

## A STUDY ON FACTORS AFFECTING THE DIFFUSION OF AUTONOMOUS VEHICLES

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**ABSTRACT.** *Based on the TAM (technology of acceptance model), this study investigated the effect of product, communication and consumer characteristics on the intention to accept autonomous vehicles. The results show that convenience, playfulness, trust, social influence, experience and consumer knowledge were found to have a significant effect on perceived usefulness. Convenience, simplicity, trust, social influence, and consumer knowledge had a positive effect on perceived ease-of-use. Perceived usefulness and perceived ease-of-use were verified to have a significant effect on acceptance intention. Lastly, the social influence, which was redefined as the impact on society as a whole, was confirmed as a valid variable. This study redefined the social influence that was limited and defined in previous studies according to the characteristics of the 4th industrial revolution to confirm its role.*

**Keywords:** Autonomous vehicle, Innovation diffusion theory, Discontinuous innovation product, Social influence, Intention to accept

**1. Introduction.** Studies related to the acceptance of autonomous vehicles focus on product characteristics as factors influencing the diffusion and overlook communication characteristics and consumer characteristics. This presents a limitation with regard to comprehensively understanding the effect on diffusion. Ram [1], who presented the theory of innovation, further stated that in the process of adopting an innovation, not only the characteristics of the innovation, but the characteristics of consumers should also be considered. In addition, social influence is an important factor in technology acceptance and previous studies define by limiting it to conformance to the use of the reference group [2]. However, autonomous vehicles combined with next-generation information technology pose a threat to drivers such as taxi drivers and truck drivers. Certain occupations will be affected, such as auto mechanics who have to learn new skills. As a product it can affect society as a whole, such as changes in consumer driving habits and lifestyles. If the autonomous vehicle is a product that affects not only the individual but also the society to which the individual belongs, measuring the influence or ripple effect while considering the group that affects the acceptance intention of autonomous vehicle as just a reference group is a limitation. Thus, this study is to expand the scope of social influence and examine the effect of product, communication, and consumer characteristics with innovation diffusion theory [3] as antecedent factors of the TAM model. This study is structured as follows. Section 2 presents product characteristics, communication characteristics, and consumer characteristics of the innovation theory as antecedent factors of TAM, and hypothesizes the relationship these factors have on the acceptance of autonomous vehicles. Section 3

describes data collection and analysis. Section 4 describes the results. Finally, Section 5 consists of a conclusion.

**2. Background and Hypotheses<sup>1</sup>.** Convenience related to acceptance of autonomous vehicles can be viewed as the cost to users in time and effort related to using autonomous vehicles. An autonomous vehicle recognizes and determines road and driving conditions on its own, plans a driving route by itself, and can control according to the route plan. Although the driver does not drive using their hands and feet, if the driver requires less time and effort to arrive at the destination, a positive attitude and behavioral intention toward autonomous vehicles can be expected from consumers.

*H1a: The convenience of autonomous vehicles will have a positive impact on perceived usefulness.*

*H1b: The convenience of autonomous vehicles will have a positive effect on perceived ease-of-use.*

According to KPMG's 2018 survey [4] of global automobile company executives, the areas that future-minded car companies are paying attention to are "rest and social activities", "work and concentration", and "enjoy entertainment and driving". Playfulness is the degree to which one believes that using an autonomous vehicle will be enjoyable and fun [5]. An individual can enjoy various information and entertainment systems while moving, which is an important characteristic. This enjoyment will influence consumers towards having a positive perception of the usefulness of autonomous vehicles.

*H2: The playfulness of autonomous vehicles will have a positive impact on perceived usefulness.*

An autonomous vehicle incorporates cutting-edge technology, but if it is easier and simpler to operate than one thinks, consumers will consider it easy to use and, consequently, perceive a higher value from the product. Kaye et al. [6] verified the intention to accept automated vehicles by applying the UTAUT and confirmed that performance expectation and effort expectation have a significant effect on acceptance intention. If performance expectation is related to benefits, effort expectation is related to simplicity.

*H3a: The simplicity of autonomous vehicles will have a positive impact on perceived usefulness.*

*H3b: The simplicity of autonomous vehicles will have a positive effect on perceived ease-of-use.*

According to the report by the US National Highway Traffic Safety Administration, driver negligence accounts for about 94% of car accidents. If autonomous vehicles are used, traffic accidents due to driver negligence can be minimized, which can greatly contribute to reducing traffic fatalities. Moreover, properly controlling the vehicle's speed can increase energy efficiency and save fuel. This is a positive means to reduce not only fuel consumption but also environmental pollution. Blankesteyn et al. [7] described autonomous vehicles as an alternative to eco-friendly mobility that reduces traffic accidents caused by driver negligence and meets environmental regulations. Environmental issues are a major issue around the world today. Accordingly, if a new product, that is, the autonomous vehicle, satisfies social values, individuals will find the product more useful, and this may have a positive effect on acceptance intention.

*H4: Compatibility of autonomous vehicles will have a positive effect on perceived usefulness.*

Verberne et al. [8] suggested that trust is an important psychological factor in the acceptance of automated technologies in autonomous vehicles. Ward et al. [9] further found that trust is an important factor along with perceived risks, benefits, and knowledge

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<sup>1</sup>For the popularization of autonomous vehicles, price issues, related laws and regulations, and road system maintenance are also important issues. However, since this study focuses on factors that can be solved from the consumer's point of view through marketing strategies, the above problems are excluded.

with regard to the intention to use automated means of transportation. Along with risk, trust is an important factor in diagnosing whether an individual accepts automation [10]. The advent of new information technology provides improved benefits, but any product of discontinuous innovation that did not exist before faces resistance or is considered a threat as something never experienced before. This is when trust acts as a factor that reduces the risk from such resistance or threat factors [11]. Dai et al. [12] demonstrated through an experiment that trust influences attitude, which affects behavior toward autonomous vehicles, and confirmed the indirect effect of trust on behavior.

*H5a: Trust in autonomous vehicles will have a positive impact on perceived usefulness.*

*H5b: Trust in autonomous vehicles will have a positive impact on perceived ease-of-use.*

Social influence is very high with regard to the products of the Fourth Industrial Revolution [13]. Although this study mentioned about the negative impact of autonomous vehicles on our society in the introduction, it also has a positive impact on our society. For example, autonomous vehicles are attracting attention as a solution to problems such as rapid urbanization, traffic congestion, environmental problems, and energy inefficiency [14]. A product with high social influence can increase the likelihood of a consumer's purchase [2].

*H6a: The social influence of autonomous vehicles will have a positive effect on perceived usefulness.*

*H6b: The social influence of autonomous vehicles will have a positive effect on perceived ease-of-use.*

Product experience leads to more positive perception for product value through direct and indirect contact with consumers [15]. Consumers cannot accurately determine the safety of the product, which has not yet been launched or used. Therefore, when the perceived risk is high, such as in the case of an autonomous vehicle, the experiential factor reduces consumers' anxiety in the process of use. Conversely, through experience, the consumers will perceive the usefulness of the product and realize that it is easier to use than they thought.

*H7a: Experience with autonomous vehicles will have a positive impact on perceived usefulness.*

*H7b: Experience with autonomous vehicles will have a positive effect on perceived ease-of-use.*

The amount of consumer knowledge depends on the extent to which they have similar experiences or information regarding a new technology or product. When consumers evaluate a new product, they evaluate it based on their knowledge of the existing product and decide whether to accept it. Thus, the level of consumer knowledge plays an important role in recognizing and evaluating the differences between the existing product and the new innovative product [16]. As knowledge of autonomous driving functions accumulates, the understanding of various features and their usefulness will be better recognized.

*H8a: Consumer knowledge of autonomous vehicles will have a positive impact on perceived usefulness.*

*H8b: Consumer knowledge of autonomous vehicles will have a positive effect on perceived ease-of-use.*

Gu et al. [17] suggested that the usefulness and ease-of-use perceived by users about mobile payment services have a significant effect on their intention to use mobile payment services. Venkatesh and Davis [18] stated that perceived usefulness and ease-of-use simultaneously affect intention to use. These results can be applied to autonomous vehicles as well.

*H9: Perceived usefulness will have a positive effect on the acceptance intention of autonomous vehicles.*

*H10: Perceived ease-of-use will have a positive effect on the acceptance intention of autonomous vehicles.*

Figure 1 shows the conceptual model.

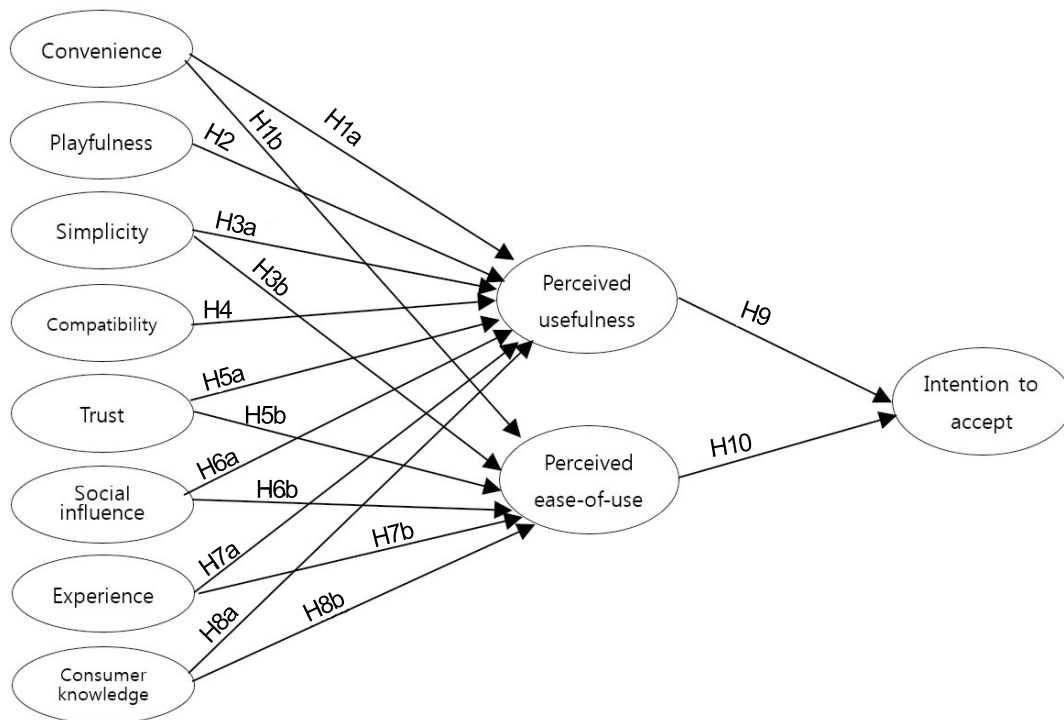


FIGURE 1. Conceptual model

### 3. Methodology.

**3.1. Data collection and analysis.** This study conducted an online survey through the Google platform from July 19, 2021, to July 31, 2021, for general consumers interested in automobiles, by convenient sampling. A total of 250 survey questionnaires were distributed and collected, and 242 responses were used for analysis, excluding 8 that responded insincerely. Mobile coupons were provided to respondents who completed the survey. The measure used in the surveys was a 5-point Likert scale. Before the respondents responded to the survey, an explanation of autonomous vehicles was given to the participants.

**3.2. Measurement results.** The reliability and validity of the construct were analyzed. First, the internal consistency was confirmed by the value of Cronbach's  $\alpha$ . The analysis revealed that Cronbach's  $\alpha$  for all 11 factors exceeded 0.7. In addition, validity was measured by factor analysis using principal component analysis and orthogonal rotation method (Varimax). The eigenvalues of all 11 factors were greater than 1, and factor loading was greater than 0.5, verifying the validity.

The goodness-of-fit of the entire model was  $\chi^2 = 722.61$ ,  $p = .000$ ,  $df = 379$ ,  $\chi^2/df = 1.907$ ,  $CFI = .93$ ,  $GFI = .84$ ,  $AGFI = .80$ ,  $IFI = .93$ ,  $NFI = .87$ ,  $RMR = .046$ . It was found to be above or close to the goodness-of-fit criterion. All the concept reliability (CR) values exceeded 0.7 and the average variance extracted (AVE) was confirmed to be greater than 0.5. All of the  $t$ -values of the measurement items had a value greater than 2, confirming the convergent validity [19]. The value calculated by [correlation  $\pm$  (2 \* standard error)] in the 95% confidence interval was 0.063 to 0.708. As it did not exceed 1 [20], discriminant validity was secured. Table 1 below shows these results.

TABLE 1. Reliability and validity analysis

Constructs	Items	Satisfied efficient	t-value	SE	CR	AVE
Convenience	$\chi_1$	.91	17.66***	.05	.881	.716
	$\chi_2$	.93	18.28***	.05		
	$\chi_3$	.67	11.49***	.06		
Playfulness	$\chi_4$	.73	11.02***	.07	.708	.513
	$\chi_5$	.70	10.57***	.07		
Simplicity	$\chi_6$	.80	14.39***	.06	.889	.728
	$\chi_7$	.94	18.40***	.05		
	$\chi_8$	.82	14.96***	.05		
Compatibility	$\chi_9$	.81	15.10***	.05	.907	.766
	$\chi_{10}$	.94	19.01***	.05		
	$\chi_{11}$	.87	16.74***	.05		
Trust	$\chi_{12}$	.80	14.16***	.06	.842	.643
	$\chi_{13}$	.91	17.08***	.05		
	$\chi_{14}$	.68	11.39***	.06		
Social influence	$\chi_{15}$	.81	15.10***	.05	.817	.696
	$\chi_{16}$	.96	15.39***	.06		
Experience	$\chi_{17}$	.78	13.08***	.06	.805	.582
	$\chi_{18}$	.85	14.62***	.06		
	$\chi_{19}$	.64	10.33***	.06		
Consumer knowledge	$\chi_{20}$	.85	15.62***	.05	.864	.682
	$\chi_{21}$	.90	16.91***	.05		
	$\chi_{22}$	.71	12.17***	.06		
Perceived usefulness	$y_1$	.68	11.53***	.06	.861	.676
	$y_2$	.87	16.18***	.05		
	$y_3$	.90	17.05***	.05		
Perceived easiness	$y_4$	.86	16.70***	.05	.939	.836
	$y_5$	.92	18.59***	.05		
	$y_6$	.96	20.04***	.05		
Intention to accept	$y_7$	.81	14.88***	.05	.880	.709
	$y_8$	.83	15.37***	.05		
	$y_9$	.88	16.92***	.05		
Mode fit	$\chi^2 = 722.61, p = .000, df = 379, \chi^2/df = 1.907, CFI = .93, GFI = .84, AGFI = .80, IFI = .93, NFI = .87, RMR = .046$					

\*\*\*  $p < .001$ , SE: standard error, CR: composite reliability, AVE: average variance extracted

4. **Results.** Structural equations were conducted through Lisrel 8 with items that secured reliability and validity. The goodness-of-fit of the model was  $\chi^2 = 25.568, p = .00752, df = 11, \chi^2/df = 2.324, CFI = .98, GFI = .98, AGFI = .89, IFI = .98, NFI = .97,$  and  $RMR = .035$ . The proposed research model fits the actual data well. Most of the hypotheses supported the expected relationships, and the concrete results are as follows.

Convenience ( $\beta = .246, t\text{-value} = 4.403$ ), playfulness ( $\beta = .114, t\text{-value} = 2.157$ ), and trust ( $\beta = .170, t\text{-value} = 3.024$ ) were found to have a significant effect on perceived usefulness. However, simplicity ( $\beta = .042, t\text{-value} = .755$ ) and compatibility ( $\beta = .116, t\text{-value} = 1.897$ ) had no significant effect. Social influence ( $\beta = .118, t\text{-value} = 2.425$ ) and

experience ( $\beta = .119$ ,  $t$ -value = 2.389) were found to have a significant effect in terms of assumption about the positive effect of communication characteristics on perceived usefulness. Consumer knowledge had a positive effect on perceived usefulness ( $\beta = .187$ ,  $t$ -value = 3.741).

Convenience ( $\beta = .137$ ,  $t$ -value = 2.329), simplicity ( $\beta = .187$ ,  $t$ -value = 3.106), and trust ( $\beta = .206$ ,  $t$ -value = 3.526) were found to have a significant effect on perceived ease-of-use. Social influence ( $\beta = .194$ ,  $t$ -value = 3.540) was found to have significant effect, but experience ( $\beta = .080$ ,  $t$ -value = 1.451) was found to have no significant effect. Consumer knowledge had a positive effect on perceived ease-of-use ( $\beta = .182$ ,  $t$ -value = 3.283).

Perceived usefulness ( $\beta = .401$ ,  $t$ -value = 7.255) and perceived ease-of-use ( $\beta = .394$ ,  $t$ -value = 7.128) for acceptance intention were verified to have a significant effect as in the previous studies.

**5. Conclusion.** Based on the innovation diffusion theory of Rogers [3], this study integrates the variables affecting the spread of autonomous vehicles with the technology acceptance model and identifies the factors affecting the acceptance intention for autonomous vehicles. The contributions of this study are as follows. First, this study proposes the social influence of the technology acceptance model from the reference group to the overall change in society and verified its significance. Second, this study argues that autonomous vehicles should be regarded as discontinuous innovative products from the consumer's point of view and that various factors of innovation should be considered. Lastly, to influence consumers' purchase intentions, it should be preceded by consumers' positive attitude towards the product, and the positive attitude is formed through beliefs about the product. If this is incorporated into an advertisement message that needs to be presented step-by-step, it would be "Awareness-Provision of Information-Favorable Attitude-Preference-Confirmation-Purchase Intention". During empirical analysis, all 242 people except 1 were aware of the autonomous vehicle. The next stage of advertising is provision of information. There are issues that need to be resolved in relation to road reform and legal system reform, but there is a need to deliver a message that provides various kinds of information about the positive functions and benefits of autonomous driving to increase the popularization of autonomous vehicles.

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