Analysing intentions to adopt shared electric mobility using structural equation modelling approach

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SHORT SUMMARY

Among the well-established sustainable transportation strategies, shared electric mobility has emerged as a promising alternative. This study investigates the factors influencing behavioural intentions to adopt shared electric mobility services, employing an extended model combining Technology Acceptance Model (TAM) and Theory of Planned Behaviour (TPB) theories within the Structural Equation Modeling (SEM) framework. The study was conducted in the United Kingdom with 726 responses. Key findings reveal that personal innovativeness, perceived usefulness, and social influence positively drive shared electric mobility adoption intentions, while scepticism, perceived risk, and habitual reliance on private vehicles act as significant barriers. Furthermore, habit of car-usage has positive impacts user' scepticism and perceived risk, and negative impact on perceived usefulness, underscoring the critical role of habit in shaping adoption behaviours. These results contribute to a deeper understanding of adoption dynamics, offering valuable insights for policymakers and service providers to formulate interventions that promote shared electric mobility adoption.

Keywords: Behavioural intention; Mobility adoption; Shared electric mobility; Structural equation modeling; Technology acceptance model (TAM); Theory of planned behaviour (TPB)

1. INTRODUCTION

The transition to sustainable transport is a critical element in addressing the global challenge of climate change, urban congestion, and environmental degradation. Sustainable transportation solutions, including electric vehicles and shared mobility systems, have become an essential focal point for policymakers, urban planners, as well as researchers in pursuit of environmental sustainability and social welfare (Oeschger et al., 2020). Among the well-established sustainable transportation strategies, shared mobility with electrification have emerged as a promising alternative. These include electric-car sharing, electric-bike sharing, and electric-scooter sharing programs, which have gained popularity in cities across the globe (Liao and Correia, 2022). It has the potential to democratise access to clean transport with affordable prices especially where the localities which – a) are not well served by public transport, and 2) include lower-income households which may otherwise be excluded from the EV market due to high upfront costs. The shared electric mobility systems combine the environmental benefits of electric vehicles with the flexibility and resource efficiency of shared mobility, leading to reduced carbon footprint of transportation activities (especially when charged using renewable energy sources), lower traffic congestion, and decreased demand for parking space (Fukushige et al., 2021; Zhou et al., 2023).

However, despite the potential of shared electric mobility to alleviate environmental and urban mobility issues, adaption rates remain limited across different regions and populations (Bösehans et al., 2023).

The adoption of shared electric mobility systems has garnered considerable attention in recent years, with many studies focusing on understanding user intentions and identifying the key factors that drive the shift towards sustainable transport modes. Previous research has investigated shared electric mobility adoption across a range of contexts, such as the impact of modal shift – where users transition from traditional transport options to shared electric alternatives (e.g., e-scooters, e-bikes, and e-cars) – and how such shifts affect overall transportation systems, usage patterns and user characteristics, examining how personal traits like age, income, and education influence the adoption of shared electric vehicles (SEVs) across different user demographics, role of the built environment and spatial configurations, accessibility and connectivity. Despite the growing body of literature on the adoption of shared electric mobility, there is still room to understand the impact of users' perspectives on the usage of these services. Most studies focus primarily on technological and infrastructural factors, with less attention given to the psychological and habitual aspects of transportation choices. As such, this research aims to add knowledge to the current literature by examining – a) the influence of factors associated with TAM and TPB models, b) mediating and moderating effects of habit on intentions, c) impacts of vehicle ownership and other sociodemographic characteristics and, d) influence of psychometric variables on user's decision-making process.

2. METHODOLOGY AND SURVEY

This study uses the underlying concepts of TAM (Davis, 1989) and TPB (Ajzen, 1991) models to analyse users' intentions to use shared electric mobility services. These models pose that the intention to use/adopt a service/technology has the direct effect on the behaviour. This study hypothesised that the latent variables, namely, personal innovativeness, scepticism, perceived risk, perceived usefulness, social influence (also termed as social norm), and environmental awareness have direct influence on the behavioural intention to adopted shared electric mobility. Additionally, habit (of using private vehicle) is supposed to directly and indirectly impact the consumers' intention. Several individual level characteristics (see Figure 1) are also considered to examine their direct and moderating effects on latent variables and relationships between latent variables respectively.

A structural equation modelling (SEM) approach is well-suited to analyse the inter-relationships amongst latent variables through the systematic set of measurement and structural models. Within the SEM framework, multiple regression models are analysed to test the impact of various latent factors and other explanatory variables on the behavioural intention. Firstly, the underlying latent constructs were extracted based on selected measurement variables using an exploratory factor analysis (EFA). Subsequently, the confirmatory factor analysis (CFA) was performed along with several tests for internal consistency, convergent and discriminant validity (using HTMT correlations), multicollinearity, and composite reliability to confirm the factor structure obtained through EFA. Lastly, a covariance-based SEM (CB-SEM) model was estimated to test the proposed hypotheses according to the conceptual model presented in Figure 1. Please note that all the underlying interrelationships between latent constructs (i.e., path analysis) and confirmatory factor analysis were estimated simultaneously in the final SEM model.

A web-based questionnaire survey was designed based on the conceptual framework presented in Figure 1. At the beginning of the survey, participants were presented with a brief explanation of

the station-based shared electric mobility services using text and figure. In the first part of the survey, participants were asked to declare their level of agreement on each psychometric statements on a 5-point Likert's scale ranging from 1 = "totally disagree" to 5 = "totally agree" with middle point 3 = "neutral". The measurement items used this study for habit were based on the 12-item Self-Report index of habit strength (Verplanken and Orbell, 2003). Several sociodemographic and travel-related characteristics such as age, gender, occupation (employment), household income, level of education, and vehicle ownership (car, motorbike, bicycle, e-bike, e-scooter) were collected through multiple-choice questions.

The survey was administered in the England during July/August 2024 after pretesting of the survey in May 2024. Several cities including, Birmingham, Manchester, Liverpool, Leeds, Nottingham, and Sheffield were selected for this study. These cities exhibit comparable demographics, transport infrastructure including availability of shared electric mobility services, economic profile, and car-dominant commute which makes it suitable to operationalise aggregated behavioural data to investigate travellers' intentions to adopt SEVs. Participants were recruited using an online panel for market research which allowed for control in terms of sample representativeness. The target population includes the adults (over 18 years of age) who possess driving license, living in one of the selected cities, commute at least 2 days a week within the city limits to ensure that the participants can pick-up/drop-off and travel using SEVs for their commute journey. After screening off the ineligible participants and removing unengaged/poorly-attended samples, 726 observations were considered for the further analysis.

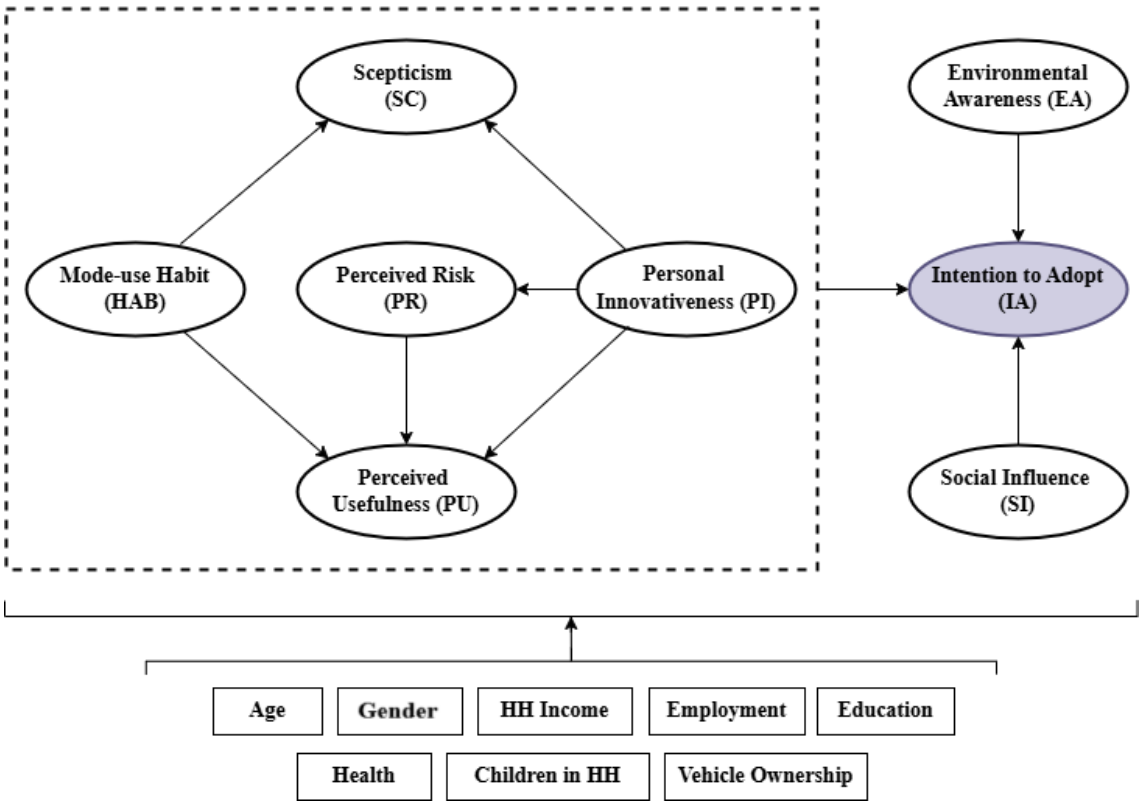

Figure 1. Conceptual framework

3. RESULTS AND DISCUSSION

After testifying the model's qualitative measures based on the exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), SEM analysis was conducted on the derived latent constructs as well as other exogeneous variables (i.e., sociodemographic and travel characteristics). A bootstrapping method with 5000 draws at 95% confidence interval was employed to scrutinize the estimated structural model. Figure 2 graphically portrays all the significant effects from the derived SEM model.

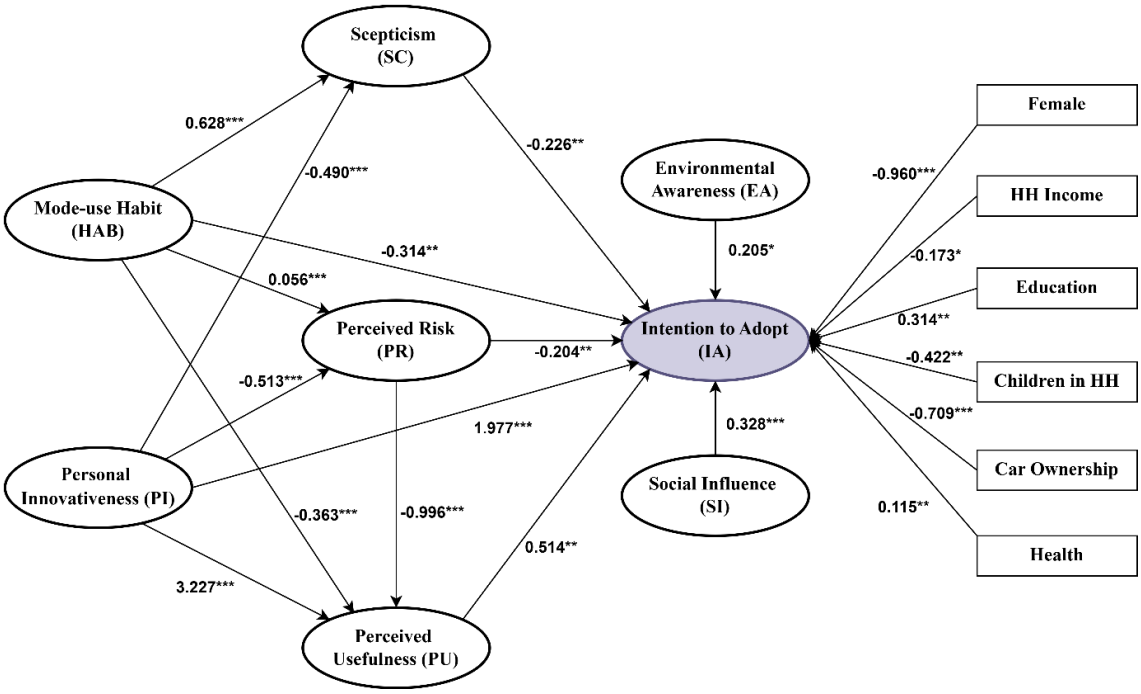

Figure 2. Graphical representation of the SEM model
(***: p-value < 0.01; **: p-value < 0.05; *: p-value < 0.10)

Table 1. Mediation effects of latent variables

Path	Direct Effect	Indirect Effect	Total Effect	Comment
HAB → SC → IA	-0.395***	0.142**	-0.253**	Partial Mediation
HAB → PU → IA	-0.395***	-0.046***	-0.441***	Partial Mediation
HAB → PR → IA	-0.395***	0.010	-0.385**	No Mediation
PI → SC → IA	1.977***	-0.110*	1.867***	Partial Mediation
PI → PU → IA	1.977***	0.407*	2.384***	Partial Mediation
PI → PR → IA	1.977***	-0.096	1.881***	No Mediation
PR → PU → IA	-0.204**	-0.512*	-0.716***	Partial Mediation

(***: *p*-value < 0.01; **: *p*-value < 0.05; *: *p*-value < 0.10).

Table 1 summarises the direct, indirect, and total effects on IA through given mediators. Further, the moderating effects of several demographic variables have been investigated by employing the interaction terms as illustrated in first column of the Table 2.

Table 2. Moderating effects of sociodemographic variables

Path	Std Estimate	Std Error	t-stat	95% CI LB	95% CI UB	p-value
Female × PR → IA	0.028	0.007	3.717	0.013	0.042	0.000
Female × SC → IA	0.229	0.097	2.362	0.039	0.419	0.018
Education × PI → IA	0.237	0.060	3.937	0.119	0.355	0.000
Age × PI → IA	-0.466	0.142	3.276	-0.744	-0.187	0.001
FTW × PU → IA	-0.193	0.079	2.426	-0.348	-0.037	0.015

According to the results, personal innovativeness (PI) emerged as the strongest positive determinant of SEV adoption intentions. Besides, PI has a significant negative influence on the scepticism and perceived risk, whereas strong positive influence on perceived usefulness. This underscores the role of individuals openness to new ideas and technologies in driving early adoption. Highly innovative individuals are more likely to perceive SEVs as viable, useful and less-risky alternatives. The significant positive influence of perceived usefulness (PU) highlights the importance of SEVs' functional benefits, such as convenience, cost savings, and flexibility perceived amongst the positive adopters. Social influence significantly impacts the IA, indicating that societal norms and peer behaviours shape individual decisions. This finding underscores the importance of leveraging social networks and community engagement in promoting shared electric mobility. Although environmental awareness (EA) influences adoption intentions, its effectiveness is smaller compared to other factors, looking to the smaller coefficient. This suggests that while users acknowledge environmental benefits, these alone may not drive the adoption. Lastly, perceived risk also negatively affects adoption intentions, indicating the concerns about safety, data privacy, and operational reliability discourage potential users. Efforts to reduce perceived risks through proper safety measures, secure payment systems, and user-friendly platforms are essential.

Habitual use of private vehicles significantly hinders SEV adoption. Mediation analysis further reveals that entrenched travel habits shape perceptions of SEVs by increasing scepticism and perceived risk while reducing perceived usefulness. These indirect effects suggest that habitual private vehicle users exhibit higher risk perception and scepticism associated with SEVs, leading to reduced adoption intentions.

Gender differences reveal that females are less likely to adopt SEVs, possibly due to heightened safety concerns and logistical challenges. This finding aligns with studies that highlight gender-specific barriers in shared mobility adoption. Moderation analysis further highlights this issue as the influence of scepticism (SC) and perceived risk (PR) on IA is stronger amongst females. Moderating effect of age on relationship between innovativeness and adoption intentions reveals

the reduced innovativeness amongst higher age-group which can limit the adoption amongst these individuals. Higher education attainment positively influences adoption intentions, suggesting that educated individuals are more open to innovative and sustainable transportation options, possibly due to more awareness knowledge. A marginally negative effect of household income on adoption intentions highlights the need to appeal to diverse income segments through flexible pricing models. The presence of children negatively affects the intentions, possibly due to less convenience, family safety and logistical challenges such as child seats which likely deter families from considering SEVs. Car ownership strongly discourages adoption intentions, reflecting that the car owners exhibit lower intentions to adopt SEVs. Besides, it also moderates the relationship between PU and IA. In this context, for car owners, the perceived usefulness of SEVs must be demonstrated more compellingly to overcome their preferences for private cars.

Policy implications: Addressing the psychological, habitual, and sociodemographic barriers identified in this research can significantly enhance the SEVs adoption rates and contribute to broader sustainability goals. Reducing scepticism and perceived risks is pivotal in fostering trust and confidence among potential users. Implementing stringent quality control measures to ensure reliability and service consistency is essential. Safety concerns can be addressed through real-time monitoring systems, in-app emergency features, and secure payment mechanism, which can collectively reduce perceived operational and data privacy risks. These efforts should be complemented by campaigns that emphasize SEVs' practicality, such as cost savings, convenience, and environmental benefits. Disrupting established habits of private vehicle use requires thoroughly designed incentives and behavioural nudges. Financial incentives may include free day-trials, discounted rates, loyalty programs, and promotional offers which can entice users to try SEVs. Behavioural interventions, such as gamification strategies rewarding frequent users, employer-sponsored commuter subsidies create a favourable context for habit formation (of using SEVs). Interventions aimed at breaking these habits, such as restrictions on private vehicles in city centres or the introduction of congestion pricing, can create opportunities for users to explore SEVs. These provisions should be well accompanied by the user-friendly interfaces (i.e, mobile apps) and ample availability of variety of SEVs at shared mobility stations.

The gender gap in SEVs adoption highlights the need for inclusive service designs. Gender-sensitive strategies, including awareness campaigns tailored to women’s specific needs can further bolster their confidence in adopting shared electric mobility services. Educational and outreach programs play a significant role in expanding SEV adoption across diverse user groups by shrinking the effects perceived risks and scepticism, while raising the awareness about the benefits (environmental, societal, and economical) of shared electric mobility among younger and employed populations as well as higher income individuals. Younger individuals (<25 years old), who are not yet fully into car ownership/usage culture and usually open to innovative travel options, should essentially be targeted towards sustainable options. For higher income groups, offering premium services with enhanced comfort and convenience can also be appealing, positioning SEVs as a viable alternative to private cars. Successful policy implications also hinge on creating an ecosystem that supports shared electric mobility. Connecting potential neighbourhoods with important train, bus, and tram stations through concepts of shared mobility hubs is another vital policy focus.

4. CONCLUSIONS

This study provides an in-depth examination of the factors influencing behavioural intentions to adopt shared electric mobility services. By employing latent constructs from the Technology Acceptance Model (TAM) and Theory of Planned Behaviour (TPB) within the Structural Equation Model (SEM) framework, the findings shed light on the psychological, habitual, and sociodemographic determinants of shared electric mobility adoption. These results contribute to a deeper understanding of adoption dynamics, offering insights for formulating interventions that promote SEVs.

Personal innovativeness emerged as a key driver, emphasizing the importance of individual openness to new technologies. Perceived usefulness significantly influenced adoption intentions, highlighting the value of SEVs' practical benefits, including cost savings and convenience. Scepticism and perceived risk were found to be major barriers, deterring potential users, particularly females, by amplifying doubts about reliability, safety, and privacy. Habitual private vehicle usage posed an additional challenge, with direct and indirect effects on reducing adoption intentions by shaping perceptions of SEVs through increased scepticism and risk concerns. The study also revealed significant sociodemographic effects, with gender, education, and household characteristics playing moderating roles. Females reported lower adoption intentions, primarily due to safety concerns, while highly educated individuals demonstrated greater openness to SEVs. The presence of children in households and car ownership negatively influenced adoption, pointing to logistical and competitive barriers that require targeted policy responses.

In conclusion, the policy recommendations derived from this study provide a comprehensive framework for transport planners, policymakers, and service providers paving the way for a sustainable transition to shared electric mobility.

ACKNOWLEDGEMENTS

The authors acknowledge the in-house fundings from the University of Birmingham and University of Niccolò Cusano, which greatly assisted in conducting an online survey for this study.

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