

Article

Acceptance of Automated Cars and Shared Mobility Services: Towards a Holistic Analysis for Sustainable Mobility Systems

Thu Trang Nguyen ^{1,*} , Florian Ratz ²  and Mario Hirz ¹ ¹ Institute of Automotive Engineering, Graz University of Technology, Inffeldgasse 11/II, 8010 Graz, Austria; mario.hirz@tugraz.at² Armengaud Innovate GmbH, Paracelsusweg 1, 8144 Tobelbad, Austria; florian.ratz@armengaud.at

* Correspondence: t.nguyen@tugraz.at

Abstract

Understanding public acceptance is pivotal for integrating automated cars (AC) and shared mobility services (SMS) into mobility systems. This paper presents a holistic framework and demonstrates its application based on a dataset ($N = 419$; EU-focused sub-sample $N = 289$) originating from an online survey, capturing metrics like socio-demographics, mobility habits, and perceptions. Acceptance was measured as willingness to use (WTU), and links to willingness to pay (WTP) were examined. A two-stage approach was conducted: non-parametric screening (Chi-square, Spearman's rank correlation) and proportional-odds ordinal logistic models. Results show that 25.6% would likely use AC and 21.1% would use SMS. WTP for SMS is positively associated with WTU ($p < 0.001$), whereas WTP and WTU are not statistically related for AC. Perceived usefulness and ease of use are positively related to WTU for both AC and SMS (all $p < 0.01$). The acceptance of SMS correlates positively with the acceptance of AC ($p < 0.001$), and the preference for combining SMS with public transport (PT) is associated with higher acceptance. The ordinal logistic models confirm these patterns after adjustment, with perceptions/experience and (for SMS) pricing and PT-related variables remaining significant, while several socio-demographic effects attenuate. The cross-country results indicate modest acceptance in Austria and the UK, aligning with recent European evidence.



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Keywords: automated cars; shared mobility; willingness to use; willingness to pay

1. Introduction

The car industry is facing tremendous changes forced by carbon neutrality-focused policies, advanced technologies in propulsion systems, exhaust treatment, communication methods, autonomous driving systems, and innovative business models [1,2]. Cooperative, Connected, and Automated Mobility (CCAM) is believed to become highly relevant and a reshaping factor of current and future mobility systems [3–5], enabling automated vehicles (AVs) and shared mobility systems (SMSs).

AVs are considered as one of the most disruptive concepts in the mobility market [6] and are expected to ease traffic congestion, as well as to reduce emissions by applying smarter mobility management, i.e., platooning or searching for the least congested route [7,8]. There are six levels of automation in road traffic defined by SAE International, ranging from no automation, over driver assistance, partial automation, conditional automation, and high automation, to full automation [9]. Automated cars (ACs) achieving

levels 1 to 3 are available on the market, offering greater safety, higher comfort, and simplified driving. Meanwhile, several companies, e.g., Waymo, GM Cruise, and Zoox, but also automotive manufacturers, e.g., Daimler, BMW, and Tesla, are working on AC at levels 4 and 5. In some cases, fully automated cars are already in operation in general traffic, e.g., Waymo in San Francisco and Phoenix. In this context, governments worldwide are preparing regulations for a future of mobility, including AV [10,11].

On the other hand, SMSs have a long history. Shared mobility is the short-term access to a vehicle depending on the user's needs and convenience, without requiring ownership of the vehicle [12]. SMSs have been available in Europe for over two decades in the form of various business models, such as business-to-business, business-to-consumer, and peer-to-peer. They are offered using different supply methods, i.e., two-way (pickup and return at a fixed location), one-way (pickup and return at different fixed locations), and free-floating (pickup and return at various locations in a similar area) [13]. Shared mobility can lead to a reduction in private cars, and as a result, less parking space is required. Moreover, it has the potential to reduce the total driven mileage, thereby lowering greenhouse gas emissions of the mobility sector [7,14,15]. In this paper, four sharing models are considered, namely car rental (CR), car sharing (CS), carpooling (CP), and ride hailing (RH). CR is the service of temporarily hiring a vehicle from a rental company for a fee and on a short-term basis, typically ranging from a few hours to a couple of weeks. CS is characterized by cars owned by a company and users paying a fee for the car usage. In CP, different passengers share the same ride when they have the same starting point and destination. The cars are owned by individuals; often the drivers and the passengers pay a fee to the drivers, as well as a possible fee to the digital platform that offers the service. In RH, cars are owned by individuals or a company, and the passengers do not drive the cars themselves but pay a fee to be transported from A to B. Hereafter, we use "automated vehicles (AV)" as the broad term and "automated cars (AC)" for passenger cars; "shared mobility services (SMS)" consistently denotes CR, CS, CP, and RH as defined.

As a future with an integral part of AC and SMS in the mobility systems is clearly on the horizon, it has become vital to understand how people perceive these innovative mobility solutions, their level of acceptance, as well as which factors influence their willingness to use (WTU). There have been a large number of studies carried out in this domain, as will be detailed in the following section. However, they usually focus on one of the two concepts [16–21], thereby missing out potential interlinks in people's perception of them [22]. In addition, while some research work did consider both AC and SMS under the same umbrella, they mostly focused on finding out factors influencing users' WTU AC and SMS as a whole sample [7,23], yet they often lack a comprehensive approach to understand the acceptance level in general. Therefore, this paper proposes a framework for a holistic analysis of the general acceptance regarding AC and SMS, and showcases its application by using survey-collected data.

Another point is that studies exploring to what extent European people are willing to use AC and SMS are scarce [24]. Yet with the European New Green Deal and the goal of becoming the first carbon-neutral continent in the world [25], it is crucial to obtain a viewpoint of European residents on this topic. As a country's specific context, such as low/high income status [26], gross domestic product (GDP) per capita [24], and its accident rate [17], is apparently an indicator of the general acceptance level of its citizens, new data and analyses for Europe as a whole, as well as data from certain member countries, are called for [27]. Thus, the aim of this paper is twofold. First, to propose a holistic framework for evaluating the user acceptance of AC and SMS. And second, to provide pilot evidence from a European online survey. Due to time and resource constraints, the sample size is

limited, and therefore the results are preliminary, and yet they can serve as a stepping stone for further research in this domain.

This study contributes to sustainable mobility transitions by linking user acceptance to pricing and integration with public transport (PT), two levers that shape the mode shift and system efficiency. By jointly analyzing AC and SMS within the same sample and mapping WTU to WTP, behavioral and economic conditions are identified under which shared, automated, and PT solutions can lower vehicle-kilometers traveled, emissions, and resource use, while maintaining accessibility.

The following Section 2 reviews related work and outlines research gaps, while Section 3 presents the utilized framework, data, and the applied methodology. Section 4 reports results and contains the discussion, including cross-country aspects. Section 5 concludes with implications for sustainability, limitations, and directions for future research.

2. Literature Review

A large number of studies on the acceptance of AVs attempt to identify factors influencing people's perception of the technology. For instance, Nastjuk et al. [16] utilized a mixed-method approach, with a qualitative research design and a model based on the Technology Acceptance Model (TAM) and an online survey (N = 316) to explore the elements that contribute to end-user acceptance of autonomous driving. Pigeon et al. [28] conducted a systematic review of studies published between 1999 and 2019 on the topic of acceptance, acceptability, and usage of non-rail AV in PT. They found out influencing factors at the micro-level, being age, gender, education, income, employment, place of residence or workplace (socio-demographic parameters), travel purpose and weather, attitude towards PT, travel habits, mobility difficulties (travel behavior parameters), trust in AV, technology interest, control, and ecological values (personality parameters). Wintersberger et al. [18] used an online survey (N = 192) and statistical tests to understand if the Austrian market is ready for adopting AV. The study shows that while Austrian consumers have a good understanding of autonomous driving and AV, they express concerns regarding reliability, cybersecurity, and CS models in the future.

On a global scale, Nordhoff et al. [24] conducted a survey (N = 7755) covering 116 countries in order to understand the acceptance level of AV, as well as how countries differ in their people's opinions. They found out that the general public would find taking a ride in an AV quite enjoyable. However, participants still express their favor over the ability to retain some degree of control in an AV. A recent review by Alqahtani [29] confirms that trust, perceived safety, cybersecurity, and interface design remain first-order predictors of acceptance, with media and regulatory context shaping cross-regional differences. With regard to Europe, Hudson et al. [17] used data from Eurobarometer in the last two months of 2014 on about 1000 citizens in each EU country to analyze their opinions on AV. They concluded that younger individuals, males, city inhabitants, and those with higher education are more in favor of AV. In a rare attempt to understand expectations from different subgroups of transport passengers towards AV, Niesel & Haustein [27] divided the users (N = 3040) into three segments. Their profiling results in enthusiasts being male and younger citizens in urban areas; skeptics are of older age groups and usually live in areas with lower population density; and the indifferent drivers are those without a car or who do not like driving. Orfanou et al. [30] have presented a framework for modeling and impact assessment of AV. They argued that survey-collected data combined with data gained via test vehicles has the potential to develop an accepted AV behavioral model, which can be used as a simulation tool for impact assessment. New cross-country evidence by Torrao et al. [31] shows the gender gap in AV acceptance is heterogeneous across Eu-

rope and is larger in countries with higher GDP and Gender Equality Index, suggesting context-dependent equality mechanisms.

WTU and willingness to pay (WTP) may have a strong connection. For instance, Liu et al. [32] found that WTP for AV is influenced by familiarity, age, education, and income, with trust and perceived benefit being positive, while perceived risk and dread are opposite (N = 1355). Meanwhile, Bansal & Kockelman [33] used WTP as one of their indicators to predict Americans' adoption levels of connected and automated vehicles in 30 years. Their study (N = 2167) shows an increase in WTP from the public at large, a significant reduction in technology costs, and that supportive policies are critical to achieve a homogeneous technology mix in the USA's light-duty vehicle fleet by 2045. Since it is considered that AVs and SMSs can play a key role for people with disabilities in satisfying their mobility needs [34,35], Miller et al. [36] made an effort to investigate how individuals with different mobility and communication needs perceive the introduction of AVs in PT. They found out that these groups (N = 300) have positive opinions on AVs in PT, yet are concerned about several safety-related issues. European segmentation indicates high but uneven WTP for level 3 automation, with conservative and some younger segments displaying lower WTP, despite their interest [37]. Furthermore, a meta-synthesis also shows that AVs can reduce the value of time relative to conventional cars, albeit with wide heterogeneity by study design and user profile [38]. In addition, survey evidence from four European living labs shows users are willing to pay for physical integration (PT within walking distance, placemaking features), but not for digital integration, implying a public/operational funding need for platform services [39].

Within the theme of acceptance regarding SMS, there is a vast array of research on attitude and perception towards CS, with many trying to figure out the factors motivating or preventing people from using these services. For example, Svennevik et al. [19] conducted interviews (N = 58) and workshops to reveal that advanced digital technologies and regulations are the key factors leading to changes in business models and social norms, resulting in acceptance of CS. It is also recommended to combine electric vehicles (EVs) and CS in policies, as it can make them more accessible to people [40] or influence people's choices [41,42]. While CS is often considered more suitable in urban areas, Isaksson & Pongolini [13] installed a CS trial in a low-income, fairly low-density, suburban area and interviewed the participants (N = 11). Their results reveal three interrelated processes, namely making CS understandable and useful, integrating CS in daily usage, and communication about how to share a car properly, together with other concerns such as the environmental advantages of sharing and the social benefits to enhance daily life. Similarly, Mitra [43] explored how CS impacts lower-income households (N = 42,431) in California, USA. The author concluded that CS usage actually enhances mobility for both lower- and higher-income families, yet the effect on the former is more substantial, particularly when combined with PT. Coengrachts et al. [44] conducted an analysis across 311 European cities and found that shared-mobility provision is highly fragmented and sensitive to regulatory strictness, economic potential, and operator mix; scooters dominate many markets, while public schemes persist for bikes and cars.

Using another approach, Hu et al. [45] focused on CS usage frequency and its main influencing factors. They found out that at the moment, CS users (N = 14,623) consist mostly of younger people of 25–39 years old and mainly men, yet the market potential for female users is larger. Jain et al. [21] conducted in-depth interviews with focus groups (N = 5) and station-based CS members, former members, and non-members (N = 18) to identify motivators and barriers to CS adoption. They found out that CS adoption involves a multi-stage decision-making process and not just a simple yes/no question. In addition, psycho-social determinants differ for peer-to-peer and fleet-based CS. In a rare study using

segmentation to understand how free-floating car sharing (FFCS) affects car ownership over a period of 2.5 years, Haustein [46] found that car ownership changes occur more among car sharers ($N = 776$) than non-sharers ($N = 720$). Furthermore, Julagasigorn et al. [47] conducted a systematic literature review to identify psychological factors and theories associated with people's motivation to use CP. Their study revealed that the Theory of Planned Behavior, the Norm-Activation Model, Consumer Perceived Value, Social Capital, and TAM suit CP research the most. They also recognized eighteen factors, classified into four groups: demographic (age, income, number of people in a household, marital status, education, number of cars in a household), psychological (saving money, reducing congestion, reliability, saving time, environment/sustainability, comfort, convenience, socializing, trust), policy intervention (parking availability, parking cost, cost subsidy, guaranteed ride home, high occupancy vehicle lanes), and situational (fixed/regular work schedule, commute distance, time commuting, population density, fuel costs).

Another research approach is to consider different aspects of automated driving and shared mobility together. Focusing on the potential adoption of AV by CS clients, Curtale et al. [22] found that electric car sharing (ECS) users ($N = 2154$) would highly accept autonomous driving features. Wu et al. [48] applied a mixture of the trust-in-automation three-factor model, the Unified Theory of Acceptance and Use of Technology model, and the Trust Theory. The study ($N = 451$) shows that while the autonomy level may potentially increase public acceptance, both directly and indirectly, anthropomorphic characteristics can only make an impact via trust. Tian et al. [23] modeled choices of using AV or shared cars according to the Random Utility Theory. Their results ($N = 542$) show that people who are more likely to purchase an AV are individuals less than 50 years old who have a salary higher than 90,000 CNY/year, especially those living with their partners and who do not own a car. Regarding CS, male participants like it more than females, and so do young people and households with lower income. Another example is Thurner et al. [7], who provided insights into the Russian market by studying how the people ($N = 1671$) would adopt EVs, CS, and AVs. Their findings show that age and gender are predictors of the willingness to try EVs and AVs, while CS is positively opinionated by general urban citizens, regardless of their age, income, gender, or education. Zhou et al. [49] examined the effect of using CS and shared AVs on the mode choices of 1500 households in Australia. They concluded that the experience of CS users seems to influence household mode choice significantly, in particular, increasing the likelihood of choosing more diversified means such as two-wheeler sharing and taxi, while decreasing the use of private vehicles. They also highlight that higher-income people would perceive autonomous driving positively, yet female, non-drivers, and seniors generally consider the technology negatively or with caution.

In another study on acceptance of FFCS, Zhua et al. [20] proposed a value adoption model based on self-efficacy ($N = 318$). Similarly, Zhu et al. [50] investigated motivation factors of adopting ridesharing (RS) among people ($N = 314$) and found that self-efficacy plays the key role and directly affects the value perceptions and indirectly impacts behavioral intentions. Wang et al. [51] explored factors affecting WTU RS, based on data collected from non-users ($N = 378$). The results show that while the perceived value influences WTU RS positively, perceived risk has a negative effect.

Based on the literature review, several criteria are recognized as having potential impacts on the acceptance of AC and SMS. To be specific, SMSs are reported to be favored by people of younger age [22,52,53], having higher education [54], and from small households, i.e., living alone [55] or without children [52,56]. However, living location comes with mixed results, as they are found living in rural and less populated areas [57] or urban cities [22,58–61]. The gender aspect is also contradictory, as Efthymiou et al. [52] and Tian

et al. [23] found males prefer CS, yet Kim et al. [62] concluded that women have higher WTU CS than men. Similarly, income also has different findings. Correia & Viegas [63] and Efthymiou et al. [52] found that CS appeals to lower-income people, while Prieto et al. [55] and Martin & Shaheen [59] reported that the middle to upper class are CS supporters. Additionally, people who hold a job or come from a car-owning household have less interest in CS [23]. Travel purpose can be another factor [58], as commuting or business travel plays an important role in promoting CS [64].

On the other hand, individuals who perceive AV positively are mainly male [65–67], younger [33,66], have awareness and experience with automation [66], have high driving mileage [24], travel with several transport modes [33], are technology-oriented [24], and live with partners [23]. The WTP for AV is higher with higher income [66]. It is interesting to note that, even though AVs are considered to provide transportation solutions to disadvantaged people, such as non-drivers, seniors, and individuals with disabilities [66,68], it is reported that mobility-impaired individuals have lower WTU than average people [69]. It is also concluded that whether a car is electric has a positive effect on the acceptance of both AV [23] and CS [22]. Details of the reviewed studies can be seen in Table 1 in the last part of this section.

Table 1. Summarized main information from the reviewed studies.

Ref.	Objective and Location	Methods	Main Findings
[16]	AV Germany	Mixed: qualitative research, TAM and online survey (N = 316)	Attitude → Usage intention (+) Perceived usefulness → attitude (+) Perceived ease of use → attitude (+) Subjective norm → Perceived usefulness (+) Trust → Intention to use (+) Personal innovativeness → Perceived usefulness (+) Personal innovativeness → Perceived ease of use (+) Perceived relative advantage → Perceived usefulness (+) Perceived relative advantage → Attitude (+) Compatibility of AVs with mobility needs → Perceived usefulness (+), Attitude (+), Intention to use (+) Perceived enjoyment → Perceived ease of use (+) (Positive) price evaluation → Intention to use (+)
[17]	AV Europe	Regression analysis, factor analysis	Attitude to robots, individual self-interest → Attitude to AVs Age → Attitude (−) Male → Attitude (+) City residents → Attitude (+) High Education → Attitude (+) Accident rate → Attitude (+)
[18]	AV Austria	Online survey (N = 192), Spearman's rank correlation and Mann–Whitney U test	Female → Concern (+) Automation level → Safety (+) Concern → WTU (−) Automation level → WTU (+)
[22]	ECS AECS France, Italy, the Netherlands, Spain	Survey (N = 2154), The extended UTAUT and safety construct	ECS: Age → Behavioral intention to use (BI) (−) High education → BI (+) City size → BI (+) AECS: Female → BI (−) Age → BI (−) High income → BI (+) BI ECS → BI AECS (+) Impacts of psychological factors and socio-demographic characteristics differ across countries

Table 1. Cont.

Ref.	Objective and Location	Methods	Main Findings
[23]	AV, CS, SAV Dalian, China	The random utility theory, survey (N = 542)	Age (<50 years old) → Willingness to buy (WTB) AV (+) Income (>90,000 CNY/year) → WTB AV (+) Number of people in household (>1) → WTB AV (+) Number of cars in household (>0) → WTB AV (−) Driving experience → WTU AV (+) Male → WTU CS (+) Age → WTU CS (−) Income → WTU CS (−) Employment → WTU CS (−) Number of cars in household (>0) → WTU CS (−)
[36]	SAV Singapore	Online survey (N = 300), focus group (N = 53)	Attitude (+) Safety → Attitude (−)
[48]	SAV Singapore	Survey (N = 451), three-factor model, UTAUT model, trust theory, structural equation modeling	SAV anthropomorphism → Trust in SAVs (+) Human trust propensity → Trust in SAVs (+) Human trust propensity → Acceptance SAVs (+) SAV autonomy → Trust in SAVs (+) SAV autonomy → Acceptance SAVs (+) Effort expectancy → Trust in SAVs (+) Effort expectancy → Acceptance SAVs (+) Human-SAV facilitating condition → Acceptance SAVs (+) Social influence → Trust in SAVs (+) Social influence → Acceptance SAVs (+) Trust in SAVs → Acceptance SAVs (+) The effect of SAV anthropomorphism on Acceptance SAVs is mediated by Trust in SAVs The effect of human trust propensity on Acceptance SAVs is mediated by Trust in SAVs The effect of SAV autonomy on Acceptance SAVs is mediated by Trust in SAVs The effect of effort expectancy on Acceptance SAVs is mediated by Trust in SAVs
[7]	CS, EV, AV Russia	Survey (N = 1671), logistic regression, segmentation	Age → WTT (−) Driving license → WTT EV (+), WTT AC (−), WWT CS (−) Male → WTT AC (+), WTT EV (+), WTT CS (+) Female → WTT AC (−), WTT EV (−) City residents → WTT AC (+), WTT EV (+), WTT CS (+) Number of people in household → WTT CS (+), WTT AC (+) Higher education does not affect attitudes towards CS, EV, AV CS is attractive to all users regardless of income, education, gender
[27]	AV Denmark	Online survey (N = 3040), cluster analysis (k-means algorithm)	Enthusiasts: male, younger, metropolitan occupants Skeptics: older, non-metropolitan occupants Indifferent drivers: no cars, negative feelings towards driving Expected advantages of AVs and behavioral change are different among the various segments
[26]	AV Global	Online survey (N = 4886)	Income, driving frequency → WTP (+) Mileage → WTP (+) Current use of ACC (adaptive cruise control) → WTP (+) A wide spectrum of acceptance towards AVs 22% do not want to pay more for level 5 AVs 5% WTP more than 30,000 USD 33% perceive AVs as highly enjoyable 69% estimate AVs will reach 50% market share by 2050 A large share of users would not like to pay anything extra for AVs, eps. for higher automation levels Concerns about software hacking/misuse, legal issues, and safety
[32]	AV Tianjin and Xi'an, China	Surveys (N = 586 (Tianjin), N = 769 (Xi'an))	Awareness of AVs → WTP (+) Age → WTP (−) Income → WTP (+) Education → WTP (+) Trust, perceived benefit → WTP (+) Perceived risk, dread → WTP (−) Participants with awareness of AVs have higher WTP and trust, also perceived higher benefits, lower risks and dread About 26% do not want to pay more for AVs

Table 1. Cont.

Ref.	Objective and Location	Methods	Main Findings
[24]	AV Global	Online survey (N = 7755), factor analysis	Perceived usefulness, intention to use, ease of use, pleasure, trust in AVs, mobility-related knowledge, thrill seeking, exert manual control, car-free preference, comfortable with technology → Attitude AVs Higher GDP → lower WTU Higher GDP → less supportive car-free atmosphere Higher GDP → less comfortable with technology Lower GDP → higher thrill seeking
[49]	CS, SAV Australia	Survey (N = 1500), Logit model	Household income → WTU CS (−), WTU SAV (+) Age → WTU CS (−), WTU SAV (−) Environmentally conscious → WTU CS (+) Household car ownership → WTU CS (−) Male → WTU CS (+) Female, Non-drivers → WTU SAV (−) Current travel mode → WTU CS Trip purposes → WTU CS
[19]	CS Oslo, Norway, Malmö, Sweden, Rotterdam, Netherlands	Interview (N = 58), workshops (3 half-day)	New digital technologies, regulation → business models and social aspect of mobility → acceptance CS Usage of private cars → WTU CS (−) EVs combined with CS → CS (+)
[20]	FFCS Beijing, Shanghai, and Guangzhou, China	Online survey (N = 318)	Economic value, functional value, comparative value, emotional value → Perceived value of FFCS Economic value is the greatest determinant of overall value perception Comparative value is vital: adoption of FFCS only when relative advantages can offset costs/risks of mode switching Functional value is not the main component in perceived value of FFCS Improvement in social value, epistemic value: not significant
[51]	RS China	Survey (N = 378, purely non-users), structural equation model	Perceived value → WTU RS (+) Perceived risk → WTU RS (−) Perceived risk moderates the effect of perceived value on WTU RS positively
[50]	RS Beijing, China	Survey (N = 314)	Self-efficacy → Perceived value → Behavioral intentions Functional value, emotional value, social value → Overall perceived value of RS Learning effort, risk perception are not significant perceived costs for RS users
[13]	ECS A small municipality in suburban area, Sweden	Interview (N = 11, participants of the CS trial)	Interrelated: Making the technology understandable and useful; Integrating carsharing in everyday practices; Negotiations and communications about the proper way to share a car. Highlighted: The environmental advantages of sharing; The social benefits and how it might enrich everyday life
[45]	CS Beijing, China	CS order data and users' trajectory data, multi-factor influence model	Female → higher FCU than male Female → CS preference (+) Age → FCU (−) (main users 25–39 years old) Male → CS usage (+) Weekday → CS usage (+) Commute distance → CS user (−) Coupon to join CS → CS user (+) Travel distance and duration, Weekday usage, Station location → FCU
[21]	CS Melbourne, Australia	Theory of Planned Behavior, focus group (N = 5), semi-structured interview (N = 18)	Key motivators: cost saving, environment, convenience Other motivators: sharing with the community, reducing/avoiding car-related hassles (e.g., maintenance, parking), a desire to possess less Barriers: normative beliefs about car ownership, perceived difficulties in using CS (e.g., families with children), effort to plan, book and use CS
[46]	FFCS Copenhagen, Denmark	Surveys (2.5 years apart, N = 776 FFCS users, 720 non-users), multinomial regression	FFCS users → Reduction in car ownership (+), Changed household composition, private parking space, the initial number of cars in the household → Changed car ownership

Table 1. Cont.

Ref.	Objective and Location	Methods	Main Findings
[43]	CS California, US	Statistical data, structural equation model	CS membership enhances mobility for lower/higher-income households The effect of CS membership is significantly larger on lower-income households.
[29]	AV Global	Review of recent studies (2018–2024); synthesis of acceptance drivers	Trust → Acceptance (+) Perceived safety, cybersecurity → Acceptance (+) UI/UX clarity, transparency → Acceptance (+) Media/policy context → Attitudes and intentions Demographics (age, gender) → Mixed/Context-dependent
[31]	AV Europe; eight countries	Cross-country survey analysis; regression models; cross-level comparisons	Male → Acceptance (+) (heterogeneous across countries) Higher GDP per capita, Gender Equality Index → Larger gender gap Country effects (culture/policy) → Significant Overall acceptance varies strongly by national context
[37]	AV Europe	Online stated-preference survey; segmentation; WTP estimation	Perceived usefulness, trust → WTP (+) Heterogeneous segments: some high WTP, others low/zero Safety and cost perceptions → WTP (±) Not all willing to pay a premium despite positive attitudes
[38]	AV Global	Quantitative synthesis/meta-review of empirical studies (value, costs, VOT)	Private AVs → Lower perceived value-of-time (VOT) (on average) Benefits/costs vary by context and study design Significant heterogeneity by user characteristics Evidence base growing but uneven across settings
[39]	SMS Europe; 4 cities	Stated-choice joint survey; WTP estimation for hub attributes	Physical integration (PT within walking distance, placemaking) → WTP (+) Digital/platform integration → WTP (0/−) Implication: back-end services may need public/operational funding Design features can shift acceptance and usage

Summarizing, prior scientific work consistently highlights first-order drivers of acceptance, i.e., trust, perceived safety, and interface clarity, while reporting mixed socio-demographic effects [18,28,29]. These contradictions are considered as products of (1) methodological heterogeneity across stated-preference/WTP versus intention surveys and qualitative versus quantitative research designs [21,28,32,33], (2) contextual moderators (urbanity/market structure, regulation, operator mix, and country-level factors) [17,31,44,58,59], and (3) a gap between WTU and WTP, where positive attitudes do not necessarily translate into paying a premium price [32,33,37]. Recent European evidence shows that gender effects are heterogeneous rather than universal, varying with macro indicators (e.g., GDP per capita, Gender Equality Index) [23,31,52]. Likewise, income effects are non-linear and often confounded by ownership and location [52,55,63]. Addressing these research gaps, our study jointly analyzes AC and SMS within the same sample, maps WTU to WTP, and incorporates PT integration and pricing to explain divergent findings and identify policy levers (safety communication, interface design, pricing, and physical integration with PT) [38,39].

3. Methodology

In this paper, acceptance is considered to be similar to acceptability and usage, even though they are distinguished in [28]. The acceptance level is measured via WTU, which can be a synonym for behavioral intention to use [22,66], as well as “would like to take a ride in” [70], or willingness to try [7]. We examine not only willingness to use automated cars (WTU_AC) and willingness to use shared mobility services (WTU_SMS), but also how people would consider the combination of SMSs and PT (WTU_CombiPT) versus using their private vehicle. Since CS has a great potential to pair with PT as a first/last mile

solution, and it is found that the demand for SMSs is strong near PT locations [66], yet there are very few studies examining the acceptance of the combined solution [43]. Another parameter, which is worth measuring, is the WTP, in which ACs are expected to be more expensive than a normal car, while SMSs are considered the opposite. This paper explores five hypotheses, as presented in Table 2.

Table 2. The paper’s five hypotheses.

Code	Hypothesis	Reference
H1	WTU ACs and WTU SMSs have a positive connection	[7,22,23]
H2	Regarding ACs, WTU has a connection to WTP	[32]
H3	Regarding SMSs, WTU has a connection to WTP	[23]
H4a	People considering ACs useful and easy to use are more willing to use AC	[16,24]
H4b	People considering SMSs useful and easy to use are more willing to use SMS	[20,51]
H5	People who prefer to use the combination of SMSs and PT over their private vehicle have higher acceptance of SMSs than people who prefer their private vehicle	[45,46]

This paper’s contributions are twofold: firstly, proposing a holistic acceptance framework jointly analyzing AC and SMS, including an acceptance-by-category metric enabling like-for-like comparisons; and secondly, an EU pilot applying a two-stage (bivariate and ordinal-logit) strategy that links WTU to pricing and other socio-economic aspects.

3.1. Holistic Framework

We argue that in order to comprehensively understand the acceptance of AC and SMS and its influencing factors, it is important to first explore them together with the same audience, for WTU AC and WTU SMS have potential connections, as indicated by Thurner et al. [7]. Secondly, to include a segmentation analysis for investigating a wide spectrum of (potential) users. In addition to the application of statistical methods to figure out the influencing factors of the WTU. And lastly, cross-country aspects should be explored in case several countries are involved. Figure 1 illustrates this holistic framework.

In the first step, acceptance-related constructs and/or criteria are identified and classified based on one or a few theory models, a literature review, or qualitative research. Subsequently, the hypotheses are developed and are to be tested in research work. From there, a qualitative and/or quantitative research design is conducted, followed by the step of data collection. For this study, the data have been gathered through an online survey.

For the data analysis step, a descriptive approach has been performed to process the information of the sample, as well as to investigate the general acceptance level [26,32,65,67,70]. Moreover, a segmentation analysis, on the other hand, is a way of “zooming in” and leads to insights from certain groups of people with similar opinions [27,46]. Going beyond the frequency consideration, an influencing factor analysis is meant to identify which parameters have a noticeable effect on the WTU by examining the data statistically [7,16–18,22,23,32,48]. The influencing factors are recognized when they are statistically significantly associated with the WTU in either direction. The cross-country analysis is another part of the investigation, but it is optional as it depends on the scope of the study [17,24,26].

The choice of methods to be applied in research depends entirely on the research’s scope and its research questions to be answered. The current paper excludes the segmentation analysis, as it is not relevant to examining our hypotheses.

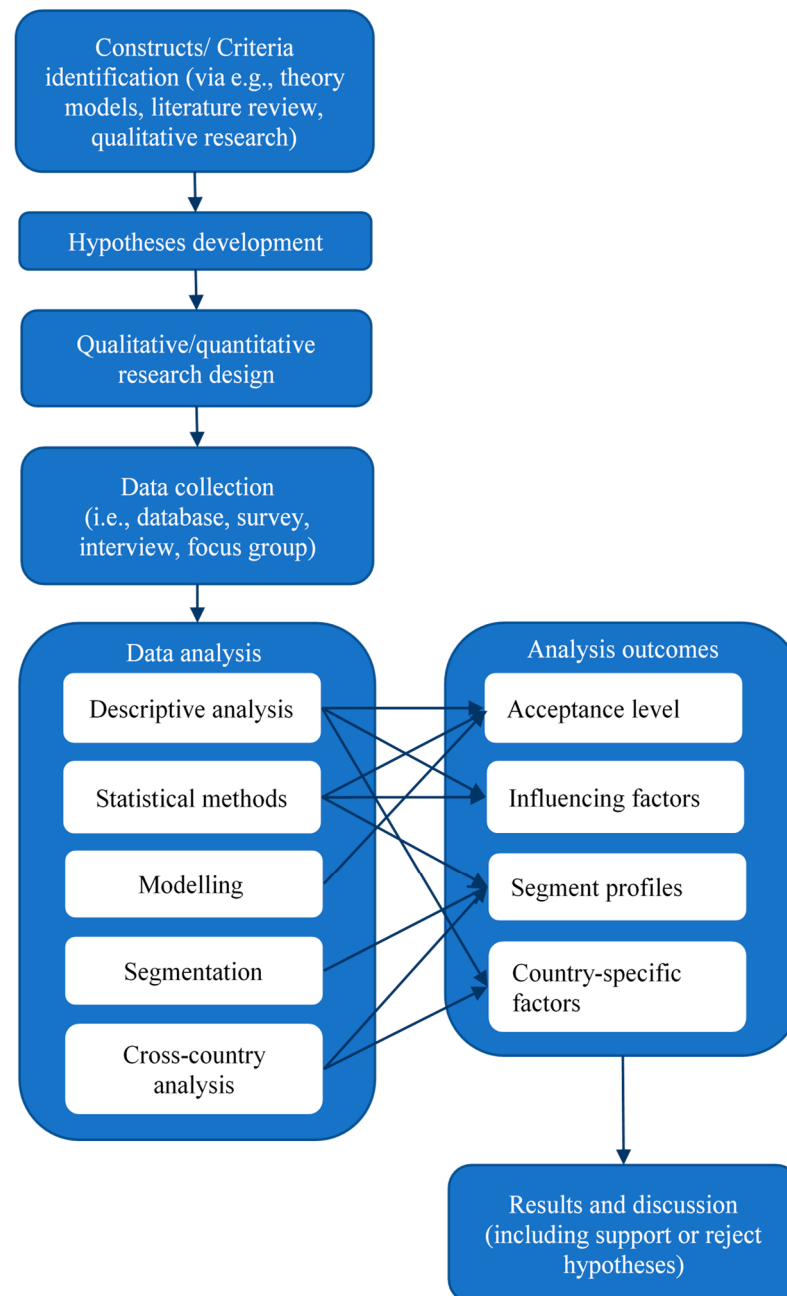


Figure 1. A holistic framework for acceptance analysis.

3.2. Survey Design and Acceptance by Category

The survey is designed in Google Forms, targeting English-speaking current and potential users of AC and SMS. It is composed of three parts: background information, perception of AC, and perception of SMS. The first part aims at collecting various socio-demographic information, as well as mobility-related habits and usage. Respondents are asked to select their country of residence from a list of 27 European member states, as well as 4 EFTA countries and the UK.

In the next sections, respondents are asked to rank their knowledge of ACs, their opinion of their usefulness, ease of use, motivators and barriers, usage purposes, preferred business model, possible non-driving activities to engage in, and their WTP and WTU. It is worth mentioning that ACs are defined as fully automated vehicles (SAE level 5) in this survey, as stated clearly at the beginning of this section in the survey.

One important aspect of the survey is that we utilized closed questions with multiple choices—in most cases, respondents can choose one option, yet multiple options are possible in questions such as “what are your travel modes”, “which travel purpose would you use AC/SMS for”, or “which SMS have you already used”. Furthermore, ranking is utilized for understanding the magnitude of importance, with a 5-point Likert scale ranging from 1 (most important) to 5 (least important). The WTU is measured similarly for both AC and SMS, where respondents can rate among 1 (Not at all), 2 (Maybe), 3 (I will consider it), 4 (I will use it), and 5 (I will definitely use it). A rating of 4 or 5 is accounted for “being willing to use”, as reported in Lang et al. [70]. A new method for the comparative assessment of category-based acceptance is proposed, in which the acceptance of one category (e.g., male, city resident) is measured by the percentage of those who are willing to use the technology or service in that category; see the equation below. In this way, comparisons can be made straightforward between different categories, which represents an enhancement in contrast to the state-of-the-art.

$$WTU_{X_i} = \frac{Freq_{4-X_i} + Freq_{5-X_i}}{\sum_{j=1}^5 Freq_{j-X_i}} * 100\% \quad (1)$$

where WTU_{X_i} represents the acceptance or WTU of the technology/service X by category i . In this case, X is either AC or SMS. $Freq_j$ is the frequency of rating j regarding WTU_{X_i} ($j = 1-5$).

On the other hand, WTP for AC starts from “same as a normal car” and goes up 10% for each continuous option, while WTP for SMS starts from the same point, but reduces 10% for each option, respectively. The survey was first tested in a limited trial round, where 15 participants, mixed among students and researchers, were asked to fill in the survey and provide feedback on its design. The inputs received from the trial round led to an adjustment of the survey prior to the mass dissemination via professional and personal networks, social media, and survey swap platforms. The survey details can be found in the Supplementary Materials of this paper.

3.3. Dataset Description

Between May and August 2022, 431 complete responses have been collected. After the dataset cleaning, 419 remained, of which 289 belong to the targeted European region (EU-27, EFTA, and UK). The survey included (1) socio-demographics (gender, age group, living area, education, household composition, car ownership), (2) mobility habits (driving license, annual mileage, commuting distance, PT usage, mobility cost share), and (3) perceptions and intentions for AV/AC and SMS (knowledge of AV, perceived usefulness and ease of use, WTU, WTP relative to a normal car, experience with CR, CS, CP, and RH, and preference for combining SMS with PT).

3.4. Cross-Country Analysis

National context seems to have noticeable implications on general acceptance of AV [17,24] and CS [22], with developed countries being less attracted by autonomous driving in the market [26], while a high rate of car ownership can lead to low acceptance of CS, and countries with a low road fatality ratio possibly show more interest in CS [22]. Table 3 summarizes general acceptance of fully automated cars (i.e., people who are likely or very likely to use these vehicles or would take a ride in such vehicles). In Hudson et al. [17], citizens from the EU-27 plus the UK have quite low acceptance of AC, as they averaged at 3.65 on a 10-point scale from 1 (totally uncomfortable) to 10 (totally comfortable). Of all countries, only Poland shows more than 5 points (5.36), followed by the Netherlands, Sweden, Denmark, and Lithuania. The countries that have the least favorable attitude

toward AC are Cyprus (the lowest, 2.43), Malta, Greece, Spain, and Croatia. With regard to SMS, relevant figures are very rare to be seen in the literature. For instance, Zhou & Kockelman [71] reported an estimated WTU CS of 13.4% in Austin, Texas, USA. While about 33% of young Greek individuals possibly use CS currently, according to [49,52].

Table 3. Summary of acceptance level in the literature regarding the use of automated vehicles (AV).

Country	WTU/Would Take a Ride (% of Sample)	Unwillingness to Pay More (% of Sample)
Global	58% [70] 56% [26] About 50% [33,65]	22% [26]
China	75% [70]	22% [67] 26% [32]
France	58% [70]	-
Germany	44% [70]	-
India	85% [70]	30% [67]
Japan	36% [70]	68% [67]
Netherlands	41% [70]	-
Singapore	62% [70]	-
UAE	70% [70]	-
UK	49% [70]	60% [67]
US	52% [70]	59% [33] 55% [67]
Australia	-	55% [67]

In this paper, the threshold utilized by Kyriakidis et al. [26] has been applied, meaning that a cross-country analysis will be carried out for countries with 25 or more respondents in the sample.

3.5. Statistical Tests

This step means to recognize factors whose association with WTU is statistically significant. Depending on the nature of the data, for example, frequencies or scores, number of independent variables, experimental or correlational design, number of groups for comparison, and type of data (e.g., continuous, categorical, binary, or ordinal), there is a vast array of statistical methods to be utilized [72]. In this section, the selected and executed methods for this study will be briefly introduced but not explained in detail, as it is beyond the paper's main scope.

Because the outcome scales are ordinal and the number of candidate predictors is large relative to our “events” (shares rating 4 and 5), we followed a theory-guided, two-stage strategy. Firstly, we ran bivariate, non-parametric tests suited to the data type, namely Chi-square for nominal/ordinal groupings and Spearman's rank correlation for ordered items, to identify variables with detectable association to WTU AC and WTU SMS in this pilot (see Appendix A Tables A1 and A2). Secondly, we estimated proportional-odds (ordinal logit) models including (1) variables flagged by the bivariate screen and (2) a small set of theory-critical controls (gender, basic travel modes, and preference/experience constructs), even when their bivariate association was weak, to mitigate omitted-variable bias. This balances parsimony (respecting events-per-variable (EPV) constraints) with content validity. The full specification and estimates are reported in Appendix A Tables A3 and A4.

Hypotheses H1–H5 were tested as follows: H1 (WTU_SMS $\leftrightarrow$ WTU_AC) via Spearman correlation; H2 (WTU_AC $\leftrightarrow$ WTP_AC) and H3 (WTU_SMS $\leftrightarrow$ WTP_SMS) via Spearman; H4a/H4b (usefulness, ease-of-use $\leftrightarrow$ WTU) via Chi-square for ordinal groupings; and H5 (preference for SMS + PT $\leftrightarrow$ WTU) via Chi-square/Spearman. In addition, proportional-odds ordinal logistic models for WTU_AC and WTU_SMS are estimated

to verify the multivariate robustness of these relationships. Appendix A Tables A1–A4 report effect sizes, *p*-values, and several socio-demographic associations that attenuate after adjustment.

4. Results and Discussion

4.1. General Acceptance

Except for Hungary, Latvia, Liechtenstein, Lithuania, Luxembourg, Romania, and Slovakia, responses have been received from all other countries in the targeted area, with the highest amount belonging to Austria (28%), followed by the UK (17%), as can be seen in Figure 2. More details and other parameters of the sample ($N = 289$) are shown in Table 4. Given that the studied EU region has a total population of approximately 490 million inhabitants [73] and applying Taro Yamane's sample size equation [74,75], this sample provides a confidence interval of 94.12% with a margin of error of 5.88%. As a 95% confidence interval within a 5% margin of error is considered a normal industry standard for an excellent sample [76], this sample indicates a fairly representative size for the pilot study. This limitation of the data size means that our findings are not absolute, but rather, they provide a reference for discussing previous and current research outcomes. Furthermore, the sample is a very good representation in terms of gender distribution, with 50.5% being female, in comparison to 51.1% of the EU-27, 50.6% of the UK, and between 48.7% and 50.4% of EFTA countries [77]. It is also interesting to see that the sample has 0.7% of participants defined as non-male/female. Urban population is also well represented among the participants with about 66%, as indeed the majority of inhabitants in the targeted area live in cities, e.g., an average of 67% in EFTA countries and between 54% and 98% in the EU-27 [78]. On the other hand, the survey participants belong to younger age groups, with about 95% being in the range of 18 to 44 years old. This is understandable, as the survey has been conducted online and required participants to be fluent in English, which are two requirements that may have favored younger participants and may have been influenced by the participants' age in general.

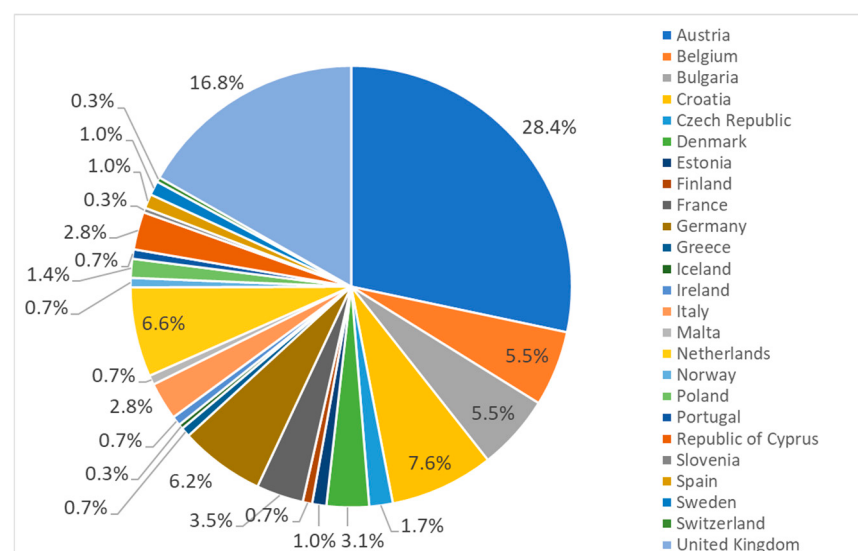


Figure 2. Respondents' country of residence.

Table 4. Descriptive information and acceptance by category.

Parameter	Category	Frequency	Percentage	WTU_AC	WTU_SMS
Gender	Male	141	48.8%	28.4%	17.0%
	Female	146	50.5%	21.9%	24.7%
	Others	2	0.7%	100.0%	50.0%
Living area	City	190	65.7%	27.9%	23.2%
	Suburb	58	20.1%	17.2%	17.2%
	Countryside	41	14.2%	26.8%	17.1%
Age (years old)	<18	1	0.3%	0.0%	0.0%
	18–24	101	34.9%	23.8%	20.8%
	25–34	138	47.8%	29.0%	22.5%
	35–44	36	12.5%	19.4%	13.9%
	45–54	8	2.8%	37.5%	50.0%
	55–64	5	1.7%	0.0%	0.0%
Driving license	Yes	245	84.8%	26.1%	18.4%
	No	44	15.2%	22.7%	36.4%
Car accident experience	Yes	140	48.4%	26.4%	15.7%
	No	149	51.6%	24.8%	26.2%
Highest education	High school diploma	61	21.1%	21.3%	19.7%
	Completed higher education studies	216	74.7%	26.9%	21.3%
	Pupil, student, apprentice	12	4.2%	25.0%	25.0%
Physical disadvantages	Yes	51	17.6%	19.6%	9.8%
	No	238	82.4%	26.9%	23.5%
Commute distance (km)	<5	117	40.5%	31.6%	29.1%
	5–10	106	36.7%	24.5%	17.0%
	10–20	36	12.5%	16.7%	16.7%
	>20	30	10.4%	16.7%	10.0%
Number of people in a household	1	39	13.5%	15.4%	33.3%
	2	71	24.6%	31.0%	16.9%
	3	84	29.1%	33.3%	25.0%
	4	66	22.8%	15.2%	13.6%
	5	22	7.6%	31.8%	18.2%
	>5	7	2.4%	14.3%	28.6%
Number of cars in a household	0	55	19.1%	21.8%	41.8%
	1	119	41.3%	27.7%	24.4%
	2	77	26.7%	26.0%	10.4%
	3	29	10.1%	31.0%	3.4%
	>3	8	2.8%	0.0%	0.0%
Car mileage/year (km)	0	5	0.0%	20.0%	40.0%
	<5000	87	30.3%	23.6%	39.3%
	5001–10,000	95	33.1%	27.4%	13.7%
	10,001–15,000	65	22.6%	20.0%	12.3%
	15,001–20,000	22	7.7%	40.9%	0.0%
	>20,000	13	4.5%	30.8%	23.1%
Frequency usage of PT	Daily	45	15.6%	26.7%	17.8%
	Several times per week	93	32.2%	23.7%	31.2%
	Several times per month	85	29.4%	22.4%	17.6%
	Rarely	57	19.7%	29.8%	15.8%
	Never	9	3.1%	44.4%	0.0%
Mobility costs (incl. car-related expenses) (% of income)	1–5%	91	31.5%	22.0%	24.2%
	5–10%	133	46.0%	25.6%	21.8%
	10–15%	49	17.0%	36.7%	16.3%
	15–20%	14	4.8%	7.1%	14.3%
	>20%	2	0.7%	50.0%	0.0%

Figures 3 and 4 depict the general acceptance among participants, particularly the WTU (Figure 3) and the WTP (Figure 4). The percentages and figure callouts are verified against the underlying frequencies. Regarding the WTU_AC, the frequency of participants indicating a rating of 4 and 5 is 56 and 18, respectively, resulting in an acceptance level of 25.6%. Furthermore, the survey data reveal 55 ratings of 4 and 6 ratings of 5 with regard to WTU_SMS, representing 21.1% of participants. In fact, the majority of the participants rated 3 for both options (40% for ACs and 42% for SMSs), implying that they are considering but do not yet like to use these two sustainable mobility systems. While this is way below the reported global opinion of roughly 50% in terms of ACs (see Table 3), our results in fact reflect the findings by Hudson et al. [17], who show a very modest acceptance toward AVs all over Europe. While there is a lack of sources displaying the acceptance level for SMSs, this finding is backed up by the fact that businesses for SMSs are still not profitable due to the low number of customers [79]. When SMSs are combined with PT as an additional mobility mode, it has an effect on people's mode choice with regard to those who are most enthusiastic about SMS. In particular, the WTU, the combination of personal vehicles, resulted in 18.2%. The number of participants who will choose the combination of SMS and PT over using their own cars is almost three times the number of people who will definitely use SMS.

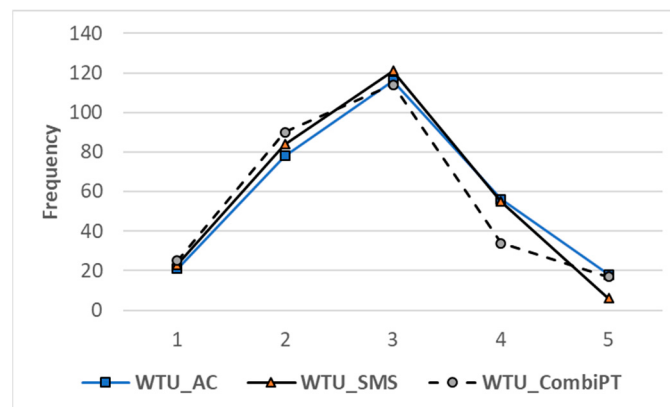


Figure 3. Willingness to use (WTU) automated cars (ACs), shared mobility services (SMSs), and a combination of SMSs and public transport (CombiPT).

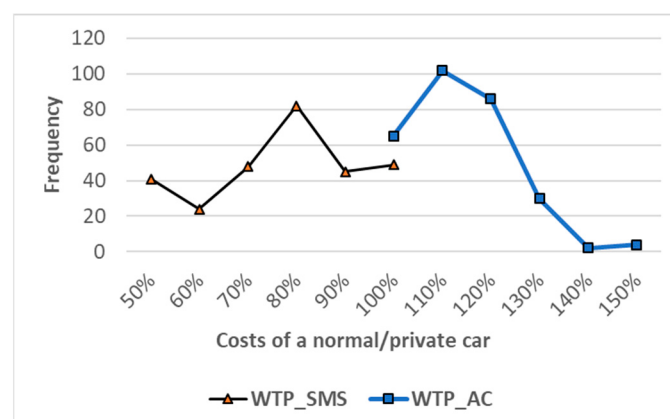


Figure 4. Willingness to pay (WTP) for automated cars (ACs) and shared mobility services (SMSs).

With regard to the WTP, 22% (65 respondents) do not want to spend any extra on AC, which is in a similar range as the global result (see Table 3). Surprisingly, the highest number of respondents (35%) would agree to pay up to 10% extra in contrast to a normal car, and almost 30% even have the WTP up to 20% more. This shows that costs do not play

a big role for potential customers of AC, up to 1.2 times the costs of a non-autonomous one. On the other hand, 17% of participants (corresponding to a frequency of 49) express that they have the WTP the same as for a private car when using SMS, yet the majority would like to pay less, e.g., 28.4% want to pay 20% less than using their private cars, and about 17% would like to have even 30% less costs. This implies that costs can be one factor to attract or discourage people from using SMS. Regarding the apparent WTP/WTU contradiction, many respondents express positive acceptance but still expect cost parity, especially for SMSs, where lower operating costs are anticipated at scale.

4.2. Influencing Factors on Acceptance of AC and SMS

As can be seen from the test results in Appendix A Tables A1 and A2, WTU_AC and WTU_SMS indeed have a positive connection, albeit statistically weak ($p < 0.001$), confirming the hypothesis H1. While the WTU_AC has no statistical relationship with the WTP_AC, with regard to SMS, WTP and WTU have a moderate and positive connection ($p < 0.001$). Therefore, H2 is rejected and H3 is supported. Our data indeed supports the conclusion of several studies, e.g., [16,24], that perceived usefulness and perceived ease of use are linked to the intention to use AC (both $p < 0.001$). This also applies to the acceptance of SMS, as perceived usefulness and perceived ease of use are both statistically related to WTU_SMS ($p < 0.001$ and $p < 0.01$, respectively). Therefore, H4a and H4b are both supported. The preference to use the combination of SMS and PT over private vehicles is positively linked to not only WTU_SMS ($p < 0.001$) but also WTU_AC ($p < 0.05$). Hence, H5 is supported.

Furthermore, the ordinal logistic models (Appendix A Tables A3 and A4) confirm these patterns after simultaneous adjustment: knowledge/frequency and preference terms remain first-order correlates of both outcomes; several raw socio-demographic associations seen in the bivariate view attenuate once perceptions/experience are included; and for SMS, pricing (WTP) and PT-related use retain independent associations. This coherence between the bivariate screen and the parsimonious multivariate models strengthens the internal validity of our findings within the limits of a pilot sample.

Additionally, the statistical tests confirm several observations that can be drawn from the results of the descriptive analysis outlined in Table 4. To be specific, men indeed have higher acceptance than women regarding AC, with 28.4% versus 21.9% ($p < 0.05$). The number of cars owned by a household has an effect on WTU_SMS ($p < 0.001$). It is clearly shown in Figure 5 that the WTU_SMS declines almost linearly with each owned car added to the household. Car-free households accept SMS wholeheartedly, with almost 42% who would like to use the services, then declines to 24.4% when people own a car, 10.4% with two cars available, and only 3.4% with three. When a household has more than three cars, the acceptance level for SMSs is basically zero. An ownership of three cars seems to be a threshold for people's acceptance of both ACs and SMSs. The annual car mileage has a negative impact on how people accept SMSs ($p < 0.01$). On the other hand, the frequency of usage of PT is positively linked to WTU_SMS ($p < 0.01$). Interestingly, daily PT users seem not to be supportive of SMSs, with only 17.8% of them having WTU SMSs (Figure 6). It is possible that for these passengers, the first/last mile problem is not an issue, and they enjoy the services provided by PT more than others. People who are frequent PT users are fond of SMS the most, as 31.2% have the WTU these services, and the ones who are not likely to use PT seem not to use SMSs either, as they may prefer walking or using their own vehicles.

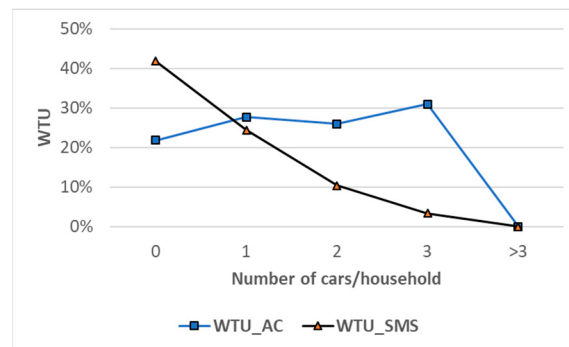


Figure 5. Effects of car ownership on willingness to use (WTU).

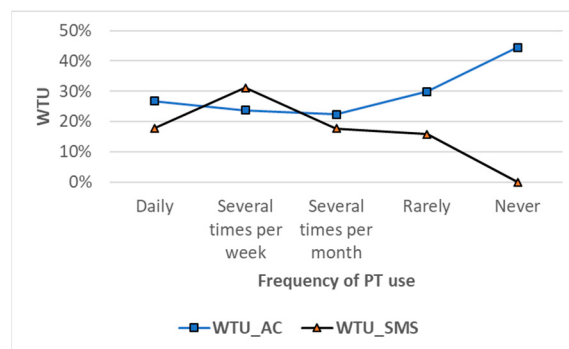


Figure 6. Effects of public transport (PT) usage on willingness to use (WTU).

Knowledge of AC affects WTU_AC positively ($p < 0.001$). As indicated in Table 5, the majority of people have little knowledge of AC, even though they are aware of the technology, as shown by 61.2% of the participants in the survey. This corresponds to a very low acceptance, namely 17.5%, which is only higher than people who have no idea about AC at all. Understanding the technology of AC is indeed helpful, as almost 40% of the participants with a rich knowledge of AC are supportive of it, while almost 36% of people who work on the topic of AC as students or researchers are willing to use it, just like those who develop such vehicles. Previous experience with CS ($p < 0.01$), CP ($p < 0.01$), and RH ($p < 0.001$) seems to positively affect people's acceptance of SMS, while experience with CR ($p < 0.01$) and RH ($p < 0.001$) has a similar impact on WTU_AC. Furthermore, experienced users of SMS show interesting results. While only 15.5% of the participants have used RH, they are the biggest supporting group of SMSs, with 40.3%. The group of CP users comes second, as 19.2% of the participants are among those, yet 36.4% of them show WTU SMS. About a quarter of the sample has used CS, expressed by an acceptance of roughly 29%. CR is probably the most "traditional" sharing business, reflected in about 38% of the participants having experiences with it, the highest amount, yet they have a modest WTU_SMS, standing at 23.2%. Additionally, drivetrain technology is related to both WTU_AC and WTU_SMS ($p < 0.01$ and $p < 0.001$, respectively). The commuting distance is negatively linked to the acceptance of AC ($p < 0.05$) and SMS ($p < 0.05$). In addition, the WTU AC or SMS has a positive relationship with the expected frequency of usage of that mobility solution (both $p < 0.001$).

Table 5. Acceptance by category according to specific parameters.

Parameter	Category	Frequency	Percentage	WTU_AC	WTU_SMS
Knowledge of AC	No idea	8	2.8%	12.5%	-
	Aware, little knowledge	177	61.2%	17.5%	-
	Know a lot	88	30.4%	39.8%	-
	Study or research about	15	5.2%	35.7%	-
	Develop	1	0.3%	100.0%	-
	No experience	25	8.7%	-	8.0%
Experience with SMS	Car rental (CR)	151	37.7%	-	23.2%
	Car sharing (CS)	111	27.7%	-	28.8%
	Carpooling (CP)	77	19.2%	-	36.4%
	Ride hailing (RH)	62	15.5%	-	40.3%

Figures 7–9 depict how people rank different aspects as their motivation or barrier to using ACs, as well as their motivation to use SMS. Distribution of importance rankings (1 = most important, 5 = least important) across all respondents. Bars show the percentage of participants assigning each rank to each factor. Across all three figures, respondents reveal distinct yet comparable patterns in how they evaluate motivations and barriers for adopting automated cars and shared mobility services. Safety consistently emerges as a top-ranked concern, valued as a primary motivator for adoption (Figure 7) but also as a major barrier when trust and reliability are uncertain (Figure 8). Cost considerations appear in both motivational and deterrent contexts, indicating that affordability remains pivotal to acceptance. Convenience-related aspects, such as non-driving and comfort, rank highly as motivations in both automated and shared mobility contexts, suggesting users appreciate stress-free travel and time for other activities. Conversely, emotional and experiential factors such as fondness for driving or low trust contribute more strongly to resistance toward automation. In the shared mobility context (Figure 9), environmental concerns add an additional motivational dimension, implying greater sustainability awareness among users considering collective transport options. Overall, the rank distributions highlight that user acceptance depends on a nuanced balance between perceived safety, cost, comfort, and environmental benefit rather than on a single dominant factor.

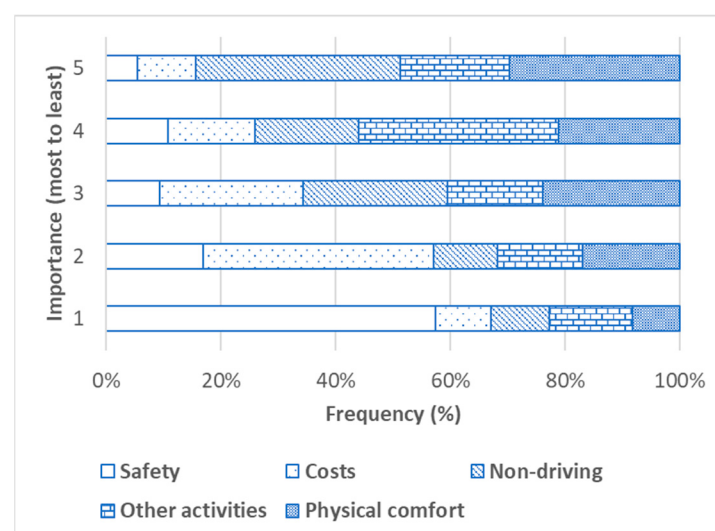


Figure 7. Motivation to use automated cars (ACs). Distribution of respondents' importance rankings (1 = most important, 5 = least important) regarding potential motivations for using automated cars. Bars indicate the percentage of participants assigning each rank to key factors, including safety, costs, non-driving convenience, other activities during travel, and physical comfort.

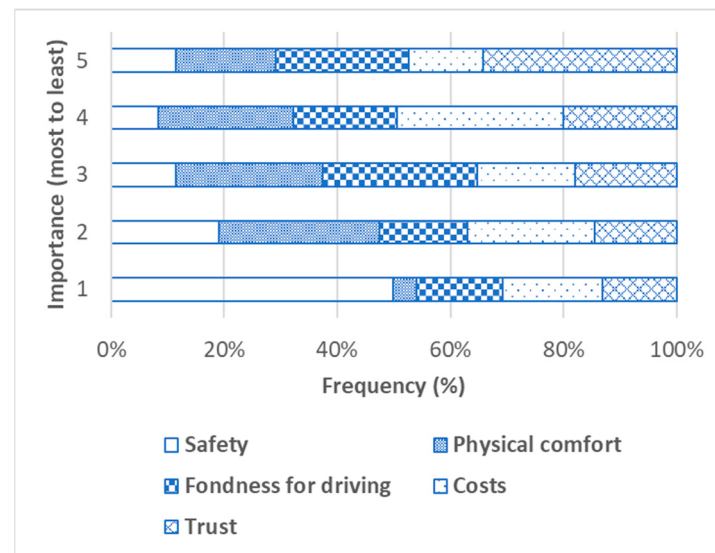


Figure 8. Barrier to using automated cars (ACs). Distribution of importance rankings (1 = most important, 5 = least important) reflecting perceived barriers to the use of automated cars. Frequencies show how respondents prioritized safety, physical comfort, fondness for driving, costs, and trust as obstacles influencing adoption.

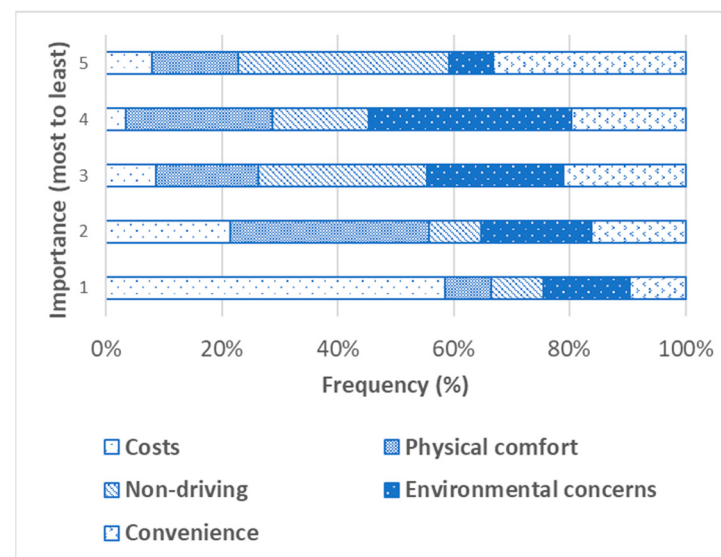


Figure 9. Motivation to use shared mobility services (SMSs). Distribution of respondents' rankings (1 = most important, 5 = least important) for motivations to use shared mobility services. Percentages represent how participants rated factors such as costs, physical comfort, non-driving convenience, environmental concerns, and overall convenience.

The ability to conduct other activities during driving seems to be important to potential users of AC, as Figure 10 implies that future AC passengers are likely to use the free time for interaction with other passengers, eating and drinking, or performing individual activities. Working, watching movies, and gaming are among the popular selections of the survey participants. Probably because ACs are considered to be used for short-distance trips and may not be adequately equipped for those activities. Regarding the choice of the business model for AC, ownership is the most favored option, followed by leasing and then renting, while sharing an AC is the least preferred choice for the survey participants (see Figure 11). Consequently, this means shared AC may not be suitable for individuals. People expect to use AC and SMS for different travel purposes, as shown in Figure 12. Commuting to work

and professional business are the most popular uses for both sustainable mobility systems. As most of the participants are of working age, it shows that AC and SMS will be used for work-related trips rather than personal ones during leisure time.

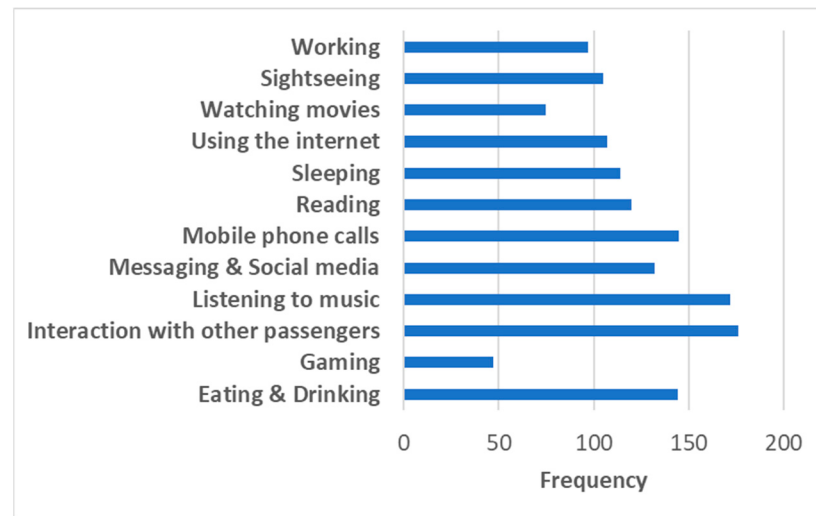


Figure 10. Non-driving activities while using automated cars (ACs).

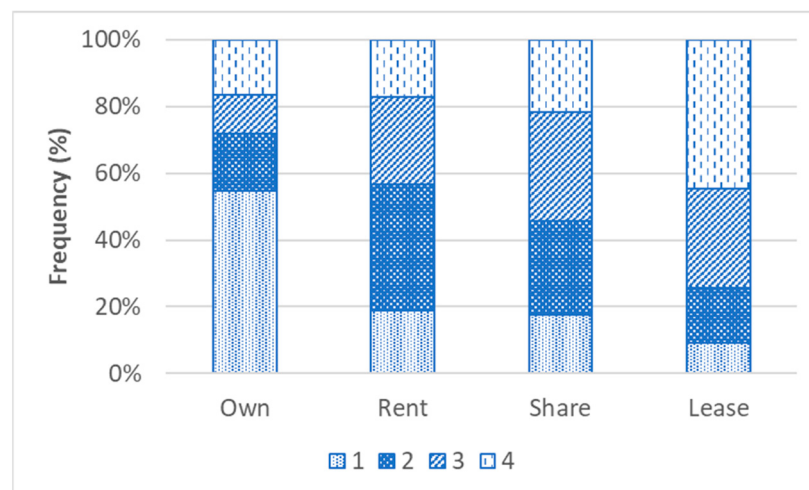


Figure 11. Preferred business model for automated cars (ACs), from 1 (most favorite) to 4 (least favorite).

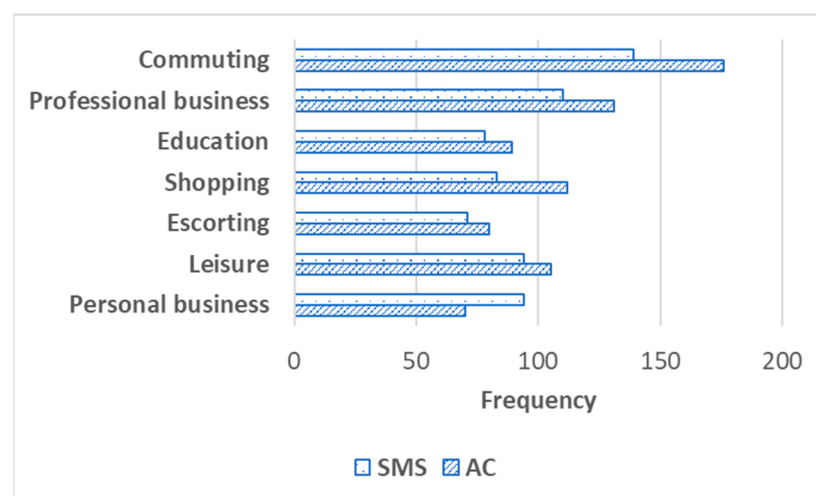


Figure 12. Travel purposes when using automated cars (ACs) and shared mobility services (SMSs).

These results reaffirm the holistic view that user acceptance of new mobility services arises from interlinked technological, economic, and social dimensions. These findings show that users' perceived usefulness and ease of use emerged as central to acceptance, consistent with recent European evidence on mobility adoption [22,28,29,35,38]. The role of pricing and affordability is likewise confirmed by studies on mobility pricing schemes, which show that acceptability hinges on how costs are structured relative to perceived benefit [13,23,44–46].

4.3. Cross-Country Aspects

As can be seen and compared, Table 6 outlines the WTU_AC and WTU_SMS of two countries (Austria and the UK) and the studied EU region. In terms of AC, the acceptance in the UK is lower than in the studied EU region (23% vs. 26%), while Austria has the highest acceptance with 32%. These numbers are much lower than in the figures reported by Lang et al. [70]. However, the results from Austria and the UK are highly in line with Hudson et al. [17], who reported that the attitude toward AVs in the two countries is a lack of enthusiasm, with scores of 4.14 and 3.43 on a scale of 10, respectively. This pattern resonates with broader European findings: recent reviews note that in many European countries, AV acceptance rarely exceeds 30–35% under current conditions [29]. This finding is also similar to Hudson et al. [17] in the sense that Austria has a higher acceptance than their reported EU-28 (EU-27 plus the UK), while the UK is below the regional average of 3.65. Moreover, the results of this study are comparable with Wintersberger et al. [18], who indicated that 37.5% of Austrian participants are willing to use AV for personal use. Regarding the WTP for AC, the results point out that even though Austria has the highest acceptance level for AC, 34% of the Austrian survey participants do not want to pay more for such vehicles, which is noticeably higher than in the studied EU region (22%) and the UK (27%). The regional result is in the same range as the global level [26]. However, the survey results for the UK largely differ from Bansal & Kockelman [33] and Schoettle & Sivak [67], who concluded that more than half of the people in the two countries are unwilling to pay more. Instead, the outlined results indicate that the majority of participants are willing to pay more for the use of AC. This can be explained by the fact that most of our participants are young (18–34 years old) and therefore more willing to try and open-minded toward new technologies.

Table 6. Acceptance of automated cars (ACs) and shared mobility services (SMSs) according to selected countries.

Area	WTU_AC	WTU_SMS	WTP the Same as a Normal/Private Car	
			For AC	For SMS
The studied EU region	25.6%	21.1%	22.5%	17.0%
Austria	31.7%	11.0%	34.1%	18.3%
UK	22.9%	25.0%	27.1%	27.1%

As it seems, SMSs are not favored by Austrian people, with only 11% of the survey participants showing WTU SMSs, which is almost half of the regional acceptance. This can be explained by cultural context, since Austrians are not likely to share cars. Wintersberger et al. [18] reported that 45% of their participants will never be able to share a car, and 73% of people will not share or lend their AV even to make some extra money. The UK appears to be more welcoming toward SMSs, with 25% and 22.9% of participants accepting to use these services, respectively. This is probably due to their openness to innovative technologies and advanced business models.

5. Conclusions

The paper proposes a holistic framework for acceptance assessment of automated cars (ACs) and shared mobility services (SMSs) and presents a pilot study by using data collected via an online survey, focusing on European citizens. Our main findings are that about 26% of the survey participants are willing to use ACs, while 21% would like to use SMS. Approximately 22% of the sample do not want to spend any extra on AC, and 17% of the participants are willing to pay the same as the costs of using a private car for SMSs. Costs can be one factor to attract or discourage people from using SMSs. The acceptance of SMS seems to decline with each car added to a household, and having more than three cars may imply a rejection of both SMSs and ACs. People with a rich knowledge of AC support the technology more, and previous experience with shared mobility positively affects people's acceptance of both SMSs and ACs. The perceived usefulness and perceived ease of use have a positive relationship with the willingness to use (WTU). Safety has been identified as the most important motivator as well as the biggest barrier for using AC, while costs can motivate people to use SMSs. People would like to own or lease an AC, whereas sharing an AC seems to be the least favored option.

The results also indicate the necessity to understand how people perceive automated driving and SMS in combination. In this context, the acceptance of SMSs appears to have a positive connection to the acceptance of ACs. Additionally, the willingness to pay (WTP) for SMSs seems to be positively linked to the WTU for such services. The preference for using SMS combined with public transport (PT) over private cars can influence the WTU positively. The vehicle's drivetrain technology is probably associated with the level of acceptance. The number of cars in a household and car mileage can negatively affect the WTU SMS, while the frequency of usage of PT can positively impact it. On average, the studied EU regions, Austria and the UK, show a low to medium-low acceptance for AC. At the same time, people from the UK accept SMS much more than the Austrian survey participants.

By identifying where acceptance is strongest (e.g., PT-inclined users; car-free households) and which factors matter (usefulness, ease of use, pricing), the results support policy measures that pair SMS with PT, manage car parking and car ownership, and target education and safety communication. However, the results have certain limitations. The pilot sample is modest and self-selected, relying on self-reported intentions, and of cross-sectional character. Due to these reasons, the conclusions provided are meant to be a reference and are not claimed to be absolute. This study serves as a stepping stone to indicate the usefulness of the applied holistic framework, as well as to point out that further studies are required. However, by introducing a comprehensive approach for acceptance analysis, this paper contributes to the current research efforts, which are not limited to automated driving and SMS only. In this way, the introduced methodology can be applied for user-related investigations in other fields, too.

The two-stage design to analyze the data of the pilot sample, e.g., non-parametric screening followed by parsimonious ordinal logits, is appropriate for a pilot with limited events-per-variable and heterogeneous item types. The fact that multivariate estimates reproduce the direction and ordering from the bivariate screen suggests that perceptions/experience and pricing/integration are robust levers. To further improve the findings of this study, future research will aim to apply the proposed methodology framework, where larger samples will be analyzed to test partial proportional-odds and regularized models, and will include country/context interactions, as well as segmentations. In this way, future studies can be designed to investigate sustainable mobility strategies by pairing SMS with PT and targeting safety and pricing communication.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su17219610/s1>, The survey form and the supplementary codebook.

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Institutional Review Board Statement: Ethical review and approval were waived for this study by the Ethics Committee of Graz University of Technology, as data collection had been completed in 2022, prior to the committee’s establishment in January 2024. The research was conducted in accordance with the European Code of Conduct for Research Integrity and the Guidelines on Safeguarding Good Scientific Practice of Graz University of Technology.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Survey data is not available due to the general data protection regulation.

Conflicts of Interest: Author Florian Ratz was employed by the company Armengaud Innovate GmbH. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

SMS	Shared Mobility Services
AC	Automated Car
AV	Automated Vehicle
WTU	Willingness to Use
CCAM	Cooperative, Connected, and Automated Mobility
TAM	Technology Acceptance Model
PT	Public Transport
CS	Car Sharing
WTP	Willingness to Pay
EV	Electric Vehicles
FFCS	Free-Floating Car Sharing
BI	Behavioral Intention to Use
UTAUT	Unified Theory of Acceptance and Use of Technology
ECS	Electric Car Sharing
AECS	Automated Electric Car Sharing
WTB	Willingness to Buy
SAV	Shared Automated Vehicles
EC	Electric Cars
GDP	Gross Domestic Product
RS	Ridesharing
FCU	Frequency of Car Sharing Use
CR	Car Rental
EFTA	European Free Trade Association
RH	Ride hailing
CP	Carpooling
WTT	Willingness to Try
ACC	Adaptive Cruise Control
UI/UX	User Interface/User Experience
VOT	Value-of-time
EPV	Events-per-variable

Appendix A

All variables appearing in Tables A1–A4 are elaborated in the Supplementary Codebook.

Table A1. Chi-Square Test Results.

Parameters for Chi-Square Test		<i>p</i> -Value	Parameters for Chi-Square Test		<i>p</i> -Value
WTU_AC	Living area	0.596	WTU_SMS	Living area	0.491
	Gender	0.030 *		Gender	0.077
	Driving license	0.937		Driving license	0.076
	Accident experience	0.956		Accident experience	0.051
	Education	0.560		Education	0.918
	Physical disadvantages	0.321		Physical disadvantages	0.094
	Useful_AC	0.000 ***		Useful_AC	0.000 ***
	ETU_AC	0.000 ***		ETU_AC	0.219
	Used_CR	0.004 **		Used_CR	0.313
	Used_CS	0.155		Used_CS	0.002 **
	Used_CP	0.526		Used_CP	0.001 **
	Used_RH	0.000 ***		Used_RH	0.000 ***
	Preference_SMS	0.001 ***		Preference_SMS	0.001 **
	Useful_SMS	0.002 **		Useful_SMS	0.000 ***
	ETU_SMS	0.069		ETU_SMS	0.005 **
	Drivetrain	0.002 **		Drivetrain	0.000 ***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A2. Spearman's Rank Correlation Test Results.

Parameters for Spearman's Rank Correlation Test		<i>r</i>	Ts	<i>p</i> -Value
WTU_AC	Age group	−0.022	0.375	0.708
	Commute distance	−0.140 (vw)	2.391	0.017 *
	No_people/household	−0.022	0.368	0.713
	No_cars/household	0.001	0.022	0.983
	Car mileage	0.057	0.975	0.330
	FreqUse_PT	0.002	0.026	0.980
	Mobility costs	0.013	0.220	0.826
	Knowledge_AC	0.227 (w)	3.951	0.000 ***
	FreqUse_AC	0.336 (w)	6.046	0.000 ***
	WTP_AC	0.090	1.522	0.129
	FreqUse_SMS	0.054	0.909	0.364
	WTU_CombiPT	0.127 (vw)	2.169	0.031 *
	WTP_SMS	0.042	0.715	0.475
	WTU_SMS	0.262 (w)	4.593	0.000 ***
WTU_SMS	Age group	0.001	0.011	0.991
	Commute distance	−0.170 (vw)	2.927	0.004 *
	No_people/household	−0.046	0.774	0.439
	No_cars/household	−0.317 (w)	5.656	0.000 ***
	Car mileage	−0.158 (vw)	2.715	0.007 **
	FreqUse_PT	0.170 (vw)	2.916	0.004 **
	Mobility costs	−0.091	1.554	0.121
	Knowledge_AC	0.074	1.257	0.210
	FreqUse_AC	0.049	0.830	0.407
	WTP_AC	0.096	1.630	0.104
	FreqUse_SMS	0.262 (w)	4.593	0.000 ***
	WTU_CombiPT	0.276 (w)	4.864	0.000 ***
	WTP_SMS	0.628 (m)	13.680	0.000 ***

N = 289, DF = 287, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, vw: very weak, w: weak, m: moderate.

Table A3. Ordinal Logistic Model Results for WTU_AC (Ordinal Logit, Link = Logit).

Predictor	OR	95% CI	p-Value
GenderMale	1.373	0.943–2.001	0.0983
GenderOther	21.922	1.661–553.664	0.0225 *
CommuteD	0.967	0.926–1.010	0.1302
Transport_bikeYes	1.613	1.062–2.457	0.0253 *
Transport_carYes	1.133	0.762–1.686	0.5379
Know_ACKnow a lot	2.165	1.426–3.301	0.0003 *
Know_ACNo knowledge	2.254	0.738–6.858	0.1504
Know_ACStudy and research	1.844	0.813–4.175	0.1412
FreqUse_ACFew times per week	0.591	0.336–1.035	0.0668
FreqUse_ACNever	0.022	0.006–0.072	0.0000 *
FreqUse_ACOnce per month	0.337	0.155–0.726	0.0057 *
FreqUse_ACOnce per week	0.382	0.203–0.712	0.0026 *
FreqUse_ACRarely	0.132	0.058–0.297	0.0000 *
WTU_SS.L	11.377	5.092–26.053	0.0000 *
WTU_SS.Q	2.035	1.037–4.033	0.0398 *
WTU_SS.C	1.090	0.649–1.841	0.7456
WTU_SS^4	0.938	0.657–1.338	0.7226
Preference_SSYes	0.468	0.317–0.688	0.0001 *

* $p < 0.05$; OR = odds ratio; 95% CI = 95% confidence interval. Ordered predictors are coded to reflect increasing levels; an OR > 1 indicates higher levels are associated with higher willingness. For frequency variables, the omitted baseline is “Daily”.

Table A4. Ordinal Logistic Model Results for WTU_SS (Ordinal Logit, Link = Logit).

Predictor	OR	95% CI	p-Value
CarTyp_MSYes	0.678	0.380–1.202	0.1845
CarTyp_SmulYes	0.666	0.173–2.566	0.5510
Preference_SSYes	1.920	1.204–3.076	0.0063 *
DrivetrainYes, I would prefer electric cars	1.838	1.109–3.062	0.0187 *
No_C	0.737	0.547–0.990	0.0431 *
TbC> 20,000 km	1.980	0.525–7.578	0.3146
TbC0	3.141	0.336–34.023	0.3194
TbC10,001–15,000 km	0.662	0.359–1.217	0.1849
TbC15,001–20,000 km	0.414	0.157–1.083	0.0727
TbC5001–10,000 km	0.591	0.337–1.032	0.0648
FreqUse_PTNever	1.265	0.229–6.501	0.7825
FreqUse_PTRarely	1.489	0.693–3.216	0.3088
FreqUse_PTSeveral times per month	1.837	0.967–3.508	0.0640
FreqUse_PTSeveral times per week	1.479	0.798–2.745	0.2137
WTU_AC.L	8.564	3.732–20.094	0.0000 *
WTU_AC.Q	1.437	0.684–3.010	0.3360
WTU_AC.C	1.129	0.634–2.016	0.6803
WTU_AC^4	1.146	0.764–1.723	0.5104
FreqUse_SSFew times per week	0.368	0.139–0.975	0.0437 *
FreqUse_SSNever	0.055	0.012–0.242	0.0001 *
FreqUse_SSOOnce per month	0.405	0.139–1.177	0.0966
FreqUse_SSOOnce per week	0.335	0.126–0.890	0.0277 *
FreqUse_SSRarely	0.257	0.091–0.724	0.0100 *
WTP_SS1–10% less than the costs of using your own car	1.728	0.756–3.979	0.1961
WTP_SS10–20% less than the costs of using your own car	1.652	0.733–3.748	0.2272
WTP_SS20–30% less than the costs of using your own car	3.225	1.385–7.604	0.0069 *
WTP_SS30–40% less than the costs of using your own car	3.475	1.231–9.906	0.0189 *
WTP_SSSame as the costs using your own car	2.564	1.065–6.232	0.0364 *

* $p < 0.05$; OR = odds ratio; 95% CI = 95% confidence interval. Ordered predictors are coded to reflect increasing levels; an OR > 1 indicates higher levels are associated with higher willingness. For frequency variables, the omitted baseline is “Daily”.

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