

# Tourism in the virtual age: Predicting the adoption of virtual reality applications in tourism

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**Abstract:** Virtual Reality (VR) has grown rapidly since the COVID-19 pandemic and continues to grow even after the pandemic is over. In the tourism industry, VR applications are often used in the tourism process to promote destinations and attract tourists to visit. Starting from the quality of VR applications, tourists will intend to use VR applications if these applications have good quality. For this reason, by assessing VR quality and incorporating it into TAM, this study aims to explore the adoption of VR applications in the tourism sector. This study included 400 VR users as participants. Using the partial least square structural equational model (PLS-SEM), a number of hypotheses were assessed. The findings demonstrate that VR quality significantly influences all TAM constructs, including attitude and intention to use. Then, attitude is significantly influenced by perceived usefulness and ease of use. Finally, the intention to use is significantly influenced by attitude. These results indicate that VR quality that is useful and easy to use will determine the adoption of VR applications in tourism. This paper advances both theory and practice by explaining the importance of VR quality and TAM in the adoption of VR applications in tourism.

**Keywords:** attitude, intention to use, perceived ease of use, perceived usefulness, VR quality

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## Introduction

In the tourism sector, virtual reality (VR) has drawn a lot of attention as a tool for increasing visitor experiences and promoting locations. A increasing body of study on the use of VR in tourism has been done over the past two decades, exploring its potential benefits and challenges (Buhalis & Law, 2008). By immersing users in a simulated environment, VR offers a realistic and interactive experience of a tourist destination without actually being there (K. Jung et al., 2020; Vishwakarma et al., 2020). Moreover, VR has the potential to influence tourists' travel decisions (M. Lee et al., 2020). Travelers explore a destination cognitively before they arrive through a variety of channels, such as social media (Rafdinal et al., 2022), smart tourism (Kusdibyso et al., 2023), and VR (Gibson & O'Rawe, 2018; Wibisono et al., 2023). VR can provide tourists with a more immersive and interactive way to explore and evaluate a destination, allowing them to experience its attractions, culture, and ambiance virtually. This can have a significant impact on their tourist attitude and ultimately influence their travel intention (M. Lee et al., 2020; Nguyen et al., 2023). This technology has the ability to completely transform how tourists plan for and enjoy their travels, as well as the way destinations market themselves to potential visitors. Understanding these factors is crucial for the successful implementation of VR in tourist destinations and the development of effective marketing strategies.

Understanding the factors that influence the adoption of VR in this context is crucial for destination managers and marketers to effectively implement and promote VR experiences. One approach to studying technology adoption is the Technology Acceptance Model (TAM), which has been widely used to examine users' acceptance and usage of various technologies (Davis, 1989). According to the TAM, "perceived usefulness and perceived ease of use are the two main elements that affect users' acceptance of a technology" (Davis, 1989). These two factors

have been found to significantly influence users' attitudes and intentions to adopt and use technology (Davis, 1989; Hardiyanto et al., 2022; Wibisono et al., 2023). In the context of VR in tourism, The TAM can be used to comprehend how tourists will accept and use VR (Schiopu et al., 2021). The perceived usefulness of VR in this context can be related to the extent to which tourists believe that VR can enhance their travel experiences, provide a more immersive and realistic representation of the destination, and offer unique and engaging activities (Schiopu et al., 2021; Wibisono et al., 2023). Perceived ease of use can be related to the ease with which tourists can access and navigate VR experiences, as well as the user-friendliness of the technology (Schiopu et al., 2021; Wibisono et al., 2023). TAM does not examine aspects of the technology's quality. The quality of the VR experience itself is another important factor to consider in the adoption of VR in tourism. The quality of VR experiences can include factors such as content quality, system quality, and vividness (T. Jung et al., 2015; M. Lee et al., 2020; Yim et al., 2017). High VR quality is more likely to elicit positive user experiences and enhance the perceived usefulness and ease of use of the technology (Godovykh et al., 2022; M. Lee et al., 2020). Integrating the TAM with VR quality can provide a comprehensive framework for understanding and predicting tourists' adoption of VR in tourism. By considering both the perceived usefulness and ease of use of VR, as well as VR quality, destination managers and marketers can develop strategies to promote VR experiences that meet tourists' expectations and enhance their overall travel experiences. Theoretically, this study will complement previous literature on the effect of VR applications adoption in tourism (Kusdibyoy et al., 2023; W. J. Lee & Kim, 2021; Susanto et al., 2020; Wibisono et al., 2023) by integrating VR quality and TAM.

The application of VR in various tourist destinations has also been evaluated, such as in Korea's main heritage Kwanghee (K. Jung et al., 2020), Korean theme park (T. Jung et al., 2015), and tourism destinations in Vietnam (Nguyen et al., 2023). The usage of VR applications in Indonesian tourist destinations is investigated in this study. The development of VR in tourism destinations has occurred since the COVID-19 pandemic hit (Godovykh et al., 2022; Schiopu et al., 2021). In Indonesia, the COVID-19 pandemic caused the number of tourist visits in Indonesia to decrease drastically with the number of tourist visits from abroad decreasing by almost 74.9% or around four million tourists. Meanwhile, visits from domestic tourists decreased by around 30% or 198 million tourists (Ministry of Foreign Affairs of the Republic of Indonesia, 2021). The Ministry of Tourism and Creative Economy has implemented many steps to prepare for tourism recovery, including implementing VR technology in many tourist destinations in Indonesia. Researching VR in Indonesian tourism destinations can contribute to the knowledge in the field of sustainable tourism. The field of sustainable tourism focuses on the intersection of information technology and tourism management (Lu et al., 2022). By studying the adoption of VR applications in Indonesian destinations, this study can contribute to the existing knowledge on the use of this technology in the tourism industry. This study can provide insights into the challenges and opportunities of implementing VR applications in tourism destinations, which can be valuable theoretically and practically.

### *VR quality in tourism destination*

VR has gained significant attention in various fields, including education (Du et al., 2022), e-learning and agriculture (Jimenez et al., 2021), games (Jang & Park, 2019), and tourism (Godovykh et al., 2022; M. Lee et al., 2020). VR enables marketers to give customers the most realistic experience of a product, service, or location without the necessity for physical collocation (W. J. Lee & Kim, 2021). Using VR technology or VR content, user can virtually inhabit a space and feel as though they are truly there. Therefore, using 3D pictures, audio, and other multi-sensory modalities, VR enables users to obtain information (Tussyadiah et al., 2018). With technological advancement, customers easily engage in virtual environments provided by VR. Previous studies have proven that technical quality aspects of technology determine VR adoption which are analyzed from various quality aspects such as content quality, functional quality, system quality, vividness (Godovykh et al., 2022; M. Lee et al., 2020) sense of presence and immersive (Argyriou et al., 2020; Bogicevic et al., 2019), perceived usefulness, perceived ease of use (El-Said & Aziz, 2022; Wibisono et al., 2023), attitude and behavioral intention (Godovykh et al., 2022; M. Lee et al., 2020; Wibisono et al., 2023). Thus, as technology ad-

vances, customers readily embrace virtual environments facilitated by VR. The adoption of VR hinges on technical quality attributes, evaluated through aspects like content quality, functional quality, system quality, and vividness, while its impact on users is assessed through factors like sense of presence, immersion, perceived usefulness, ease of use, attitude, and behavioral intention.

In tourism, VR technology is a promising tool for enhancing tourism experiences and promoting destinations (Godovykh et al., 2022). Customers can view accurate representations of cities, hotels, restaurants, and other attractions via virtual tours from anywhere in the world (Tussyadiah et al., 2018). Initially, Buhalis and Law (2008) analyzed eTourism which explains the evolution of industrial technology, one of which is VR, emphasizing the challenges faced by researchers and the potential for developing eTourism in the future. The development of VR adoption in tourism has grown since Covid-19, showing the relevance of VR in the context of changing travel patterns and the need for innovative solutions (Leung et al., 2023). After Covid-19, VR in tourism is increasingly being used which shows that people are ready to use VR in the tourism industry (Godovykh et al., 2022; Wibisono et al., 2023). Wibisono et al. (2023) prove that even though COVID-19 is over, VR will still be used in the tourism industry and prove that people are ready to use this technology. VR has become a promising tool in tourism, allowing customers to experience realistic virtual tours of destinations worldwide, enhancing tourism experiences (M. Lee et al., 2020). The growing adoption of VR in tourism, especially post-COVID-19, as highlighted by various studies, indicates its relevance in adapting to changing travel patterns and suggests that the public is ready to adopt VR within the tourism industry.

### *Technology Acceptance Model in VR*

TAM is a widely used model for understanding users' acceptance and adoption of technology (Mulyawan & Rafdinal, 2021). It was first proposed by in 1989 (Davis, 1989). According to the model, perceived usefulness and perceived ease of use are the two key variables that affect people' adoption of technology. As opposed to perceived ease of use, which relates to "how much users think a technology is simple to use", perceived usefulness measures "how much users think a certain technology will improve their performance or productivity" (Davis, 1989). Initially, perceived usefulness and perceived ease of use, were suggested to measure attitude (Scherer et al., 2019; Venkatesh, 2000). Perceived usefulness, perceived ease of use, and attitude all have an impact on behavioral intention, which in turn has an impact on actual usage (Flavian et al., 2020; Venkatesh, 2000). Later studies upgraded TAM by incorporating new components, especially from the quality aspect. For example, TAM is integrated with game quality (Mulyawan & Rafdinal, 2021; Rafdinal et al., 2020), information quality, and system quality (Yu & Huang, 2022). These studies prove that in technology adoption, TAM and quality cannot be separated because they are related to technology acceptance which is assessed from the technical aspect of technology.

Previous studies have used the TAM to analyze user acceptability of and intention to use VR for tourism context (El-Said & Aziz, 2022; Schiopu et al., 2021; Wibisono et al., 2023). Schiopu et al. (2021) used TAM in VR adoption during the Covid-19 pandemic which showed that perceived usefulness, substitutability, and ease of use of VR were all factors that affected intention, and their effects were all mediated by peoples' interest in using VR for tourism. Wibisono et al. (2023) analyzed VR adoption in the tourism industry in Indonesia which also measured the readiness of the community to adopt VR, which showed that TAM was able to prove VR adoption in Indonesia. (El-Said and Aziz, 2022) tested the adoption of virtual tours, which showed that the ability of TAM and PADM models to forecast users' intentions to adopt VTs and the impact of those intentions on users' propensity to visit the actual site. Regarding the acceptance and implementation of VR in the context of tourism, TAM has been widely used. It has been discovered that users' intentions to utilize VR for tourism are highly influenced by their perceptions of the technology's usefulness and ease of use. Integrating the TAM with other theories provide a more comprehensive understanding of users' experience in VR tourism.

## Hypotheses Development

Previous studies demonstrated a significant relationship between perceived usefulness and VR quality as measured by various types of quality and various usefulness responses. VR technology attempts to give users a sensation of presence and immersion, making them feel physically present in a virtual world (Bogicevic et al., 2019). The degree of immersion is determined by the characteristics of the technology, such as the extent to which it can deliver a vivid and encompassing illusion of the virtual environment (Vishwakarma et al., 2020). A proper VR quality that provides vividness and interactivity can help tourists interpret the information displayed in VR tourism and influence perceived usefulness and perceived ease of use (Nguyen et al., 2023). Moreover, when the VR system provides a high-quality experience, users perceive it as a beneficial medium that enhances their tourism activities (M. Lee et al., 2020). The quality of the VR system is related to the perception of usefulness, ease of use, and the system's ability to effectively deliver benefits (Guo et al., 2022; Wibisono et al., 2023). Overall, high-quality VR experience in tourism can enhance the perceived usefulness of the technology (Wibisono et al., 2023). Although previous studies analyzed VR quality from different types of quality aspects and different usefulness responses, they showed that VR quality had an effect on perceived usefulness.

H1. VR quality has a positive and significant effect on perceived usefulness

Previous studies agree that quality assessment in VR is in line with the IS success model proposed by (DeLone and McLean, 1992) which measures system effectiveness, information effectiveness, usage, satisfaction, personal impact, and organizational impact (Godovykh et al., 2022; M. Lee et al., 2020). Later, this model modified individual and organizational impacts were replaced with net benefits (DeLone & McLean, 2016). With these adjustments, the IS success model allowed researchers to broaden multiple types of quality according on the context and goal of the research. Nguyen et al. (2023) prove that the VR quality is determined by vividness and interactivity. Related to visuals, the visual design determined by the visual design of the application, the size of 3D objects, and the layout affect the perceived ease of use (K. Jung et al., 2020). Another study tested VR system quality which showed easy to use and navigate in VR which is an assessment of system quality (M. Lee et al., 2020). The ease of use of a VR is closely related to the tourists' ability to interpret the information displayed in VR tourism (Du et al., 2022). This shows that the VR quality plays a crucial role in determining the perceived ease of use (Nguyen et al., 2023; Wibisono et al., 2023). These studies prove that visual and system aspects will influence the ease of use of VR. A high-quality VR can enhance the ease of use. Thus:

H2. VR quality has a positive and significant effect on perceived ease of use

The tourism sector now extensively uses emerging VR technology, offering immersive experiences that can influence consumers' attitudes towards tourism destinations (Tussyadiah et al., 2018). The main effects of virtual travel are determined by the users' emotional reactions, attitudes, and behavioral intents (Godovykh et al., 2022). Empirical evidence supporting the effectiveness of VR in shaping consumers' attitudes and behavior toward tourism destinations (Tussyadiah et al., 2018). Quality, technology acceptability, information-related, and affective aspects' influence on attitudes (Godovykh et al., 2022). In fact, various types of quality will affect attitudes towards VR (M. Lee et al., 2020) and attitudes towards tourist destinations (Godovykh et al., 2022; Tussyadiah et al., 2018). M. Lee et al. (2020) evaluated VR quality which was assessed from content quality, system quality, and vividness, showing its effect on attitude toward the VR. In line with that study, (Godovykh et al., 2022) also evaluates content quality and system quality but add the functional quality of VR technology which will influence attitudes towards tourist destinations (Godovykh et al., 2022). Finally, high-quality VR may allow visitors to spend more time and effort looking up information, which could improve their attitude and actual visits (Nguyen et al., 2023). It can be stated that VR quality affects attitude.

H3. VR quality has a positive and significant effect on attitude

VR as a powerful tool in the tourism industry, offering immersive experiences that can significantly impact tourists' behavioral intentions (M. Lee et al., 2020). Because TAM focuses on the technical aspects of technology, the main intention to measure is the intention to use VR. Various qualities are measured to prove their effect on the intention to use. Studies have shown that quality factors such as content quality and system quality significantly influence the intention to use VR (M. Lee et al., 2020). Another study proves that service and display quality affect the intention to play VR games (Jang & Park, 2019). These factors can also be relevant in the tourism context, where the VR quality experience plays a role in shaping tourists' intentions (Godovykh et al., 2022). Furthermore, the confirmation of expectations from previous VR use has been found to influence attitudes and continuance intention to use VR technology (M. Lee et al., 2020; Rahimizhian et al., 2020). High-quality VR experience in tourism can enhance the perceived usefulness of the technology (Wibisono et al., 2023), which will ultimately lead to intentions to use VR and intentions to travel (Nguyen et al., 2023; Yang et al., 2022). Thus, the quality of VR applications in tourism has a significant effect on tourists' intention to use. Hypothesis for this influence:

H4. VR quality has a positive and significant effect on intention to use VR

The perceived usefulness of VR in tourism has been identified as a crucial factor influencing tourists' attitudes towards this technology (Özekici & Küçükergin, 2023; Wibisono et al., 2023). Originally, in TAM, perceived usefulness refers to "the extent to which individuals believe that using a particular technology will enhance their performance and productivity" (Davis, 1989). Kim et al. (2021) examined interactivity and vividness on consumer VR shopping experiences, and discovered that perceived usefulness had a more substantial impact on attitude toward VR. Furthermore, previous studies have proven the influence of perceived usefulness on attitudes towards technology such as mobile games (Mulyawan & Rafdinal, 2021), VR applications in education (Jimenez et al., 2021), VR in tourism (Özekici & Küçükergin, 2023; Wibisono et al., 2023), and the differences between VR and AR in tourism (Guo et al., 2022). Previous studies have proven that the positive attitude of VR is because users get destination information, improve the efficiency of travel, and are useful in the travel process (Geng et al., 2022; Wibisono et al., 2023). Thus, the perceived usefulness of VR in tourism has significant effect on tourists' attitudes towards this technology. Hypothesis for this influence:

H5. Perceived usefulness has a positive and significant effect on attitude

Perceived ease of use is a crucial factor in determining users' attitudes towards VR technology in various contexts, including tourism. At the beginning, Davis (1989) explains that the perceived ease of use reflects "how easy a person thinks it is to use a specific system". In the context of tourism, perceived ease of use is defined as "the extent to which a person believes that the utilization of VR tourism is easy and without effort" (Geng et al., 2022). VR Applications should be intuitive to use, operate, and deliver clear information. Previous research have demonstrated the impact of perceived ease of use on attitude in different context such as AR in tourism (Yung & Khoo-Lattimore, 2019), VR tourism (Wibisono et al., 2023), or the difference between VR and AR (Geng et al., 2022). Overall, the perceived ease of use of VR has a significant effect on users' attitudes. Therefore, it can be stated that perceived ease of use of VR will influence attitudes towards VR. Hence:

H6. Perceived ease of use has a positive and significant effect on attitude

Attitude toward VR has been recognized as a significant factor influencing users' intention to use VR (Jimenez et al., 2021; Özekici & Küçükergin, 2023; Wibisono et al., 2023). In TAM, Attitude refers to an individual's overall evaluation or feeling toward a particular object or technology (Davis, 1989). Previous studies have examined the effect of attitude towards VR on behavioral intention in various contexts, such as e-learning, agriculture, and virtual reality applications (Jimenez et al., 2021) and tourism applications (Jimenez et al., 2021; Wibisono et al., 2023). However, the assessments of intention in previous studies were divided into two, namely intention to use VR (Jimenez et al., 2021; Wibisono et al., 2023) and the intention to visit destinations (M. Lee et al., 2020; Tussyadiah et al., 2018) which shows that these two intentions are

influenced by attitude toward VR. This study assesses the intention to use VR because it focuses on technical aspects of technology adoption (Davis, 1989; Kusdibyo et al., 2023). Focusing on the context of intention to use VR in tourism, a previous study showed that after COVID-19, people were ready to adopt VR, which would affect their attitude and intention to use VR (Wibisono et al., 2023). In line with this study, another study added anxiety and social contact factors that determine attitude which ultimately affects intention to use (Özekici & Küçükergin, 2023). Although there are two perspectives on intention to adopt VR, this study focuses on the intention to use VR. It can be hypothesized:

H7. Attitude has a positive and significant effect on behavioral intention

## Methodology

Purposive sampling was utilized in this study's data collecting method. Data collection through surveys distributed online. The data was gathered during the initial three weeks of June 2023. The respondents in this study were tourists who had used VR applications in Indonesia with a total of 400 respondents. To ensure this, control questions were made in the questionnaire asking when the last VR application was used and what application was used. The G\*Power application was used to compute the minimum number of samples required (Ringle & Sarstedt, 2016). Considering the results of the computation and the model's structure (Power= 0.80,  $f^2 = 0.15$ ,  $\alpha = 0.05$ ), it was found that the sample size had to be at least 85. Thus, 400 samples were above the criteria minimum required (Ringle & Sarstedt, 2016).

Some of the questions were designed to elicit information about the participants' demographics in order to assess them more effectively. A assessment of the questions revealed that the participants' genders were almost equally distributed. The demographic results showed that the respondents were female (51.2%) compared to male (48.8%). The age of the majority of respondents was in the range of 18 to 23 years old (78.4%) followed by 24 to 29 years old (13.6%), less than 17 years old (5.8%), and over 30 years old (2.2 %). More than half of the respondents (72.6%) were students, followed by entrepreneurs (9.4%), professionals (2.8%), civil servants (1%), and others (14.2%). Because the respondents were young, the majority of their monthly income earned was less than IDR 5,000,000 (93.2%). The respondents reported that they used VR applications every month. Thus, it can be concluded that the respondents in this study are young and have a high interest in VR applications.

## Research Instrument and Measurement

This study's primary goal is to determine how VR application quality affects users' intentions to use VR using TAM. To assess the relative contribution of VR quality in driving intention to use VR applications, it is important to measure attitudes towards VR applications, how useful and easy to use they are for tourists before visiting a tourist destination. Thus, VR quality and TAM were measured in this study. VR quality is measured by three dimensions, namely content quality, system quality, and vividness. Content quality is measured by four items regarding visual overview, accurate, interesting, and valuable (T. Jung et al., 2015; M. Lee et al., 2020). System quality is measured with four items that describe reliability, quick load the contents, user-friendly interface, and interactive (T. Jung et al., 2015; M. Lee et al., 2020). Vividness was measured with six items that assess clear, strong, right, sharp, vivid, and well-defined VR visuals (M. Lee et al., 2020; Yim et al., 2017). Perceived usefulness, perceived ease of use, attitude, and intention to use VR are each four variables in TAM that were adapted from prior studies that focused on VR adoption in the tourism industry (Özekici & Küçükergin, 2023; Wibisono et al., 2023). More details are shown in Table 1. All statement items in the questionnaire were measured using a 5-point Likert scale, where 1 indicates "strongly disagree" to 5 "strongly agree". There are three sections to the questionnaire. The first section of the survey is where the participant declares their desire to participate. The respondents' demographic information is included in the second section (gender, age, education, income, regional origin/domicile). The third section includes statements regarding the research variables. Before collecting data, to ensure that the survey questions were understandable and that there were no technological issues that may hinder the collection of data, 30 respondents were tested as part of a pilot test.

**Table 1.** Instrument survey

Construct	Indicator	Source
Content quality	CQ1. The content shown on VR apps gave an overview of tourism destination	(T. Jung et al., 2015; M. Lee et al., 2020)
	CQ2. The content shown on VR apps is accurate	
	CQ3. The content shown on VR apps is interesting	
	CQ4. The content shown on VR apps is valuable	
System quality	SQ1. VR apps operates reliably with no crashes, etc.	(T. Jung et al., 2015; M. Lee et al., 2020)
	SQ2. Quickly load the contents	
	SQ3. User-friendly interface	
	SQ4. Interactive interface	
Vividness	VI1. This VR app's visual was unclear/clear.	(M. Lee et al., 2020; Nguyen et al., 2023; Yim et al., 2017)
	VI2. This VR app's visual was weak/strong.	
	VI3. This VR app's visual was fuzzy/right.	
	VI4. This VR app's visual was dull/sharp.	
	VI5. This VR app's visual was hazy/vivid.	
	VI6. This VR app's visual was poorly defined/well-defined	
Perceived usefulness	PU1. A useful tool	(El-Said & Aziz, 2022; Özekici & Küçükergin, 2023; Wibisono et al., 2023)
	PU2. Develops a genuine sense of place.	
	PU3. Advantages are greater than disadvantages	
	PU4. A fun technological innovation	
Perceived ease of use	PE1. Utilizable without professional assistance	(El-Said & Aziz, 2022; Özekici & Küçükergin, 2023; Wibisono et al., 2023)
	PE2. Is understandable and clear	
	PE3. Easy to install and use	
	PE4. VR apps is flexible to interact with	
Attitude	AT1. Using the VR apps is a good idea	(Özekici & Küçükergin, 2023; Wibisono et al., 2023)
	AT2. Using the VR apps is a wise idea	
	AT3. I support the idea of using the VR apps	
	AT4. Using the VR apps would be pleasant	
Intention to use	IU1. Like the idea of using VR apps	(Gibson & O'Rawe, 2018; Özekici & Küçükergin, 2023; Wibisono et al., 2023)
	IU2. Probably will use VR apps again	
	IU3. Tell friends or other people about the VR activity related to tourism	
	IU4. Promote the content of the VR app activity that is relevant to tourism to others	

### Data analysis

This study uses a quantitative approach. Despite the fact that TAM has been evaluated in a variety of settings, this study has an exploratory aspect because it contributes to the integration of variables in the existing model, namely VR quality. For this reason, variance-based SEM (PLS-SEM) is a valid analytical technique for this purpose. PLS-SEM is used to evaluate data because it allows for statistical testing of all relationships between variables in the conceptual model at once (Hair et al., 2019). In addition, the existence of a second-order construct (i.e. VR quality) in the model makes PLS-SEM a suitable analytical technique (Chin, 1998; Hair et al., 2019). In testing the model, a two-stage analysis was used to analyze the research data. The first is the measurement model evaluation, this stage is assessing the reliability and validity of the constructs used. The second stage is the structural model evaluation, which is used to assess  $R^2$ ,  $Q^2$ , and path coefficients to see the relationship between variables (Hair et al., 2019) which answers the objectives of this research.

## Results and Discussions

### Results

#### Reflective measurement model

Testing for validity and reliability contributes in the analysis of the measurement model (Hair et al., 2019). To examine the reliability, the Cronbach's alpha,  $\rho_A$ , and composite reliability (CR) tests were used. The recommended values are 0.70 for each of these measures (Hair et al., 2019). The results of the reliability testing are satisfactory; and therefore, show the reliability of all constructs in this study (see Table 2). For validity testing, evaluation of convergent and discriminant validity is suggested (Hair et al., 2019). Tests of average variance extracted (AVE) and outer loadings were performed for convergent validity. The AVE value must be  $>0.50$  and outer loading  $>0.708$  which shows the reflexivity of the indicators towards the construct (Hair et al., 2019).

**Table 2** Reflective measurement model

Latent Variable	Indicator	Loadings	Cronbach's alpha	$\rho_A$	CR	AVE
Content Quality	CQ1	0.818	0.839	0.840	0.893	0.675
	CQ2	0.848				
	CQ3	0.824				
	CQ4	0.796				
System Quality	SQ1	0.768	0.785	0.787	0.861	0.608
	SQ2	0.773				
	SQ3	0.822				
	SQ4	0.755				
Vividness	VI1	0.702	0.831	0.840	0.889	0.668
	VI2	0.773				
	VI5	0.822				
	VI6	0.755				
Perceived usefulness	PU1	0.897	0.872	0.872	0.921	0.796
	PU2	0.892				
	PU4	0.886				
Perceived ease of use	PE1	0.897	0.910	0.912	0.937	0.788
	PE2	0.877				
	PE3	0.891				
	PE4	0.885				
Attitude	AT1	0.884	0.912	0.913	0.938	0.791
	AT2	0.894				
	AT3	0.912				
	AT4	0.867				
Intention to use	INT1	0.702	0.779	0.836	0.866	0.683
	INT2	0.872				
	INT3	0.819				
	INT4	0.863				

Note(s): CR = composite reliability; AVE = average variance extracted;  $\rho_A$  = Dijkstra-Henseler's rho.

The findings in Table 3 demonstrate that the values of both measures were accurate, confirming the convergent validity. Henseler et al. (2015) proposed testing the "Heterotrait-Monotrait ratio (HTMT)" of correlations for discriminant validity. The values of HTMT should be less than 0.85. In Table 6, the discriminant validity is confirmed. This shows that there are no multidimensional indicators.



**Table 3** Heterotrait-Monotrait (HTMT)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Content quality							
(2) System quality	0.666						
(3) Vividness	0.268	0.348					
(4) Perceived usefulness	0.603	0.603	0.392				
(5) Perceived ease of use	0.491	0.561	0.339	0.674			
(6) Attitude	0.597	0.525	0.437	0.772	0.752		
(7) Intention to use	0.559	0.477	0.149	0.431	0.456	0.502	

### Formative measurement model

Due to its reflected first-order dimensions, the VR quality construct is thought to be a second-order formative construct. Both at the individual and construct levels, its content validity was assessed. The findings of the bootstrap test demonstrated strong significance for each weight in the VR quality construct at the individual level (0.305-0.510), where the bootstrap-based empirical 95% confidence interval (see Table 4). The levels of the variation inflation factor (VIF) for the VR quality factors ranged from 1.095 to 1.474. According to these findings, multi-collinearity among the first-order constructs is not a problem because the VIF values are below the cutoff value of 3 (Hair et al., 2019). In the outer measurement model, first-order factors were thus retained.

**Table 4** Content validity of the formative measurement construct

Higher order relationships	Weights	T value	P value	VIF
Content quality -> VR Quality	0.510	17.240	0.000	1.095
System quality -> VR Quality	0.487	18.499	0.000	1.433
Vividness -> VR Quality	0.305	7.390	0.000	1.474

### Structure model

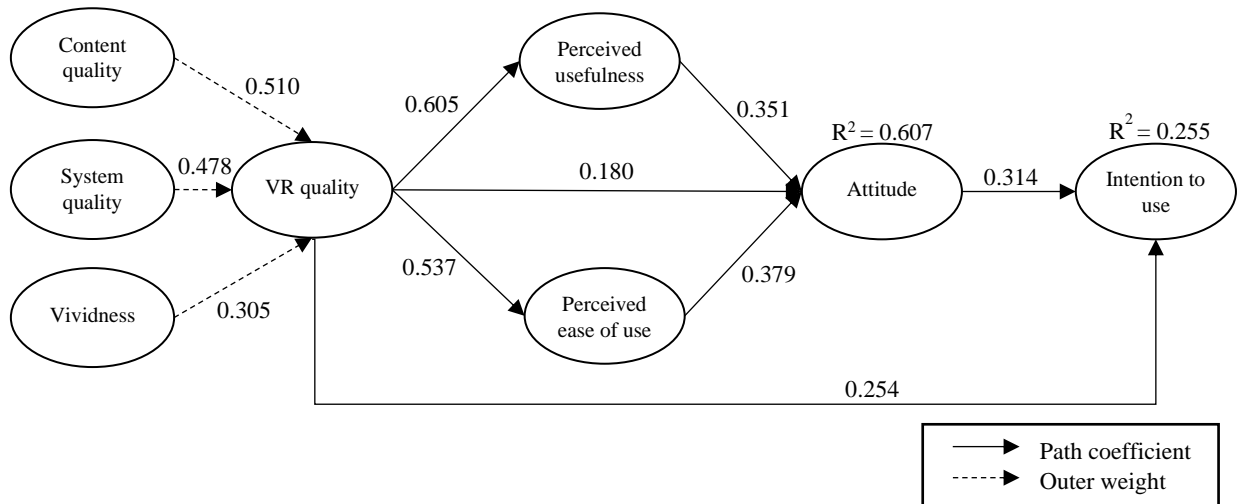
The inner structural model was assessed in this second step (Table 5). R2 results showed that the model can explain significant amounts of the variation of the endogenous latent constructs. 0.607 and 0.255, respectively, were the R<sup>2</sup> values for attitude and intention to use (Figure 2). It demonstrates how exogenous constructions with low to moderate criteria have an impact on each of the above constructs. The PLS-SEM literature refers to these indicators as cross-validated redundancy measures, and their predictive power was used to evaluate the structural model (Hair et al., 2019). Blindfolding procedures were used for evaluating Stone-Geisser (Q<sup>2</sup>) values as the main indicator of predictive significance. The results for attitude and intention to use in Q<sup>2</sup> were 0.596 and 0.251, respectively. The path model's small, medium, and great predictive importance are explained by the Q<sup>2</sup> values at 0 and 0.25 and 0.50, respectively (Hair et al., 2019). The results demonstrate that all constructs have an acceptable power for relevance prediction.

**Table 5** Hypotheses results

Path	$\beta$	T - Values	P - Values	Supported
H1. VR Quality -> Perceived usefulness	0.605	16.117	0.000	Yes
H2. VR Quality -> Perceived ease of use	0.537	11.455	0.000	Yes
H3. VR Quality -> Attitude	0.180	3.476	0.000	Yes
H4. VR Quality -> Intention to use	0.254	3.648	0.000	Yes
H5. Perceived usefulness -> Attitude	0.351	7.396	0.000	Yes
H6. Perceived ease of use -> Attitude	0.379	7.140	0.000	Yes
H7. Attitude -> Intention to use	0.314	5.473	0.000	Yes

The seven aforementioned hypotheses were tested collectively using the SEM-PLS technique. Data analysis revealed that the empirical evidence supported hypotheses H1 to H7. The results showed that VR quality significantly influenced perceived usefulness ( $\beta = 0.605$ ,  $t >$

16.117), perceived ease of use ( $\beta = 0.537$ ,  $t > 11.455$ ), attitude ( $\beta = 0.180$ ,  $t > 3.476$ ), and intention to use ( $\beta = 0.254$ ,  $t > 3.648$ ) supporting hypothesis H1, H2, H3, and H4 respectively. It was discovered that attitude was significantly influenced by perceived usefulness ( $\beta = 0.351$ ,  $t > 7.396$ ), supporting hypothesis H5. The impact of perceived ease of use on attitude was shown to be significant ( $\beta = 0.379$ ,  $t > 7.140$ ), supporting hypothesis H6. Finally, attitude has significant effects on intention to use ( $\beta = 0.314$ ,  $P < 5.473$ ); hence H7 is supported (Tables 5).



**Figure 2.** Result model

## Discussions

This study establishes that the adoption of VR applications in tourism can be predicted by combining TAM and VR quality into a single research framework. This integration model is confirmed by previous research on VR quality (M. Lee et al., 2020; Nguyen et al., 2023; Yim et al., 2017) and TAM in VR in tourism (K. Jung et al., 2020; Wibisono et al., 2023). VR quality explains the technical aspects of VR technology (M. Lee et al., 2020) while measuring perceived usefulness and perceived ease of use as a TAM construct is specifically designed to measure reasons for technology adoption (Wibisono et al., 2023). This model broadens the application and strength of the previous two models' explanations in VR marketing contexts (Godovykh et al., 2022; K. Jung et al., 2020; Nguyen et al., 2023). Despite the fact that there have been research on TAM and VR quality, no previous study has tested VR quality and TAM in a single model and proven good explanatory power for the integration of this model in the context of VR applications. In addition, this model has been validated and verified to explain the intention to adopt VR apps in tourism which contributes to a deeper understanding of the acceptance behavior of VR applications in this industry.

Second, this study expands TAM in the VR tourism sector by adding technology quality factors, namely VR quality. This study reveals the important function of VR technology quality in shaping perceived usefulness, perceived ease of use, attitude, and intention to use VR applications in Indonesia. Explicitly, this study notes that VR quality does not only have a direct impact on the main constructs in the TAM model, but also determines attitude and supports their intention to use the VR application. High-quality VR experiences are more likely to elicit positive user experiences and enhance the perceived usefulness and ease of use of the technology (Godovykh et al., 2022; M. Lee et al., 2020) which ultimately influences attitude and intention to use (Nguyen et al., 2023; Yang et al., 2022). This study not only verifies previous studies that noted the important role of VR quality in the adoption of VR applications in the tourism context but also broadens our understanding that VR quality has successfully become the basis for the adoption of VR applications in this industry.

In TAM, perceived usefulness and perceived ease of use are crucial elements in determining attitudes and intentions to use VR applications. These results show that a person's attitude about using VR improves the more they believe it to be an useful and easy-to-use technology

which ultimately influences the intention to use it, this supports the results of previous studies (K. Jung et al., 2020; Wibisono et al., 2023). The findings also indicate that attitude and intention to use are influenced by perceived usefulness and perceived ease of use, although the R square test results on intention to use are still unsatisfactory. Because only attitude and VR quality have an impact on intention to use, according to the research model. Other elements, such as interest in virtual reality and perceptions of sustainability (Schiopu et al., 2021), desire (Geng et al., 2022), and enjoyment (El-Said & Aziz, 2022) might be argued to influence intention to use. In addition, because virtual environments do not entirely duplicate real-world travel experiences, VR is thought to have a limited potential to replace actual travel. Even though VR has high quality, is useful and easy to use, the direct tourism experience factor is more desired by tourists (Schiopu et al., 2021). Nevertheless, this study proves that perceived usefulness and perceived ease of use will influence attitudes and intentions to use VR in tourism. So, it can be explained that VR applications will be easier to adopt in traveling if the application is useful and easy to use which supports the tourist travel process. This study contributes to the body of knowledge by emphasizing the importance of perceived usefulness and perceived ease of use in the adoption of VR applications in the tourism sector.

### *Managerial Implication*

This study formulates a quality-centered assessment of VR applications by identifying the important factors that affect VR quality and their impact on TAM constructs and intention to use. This study identified three important VR quality components, namely content quality, system quality, and vividness which significantly and positively impact perceived usefulness, perceived ease of use, attitude, and intention to use. This shows that the quality factor of VR is the main determinant of VR adoption in tourism. Because VR quality is a technical aspect of technology, tourism destination marketers can work closely with VR applications and content developers. Based on the three qualities assessed, on content quality, the content created must be accurate, interesting, and present a real destination. In system quality, VR applications must be reliable, quickly load contents, user-friendly, and interactive in the process of using them. In vividness, VR's visual appearance must be clear, strong, right, sharp, vivid, and well-defined. Through these three qualities, users will feel the benefits of VR applications and feel that VR applications are easy to use, which will ultimately affect their intention to use them in the travel process.

According to our findings, attitudes, usefulness, and ease of use all have similar effects on intention to use. Perceived usefulness and perceived ease of use are essential factors in user interactions with VR applications, and are seen as critical moments of truth for laying the groundwork for long-term use. These factors (perceived utility and perceived ease of use) should be balancedly considered when developing an effective acceptance improvement plan. With a system lacking one of these attributes, it would be impossible to build VR tourism demand. The ability of a particular VR application to replace corporeal travel must be justified by its practitioners. As a result, they will have a beneficial impact on people's behavioral intention to utilize VR in tourism. Additionally, considering the use of VR in pre-recreation processes (Godovykh et al., 2022; W. J. Lee & Kim, 2021), setting up VR pre-recreation platforms in their tourist sites would be advantageous for destination marketers. Thus, the benefits of VR applications in traveling will be better. Businesses can implement their pre-service marketing strategies through VR-based tourist destination applications. For this VR application-based marketing strategy to be effective, a marketing strategy with VR content is needed that will evoke positive emotions and positive attitudes of users. From a VR application developer perspective, they must create VR content that is sophisticated, immersive, realistic, and easy for users to use. By making this be applied via various platforms and devices, it will make VR applications more massively adopted. For this reason, it is necessary to collaborate with companies that can offer competent VR applications.

However, the implementation of VR applications in tourism destinations faces several practical challenges. First, the high initial cost of developing high-quality VR content and systems can be prohibitive for many tourism operators, especially smaller businesses with limited budgets (Rafidinal et al., 2024). Additionally, there is the challenge of ensuring that the VR technolo-

gy is accessible to a wide audience, as not all potential users have access to VR headsets or the necessary hardware to experience VR content effectively. Another significant challenge is the need for continuous updates and maintenance of VR content to keep it relevant and engaging, which requires ongoing investment in technology and creative resources. Furthermore, there can be resistance from stakeholders who are accustomed to traditional methods of marketing and might be skeptical about the return on investment for VR technologies. Lastly, there are technical challenges related to ensuring a seamless and immersive user experience, such as preventing motion sickness, ensuring compatibility across different devices, and achieving high-quality, realistic graphics that truly replicate the travel experience. Addressing these challenges requires strategic planning, collaboration, and sustained investment to fully leverage the potential of VR in the tourism industry.

### Limitations and future research

This study acknowledges several limitations. First, although this study focuses on VR applications, the number of VR applications used by respondents which determines their perception of quality will vary depending on the application used. Thus, future studies can focus on specific VR applications in tourism or compare between applications. Second, because VR in developing countries like Indonesia is still in its growth stage, the results will be different from countries with higher levels of VR adoption. So, future studies can analyze the adoption of VR applications in other countries. Based on the results, R2 shows an unsatisfactory value, meaning that many other factors influence the intention to use VR applications in tourism. Thus, future studies can use other technology adoption theories to assess VR adoption in tourism.

### Conclusions

This study confirms that integrating the Technology Acceptance Model (TAM) with VR quality factors provides a robust framework for predicting the adoption of VR applications in tourism. By combining these models, the study highlights the critical role of VR quality in influencing perceived usefulness, perceived ease of use, attitude, and intention to use VR applications, particularly within the Indonesian context. The findings demonstrate that high-quality VR experiences enhance user perceptions of the technology's usefulness and ease of use, thereby positively affecting their attitudes and intentions to adopt VR. Although the explanatory power of the model for intention to use is not wholly satisfactory, the study underscores that perceived usefulness and ease of use are pivotal in shaping users' attitudes and intentions. Additionally, it acknowledges that VR cannot entirely replace real-world travel experiences but can complement the tourism process. This research enriches the understanding of VR application adoption in tourism by validating the importance of these factors and suggesting that useful and user-friendly VR applications are more likely to be adopted by tourists.

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