Understanding Heterogeneity in Autonomous Taxi Preferences in Luxembourg: A Latent Class Choice Model Approach

Malvika Dixit*[1], Tai-Yu Ma[2]

[1] Research Associate, Urban Development & Mobility, LISER, Luxembourg

[2] Research Scientist, Urban Development & Mobility, LISER, Luxembourg

SHORT SUMMARY

Autonomous taxis and shared autonomous mobility are expected to transform urban transport systems, yet their adoption depends on user acceptance, particularly of ride-sharing services. This study investigates preferences for conventional taxi, autonomous taxi, and shared autonomous taxi for home-to-airport trips in Luxembourg, with a focus on preference heterogeneity. Using data from a stated preference experiment with 1,373 respondents, we estimate both a Multinomial Logit (MNL) model and a Latent Class Choice Model (LCCM) to identify distinct behavioral segments. The results show that cost, travel time, and waiting time significantly influence choices, with waiting time having a stronger impact than in-vehicle time. The LCCM reveals two segments: a privacy-sensitive group that is more cost-sensitive and strongly reluctant to use shared autonomous taxis for longer trips, and a sharing-oriented group that is more open to shared autonomous mobility. Trip length plays a critical role, with shared options becoming less attractive for longer journeys. These findings highlight the importance of accounting for preference heterogeneity and suggest that shared autonomous mobility may face adoption barriers for longer, purpose-driven trips such as airport access.

Keywords: Automated and connected driving; Shared Mobility; Travel Behavior; Latent class; Autonomous taxi; Luxembourg

1. INTRODUCTION

Autonomous vehicles (AVs) and shared mobility are expected to significantly transform urban transport systems by improving safety, efficiency and accessibility (Fagnant & Kockelman, 2015). In particular, the combination of automation and ride-sharing has the potential to reduce fleet sizes and operational costs while maintaining service levels (Lokhandwala & Cai, 2018). However, the extent to which their benefits can be realized depends critically on user adoption, and, more importantly, the acceptance of ride-sharing services.

Many European countries are gearing towards the introduction of Autonomous Taxis in the coming years. Despite growing interest in AVs, user preferences for autonomous and shared autonomous taxis remain insufficiently understood, particularly in the European context. Existing studies have examined attitudes toward AVs and shared mobility (Nazari et al., 2018), but evidence on how users trade off cost, travel time, waiting time, and sharing in realistic decision contexts remains limited. This gap is especially relevant for regions such as Luxembourg, where taxi use is relatively low and typically associated with specific trip purposes, such as airport access.

Most early studies rely on Multinomial Logit (MNL) models to analyze travel behavior. While useful, these models assume homogeneous preferences across individuals, potentially masking

important differences in behavior. To address this, a large body of work on shared AVs has employed Mixed Logit models to capture continuous heterogeneity in preferences (Gkartzonikas et al., 2022; Krueger et al., 2016; Yap et al., 2016) while other studies have used integrated choice and latent variable (ICLV) models to incorporate attitudinal effects (Lavieri & Bhat, 2019). However, these approaches have primarily focused on general travel behavior or commuter contexts, and provide limited insights into how discrete behavioral segments differ in their acceptance of shared autonomous mobility, particularly for purpose-specific trips such as airport access.

This study addresses these gaps by investigating preference heterogeneity in the choice between conventional taxi, autonomous taxi, and autonomous taxi with ride-sharing (referred to as shared autonomous taxi in this paper) for home-to-airport trips in Luxembourg. Using data from a stated preference experiment, we compare a standard MNL model with a Latent Class Choice Model (LCCM) to identify distinct behavioral segments. The analysis examines how cost, travel time, waiting time, and trip length influence choices across population groups.

The results show that while all service attributes significantly affect choices, preferences vary across segments. One segment exhibits strong resistance to shared AV for longer trips, reflecting privacy and reliability concerns, while another is more open to shared and autonomous mobility. Waiting time emerges as more influential than in-vehicle time, with sensitivity decreasing for longer trips. These findings provide insights into the behavioral drivers of shared AV adoption and inform the design of airport access systems in Luxembourg and similar contexts.

2. METHODOLOGY

To elicit individual preferences for autonomous taxi (AV taxi) and shared autonomous taxi (shared AV), we designed a stated preference (SP) experiment, embedded within a larger web-based survey conducted in Oct-Nov 2025, aimed at understanding the value of time in the context of autonomous vehicles for the Luxembourg residents and its cross-border workers living in France, Germany and Belgium. The taxi SP experiment was presented only to Luxembourg residents, and further to a randomly selected half of this group, while the remaining respondents completed a separate module on time-use behaviour. The resident sample was obtained using stratified random sampling based on income, social security affiliation, and gender, and respondents were invited via postal invitations.

The SP experiment focused on a policy-relevant scenario: a trip from the respondent's home to the airport. Respondents chose between four alternatives: a conventional taxi, an AV taxi, a shared AV taxi (ride-sharing using an AV vehicle), and a "none" option. Prior to the experiment, the hypothetical alternatives were described as follows:

- Self-driving taxi (Exclusive): This is a private, fully autonomous vehicle with no driver and no option for passengers to take control. You travel alone, directly to your destination.
- Shared self-driving taxi: This is also a fully autonomous vehicle, but you share the ride with other passengers who are going in the same general direction. The vehicle may make brief stops to pick up or drop off other people, similar to a carpool or a shared shuttle service.

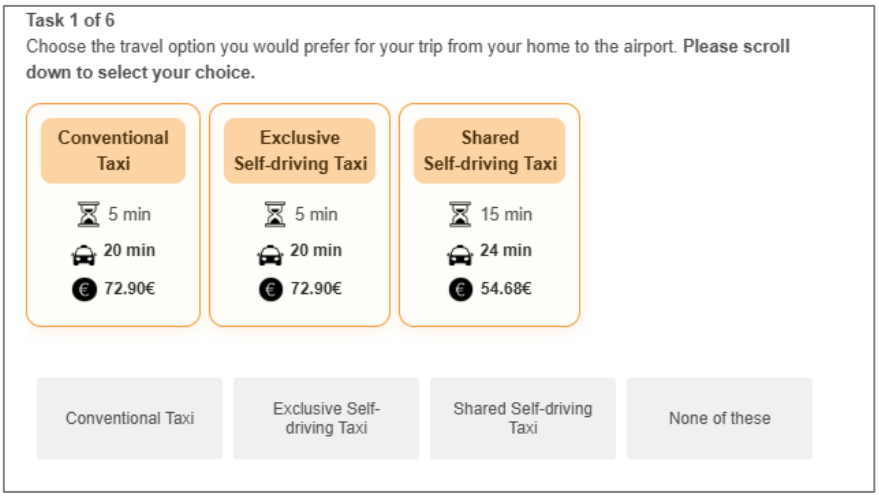


Figure 1: Sample choice task

Each respondent completed six choice tasks (Figure 1). Attribute levels were pivoted to individual travel conditions using travel times and distances computed from reported home locations via the Google Maps API. The attributes included cost, in-vehicle travel time, and waiting time, with three levels each (Table 1). A random experimental design was adopted due to the absence of reliable priors (Walker et al., 2018). 200 choice scenarios were generated, with six randomly assigned to each respondent. Dominated alternatives were removed to improve realism and data quality.

Table 1: Attribute levels used for SP experiment

Alternative	Attribute	Levels
Taxi & AV taxi	Travel time (multiplier)	[0.75, 1, 1.25]
	Cost (multiplier)	[0.7, 0.9, 1.2]
	Waiting time (min)	[2, 5, 10]
Shared AV	Travel time (multiplier)	[1.1, 1.3, 1.5]
	Cost (multiplier)	[0.5, 0.65, 0.90]
	Waiting time (min)	[5, 10, 15]

In addition to the SP experiment, socio-demographic and attitudinal data were collected. Attitudes were measured using five-point Likert scale statements and analyzed using Exploratory Factor Analysis (EFA), resulting in three factors: discomfort with sharing, environmental commitment, and distrust in AV technology. Only discomfort with sharing was significant in the choice models. This factor combines the following items (inspired from (Lavieri & Bhat, 2019)): “I don't mind sharing a ride with strangers if it reduces my costs” (-0.640), “Having privacy is important to me when I make my trip” (0.769), and “I feel uncomfortable sitting close to strangers” (0.681). Higher values indicate stronger dislike of sharing. Factor scores were standardized (z-scores). Prior experience with shared mobility was recorded as a binary variable (use vs. no use). Interest in AV taxis was measured using a four-category question and recoded into a binary indicator reflecting willingness to try AV taxis.

An MNL model was first estimated as a benchmark. In this specification, interactions between socio-demographic variables and alternative-specific constants were included to capture observed heterogeneity, particularly for income, age, and trip length effects. More complex specifications

(e.g., time-dependent cost) improved fit but reduced interpretability and were not retained. A parsimonious model was therefore used as the baseline.

To capture unobserved heterogeneity, a LCCM was estimated. The LCCM assumes a finite number of segments with distinct preferences (Hess, 2024). Class membership probabilities were modelled as a function of socio-demographic and attitudinal variables, including age, income, interest in AV taxi, ride-sharing experience, and attitudes toward sharing. In contrast to the MNL, these variables enter the class membership model rather than the utility functions, allowing a clear separation between preference heterogeneity and its drivers. All models were estimated using Biogeme (Bierlaire, 2023). The final models were selected based on statistical fit (log-likelihood, AIC and BIC) and interpretability, with parsimonious specifications preferred for stability.

3. RESULTS AND DISCUSSION

Table 2 presents the estimation results for the benchmark MNL model and the preferred two-class LCCM, based on data from 1,373 respondents. Respondents who selected the "none" option in all choice tasks (7% of the sample) were excluded, as their choices do not provide variation in attribute trade-offs and therefore do not contribute to parameter identification. The MNL results show that cost, in-vehicle travel time, and waiting time significantly reduce the utility of airport access alternatives. In addition, travel time in AV taxis carries an additional negative premium, indicating that time spent in autonomous vehicles is perceived as more burdensome than in conventional taxis.

This may reflect the specific context of airport access trips, where reliability and punctuality are prioritized over opportunities for multitasking. While previous studies have reported reduced values of time in shared AV settings (e.g.: Krueger et al., 2016; Steck et al., 2018), others report higher perceived burdens in specific contexts, such as first-/last-mile connections (Yap et al., 2016). The results suggest that, for airport trips, perceived benefits of automation may be limited, with concerns related to reliability and comfort outweighing potential advantages. The increasing realism of AV taxi deployment in Europe may also lead respondents to form more cautious expectations compared to earlier studies. In contrast, the valuation of travel time in shared AV appears closer to that of conventional taxi, suggesting that the presence of other passengers may not substantially increase perceived burden beyond that of a driver. This aligns with the hypothesis by Singleton (2019) that shared AV services may primarily attract more cost-conscious users, for whom sharing is an acceptable trade-off.

Trip characteristics further influence behavior. Longer trips reduce the likelihood of opting out and decrease the attractiveness of shared AV, indicating lower willingness to share for longer airport journeys. In the Luxembourg context, this likely reflects stronger preferences for privacy, comfort, and directness, particularly when luggage and reliability are important. The MNL also captures observed heterogeneity: high-income respondents are more favorable toward AV taxis, while younger and lower-income respondents are more inclined toward shared AV, consistent with Patel et al. (2023). However, the MNL assumes homogeneous sensitivities, potentially masking important behavioral differences.

The two-class LCCM improves model fit relative to the MNL across log-likelihood, AIC, and BIC, while yielding behaviorally interpretable segments. A three-class model was also tested but did not provide stable or meaningful additional segmentation, and was therefore not retained.

Table 2: Estimation results for the MNL and Latent Class Choice Model (robust t-stats in parentheses) N = 1,373 respondents

Parameter	Multinomial Logit Model	Latent Class Choice Model	
		LC1: Privacy-sensitive users (53%)	LC2: Sharing oriented users (47%)
Cost	-0.018 (-16.3)	-0.03 (-8.1)	-0.021 (-7.9)
Travel time	-0.018 (-5.2)	-0.013 (-2.4)	-0.013 (-2.4)
AV travel time premium	-0.009 (-2.7)	-0.015 (-2.7)	-0.015 (-2.7)
Waiting time (taxi)	-0.071 (-9.4)	-0.1 (-9.4)	-0.078 (-4.6)
Waiting time (AV taxi)	-0.072 (-9.1)	-0.059 (-5.7)	-0.108 (-6.8)
Waiting time (Shared AV)	-0.036 (-6.4)	-0.098 (-4.7)	-0.049 (-5.8)
ASC (taxi)	3.771 (23.9)	7.25 (12.8)	2.35 (6.4)
ASC (AV)	3.875 (23.8)	7.06 (11.6)	3.06 (8.5)
ASC (Shared AV)	3.726 (23.4)	4.7 (7.9)	4.03 (12)
Shared AV × long trip (>30 mins)	-0.278 (-3.1)	-1.8 (-2.3)	-0.579 (-3.1)
None × long trip (>30 mins)	-1.543 (-7.1)	-5.54 (-4.8)	-1.7 (-3.7)
AV x high income	0.166 (2.2)	-	-
Shared AV × low income	0.155 (2.6)	-	-
Shared AV × young than 30 years	0.228 (3.7)	-	-
Class membership model			
Intercept	-	-	-0.282 (-1.8)
AV interest	-	-	0.462 (2.8)
Low income	-	-	0.327 (1.9)
Age 65 and over	-	-	-0.671 (-3.9)
Experience with ride-sharing	-	-	0.459 (3.1)
Dislike of sharing	-	-	-0.993 (-13.1)
Model fit statistics			
Final log-likelihood	-10023.28	-8261.928	
Adjusted rho-squared	0.121	0.278	
AIC	20076.56	16575.86	
BIC	20181.81	16711.7	

Both latent classes exhibit negative and significant cost, travel time, and waiting time coefficients, confirming the importance of generalized travel burden. Travel time and the AV-specific premium were specified as generic across classes, as class-specific estimates were unstable, suggesting limited heterogeneity in time sensitivity relative to cost and waiting time.

The model identifies two distinct segments. The first class, labeled *privacy-sensitive users* (53%), is more cost-sensitive and exhibits a strong aversion to shared AV for longer trips, with a large negative coefficient for the shared AV-long trip interaction (-1.82). The second class, labeled *sharing-oriented users* (47%), is less cost-sensitive and shows a weaker negative response to shared AV for longer trips, indicating greater openness to shared mobility. Differences in waiting time sensitivities further distinguish the classes. Privacy-sensitive users are more sensitive to waiting for shared AV and conventional taxis, suggesting aversion to inconvenience associated with shared or indirect services. In contrast, sharing-oriented users are more sensitive to waiting for AV taxis, indicating greater concern for service responsiveness.

The class membership model provides additional insights into segment composition. Sharing-oriented users are more likely to express a interest in trying AV taxis, have prior ride-sharing

experience, report lower levels of dislike toward sharing rides, and are more likely to be younger. This suggests that openness to shared AV is associated with familiarity and positive attitudes toward emerging mobility options.

Overall, the comparison between MNL and LCCM highlights the importance of accounting for preference heterogeneity. While the MNL captures average effects, it masks the presence of a segment that is both more cost-sensitive and significantly less willing to use shared AV for longer trips.

4. CONCLUSIONS

This paper examined preferences for conventional taxi, autonomous taxi, and shared autonomous taxi for home-to-airport trips in Luxembourg based on a recent SP survey, with a focus on preference heterogeneity. Comparing a MNL model with a LCCM, the results show that while cost, travel time, and waiting time influence choices on average, substantial differences exist across user segments.

The LCCM identified two groups: a *privacy-sensitive* segment that is more cost-sensitive and strongly reluctant to use shared AV for longer trips, and a *sharing-oriented* segment that is more open to shared and autonomous mobility. This indicates that resistance to shared AV is concentrated among specific users, particularly for longer airport trips. Waiting time emerged as a key determinant of choice, while the attractiveness of shared AV decreases with trip length, highlighting the importance of privacy, comfort, and reliability. From a policy perspective, reducing waiting times and offering differentiated service options may improve adoption.

These findings provide insights into the behavioral drivers of shared AV adoption and inform the design of airport access systems in Luxembourg and similar contexts. Future research could extend the analysis to revealed preferences and other trip contexts.

ACKNOWLEDGEMENTS

This research was funded, in whole, by the Luxembourg National Research Fund (FNR), grant reference INTER/DFG/23/17934752. For the purpose of open access, and in fulfilment of the obligations arising from the grant agreement, the author has applied a Creative Commons Attribution 4.0 International (CC BY 4.0) license to any Author Accepted Manuscript version arising from this submission. The authors thank Prof. Constantinos Antoniou, Dr. Mohamed Abouelela and Saleh Ardameh for their valuable feedback on survey design.

REFERENCES

Bierlaire, M. (2023). *A short introduction to Biogeme* (Technical Report TRANSP-OR 230620). Transport and Mobility Laboratory, ENAC, EPFL.

Fagnant, D. J., & Kockelman, K. (2015). Preparing a nation for autonomous vehicles: Opportunities, barriers and policy recommendations. *Transportation Research Part A: Policy and Practice*, *77*, 167–181. https://doi.org/10.1016/j.tra.2015.04.003

Gkartzonikas, C., Ke, Y., & Gkritza, K. (2022). A tale of two modes: Who will use single user and shared autonomous vehicles. *Case Studies on Transport Policy*, *10*(3), 1566–1580. https://doi.org/10.1016/j.cstp.2022.05.015

Hess, S. (2024). Latent class structures: Taste heterogeneity and beyond. In *Handbook of Choice Modelling* (pp. 372–391). Edward Elgar Publishing. https://www.elgaronline.com/ed-collchap/book/9781800375635/book-part-9781800375635-21.xml
Krueger, R., Rashidi, T. H., & Rose, J. M. (2016). Preferences for shared autonomous vehicles. *Transportation Research Part C: Emerging Technologies*, *69*, 343–355. https://doi.org/10.1016/j.trc.2016.06.015
Lavieri, P. S., & Bhat, C. R. (2019). Modeling individuals' willingness to share trips with strangers in an autonomous vehicle future. *Transportation Research Part A: Policy and Practice*, *124*, 242–261. https://doi.org/10.1016/j.tra.2019.03.009
Lokhandwala, M., & Cai, H. (2018). Dynamic ride sharing using traditional taxis and shared autonomous taxis: A case study of NYC. *Transportation Research Part C: Emerging Technologies*, *97*, 45–60. https://doi.org/10.1016/j.trc.2018.10.007
Nazari, F., Noruzoliaee, M., & Mohammadian, A. (Kouros). (2018). Shared versus private mobility: Modeling public interest in autonomous vehicles accounting for latent attitudes. *Transportation Research Part C: Emerging Technologies*, *97*, 456–477. https://doi.org/10.1016/j.trc.2018.11.005
Patel, R. K., Etminani-Ghasrodashti, R., Kermanshachi, S., Rosenberger, J. M., & Foss, A. (2023). Exploring willingness to use shared autonomous vehicles. *International Journal of Transportation Science and Technology*, *12*(3), 765–778. https://doi.org/10.1016/j.ijtst.2022.06.008
Singleton, P. A. (2019). Discussing the "positive utilities" of autonomous vehicles: Will travellers really use their time productively? *Transport Reviews*. (world). https://www.tandfonline.com/doi/full/10.1080/01441647.2018.1470584
Steck, F., Kolarova, V., de-Birke, F. B., Trommer, S., & Lenz, B. (2018). How Autonomous Driving May Affect the Value of Travel Time Savings for Commuting. *Transportation Research Record*, *2672*(46). https://doi.org/10.1177/0361198118757980
Walker, J. L., Wang, Y., Thorhauge, M., & Ben-Akiva, M. (2018). D-efficient or deficient? A robustness analysis of stated choice experimental designs. *Theory and Decision*, *84*(2), 215–238. https://doi.org/10.1007/s11238-017-9647-3
Yap, M. D., Correia, G., & van Arem, B. (2016). Preferences of travellers for using automated vehicles as last mile public transport of multimodal train trips. *Transportation Research Part A: Policy and Practice*, *94*, 1–16. https://doi.org/10.1016/j.tra.2016.09.003