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Southeast Asian consumer acceptance of 3D virtual fitting technologies in cross-border online shopping

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Abstract

The purpose of this study is to investigate Thai, Vietnamese and Indonesian consumers' responses to cross-border online shopping for Korean fashion products using 3D virtual fitting technology. In order to examine the factors affecting a consumer's attitude toward virtual fitting technology and the purchase intention of Korean fashion products, technology acceptance model, which represents cross-border site characteristics, and technology readiness, which represents a consumer's belief in technology, were used in combination with technology readiness and acceptance model. An online survey was conducted with male and female consumers in their 20 s and 30 s residing in Vietnam, Indonesia, and Thailand. A structural equation model analysis was performed using smart PLS to verify the research model. Among the dimensions of technological readiness, optimism and innovativeness had a positive effect on consumers' perceptions of the cross-border site, and discomfort had a negative effect. Perceived usefulness, enjoyment, and perceived fit had a significant effect on the attitude toward virtual fitting technology, and the effect of enjoyment was the greatest. This study highlighted the role of each dimension of technology readiness by verifying consumer acceptance of virtual fitting technology in cross-border online transactions. It also emphasized the role of perceived enjoyment in technology acceptance.

Keywords: 3D virtual fitting technology, Southeast Asia, Technology readiness and acceptance model, Technology acceptance model, Technology readiness

Introduction

As the commercial boundaries between countries blur due to the ubiquity of the Internet and mobile devices and the development of overseas transportation, the trend of direct overseas purchases or cross-border shopping is increasing among consumers who value rational purchases around the world. Cross-border e-commerce refers to the online purchase and sale of goods and services across borders to international markets or consumers (Mensah et al., 2020). The development and proliferation of cross-border e-commerce driven by the growth of the global online retail sector presents numerous opportunities for both consumers and companies (Han et al., 2023; Huang & Chang, 2019; Mensah et al., 2020). In particular, Southeast Asia has garnered attention as one

of the fastest growing e-commerce markets in the world (Geldman, 2021). According to a recent report, despite the global economic depression, the e-commerce market in Southeast Asia was valued at approximately \$100 billion in 2020 and is expected to grow to \$300 billion by 2025 (Vinculum, 2021). The recent Korean Wave and the increased awareness of Korean brands and the excellence of Korean products have led more Southeast Asian consumers to purchase Korean products through domestic online shopping malls (Lee et al., 2020). In line with this phenomenon, it is essential for Korean companies to understand the behavior of overseas consumers and develop strategies tailored to each country. Korean companies will then be able to attract consumers and compete with global online retailers in the Southeast Asian market.

Compared to the pre-pandemic period, Southeast Asian consumers' digital consumption accelerated after the pandemic, and online overseas purchases of clothing increased by 5% (Google et al., 2020). However, the inability to actually try on clothes has been perceived as a limitation of overseas online purchases and has affected the global growth of online clothing shopping. 3D virtual fitting technology is expected to help overcome these difficulties. In fact, many companies are trying to provide better services to consumers through virtual fitting services in various on/offline environments. For example, GAP launched a mobile app called 'DressingRoom by Gap' in January 2017 to provide a virtual fitting service based on GAP's products so that customers can choose clothes that fit their body type. Nike and Converse have also provided a service that allows consumers to try on shoes virtually (Hirschfeld, 2020).

Previous studies on virtual fitting technologies have mainly been conducted in the United States (Plotkina & Saurel, 2019), Europe (Beck & Crié, 2018), and Northeast Asian countries (Lee et al., 2022). Unlike these countries, Southeast Asian countries have a high proportion of young consumers, a growing middle class, and developed wireless-based mobile use (Vinculum, 2021). In addition, Southeast Asian countries tend to be open to the acceptance of new cultures and technologies (Cho et al., 2017). In this study, three Southeast Asian countries, Vietnam, Indonesia, and Thailand, were selected to investigate consumer acceptance of virtual fitting technology in cross-border e-commerce. A study by Facebook and Bain & Company found that digital consumers in ASEAN will spend three times as much in 2025 compared to 2018 (The ASEAN Post, 2019). Based on the 2025 forecast, the Southeast Asian countries that are strong in online shopping in terms of sales and number of consumers are Indonesia, Vietnam, and Thailand, in that order. Therefore, these three countries were selected for the study. The Southeast Asian market is growing in importance as an alternative to the saturated domestic online market because it is geographically close to Korea and has a high proportion of young consumers who can adopt new technologies relatively easily. As the market size of 3D virtual fitting is gradually increasing and technology development continues, it is necessary to verify the effectiveness of introducing 3D virtual fitting technology in Southeast Asian countries in order to improve the global competitiveness of Korean fashion companies.

The purpose of this study is to examine consumer acceptance of virtual fitting technology in cross-border e-commerce in three Southeast Asian countries (Vietnam, Indonesia, and Thailand). Through this, this study aims to verify the difference in technology acceptance between countries. In other words, this study was conducted to find out

how technology readiness (optimism, innovativeness, discomfort, insecurity) affects perceived ease of use, perceived usefulness, perceived enjoyment, and perceived fit, and how these factors in turn affect attitude and purchase intention. It is important to find out whether Southeast Asian consumers accept 3D virtual fitting technology in cross-border e-commerce because it will determine the direction of development of internet shopping malls using virtual fitting technology. To verify consumer responses, we intend to apply the integrated technology readiness and acceptance model (TRAM) in relation to technology acceptance. The technology acceptance model (TAM) by Davis (1989) has been most widely cited and used empirically to explain the process that determines a consumer's beliefs about and intention to use new information technology. Although a few studies on virtual fitting technology have also applied traditional TAM, it is generally focused on utilitarian characteristics (e.g. usefulness, ease of use) (Lee et al., 2022). However, researchers argue that consumer expectations about the emotional experience of using technology may increase their intention to adopt virtual fitting technology (Li & Xu, 2020). TAM is considered insufficient to explain consumers' acceptance of virtual fitting technology in fashion shopping, especially given that the fashion shopping journey involves both utilitarian and hedonic aspects. Therefore, in this study, we intend to apply extended TAM by considering not only utilitarian but also hedonic beliefs and perceived fit as beliefs related to virtual fitting. In addition, it is important to know whether consumers are ready to use virtual fitting technology. Technology readiness (TR) can be used to determine if people are ready to embrace new technologies (Parasuraman, 2000). To better understand the behavior of consumers in adopting technology, it is necessary to apply the TRAM that integrates TR and TAM. Lin et al. (2007) made TRAM by integrating two beliefs of TAM's perceived ease of use and perceived usefulness into TR to improve the applicability of TR for specific technologies. This model was found to integrate the individual characteristic dimension of TR with the system characteristic dimension of TAM and to improve the explanatory power of individual components (Godoe & Johansen, 2012). In this study, in addition to the two beliefs of TAM, perceived enjoyment and perceived fit factors related to virtual fitting technology are also considered.

This study contributes to the current literature as follows. First, our academic understanding of the acceptance of virtual fitting technology can be furthered by applying TRAM, which integrates technology readiness and extended TAM, in the context of technology-based e-commerce research. Second, unlike previous studies, this study was expanded to Southeast Asian countries where little research has been conducted. The results of this study contribute to understanding consumers in Southeast Asian countries, unlike existing technology acceptance studies targeting the United States, Europe, and Northeast Asian countries. In particular, it can be used to increase the global competitiveness of Korean fashion products through online shopping malls using 3D virtual fitting technology. Third, practical verification targeting Southeast Asian consumers expands academic understanding of consumers in each country and contributes to designing e-commerce strategies in practice.

Literature Review

3D virtual fitting technology for online shopping

3D virtual fitting technology refers to a kind of image interactivity technology that allows users to experience products online as if they were real. (Yang et al., 2019). Pachoulakis and Kapetanakis (2012) indicated that 3D virtual fitting technology can solve the disadvantages of online shopping that cannot be tried on. Since virtual fitting technology was developed so that consumers can evaluate clothing by providing information similar to that which is gathered through direct experience with the product, it is possible to examine factors such as color, size, and style without actually wearing the clothes (Kim & Forsythe, 2008; Tawira & Ivanov, 2023). Using virtualization technology can improve consumer awareness and attitudes and potentially increase purchases (Kim & Forsythe, 2007, 2008), which can help fashion companies grow globally.

Previous studies have shown that virtual fitting services play an important role in online consumer purchasing decisions (Merle et al., 2012; Park & Kim, 2023). These virtualization technologies not only convey product information, but also provide a more enjoyable shopping experience through interaction and customer engagement (Kim & Forsythe, 2007; Pachoulakis & Kapetanakis, 2012). Research on website and AR-based virtual fitting and VR store service experiences have been conducted (Kim & Forsythe, 2008; Lee et al., 2022; Li & Xu, 2020; Plotkina & Saurel, 2019), but few studies have been conducted on the acceptance of 3D virtual fitting technology in cross-border online shopping targeting Southeast Asian consumers. This study aims to study the consumer response to 3D virtual fitting for rapidly growing consumers in Southeast Asia.

Technology readiness (TR)

TR is the concept of how well prepared a person is to accept new technologies (Parasuraman, 2000). Parasuraman (2000) developed the technology readiness index (TRI) scale suggesting that internet technology affects shopping behavior according to the level of TR of consumers. Customers' propensity to embrace technology varies due to the interaction between the drivers—optimism and innovativeness—and inhibitors—discomfort and insecurity—of TR. Optimism refers to the belief that technology plays a positive role in improving one's degree of control, flexibility, and efficiency in life, and innovativeness refers to the tendency of a person to become a technology pioneer or thought leader. Among the inhibitors, discomfort refers to a lack of control over technology and feelings of being overwhelmed by it, and insecurity refers to the distrust of technology and skepticism about the ability to function properly. Optimism and innovativeness are positive drivers that make consumers use technology-related products or services and form a positive attitude toward technology, but discomfort or insecurity are negative drivers that make them reluctant to use technology (Lin & Hsieh, 2006).

In constructing the TRAM model, this study considered TR as an important antecedent variable affecting TAM. Related studies have found that consumers with higher TR make twice as many online purchases as consumers with lower TR (Parasuraman & Colby, 2001) and are positive about internet shopping (Lin & Hsieh, 2006). Some previous studies used TR as a single factor (Ferreira et al., 2014; Lin & Chang, 2011; Lin et al., 2007), but many studies considered the four factors of the TRI scale of Parasuraman

(2000). (Chiu & Cho, 2021; Lin & Hsieh, 2007; Park et al., 2020). Positive and negative beliefs about technology can coexist and the higher the optimism and innovativeness, and the lower the anxiety and discomfort, the more likely it is that new technologies will be accepted (Hoffman et al., 1999). Thus, since each element of TR can affect consumers' adoption of 3D virtual fitting technology in an online shopping environment, this study considers the four factors of TR to construct a model.

The technology acceptance model (TAM) and extended TAM

The TAM was developed to address the reasons users accept or reject information technology. It is a concrete and concise framework for predicting and explaining users' adoption of information technology (Davis, 1989). This model was based on the theory of reasoned action (TRA) proposed by Fishbein and Ajzen (1975). According to TRA, the performance of a specific human behavior is determined by the behavioral intention, and the behavioral intention is determined by the individual's attitude and subjective norm. In other words, an individual's attitude is an individual's positive or negative feelings about a specific behavior and is related to the outcome of performing the behavior and the individual's beliefs to evaluate the outcome. The TAM accepts the causal relationship of TRA and explains the user's acceptance intention for the new system using two beliefs: perceived usefulness and perceived ease of use (Davis, 1989). The TAM was established based on TRA, but Davis (1989) excluded subjective norm from the TAM because of the uncertainty of measurement. Perceived usefulness refers to the degree to which an individual believes that the use of a particular system improves their performance, and perceived ease of use is defined as the extent to which an individual believes that a particular system can be used without much effort (Davis, 1989; Davis et al., 1989).

These two beliefs alone have limitations in explaining consumers' adoption of 3D virtual fitting technology in cross-border e-commerce shopping (Kim & Forsythe, 2007). Davis (1989)' TAM pointed out that there was a limitation in explaining technology acceptance because it was too simple (Bagozzi, 2007). The expanded TAM, which adds various variables, has been proposed to compensate for this (Venkatesh & Davis, 2000). Therefore, this study intends to consider two factors, perceived enjoyment and perceived fit, in constructing an expanded TAM. Childers et al. (2001) proposed the TAM including enjoyment, a hedonic aspect that was not seen in the existing TAM because the motivation to participate in shopping includes both utilitarian and hedonic dimensions. Perceived enjoyment refers to the degree to which users feel that the act of using technology is themselves enjoyable, regardless of the importance of predicted performance (Davis et al., 1992). Many researchers have also emphasized the importance of perceived enjoyment in TAM by adding perceived enjoyment in addition to perceived usefulness and ease of use (Bruner & Kumar, 2005; Kim & Forsythe, 2008; Plotkina & Saurel, 2019; Van der Heijden, 2004). In this study, perceived fit, which is a belief related to virtual fitting, was also considered in the expanded TAM. Perceived fit is a concept about how well the service environment to which technology is applied meets individual preferences (Kang & Lee, 2015). Perceived fit in this study indicates the degree to which virtual fitting technology satisfies individual preferences in an online shopping environment. 3D virtual fitting technology can increase perceived fit as it helps consumers to evaluate suitability before purchasing a fashion product (Beck & Crié, 2018). In an

online shopping environment, the physical environments of VR shopping feel as if they are related to oneself, consumers may be attracted to the item (Merle et al., 2012). Hong et al. (2004), who studied online shopping behavior, showed that a good fit between shopping tasks and information formats can improve online shopping performance. Thus, perceived fit in an e-commerce environment where 3D virtual fitting technology is applied is expected to lead to a positive attitude toward technology as it is perceived as a good fit for the individual in using technology. As such, this study intends to consider perceived usefulness and perceived ease of use as well as perceived enjoyment and perceived fit as antecedent variables of attitude.

The integrated technology readiness and acceptance model (TRAM)

In this study, to deal with Southeast Asian consumer acceptance of virtual fitting technology, we intend to utilize TRAM related to technology acceptance. TRAM was proposed by Lin et al. (2007) to study the acceptance intention for e-service, and it indicates that TR, which is a user's personal characteristic, works in TAM. Lin et al. (2007) used TRAM to increase consumer accountability for the adoption of new technologies and expand the applicability of previous models. TRAM is a model that complements the limitations of the existing TAM by integrating TR—the consumer's personal factor—and perceived usefulness and perceived ease of use, which are system characteristics. However, studies that applied TRAM did not consider the multidimensional characteristics of TR by considering technology readiness as a single factor and not dividing it into sub-dimensions. (Lin et al., 2007). Subsequent studies have shown that subdimensions of TR can have different effects on consumer response to technology (Chen & Lin, 2018; Lam et al., 2008; Park et al., 2020; Walczuch et al., 2007). In this study, each of the four TR subdimensions is expected to have a different effect on consumer response, and we intend to consider all four factors.

TRAM Framework and hypothesis development

Optimism and innovativeness are positive drivers of TR. Consumers who feel optimistic about new technologies have positive beliefs about new technologies for freedom, control, and effective work performance through technology (Chen & Lin, 2018; Parasuraman, 2000; Sunny et al., 2019). In other words, consumers with an optimistic attitude toward new technologies are more likely to perceive the usefulness and ease of use of virtual fitting technologies as they actively use them with the belief that new technologies will provide efficiency and flexibility. Previous studies have shown a positive relationship between optimism and perceived enjoyment by revealing that higher optimism induces enjoyment in using technology in fashion stores (Park et al., 2020). Furthermore, the positive belief of highly optimistic consumers in the new technology will increase the perceived fit by satisfying the individual's preference for virtual fitting technology.

Next, innovativeness is an important positive driver in technology adoption. Consumers with strong technological innovativeness have a strong motivation to accept technology and a strong tendency to apply their technology-related knowledge to technology-based products (Lam et al., 2008; Parasuraman & Colby, 2001). Therefore, the greater the innovativeness, the greater the perception of the ease of use and usefulness of e-commerce virtual fitting technology. In addition, since highly innovative consumers

are more likely to try and enjoy using new innovations more positively (Rouibah et al., 2016), innovativeness is expected to form a positive relationship with perceived enjoyment. Virtual fitting technology can increase perceived fit by satisfying consumer needs, which in turn enriches consumers with experiences of reality in an online environment (Poushneh, 2018).

H1. The optimism of TR will have a positive effect on (a) perceived ease of use, (b) perceived usefulness, (c) perceived enjoyment, and (d) perceived fit.

H2. The innovativeness of TR will have a positive effect on (a) perceived ease of use, (b) perceived usefulness, (c) perceived enjoyment, and (d) perceived fit.

Discomfort or insecurity is a negative driver for technology adoption. Discomfort is considered important in technology adoption because it refers to a feeling of lack of control over a particular technology and can lead to distrust of the technology (Lu et al., 2012). Consumers with a high level of discomfort are less likely to explore new technology-based products and services (Son & Han, 2011). Therefore, the greater the discomfort, the lower the likelihood that the consumer will perceive the product or service as useful and easy to use. In addition, comfort in a shopping environment can induce enjoyment (Ainsworth & Foster, 2017), whereas an uncomfortable atmosphere can reduce enjoyment. In addition, virtual fitting technology increases perceived fit that satisfies individual preferences by providing convenience to consumers. However, the increased discomfort of the individual leads to a more negative response because it leads to the perception of the new technology as complex (Mick & Fournier, 1998). Therefore, an increase in discomfort may reduce the likelihood of exploring a virtual fitting service, resulting in a decrease in perceived fit.

Insecurity is the result of a lack of trust in technology and its ability to function properly (Parasuraman, 2000). Perceived insecurity is generally recognized as contributing to the slowing of the adoption of e-commerce (Hoffman et al., 1999). Jin (2013) found that negative TR drivers such as discomfort and insecurity had a negative effect on perceived usefulness and ease of use. Therefore, it is expected that the negative TR drivers will have a negative effect on the technical acceptance of the virtual fitting technique. Such negative TR can reduce an individual's emotional state such as the enjoyment gained from interacting with new technology (Ferreira et al., 2014), and a lack of trust or concerns about technology can negatively affect e-commerce and reduce perceived fit. Accordingly, the following hypotheses were formulated.

H3. Discomfort of TR will have a negative effect on (a) perceived ease of use, (b) perceived usefulness, (c) perceived enjoyment, and (d) perceived fit.

H4. Insecurity of TR will have a negative effect on (a) perceived ease of use, (b) perceived usefulness, (c) perceived enjoyment, and (d) perceived fit.

Perceived ease of use and perceived usefulness are known to be factors that positively influence attitudes (Davis, 1989). Perceived ease of use not only directly affects one's attitude toward use, but also has been found to affect one's attitude toward use through cognitive usefulness and is considered a prerequisite for usefulness (Adams et al., 1992). As such, TAM provides a useful analytical framework for the use and adoption of information technology through variables such as perceived usefulness, perceived ease of use, attitude, and behavioral intention. Accordingly, the following hypotheses were developed.

H5. Perceived ease of use will have a positive effect on perceived usefulness.

H6. Perceived ease of use will have a positive effect on attitude.

H7. Perceived usefulness will have a positive effect on attitude.

Previous studies have found that perceived enjoyment in the shopping environment plays an important role in the TAM. Chung and Tan (2004) found that enjoyment had a positive effect on users' continuous use of search websites. In addition, Lu et al. (2009) presented an extended TAM that included perceived enjoyment in the TAM for instant messages and revealed that perceived enjoyment had a positive effect on attitude and intention to use. Bruner and Kumar (2005) analyzed the effect on attitude by adding perceived enjoyment to perceived usefulness and ease of use.

In the online shopping environment, consumers have a limited ability to collect product information, which increases product risk if consumers cannot accurately evaluate product quality (Kim & Forsythe, 2008). In particular, the uncertainty associated with not trying on clothing increases, and 3D virtual fitting technology in online shopping can reduce the perceived risk for consumers (Shim & Lee, 2011). Virtual fitting technology can increase the perceived fit by helping users to make their online experience similar to one in real life (Pachoulakis & Kapetanakis, 2012). This can lead users to have a positive attitude towards the technology. Also, it was found that virtual fitting technology plays an important role in online purchase decisions (Merle et al., 2012). Accordingly, the following hypotheses were proposed.

H8. Perceived enjoyment will have a positive effect on attitude.

H9. Perceived fit will have a positive effect on attitude.

H10. Attitude will have a positive effect on purchase intention.

Previous studies have shown that Southeast Asian countries have different consumer behaviors. Han et al. (2016) analyzed online shopping behavior of consumers in Malaysia, Indonesia, and Vietnam, and confirmed that consumers in each country showed characteristic purchasing behavior. For example, Indonesian consumers show high mobile usage, while Vietnamese consumers prefer convenient payment methods. Although Vietnam, Indonesia, and Thailand are Southeast Asian countries, there are likely to be differences in consumer behavior from one country to another. While individual studies are being conducted on each country, it is difficult to find a study comparing consumer acceptance in online shopping in these three countries. Therefore, it would be more efficient to propose a customized sales strategy for Korean fashion products that considers the characteristics of consumers in each country. The hypotheses suggested above seem to differ by country, so the following hypotheses were established.

H 11. In the proposed model, the relationships between variables will differ across the three countries.

The research model based on the research hypotheses established so far is shown in Fig. 1. We introduced experiences with purchasing South Korean fashion products as control variable that could influence purchase intention and attitudes.

Methods

Sampling and data collection

We collected data from male and female consumers in their 20 s and 30 s living in Vietnam, Indonesia, and Thailand through an online specialized survey company. The survey

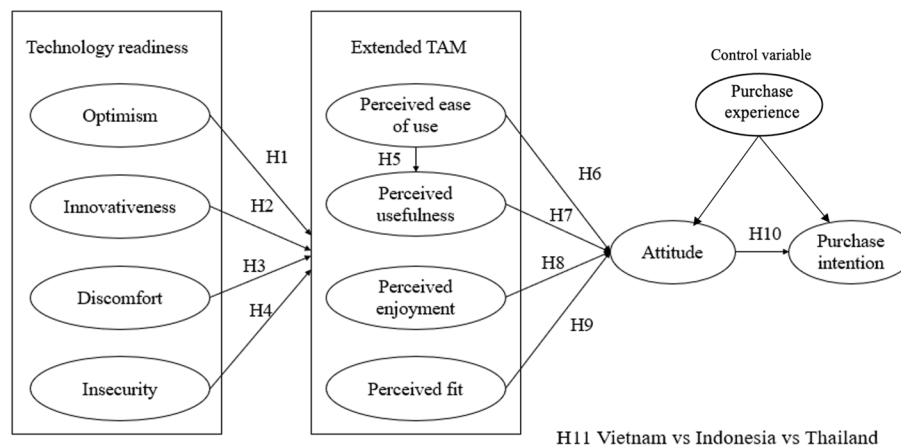


Fig. 1 Proposed hypotheses to test consumer acceptance of 3D virtual fitting technologies in cross-border online shopping

firm sent out an e-mail invitation with the survey URL to their panels. Survey participants were informed that completion of the questionnaire was anonymous and voluntary. Participants first watched a video for approximately 1 min explaining the usage of the 3D virtual fitting technology. The procedure demonstrated in the video for utilizing the 3D virtual fitting is as follows: When purchasing fashion items through online shopping, consumers can input their body size to generate an avatar. Subsequently, when selecting a fashion product, they can virtually try it on and verify the fit through the 3D virtual fitting system. Respondents responded to the questionnaire assuming that they were purchasing fashion products using the 3D virtual fitting system via an online shopping site. A total of 600 data were used for final analysis—200 for each country—using a quota sampling method with gender and age. The total sample was 50% male and 50% female, and respondents’ ages were evenly distributed between the 20 s and 30 s.

Looking at the level of education, 160 (80%) of Vietnamese respondents, 120 (60%) of Indonesian respondents, and 151 (75.5%) of Thai respondents had a bachelor’s degree. Among Vietnamese respondents, 103 (51.5%) had never visited Korea, compared to 123 (61.5%) of Indonesian respondents, and 82 (41.0%) of Thai respondents. It was found that 172 (86%) of Vietnamese respondents, 153 (76.5%) of Indonesian respondents, and 150 (75%) of Thai respondents had experience purchasing Korean fashion products. Table 1 presents the demographic characteristics of the respondents.

Measurements

The constructs included in this study were measured via multi-item scales adapted from previous studies. The questionnaire consisted of seven sections measuring technology readiness, perceived ease of use, perceived usefulness, perceived enjoyment, perceived fit, attitude, purchase intention, and demographic variables. Technological readiness was measured using 16 items developed by Parasuraman and Colby (2001). Perceived ease of use and perceived usefulness were measured with three items each using items presented in the study of Childers et al. (2001). Perceived enjoyment was determined by modifying the four items presented in the study of Plotkina and Saurel (2019). The perceived fit of the 3D virtual fitting system was adopted from Kang and

Table 1 Demographic information about the respondents

Characteristic		Vietnam	Indonesia	Thailand
Gender	Male	100 (50%)	100 (50%)	100 (50%)
	Female	100 (50%)	100 (50%)	100 (50%)
Age	20's	100 (50%)	100 (50%)	100 (50%)
	30's	100 (50%)	100 (50%)	100 (50%)
Education	Below high school	1 (0.5%)	1 (0.5%)	2 (1.0%)
	Completed High school	14 (7.0%)	39 (19.5%)	16 (8.0%)
	Have associate degree	11 (5.5%)	18 (9.0%)	17 (8.5%)
	Have bachelor's degree	160 (80%)	120 (60.0%)	151 (75.5%)
Frequency of visiting Korea	Have graduate degree	14 (7.0%)	22 (11.0%)	14 (7.0%)
	None	103 (51.5%)	123 (61.5%)	82 (41.0%)
	1–2 times	81 (40.5%)	57 (28.5%)	90 (45.0%)
	3–4 times	13(6.5%)	16 (8.0%)	20 (10.0%)
Purchase experience for Korean fashion product	Over 5 times	3 (1.5%)	4 (2.0%)	8 (4.0%)
	Yes	172 (86%)	153 (76.5%)	150 (75.0%)
	No	28 (14%)	47 (23.5%)	50 (25.0%)

Lee (2015). The attitude toward using the 3D virtual wearing system was measured with three items based on the study of MacKenzie et al. (1986). Finally, the intention to purchase the Korean fashion product using the 3D virtual fitting system was measured with the three items used in the study of Plotkina and Saurel (2019). All constructs were measured on 7-point Likert-type scales (1 = strongly disagree and 7 = strongly agree).

Results

Measurement Validity and Reliability

To analyze the research model, we used Partial Least Squares (PLS) analysis with SmartPLS 3.0 software. Following the recommended two-stage analytical procedures for SEM, we tested the measurement model (validity and reliability of the measures) and then examined the structural model (Hair et al., 2021). Prior to evaluating the validity and reliability, the factor loading value of one of the 16 technical readiness items was less than 0.5, so we removed it.

First, the measurement model was tested for convergent validity. This was assessed through factor loadings, Composite Reliability (CR), and Average Variance Extracted (AVE). Table 2 shows that all item loadings exceeded the recommended value of 0.6 (Chin et al., 2008). Composite reliability values exceeded the recommended value of 0.7 while the average variance extracted exceeded the recommended value of 0.5 (Hair et al., 2021). To assess the discriminant validity, we used Fornell and Larcker's (1981) criteria. Table 3 shows that the square root of the AVE (diagonal values) of each construct is larger than its corresponding correlation coefficients, pointing towards adequate discriminant validity (Fornell & Larcker, 1981).

Second, the results of the reliability tests (see Table 3) show that the individual Cronbach's alpha coefficients of the constructs ranged from 0.83 to 0.92—greater than 0.7 (Hair et al., 2021). Therefore, the measurement model had satisfactory reliability.

Table 2 Validity and reliability for constructs

Constructs	Items	Loadings	AVE	CR
Optimism	New technologies contribute to a better quality of life	.87	.76	.92
	Technology gives me more freedom of mobility	.86		
	Technology gives people more control over their daily lives	.86		
	Technology makes me more productive in my personal life	.87		
Innovativeness	Other people come to me for advice on new technologies	.82	.71	.90
	In general, I am among the first in my circle of friends to acquire new technology when it appears	.85		
	I can usually figure out new high-tech products and services without help from others	.84		
	I keep up with the latest technological developments in my areas of interest	.85		
Discomfort	When I get technical support from a provider of a high-tech product or service, I sometimes feel as if I am being taken advantage of by someone who knows more than I do	.89	.73	.91
	Technical support lines are not helpful because they don't explain things in terms I understand	.84		
	Sometimes, I think that technology systems are not designed for use by ordinary people	.82		
	There is no such thing as a manual for a high-tech product or service that's written in plain language	.85		
Insecurity	People are too dependent on technology to do things for them	.90	.80	.92
	Too much technology distracts people to a point that is harmful	.91		
	Technology lowers the quality of relationships by reducing personal interaction	.86		
Perceived ease of use	This shopping technology would be clear and understandable	.89	.75	.90
	This shopping technology would not require a lot of mental effort	.79		
	This shopping technology would be easy to use	.90		
Perceived usefulness	This shopping technology would improve my shopping productivity when I am buying Korean apparel products	.91	.85	.94
	This shopping technology would enhance my effectiveness in Korean apparel shopping	.93		
	This shopping technology would be useful in buying Korean apparel products that I want	.91		
Perceived enjoyment	Shopping with this technology would be fun for its own sake	.89	.82	.94
	Shopping with this technology would involve me in the shopping process	.89		
	Shopping with this technology would be exciting	.92		
	Shopping with this technology would be enjoyable	.90		
Perceived fit	This shopping technology is currently configured to the way I want it to be	.90	.84	.93
	The current configuration of this shopping technology suits my needs	.92		
	This shopping technology in its current configuration is exactly what I want	.91		
Attitude	The idea to buy Korean apparel products using this shopping technology is appealing	.91	.84	.94
	I would like to buy Korean apparel products using this shopping technology	.92		
	Using this shopping technology to buy Korean apparel products would be a good idea	.92		

Table 2 (continued)

Constructs	Items	Loadings	AVE	CR
Purchase intention	It is likely that I will transact with this shopping technology to buy Korean apparel products in the near future	.89	.83	.93
	Given the chance, I intend to use this shopping technology to purchase Korean apparel products	.91		
	I want to purchase Korean apparel products using this shopping technology	.92		

Table 3 Correlation analysis among the major constructs

Constructs	Cr. α	1	2	3	4	5	6	7	8	9	10
Attitude	.91	.92									
Discomfort	.88	.02	.85								
Perceived enjoyment	.92	.83	.05	.90							
Perceived fit	.90	.78	.15	.82	.91						
Innovativeness	.86	.61	.29	.64	.66	.84					
Insecurity	.87	.07	.69	.08	.14	.15	.89				
Optimism	.89	.73	.12	.78	.73	.70	.13	.87			
Perceived ease of use	.83	.74	.07	.83	.76	.59	.11	.74	.86		
Purchase intention	.89	.85	.09	.81	.80	.64	.08	.73	.73	.91	
Perceived usefulness	.90	.79	.00	.85	.76	.59	.07	.76	.79	.79	.92

Note: Values on the diagonal (bolded) are square root of the AVE while the off-diagonals are correlations

Hypothesis testing

To assess the structural model, Hair et al. (2021) suggested looking at the R², beta, and corresponding t-values via the bootstrapping procedure with a resample of 5000. They also suggested that, in addition to these basic measures, researchers should report the predictive relevance (Q²) and the effect sizes (f²).

First, we assessed the effect sizes (f²). To measure the effect size, we used Cohen’s (1988) guidelines, which are 0.02 for small effects, 0.15 for medium effects, and 0.35 for large effects. Table 4 shows that the relationships had small, medium, and large effects. The R² values of the endogenous variables perceived ease of use, perceived usefulness, perceived enjoyment, perceived fit, attitude, and purchase intention were 0.57, 0.71, 0.64, 0.5, 0.74, and 0.74, respectively. The predictive sample reuse technique (Q²) can also effectively show predictive relevance (Chin et al., 2008). Based on the blindfolding procedure, Q² shows how well data can be reconstructed empirically using the model and the PLS parameters. For this study, Q² was obtained using cross-validated redundancy procedures. A Q² greater than 0 means that the model has predictive relevance, whereas a Q² less than 0 means the model lacks predictive relevance. In this study, Q² for both endogenous variables indicates acceptable predictive relevance.

Hypotheses 1–4 examined the associations between TR and consumer perceptions of the 3D virtual fitting system (perceived ease of use, usefulness, enjoyment, and fit). In support of H1a–d, optimism had a significant impact on perceived ease of use ($\gamma=0.61$), usefulness ($\gamma=0.35$), enjoyment ($\beta=0.63$), and fit ($\gamma=0.51$). Also, innovativeness positively influenced ease of use ($\gamma=0.18$), perceived usefulness ($\gamma=0.09$), enjoyment ($\gamma=0.22$), and fit ($\gamma=0.30$), supporting H2a–d. Discomfort negatively

Table 4 Structural equation modeling (SEM) analysis results

Hypotheses	Path Coefficient	t-value	Results	f square
H1a: Optimism → Perceived ease of use	.61	15.19***	Supported	0.42
H1b: Optimism → Perceived usefulness	.35	6.75***	Supported	0.15
H1c: Optimism → Perceived enjoyment	.63	15.26***	Supported	0.53
H1d: Optimism → Perceived fit	.51	9.44***	Supported	0.30
H2a: Innovativeness → Perceived ease of use	.18	3.99***	Supported	0.03
H2b: Innovativeness → Perceived usefulness	.09	2.07*	Supported	0.01
H2c: Innovativeness → Perceived enjoyment	.22	5.21***	Supported	0.06
H2d: Innovativeness → Perceived fit	.30	6.10***	Supported	0.10
H3a: Discomfort → Perceived ease of use	−.10	2.26*	Supported	0.01
H3b: Discomfort → Perceived usefulness	−.13	3.07**	Supported	0.03
H3c: Discomfort → Perceived enjoyment	−.13	3.05**	Supported	0.02
H3d: Discomfort → Perceived fit	−.03	0.67	Rejected	0.00
H4a: Insecurity → Perceived ease of use	.07	1.60	Rejected	0.01
H4b: Insecurity → Perceived usefulness	.04	1.24	Rejected	0.00
H4c: Insecurity → Perceived enjoyment	.05	1.39	Rejected	0.01
H4d: Insecurity → Perceived fit	.04	1.02	Rejected	0.00
H5: Perceived ease of use → Perceived usefulness	.48	10.11***	Supported	0.35
H6: Perceived ease of use → Attitude	.02	0.45	Rejected	0.00
H7: Perceived usefulness → Attitude	.22	3.68***	Supported	0.04
H8: Perceived enjoyment → Attitude	.43	6.51***	Supported	0.12
H9: Perceived fit → Attitude	.22	3.92***	Supported	0.06
H10: Attitude → Purchase intention	.84	51.25***	Supported	2.66
Purchase experience → Attitude	.12	2.13*		0.01
Purchase experience → Purchase intention	.22	3.98***		0.03

Significant at * $p < .05$, ** $p < .01$, *** $p < .001$

influenced ease of use ($\gamma = -0.10$), perceived usefulness ($\gamma = -0.14$), and enjoyment ($\gamma = -0.13$), but did not influence fit. Therefore, H3a–c were supported, but H3d was rejected. Insecurity had no significant effect on anything, so H4a–d were not supported. In support of H5, perceived ease of use had a significant impact on usefulness ($\beta = 0.48$). Except for perceived ease of use, only usefulness, enjoyment, and fit had a significant effect on attitudes toward the 3D virtual fitting system, so H7, H8, and H9 were accepted, and H6 was rejected. Finally, attitude toward the 3D virtual fitting system had a significant impact on the purchase intention for Korean fashion products using the 3D virtual fitting system ($\beta = 0.85$), supporting H10. The hypothesis test results are shown in Table 4.

PLS analysis was performed for each country to test Hypothesis 11, and the results are shown in Table 5. The TRAM model was individually applied to three countries, and PLS analysis was conducted. The results revealed that the CR and AVE values provided by the individual models for each country met the established criteria, ensuring discriminant validity as well. Among the factors of technological readiness, optimism and insecurity did not show any difference between the three countries. However, innovativeness did not have a significant effect on perceived ease of use except for in the case of Thai consumers. Discomfort had a negative effect on perceived ease of use, perceived usefulness, and perceived enjoyment for Vietnamese consumers. To these

Table 5 Analysis of three countries in the TRAM model

Hypotheses	Vietnam		Indonesia		Thailand	
	Path Coefficient	t-value	Path Coefficient	t-value	Path Coefficient	t-value
H1a: Optimism → Perceived ease of use	.66	10.39***	.50	7.32***	.68	8.24***
H1b: Optimism → Perceived usefulness	.32	4.26***	.35	3.54***	.43	4.50***
H1c: Optimism → Perceived enjoyment	.67	11.48***	.55	6.86***	.66	7.54***
H1d: Optimism → Perceived fit	.51	5.09***	.43	4.75***	.56	7.46***
H2a: Innovativeness → Perceived ease of use	.17	2.14*	.28	4.24***	.08	1.04
H2b: Innovativeness → Perceived usefulness	.10	1.67	.12	1.40	.01	0.16
H2c: Innovativeness → Perceived enjoyment	.23	3.42***	.20	2.77**	.21	2.63**
H2d: Innovativeness → Perceived fit	.33	3.71***	.31	4.00***	.28	3.52***
H3a: Discomfort → Perceived ease of use	-.15	2.16*	-.02	0.29	-.12	1.33
H3b: Discomfort → Perceived usefulness	-.11	2.11*	-.10	1.17	-.11	1.76
H3c: Discomfort → Perceived enjoyment	-.13	2.45*	-.09	0.89	-.17	1.88
H3d: Discomfort → Perceived fit	-.05	0.69	-.02	0.19	-.08	1.10
H4a: Insecurity → Perceived ease of use	.11	1.73	.02	0.31	.15	1.70
H4b: Insecurity → Perceived usefulness	.02	0.47	-.06	0.57	.01	0.31
H4c: Insecurity → Perceived enjoyment	.08	1.49	-.10	1.29	.08	0.97
H4d: Insecurity → Perceived fit	.07	1.06	-.03	0.39	.13	1.69
H5: Perceived ease of use → Perceived usefulness	.54	7.09***	.38	4.54***	.51	6.01***
H6: Perceived ease of use → Attitude	-.08	0.83	.14	1.68	.00	0.03
H7: Perceived usefulness → Attitude	.22	1.96*	.19	2.38*	.27	2.35*
H8: Perceived enjoyment → Attitude	.51	3.91***	.36	3.39***	.43	3.99***
H9: Perceived fit → Attitude	.25	1.88	.22	2.22*	.21	2.52*
H10: Attitude → Purchase intention	.87	35.09***	.76	20.87***	.88	4.83***
Purchase experience → Attitude	.15	1.23	.10	1.00	.08	0.88
Purchase experience → Purchase intention	.14	1.38	.45	4.21***	.06	0.73

Significant at *p<.05, **p<.01, ***p<.001

same consumers, perceived fit did not appear to have a significant effect on attitude. The research model showed differences in some pathways between the three countries, so Hypothesis 11 was adopted.

Conclusions

The purpose of this study is to analyze Thai, Vietnamese, and Indonesian consumer responses to cross-border online shopping for Korean fashion products using 3D virtual fitting technology by implementing TRAM combining TAM and technical readiness. The specific results are as follows. First, optimism and innovativeness, positive factors of technological readiness, were found to positively affect consumers' perceived usefulness, ease of use, enjoyment, and perceived fit. However, discomfort—a negative factor—adversely affects consumers' perceived usefulness, ease of use, and enjoyment. Insecurity did not appear to have any effect. In line with previous findings (Blut & Wang, 2020; Park et al., 2020), this study confirmed that motivators play a more critical role than inhibitors in the technological readiness that explains 3D virtual fitting technology acceptance in cross-border online shopping. Specifically, optimism was found to have the most important influence on perceived usefulness, ease of use, enjoyment, and perceived fit. Discomfort—which causes one to feel a lack of control over technology and perceive technology as a threat (Taylor et al., 2002)—has a negative effect. In the relationship between the mediating variables and the dependent variable, perceived ease of use did not directly affect attitude toward virtual fitting technology, but indirectly influenced attitude through usefulness. Perceived enjoyment and fit also significantly impact attitude, ultimately influencing the purchase intention for Korean fashion products. Among the four mediating variables, it was revealed that perceived enjoyment exerted the most significant influence on attitude. This finding highlights the greater importance of the enjoyment factor over traditional variables like perceived usefulness and perceived usability. This alignment with recent prior research (Bruner & Kumar, 2005; Chung & Tan, 2004; Lu et al., 2009) demonstrates the growing significance of hedonic motivation over utilitarian motivation in technology acceptance, showcasing the increasing importance of pleasurable motivations in addition to practical ones. Thus, the possibility of using virtual fitting technology during cross-border online shopping to support the online sales of Korean fashion products was confirmed. Finally, because of analyzing the difference in TRAM by country, optimism was determined as an important variable affecting all countries. Innovativeness was an influencing factor in Vietnam and Indonesia but did not affect Thai consumers. In particular, for Vietnamese consumers, discomfort negatively affects the perceived ease of use, usefulness, and enjoyment. Accordingly, fashion retailers must implement cross-border online strategies differentiated by country.

Theoretical implications

This study examined how technology readiness affects cross-border online shopping using 3D virtual technology, implementing TAM, and the difference in TRAM across three Southeast Asian countries. By testing the proposed research model, our results make important contributions to the present theory. First, this study demonstrated the possibility of integrating the TAM (Technology Acceptance Model) and the Technology Readiness Model. In other words, this study has academic significance as it supplements and develops existing studies on the acceptance of 3D virtual fitting technology by applying TRAM and including extended TAM. This study is significant as it empirically analyzed TRAM, in which TR, representing consumer characteristics, was integrated

into an extended TAM. That is, the superiority of TRAM was proven in the acceptance of 3D virtual fitting technology. Extant studies have explained the acceptance of 3D virtual fitting technology in cross-border online transactions using TAM (Davis, 1989), describing consumers' beliefs and intentions to use new information technologies. However, other factors, such as consumer characteristics, must also be considered to understand consumer behavior toward technology adoption. This study showcased that positive factor of technological readiness such as optimism and innovativeness, along with negative factors like discomfort, can act as significant antecedents within the TAM mode. This aligns with the findings of the study by Musyaffi et al. (2022), which investigated digital banking adoption in the post-COVID-19 pandemic era, providing similar evidence. However, while the study by Musyaffi et al. (2022) emphasized innovativeness as the most crucial factor, this current study revealed that optimism plays the most significant role in technology adoption. This highlights the variation depending on the nature of the technology, indicating that the key factors in technological readiness can differ across technologies. Thus, it emphasizes the need for strategies that take into account the characteristics of the technology. Second, the strength of this study is that it includes hedonic variables and virtual fitting-related variables in addition to traditional elements of TAM such as perceived usefulness and perceived ease of use. This study includes perceived enjoyment, which is a hedonic variable, perceived fit, which is a variable related to virtual fitting, and perceived usefulness and ease of use, which are exogenous variables of TAM (Lin et al., 2007; Lin & Hsieh, 2006). During the early days of utilizing TAM for technology acceptance, the focus was primarily on traditional variables like perceived usefulness and perceived ease of use (Bruner & Kumar, 2005; Childers et al., 2001; Ferreira et al., 2014; Hwang et al., 2016; Ko et al., 2009; Oh et al., 2009). The initial research of TAM was considered to primarily focus on extrinsic motivation related to the practical aspects of information technology (Choi & Kim, 2016). With the recognition that intrinsic motivations like perceived enjoyment, in addition to extrinsic motivations, can enhance behavioral intention in technology acceptance (Davis et al., 1992), perceived enjoyment is now considered an important antecedent in technology adoption. In this study, an extended TAM was constructed by incorporating the factors of perceived enjoyment and perceived fit. Both of these factors were proven to influence attitudes toward cross-border online shopping, once again highlighting their importance. Thirdly, this study analyzed technology readiness by dividing it into positive factors (optimism and innovativeness) and negative factors (discomfort and insecurity). In previous studies (Parasuraman, 2000; Parasuraman & Colby, 2001) that developed a technology readiness scale, the four dimensions were presented separately. However, in subsequent studies (Jin, 2013; Lin et al., 2006), the sum of the technical readiness scores was used, which offsets positive and negative factors; thus, it is impossible to distinguish which factors influence technology acceptance more. Therefore, in this study, the four sub-dimensions of technical readiness were individually verified, contributing to a better understanding of technological readiness. By analyzing the four dimensions separately, it was revealed that in the acceptance of 3D virtual fitting technology, optimism emerged as the most crucial factor. This suggests that considering consumer optimism is essential for future adoption of such technologies. In Vietnam, discomfort was identified as a significant factor affecting technology acceptance. However, for all three countries, it was

revealed that insecurity is not a crucial factor in the adoption of 3D virtual fitting technology. This implies that not only advanced countries but also Southeast Asian countries have managed to alleviate much of the apprehension towards technology, suggesting the presence of a positive atmosphere for technology acceptance. The inference can be drawn that Southeast Asian countries have overcome the perception that they are technologically lagging behind advanced nations. Thus, to enhance inter-country trade, there is a need to discard the notion that applying technologies like the 3D virtual fitting system is challenging for these countries due to perceived technological limitations. Efforts should be directed towards integrating IT into shopping environments to stimulate cross-border transactions, breaking away from the perception that technology development is slower in Southeast Asian nations compared to developed countries. Finally, this study is significant as it expands the existing 3D virtual fitting technology centered in the US, Europe, and Northeast Asia (Beck & Crié, 2018; Lee et al., 2022; Plotkina & Saurel, 2019) to Southeast Asian countries. Southeast Asia has recently attracted attention for its growth potential in the fashion market, but the application of 3D virtual fitting technology has not been academically verified. In line with this trend, our study is academically significant, examining the acceptance of 3D virtual fitting technology for Southeast Asian consumers.

Managerial implications

This study suggests that when fashion retailers use virtual fitting technology in a cross-border online shopping situation, it is necessary to understand consumers' beliefs about adopting technology. Our analysis of how consumers in three countries Southeast Asia understand and accept virtual fitting technology provide the following insights required by Korean fashion retailers to understand the behavior of consumers in these countries and develop customized strategies for each country. First, fashion retailers should implement strategies to reduce discomfort and raise expectations for technology if they are to promote consumer purchases. For example, uploading a demonstration using virtual fitting technology to an online site or introducing a real-time feedback system such as a chatbot reduces a consumer's discomfort about technology. Furthermore, it is essential to emphasize that the 3D virtual fitting system is a positive technology that recommends well-fitting clothes to consumers, allowing them to confirm the fit. Efforts should be directed towards activating consumer reviews from those who have made purchases to improve perceptions of the technology. Second, since the perceived enjoyment had the greatest effect on the attitude toward the virtual fitting system, cross-border online retailers should emphasize that the introduction of this technology will provide a new and enjoyable experience. This is also consistent with the results of Baker et al. (2019), which emphasize the hedonic value over the practical value in online shopping. To enhance enjoyment, it's essential to offer a variety of content to reduce monotony. For instance, providing diverse combinations of outfits, allowing users to coordinate hair, makeup, and accessories together, is crucial. To ensure sustained enjoyment, a wide range of clothing options must be available, rather than just one-time experiences. Additionally, offering contextual backgrounds for the attire can heighten realism and enjoyment. For instance, providing a beach backdrop for swimwear or an office setting for formal attire can further elevate the sense of immersion and delight. Lastly, this study

was conducted on three countries in Southeast Asia. This has been demonstrated by applying the TRAM to three different countries, providing strong validity and further enhancing the model. Moreover, the variations in the influence of variables used in the model across these three countries offer insights into understanding the unique characteristics of each country individually. In other words, even in the same Southeast Asian country, consumers' reactions to technology may differ along with the political, economic, and cultural environments. Therefore, in order to target Southeast Asian consumers, it is necessary to understand the differences between consumers by country and provide customized strategies accordingly. Ultimately, fashion retailers who make good use of this strategy will be well-positioned to compete with global online retailers in the Southeast Asian market to attract consumers.

Limitations and future research directions

Although this study provides valuable implications, there are several limitations. Despite the growth of cross-border e-commerce, there remains an insufficient number of global sites that have introduced virtual fitting technology domestically and abroad. There is a limit to the actual experience because the response was made by watching a video using the virtual fitting technology. Future research should investigate the experiences and satisfaction of consumers after actually using the virtual fitting technology. Even though it is an online transaction, factors such as a country's or product's image can affect whether a consumer makes a purchase since it is a cross-border transaction. Cultural factors such as Korea's image as a country and Korean Wave should therefore be considered in future research. Lastly, additional research on cross-border online transactions is needed because factors such as shipping, returns, and price fluctuations due to exchange rates can affect purchases.

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Author contributions

HSY: Conceptualization, article structure construction, methodology, and data analysis, writing the manuscript; YJK: writing the manuscript, reviewing, editing. Both authors read and approved the final manuscript.

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Availability of data and materials

Please contact the authors for data requests.

Declarations

Ethics approval and consent to participate

This research was conducted under the approval and supervision of Sangmyung University Institutional Review Board (IRB Approval No: IRB-SMU-S-2020-4-003) regarding ethical issues including consent to participate.

Competing interests

The authors declare that they have no competing interests.

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