the ability to conveniently access transport infrastructure forms a critical precursor to sustainable and equitable mobility. Handy (2002). It refers to the ease with which people can reach desired destinations or engage in activities (Jamei et al., 2022), and plays a crucial role in shaping individuals' transport mode choices.

Access conditions are not necessarily perceived or valued equally across different users, transport modes, and contexts. In this study, we focus on objective access-related attributes, specifically access distance, access time, travel time, and cost. This choice is deliberate: although subjective dimensions such as perceived convenience or comfort are important, objective measures are more readily quantifiable and more easily comparable across countries within a common experimental design. The analysis therefore does not aim to capture the full perceived experience of accessibility, but rather to isolate the behavioural relevance of measurable first- and last-mile conditions in commuters' transport mode choice.

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1.1. State of the art

Improving access to public transport (PuT) can increase uptake, yet *network design* introduces a classic trade-off: decreasing access distance by adding stops tends to increase dwell time, reduce commercial speed, and impair reliability. Analytical and empirical studies show that optimal stop spacing minimises the sum of walking, waiting, in-vehicle, and dwelling penalties; the social optimum varies with demand density, trip length, and congestion (Tirachini, 2014). These insights imply that *reducing access impedance does not necessitate uniform stop densification*; alternatives include targeted pedestrian connectivity (shortcuts, crossings), *express–local* patterns, and interchange design that preserves speed while improving access. Recent continuum-approximation and corridor-design work extends these results, showing how spacing, frequency, and operational patterns co-determine generalised costs and should be co-optimised rather than tuned in isolation (Ouyang et al., 2014). The effect of access improvements must be read against spacing and speed; policy levers that cut walking time while protecting line speed (e.g., pedestrian permeability, micromobility feeders, express services) are often superior to blanket stop densification.

Within discrete choice models, *access/egress time* typically enters utility as a separable disutility component, enabling monetisation via the marginal rate of substitution with the cost coefficient (i.e., willingness-to-pay to reduce access time). Although many studies estimate values of time and reliability (Abou-Zeid et al., 2010; Montes et al., 2023; Jaber et al., 2023; Wang et al., 2025), fewer explicitly monetise first- and last-mile access impedance across modes and geographies on a common experimental platform-needed for comparable policy trade-offs (e.g., pedestrian permeability vs. frequency or stop spacing). Our approach contributes by reporting *mode- and country-specific monetary values of access* in a unified stated preference (SP) design, offering portable inputs to the design of the corridor and station-area.

Existing studies confirm that first- and last-mile conditions matter for transport choice, but they differ considerably in terminology, model specification, and empirical setting, which limits direct comparability across modes and countries (Jaber et al., 2023; van Kuijk et al., 2022; Garus et al., 2022). The literature also shows that access improvements must be interpreted against broader network design trade-offs, especially the tension between shorter access distances and lower operating speed caused by denser stop spacing. What remains relatively scarce is harmonised cross-country evidence that isolates and monetises access-related impedance within a common stated-preference framework (Ranjan and Sinha, 2025).

This study addresses that gap through a deliberately controlled comparison of four European contexts. Its contribution is threefold: it provides a cross-country comparison under a unified stated-preference design, offers explicit valuation of access-related attributes, and identifies where comparative inference remains stronger or weaker across contexts. Rather than aiming to provide a complete behavioural explanation of commuter choice, the paper focuses more narrowly on the role of access distance, access time, travel time, and cost in a short urban commuting setting.

Accordingly, the paper isolates and compares generalised cost sensitivity in short urban commuter choice experiments across four European contexts under this unified framework.

2. Methodology

This study draws on data collected within the international KIC MaaS_together project. The analysis uses a stated-preference experiment designed to compare how respondents evaluate selected transport alternatives under different combinations of access distance, access time, travel time, and cost. A revealed-preference design was not suitable for this purpose because the study required controlled variation in hypothetical service attributes across multiple transport options and countries. The methodology section therefore first describes the experimental design and then the modelling approach applied.

We conducted a stated-preference experiment to examine how residents in urban areas of Germany, the United Kingdom, the Czech Republic, and Poland value selected transport alternatives and their access conditions. The design followed established stated-preference experiment design recommendations (Hensher et al., 2005; Ferreira et al., 2022a; Li et al., 2020; de Sá and Pitombo, 2021; Kato, 2025). The alternatives, attributes, and levels were defined through two streams of focus groups. First, in consultation with urban transport experts to define alternatives and potential attributes; second, with mobility users and survey-design experts to frame the experiment scope in terms of main attributes and level targets. The final levels, shown in Table 1, were chosen to balance simplicity for respondents while still reflecting realistic service conditions derived from local provider offers and observed user experience. Attributes are therefore defined by two or three levels, depending on their importance and the need to keep the task interpretable. A base level was set as the current average value (2020) of cities belonging to the target countries. The remaining levels were defined in two ways: either representing potential improvements, thus making the alternative more attractive, or, for travel time, matching a private car trip or reflecting worse performance (with the exception of **public transport (PuT)**, whose travel time is usually not comparable to the private car, particularly in urban centres).

The defined scenario consisted of a single urban commute trip of approximately 5 km through the city centre. This controlled short-distance setting was chosen to improve comparability across the four study contexts and to isolate sensitivity to the analysed attributes, while still representing a common urban scenario; for example, Krauss et al. (2022) indicates that almost 90% of all urban trips in Germany are below 20 km, of which close to 55% are below 4 km. It also aligns with scenarios considered in recent research such as Esztergár-Kiss et al. (2022), where it is argued that, when considering micromobility, it is necessary to balance a short enough distance for micromobility to be viable, but not so short that other modes are no longer viable. The private car was not explicitly included in the choice set, as the aim was to focus on trade-offs among the selected transport alternatives and their access conditions. However, each presented scenario allowed for the selection of "None of the above", which implied the use of private transport. Nevertheless, it is important to understand that stated-preference experiments are hypothetical choices, thus they have reduced behavioural realism and should be understood as a deliberate simplification of a broader real-world choice environment. The attribute values were calibrated for an exemplary city in each country using Google Maps and local provider applications to infer travel times and price ranges; the resulting values are shown in Table 2.

In the present paper, additional variables such as subjective (perceived) accessibility factors are not included in the estimated specification. This was a deliberate choice made to preserve a common model structure across countries and to focus the comparison on transport-mode attributes and access-related factors. While this improves interpretability of cross-country differences, it also removes potentially relevant sources of behavioural heterogeneity; this limitation is revisited in the discussion section. The influence of socio-demographic factors on mode choice was investigated in another paper by the authors using the same dataset (Matowicki et al., 2022).

One of the transport modes presented to respondents was Mobility-as-a-Service (MaaS). It should be noted that while MaaS is generally understood as an integrated mobility concept that includes service bundling, booking, and payment integration, in this stated-preference experiment it was operationalised in a simplified form as an intermodal travel option combining multiple transport modes within a single trip. Nevertheless, the survey provided a definition of MaaS to the participants, which read as: *"Mobility-as-a-Service describes a shift away from personally owned modes of transportation and towards mobility services. This is achieved by combining public and private transportation providers*

Table 1
Levels for the stated preference experiment which is then adapted to each countries as per local prices.

Alternative	Attribute	Levels		
		Level 1	Level 2	Level 3
Public Transport (PuT)	Price	Current	50%	Free
	Travel time	Current	80%	60%
	Additional walking time	0 min	5 min	10 min
Carsharing	Price	Current	75%	
	Travel time	Current	+20%	
	Distance to car	Up to 400 m	Up to 1000 m	
Bike sharing	Price	50% today PuT price	25%	Free
	Travel time	Routing time google maps + 20%	Routing time google maps + 50%	
	Walking distance to hub	Up to 400 m	Up to 1000 m	
	Route conditions	Cycling Lane	Street	
Micromobility	Price	Current	75%	50%
	Travel time	like bike	+25%	
	Walking distance to scooter	up to 400 m	up to 1000 m	
	Route conditions	Cycling Lane	Street traffic	
On-demand mobility	Price	Current	75%	50%
	Travel time	100% of today car	+20%	+50%
	Walking distance to pick-up point	100 m	500 m	
	Number of foreign passengers sharing the ride	1	3	7
Combination: PuT + micromobility	Price	150% of today PuT	100%	75%
	Travel time	PuT time + walking	PuT time + half walking	PuT time

Note: The percentage values for levels (e.g., 80% for public transport) represent the proportion of the current price or time relative to its baseline value. For example, "80% of current price" refers to a 20% discount on the standard fare, while "80% of current time" implies a 20% reduction in travel time.

Table 2
Base values for the SP experiment levels at the different countries according to real data collected in major cities.

Country	Public Transport (PuT)		Carsharing	Bike sharing	Micromobility	On-demand
	Price	Travel time	Price	Travel time	Price	Price
UK	4.90 GBP	12 min	4.50 GBP	15 min	5.99 GBP	8.77 GBP
Germany	2.60 EUR	10 min	5.10 EUR	11 min	4.85 EUR	11.30 EUR
Czech Republic	24 CZK	15 min	30 CZK	22 min	81 CZK	135 CZK
Poland	3.40 PLN	20 min	17.85 PLN	18 min	14 PLN	20 PLN

through a unified gateway. Imagine that there is such a Mobility-as-a-Service offer within your city. This means that you can plan an intermodal trip by combining different modes of transport according to your needs. This service is offered by one single provider, so booking, processing, and payment take place on one and the same platform (app)" (see Fig. 1).

2.1. Application to discrete choice analysis

Discrete choice analysis involves modelling decisions in which individuals choose from a finite set of alternatives. Let y_i represent the observed choice for the individual i from a set of alternatives C (Eq. (1)).

$$P(y_i|C) = \frac{\exp(V_i)}{\sum_{j \in C} \exp(V_j)} \tag{1}$$

where $P(y_i|C)$ represents the probability that the individual i chooses the alternative j from the set of alternatives C, based on the utility V_j.

Discrete choice analysis is used to model decisions among a finite set of alternatives. In this study, we apply a Bayesian formulation of the choice model in order to estimate parameter uncertainty in a consistent way across the analysed contexts and to improve stability under uneven choice frequencies across transport modes. This is particularly useful in our data, where some alternatives were selected much less frequently than others (see Fig. 2(a)). The Bayesian specification should not be interpreted as the only possible modelling approach, but as a suitable framework for comparative inference in the present stated-preference setting (Daziano et al., 2013).

2.2. Model specification

The application of Bayesian methods to discrete choice analysis involves the description of prior and posterior distributions for the choice probabilities beta. Let $\pi(\beta)$ denote the prior distribution. The posterior distribution is then updated using Bayes' theorem (Bayes, 1763):

$$L(\beta) = \prod_{i=1}^{N} P(y_i|X_i, \beta) \tag{2}$$

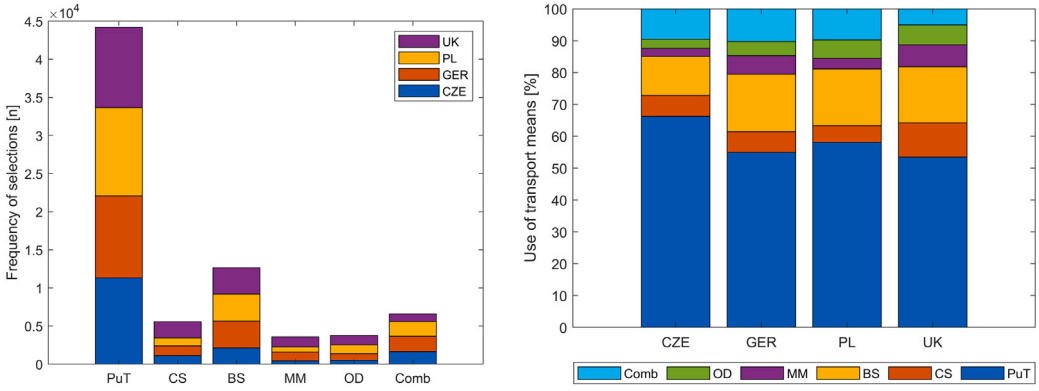
where $P(y_i|X_i, \beta)$ represents the probability that an individual i makes a choice y_i given covariates X_i and parameters β and N is the number of observations.

According to this principle, we calculated the conditional probability that an individual would choose a specific transport mode giving information about the prices, travel times, and convenience levels as presented in the previous subsection.

Regarding the parameters verified in the model, in a previous study on the data set presented (Matowicki et al., 2022), the analysis carried out in the elaborated research focused solely on the effect of socioeconomic characteristics and personal beliefs (latent variables) on the intention to use a specific transport mode. In the current analysis, we focus on the effect of the transport mode parameters and their effect on the choice of transport mode regardless of the innate response characteristics. This means that the only independent variables that we considered in our models were transport mode parameters and the

Public Transit	Price	For free	A
	Travel time	7.2 minutes	
	Walking time	0 minutes	
Car-Sharing	Price	3.38 £	B
	Travel time	15 minutes	
	Distance to the car	Up to 400 yd	
Bike-Sharing	Price	For free	C
	Travel time	19.2 minutes	
	Distance to the bike	Up to 400 yd	
	Route condition	Street	
Micro-Mobility	Price	3.00 £	D
	Travel time	19.2 minutes	
	Distance to the scooter	Up to 400 yd	
	Route condition	Street	
On-Demand Mobility	Price	4.39 £	E
	Travel time	15 minutes	
	Distance to the pick-up-point	100 yd	
	Number of passengers (including you)	1	
Intermodal Routing	Price	3.68 £	F
	Travel time	12 minutes	

Fig. 1. Example of one of the SP experiments shown in the online survey, with values for each transport mode parameters generated with orthogonal survey design.



(a) Distribution of country origin by transport mode.

(b) Distribution of transport modes by country of origin.

Fig. 2. Distribution of commuter responses with respect to transport mode and country of origin.

response country of origin. Interpersonal characteristics in each country specific respondent group were not allowed as influencing parameters. The comparability of the country specific samples was ensured through professionally organised panel data with representative samples.

2.3. Perceived value estimation

After estimating the effects of individual transport-mode attributes on stated choice probability (see Eq. (1)), we derived the Value of Time

(VoT) and the Value of Access (VoA) using the standard coefficient-ratio approach commonly applied in discrete choice research (Krauss et al., 2022; Dubernet and Axhausen, 2020; Abdel-Aal, 2017; Abou-Zeid et al., 2010). VoT was obtained from the ratio of the time and cost coefficients, while VoA was derived analogously for the access-related attribute (see Eqs. (3) and (4)). To improve interpretability and comparability across modes and groups, access distance was expressed in time-equivalent terms using established walking-speed assumptions (Alves et al., 2020). Not all VoT and VoA values could be derived robustly for every context, which was caused by a statistically insignificant effect of either the price or distance parameter in some cases. Only those results for which both parameters were evaluated as significant at the level of $\alpha = 0.01$ are therefore presented and interpreted.

$$VoT = \frac{\partial U_{TravelCost}}{\partial TravelTime} = \frac{\frac{\partial U}{\partial_{TravelCost}}}{\frac{\partial U}{\partial TravelTime}} = \frac{\beta_{TravelTime}}{\beta_{TravelCost}} \tag{3}$$

$$VoA = \frac{\partial U_{TravelCost}}{\partial_{Walking\,Distance}} = \frac{\frac{\partial U}{\partial TravelCost}}{\frac{\partial U}{\partial Walking\,Distance}} = \frac{\beta Walking\,Distance}{\beta_{TravelCost} \times S_{Walking}} \tag{4}$$

where β are the coefficients resulting from the Logit model for each mode of transport, and the walking speed is adopted from Alves et al. (2020).

VoT and VoA are thus represented in monetary terms and, in order to facilitate interpretation of the results, they are converted into € currency.

3. Results

The survey containing the stated-preference (SP) experiment was conducted in the four countries during October 2020, reaching a total of 6405 participants (1607 in Germany, 1061 in the United Kingdom, 1596 in the Czech Republic, and 1061 in Poland). The sample represents individuals living in cities with at least 80 000 inhabitants, who are regular commuters (identified as travelling at least three days per week) to ensure that the respondents are familiar with the different transport modes and services presented in the experiment.

Before presenting the detailed results, it is important to note that the stated choices in the experiment were unevenly distributed across transport modes. Public transport dominated the responses, while some alternatives, such as micromobility or MaaS (Mobility-as-a-Service), were selected much less frequently. This pattern is relevant for interpretation: the reported effects should be understood primarily as relative changes in stated choice probability rather than as evidence of large absolute shifts in mode shares.

The first step taken to perform a sensitivity analysis of commuter choice behaviour based on "closeness to" or distance to the transport mode access point was the χ^2 independence test. This method verified the strength of the dependency between the individual transport mode parameters examined in our study and the preference for a given transport mode. This was carried out independently in each country surveyed.

The results achieved are reported in Table 3. Due to the size of the available data set, the threshold for the value of Pearson's p to confirm dependency was chosen at $p < 0.01$. Variables that were confirmed as significant under these conditions for each country and transport mode are in bold.

A small number of coefficients showed counterintuitive directional patterns. Because the orthogonal SP design and the restricted specification do not permit reliable causal attribution, these cases are not over-interpreted here and are revisited as a limitation.

3.1. Impact on the choice of public transport

The analysis of the results on public transport reveals that the effects of all examined variables are statistically significant when it comes to influence on the choice of modes. However, its effect is far from unanimous. Detailed analysis shows that despite the consistent positive effect of price on choice probability (up to 9.3%), this effect is dominated by the population of the Czech Republic, which overwhelmingly shows a probability change of 42,8% in the case of free public transport. In contrast, the effect on the UK seems to be negative. As to the reasoning for this behaviour, the present design does not allow a reliable causal explanation of this pattern. Some hypotheses are given in the preamble of this section; another might be fear of overcrowding of free public transport, which is already extremely overloaded in large cities in the United Kingdom. However, this is just a hypothesis and cannot be confirmed in this study as it would require an additional survey with a Likert state evaluation of public transport by the respondents. Similar results were discovered for the overall travel time of PuT in the proposed scenarios (see Table 4). The last parameter of public transport had a more straightforward impact on the probability of choice. Here, the effect investigated was the amount of time it took to walk to or from the PuT stop from/to the origin/destination. In the case of the Czech Republic and Poland, the change was approximately 20% in favour of public transport when we decreased the walking distance to/from the stops. The positive change was also observed in the case of Germany, although it was much smaller in magnitude and did not progress linearly with a decrease in walking distance. The effect, once again, had a very unclear impact on the respondents from the United Kingdom.

3.2. Impact on choice of carsharing

Interpreting carsharing results is much more straightforward. The effect of the advantageous carsharing parameters significantly improved the attractiveness of this transport mode in the Czech Republic and the United Kingdom. The two factors that had the most significant effect were the overall decrease in travel time and the distance from the shared car. In the Czech Republic, once again, similar to public transport prices, the price also had a significant effect. Specifically, *the walk distance to shared parking* was shown to have the potential to improve the adaptability of this mode of travel by almost 20% in the case of the Czech Republic and 11.3% in the United Kingdom. In contrast to public transport, this attractiveness of transport modes was affected by any parameter change in the case of the German and Polish respondents. More detailed results for car sharing are presented in Table 5.

3.3. Impact on choice of bike sharing

The third transport mode investigated in the context of the value of the access distance was bike sharing. The parameters of this transport mode that were investigated are trip price, overall travel time, walking distance to bike parking, and route conditions (existence of a cycling lane or the necessity of riding a bike on a street with cars). The price of this service had the most significant impact on commuters from the Czech Republic. The free use of bike sharing services offers a potential increase of 31,4% in willingness to use shared bikes. As mentioned in the beginning of this section, the impact of travel time is less uniform across different countries. Surprisingly, among Polish commuters, longer travel time seems to have a positive impact on the probability of this choice of transport mode in Poland, while having a statistically significant negative impact on commuters in the United Kingdom. Other parameters examined (walking distance to bike share station and existence of cycling infrastructure) had a positive impact on the probability of use among respondents. The only country whose citizens remained uninfluenced by variations in those parameters is Poland. In the case of the Czech Republic, Germany, and the UK, the possibility of using the cycle lane throughout the length of the trip increases the perceived attractiveness of this mode by about 18% (2–3 percentage points and shown in Table 6).

Table 3
Dependency test results for choosing specific transport mode based on its parameters. Variables identified as significant are in bold.

Transport mode	Variable	All data	Czech Rep.	Germany	Poland	UK
Public transport	Price	**0.000**	**0.000**	0.0481	0.974	**0.000**
	Travel time	**0.000**	**0.000**	**0.000**	0.089	**0.000**
	Additional walking times	**0.000**	**0.000**	0.031	**0.000**	0.186
Carsharing	Price	0.047	**0.001**	0.941	0.740	0.593
	Travel time	**0.000**	**0.002**	0.721	0.982	**0.000**
	Distance to car	**0.002**	**0.000**	0.184	0.479	**0.004**
Bike sharing	Price	**0.00**	**0.000**	0.158	0.351	**0.002**
	Travel time	0.035	0.014	0.989	**0.000**	**0.000**
	Walking distance	**0.000**	**0.000**	0.308	0.412	0.029
	Route conditions	0.259	**0.000**	**0.000**	0.996	**0.000**
Micromobility	Price	0.197	0.596	0.834	0.708	**0.009**
	Travel time	0.741	0.557	0.127	0.081	**0.004**
	Walking distance	0.054	0.282	0.090	**0.006**	0.319
	Route conditions	0.987	0.999	0.428	0.067	0.557
On-demand transport	Price	0.484	**0.008**	0.855	0.588	0.407
	Travel time	**0.003**	0.109	0.834	0.424	0.017
	Walking distance	0.679	0.099	0.085	0.074	0.044
	Number of passengers	0.314	0.151	0.366	0.043	0.043
MaaS	Price	**0.000**	**0.000**	0.830	**0.007**	0.025
	Travel time	**0.000**	**0.001**	**0.000**	**0.002**	0.356

Table 4
Probability of choosing PuT given specific parameters value (relative change from default state in brackets).

	All data	Czech Rep.	Germany	Poland	UK
Price (Free)	0.535 (0%)	0.718 (0%)	–	–	0.432 (0%)
Price (50%)	0.513 (−4.6%)	0.583 (−18.7%)	–	–	0.470 (8.8%)
Price (Current)	0.491 (−9.3%)	0.411 (−42.8%)	–	–	0.500 (15.8%)
Travel time (60%)	0.507 (0%)	0.625 (0%)	0.467 (0%)	–	0.426 (0%)
Travel time (80%)	0.545 (7.5%)	0.599 (−4.1%)	0.489 (4.6%)	–	0.447 (4.6%)
Travel time (Current)	0.516 (1.8%)	0.580 (−7.2%)	0.496 (6.2%)	–	0.465 (9.1%)
Additional walking time (0 min)	0.538 (0%)	0.662 (0%)	–	0.592 (0%)	–
Additional walking time (5 min)	0.534 (−0.6%)	0.609 (−7.9%)	–	0.528 (−10.9%)	–
Additional walking time (10 min)	0.465 (−13.6%)	0.495 (−25.3%)	–	0.473 (−20.1%)	–

Table 5
Probability of choosing carsharing given specific parameters value (relative change from default state in brackets).

	All data	Czech Rep.	Germany	Poland	UK
Price (75%)	–	0.066 (0%)	–	–	–
Price (current)	–	0.054 (−17.8%)	–	–	–
Travel time (Current)	0.070 (0%)	0.065 (0%)	–	–	0.105 (0%)
Travel time (20%)	0.061 (−12.8%)	0.055 (−17.8%)	–	–	0.080 (−24.2%)
Distance to the car (400 m)	0.068 (0%)	0.066 (0%)	–	–	0.098 (0%)
Distance to the car (1000 m)	0.063 (−7.7%)	0.053 (−19.9%)	–	–	0.087 (−11.3%)

Table 6
Probability of choosing bike sharing given specific parameters value (relative change from default state in brackets).

	All data	Czech Rep.	Germany	Poland	UK
Price (Free)	0.153 (0%)	0.126 (0%)	–	–	0.155 (0%)
Price (25% of today PuT)	0.148 (−3.6%)	0.115 (−8.6%)	–	–	0.159 (2.4%)
Price (50% of today PuT)	0.141 (−8.1%)	0.086 (−31.4%)	–	–	0.135 (−13.1%)
Travel time (current according to google)	–	–	–	0.158 (0%)	0.165 (0%)
Travel time (current + 50%) and -	–	–	–	0.177 (12.8%)	0.137 (−17.2%)
Walking distance (400 m)	0.153 (0)	0.123 (0%)	–	–	–
Walking distance (1000 m)	0.144 (−6.11%)	0.103 (−15.6%)	–	–	–
Using common street	–	0.103 (0%)	0.145 (0%)	–	0.136 (0%)
Using cycling lane	–	0.123 (18.4%)	0.171 (17.7%)	–	0.165 (17.6%)

3.4. Impact on choice of micro mobility

As presented in Fig. 2(a), micromobility represents 4.4% of the total sample size. Since the total sample size was 85 280 records, this choice was not popular enough to identify meaningful dependencies within the criterion of statistical significance at the p-value of 0.01. Although the independence test χ^2 showed significant results in the case of travel time and distance to the micromobility station, the absolute changes in probability presented in Table 7 are rather negligible. The general sensitivity to the MM parameters is visible only in the case of Poland (walking distance to the station) and the UK (price and overall travel time).

Table 7
Probability of choosing micromobility service given specific parameters value (relative change from default state in brackets).

	All data	Czech Rep.	Germany	Poland	UK
Price (50%)	–	–	–	–	0.064 (0%)
Price (75%)	–	–	–	–	0.064 (0%)
Price (current)	–	–	–	–	0.055 (−14.6%)
Travel time (like bike)	–	–	–	–	0.064 (0%)
Travel time (125% of bike time)	–	–	–	–	0.055 (−14.1%)
Walking distance (400 m)	–	–	–	0.035 (0%)	–
Walking distance (1000 m)	–	–	–	0.028 (−20%)	–
Common street	–	–	–	–	–
Using cycling lane	–	–	–	–	–

Table 8
Probability of choosing On-demand service given specific parameters value (relative change from default state in brackets).

	All data	Czech Rep.	Germany	Poland	UK
Price (50%)	–	0.040 (0%)	–	–	–
Price (75%)	–	0.039 (−2.5%)	–	–	–
Price (current)	–	0.038 (−5.0%)	–	–	–
Travel time (like today car)	0.028 (0%)	–	–	–	–
Travel time (car + 20%)	0.026 (−7.1%)	–	–	–	–
Travel time (car + 50%)	0.023 (−17.9%)	–	–	–	–
Walking distance (100 m)	–	–	–	–	–
Walking distance (500 m)	–	–	–	–	–
1 passenger sharing route	–	–	–	–	–
3 passengers sharing route	–	–	–	–	–
7 passengers sharing route	–	–	–	–	–

Table 9
Probability of choosing MaaS given specific parameters value (relative change from default state in brackets).

	All data	Czech Rep.	Germany	Poland	UK
Price (75% of PuT)	0.085 (0%)	0.109 (0%)	–	0.102 (0%)	–
Price (100% of PuT)	0.073 (−14.4%)	0.084 (−22.9%)	–	0.094 (−7.4%)	–
Price (current)	0.067 (−21.13%)	0.049 (−55.2%)	–	0.069 (−32.4%)	–
Travel time (PuT time)	0.083 (0%)	0.093 (0%)	0.104 (0%)	0.095 (0%)	–
Travel time (PuT plus half of walking)	0.080 (−4.1%)	0.090 (−3.2%)	0.091 (−12.8%)	0.099 (4.5%)	–
Travel time (PuT + walking)	0.063 (−24.8%)	0.075 (−19.9%)	0.060 (−42.2%)	0.078 (−18.1%)	–

3.5. Impact on choice of mobility on demand

Mobility on demand represents the smallest relative portion of survey responses, only about 4.2% of the overall sample. In contrast to micromobility, the sensitivity to this parameter was identified in the overall sample in the case of the travel time parameter and in the Czech Republic for the price parameter. Although the latter presents a negligible absolute change of approximately 0.01%, the influence of travel time on overall data is relatively more visible, with an almost 18% change between current travel time and an increase of 50% (see Table 8).

3.6. Impact on choice of mobility as a service

Finally, we analysed the MaaS-related integrated mobility option included in the experiment. In this case, respondents evaluated the alternative based only on total travel time and trip price. At the aggregate level, both attributes were relevant, but country-level patterns differed. In the Czech Republic, price appears to be the more influential factor, whereas in Germany and Poland, total travel time plays a stronger role. In the United Kingdom, the number of stated choices for this alternative was too small to identify stable country-specific effects. These results should therefore be interpreted cautiously and as evidence on a limited MaaS-inspired experimental option rather than on the full MaaS concept. Detailed results are presented in Table 9.

3.7. Perceived value of time and mode availability (distance to)

In addition to the marginal probability sensitivities reported in Sections 3.1–3.6, we provide two complementary post-estimation views on how respondents value (i) in-vehicle travel time and (ii) first-/last-mile access to a mode hub (stop, station, vehicle location). First, we summarise the *relative importance* of the three core attributes (price, travel time, and distance to the mode hub) in the overall utility formation. Second, we report monetised measures — Value of Time (VoT) and Value of Access (VoA) — derived from the estimated marginal utilities.

To communicate which attribute drives utility within each mode–country segment, we compute a part-worth style importance measure, conceptually aligned with the post-estimation importance analysis used in related stated-choice work (e.g., Krauss et al., 2022). In brief, for each attribute we quantify its utility contribution over the range of levels used in the SP design and express it as a share of the total contribution across the three attributes. The resulting shares (in %) are reported in Fig. 3. The hatched bars indicate that no stable importance profile is reported for that mode–country segment because the underlying model did not yield a sufficiently robust set of statistically significant coefficients (consistent with Table 10 reporting logic).

Several consistent patterns emerge. For public transport (PuT), the Czech sample is dominated by *price* in the formation of utilities (largest share in Fig. 3), while Germany and the UK are predominantly driven by *travel time*. Poland stands out by showing an importance profile dominated by *the distance to the stop*, indicating that the first-mile access is the main behavioural lever for PuT in that segment. For carsharing (CS), travel time dominates where a decomposition is feasible, but distance-to-vehicle remains non-negligible in the Czech sample. For bike sharing (BS), the Czech sample is strongly driven by distance to the docking station, while the UK shows a travel-time-dominated profile with a secondary role of price. For micromobility (MM), the UK shows a

Table 10
Estimated VoT, VoA, and β coefficients for price, travel time and distance to transportation mode hub for each transport mode and country of respondents residence - only statistically significant results are presented.

		Czech Rep.	Germany	Poland	UK
β Estimates	PuT price	1.3847	–	–	0.0484
	Put travel time	0.0347	0.0303	–	0.0434
	Put distance to hub	0.0718	–	0.0485	–
	PuT VoT	0.15 €/h	–	–	5.38 €/h
	PuT VoA	0.31 €/h	–	–	–
β Estimates	CS price	0.0280	–	–	–
	CS travel time	0.0632	–	–	0.1017
	CS distance to hub	0.0295	–	–	0.0165
	CS VoT	13.55 €/h	–	–	–
	CS VoA	6.32 €/h	–	–	–
β Estimates	BS price	0.0327	–	–	0.0569
	BS travel time	–	–	0.0253	0.0463
	BS distance to hub	0.0240	–	–	–
	BS VoT	–	–	–	4.89 €/h
	BS VoA	4.41 €/h	0.16 €/h	–	–
β Estimates	MM price	–	–	–	0.0584
	MM travel time	–	–	–	0.0339
	MM distance to hub	–	–	−0.0269	–
	MM VoT	–	–	–	3.48 €/h
	MM VoA	–	–	–	–

Note: PuT - public transport; CS - carsharing, BS - bike sharing; MM - micromobility.

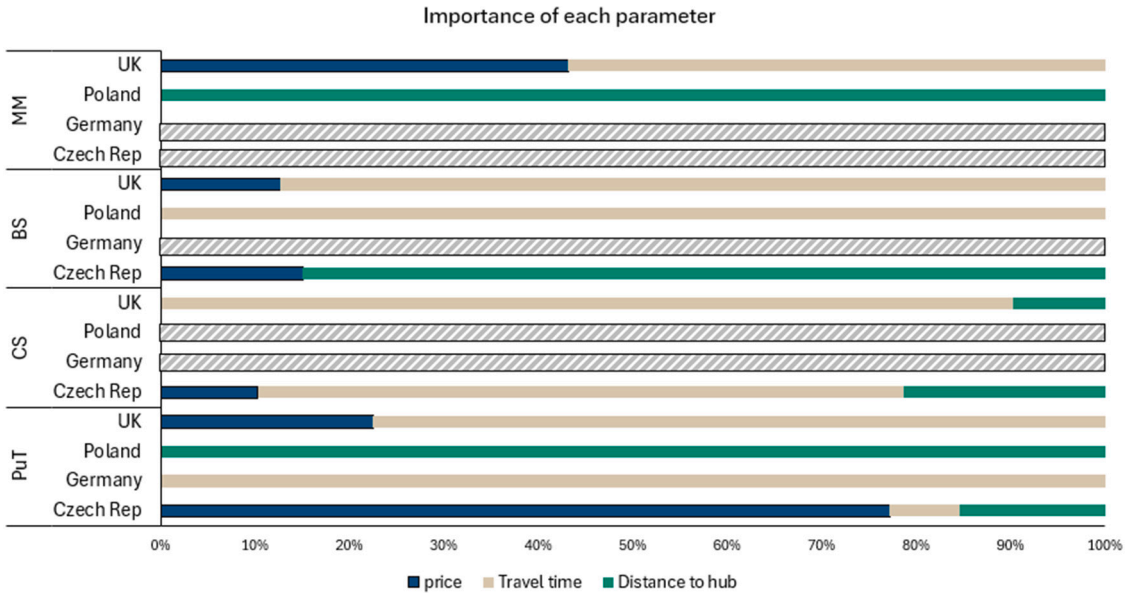


Fig. 3. Relative importance of the SP attributes (price, travel time, distance to mode hub) by mode and country, computed from the estimated marginal utilities and the attribute level ranges used in the experiment. Hatched bars indicate segments where a reliable importance decomposition cannot be reported due to insufficiently robust parameter estimates.

mixed profile between price and travel time, while Poland is dominated by access distance, consistent with the strong role of proximity of the first-mile in that segment.

Following the standard willingness-to-pay interpretation in discrete choice modelling, we estimate the perceived Value of Time (VoT) and Value of Access (VoA) implied by the discrete choice models as ratios of the marginal utilities of travel time and access distance to the marginal utility of price (Eqs. (3)–(4)). For interpretability, we express both measures in euros per hour, after converting national currencies using average exchange rates and transforming the access distance into walking time using the reference walking speed adopted from Alves et al., 2020. Where the price coefficient is not statistically significant, the corresponding VoT/VoA is not reported because the ratio would be unstable. Table 10 summarises the statistically significant coefficients and the resulting VoT/VoA estimates by mode and country.

For public transport, statistically robust VoT estimates are obtained for the Czech Republic and the United Kingdom. In the Czech sample, the VoT for PuT is modest (0.15 €/h), while it is higher in the UK (5.38 €/h), indicating that the UK respondents are more willing to trade money for reductions in-vehicle time. An estimate of VoA for public transport is identified only for the Czech Republic (0.31 €/h of walking time). In Poland, although the access distance enters significantly at the utility level, the lack of a robust price coefficient prevents reporting a stable monetised VoA, which is consistent with the dominance of distance in the importance decomposition in Fig. 3.

For carsharing, the Czech respondents show statistically significant effects of price, travel time and vehicle distance, resulting in a VoT of 13.55 €/h and a VoA of 6.32 €/h. For the UK, travel time and access distance enter significantly for carsharing, but the price effect

does not, so a monetised VoT/VoA cannot be reported despite the clear directional preference for faster and more proximal carsharing options.

For bike sharing, estimated valuations emphasise the access distance in the Czech Republic (VoA 4.41 €/h), while in the UK travel time is monetised (VoT 4.89 €/h). In Germany, only a very small access valuation is obtained for bike sharing (VoA 0.16 €/h), suggesting that access distance plays a comparatively minor role there. For micromobility, statistically significant price and travel-time coefficients are observed only in the UK (VoT 3.48 €/h). In Poland, the access distance affects the utility of micromobility, but the absence of a robust price coefficient prevents a stable monetised VoA.

Taken together, Fig. 3 and Table 10 provide a coherent picture of cross-country heterogeneity: the Czech Republic stands out by exhibiting strong access sensitivity for shared modes (particularly bike sharing and carsharing), whereas the UK more consistently monetises in-vehicle time. Poland repeatedly exhibits strong access effects in utility (PuT and micromobility) while lacking stable monetisation due to weak price sensitivity in the corresponding segments.

4. Discussion and conclusions

The results of this study highlight the significant role that access, mainly walking time to and from public transport stops, plays in shaping the choice of transport modes in the four European countries studied. Our findings highlight the role of first/last-mile access distance value, in shaping the choice of transport modes. Reducing walking times significantly increases the use of public transport, particularly in the Czech Republic and Poland, where the ease of physical access appears to be a decisive factor. These results highlight the need to prioritise investments in infrastructure that reduces walking distances, such as additional bus stops or improved connectivity. In the case of the Czech Republic and Poland, these reductions of up to 20%–25% in walking time led to substantial increases in the likelihood of choosing public transport. These findings align with previous research (Halldórsdóttir et al., 2011), which emphasises that improving the proximity to public transport stops is essential to encourage greater use of public transport, particularly for short trips.

In contrast, in Germany and the United Kingdom, the sensitivity to walking distance is less pronounced, likely due to the increased availability and higher quality of public transport infrastructure in these countries. Differences in response to walking distance between countries may also reflect varying cultural and economic expectations about public transport (Gundlach et al., 2018).

The VoT and VoA estimates refine these findings by showing how commuters trade monetary cost against travel time and access burden. In general, the results suggest that access-related penalties are valued more strongly than in-vehicle time in several contexts, which is broadly consistent with the wider literature on out-of-vehicle travel components. For example, as shown in Ferreira et al. (2022b), which indicates higher disutility for walking time than for in-vehicle time when using PuT, and similarly by Krauss et al. (2022), which extends this finding to micromobility. At the same time, not all country- and mode-specific values could be monetised robustly, mainly because some price coefficients were not statistically informative enough for a stable interpretation. The comparative evidence is therefore meaningful, but not equally strong for all modes and contexts. These results align with recent research using similar methodology and target modes. In Curtale and Liao (2023), a stated-preference experiment with a similar scenario and data collected in the same year was also used to examine, among other aspects, the value of time across different modes, including e-bike, PuT, and car sharing. In the four different European countries where the experiment was conducted — the Netherlands, Italy, France, and Spain — statistical significance in the marginal values of both travel time and cost was achieved only in the Italian sample. This highlights that in some constrained contexts of price and travel time variation, potential users do not always show sensitivity to both attributes. In the example of mobility hubs by Grigolon et al. (2025), it is shown that access time for last/first-mile shared modes is the most important mobility hub category in a survey that included respondents from eastern Austria, Brussels, and Munich. The results estimate a willingness to pay between €4 and €6 to ensure that shared modes are within walking distance.

Our VoT estimates also align with national valuation studies that are used to underpin cost–benefit analysis. For the Netherlands, Kouwenhoven et al. (2014) report VoT for passenger transport that, for urban rail and local public transport, are of comparable order to our estimates (Kouwenhoven et al., 2014). The most recent Dutch update, the "Values of Time, Reliability and Comfort in the Netherlands 2022" study, finds average values of time for local public transport of roughly 7–14 EUR/h (2022 prices, including taxes), depending on trip purpose, which again is very close to the range implied by our model results (Significance, 2023). Similarly, the Norwegian valuation study recommends VoT levels for urban public transport that are of the same order of magnitude (Flügel et al., 2020), while the Australian ATAP guidelines adopt values for public transport in-vehicle time that are, after currency conversion and income adjustment, consistent with our estimates (ATAP Steering Committee, 2021). Taken together, these comparisons suggest that the VoT in our study is neither unusually low nor high, but sits comfortably within the current international evidence base for urban passenger transport.

With respect to access time, the coefficients in Table 10 imply that walking access/egress is valued substantially more negatively than in-vehicle time, with VoA/VoT ratios on the order of roughly 1.5–2.0 depending on user segment. This pattern is in line with meta-analytic evidence for Europe. Wardman et al. (2016) report walking-time multipliers of about 1.45 for urban trips and 1.70 for inter-urban trips relative to vehicle time, and slightly higher multipliers for waiting time, indicating that out-of-vehicle components are systematically penalised compared to vehicle time (Wardman et al., 2016). Abrantes and Wardman similarly find that walk and wait time are valued significantly more than in-vehicle time, and that the often-used rule-of-thumb multiplier of 2 is at the upper end of what is supported by British evidence (Abrantes and Wardman, 2011). The Norwegian valuation study uses a recommended multiplier of about 1.3 for access time to public transport relative to in-vehicle time (Flügel et al., 2020), the Australian ATAP technical report summarises Australian and New Zealand studies with typical access and connection-time multipliers of around 1.5 in equivalent in-vehicle minutes (ATAP Steering Committee, 2021), and the latest Dutch valuation study provides access/exit and waiting-time multipliers for public transport that are also defined relative to in-vehicle time and are mostly between 1.5 and 2.0 (Significance, 2023). In this context, our implied VoA multipliers can be interpreted as being toward the upper part of the empirically supported range, which is plausible given that our study focuses on large towns and cities above 100,000 inhabitants, where average income is higher and thus time loss tends to have higher value as well.

Overall, the comparison indicates that both the level of VoT and the relative weighting of access time in our model are well anchored in the current international literature. The fact that our VoA/VoT ratios are at the higher end of the range reported in national guidelines suggests that policies which reduce access distances, improve walkability, or relocate stops and stations closer to trip origins and destinations may yield particularly large perceived benefits in the study area, beyond what would be inferred from in-vehicle time savings alone.

At the same time, improved access should not automatically be interpreted as support for denser stop spacing everywhere. Reducing access distance by adding stops may improve local accessibility, but can also reduce commercial speed and worsen network performance. The policy relevance of the present findings therefore lies in showing that access matters, not in advocating a single universal design response. In many cases, targeted pedestrian improvements, better interchange

design, or feeder micromobility may achieve similar benefits at lower operational cost.

The results also support the importance of cycling infrastructure for the attractiveness of bike-sharing services. This is consistent with previous research and reinforces the view that active-mode integration remains an important component of sustainable urban mobility policy.

The results for the MaaS-related integrated mobility option should be interpreted cautiously. In the aggregate sample, and particularly in Germany and Poland, total travel time appears more influential than price, whereas in the Czech Republic, price seems more important. In the United Kingdom, the number of relevant choices was too small for stable inference. These findings are informative for the tested multimodal option, but they should not be overgeneralised to MaaS as a broader ecosystem concept.

This study shows that first- and last-mile conditions matter for commuter transport mode choice, but their importance varies across modes and countries. Its main contribution lies in providing a harmonised cross-country comparison of access-related valuation and in identifying where such comparison is more and less robust. For policy, the results support explicit consideration of access conditions in sustainable urban mobility planning, while also indicating that accessibility improvements must be balanced against broader network and operational trade-offs.

4.1. Limitations and future research

Several limitations should be considered when interpreting the findings. The study is based on stated-preference data collected for a controlled short urban commuting scenario, which improves comparability but limits behavioural realism and transferability to longer trips, non-commuting purposes, or rural contexts. The model specification also focuses on objective access-related attributes and excludes socio-demographic, attitudinal, and behavioural covariates, which supports comparability across countries but omits relevant heterogeneity. In addition, not all VoT and VoA estimates could be derived robustly for every mode and country, which constrains full cross-country comparability. Future research should therefore extend the analysis using richer behavioural variables, broader travel contexts, and, where possible, revealed-preference or hybrid data.

Some results showed a higher probability of mode choice despite increased cost or time; while we hypothesise that these reflect behavioural preferences for service reliability or specific mode combinations, we recognise that these patterns require further empirical validation to rule out potential survey design effects or model limitations.

CRediT authorship contribution statement

Michal Matowicki: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Marco Amorim:** Writing – review & editing, Validation, Methodology, Formal analysis, Data curation. **Pavla Pecherkova:** Visualization, Software, Data curation. **Ondrej Pribyl:** Writing – review & editing, Supervision, Investigation.

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Declaration of competing interest

The authors state that there is no conflict or competing interests in this work.

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