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The Relationship between Innovative Technology and Driver's Resistance and Acceptance Intention for Sustainable Use of Automobile Self-Driving System

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Abstract: The purpose of this study was to empirically analyze the relationship between the characteristics of innovative technology, innovation resistance, and acceptance intention of automobile autonomous driving systems by applying the technology acceptance model (TAM), a representative innovative technology in the era of the 4th Industrial Revolution. A survey was conducted on drivers living in Seoul, Korea, and the following main results were derived based on the survey data for 567 people. First, the perceived usefulness and perceived ease of use of the autonomous driving system were found to have a significant negative effect on innovation resistance, but the perceived risk factors did not have a significant effect on innovation resistance. Second, it was found that the driver's innovation resistance to the autonomous driving system had a significant negative effect on the acceptance intention. Third, the perceived risk of the autonomous driving system directly had a significant negative effect on the acceptance intention, but the perceived usefulness and perceived ease of use did not directly significantly affect the acceptance intention. Through this study, it was confirmed that resistance to innovative technologies can play an important role in enhancing the acceptance intention for sustainable use of automobile autonomous driving systems by drivers.

Keywords: automobile autonomous driving system; technology acceptance model (TAM); characteristics of innovative technology; innovation resistance; acceptance intention

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1. Introduction

Recently, automobile companies around the world have started developing fully autonomous vehicles centering on Tesla in the United States and are currently rapidly spreading. In the near future, most cars on the road are expected to be fully autonomous. Compared to vehicles driven by existing drivers, fully autonomous vehicles have both positive aspects such as convenience and negative aspects such as accident risk due to malfunction. When innovative technologies or services are introduced according to the modernization and futurization of our society, consumers show both acceptance and rejection. At the stage of embracing innovative technologies or services, consumers should also pay attention to the view of innovation resistance, which suggests that consumers refuse to accept innovation because they face very complex psychological situations [1,2]. In particular, it is necessary to pay attention to the psychological changes in consumers because the vehicle's fully autonomous driving technology is a disruptive innovative technology that can completely change the driving pattern of the automobile market and consumers in the era of the 4th Industrial Revolution.

Innovation requires consumer change, and resistance to sudden change can be said to be a natural consumer response. In the case of the technology acceptance model (TAM) and the innovation diffusion model, there is a limitation in research because they approach innovation only in a positive aspect (adoption and technology diffusion). Therefore, in early innovation studies, it may be more meaningful to conduct research on consumers with innovation resistance than to conduct research on diffusion with consumers with innovation

acceptance [3]. In addition, it is pointed out that users' innovation resistance is an important factor in the adoption and spread of innovative technologies [4,5]. In the case of the innovation diffusion theory, there is a limitation in that it is a study focusing on technical characteristics by analyzing adoption factors focusing on innovation characteristics [6,7].

In this theory of innovation diffusion, Ram (1987) explained that many research studies were conducted assuming that all innovations were positive [1]. In other words, studies related to technology acceptance, such as the theory of planned behavior (TPB), technology acceptance model (TAM), and unified theory of acceptance and use of technology (UTAUT), were all considered positive for innovation and conducted research [8,9]. However, in the process of adopting innovation, it is necessary to consider not only the characteristics of innovation but also the characteristics of consumers; therefore, a study that considers the psychological characteristics of consumers is necessary. Innovation is not a concept that is perceived and accepted as useful to all consumers. There is also resistance to innovation. This resistance to innovation is not an opposite or negative concept of innovation acceptance but a process that occurs in the process of accepting innovative technology [10], i.e., user innovation resistance is a concept that refers to consumer refusal to change when innovative technology or service is first introduced. The concept of the user's innovation resistance was first argued by Sheth (1981) [3]. Afterward, Ram (1987) [1] summarized the concept of users' innovation resistance, and as a result, it was defined as the psychological state of consumers who refused to change from the current state. In other words, it was argued that resistance such as a sense of threat due to innovative change naturally arises in the process of accepting innovation. However, if the user's innovation resistance continues, the social spread and acceptance of innovative technology may be delayed or extinguished in the market; therefore, it is necessary to analyze the factors affecting the user's innovation resistance and take appropriate measures. In fact, most companies face difficulties in the failure of innovative products and services, and the main cause of this has been found to be due to consumer innovation resistance [11,12].

Until now, studies applying the technology acceptance model (TAM) in various industrial fields have been conducted. Kim et al. (2018) [13] applied the TAM to the factors affecting the acceptance of ICT convergence/complex technology by farmers to raise alternatives and problem solutions for expanding and settling ICT convergence/complex in rural areas [14]. In the tourism industry, research was conducted on the acceptance of hotel products using social commerce platforms using the innovative technology acceptance model (TAM), which is related to high-tech technologies, by applying an extended TAM to AI speakers [15]. In this way, studies using the innovative technology acceptance model (TAM) have been conducted in various fields, industries, technologies, and products, but studies on the resistance and acceptance of fully autonomous vehicle technology, which is a key industry in the era of the 4th Industrial Revolution, are relatively limited. Therefore, the purpose of this study was to empirically analyze how the usefulness, ease of use, and perceived risk, which are the characteristics of the innovative technology of the complete autonomous driving system, affect drivers' innovation resistance and acceptance intention of innovative technology for sustainable use and diffusion worldwide. Through this analysis, we intended to derive the characteristics of the innovative technology of the fully autonomous driving system that affects consumers' resistance to innovative technology and acceptance of the technology.

2. Theoretical Background

This section describes the concept of innovation characteristics, innovation resistance, and acceptance intention according to the technology acceptance model, which is the basis for the automobile autonomous driving system, and previous studies.

2.1. Automobile Autonomous Driving System

An autonomous driving system of an automobile refers to a system in which the automobile system controls itself according to independent judgment on behalf of the

driver. In other words, an autonomous vehicle refers to a vehicle that can operate safely on its own by minimizing the driver's driving operation while recognizing the driving environment by itself without the driver's operation to determine the risk and plan and control the driving route. Technically, self-driving systems automatically drive to their destinations through various sensors installed in the hardware [16]. With the remarkable development of AI, sensors, semiconductors, cameras, and 5G communication, many automobiles are commercialized.

As shown in Table 1, the Society of Automotive Engineers (SAE) [17] defines self-driving cars as classified from Level 0 to Level 5, with Level 0 meaning manual operation and Level 5 all road or environmental conditions. The vehicle system determines and drives by itself and classifies the level of fully automatic operation that does not require the driver. In addition, the steps in between are classified and defined as follows: Level 1 is "Driver Assistance". Operation by the system is supported in steering functions such as acceleration or change in direction. Level 2 is partially automatic operation. The system supports more advanced functions than Level 1 in acceleration and steering. However, up to this level, the driver must be the main agent, intervene in driving, and be aware of the surrounding situation. Level 3 is conditional automation. Even though Level 3 is conditional automatic operation, it is differentiated from the previous step in that all operations are in charge of the system. However, the driver should still be ready to immediately intervene in the driving situation at any time in preparation for an emergency situation. Level 4 is high automation. At this level, the vehicle's autonomous driving system controls the intervention operation in all driving situations so that problems do not arise without responding to driving situations [17].

Table 1. Definition of self-driving system by step.

Step	Sortation	Definition
Step 0	Deautomation	Regular cars without self-driving capabilities
Step 1	Driver assistance function	Automatic brake, automatic speed adjustment, etc., driving assistance
Step 2	Partial autonomous driving	Two or more automation functions are operated simultaneously while the driver is driving, partial autonomous driving, and constant supervision of the driver is required
Step 3	Conditional autonomous driving	Limited autonomous driving by artificial intelligence in automobiles is possible, but driver intervention is essential depending on specific situations
Step 4	Advanced self-driving	No driver intervention or monitoring is required when driving in a road environment including on-site driving
Step 5	Full automation	No driver intervention required in all environments

Ref.: SAE, Society of Automotive Engineers [17].

Separately, the National Highway Transportation Agency (NHTSA) defines autonomous driving levels as shown in Table 2. Level 3 is defined similarly to the SAE. However, the difference is that the NHTSA defines the corresponding matters of Level 4 and Level 5 defined by the SAE as Level 4. The ultimate goal of autonomous driving is completely autonomous driving, in which the driver does not have to pay attention to or intervene in the driving situation at all, which corresponds to Level 4 and Level 5 defined by the SAE and Level 4 defined by the NHTSA [18].

Apart from the self-driving car stage defined by the International Association of Automobile Engineers (SAE) and the National Highway Traffic Safety Administration (NHTSA), the automobile industry and Tier-1 parts companies are introducing products such as self-driving trucks and shuttles to specific areas under the definition of "self-driving Level 2+." "Level 2+" refers to the intermediate stage between Level 2 equipped with various ADASs and Level 3 where all functions of the vehicle can be automatically controlled, but autonomous driving on/off is possible at the discretion of the driver.

Table 2. Definition of self-driving by level.

Level	Definition
Level 0	Driver controls all movements
Level 1	Initial operation autonomy (automatic emergency stop, constant speed driving ACC)
Level 2	Automate more than one rudimentary operation
Level 3	Automate to monitor everything around driver
Level 4	Fully autonomous driving without the need for a driver

Ref.: NHTSA, National Highway Transportation Agency [18].

Table 3 presents classification of self-driving cars by institution. As shown in Table 3, according to the classification of the Society of Automotive Engineers (SAE) and the National Highway Traffic Safety Administration (NHTSA), Level 3 is partially autonomous, but technically, all control functions of the vehicle are automated. From Level 3, when an accident occurs in the autonomous driving mode, the responsibility for the accident passes from the driver to the vehicle manufacturer [19]; therefore, Level 3 is greatly different from Level 2 in that the vehicle manufacturer is responsible for the accident in the autonomous driving mode. Until the development of fully autonomous driving technology, the current technology is not mature to implement Level 3 in all regions, and regulations or consumers are not ready to accept it; therefore, self-driving technology is only applied to specific regions and vehicles for specific purposes. Korea has also begun to provide legal support for the development of autonomous vehicles by legally defining safety standards for Level 3 of the autonomous driving system at the government level [20].

Table 3. Classification of self-driving cars by institution.

NHTSA Level	SAE Level	Definition of Autonomous Level		Characteristics
0	0	No automation		No support
1	1	Driver assistance		Provides driving information, generates alerts, and supports some controls
2	2	Automated	Partial automation	Automates some of the vehicle controls according to driver selection in special circumstances
3	3	Automated	Conditional automation	Automates all vehicle controls, driver manually/automatically selected
4	4	Autonomous	High automation	The vehicle can drive on its own in all traffic conditions. Commercialization distance, legal/institutional problem resolution required
4	5	Autonomous	Full automation	The vehicle can drive on its own in all traffic situations without any legal or institutional problems

Ref.: United States Dept. of Transportation (2018) [21].

2.2. Innovation Characteristics and Technology Acceptance Model (TAM)

The technology acceptance model (TAM) is a model that describes the factors that affect the acceptance of IT devices and IT users. This model is a theory that argues that the perceived usefulness and ease of use of new innovations affect the attitude toward the use of innovative products or technologies due to the cognitive nature of consumers associated with innovation [22]. The technology acceptance model presents two leading factors for accepting new innovative technologies: perceived usefulness of consumers and perceived ease of use. First, perceived usefulness refers to the degree to which the consumer believes that using any innovative product or service is useful to the consumer or that a profit will be generated. Perceived ease of use means how convenient and easy it is for consumers to use any innovative product or service. Therefore, the intention of consumers to accept new technologies is determined by their attitude toward the use of new innovations and their perceived usefulness and perceived ease of use [22]. The technology acceptance model

proposed by Davis et al. (1989) is an extended rational behavior theory (TRA), in which users have the intention to accept technology depending on the usefulness and ease of use of a particular technology [23].

Recently, several empirical studies have been reported regarding acceptance models on autonomous driving, e.g., Rahmann et al. (2017), Panagiotopoulos and Dimitrakopoulos (2018), Kuhn and Marquardt (2019), and Casidy et al. (2021). Waytz et al. (2014) [24] experimentally studied the effect of anthropomorphism of autonomous vehicles on trust and acceptance. In their study, participants using driving simulators drove regular cars. In addition, participants drove autonomous vehicles capable of controlling steering and speed. Finally, participants drove similar autonomous vehicles with additional anthropomorphic features such as name, gender, and voice. According to the results of the study, participants believed that the more anthropomorphic features the vehicle acquired, the more performance would improve. It was predicted that trust in these autonomous vehicles would ultimately have a positive effect on the intention to use them. Rahmana et al. (2017) [25] studied the acceptance of advanced driver assistance systems (ADASs) by applying the technology acceptance model (TAM), the theory of planned behavior (TPB), and the unified theory of acceptance and use of technology (UTAT) to ADASs such as self-driving vehicles. The result shows that all the models (TAM, TPB, and UTAUT) can explain driver acceptance with their proposed research model and driver attitude toward using the ADAS and their perception of its usefulness, ease of use, etc. The TAM was found to perform the best in modeling driver acceptance. Panagiotopoulos and Dimitrakopoulos (2018) [26] investigated consumers' perception of autonomous vehicles and empirically verified the effect of perceived usefulness and perceived ease of use on usage intention/purchase intention. According to the survey, 62% of consumers considered themselves late adopters of new technology, and only 44% of consumers considered self-driving cars safe if they owned self-driving cars. These results suggest that more than half (50%) of consumers are passive in accepting new innovative technologies and still question the safety of autonomous vehicles regardless of actual stability. Both the perceived usefulness and perceived ease of use of consumers were found to have a significant positive effect on the intention to use or purchase an autonomous vehicle, and in particular, the perceived usefulness had a relatively greater effect on the intention to use or purchase an autonomous vehicle. Kuhn and Marquardt (2019) [27] conducted an experimental study on Mercedes-Benz E-Class or S-Class level 2 driver assistant systems using eye-tracking glasses. Since the perception and evaluation of the automatic driving function are expected to be correlated with the driver's behavior, the gaze-tracking data as an implicit behavior measurement were experimentally investigated for the acceptance of automatic driving by autonomous vehicles. Casidy et al. (2021) [28] conducted an empirical study on consumer resistance and acceptance of AI-based technology in the context of autonomous vehicles. They explained that consumer resistance is a major barrier to spreading radical innovation into the mainstream. Among the many factors affecting consumer resistance and acceptance, self-branding was set as a predictor to verify whether the brand of autonomous vehicles had an impact on radical innovation adoption by mitigating consumer resistance. As a result, it was found that self-brand factors of autonomous vehicles negatively affect usage barriers and positively affect usage intentions. These results suggest that brand factors can be an important factor in consumer resistance and intention to use autonomous vehicles, one of the AI-based innovations.

2.3. Innovation Resistance

Sheth (1981) [29], who first conducted a study on the concept of innovation resistance, presented the concept of resistance in acceptance, not resistance in the opposite concept of innovation. He argued that the negative feelings brought about by innovation can be expressed as uncertain feelings about innovative new technologies, lack of trust, and constant doubts. Developing this concept, Rogers (2003) [30] stated that consumers go through the five stages of knowledge → persuasion → decision → execution → confirmation to accept innovative technologies or products. Most consumers felt that they were

reluctant to change because they were inclined to maintain the status quo, and therefore, they had a greater sense of resistance to innovation after the introduction of new technologies [11]. If innovation resistance reduces the resistance consumers feel by paying attention to the characteristics of existing research and the independent nature of innovation, it can mass-produce more purchases and consumer segments in early acceptance of products [31].

2.4. Acceptance Intention

Acceptance intention can be defined as the intention of consumers to continue to accept some product or service [30]. In this respect, the more consumers perceive the autonomous driving system focused on in this study as useful and easy to use, the more positive their attitude and intention for actual use will be, which increases the dissemination and use of innovative technologies such as autonomous driving systems. Acceptance intention is regarded as a starting point for actual use, and this becomes a direct determinant of the use of new and innovative information and communication technologies. Therefore, including acceptance intention increases the predictive power of actual use compared to not.

3. Research Design and Methodology

3.1. Subjects of Investigation

The demographic characteristics of 567 Korean drivers, the sample of this study, are shown in Table 4. The age group was the largest with 262 people in their 30s (46.2%), followed by 143 people in their 40s (25.2%), 122 people in their 20s (21.5%), and 40 people in their 50s or older (7.1%). The number of employed people was 376 (66.3%), followed by 138 housewives (24.3%), 32 students (5.6%), and 18 professionals/self-employed (3.2%). The average monthly (household) income was distributed in the order of 162 people (28.6%) with KRW 4–6 million, 159 people (28.0%) with KRW 2–4 million, and 159 people with more than KRW 6 million (28.0%). In terms of driving experience, there were 23 people (4.1%) with under 1 year, followed by 121 people (21.3%) with 1 year-3 years, 135 people (23.8%) with 3 years-5 years, and 288 people (50.8%) with over 5 years.

Table 4. Demographic characteristics of the subjects.

Variables		N	%
Age	20s	122	21.5
	30s	262	46.2
	40s	143	25.2
	50s and above	40	7.1
Occupation	Office workers/public officials	376	66.3
	Housewife	138	24.3
	Student	32	5.6
	Professional/self-employed person, etc.	18	3.2
		3	0.5
Monthly Income	Less than KRW 2 million	87	15.3
	KRW 2∼4 million	159	28.0
	KRW 4∼6 million	162	28.6
	More than KRW 6 million	159	28.0
Driving Experience	less than a year	23	4.1
	1∼3 years	121	21.3
	3∼5 years	135	23.8
	More than 5 years	288	50.8
Total		567	100.0

3.2. Research Models and Hypotheses

In this study, the innovation characteristic variable of the autonomous driving system was designed as an independent variable, and the acceptance intention variable for the autonomous driving system was designed as a dependent variable. In addition, the recipient's

innovation resistance was set as a parameter for the autonomous driving system. In the case of the innovation characteristics of the autonomous driving system, they were composed of a total of three factors—perceived usefulness, perceived ease of use, and perceived risk—referring to previous studies, and innovation resistance and acceptance intention were each composed of one factor. The model of this study was as shown in Figure 1.

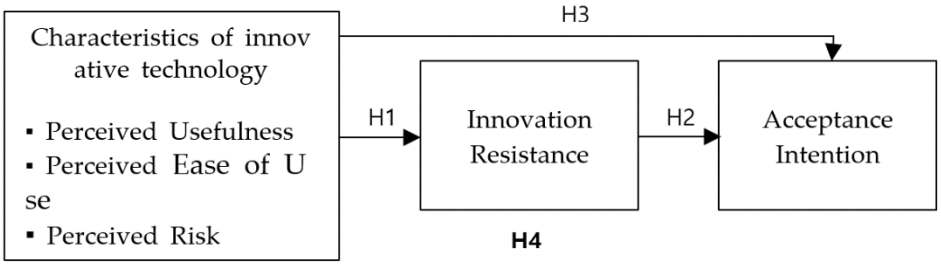


Figure 1. Research model of this study.

Innovation resistance occurs when an innovative product or service is less attractive than the existing product or service to be replaced by the consumer or is less attractive than the product or service currently in use [32,33]. In a study examining the acceptance process of e-books, Yoon and Kim (2014) [4] empirically verified that the higher the relative advantage, the lower the innovation resistance. Shin (2016) [34] presented the results that the relative advantage has a negative effect on innovation resistance and complexity has a positive effect on innovation resistance. The study by Oh et al. (2006) [35], through empirical research, found that the higher the user perceives the relative usefulness, the lower the innovation resistance. In addition to perceived usefulness, a representative innovation characteristic that affects innovation resistance and acceptance is perceived risk. An empirical study by Lim et al. (2015) [36] found that the greater the degree of risk perceived by consumers (users), the higher the resistance to innovation. In the study by Arts et al. (2011) [37], based on the technology acceptance model, it was also found that the perceived risk had a negative effect on acceptance intention. Meanwhile, Bae (2016) [38] empirically investigated that the higher the suitability of consumers (users) to perceive products/services, the lower the resistance to innovation. Based on the preceding studies above, it can be inferred that there is a significant relationship between the characteristics of innovative technology, innovation resistance, and acceptance intention, and thus the following hypotheses were established in this study.

Hypothesis 1 (H1). *The innovation characteristics of the autonomous driving system will affect innovation resistance.*

Hypothesis 1-1 (H1-1). *The perceived usefulness of the autonomous driving system will affect innovation resistance.*

Hypothesis 1-2 (H1-2). *The perceived ease of use of the autonomous driving system will affect innovation resistance.*

Hypothesis 1-3 (H1-3). *The perceived risk of the autonomous driving system will affect innovation resistance.*

Hypothesis 2 (H2). *Innovation resistance to the autonomous driving system will affect acceptance intention.*

Hypothesis 3 (H3). *The innovation characteristics of the autonomous driving system will affect acceptance intention.*

Hypothesis 3-1 (H3-1). *The perceived usefulness of the autonomous driving system will affect acceptance intention.*

Hypothesis 3-2 (H3-2). *The perceived ease of use of the autonomous driving system will affect acceptance intention.*

Hypothesis 3-3 (H3-3). *The perceived risk of the autonomous driving system will affect acceptance intention.*

Hypothesis 4 (H4). *The innovation characteristics of the autonomous driving system will affect acceptance intention by mediating innovation resistance.*

Hypothesis 4-1 (H4-1). *The perceived usefulness of the autonomous driving system will affect acceptance intention by mediating innovation resistance.*

Hypothesis 4-2 (H4-2). *The perceived ease of use of the autonomous driving system will affect acceptance intention by mediating innovation resistance.*

Hypothesis 4-3 (H4-3). *The perceived risk of the autonomous driving system will affect acceptance intention by mediating innovation resistance.*

3.3. Measurement

3.3.1. Innovation Characteristics of the Autonomous Driving System

The innovation characteristics of the autonomous driving system were composed of three sub-factors: usefulness, ease of use, and risk perceived by users based on the studies by Ram and Sheth (1989) [31] and Kim (2018) [39]. All questions were measured on a Likert 5-point scale, and the higher the score, the greater the driver's perception of the usefulness, ease of use, and risk of the autonomous driving system.

3.3.2. Innovation Resistance

The driver's innovation resistance to the autonomous driving system was composed of one factor based on the research by Ram (1987) [1] and Kim (2018) [39]. All questions were measured on a Likert 5-point scale, and the higher the score, the greater the driver's innovation resistance to the autonomous driving system.

3.3.3. Acceptance Intention

The driver's intention to accept the autonomous driving system was composed of one factor based on the research by Venkates et al. (2003) [9] and Yoon (2012) [40]. All items were measured on a Likert 5-point scale, and the higher the score, the greater the driver's intention to accept the autonomous driving system.

3.4. Data Processing

The statistical processing of the collected data for this study was conducted using the SPSS and AMOS statistical programs (version 26.0, IBM, Armonk, NY, USA). First, the frequency and percentage were calculated to find out the demographic characteristics of drivers living in Seoul, Korea. Second, a confirmatory factor analysis (CFA) was performed to verify the reliability of the measurement tools for the innovation characteristics, innovation resistance, and acceptance intention of the autonomous driving system, and Cronbach's α coefficient was calculated. Third, a structural equation model (SEM) was used to verify the hypotheses and to examine the relationship between the characteristics of innovative technology, innovation resistance, and acceptance intention of the autonomous driving system. Fourth, the bootstrapping method was applied to verify the mediation effects of the innovation resistance between the characteristics of innovative technology and the acceptance intention of the autonomous driving system.

4. Results

4.1. Verification of Reliability and Validity of Measurement Tools

First, the Cronbach's α coefficient was calculated to verify the reliability of the measurement tool for the innovation characteristics, innovation resistance, and acceptance intention of the autonomous driving system. Reliability refers to the consistent degree between measured multivariate variables, which is the variance of measurements that appear when repeatedly measured for the same concept, generally considered to be reliable if the Cronbach's α value is 0.60 or higher. As shown in Table 5, the reliability verification results show the perceived usefulness of the innovation characteristics of the autonomous driving system as 0.809, perceived ease of use as 0.868, perceived risk as 0.731, innovation resistance as 0.860, and acceptance intention as 0.833. Therefore, it was confirmed that the research variables were composed of questionnaire items with sufficient internal consistency, and the reliability of the measurement tool was ensured.

Table 5. Verification of reliability of the measurement tool.

Variables		Number of Items	Cronbach's α
Innovation Characteristics	Perceived usefulness	3	0.809
Innovation Characteristics	Perceived ease of use	3	0.868
Innovation Characteristics	Perceived risk	3	0.731
Innovation Resistance		5	0.860
Acceptance Intention		3	0.833

Next, a confirmatory factor analysis was performed to verify the convergent validity and discriminant validity of the measures of perceived usefulness, perceived ease of use, perceived risk, innovation resistance, and acceptance intention, which are innovation characteristics of the autonomous driving system. In order to evaluate the fit of the measurement model, it is very important to select an appropriate fit index that is not sensitive to the size of the sample and considers the simplicity of the model [41]. Therefore, in this study, χ^2, standardized root mean resolution (SRMR), TLI (Tacker–Lewis Index), and CFI (Comparative Fit Index) were used. In general, χ^2 is usually suitable when $p > 0.05$ but sensitive to the number of samples; therefore, other goodness-of-fit indices should be considered first. TLI and CFI generally suggest a good fit if 0.90 or higher, and SRMR shows a good fit if 0.08 or lower [42]. In the case of RMSEA, where the confidence interval is presented, if it is less than 0.05, it is evaluated as a good fit; if it is less than 0.08, it is evaluated as a good fit; and if it is less than 0.10, it is evaluated as a normal fit [43].

As a result of reviewing the correction index by performing confirmatory factor analysis, item 2 of innovation resistance showed a high correlation with other items, which hindered discrimination validity and unidimensionality; therefore, it was additionally removed from the measurement model. Looking at the suitability of the measurement model of this study, 22 = 766.523 (df = 231, $p < 0.001$), SRMR = 0.059, TLI = 0.903, CFI = 0.919, and RMSEA (90% CI) = 0.064 (0.059~0.069) show good suitability, indicating that the measurement model was suitable for the data. In addition, the factor loads of all measurement variables for potential variables, such as perceived usefulness, perceived ease of use, perceived risk factors, and innovation resistance and acceptance intention for the autonomous driving system, were all statistically significant ($p < 0.001$), and all of the standardized factor loads were higher than 0.50.

Table 6 shows confirmatory analysis result. As shown in Table 6, in order to analyze the convergent validity of the variables, construct reliability (CR) and average variance extracted (AVE) were estimated. First, convergent validity refers to the degree of correlation

between two or more measurement items for one latent variable, and in general, if the construct reliability is 0.70 or higher and the average variance extracted value is 0.50 or higher, the construct validity is considered to be acceptable. As shown in Table 7, in terms of construct reliability (CR), perceived usefulness (0.910), perceived ease of use (0.890), perceived risk (0.818), innovation resistance to the autonomous driving system (0.891), and acceptance intention (0.893) were all 0.70 or higher. Consequently, convergent validity was confirmed.

Table 6. Confirmatory analysis.

Variables	Item	Non-Standardized Factor Loading	Standardized Factor Loading	Standard Error	*t*	Construct Reliability	Average Variance Extracted
Perceived Usefulness	→ PU 1	1.000		0.873		0.910	0.774
	→ PU 2	0.927	0.047	0.839	19.927 ***	0.910	0.774
	→ PU 3	0.690	0.048	0.593	14.271 ***	0.910	0.774
Perceived Ease of Use	→ UA 2	1.000		0.773		0.890	0.730
	→ UA 3	1.213	0.057	0.886	21.206 ***	0.890	0.730
	→ UA 4	1.103	0.055	0.826	20.141 ***	0.890	0.730
Perceived Risk	→ PR 1	1.000		0.673		0.818	0.600
	→ PR 2	1.122	0.088	0.750	12.705 ***	0.818	0.600
	→ PR 3	0.918	0.078	0.640	11.810 ***	0.818	0.600
Innovation Resistance	→ IR 1	1.000		0.708		0.891	0.670
	→ IR 3	1.229	0.074	0.766	16.574 ***	0.891	0.670
	→ IR 4	1.274	0.075	0.784	16.916 ***	0.891	0.670
	→ IR 5	1.256	0.075	0.779	16.819 ***	0.891	0.670
Acceptance Intention	→ AI 1	1.000		0.865		0.893	0.737
	→ AI 2	1.090	0.043	0.888	25.100 ***	0.893	0.737
	→ AI 3	0.835	0.049	0.654	16.951 ***	0.893	0.737

χ^2 = 766.523 (df = 231, p = 0.000), SRMR = 0.059, TLI = 0.903, CFI = 0.919, RMSEA (90% CI) = 0.064 (0.059~0.069), *** $p < 0.001$.

Table 7. Correlation between the research variables.

Variables	Innovation Characteristics			Innovation Resistance	Acceptance Intention
	Perceived Usefulness	Perceived Ease of Use	Perceived Risk		
Perceived Usefulness	0.774	(0.115)	(0.059)	(0.265)	(0.238)
Perceived Ease of Use	0.339 ***	0.730	(0.359)	(0.193)	(0.161)
Perceived Risk	–0.243 ***	–0.599 ***	0.600	(0.093)	(0.138)
Innovation Resistance	–0.515 ***	–0.439 ***	0.305 ***	0.670	(0.549)
Acceptance Intention	0.488 ***	0.401 ***	–0.372 ***	–0.741 ***	0.737

*** $p < 0.001$. The diagonal value is the average variance extracted value. The value below the diagonal is the correlation coefficient, and the value above the diagonal is the square value of the correlation coefficient.

Lastly, looking at the discriminant validity between variables, discriminant validity shows how different one latent variable is from the other, and the most conservative evaluation method is that the average variance extracted value of each of the two latent variables is greater than the square of the correlation coefficient of the two latent variables. As a result of confirming the discriminant validity by comparing the square of the correlation coefficient presented in Table 7 with the average variance extracted value, the discriminant validity between the latent variables was secured. On the other hand, the

research variables perceived usefulness and perceived ease of use, which are factors of the innovation characteristics of the autonomous driving system, showed a significant negative correlation with acceptance intention. The perceived risk showed a significant positive correlation with innovation resistance and a significant negative correlation with acceptance intention. Finally, there was a significant negative correlation between innovation resistance and acceptance intention for the autonomous driving system. Examination of the correlation between the research variables showed a direction consistent with the hypothesis set in this study.

4.2. Verification of Research Hypothesis

Table 8 shows the results of the verification of the research hypotheses to investigate the relationships between innovation characteristics (perceived usefulness, perceived ease of use, perceived risk), innovation resistance, and acceptance intention of the autonomous driving system.

Table 8. Verification of the research hypotheses (SEM).

Path			B	SE	β	*T (C.R)*	*p*
Perceived Usefulness	→	Innovation Resistance	−0.195	0.046	−0.216	−4.235	0.000
Perceived Ease of Use	→	Innovation Resistance	−0.125	0.046	−0.161	−2.738	0.006
Perceived Risk	→	Innovation Resistance	0.033	0.060	0.032	0.549	0.583
Innovation Resistance	→	Acceptance Intention	−0.646	0.079	−0.512	−8.203	0.000
Perceived Usefulness	→	Acceptance Intention	0.055	0.053	0.047	1.044	0.297
Perceived Ease of Use	→	Acceptance Intention	−0.076	0.052	−0.077	−1.460	0.144
Perceived Risk	→	Acceptance Intention	−0.149	0.068	−0.118	−2.201	0.028

B: Non-standardized path coefficient; SE: Standard error; β: Standardized path coefficient.

First, the results of the verification of research Hypothesis 1, which predicted that the innovation characteristics of the autonomous driving system would affect the innovation resistance, were examined. As a result, among the factors of the innovation characteristics of the autonomous driving system, perceived usefulness (standardized path coefficient = −0.216, t = −4.235, $p < 0.001$) and perceived ease of use (standardized path coefficient = −0.161, t = −2.738, $p < 0.01$) were found to have a significant negative effect on innovation resistance, but perceived risk did not have a significant negative effect on innovation resistance. These results imply that the higher consumers perceive the usefulness and ease of use of the autonomous driving system, the lower their resistance to the autonomous driving system; therefore, it can be seen that the perceived usefulness and ease of use are the main predictors affecting innovation resistance. Therefore, research Hypotheses 1-1 and 1-2 were accepted, but 1-3 was rejected.

Next, the results of the verification of Hypothesis 2, which predicted that innovation resistance to the autonomous driving system would affect the intention to accept, were examined. As a result, it was found that consumers' resistance to the autonomous driving system has a significant negative effect on acceptance intention (standardized path coefficient = −0.512, t = −8.203, $p < 0.001$). These results mean that the lower the consumers' innovation resistance to the autonomous driving system, the higher the intention to accept the autonomous driving system. Therefore, Hypothesis 2 was accepted.

Next, the verification results of research Hypothesis 3, which predicted that the innovation characteristics of the autonomous driving system would affect the intention to accept, were examined. As a result, the perceived risk of the autonomous driving system has

a negative effect that directly means the intention to accept (standardized path coefficient = −118, t = −2.201, $p < 0.05$). However, the perceived usefulness and perceived ease of use did not directly have a significant effect on acceptance intention. These results mean that the higher the risk of the autonomous driving system, the lower the intention to accept the customized autonomous driving system; therefore, it can be seen that the perceived risk factor among the innovation characteristics of the autonomous driving system is the main predictor. Therefore, research Hypothesis 3-3 was accepted, but 3-1 and 3-2 were rejected.

Finally, bootstrapping was performed to verify research Hypothesis 4, which assumed the mediating effects of innovation resistance between the characteristics of innovative technology and acceptance intentions of the autonomous driving system. In the bootstrapping method, if the 95% confidence interval (CI) does not contain a zero, it is considered that the mediating effect is significant at the significance level of 0.05. The results of the research Hypothesis H4 verification are shown in Table 9.

Table 9. Mediating effects of innovation resistance (bootstrapping).

Path			Indirect Effect				
			Non-Standardized Coefficient	Standard Error	Standardized Coefficient	95% CI	*p*
Perceived Usefulness	Resistance	Acceptance Intention	0.402	0.088	0.378	(0.145~0.448)	0.000
Perceived Ease of Use	Resistance	Acceptance Intention	0.388	0.090	0.355	(0.094~0.387)	0.007
Perceived Risk	Resistance	Acceptance Intention	−0.316	0.074	−0.289	(−0.213~−0.089)	0.011

Bootstrapping sampling (N = 1000).

The result shows that the perceived usefulness of the autonomous driving system → resistance → acceptance intention (standardized path coefficient = 0.378, 95%CI: 0.145~0.448, $p < 0.00$), perceived ease of use → resistance → acceptance intention (standardized path coefficient = 0.355, 95%CI: 0.094~0.387, $p < 0.01$), perceived risk → resistance → acceptance intention (standardized path coefficient = −0.289, 95% CI: −0.213~−0.089) paths all did not contain a zero in the 95% confidence interval. These results confirm that perceived usefulness, perceived ease of use, and perceived risk among the characteristics of innovative technology of the autonomous driving system affect acceptance intention by mediating innovation resistance. Accordingly, research Hypotheses 4-1, 4-2, and 4-3 were all supported.

5. Discussion

The discussion focusing on the hypothesis verification results of this study is as follows.

First, as a result of verifying the effect of the innovation characteristics of the autonomous driving system on innovation resistance, perceived usefulness and perceived ease of use were found to have a significant negative effect on innovation resistance, but the perceived risk factor did not have a significant effect on innovation resistance. These results mean that the higher the drivers perceive the usefulness and ease of use of the autonomous driving system, the lower the innovation resistance to the autonomous driving system. Therefore, in order to lower the innovation resistance to the autonomous driving system, it is necessary to sufficiently persuade drivers of the perceived usefulness and perceived ease of use, which are positive factors rather than negative factors of the autonomous driving system. Yoon et al. (2014) [4] studied the acceptance process of e-books and empirically verified that the higher the perceived usefulness, the lower the innovation resistance. Shin (2015) [34] studied the acceptance process of wrist-type wearable devices and reported that perceived usefulness had a negative effect on innovation resistance. Oh (2007) [35] also identified a relationship in which the higher the user perceives the relative usefulness compared to existing products, the lower the innovation resistance. Lim et al. (2015) [36] also reported a relationship in which innovation resistance

increases as the degree of the perceived risk of consumers (users) increases. Meanwhile, Bae et al. (2016) [38] empirically established that the higher the suitability of consumers (users) to perceive products/services, the lower the resistance to innovation. The above studies tend to be consistent with the results of this study, and therefore, it can be seen that they support the results of this study. Panagiotopoulos and Dimitrakopoulos (2018) [25] also empirically verified the effect of consumers' perceived usefulness and perceived ease of use of autonomous vehicles. According to their research, both the perceived usefulness and perceived ease of use of consumers were found to have a significant positive effect on the intention to use or purchase an autonomous vehicle, and in particular, the perceived usefulness had a relatively greater effect on the intention to use or purchase an autonomous vehicle. These results support the results of this study, in which both perceived usefulness and perceived ease of use have a positive effect on the intention to accept autonomous vehicles, and among them, perceived usefulness has a greater effect than perceived ease of use.

Second, as a result of verifying the effect of innovation resistance to autonomous driving systems on acceptance intention, drivers' innovation resistance to autonomous driving systems has a significant negative effect on acceptance intention. These results mean that the lower the consumers' innovation resistance to the autonomous driving system, the higher the intention to accept the autonomous driving system. Rogers (2004) [44] suggested that when resistance to innovative technology is eased, it is possible for recipients to accept innovative technology, and if such resistance is stronger than a certain level, the acceptance period is delayed or it is not accepted at all, which can be seen as an argument in line with the results of this study. In addition, it can be seen that the results of the study by Lim et al. (2015) [36], Bae (2016) [37], and Ram (1987) [1] suggest that the resistance of the consumers to innovative technology had a significant negative effect on the acceptance intention of the consumers.

Third, as a result of verifying the effect of the innovation characteristics of the autonomous driving system on the acceptance intention, the perceived risk of the autonomous driving system has a negative effect directly on the acceptance intention and perceived usefulness, but perceived ease of use does not directly have a significant effect on acceptance intention. This result means that the higher the risk of the autonomous driving system, the lower the intention to accept the autonomous driving system; therefore, it can be seen that the perceived risk factor among the innovation characteristics of the autonomous driving system is the main predictive factor. In the study by Arts et al. (2011) [37], based on the technology acceptance model, it was also found that the perceived risk had a negative effect on acceptance intention. A study by Jang (2019) [45] showed that the relative advantage of the autonomous vehicle system had a significant positive effect on the acceptance intention of the recipients, and the complexity factor had a significant negative effect on the acceptance intention of the recipients, but the perceived risk did not significantly affect the acceptance intention. The relative advantage corresponds to the perceived usefulness in this study, and the complexity corresponds to the perceived usability; therefore, these results can be seen as partially consistent with the results of this study. Meanwhile, Shin (2019) [46] reported that the perceived usefulness of innovative technologies such as cloud computing services in the information age had a positive effect on the acceptance intention of the recipients. This can be seen as a trend consistent with the research results of this study. In addition, the results of a study by Choi (2016) [47], which reported that the perceived usefulness and perceived ease of use of digital convergence had a positive effect on the acceptance intention of recipients, also show a trend consistent with this study and thus support the results of this study.

Fourth, in terms of the effects of the characteristics of innovative technology on the acceptance intention of autonomous driving systems, the mediating effect of innovation resistance was significant. These results imply that the innovative characteristics of the autonomous driving system, such as usefulness, ease of use, and risk perceived by drivers,

affect drivers' resistance to the autonomous driving system and ultimately their acceptance intention.

6. Conclusions and Suggestions

The results of this study suggest that drivers are relatively useful compared to self-driving systems and conventional driver vehicles, and the higher the perception of ease of use, the lower the rejection attitude or resistance to the self-driving system, ultimately increasing the acceptance intention. When innovative technologies appear in society, resistance and acceptance of members of society coexist; therefore, in order for innovative technologies to be widely distributed and spread in society, resistance must be lowered and acceptance must be increased. Since resistance to innovative technologies hinders sustainable use, sustainable use and dissemination are possible only when resistance to innovative technologies is lowered. In the end, it can be confirmed that resistance to innovative technologies can play an important role in increasing the acceptance intention for sustainable use by taking advantage of the relative advantages of the autonomous driving system. Through the empirical analysis of this study, the influence of the innovation characteristics, innovation resistance, and acceptance intention of the system was verified by applying the TAM model to the automobile self-driving system, which is an innovative technology in the 4th Industrial Revolution. In addition, the role of innovation resistance that inevitably appears in the path to acceptance intention of the autonomous driving system was identified. Through this, this study confirmed that drivers' vague resistance can be lowered and ultimately acceptance can be increased by accurately recognizing the positive characteristics of the autonomous driving system so that the inevitable innovation resistance can be lowered. Acceptance through such resistance mitigation will lead to the sustainable diffusion of autonomous vehicles in future societies.

Research on the application of the existing technology acceptance model has been mainly conducted only on information and communication technology, but this study can provide academic significance and differentiation from other studies in that it derives factors of innovation characteristics predicting resistance and acceptance of new innovation by applying it to automobile self-driving systems. This study can provide a theoretical contribution in that it empirically identified the process of reaching innovation resistance and acceptance intention by setting usefulness, ease of use, and risk factors perceived by consumers through the application of the technology acceptance model. In addition, in this study, it was found that the factor affecting the consumer's acceptance intention was the perceived risk, which could provide important implications for autonomous driving car manufacturers and suppliers. In other words, the usefulness and ease of use perceived by consumers have a positive effect on the consumer's innovative resistance, but eventually, the risk perceived by consumers has a decisive effect on the consumer's acceptance intention. The government also needs to strengthen the safety screening of autonomous driving cars and grant licenses to autonomous driving car manufacturers and suppliers who have sufficiently secured safety in order to address consumers' perception of risks.

This study, like existing empirical studies, has the following limitations. First, this study was derived by setting only 567 drivers aged 20 or older living in Seoul, Korea, as a sample group. Therefore, there may be limitations in generalizing the results of this study to the results of research on all innovative products other than the automobile autonomous driving system and all drivers in Korea. Second, the subject of this study is a driver who is currently driving a vehicle driven by an existing driver and cannot accurately represent all future fully autonomous vehicle drivers. Therefore, in subsequent studies, it will be necessary to select the survey subjects so that the sample of this study can sufficiently represent the fully autonomous vehicle drivers by reflecting the demographic characteristics of the survey subjects. In addition, it is expected to be a more interesting and meaningful study if this study is complemented by reflecting several demographic characteristics, including annual income (economic power). It would also be a meaningful

study to verify differences in driver and buyer perceptions of fully autonomous vehicles, as current drivers and car buyers may have different requirements and expectations for fully autonomous vehicles. It will be also necessary to explore more various factors influencing innovation resistance and acceptance intention by considering other effects that affect drivers' innovation resistance and acceptance intention for autonomous vehicles in the research model. Third, this study conducted a cross-sectional study through a survey study at a certain point in analyzing the relationship between the innovation characteristics, innovation resistance, and acceptance intention of the automobile autonomous driving system perceived by the surveyed drivers. It is not known whether the actual acceptance behavior of the drivers under investigation was reached. Therefore, in the follow-up study, it is necessary to expand the sample scope of this study limited to drivers living in Seoul to expand the survey target to drivers in other regions in Korea or other countries to derive more generalized results. In addition, in subsequent studies, it will be possible to derive more meaningful research results by conducting longitudinal studies that observe the actual use of the autonomous driving system in a certain period.

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