Valuation of Travel Time and Autonomous Vehicle Features: The Role of Acceptance and Trust in Mode Choice

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Short summary

The widespread adoption of autonomous vehicles (AVs) is expected to fundamentally reshape how individuals perceive and value their travel time. However, the psychological constructs that interpret this relationship have not been sufficiently studied. This study examines the influence of attitudinal factors, specifically non-shared autonomous vehicle (NSAV) acceptance and technology trust, on travel time preferences and the Value of Time (VOT) for AVs. Using stated preference (SP) survey data from Oxfordshire and the West Midlands, England, we developed a hybrid choice model (HCM). This model analyzes user choices among four transportation modes: private vehicle (PV), public transit (PT), private autonomous vehicle (PAV), and shared autonomous vehicle (SAV) while including latent psychological constructs derived from attitudinal indicators. The modeling results show that NSAV acceptance is a strong and significant predictor of both PAV and SAV adoption, while trust indicates a significant negative effect on SAV choice, suggesting that concerns about privacy and shared riding reduce willingness to use shared automated services. VOT estimates exhibit meaningful heterogeneity across income, age, and gender, consistent with the model's socio-demographic interaction structure. In terms of AV features, safety perception emerged as a marginally significant positive attribute, while connectivity and dynamic routing features were found to be statistically insignificant. These findings highlight the importance of including psychological factors alongside conventional travel characteristics when modeling the adoption of AVs and planning for such services, providing practical implications for service providers and policymakers in the design of future autonomous transportation.
Keywords: Value of Time, Automated Vehicles, Hybrid Choice Model, Acceptance, Trust, UK.

1 Introduction

The value of time (VOT) is a concept in transport economics that represents the monetary value individuals assign to time saved in travel (Jara-Díaz, 2007). As autonomous vehicles (AVs) are expected to transform travel, they will also alter how passengers perceive and value their time in transit. Unlike conventional driving, which requires continuous attention to the roads, AVs at Levels 4 and 5 of automation free drivers from the driving task and enable them to engage in other activities during travel (Ettema & Verschuren, 2007). This shift in the travel experience has generated considerable academic interest in understanding how automation may affect VOT estimates, and what factors drive the observed variability across empirical studies. As the levels 4 and 5 of AVs have not yet been introduced to the road network, it is difficult for survey participants to visualize their functionality and the associated travel experience (Gkartzonikas & Gkritza, 2019; Kolarova et al., 2019). As a result, most empirical research relies on SP surveys to analyze potential changes in passengers' VOT. In these SP surveys, respondents encountered hypothetical choice scenarios designed to help explain their preferences (Train & Wilson, 2008). Although presenting hypothetical choice scenarios may not accurately reflect real behavior, the final choices and the choices of respondents may differ. The empirical findings for VOT vary widely in both direction and magnitude. While some studies show significant reductions in VOT due to increased convenience, safety, and multitasking capabilities (Steck et al., 2018; Kolarova et al., 2018, 2019; Harb et al., 2022; Kato et al., 2024), others report no reductions or, in some cases, even increases in VOT in some scenarios (M. Yap et al., 2015; M. D. Yap et al., 2016; De Looff et al., 2018; de Almeida Correia et al., 2019; Gao et al., 2019; Krueger et al., 2019; Kolarova & Steck,

2020; Sun et al., 2020; Polydoropoulou et al., 2021; Lavoie et al., 2024). These observed variations could be due to differences in survey design, in-vehicle AV experience attributes, modeling frameworks, attitudinal and socio-demographic heterogeneity, and contextual influences. Given the wide range of factors influencing users' preferences for AVs, identifying the sources of variation in travel time preferences is essential for developing realistic and differentiated scenarios regarding the impact of autonomous driving on mode choices and travel demand. The present study contributes to the existing literature by examining the influence of NSAV acceptance and trust on travel time preferences for AVs. Additionally, it provides empirical evidence on the extent to which these factors, along with the socio-economic characteristics that explain them, contribute to heterogeneity in the value of travel time savings for AVs. To capture these behavioral and attitudinal dimensions, selecting an appropriate modeling framework is crucial for accurately capturing passenger behavior and deriving reliable VOT estimates. The MNL model assumes fixed taste parameters across individuals, limiting its ability to capture preference heterogeneity (Hensher & Greene, 2003). While the Mixed Logit model extends this by allowing taste coefficients to vary randomly across individuals, it examines heterogeneity statistically without explicitly linking it to underlying psychological or attitudinal constructs. To overcome this limitation, the present study employs a Hybrid Choice Model (HCM), which combines traditional discrete choice with latent variables representing unobservable factors such as attitudes and trust in automation (Ben-Akiva et al., 2002). Empirical evidence further supports this choice: Lavieri & Bhat (2019) demonstrated that incorporating latent constructs improves both behavioral validity and predictive accuracy, while Kolarova & Cherchi (2021) showed that the relationship between technology experience and AV preferences is better explained through trust when modeled within an HCM framework.
To evaluate the VOT associated with autonomous driving, an online SP survey was conducted in 2026 to a sample recruited through a professional online panel provider. The sample comprised 200 individuals drawn to reflect the age and gender distribution of the UK population aged 18 to 80 years. The survey was conducted in Oxfordshire/West Midlands, UK, and employed a Hybrid Choice Model framework to jointly capture behavioral and attitudinal dimensions of mode choice across four alternatives: Private Vehicle (PV), Public Transport (PT), Private Automated Vehicle (PAV), and Shared Automated Vehicle (SAV).

2 METHODOLOGY

Our methodology uses an HCM to analyze mode choice in Oxfordshire and the West Midlands, UK, across four alternatives (PV, PT, PAV, and SAV). Data was collected using a web-based questionnaire designed in LimeSurvey, which comprised five main sections: (1) an attitudinal section capturing experiences with electronic devices, personality traits, and perceptions of Connected, Cooperative and Automated Mobility (CCAM) solutions; (2) a stated preference experiment; (3) current mobility behaviors; (4) socio-demographic characteristics; and (5) physical restrictions and disabilities. To process the attitudinal responses, we utilized Exploratory Factor Analysis (EFA) to reduce the dimensionality of the observed indicators and identify a smaller set of latent psychological constructs that explain the correlation structure among the variables. These latent constructs serve as inputs to the HCM. By combining latent variables with simultaneous maximum likelihood estimation in Biogeme (Bierlaire, 2003), the HCM integrates observable attributes (e.g., travel time and cost) and latent psychological factors within the utility specification, allowing the model to account for both observed and unobserved determinants of mode choice.

Alternatives and Attributes

Table 1 provides an overview of all attributes used in our stated choice experiment, along with their corresponding levels. The study considers four primary mode alternatives: PV, PT, PAV, and SAV. For each mode, explanatory variables such as access time, in-vehicle travel time (IVT), and travel cost were included. To capture the specific technological aspect of AVs, three additional attributes were included:

- Communications: The ability to communicate with other vehicles and infrastructure (V2X) for safer, coordinated driving.
- Dynamic Routing: Whether the vehicle's route adjusts dynamically to demand and traffic.
- Level of Safety: The perceived safety of the AV compared to the public transportation mode provided in the survey.

Table 1: Overview of attributes and attribute levels used in the stated choice experiment

Alternative	**Attribute**	**Attribute levels**
Private Vehicle	Access time	2, 6, 10 min
	In-vehicle time	20, 30, 40 min
	Travel cost	£4.50, £6.00, £7.50
Public Transportation	Access time	2, 6, 10 min
	Waiting time	2, 6, 10 min
	In-vehicle time	30, 45, 60 min
	Travel cost	£1.50, £3.00, £4.50
Private Autonomous Vehicle	Access time	2, 6, 10 min
	In-vehicle time	20, 30, 40 min
	Travel cost	£5.00, £6.50, £8.00
	Connectivity	No, Yes
	Dynamic routing	No, Yes
	Safety level	Lower than PT, Higher than PT
Shared Autonomous Vehicle	Access time	2, 6, 10 min
	Waiting time	2, 6, 10 min
	In-vehicle time	20, 25, 30, 35, 40, 45 min
	Travel cost (shared)	£4.00, £5.50, £7.00
	Travel cost (non-shared)	£5.50, £7.00, £8.50
	Sharing mode	Non-Shared, Shared
	Connectivity	No, Yes
	Dynamic routing	No, Yes
	Safety level	Lower than PT, Higher than PT

Choice Sets and Survey Design

A random experimental design was used to develop the choice sets presented to respondents. This approach ensures that the feature levels are varied to provide a reliable database for discrete choice modeling. In this approach, we ensured that inferior and dominant alternatives were eliminated. The survey was initially distributed to 420 individuals in Oxfordshire and the West Midlands, UK, resulting in 232 completed responses. To ensure data quality, a cleaning process was applied to remove respondents who failed attention-check questions or completed the survey in less time than the minimum required. This resulted in a final sample of 200 respondents. Each participant was presented with 8 hypothetical scenarios (choice sets) that imagined a frequent trip in which fully automated Level 4/5 vehicles are available. This resulted in 1,600 potential observations.

Exploratory Factor Analysis (EFA)

To identify the underlying psychological constructs influencing AV adoption, an Exploratory Factor Analysis was performed on the Likert-scale indicators. Based on the factor structure and internal consistency, two latent variables were identified: NSAV Acceptance (capturing the general attitude and intention towards autonomous shared services, including perceived usefulness, positive attitude, and behavioral intention to use them) and Trust (reflecting perceived reliability, security, and dependability of Connected, Cooperative and Automated Mobility (CCAM) services). The factor loadings for the indicators included in the final model are presented in Table 2.

Discrete Choice Model Specification

A set of discrete choice models (DCMs) was estimated to determine the best model for describing choice behavior in the stated choice experiment, ultimately yielding an HCM. For all models, linear-additive utility specifications were used. The utility U_{nj} for individual n choosing alternative j is assumed to be derived from four primary components:

$$U_{nj} = ASC_j + \beta' x_{jn} + \gamma'(s_n \cdot x_{jn}) + \Gamma \cdot LV_n + \epsilon_{nj} \quad (1)$$

Table 2: Estimation results of the EFA with the Likert scale indicators

Indicator	**Item Description**	**Factor 1**	**Factor 2**
NSAVPU1	An autonomous taxi will be useful for my daily travel.	0.728	-
NSAVATT1	It is a good idea to use an autonomous taxi.	0.882	-
NSAVBI1	I'd like to try using an autonomous taxi in the future.	0.893	-
NSAVBI2	If given the opportunity, I would choose to use an autonomous taxi.	0.902	-
T1	CCAM services seem dependable.	-	0.726
T2	CCAM services seem secure.	-	0.860
T3	CCAM services seem reliable.	-	0.846
Factor interpretation		NSAV Acceptance	Trust in CCAM
Eigenvalue		8.681	3.612
Variance explained (%)		64.1	35.4

1. **Attributes ($\beta' x_{jn}$):** Trip attributes (e.g., time and cost), with cost adjusted for income effects (B_{INC_ELAST}).
2. **Socio-demographic Interactions ($\gamma'(s_n \cdot x_{jn})$):** Interactions between attributes and individual characteristics.
3. **Latent Variables ($\Gamma \cdot LV_n$):** Attitudinal constructs integrated via structural and measurement equations.
4. **Error Term (ϵ_{nj}):** i.i.d. Gumbel-distributed error term.

Figure 2 provides a representation of this specification, highlighting the structural relationships between the latent psychological layer, individual characteristics, and utility.

Value of Time Calculation

The VOT is derived directly from the utility specification as the marginal rate of substitution between travel time and travel cost. The marginal utility of travel cost is given by:

$$\frac{\partial V_{in}}{\partial cost_{in}} = \frac{\beta_{COST}}{income_n^{\beta_{INC_ELAST}}} \tag{2}$$

The marginal utility of travel time is alternative-specific and, for autonomous modes, depends on socio-demographic interactions:

$$\frac{\partial V_{in}}{\partial TT_{in}} = \beta_{TT,i} + \beta_{TT,AGE,i} \cdot age_n + \beta_{TT,GEN,i} \cdot gender_n + \beta_{TT,SP} \cdot share_n \tag{3}$$

The VOT for individual n and alternative i is therefore:

$$VOT_{in} = -\frac{\partial V_{in}/\partial TT_{in}}{\partial V_{in}/\partial cost_{in}} \tag{4}$$

The parameters of the choice and latent variable models were estimated jointly to ensure statistical consistency and efficiency. The joint likelihood function accounts for both the respondent's discrete choice and their responses to the attitudinal indicators. We applied maximum-likelihood estimation to estimate the coefficient values from respondents' stated choices using the Biogeme software package (Bierlaire, 2003).

Please indicate **the mobility option** you would choose for your trip. If none of the available options are suitable, select *"None apply for me"*.

(If you are answering by **mobile device**, Please **rotate your device** to landscape mode.)

	Private Vehicle	Public Transportation	Private Autonomous Vehicle	Autonomous Taxi	None Apply for me
Access Time	2 Min	2 Min	2 Min	10 Min	
Waiting Time		2 Min		10 Min	
In-Vehicle Time	40 Min	60 Min	40 Min	20 Min	
Total Time	**42 Min**	**64 Min**	**42 Min**	**40 Min**	
Travel Cost	**£6**	**£3**	**£6.5**	**£5.5**	
Communications			**No**	**No**	
Dynamic Routing			**Yes**	**Yes**	○
Level of Safety			**Lower** than public transportation	**Higher** than public transportation	
	○	○	○	○	

Figure 1: Example of choice set as provided to respondents in survey

3 Results and discussion

The HCM was estimated using simultaneous maximum likelihood in Biogeme. The final specification includes two latent variables (NSAV Acceptance and Trust) integrated into the utility functions of the automated alternatives. The model demonstrates strong explanatory power, with the majority of structural and choice parameters achieving high statistical significance. The results of the model specification are presented in Table 3.

Model Performance and Latent Construct Influence

Simultaneous estimation confirms that psychological constructs significantly influence decision-making. NSAV Acceptance (Factor 1) enters the utility functions of both automated alternatives via alternative-specific interaction terms. The estimated coefficients are positive and highly significant for both PAV ($\Gamma_{PAV} = 0.907$, $p < 0.001$) and SAV ($\Gamma_{SAV} = 1.140$, $p < 0.001$), indicating that higher levels of acceptance increase the utility of automated modes. This suggests that positive general attitudes and behavioral intentions toward autonomous technology are key drivers of adoption. The Trust (Factor 2) was specifically incorporated into the SAV utility because it did not provide a significant effect on PAV and was subsequently removed from that utility. For the SAV utility, the coefficient was negative ($\Gamma_{2,SAV} = -0.212$, $p = 0.062$). This suggests that while respondents may trust the reliability of CCAM technology, those with higher "security and dependability" requirements may remain skeptical of the shared aspect of automated mobility, potentially due to concerns about privacy or the presence of other passengers in a shared SAV.

Baseline Mode Preferences

The Alternative Specific Constants (ASCs) reflect baseline preferences within the SP context relative to the PV. Public Transport ($ASC = -0.965$) is the most preferred alternative after private cars, followed by PAV ($ASC = -1.429$), while SAV ($ASC = -2.259$) shows a lower baseline utility. Finally, the highly negative "None" alternative ($ASC = -5.843$) indicates that respondents almost always chose one of the transport options presented rather than opting out of the trip.

Value of Time Inference

Figure 3 and Figure 4 illustrate how the VOT varies with income and age across different transport modes, while Table 4 summarizes the VOT ranges. These results challenge the assumption that

Table 3: Estimation results of the Hybrid Choice Model (HCM) - Updated.

Parameter Name	**Value**	**Std Err.**	***p*-value**
Choice Model: Common Parameters			
B_{COST}	-0.3824	0.0438	< 0.001
B_{INC_ELAST}	0.1785	0.0327	< 0.001
B_{SAFETY}	0.2064	0.1128	0.0674
Private Vehicle (PV)			
B_{ACCESS_PV}	-0.1093	0.0236	< 0.001
B_{TT_PV}	-0.0482	0.0114	< 0.001
Public Transport (PT)			
ASC_{PT}	-0.9653	0.5257	0.0663
B_{ACCESS_PT}	-0.0771	0.0239	0.0013
B_{TT_PT}	-0.0501	0.0070	< 0.001
Private Automated Vehicle (PAV)			
ASC_{PAV}	-1.4294	0.5311	0.0071
B_{ACCESS_PAV}	-0.0920	0.0259	< 0.001
B_{TT_PAV}	-0.0218	0.0131	0.0950
$B_{TT_AGE_PAV}$	-0.0111	0.0019	< 0.001
$B_{TT_GENDER_PAV}$	0.0111	0.0041	0.0065
Γ_{PAV}	0.9070	0.1023	< 0.001
Shared Automated Vehicle (SAV)			
ASC_{SAV}	-2.2590	0.5961	< 0.001
B_{ACCESS_SAV}	-0.0437	0.0310	0.1595
B_{TT_SAV}	-0.0661	0.0165	< 0.001
B_{TT_SP}	0.0120	0.0063	0.0576
$B_{TT_AGE_SAV}$	-0.0035	0.0017	0.0449
$B_{TT_GENDER_SAV}$	0.0154	0.0040	< 0.001
Γ_{SAV}	1.1402	0.1347	< 0.001
$\Gamma 2_{SAV}$	-0.2129	0.1144	0.0626
None Alternative			
ASC_{NONE}	-5.8431	0.6059	< 0.001
Structural Parameters (Acceptance)			
B_{LV_AGE}	-0.0603	0.0187	0.0012
B_{LV_EDUC}	0.2473	0.0253	< 0.001
$B_{LV_CARSHARE}$	1.0159	0.1288	< 0.001
Structural Parameters (Trust)			
B_{TRUST_GENDER}	0.1123	0.0371	0.0025
$B_{TRUST_CARSHARE}$	1.3281	0.1097	< 0.001

introducing AVs will reduce VOT. While early perspectives suggested that the ability to multitask and be freed from driving tasks would lower the burden of travel (Steck et al., 2018; Becker & Axhausen, 2018; Kolarova et al., 2018, 2019; Kato et al., 2024), these findings align with studies (Krueger et al., 2016; Singleton, 2019; Rashidi et al., 2020), which suggest that AV travel may not be perceived as positively as previously hypothesized. In fact, the observed VOT ranges for AV modes are higher than those of conventional private vehicles. This indicates that travel time in these autonomous modes is often perceived as more burdensome than traditional driving, potentially due to a loss of control or discomfort in shared environments. Overall, the results exhibit clear nonlinear patterns consistent with the HCM's structure and predictions. First, VOT increases consistently with income across all AV modes. This pattern reflects the inclusion of income into the model's cost formulation: as income rises, the marginal disutility of monetary cost decreases, leading individuals to assign a higher value to travel time savings. Second, age plays an important role in shaping VOT, especially for autonomous modes. The results show that older individuals tend to show higher VOT, which can be attributed to the negative interaction between

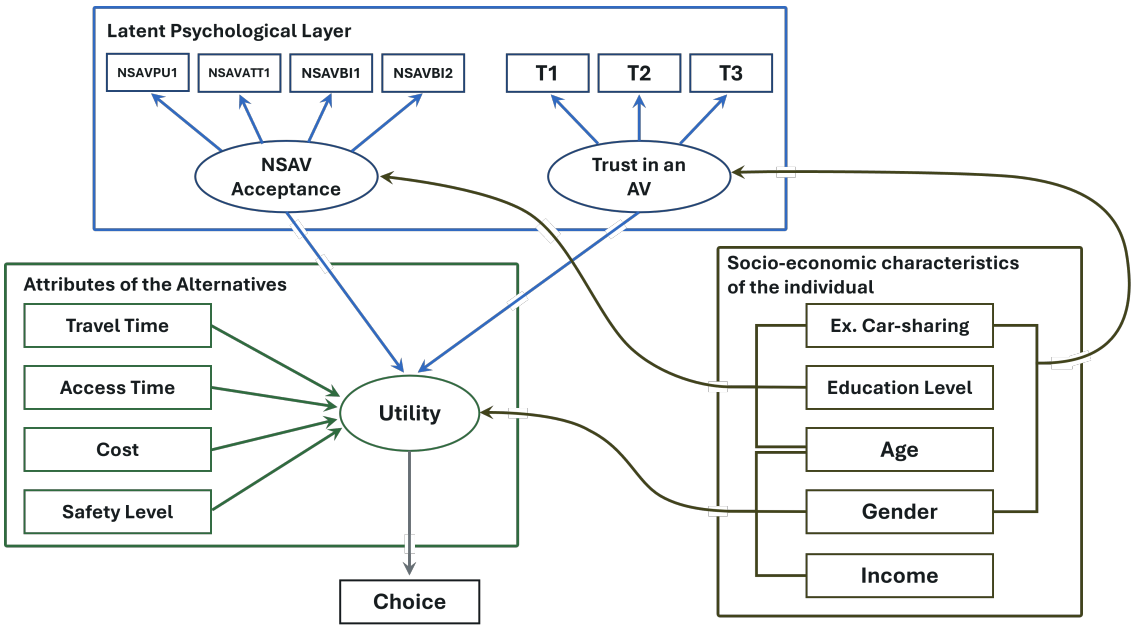


Figure 2: Hybrid Choice Model specification: integrating latent variables and alternative attributes

travel time and age in the model specification. Younger individuals show relatively lower VOT for PAVs compared to SAVs, while older individuals show relatively lower valuations for shared options. These patterns point to significant differences in vehicle preferences across age groups. Finally, gender differences further contribute to the observed heterogeneity. Specifically, the relationship between income and travel time shows that for women, the presence of co-passengers in SAVs has a stronger positive effect on travel time. This is reflected in the estimated VOT: for men, shared SAV shows a lower VOT than PAV, whereas for women, the relationship is reversed. This suggests a greater sensitivity to the social context of shared travel, potentially reflecting perceptions of convenience or safety.

Table 4: Summary of VOT range across different modes.

Mode	**VOT Range (£/hr)**
Private Vehicle (PV)	[6.94, 9.56]
Public Transport (PT)	[6.68, 9.20]
Private Automated Vehicle (PAV)	[4.26, 21.18]
Shared Automated Vehicle (Shared Riding)	[6.24, 15.65]
Shared Automated Vehicle (Not Shared Riding)	[7.9, 17.93]

Valuation of AV Technological Features

The study initially considered three specific AV features: connectivity (V2X), dynamic routing, and safety. However, during the model specification process, Connectivity and Dynamic Routing were found to be statistically insignificant and were removed to ensure a parsimonious specification. This suggests that, for the general public, the technical efficiencies of AVs are less influential on choice than the observable attributes of time, cost, and safety. Another explanation can be that respondents may lack sufficient familiarity with these technical features to meaningfully evaluate their importance in a travel context. Safety remained in the model, with a positive coefficient ($B_{SAFETY} = 0.21$), indicating that AVs are perceived as safer than public transport ($p = 0.068$). This suggests that safety perceptions positively contribute to utility, though the effect is only marginally significant. This suggests that providers should highlight AVs' safety to help users feel confident and encourage adoption of these new mobility options.

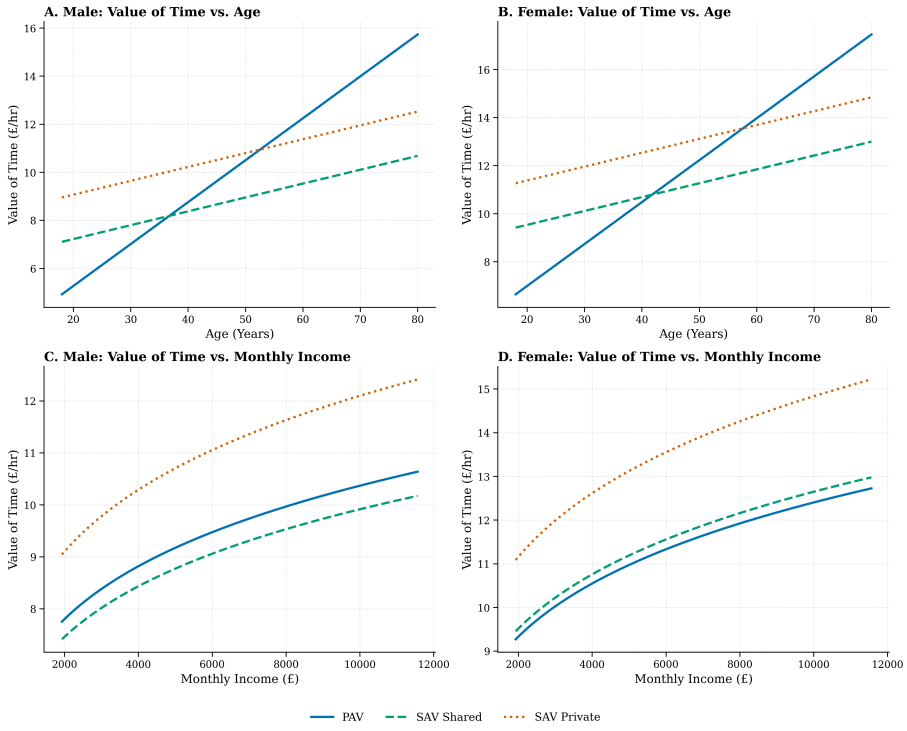


Figure 3: HCM estimates of VOT by age and monthly income across transport modes, differentiated by gender.

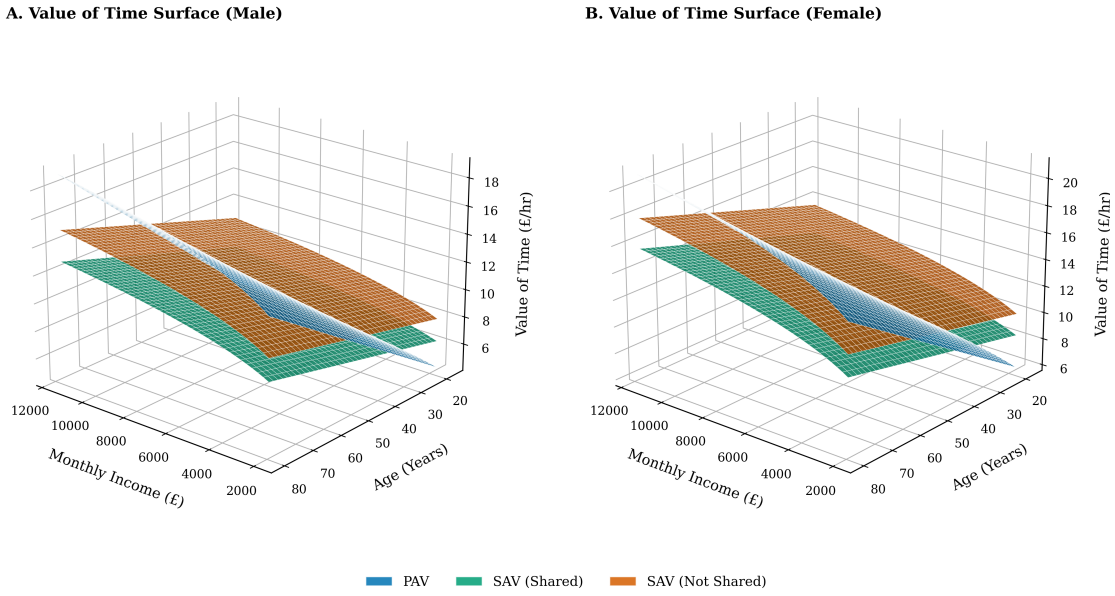


Figure 4: Estimated VOT surfaces from the HCM across age and income dimensions, segmented by gender and mode choice.

Structural and Individual Characteristics

The structural equations provide further insight into the formation of these latent attitudes. Age has a significant negative impact on NSAV Acceptance ($\beta_{LV_AGE} = -0.0603$, $p < 0.002$), suggesting that older individuals may be less accepting of automated technology. Conversely, higher education levels ($\beta_{LV_EDUC} = 0.247$, $p < 0.001$) and previous experience with car-sharing ($\beta_{LV_CARSHARE} = 1.016$, $p < 0.001$) significantly increase positive attitudes toward AVs. Considering the trust construct, gender (being male) shows a positive correlation with higher trust levels ($\beta_{TRUST_GENDER} = 0.112$, $p < 0.003$). Similar to its effect on NSAV acceptance, car-sharing experience remains a dominant predictor for increased trust in these systems ($\beta_{TRUST_CARSHARE} = 1.328$, $p < 0.001$).

4 Conclusions

This study examined the role of psychological constructs in shaping travel time preferences and VOT estimates for AVs, using a hybrid choice model estimated from stated-preference data collected from 200 respondents in Oxfordshire/West Midlands, England. By jointly modeling discrete choices and latent attitudinal variables, this analysis provides a more complete understanding of how people behave when automated vehicles are introduced. The structural equations reveal that younger individuals, those with higher levels of education, and those with prior car-sharing experience exhibit significantly more positive attitudes toward AVs. Moreover, trust was found to be a specific driver for shared mobility; while it did not significantly influence the choice for PAV, it had a significant negative impact on the utility of SAVs, suggesting that those with higher security and dependability requirements remain skeptical of shared autonomous environments. These socio-demographic patterns have direct implications for market segmentation and the targeting of early adoption strategies. VOT estimates vary by income, age, and gender, challenging the assumption that autonomous travel is perceived as less burdensome than driving. The observed VOT ranges highlight the need for differentiated pricing and service design in future autonomous transportation offerings. In particular, the finding that women place greater weight on the social context of shared travel suggests that perceptions of safety and comfort in shared ride environments warrant special attention from operators and policymakers. Several limitations of this study should be acknowledged. The sample, although representative of the Oxfordshire/West Midlands population in terms of age and gender, was limited in terms of geography and number of respondents, and its results may not be generalizable to other urban contexts and different socio-cultural settings. Furthermore, as with all SP-based research on AVs, the lack of real-world experience with Level 4 and 5 vehicles introduces an assumption bias that may affect the reliability of preference estimates. Future research should seek to replicate and extend these findings using larger, more geographically diverse samples and, where possible, consider revealed preference data as AVs gradually become available on road networks.

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