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On Modelling and Investigating User Acceptance of Highly Automated Passenger Vehicles

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ABSTRACT Highly automated passenger vehicles hold great potential to alleviate traffic congestion, enhance road safety, and revolutionize the travel journey. However, while much attention has been given to the technical aspects of this technology, the investigation of public acceptance remains crucial for successful implementation in the global market. To address this gap, this paper introduces innovative research that explores the predictors influencing consumers' intention to adopt highly automated passenger vehicles. Through an online questionnaire-based survey conducted among European adults, we extend the Unified Theory of Acceptance and Use of Technology (UTAUT) framework to incorporate three additional constructs: perceived reliability/trust, perceived financial cost, and perceived driving enjoyment. The key findings of this study underscore the significance of driving enjoyment, financial cost, social influences, and reliability/trust as influential predictors of consumers' intention to adopt highly automated passenger vehicles. By considering these factors, automotive stakeholders can gain valuable insights to develop effective strategies and approaches for the successful implementation of highly automated passenger vehicles in the near future. Last, its innovations pave the way for a transformative shift in transportation, enabling the realization of safer, more efficient, and enjoyable travel experiences for individuals and society as a whole.

INDEX TERMS Consumers' intention, highly automated passenger vehicles, human-computer interaction, perceived driving enjoyment, perceived financial cost, technology acceptance modelling, trust.

I. INTRODUCTION

In RECENT decades, significant advancements have been made in driver assistance systems and vehicle technology, driven by manufacturers, academics, and IT professionals. Vehicle automation has rapidly evolved due to progress in microprocessors, sensors, telecommunications, software, and related technologies. Out of several taxonomies in defining distinct levels of autonomy, SAE [1] represents one of the most comprehensive classification approaches, defining five levels ranging from driver assistance (L1) to full automation (L5). Research efforts worldwide aim to develop fail-operational perception and control functions for safe highly automated driving [2], addressing challenges such as environmental conditions, system failures and security [3], [4], legal issues, and user acceptance [5], [6].

The automotive industry is actively promoting the introduction of highly automated passenger vehicles (L3+) [7], expected to bring fundamental changes to transportation, offering safe, efficient, convenient, and eco-friendly travel experiences [8]. New business models, including car-sharing mobility services, are also being developed to reduce traffic congestions [9], [10].

To ensure the successful adoption of highly automated passenger vehicles, it is crucial to investigate their acceptance from the end-user perspective [11], [12], [13]. Understanding

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consumer preferences and perceptions is vital for enhancing road safety, travel experience, and traffic efficiency. While previous studies have shown a positive general opinion towards highly automated vehicles, they often overlook behavioral intentions [14], [15], [16], [17]. Factors such as driving enjoyment, environmental concerns, and pro-autonomous vehicle attitudes play significant roles in consumers' choice between regular cars, privately-owned autonomous vehicles, and shared-autonomous vehicles [18], [19], [20], [21], [22], [23], [24], [25]. Moreover, literature suggests that privately-owned highly automated passenger vehicles may be preferred over car-sharing mobility services in the long run.

Overall, investigating user acceptance and preferences is essential for the successful integration and widespread adoption of highly automated passenger vehicles, ensuring a positive impact on transport efficiency [26], [27], [28], [29], [30], [31], [32], [33].

In the light of the above, the main goal of the present study is to introduce an integrated and expanded user acceptance model to comprehend the factors that influence acceptance of highly automated (SAE L3+) passenger vehicles from a user-centric perspective. Through a unique approach, the paper attempts for the first time to model user acceptance through extending the original UTAUT social-psychological acceptance model, by integrating relevant constructs (perceived reliability/trust, perceived financial cost, and perceived driving enjoyment) that might influence the acceptance of highly automated (SAE L3+) passenger vehicles. In doing so, it attempts to respond to the following research questions:

i. How do the constructs 'performance expectancy, effort expectancy, social influence, and facilitating conditions', affect European consumers' intention to adopt and use highly automated (SAE L3+) passenger vehicles?
ii. How do the constructs 'perceived reliability/trust, perceived financial cost, and perceived driving enjoyment', affect European consumers' intention to adopt and use highly automated (SAE L3+) passenger vehicles?
iii. How do the moderating variables of age, gender, income, and education, affect European consumers' intention to adopt and use highly automated (SAE L3+) passenger vehicles?

The paper builds upon existing research by identifying motivational patterns associated with the use of highly automated (SAE L3+) passenger vehicles, while at the same time revealing the relationships between these factors. The conclusions to be extracted from the present analysis will contribute to the efforts of academia, automotive industry and IT companies in providing proper strategies that will enable implementation of highly automated passenger vehicles in the near future based on consumers' preferences, needs and expectations.

The paper is structured as follows: in Section II background work on technology acceptance modeling and the motivation for the present study are provided, whereas in Section III the extended-UTAUT research model and the hypothesis development, are described in detail. Section IV presents the research approach for testing the hypotheses. In Section V, the main findings from the implemented large-scale questionnaire survey are reported, whereas Section VI discusses the research results. Finally, Section VII presents the main outcomes, also proposing some future research recommendations.

II. BACKGROUND WORK AND MOTIVATION

A. TECHNOLOGY ACCEPTANCE MODELING

Modeling the acceptance of emerging new technologies in the automotive transportation field is necessary in understanding the factors that affect consumers' intension to adopt and use SAE L3+ passenger vehicles for their personal travels [34], [35]. On this basis, the well-known Unified Theory of Acceptance and Use of Technology (UTAUT) model has been applied in many cases for understanding consumers' intentions to adopt and use information technology systems, such as Internet banking [36], open data services [37], e-learning purposes [38], mobile services [39], etc.

With respect to vehicle technology and automated driving, some research studies have implemented the UTAUT in modeling consumers' acceptance. The work [40] used the UTAUT original version to assess users' acceptance towards the "Safe Speed and Safe Distance" driver assist system, whereas the work [41] developed and proposed the "Car Technology Acceptance Model (CTAM)", which extended the UTAUT original version by incorporating other constructs, like anxiety, perceived safety, etc. Moreover, the work [42] applied an extended UTAUT acceptance model about ADAS, which is the core technology of highly automated driving. In this model, additional determinants (self-efficacy, anxiety, trust, perceived safety, affective satisfaction) were included as direct predictors in addition to the main determinants of the original UTAUT model. In addition, the work [35] used UTAUT, TAM and TPB technology acceptance models to assess drivers' intention to accept and use ADAS.

In the field of autonomous driving and automated vehicles, the work [43] explored public acceptance with respect to ARTS (Automated Road Transport Systems), as part of the CityMobil2 European project, by using the original UTAUT. The main research outcome was that performance expectancy is the most influencing factor in consumers' intention to adopt and use ARTS. Furthermore, the work [44] used an extended UTAUT model to assess consumers' intension to use ARTS, where the determinants hedonic motivation and facilitating conditions were incorporated as direct predictors, where hedonic motivation was the most important predictor. The work [45] used the original UTAUT model to investigate user acceptance in terms of driverless shuttles in public

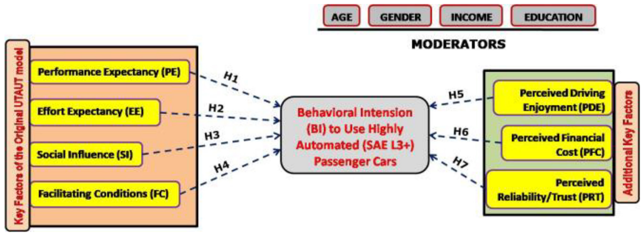

FIGURE 1. The extended UTAUT model.

transport. Results show that social influence, performance expectancy and effort expectancy were the most deciding factors for accepting such shuttles. The work [23] applied a technology acceptance framework according to the original UTAUT, where results showed that social influence, performance expectancy and effort expectancy are affecting positively consumers' intention to purchase autonomous vehicles.

In addition, the work [46] applied UTAUT2 model to investigate public acceptance towards conditionally automated (SAE L3) vehicles, where a large-scale questionnaire survey was conducted as part of L3Pilot European project. They found that social influence, performance expectancy and hedonic motivation are the main factors influencing consumers' intention to accept and SAE L3 car.

B. MOTIVATION

As mentioned previously, the majority of studies in literature focusing on investigating the consumers' acceptance towards ARTS, driverless shuttles, self-driving vehicles and semi-automated vehicle technology. In fact, the examination of the public acceptance regarding highly automated (SAE L3+) car technology has paid less attention, while it is necessary, at an early stage, for their successful implementation into the international market the next years.

Thus, knowledge about the consumers' intention to adopt SAE L3+ passenger vehicles is of crucial importance and more research efforts are required to explore the psychological factors of user acceptance. Furthermore, in most of the research studies, the existing surveys towards the acceptance of automated car technology have been conducted among small groups of respondents (usually below 500) and in individual countries, like China, U.S., France, Germany, etc. Therefore, acceptance surveys with larger samples, even among geographical regions with different ideological and cultural differences, are required to effectively extract the factors that mainly affect consumers' intention to accept SAE L3+ passenger vehicles.

III. EXTENDED-UTAUT RESEARCH MODEL

A. UTAUT PROPOSED FRAMEWORK

The original UTAUT model, as shown in Fig. 1, incorporates four key constructs (direct determinants) of user acceptance and usage behaviour, i.e., Performance Expectancy (PE), Social Influence (SI), Effort Expectancy (EE), and Facilitating Conditions (FC). According to the model, these constructs are hypothesized to positively affect technology adoption [47]. In the original UTAUT framework, the variables of age, voluntariness of use, gender and experience have been used to moderate the effects of the relationships between the above four factors and behavioral intention to use.

In order to fully investigate the factors influencing users' intention to accept and use highly automated (SAE L3+) passenger vehicles, the present analysis takes the basic framework of the initial UTAUT model (PE, EE, SI, FC) and incorporates three further factors, namely "Perceived Driving Enjoyment (PDE)", "Perceived Financial Cost (PFC)" and "Perceived Reliability/Trust (PRT)". In the following subsections, we give the description and definition of all the above determinants, which are expected to play a vital role on consumers' behavioral intentions to accept and use highly automated passenger vehicles in the (near) future. Figure 1 shows an overview about the proposed UTAUT-extended model to assess technology acceptance towards highly automated passenger vehicles. In addition, the moderating effects of age, gender, income and education were also considered in the expanded UTAUT framework.

It should be stated that the variables of voluntariness of use and experience in the original UTAUT were not included in the present study, since the vast majority of potential European consumers have no concrete experience with highly automated passenger vehicles, due to their extremely low dispersion in the international market. The highest levels in vehicle automation that are currently being commercialized are SAE L2 and SAE L3 (semi automated vehicles) with the next step being now adding more automated features to realize SAE L3+ (highly automated vehicles).

B. PERFORMANCE EXPECTANCY (PE)

According to UTAUT model, the factor "performance expectancy (PE)" is associated with the extent to which are provided benefits to users in performing certain activities when using a technology [34]. For the present analysis, PE is defined as *"the degree to which using highly automated passenger vehicles will provide benefits to individuals in performing their travel activities"*.

Various studies in the existing literature have shown that the factor PE affected significantly consumers' behavioral intention to use/accept new applications like ADAS and ARTS vehicles [40], [42], [43], [44]. Taken the above, the present work posits the following hypothesis

H1: *"Performance expectancy (PE) is a significant positive predictor of behavioral intention (BI), implying that individuals who value the perceived benefits of highly automated passenger vehicles are more likely to intend to use them"*.

C. EFFORT EXPECTANCY (EE)

This determinant is important in user acceptance analysis as prior studies have shown that complexity of technology and information loading discourages customers to adopt new technology systems. In UTAUT model, the factor "effort expectancy (EE)" is defined as the degree of ease of use associated with a new technology system or product [34]. In the present analysis, EE is defined as *"the degree of ease associated with the usage of highly automated passenger vehicles"*.

It is of utmost importance for the potential consumers highly automated vehicles to be able not only to perform complex driving tasks, but also to be easy to use and clearly to understand. So, if the consumers found that highly automated vehicles do not require much effort and are easy to use, then they are more likely to adopt them.

Regarding the effects of the factor EE on the adoption of new applications in the context of transport technology, mixed results were investigated. The study [43] founds that EE had an important effect on consumers' intention to use ARTS but it was not the strongest predictor. In addition, other studies [24], [42], [44], [48] failed to found significant influences between EE and consumers' intention to use/accept new applications like ADAS, ARTS vehicles and autonomous driving.

In the present study, it is plausible to formulate the following hypothesis

H2: *"Effort expectancy (EE) is a significant positive predictor of behavioral intention (BI), implying that individuals who perceive highly automated passenger vehicles as easy to use are more likely to intend to use them"*.

D. SOCIAL INFLUENCE (SI)

On the basis that social norms are partly motivate the travel behavior, it is obvious that potential consumers will be influenced by their interactions with their social networks, which affect their adoption decisions. According to UTAUT model, the factor "social influence (SI)" is defined as the degree to which an individual perceives that others believe he/she should use a particular technology system or product [34]. In the present analysis, SI is defined as *"the extent to which individuals perceive that important others believe that they should use highly automated passenger vehicles"*.

Research studies in ADAS and ARTS vehicles found SI to be an important predictor of behavioral intension [40], [42], [43], [44]. Moreover, the study [48] about the role of SI on the adoption of AVs showed that half of respondents would prefer important others (family, friends, neighbors, etc) to use automated vehicles before they adopt the AV technology.

Accordingly, this work posits the following hypothesis

H3: *"Social influence (SI) is a significant positive predictor of behavioral intention (BI), implying that individuals who believe that important others support the use of highly automated passenger vehicles are more likely to intend to use them"*.

E. FACILITATING CONDITIONS (FC)

In UTAUT model, the factor "facilitating conditions (FC)" is defined as the degree to which an individual believes that technical and organizational infrastructures support the use of a new technology system or product [34]. In the present analysis, FC refers to *"the extent to which individuals believe that organizational and technical infrastructures should exist to support the usage of highly automated passenger vehicles"*.

There is no doubt that driving/using highly automated passenger vehicles requires appropriate resources and knowledge, technical infrastructure design and implementation strategies. As found in the literature [10], AVs barriers suggest that if the aforementioned facilitating conditions are available, the intention to use highly automated passenger vehicles will be higher. On the other hand, when facilitating conditions are not exist, the barriers may be too high and, thus, the intention of consumers towards highly automated passenger vehicles is expected to be lower.

Although prior studies have shown that FC is not the best determinant for consumers' intention to use different information technology (IT) contexts, it is expected that the factor FC influences the users' intention to use highly automated passenger vehicles. To enhance this implication, study [44] founds that the factor FC makes positive contribution to consumers' intension to use ARTS. In a similar manner, study [49] founds that it is highly likely that the technical and infrastructure resources provided to support ARTS' implementation will influence user uptake.

Consequently, this work denotes the following hypothesis

H4: *"Facilitating conditions (FC) is a significant positive predictor of behavioral intention (BI), implying that individuals who believe that available conditions facilitate the use of highly automated passenger vehicles are more likely to intend to use them"*.

F. PERCEIVED DRIVING ENJOYMENT (PDE)

Individual mobility and passenger vehicles enhance user's freedom to drive independently to his/her desired destinations whenever he/she likes. In addition, passenger vehicles also offer hedonic benefits, as they can be used for enjoyable and exciting transport activities [50]. In this context, enjoyment of driving is also likely to play a key role in innovative vehicle technologies. This kind of hedonic motivation is called as Perceived Driving Enjoyment (PDE), and is defined as *"the degree to which individuals perceive enjoyment and pleasure derived from using highly automated passenger vehicles"*.

Prior to the international literature, the factor hedonic motivation has been assessed to be one of the most important determinants influencing consumers' intension to accept technology systems or products [34]. With respect to the vehicle automation, the analysis [44] showed that users' enjoyment was the strongest factor on consumers' intension to accept and use ARTS vehicles. Furthermore, manual driving was found to be the most enjoyable part of driving according to the study [19].

In this vein, the present study assumes the following hypothesis

H5: *"Perceived driving enjoyment (PDE) is a significant positive predictor of behavioral intention (BI), implying that individuals who perceive highly automated passenger vehicles as enjoyable and pleasant are more likely to intend to use them".*

G. PERCEIVED FINANCIAL COST (PFC)

Empirical evidence has revealed that the adoption of automated vehicles is highly associated with financial factors like purchasing costs and driving/usage costs [22]. In this context, perceived financial cost is likely to play a key role in consumers' intension to adopt and use highly automated passenger vehicles. In the present analysis, the factor Perceived Financial Cost (PFC) is defined as *"the degree to which individuals perceive financial costs derived from purchasing and using highly automated passenger vehicles".*

According to previous research studies, PFC is one of the most important factors influencing consumers' intension to accept new and innovative car technologies. In this context, the study [51] founds that cost factor was not an attractive feature towards self-driving vehicles. In a similar study [52], the cost factor was also an important requirement for the successful diffusion of autonomous vehicles in the future.

Taken the above together, PFC is considered to be one of the most influential factors by potential customers regarding highly automated passenger vehicles. In this way, the present study formulates the following hypothesis

H6: *"Perceived financial cost (PFC) is a significant positive predictor of behavioral intention (BI), implying that individuals who believe that financial costs regarding highly automated passenger vehicles will be at reasonable prices similar to currently used human-operated vehicles are more likely to intend to use them".*

H. PERCEIVED RELIABILITY/TRUST (PRT)

It is well known that vehicle automation is a complex technology and its use represents vulnerability and uncertainty. In this context, the user should entrust the driving task of his/her car to an AI-operator system [53]. Moreover, the study [54] showed that potential users will trust an automation system if it works in the manner they expect. In the present analysis, the factor PRT is defined as *"the degree to which individuals believe that highly automated passenger vehicles will ensure safe and reliable travels by protecting them from potential misuse and problems".*

Several studies in the international literature have shown that trust is a crucial determinant to a consumer' intension to accept e-government and e-services applications [55], [56] as well as innovative vehicle technologies and autonomous driving [57], [58], [59]. In this context, the analysis of [22] shown that most of the respondents somewhat concerned or extremely concerned for data privacy when using autonomous vehicles. In addition, the analysis of [58] enhances the statement that trust is a crucial contributor to AVs' adoption. Furthermore, the study [60] founds that significant concerns related to privacy and security issues were important determinants in consumers' intention to adopt autonomous vehicles.

Accordingly, this study posits the following hypothesis

H7: *"Perceived reliability/trust (PRT) is a significant positive predictor of behavioral intention (BI), implying that individuals who perceive that highly automated passenger vehicles can ensure reliable and safe travels are more likely to intend to use them".*

IV. METHODOLOGY

This section presents the design of the research methodology, as well as the questionnaire survey, the collection and analysis of data.

A. SURVEY DESIGN AND DATA COLLECTION

Similar to existing surveys in the literature, the present study followed a quantitative approach to test the expanded proposed UTAUT model. For this purpose, a questionnaire survey with structured, close-ended, questions was used in collecting data.

The developed survey contains four main sections with each section having its own purpose. Firstly, in the first section, the objective of the research is explained showing why respondents are filling in the survey, as well as a short description about the advantages, risks, and challenges of highly automated passenger vehicles. Respondents should read the simplified definitions according to SAE taxonomy [1], in order to ensure that they had a clear understanding of the different levels of vehicle autonomy. Furthermore, participants were not able to continue to the next sections without responding positively a control question that they had understood the definition with respect to high vehicle automation.

After the first section, the second part of the questionnaire survey is followed, which aimed to identify the demographic characteristics of the participants (age, gender, income, education, involvement status with the automotive field), as well as their mobility behavior characteristics. The followed third part of the questionnaire was assessed the general concerns regarding automation technologies in general and ADAS. A 31-item measurement scale (see Table 1), focusing on highly automated (SAE L3+) passenger vehicles, was implemented in the fourth and last part of the questionnaire, covering each factor specified in the proposed UTAUT framework (PE, EE, SI, FC, PFC, PDE, PRT and BI). The multiple items comprising each construct in the proposed UTAUT framework are obtained from previous research works in the existing international literature, and thus, the relative hypothesis testing for each one construct was set up.

Two phases were used for the implementation of the above questionnaire survey. Firstly, a pilot study was conducted, where the questionnaire was tested with 10 selected experts from the on-road transport mobility sector. After the feedback from the pilot study, the questionnaire was refined and

TABLE 1. Overview of constructs with the relative items coding and description that were used in the measurement scale.

Construct	Item coding	Item description
Performance Expectancy	PE1	Highly automated passenger vehicles will be useful for my travels
	PE2	Using highly automated passenger vehicles, my travels will take place in less time
	PE3	Highly automated passenger vehicles will allow me to perform other tasks (working, reading, etc) while driving
	PE4	Using highly automated passenger vehicles, my driving behavior and performance will be improved
	PE5	Using highly automated passenger vehicles, my safety on the road will be improved
Effort Expectancy	EE1	Highly automated passenger vehicles will be easy to use
	EE2	I would find highly automated passenger vehicles easy to use
	EE3	My interaction with highly automated passenger vehicles would be clear and understandable
	EE4	It would be easy for me to learn how to use highly automated passenger vehicles
Social Influence	SI1	Having people who are important to me using highly automated passenger vehicles will make me more likely to use such vehicles as well
	SI2	People who are important to me would think that I should use highly automated passenger vehicles
	SI3	People in my environment would support me in using highly automated passenger vehicles
	SI4	The trends of the global automotive community towards vehicle automation influence my behavior and will make me more likely to use highly automated passenger vehicles as well
Facilitating Conditions	FC1	I would use highly automated passenger vehicles if specific and appropriate regulatory frameworks are existing and supporting their usage
	FC2	I would use highly automated passenger vehicles if appropriate road infrastructures are existing and supporting their usage
	FC3	I would use highly automated passenger vehicles if there are compatible with the advanced driver assistance systems which are currently used in conventional passenger vehicles
	FC4	I would use highly automated passenger vehicles if I could have the necessary resources and knowledge to use them
Perceived Driving Enjoyment	PDE1	Using highly automated passenger vehicles will be exciting
	PDE2	Using highly automated passenger vehicles will be comfortable and relaxing
	PDE3	Using highly automated passenger vehicles will be enjoyable
Perceived Financial Cost	PFC1	I would like to invest money for the purchase / rental of highly automated passenger vehicles
	PFC2	The benefits of using highly automated passenger vehicles outweigh the cost of their purchasing / renting
	PFC3	The cost of purchasing / renting highly automated passenger vehicles will be at reasonable prices similar to currently used conventional passenger vehicles
	PFC4	The operating cost of using highly automated passenger vehicles will be at reasonable prices similar to currently used conventional passenger vehicles
Perceived reliability/trust	PRT1	I trust that highly automated passenger vehicles can get me safely to my destinations, even in the most challenging and demanding driving scenarios
	PRT2	I trust that highly automated passenger vehicles can drive better than me and it can interact better with the external driving environment
	PRT3	I trust that highly automated passenger vehicles can maintain the full control of the vehicle, at any moment, against cyber attacks (hacking)
	PRT4	I trust that highly automated passenger vehicles can ensure data privacy protection against cyber attacks (hacking)
Behavioral Intention (BI)	BI1	I intend to use highly automated passenger vehicles when they become available on the market
	BI2	I predict I will use highly automated passenger vehicles when they become available on the market
	BI3	I plan to use highly automated passenger vehicles when they become available on the market

a final Web-based version was developed by using Google Forms.

With respect to the dissemination process of the survey, the main decision-rule for selecting the target population was based on the statement that the present study aims to investigate the basic factors influencing European consumers' intention to adopt and use highly automated (SAE L3+) passenger vehicles from a user-centric perspective. Public acceptance assessment towards highly automated (SAE L3+) passenger vehicles was implemented among adults, aged more than 18 years old, residing in Europe. Additionally, respondents were recruited from a large panel for market research, which allowed collecting a representative sample of the European population.

The on-line survey was advertised via e-mail lists, websites and social media communication channels inviting European consumers to take part, being able to explore the attitudes, knowledge, behaviours and perceptions about highly automated (SAE L3+) passenger vehicles Respondents were informed that the data would be kept anonymously and that the completion procedure the questionnaire survey would take around fifteen to twenty minutes. In addition, respondents were further informed that the aforementioned survey is conducted within the frame of the European Prystine project. It should be noted, that the participation in the above survey was completely voluntary and no compensations were offered to the participants.

The questionnaire was disseminated between September and December 2018. 829 responses were totally returned. After filtering the returned responses, 18 questionnaires were excluded due to incomplete data. Thus, 811 valid answers were left for further analysis.

B. DATA ANALYSIS

First, Cronbach's alpha coefficient was used to measure the consistency of the indicators of the proposed UTAUT acceptance model [61]. Secondly, Exploratory Factor Analysis (EFA) was used to investigate the extent to which the total variance of the proposed framework was explained by the potential determinants included in the research model.

In addition, varimax factor rotation analysis was used to investigate the loading of the predictors [62]. Finally, in testing the hypotheses H1-H7, a multiple regression analysis was implemented, whereas the moderating effects of the proposed UTAUT model (age, gender, income, education) were also investigated.

V. RESULTS

In this section, the general characteristics and background of the respondents are described, as well as the results on testing the proposed research framework.

A. DEMOGRAPHICS

Background demographic information reveals a gender split (Q1) of 58.1% males and 41.9% females, whereas 9 participants responded *"I prefer not to answer"*. With respect to the age of the respondents (Q2), 48.0% were between 18 and 30 years old, 29.2% between 31 and 40 years old, and 22.8% more than 40 years old, whereas 3 participants responded *"I prefer not to answer"*. According to the educational level (Q3), most respondents (54.3%) were higher education diploma holders (M.Sc. or/and Ph.D.), whereas 32.8% were university/college diploma holders, and 12.9% had secondary education or less, whereas 6 participants responded *"I prefer not to answer"*. Moreover, regarding personal income (Q4), 23.1% 46.6% had a net average monthly personal income more than 2000€, 30.3% between 1000€ and 2000€, and 46.6% less than 1000€, whereas 84 participants responded "*I prefer not to answer*". Furthermore, with respect to the degree of involvement with the automotive field (Q5), 38.7% of the respondents answered that they have no active involvement, 37.5% responded that they are working in sectors relative to the automotive field (e.g., automakers, research institutions, sales, marketing, insurance companies, etc.), whereas 23.8% indicated that they attend the automotive sector by personal interest.

B. TRANSPORTATION PROFILE

Additional information towards the transportation profile of the respondents are provided in Table 2, where 89.9%

TABLE 2. Transportation profile of the respondents (means (M), standard deviations (SD), and number of respondents (n)).

Question	Response Options	Percentage (%)
Driving license (valid) for a passenger car – Q6	1. Yes	89.9
(M = 1.10, SD = 0.302, n = 811)	2. No	10.1
Passenger car ownership – Q7	1. Yes	83.5
(M = 1.17, SD = 0.372, n = 811)	2. No	16.5
How often do you use for your travels passenger vehicles? – Q8	1. Rarely/Never	4.1
(M = 2.58, SD = 1.541, n = 811)	2. Few times a year	7.0
	3. Few times a month	16.2
	4. Few times a week	23.3
	5. Every day	49.4
Hours a week (on average) using a passenger car – Q9 *(M = 1.36, SD = 0.879, n = 811)*	1. Less than 5	54.5
	2. 5 to15	38.2
	3. More than 15	7.3
What is the usual purpose of your travels with passenger vehicles? – Q10 *(M = 2.50, SD = 0.841, n = 811)*	1. I do not use passenger vehicles	7.5
	2. Professional (work, education, etc.)	49.8
	3. Personal (medical, family, shopping, etc.)	27.4
	4. Leisure (travels, walks, etc.)	15.3
How safe do you feel when you are using passenger vehicles today? – Q11 *(M = 3.53, SD = 0.814, n = 811)*	1. Not at all safe	2.1
	2. Slightly safe	7.2
	3. Moderately safe	34.0
	4. Quite safe	49.6
	5. Extremely safe	7.2
To what extent technology progress, until now, has contributed to improving the safety of your travels with passenger vehicles? – Q12 *(M = 4.03, SD = 0.888, n = 811)*	1. Not at all improved	1.0
	2. Slightly improved	6.2
	3. Moderately improved	13.7
	4. Quite improved	47.6
	5. Extremely improved	31.6
Had you ever heard of highly automated passenger vehicles before participating in the survey? – Q13 *(M = 1.16, SD = 0.442, n = 811)*	1. Yes	87.2
	2. No	9.7
	3. I do not know - I'm not sure	3.1
Had you ever any experience on using highly automated passenger vehicles before participating in this survey? – Q14 *(M = 1.74, SD = 0.491, n = 811)*	1. Yes	28.2
	2. No	69.3
	3. I do not know - I'm not sure	2.5
Level of interest in highly automated passenger vehicles before participating in the survey – Q15 *(M = 3.40, SD = 1.288, n = 811)*	1. Not at all interested	10.2
	2. Slightly interested	15.9
	3. Moderately interested	21.2
	4. Quite interested	28.5
	5. Strongly interested	24.2
Level of interest in issues related to vehicle automation before participating in the survey – Q16 *(M = 3.86, SD = 1.148, n = 811)*	1. Not at all interested	3.9
	2. Slightly interested	10.9
	3. Moderately interested	17.6
	4. Quite interested	30.6
	5. Strongly interested	37.0
What is your general opinion regarding highly automated passenger vehicles? – Q17 *(M = 2.36, SD = 1.366, n = 811)*	1. Positive	64.6
	2. Neutral	20.6
	3. Negative	7.9
	4. I do not know - I'm not sure	6.9

of the respondents stated that they have a (valid) driving license for a passenger car (Q6), 83.5% stated that they own a passenger car (Q7), 54.5% responded that they are driving less than five hours per week (Q9), 49.4% indicated that their daily commute transportation mode is to use passenger vehicles (Q8), and 49.8% stated that the purpose of their travels with passenger vehicles is usually professional (Q10). In the question *"How safe do you feel when you are using passenger vehicles today?"* (Q11), 56.8% of the respondents stated that they feel quite or extremely safe, whereas almost 80% believe that technology progress has improved the safety of their travels with passenger vehicles (Q12). Moreover, more than eight to ten of respondents (87.2%) had heard of highly automated passenger vehicles before their participation in the present survey (Q13).

Moreover, the majority of respondents had not any previous experience on using highly automated passenger vehicles before participating in this survey (Q14). Furthermore, 52.7% of the respondents indicated that they somewhat or strongly interested in highly automated passenger vehicles before participating in the survey (Q15), whereas two to three of people surveyed (67.6%) answered that they are interested with the trends of the global automotive community towards vehicle automation technology before participating in the present survey (Q16). Finally, almost

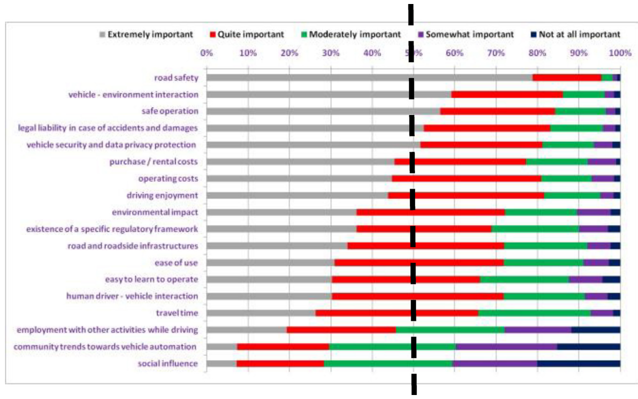

FIGURE 2. Responses on (Q18) "How important are the following features for you regarding highly automated passenger vehicles?."

65% of the people surveyed had a positive opinion regarding highly automated passenger vehicles (Q17).

In addition, regarding the question (Q18) *"How important are the following features for you regarding highly automated passenger vehicles?"*, most of the people surveyed stated that "road safety" (78.8%), "vehicle-environment interaction (59.2%), "safe operation" (56.5%), "legal liability in case of accidents and damages" (52.5%), and "vehicle security and data privacy protection" (51.7%) were the most important features for a highly automated passenger car. On the other hand, the options "employment with other activities while driving" (19.4%), "community's trends towards vehicle automation" (7.4%) and "social influence" (7.3%) were the least important features, as shown in Fig. 2.

C. EXPERIENCE WITH ADAS AND AUTOMATION TECHNOLOGIES

In this section, findings about the experience of respondents towards ADAS and automation technologies are presented. According to the results, more than one half of respondents (54%) answered that they are keeping up with the latest trends in automation technologies (Q19), and 70% are somewhat or strongly agreed with the statement "*Automation technologies provide solutions to many of my problems in my daily life* (Q20)". Moreover, most of respondents indicated that it is easy for them to use and apply automation technologies in their daily life (Q21) and they do not waste much time with their use (Q22). Almost 75% of the people surveyed considered themselves as late adopters to a new automation technology (Q23). In responding to the question (Q24) "*To what extent do you trust the automation technologies in terms of tracking - interception of sensitive information?*", only 28.0% of the respondents answered that they somewhat trusted or strongly trusted. Almost the same levels of trust towards automation technologies were stated also to the options of "*cyber security and data protection* (Q25)" and "*data loss - system failure (software, databases, etc.)* (Q26)".

In a similar basis with respect to experience with automation technologies, almost four-to-ten of respondents indicated

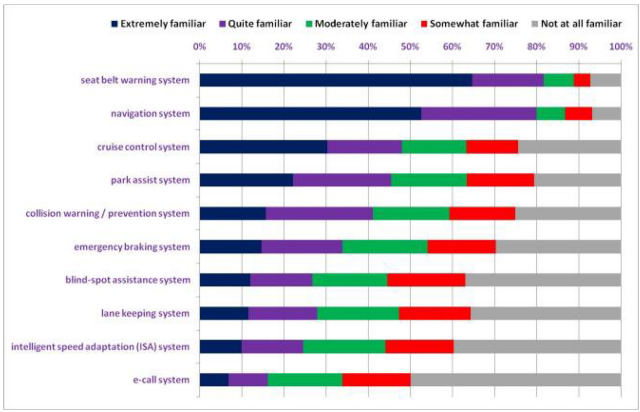

FIGURE 3. Responses on (Q31) "Indicate your level of familiarity with the following Advanced Driver Assistance Services (ADAS), which are offered today on certain models of passenger vehicles."

that they are keeping up with the latest trends in ADAS (Q27), and six-to-ten of the people surveyed stated that they somewhat or strongly agreed with the option "*ADAS make easier my driving (Q28)*". Moreover, almost 70% of the respondents answered that ADAS are easy for them to use and apply in driving (Q29) and they do not waste much time in driving (Q30). In addition, regarding the question (Q31) with respect to the level of familiarity with ADAS, most of respondents indicated that only two driver assistance services are exceeding the threshold of 50%, as the most quite/very familiar ADAS, "seat belt warning system" (81.6%) and "navigation system" (80.0%), respectively (Fig. 3). It should be noted that for all the other ADAS being available today by the automotive industry (e.g., park assist system, cruise control system, etc.) the level of respondents' familiarity is not exceeding the threshold of 50%.

D. RATINGS OF ATTITUDINAL ITEMS TOWARDS HIGHLY AUTOMATED PASSENGER VEHICLES

In Table 3, values about the means (M), standard deviations (SD) and frequency distributions are given for the relative items that were used in the measurement scale towards highly automated passenger vehicles. The highest mean rating was calculated for the item *"PDE1: Using highly automated passenger vehicles will be exciting"*, whereas the second-highest mean rating was observed for the item *"FC2: I would use highly automated passenger vehicles if appropriate road infrastructures are existing and supporting their usage"*. The third-highest mean rating was calculated for the item *"PE1: Highly automated passenger vehicles will be useful for my travels"*, with 74.1% of respondents stating that they strongly or somewhat agreed.

On the other hand, the lowest rating was obtained for the item *"PRT4: I trust that highly automated passenger vehicles can ensure data privacy protection against cyber attacks (hacking)"*, whereas the second-lowest mean rating was observed for the item *"PRT3: I trust that highly automated passenger vehicles can maintain the full control of the vehicle, at any moment, against cyber attacks (hacking)"*. The third-lowest mean rating was calculated for the item *"PFC2: The benefits of using highly automated passenger vehicles outweigh the cost of their purchasing / renting"*. A moderating rating was obtained for the item *"PE3: Highly automated passenger vehicles will allow me to perform other tasks (working, reading, etc) while driving"*, with 56.6% of respondents stating that they strongly or somewhat agreed.

TABLE 3. Descriptive statistics (means (M), standard deviations (SD), and number of respondents (n)). The 31-items of the measurement scale are presented in descending order according to their mean values (M).

Item	M	SD	n	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
PDE1	4,12	0,988	811	3.0%	4.1%	13.7%	37.0%	**42.3%**
FC2	4,10	0,945	811	2.6%	3.1%	15.4%	**39.8%**	39.1%
PE1	3,96	0,950	811	2.5%	4.6%	18.9%	**43.0%**	31.1%
FC4	3,96	0,992	811	3.3%	3.6%	20.7%	**39.0%**	33.4%
FC1	3,88	0,991	811	3.2%	5.4%	20.3%	**42.3%**	28.7%
EE2	3,81	0,920	811	1.5%	5.2%	29.5%	**39.1%**	24.8%
FC3	3,78	0,984	811	3.0%	6.2%	25.8%	**40.4%**	24.7%
EE1	3,72	0,936	811	2.0%	6.9%	28.9%	**41.3%**	21.0%
EE3	3,71	0,883	811	1.4%	5.9%	31.7%	**42.4%**	18.6%
EE4	3,68	1,085	811	3.9%	10.2%	25.2%	**34.8%**	25.9%
PDE3	3,62	0,963	811	2.6%	7.9%	33.0%	**37.6%**	18.9%
PE5	3,59	1,012	811	3.3%	10.0%	29.7%	**37.9%**	19.1%
PDE2	3,56	1,010	811	1.8%	14.2%	29.1%	**36.0%**	18.9%
PE3	3,43	1,300	811	12.1%	12.7%	18.6%	**33.4%**	23.2%
SI3	3,26	1,011	811	6.9%	10.2%	**43.9%**	28.4%	10.6%
SI4	3,19	1,146	811	11.3%	13.6%	29.7%	**35.1%**	10.2%
PFC1	3,18	1,119	811	9.0%	16.6%	**32.7%**	30.3%	11.3%
PE2	3,15	1,071	811	7.9%	16.2%	**39.6%**	25.4%	11.0%
SI1	3,14	1,152	811	13.6%	10.6%	**33.5%**	33.2%	9.1%
PRT2	3,11	1,188	811	10.5%	21.6%	26.5%	**29.0%**	12.5%
BI1	3,08	1,259	811	15.7%	15.9%	25.8%	**30.1%**	12.6%
PRT1	3,06	1,245	811	14.3%	20.0%	22.9%	**31.1%**	11.7%
PE4	3,05	1,241	811	14.5%	17.9%	**28.4%**	26.3%	12.9%
PFC3	3,04	1,029	811	13.3%	**26.4%**	26.3%	22.4%	11.6%
SI2	3,00	1,127	811	14.7%	12.8%	**37.5%**	28.2%	6.8%
BI2	3,00	1,246	811	15.3%	19.1%	**27.7%**	25.5%	12.3%
PFC4	2,99	1,141	811	11.1%	21.7%	**34.4%**	22.4%	10.4%
BI3	2,94	1,263	811	17.4%	18.6%	**29.1%**	22.7%	12.2%
PFC2	2,93	1,217	811	8.9%	16.8%	**44.0%**	22.6%	7.8%
PRT3	2,91	1,081	811	11,6%	23,3%	**32,4%**	27,6%	5,1%
PRT4	2,80	1,099	811	14,3%	24,3%	**33,2%**	23,3%	6,0%

In addition, with regards to the frequency distributions of the other attitudinal items about the PE factor (PE2, PE4, PE5), many respondents (57%) believe the statement *"PE5: Using highly automated passenger vehicles, my safety on the road will be improved"*. Only a small portion of the respondents (13.3%) were disagreed with PE5. In addition, 39.6% and 28.4% of the respondents, respectively, neither disagreed nor agreed with the statements "*PE2: Using highly automated passenger vehicles, my travels will take place in less time*" and "*PE4: Using highly automated passenger vehicles, my driving behavior and performance will be improved*".

According to the results regarding the effort expectancy (EE) relative items (EE1, EE2, EE3, EE4), most respondents strongly agreed (21.0%) or somewhat agreed (41.3%) with the statement *"EE1: Highly automated passenger vehicles will be easy to drive/use"*. In addition, almost 64% of the respondents somewhat or strongly agreed with the statement *"EE2: I would find highly automated passenger vehicles easy to use"*. Furthermore, 18.6% of the respondents strongly agreed and 42.4% somewhat agreed with the statement *"EE3: My interaction with highly automated passenger vehicles would be clear and understandable"*. In addition, the majority of respondents strongly agreed (25.9%) or somewhat agreed (34.8%) with the statement *"EE4: It would be easy for me to learn how to use highly automated passenger vehicles"*.

Moreover, according to the results regarding the social influence (SI) relative items (SI1, SI2, SI3, SI4), 33.5%, 37.5% and 43.9% of the respondents, respectively, neither agreed nor disagreed with the statements *"SI1: Having people who are important to me using highly automated passenger vehicles will make me more likely to use such vehicles as well"*, "*SI2: People who are important to me would think that I should use highly automated passenger vehicles"* and "*SI3: People in my environment would support me in using highly automated passenger vehicles"*. Moreover, 45.3% of the people surveyed agreed with the statement *"SI4: The trends of the global automotive community towards vehicle automation influence my behavior and will make me more likely to use highly automated passenger vehicles as well"*.

Regarding the facilitating conditions (FC) relative items (FC1, FC3, FC4), Table 3 shows that most of respondents agreed with the statements *"FC1: I would use highly automated passenger vehicles if specific and appropriate regulatory frameworks are existing and supporting their driving/usage"* (71.0%), *"FC3: I would use highly automated passenger vehicles if there are compatible with the advanced driver assistance systems which are currently used in conventional passenger vehicles"* (65.1%), and *"FC4: I would use highly automated passenger vehicles if I could have the necessary resources and knowledge to use them"* (72.4%). Only 5.7% to 9.2% of the respondents strongly disagreed or somewhat disagreed with the above statements FC1, FC3 and FC4.

Furthermore, according to the results regarding the perceived driving enjoyment (PDE) relative items (PDE2, PDE3), over 50% of the respondents agreed with the statements *"PDE2: Using highly automated passenger vehicles will be comfortable and relaxing"* and *"PDE3: Using highly automated passenger vehicles will be enjoyable"*.

Moreover, regarding the perceived financial cost (PFC) relative items (PFC1, PFC3, PFC4), Table 4 presents that almost four-to-ten respondents agreed with the statement *"PFC1: I would like to invest money for the purchase / rental of highly automated passenger vehicles"*, whereas a small portion of respondents agreed with the statements "*PFC3: The cost of purchasing / renting highly automated passenger vehicles will be at reasonable prices similar to currently used conventional passenger vehicles"* (34.0%), and "*PFC4: The operating cost of using highly automated passenger vehicles will be at reasonable prices similar to currently used conventional passenger vehicles"* (32.8%).

Finally, with regard to the perceived reliability/trust (PRT) relative items (PRT1, PRT2), results in Table 4 show that almost four-to-ten respondents agreed with the statements *"PRT1: I trust that highly automated passenger vehicles can get me safely to my destinations, even in the most challenging and demanding driving scenarios"* (42.8%) and *"PRT2: trust that highly automated passenger vehicles can drive better than me and it can interact better with the external driving environment"* (41.5%).

TABLE 4. Items coding of the proposed modified UTAUT-model, scale reliabilities and factor loadings.

Construct	Cronbach's α	Items coding	Factor Loading
PE	0.734	PE1	0.646
		PE2	0.553
		PE3	0.707
		PE4	0.606
		PE5	0.623
EE	0.837	EE1	0.756
		EE2	0.800
		EE3	0.787
		EE4	0.742
SI	0.782	SI1	0.897
		SI2	0.888
		SI3	0.467
		SI4	0.455
FC	0.879	FC1	0.794
		FC2	0.850
		FC3	0.764
		FC4	0.842
PDE	0.873	PDE1	0.512
		PDE2	0.595
		PDE3	0.571
PFC	0.818	PFC1	0.476
		PFC2	0.856
		PFC3	0.566
		PFC4	0.867
PRT	0.869	PRT1	0.584
		PRT2	0.645
		PRT3	0.826
		PRT4	0.855
BI	0.934	BI1	0.843
		BI2	0.888
		BI3	0.895

E. CONFIRMATORY FACTOR ANALYSIS

The measurement instruments' internal consistency and reliability were evaluated through Cronbach Alphas calculations. These values are also known as the reliability coefficients. For all eight factors, these coefficients were above the cut-off criterion of 0.7 [63], stating high reliability. More in detail, as shown in Table 4, the results indicate that PE yielded 0.734 indicating 73.4% of internal consistency, EE yielded 0.837, representing 83.7% internal consistency, SI gave a reliability coefficient of 0.782 depicting 78.2% reliability, FC yielded 0.879 depicting 87.9% reliability, PDE gave a coefficient of $\alpha = 0.873$ indicating 87.3% of internal consistency, PFC yielded 0.818 representing 81.8% internal consistency, PRT gave 0.869 depicting 86.9% reliability, and BI yielded 0.934 depicting 93.4% of internal consistency.

Additionally, in order to ensure that the aforementioned UTAUT dimensions (PE, EE, SI, FC, PFC, PDE, PRT and BI) were distinct, loadings of the variables on each dimension were conducted. Relative calculations were obtained by using varimax rotation and maximum likelihood extraction. It can be seen in the Table 4, that all the factor loadings were

TABLE 5. Pearson product moment correlations of the main variables in the proposed research framework.

	PE	EE	SI	FC	DP	PC	TDA	BI
Performance Expectancy (PE)	1							
Effort Expectancy (EE)	0.512**	1						
Social Influence (SI)	0.439**	0.366**	1					
Facilitating Conditions (FC)	0.441**	0.403**	0.538**	1				
Perceived Driving Enjoyment (PDE)	0.693**	0.610**	0.421**	0.500**	1			
Perceived Financial Cost (PFC)	0.561**	0.309**	0.349**	0.295**	0.573**	1		
Perceived Reliability/Trust (PRT)	0.647**	0.412**	0.434**	0.319**	0.626**	0.575**	1	
Behavioral Intention (BI)	0.456**	0.305**	0.373**	0.241**	0.498**	0.464**	0.475**	1

**: p-value < 0.01, M: Mean, SD: Standard Deviation

TABLE 6. Summary results of the two multiple regression analyses before and after adding the four moderating effects (age, gender, education, income).

Path / hypothesis	Independent variable	Dependent variable	Modified UTAUT-model *(standardized path coefficients β before adding moderating effects)*	Modified UTAUT-model *(standardized path coefficients β after adding moderating effects)*	Decision
H1	PE	BI	0.075#	0.067#	Rejected
H2	EE	BI	-0.019#	-0.009#	Rejected
H3	SI	BI	0.176***	0.177***	Supported
H4	FC	BI	-0.098*	-0.106*	Rejected
H5	PDE	BI	0.247***	0.242***	Supported
H6	PFC	BI	0.178**	0.197***	Supported
H7	PRT	BI	0.132*	0.138*	Supported
	Age	BI		-0.068#	
	Gender	BI		0.088*	
	Education	BI		-0.015#	
	Income	BI		0.102*	

Note: *p-value < 0.05, **p-value < 0.01, ***p-value < 0.001, # p-value non-significant

TABLE 7. Intension to use highly automated passenger vehicles related to gender and age differences.

Variable	Options	Gender		Age		
		Male (n = 466)	Female (n = 336)	18 – 30 (n = 388)	31 – 40 (n = 236)	More than 40 (n = 246)
Consumers' intension to use highly automated passenger vehicles (BI)	Strongly disagree	21.8%	25.6%	24.5%	20.9%	25.4%
	Somewhat disagree	19.7%	19.4%	23.6%	17.8%	12.7%
	Neither agree nor disagree	32.1%	29.1%	29.2%	36.4%	28.2%
	Somewhat agree	21.2%	22.5%	18.5%	21.7%	28.2%
	Strongly agree	5.2%	3.5%	4.2%	3.1%	5.4%

above the threshold of 0.4, which indicates high construct validity [62].

In addition, a Pearson product moment inter-correlation analysis was executed to check for multicollinearity. According to the results shown in Table 5, the seven independent variables PE, EE, SI, FC, PDE, PFC and PRT do not present any multicollinearity problems, as no correlations larger than 0.7 and lower than 0.2 were observed.

F. HYPOTHESES TESTING

In this subsection a multiple linear regression analysis was applied for predicting consumers' intentions towards highly automated passenger vehicles, by taking into consideration the effects of Performance Expectancy (PE), Social Influence (SI), Effort Expectancy (EE), Facilitating Conditions (FC), Perceived Financial Cost (PFC), Perceived Driving Enjoyment (PDE) and Perceived Reliability/Trust (PRT). The first phase of the regression analysis includes a baseline model without the presence of the moderating effects (age, gender, education, income). The relative standardized path coefficients β, before adding the moderating effects, are demonstrated in Table 6.

As mentioned previously, hypothesis H5 states that the factor PDE significantly affects individual BI to accept and use highly automated passenger vehicles. Based on our results, this hypothesis is supported ($\beta = 0.247$, p-value $= 0.000$). In a similar way, the results shown in Table 7 supported hypotheses H6 and H3 ($\beta = 0.178$, p-value $= 0.001$ and $\beta = 0.176$, p-value $= 0.000$, respectively), which confirms that the factors PFC and SI importantly affect individual BI to accept and use highly automated passenger vehicles. In addition, hypothesis H7 was also supported ($\beta = 0.132$, p-value $= 0.019$), which also indicates that the predictor PRT significantly affects individual BI in accepting and using highly automated passenger vehicles. The above show that the four factors PDE, PFC, SI and PRT influence consumers' BI to adopt and use highly automated vehicles. Meanwhile, the hypotheses H1 and H2 about the two constructs PE ($\beta = 0.075$, p-value $= 0.210$) and EE ($\beta = -0.019$, p-value $= 0.708$) were rejected as they found to be statistically insignificant, as well as the hypothesis H4 ($\beta = -0.098$, p-value $= 0.049$), since the predictor FC affects negatively individual BI in accepting and using highly automated passenger vehicles.

The second phase of the regression analysis was implemented by adding to the aforementioned seven independent predictors the moderating influences of age, gender, income and education. The new standardized path coefficients β, after adding the moderating effects, are also shown in Table 6. Results indicate that the moderating variables Gender ($\beta = 0.088$, p-value $= 0.032$) and Income ($\beta = 0.102$, p-value $= 0.040$) had a positive effect on consumers' BI to use highly automated passenger vehicles. Moreover, the same factors as in the first multiple regression analysis, PDE ($\beta = 0.242$, p-value $= 0.000$), PFC ($\beta = 0.197$, p-value $= 0.000$), SI ($\beta = 0.177$, p-value $= 0.000$) and PRT ($\beta = 0.138$, p-value $= 0.015$), remain the most significantly influencing predictors of behavioral intentions towards the usage of highly automated passenger vehicles. In total, according to the results of the two multiple regression analyses, the hypotheses H3, H5, H6 and H7 were supported, whereas hypotheses H1, H2 and H4 were rejected.

In addition, respondents' intension to use highly automated passenger vehicles (BI) was assessed based on age and gender differences, as depicted in Table 7. There are no noticeable differences between females and males with regards to the level of agreement with their intension to use highly automated passenger vehicles. Furthermore, respondents more than 40 years old are more likely to use highly automated passenger vehicles (33.6% strongly agreed or somewhat agreed) than those who are under 30 years old (22.7% strongly agreed or somewhat agreed).

In addition, respondents' intension to use highly automated passenger vehicles was observed based on income and education differences, as shown in Table 8. According to the results, survey respondents with a net monthly personal income above 1000€ are more likely to use highly automated passenger vehicles (31.1% strongly agreed or somewhat agreed) than those who have a lower income below 1000€ (23.2% strongly agreed or somewhat agreed). Furthermore, respondents which are university/college diploma holders

TABLE 8. Intension to use highly automated passenger vehicles related to income and education differences.

Variable	Options	Education			Income	
		High school graduate or less (n = 104)	University/ college diploma (n = 264)	Higher education diploma (n = 437)	Less than 1000€ (n = 339)	More than 1000€ (n = 388)
Consumers' intension to use highly automated passenger vehicles (BI)	Strongly disagree	37.5%	15.5%	25.2%	25.5%	23.8%
	Somewhat disagree	22.5%	17.9%	18.9%	22.4%	14.6%
	Neither agree nor disagree	18.8%	35.0%	32.5%	28.9%	30.5%
	Somewhat agree	20.0%	26.8%	18.4%	19.6%	26.8%
	Strongly agree	1.2%	4.8%	4.9%	3.6%	4.3%

TABLE 9. Summary results of the multiple regression analysis towards the original UTAUT-model.

Path / hypothesis	Independent variable	Dependent variable	Original UTAUT-model *(standardized path coefficients β before adding moderating effects)*	Decision
H1	PE	BI	0.337***	Supported
H2	EE	BI	0.058#	Rejected
H3	SI	BI	0.204***	Supported

Note: ***p-value < 0.001, # p-value non-significant

are more likely to use highly automated passenger vehicles (31.6% strongly agreed or somewhat agreed) when they become available on the market than those who have high school graduate or less (21.2% strongly agreed or somewhat agreed).

G. COMPARATIVE ANALYSIS WITH THE ORIGINAL UTAUT

In this subsection, the results derived from the implementation of the proposed UTAUT framework are compared to the original UTAUT. Table 9 shows the multiple regression analysis of the original UTAUT framework without the presence of the factor FC [47].

Results show that the constructs of PE ($\beta = 0.337$, p-value $= 0.000$) and SI ($\beta = 0.204$, p-value $= 0.000$) are both useful determinants of consumers' BI to use highly automated passenger vehicles, with PE having the strongest impact. The above result about PE is in contrast to the findings of the modified UTAUT-model where the analysis demonstrated that the factor PDE was the strongest predictor of consumers' BI towards the usage of highly automated passenger vehicles. Furthermore, the factor EE ($\beta = 0.058$, p-value $= 0.235$) seems not to affect significantly consumers' intension to adopt and use highly automated passenger vehicles which supports the corresponding finding of the modified UTAUT-model.

VI. DISCUSSION

A. ANALYSIS OF THE QUESTIONNAIRE ITEMS

According to the analysis of the respondents' demographic characteristics, a good representation of gender and involvement with the automotive field was shown. On the other hand, an overrepresentation of the age under 30 years old, is explored maybe due to the online survey distribution. This implication underlines that the present sample represents a younger audience, which is not representative for the European population. On the other hand, younger consumers are a very interesting target population group considering that highly automated passenger vehicles are still expected to be in the international market some years away. In addition, almost 75% of people surveyed considered themselves as late adopters on new technologies, which is at a high level compared to the research findings by other studies [22], [24]. This states that the vast majority of consumers are not eager to jump on using highly automated passenger vehicles and they wait before adopting this new innovative technology.

It is well known that safer driving is one of the crucial factors for the deployment of vehicle automation and would be a prerequisite for the widespread diffusion of highly automated passenger vehicles when they will become a reality to public roads. Based on the survey results, less than half of the people surveyed stated that they feel safe when they are travelling with passenger vehicles, whereas the corresponding percentage when they are using public transport means is much higher (almost 75%). This implication underlines the necessity of safety benefits and how this factor convinces the end users (potential consumers) what highly automated passenger vehicles can do in real conditions.

Additionally, more than 80% of the respondents believe that technology progress has improved the safety of their travels with passenger vehicles. This finding shows that new well-studied technologies in passenger vehicles, such as the driving automation systems, could enhance the safety perspectives of potential consumers towards the deployment of highly automated passenger vehicles in the future. Additionally, almost two-to-third of respondents are expressed serious concerns about data privacy and security issues in relation to automation technologies that they use. These notes are similar to the findings obtained by other recent studies [19], [24].

Furthermore, road safety, safe operation, vehicle-environment interaction, vehicle security, data privacy protection, and legal liability were the most important features for the people surveyed in relation to the usage of highly automated passenger vehicles. On the other hand, social influence, employment with other activities while driving, and automotive community's trends towards vehicle automation were the least important features for a highly automated passenger car. In a similar basis with respect to the level of familiarity with ADAS, the majority of respondents indicated that only two driver assistance services are exceeding the threshold of 50%, as the most quite/very familiar ADAS: seat belt warning system and navigation system. On the other hand, it should be noted that for all the other ADAS being available today by the automotive industry (e.g., park assist system, cruise control system, etc.) the level of respondents' familiarity is not exceeding the threshold of 50%. These notes are similar to the recent findings of the study [46].

With respect to the mean ratings, this study shown that the highest one was observed for the attitudinal item of the perceived driving enjoyment, since almost 80% of the respondents considering highly automated (SAE L3+)

passenger vehicles will be exciting. Meanwhile, the lowest mean rating was observed for the attitudinal item regarding the perceived reliability/trust, as only 30% of the respondents stating highly automated passenger vehicles can ensure data privacy protection against cyber attacks (hacking).

B. ANALYSIS OF THE PROPOSED UTAUT-MODEL

One of the main purposes of the present study was to provide a detailed understanding of the predictors that will affect consumers' intention to adopt and use highly automated (SAE L3+) passenger vehicles for their personal travels, through the implementation of an expanded UTAUT model. Most of the hypotheses in the proposed acceptance model were supported except the paths from PE to BI and EE to BI, which found statistically insignificant, and FC to BI, which found to affect negatively consumers' intentions to adopt highly automated passenger vehicles.

PDE was the strongest determinant, which shows that the most important factor affecting positively consumers' intention to adopt highly automated passenger vehicles is how enjoyable, comfortable and exciting will find them. This research finding confirms the study [44] about the hedonic motivation factor and the way that this factor impacts users' acceptance towards ARTS. In addition, the above implication is also supported from the results of the study [64], since the majority of the people surveyed states that autonomous vehicles would take away the driving enjoyment or pleasure.

Coming to the PFC factor, our analysis shows that this predictor has a positive influence, stating that the adoption of highly automated passenger vehicles is affected by economic factors like driving/usage operating costs and purchasing costs. A small portion of people surveyed (almost 30%) somewhat or strongly agreed that the cost of purchasing/renting highly automated passenger vehicles, as well as the operating cost of using highly automated passenger vehicles will be at reasonable prices similar to conventional ones. The above implication is also confirmed by the study [51], which has explored the cost factor and its impact on users' perceptions towards driverless vehicles. In this manner, the challenge of automotive and other related companies towards highly automated passenger vehicles research is to develop proper strategies that will enable large-scale implementations of highly vehicle automation in the near future in comparison with other transportation options (conventional vehicles, car-sharing services, etc.).

With respect to the SI factor, our results show that this predictor has a significant positive influence on BI towards highly automated passenger vehicles when they become available on the international market. The above result is also supported by previous research studies on autonomous driving and ARTS [24], [44]. In an attempt to attract more end users, developers, manufacturers and other stakeholders related to the automotive sector need to focus on generating social norms, through effective marketing campaigns, that-include the usage of highly automated passenger vehicles as a valid transportation choice for their personal travels.

What can be stated about the PRT factor is that has a positive influence on BI towards highly automated passenger vehicles. The above finding is confirmed from the results of other studies towards the effect of trust in AVs [24], [57], [60], [64]. It is noted that car manufacturers should enhance consumer confidence and trust towards highly automated passenger vehicles by providing secure and reliable driving automation systems. In this respect, potential customers' intension to use highly automated passenger vehicles will be greater.

Furthermore, the present analysis found that the factor FC has a negative influence on BI towards highly automated passenger vehicles, indicating that facilities which support the effective usage of highly automated passenger vehicles like appropriate resources, infrastructures and implementation strategies are unlikely to be a deciding predictor in potential consumer's intension to use such vehicles. The above result is confirmed by previous research effort [44], where the facilitating conditions was not found to affect positively consumers' intention to use ARTS vehicles.

Based on the regression analysis, the factor PE founds to have a statistically insignificant positive impact on BI towards highly automated passenger vehicles, within the extended UTAUT-model, which indicated that respondents are not expected highly automated passenger vehicles can provide significant mobility benefits. This finding is in contrast with other results from previous efforts [24], [42], [44], where the factors PU and PE were significant predictors on consumers' intensions to adopt autonomous driving technology. The foregoing shows that car manufacturers have improved the quality of the embedded driving systems on currently used conventional passenger vehicles, which have already met consumers' expectations and needs in performing their own travels.

In addition, the factor EE founds to have a statistically insignificant negative impact on BI towards highly automated passenger vehicles, which states that difficulty in using such vehicles is not a concern, since potential consumers become more user-friendly. This finding is in contrast to other results, where PEU [24] and EE [43] did have an effect on BI towards autonomous driving technology and ARTS, respectively. Meanwhile, our finding is in line with other related research efforts [40], [58]. The foregoing shows that currently-used passenger vehicles are well-designed, and thus, the level of effort required in using highly automated passenger vehicles is unlikely to be a deciding factor.

Furthermore, the moderating factors gender and income were found to affect the relationship between the predictors PE, SI, EE, FC, PFC, PDE, PRT and consumers' BI, in contrast to the moderating factors age and education. Regarding the effects of the age moderator, the above finding is not in line with previous findings (e.g., [34]), whereas other studies have not found any effects of the moderating factors age and gender on consumers' expectations towards automated technology systems in vehicles [40], [43]. On this basis, the results of the present analysis indicate that targeted campaigns for specific gender and income consumer groups are likely to be required in order to increase the acceptability of highly automated passenger vehicles.

C. PRACTICAL IMPLICATIONS

According to the results of the present study, some very important practical implications could be raised. Firstly, the factor PDE seems to play an important role in European consumers' desire to use highly automated passenger vehicles for their travels. The above implies that end users will still want to enjoy the driving of vehicles even with high automation capabilities. Rather than stripping away the pleasure of driving, car manufacturers realize that highly automated passenger vehicles will simply provide drivers with more choices for comfortable travelling towards the use of a clear and understandable human-machine interface (HMI) which enhancing the collaboration between the embedded operator system in the car and the driver.

Furthermore, the financial purchasing and operating cost, the trust in automation technology and the social influence appear to be important deciding factors. Therefore, stakeholders in the automotive field can consider the above implications, when applying high-tech transportation choices, by maximizing the uptake of passenger vehicles with high automation technology.

The above suggests that the benefits of highly automated passenger vehicles must be promoted to potential consumers through established communication channels. In this context, social networks could play an important role as family, friends and others represent a trusted source of information for many people. In addition, test rides and education campaigns should be implemented in order to expose to the potential consumers what highly automated passenger vehicles can do in real-field situations.

VII. CONCLUSION

Highly automated (SAE L3+) passenger vehicles are rapidly becoming a topic of international research. Gaining experience, over the coming years, with driving automation in passenger vehicles, could yield us to better understand which factors are the major determinants for consumers' willingness to use highly automated passenger vehicles. On this basis, public acceptance becomes fundamental in order to predict aspects that are likely to maximize the adoption of highly automated passenger vehicles.

Following the above, this paper follows the application of an expanded UTAUT acceptance model, through investigating the factors that aim to influence consumers' intention to accept highly automated passenger vehicles, and thus, improving our understanding towards public acceptance of such vehicles. The results provide evidence that enjoyment of driving, financial cost, social influences and reliability/trust were all useful predictors regarding consumers' intention to adopt and use highly automated passenger vehicles. The implications extracted from the present research study will contribute to the efforts of the automotive and IT companies in providing proper strategies that will enable implementation of highly automated passenger vehicles in the near future.

It should be stated that the present research effort has limitations that should be taken into consideration before interpreting the research findings. Firstly, what should be evaluated is the futuristic character of highly automated passenger vehicles at the period of the survey implementation. Therefore, the vast majority of our respondents did not have any real and concrete experience with SAE L3+ passenger vehicles and could only state on their guesses according to the information they might have gathered personally, as well as to the descriptions at the introduction of the questionnaire survey. In this direction, as the results of our survey rely to a large extent on people's imagination regarding the future operation of highly automated passenger vehicles, real demonstrations are needed to test such vehicle technologies (e.g., in operational speed and under different road/weather/traffic conditions) in order to convince the public what these vehicles can do in real conditions. Furthermore, our survey was Web-based and, thus, excluded potential users that may do not use the Internet. In addition, the majority of the respondents on our survey were relatively young (under 40 years old). Moreover, since only European people were surveyed in the present study, our results may not reflect the reality as consumers' preferences and expectations can vary among different geographical regions. In this direction, in order to better understand consumer preferences and expectations towards highly automated passenger vehicles, a further analysis could be made by collecting data from other geographical regions and compare the subsamples for similar user acceptance models and constructs. Moreover, a deep sensitivity analysis by including more demographics rather than age and gender variables could be applied to showcase their reflections to consumers' preferences and expectations towards highly automated passenger vehicles. Additionally, what could also be stated is to investigate the attitudes towards highly automated passenger vehicles among respondents with varying levels of knowledge and experience automation. Finally, part of our future activities also lies in exploiting and reporting the research work carried out currently within various research and development efforts in connected cooperative and automated mobility (CCAM), where users of dedicated CCAM services and simulators are already being investigated regarding their intentions and preferences towards automated vehicles, therefore yielding to up-scaled results and conclusions.

It is well known that consumers' behavioral responses and perceptions about innovative automotive technologies and highly automated passenger vehicles can change, in some cases, rapidly. In this respect, future analysis via extended acceptance models should be implemented to investigate deeper topics like road safety and efficiency, environmental impact, driver's productivity, etc. Thus, future research efforts should be applied to assess individuals' intention to adopt and use highly automated passenger vehicles.

In the light of the above, the implications extracted from the present study can provide significant contributions to the efforts of research and academic discussions in better understanding the factors that are expected to be the major determinants for consumers' willingness to use highly automated (SAE L3+) passenger vehicles. On this basis, automotive and IT companies could yield proper strategies in the near future, being able to maximize the public acceptance of highly automated (SAE L3+) passenger vehicles.

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