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Balancing Airport Security and Passenger Facilitation in Aviation

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Abstract:
Airport security has to adjust to a growing number of passengers while maintaining high levels of accuracy in screening. It is crucial for airport managers to explore and implement potential upgrades in the security process without compromising the passenger experience. Biometric technology emerges as an efficient solution, enabling secure clearance based on individual biometric features. Despite its effectiveness, both airports and passengers have been hesitant to embrace this technology. Moreover, limited research exists on passengers' attitudes towards repeat use of biometric security. To bridge this gap, our study focused on understanding passengers' initial and repeat usage intentions by examining the perceived benefits and risks associated with biometric security technology through a survey involving 327 participants. By using structural equation modeling to analyze the data, we established that both perceived benefits and risks significantly influence passengers' intention to initially adopt and repeatedly use biometric security. This research sheds light on how airport practitioners can create value for travelers while managing the challenges involved in implementing biometric security measures within airport settings.

Keywords: biometrics; perceived risk; perceived benefit; passenger intention; repeat use; sustainable airport management

1. Introduction

There has been no significant alteration in aviation security since the late 1990s, when walk-through metal detectors and X-ray machines were implemented in the 1970s (j, 2016). Nonetheless, the events of 9/11 in 2001 prompted the need for stronger and improved security measures. From a sustainable airport management standpoint, this new and significant security risk quickly became a crucial issue for airports. Even a single aviation security incident could result in the shutdown of an entire terminal and pose a potential safety hazard to passengers. As a result, the uncompromising concept of robust aviation security has become an unavoidable factor for airport authorities worldwide as they strive to address risks from various angles, including terrorism (Schwaninger, 2005):(Khalid & Anpalagan, 2010). A comprehensive approach to sustainable airport management, combined with robust aviation security measures, could lead to increased investment in security infrastructure by airport operators. This not only benefits the airports but also enhances safety conditions for airlines, thereby boosting their competitiveness and confidence in operating aircraft. The Airports Council International has predicted a significant increase in global passenger traffic from 8.7 billion in 2018 to an estimated 19.5 billion by 2040, comprising approximately 8.9 billion for domestic and 10.6 billion for international passenger traffic respectively (Khalid & Anpalagan, 2010).

However, the significant increase in passenger traffic could have a negative impact on aviation security and sustainable airport management. This could result in an increased workload for security agents, potentially leading to loopholes in aviation security due to limited attention during inspections. Furthermore, there may be insufficient resources to handle screening operations unless airports significantly invest in human resources. Moreover, heightened standby times could compromise the standard of excellence for passenger facilitation and affect the overall sustainability of airport operation (Khalid & Anpalagan, 2010).

As a result, international airports are advancing the implementation of advanced technologies such as biometrics to enhance airport security and improve passenger convenience for efficient terminal operations (Negri et al., 2019),(Kalakou et al., 2015). Biometric security has become increasingly relevant for its ability to provide precise and convenient services, particularly during the identification process (Negri et al., 2019)(Wilkinson, 2018).

In order to improve both the experience for passengers and security in aviation, sustainable airport management relies on the successful implementation of advanced technologies like biometrics. This depends not only on system operators such as airport managers but also on passengers' willingness to use these technologies. For instance, other information systems that aim for efficient operation, like enterprise resource planning, mostly rely on internal motivation to achieve their goals. However, the success of implementing biometric security at airports hinges on how willing passengers are to embrace it. It cannot be assumed that passengers will readily adopt the technology simply because it offers cutting-edge features. A lack of interest from users could pose a significant obstacle to successfully introducing a new information system (Nickerson, 1981), and this unfortunate experiment could lead to the inability to establish effective operational management. So, what potential factors influence passengers' decision to adopt or reject the use of new technologies like biometric security gates at airports? We have focused extensively on the perceived advantages (Turner, 2007) and risks (Stone & Grønhaug, 1993):(Featherman & Pavlou, 2003):(Jun, 2020) in this study as potential factors associated with the deployment of biometric security Rogers (Turner, 2007) claimed that the perceived advantages could play a crucial role in driving the adoption of new ideas, while(Stone & Grønhaug, 1993),Featherman and Pavlou (Featherman & Pavlou, 2003), and (Jun, 2020) It has been suggested that the perceived dangers could potentially dissuade consumers from embracing a new innovation. Therefore, if efforts are made to maximize perceived advantages and minimize perceived risks simultaneously, it may be viable for airport operators to achieve improved aviation security and passenger convenience in order to support sustainable airport management. Additionally, positive feedback from initial users could greatly encourage repeated use of the technology (Chiu et al., 2012)(Fang et al., 2011). In this scenario, the perceived advantages and potential drawbacks could serve as a mediator between initial adoption and willingness to use biometric security again. If passengers have a positive experience with perceived benefits from using biometric security, they are more likely to use the service again. On the other hand, if their first experience with biometric security is unsatisfactory, there's a greater chance that they won't give it another try. This paper focuses on identifying factors that may influence passengers' intention to reuse biometric security systems, highlighting perceived benefits, perceived risks, and initial adoption intention. Previous research on user intentions for using biometrics has mainly focused on ease of use and usefulness (James et al., 2006),(Morosan, 2010), previous studies addressed the issue by considering innovation and security from different angles (Morosan, 2011). However, few studies have tried to examine the issue from a varied perspective, taking into account the potential impact of perceived advantages, perceived risks, and initial usage intention simultaneously. As biometric security procedures rely on passenger participation, understanding the role of passenger perception in these factors would be valuable not only for innovation research but also for airport management practitioners. Furthermore, this paper aims to offer practical solutions that can be applied to ensure robust aviation security and passenger facilitation by effectively implementing biometric security at airports.

The rest of the study is structured as follows: Chapter 2 outlines the theoretical background, hypotheses, and research model; Chapter 3 discusses the methods used to collect and analyze data; Chapter 4 presents the analysis results; while Chapter 5 provides theoretical and practical implications derived from the findings along with suggestions for limitations and future research.

2. Theoretical Background and Hypotheses

2.1. Aviation Security and Biometrics for Sustainable Airport Management

Aviation safety protocols were initially created through collaboration between the International Civil Aviation Organization and the International Air Transport Association in response to a string of hijacking incidents in the late 1960s, which followed the first-ever hijacking incident in 1931(Wang et al., 2003). Security screening for all passengers and carry-on baggage became a worldwide norm starting in the 1970s (Abeyratne, 2010),

a security screening system, including a door-shaped metal detector and an X-ray machine, became standard practice in 1978 and remained largely unchanged until the 1990s. After the Air India bombing attack in 1985 and the Pan Am bombing incident in 1988, a new measure was implemented to screen all boarding passengers, including transfer passengers, along with their carry-on luggage. This was done as part of aviation security regulations to prevent bomb attempts using baggage (Hoffman, 1998).

After the 9/11 attack in 2001, there was a significant increase in the strengthening of aviation security regulations and systems worldwide (Kalakou et al., 2015),(Lyon, 2007),(Blalock et al., 2007). The ICAO revised Annex 17 to the Convention on International Civil Aviation, mandating that domestic airports adhere to equivalent security standards as much as feasibly possible (Abeyratne, 2010). The United States established the Transportation Security Administration and shifted responsibility for aviation security screening from civilian airlines to the government, aiming to implement a more stringent security screening process. The TSA mandated that all airports worldwide serving US-based airlines enforce a strong security screening process, including involvement of law enforcement. In addition, security systems need to undergo performance improvements every five years to ensure that the security equipment remains current. The United Kingdom has also implemented more stringent security measures and enhanced passenger and baggage screening . Switzerland, Sweden, and Denmark restructured the allocation of aviation security duties. Japan mandated that airlines collaborate in carrying out security screenings, while the Chinese government elevated onboard facility standards and implemented enhanced security personnel training initiatives (Abeyratne, 2010).

Aviation security measures were subsequently enhanced with increased stringency in response to new and evolving attempts at terrorist attacks(Wong & Brooks, 2015), which further complicated airport operations, especially with the continued increase in the number of airline passengers. The complex aviation security measures lead to increased inconvenience, privacy violations, and longer wait times for passengers (Khalid & Anpalagan, 2010). The aviation industry is currently encountering a number of new challenges due to the heightened focus on aviation security. These include minimizing security screening and passenger waiting times, safeguarding passenger privacy during screenings, improving working conditions for security personnel, and implementing more effective security measures to reduce human errors.

Security screening and passenger waiting times need to be minimized in order to enhance passenger convenience and the efficiency of aviation security processes for effective airport management. Unlike buses or trains, where passengers can simply board with their tickets, air travel involves several time-consuming steps before boarding. For instance, international flight passengers are advised to arrive at airports at least two hours early due to the requirements of check-in, baggage drop-off, and security screening before boarding (Blalock et al., 2007).

From an aviation security standpoint, the review of identification documents and the security screening process are often the most anxiety-inducing aspects for passengers. A significant number of passengers tend to react negatively during these steps in the boarding process. Potential strategies to handle the ongoing increase in passenger traffic at limited-space terminals may involve the implementation of more sophisticated automated systems. Consequently, biometric technologies have garnered attention as a new solution for meeting demands from the aviation industry, which seeks to enhance both security measures and passenger convenience. Biometrics involves digitally processing an individual's distinct biological characteristics(Hopkins, 1999). Biological characteristics like fingerprints, iris patterns, and facial features as well as behavioral traits such as voice, manner of walking, and handwriting can be utilized for identifying individuals. These biological features must be universal, unique, permanent, and collectible in order to be applied effectively (Prabhakar et al., 2003). Biometrics, which involves the analysis of biological data, is more convenient to use than travel documents and other authentication methods. Unlike traditional forms of ID, biometric information does not always need to be carried by a passenger and is less susceptible to being lost, stolen or replicated. This distinct advantage of biometrics fulfills the heightened security needs that the aviation industry has been seeking for some time (Prabhakar et al., 2003). Similarly, if biometric technologies are used instead of traditional security procedures at airports for passenger identification, it would lead to shorter queues and significantly improved operational efficiency. This emerging solution has the potential to enhance both aviation security and the passenger experience with great accuracy and convenience (Kim et al., 2019).

Passengers can benefit from the use of biometrics in aviation security in several ways. One advantage is that automated gates, not operated by security personnel, allow for the installation of multiple security lanes to reduce processing time and enhance operational efficiency at airports. Additionally, using sophisticated systems for authentication can improve accuracy and reduce human errors associated with aviation security levels. These benefits are particularly important for airport operators seeking sustainable airport management and many airports worldwide are rushing to integrate biometric technologies into their security systems. While the concept of biometrics is not new and early installations have occurred, most airports are still in the initial stages of implementation, requiring further research on how to encourage passengers to embrace biometric security measures.

2.2. Perceived Risk and Passengers' Use Intention

Users may perceive a risk when they are unsure about the potential results of purchasing products or using services(Kim et al., 2019). Bauer (Kim et al., 2019) ddistinguished between subjective perception of risks and objective or probabilistic risks. Other types of risks may exist, but consumers tend to only react to the perceived risks that they subjectively recognize when making purchasing decisions (Jun, 2020) argued that perceived risk can be categorized into six types: functional, temporal, financial, physical, social, and psychological risk. These risks are viewed from the perspective of consumers' intention to use services.

The first type is temporal risk which involves concerns about potential wastage of time resulting from adopting an innovation. Social risk is related to the adoption of new products or services that could create a negative image among society members. Finally, financial risk pertains to the possibility of causing economic harm due to adopting a new service or product. economic losses. Furthermore, physical risk reflects the use of an innovative product or a service that might pose a threat to their well-being, causing harm. Lastly, Functional risk pertains to worries about the functionality of the new product or service. Previous studies have noted that perceived risk in various industries significantly impacts consumers' decision to purchase products or use services, including those related to information technology (Hussain et al., 2017)(Roy et al., 2016), health (Roy et al., 2016),, tourism (Park & Tussyadiah, 2016); (Holm et al., 2017); (Holm et al., 2017), marketing (Jin et al., 2015),(Παππάς, 2016), and policies (Wang et al., 2018),(Wang et al., 2019). Notably, consumers were reluctant to use online shopping due to time-related risk (such as having to spend time returning unsatisfactory products) and social risk (like potential damage to their social image through online purchases) (Lee, 2009) It has been suggested that the perception of risks, like time risk (e.g., slow website causing delay), social risk (e.g., disapproval of personal relationships), and functional risk (e.g., online banking websites malfunctioning) have a significant impact on users' initial and repeated intention to use internet banking. Additionally (Copeland et al., 2017) One argument is that the physical risk associated with e-cigarettes, in comparison to traditional cigarettes, negatively influences college students' decisions to initially and repeatedly use e-cigarettes. Likewise, (Cho et al., 2018). The researchers proposed that both functional risk and physical risk could cause significant harm to passengers who intend to use air travel frequently. We also assumed, like the researchers did, that perceived risks play a crucial role in discouraging passengers from using biometric security due to potential system failures. In this study, we included temporal risk, social risk, physical risk, and functional risk as elements of perceived risk. These were analyzed for their impact on passengers' intention to use biometric security at airports. Temporal risk was considered because biometric security might take longer than traditional procedures such as walk-through metal detectors and X-ray machines. Functional and physical risks were deemed important because passengers may fear malfunction or injury from the biometric devices. Additionally, social risk was seen as a factor negatively affecting passenger intentions due to possible negative perceptions within society about using biometric security services.

These four types of perceived risks were expected to have a detrimental effect on initial use intentions and repeat use intentions of the biometric security service during its implementation phase. Failing to address these perceived risks could ultimately lead to the failure of the entire system and pose a major challenge for long-term airport management sustainability, we propose:

Hypothesis 1. Perceived risk influences passengers' initial use intention of biometric security negatively.

Hypothesis 2. Perceived risk influences passengers' repeat use intention of biometric security negatively.

2.3. Perceived Benefit and Passengers' Use Intention

Rogers' theory of the spread of innovation (Turner, 2007) has been referenced in different fields connected to creativity, including the realm of information technology, education, media studies (Lai, 2017), organizational studies (Flodgren et al., 2019)(Dwivedi et al., 2017), marketing , policies. The theory of 'Diffusion of Innovation' proposes that the perceived advantages, compatibility, trialability, complexity, and observability play a crucial role in determining the adoption of innovation (Turner, 2007).

Relative advantage refers to the amount of benefit provided by an innovative product or service compared to existing ones. Compatibility involves whether the innovation aligns with societal values or the personal experiences of consumers. Trialability relates to becoming more familiar with an innovation and reducing anxiety through pilot usage. Complexity pertains to how difficult it is to use innovative products or services. Finally, observability considers the visible impact that will be seen from consumers using innovative technologies or services.

Prior research on innovation implementation has emphasized that perceived benefits are a critical factor influencing users' willingness to initially and repeatedly use new technologies. For instance (Lee, 2009)suggested that the perceived advantages, like greater efficiency (e.g., faster processing and improved clarity) and suitability (e.g., online banking offers almost all the services of traditional banking methods), have a significant impact on consumers' initial inclination to adopt internet banking. Additionally, Copeland, Peltier, and Waldo argued, Relative advantage, which is a part of perceived benefit, was employed to compare e-cigarettes with traditional cigarettes and establish a positive influence on college students' initial and repeated use. Additionally, Islam (Kalkhoran & Glantz, 2016) indicated that the perceived advantages (such as comparative benefits and compatibility) of e-learning systems in comparison to traditional educational methods were key factors in encouraging users to initially adopt and continue using e-learning systems. Similarly (Al-Fadhli, 2009)The recommendation was that the ability to try out a product or service before committing to it was highly beneficial in encouraging users to initially and repeatedly use social media on mobile devices with broadband connectivity. According to this study, we also believe that the perceived advantages could play a crucial role in motivating passengers to adopt biometric security measures, which are directly linked to the effective implementation of such systems. Therefore, in our research, we included relative advantage, compatibility, and trialability as factors for assessing passengers' perception of benefits associated with using biometric security at airports. We aimed to examine how these factors relate to passengers' intention for initial adoption and repeated use of biometric security at airports.

Firstly,"relative advantage" is considered as it allows easy comparison between the benefits of biometric security and existing methods like walk-through metal detectors and X-ray machines. Secondly, "compatibility" is important because it determines if the new service (biometric security) aligns with passengers' needs and their prior experience with current airport procedures. Moreover,"trialability" plays a significant role in influencing both initial usage and repeat intent towards adopting biometrics due its option for testing before full implementation . It was anticipated that these three aspects of perceived benefit would positively impact passenger's intentions toward using Biometrics during its application phase while conveying success stories connoting sustainable airport management heightened by reliable Biometrics applications.

Therefore,,we propose following hypothesis:

Hypothesis 3. Perceived benefit influences passengers' initial use intention of biometric security positively.

Hypothesis 4. Perceived benefit influences passengers' repeat use intention of biometric security positively.

2.4. Initial Use and Repeat Use

The significance of the first impression cannot be overstated. In psychology, the initial impression occurs when an individual first encounters someone or something and forms a perceptual image of it. In a service provider-user relationship, the first impression can be influenced by various factors, including the perceived advantages and potential drawbacks for passengers (Lee, 2009). The implementation of biometric security at airports could leave a positive or negative impression on passengers based on their perception of risks and benefits during the trial. This initial experience may also impact their future use of

the system (King et al., 2019) The presentation of a website's design concept greatly impacts users' desire to return and use the site repeatedly. According to King et al., the content and identification created during a user's initial visit to a retailer's website strongly influence their intention to make repeat visits and purchases.
With regards to previous studies, we suggest that passengers' initial adoption of biometrics could impact their willingness to use it again. If passengers were dissatisfied with their first experience with biometric security procedures, they may be hesitant to use it again. Conversely, if passengers found the initial use of biometric security beneficial, they would be more likely to reuse it. The intention of repeat usage for biometric security is crucial for the successful implementation of the service as any underutilization could result in significant waste of time and budget. Failure in implementing biometric security due to lack of repeated usage would also harm sustainable airport management and hinder quality service as passenger numbers increase. Therefore, securing the intention for repeat usage by passengers is essential when considering implementing biometric security procedures at airports.
Hence, we propose the following hypothesis:
Hypothesis 5. Initial use intention influences passengers’ repeat use intention of biometric security positively.
In this research, we developed a model to examine how the perceived risk and perceived benefit of biometric security have an indirect impact on passengers' intention to use it repeatedly. We also looked at the initial use intention of biometric security to understand the overall effect of our model. Additionally, our research considered four control variables (age, gender, education, and monthly income) in order to mitigate potential confounding effects.

3. Research Method

3.1. Sampling & Surveying

A study was carried out on 362 participants from an online research agency in South Korea between September 7 and 15, 2019. The survey focused on adults aged 20 years or older who had experience with air travel. Following the exclusion of insincere responses and missing data, a statistical examination was conducted using a total of 327 valid responses. The demographic characteristics of the participants are detailed in Table 1.

Table 1. Demographic properties.

Variables		Frequency	%
Gender	Female	163	49.80%
	Male	164	50.20%
Age	20s	78	23.80%
	30s	84	25.70%
	40s	80	24.50%
	50s~	85	26.00%
Education	High School	84	25.70%
	Undergraduate	225	68.80%
	Postgraduate	18	5.50%
Monthly Income	~2M	48	14.70%
	2M~5M	157	48.00%
	5M~8M	98	30.00%
	8M~	24	7.30%

3.2. Survey Questions

This research assesses variables using measurement instruments that have been demonstrated to be dependable and valid in previous studies. The survey questions were adapted from earlier research and adjusted to suit the context of biometric security. Participants were given information about biometric security beforehand and asked to respond based on their direct and indirect experiences with the service. Except for demographic survey queries, the construct items were evaluated using a seven-point Likert scale, ranging from "strongly disagree" to "strongly agree." The mean and standard deviation values of the constructs, along with the literature sources where the scales originated, are presented in Table 2.

Table 2. Survey Questions.

Type (the Number of Questions)		Avg (SD)	Question	Sources
Perceived Risk	Temporal Risk (3)	3.27 (0.876)	It will take too much time to learn how to use biometric security.	Stone and Gronhaug
		3.40 (0.897)	If I use biometric security, I think it will require more unnecessary procedures. It will take more time.	
		3.33 (0.883)	I think I will waste even more time since I have to learn how to use biometric security.	
	Social Risk (3)	3.44 (0.866)	Using biometric security will have a negative impact on my perception/reputation.	Featherman and Pavlou
		3.80 (0.891)	If I use biometric security, I'm sure that other people will find me strange.	
		3.12 (0.956)	I'll use biometric security after seeing other people using it without going through any trouble.	
	Physical Risk (3)	3.41 (0.932)	I am concerned about the physical fatigue caused by the use of biometric security.	Stone and Grønhaug
		3.25 (0.970)	I'm worried that biometric security might cause physical discomfort or other physical side effects.	
		2.94 (0.962)	Since biometric security has yet to be verified as safe, I am concerned about the physical risks using the system.	
	Functional Risk (3)	2.52 (0.909)	I'm not sure whether the biometric security system will work as well as it is said.	
		2.86 (0.868)	I'm not sure if biometric security will provide me with as much convenience and benefits as I'd expect.	
		2.86 (0.877)	I'm not sure if the speed and convenience offered by biometric security will be practical enough.	
Perceived Benefits	Relative Advantage (3)	2.45 (0.845)	Biometric security will be more interesting compared to the conventional boarding system.	Rogers
		2.59 (1.014)	If I use biometric security, other people will think of me as being smart.	
		2.68 (0.971)	The use of biometric security will require less work from my side compared to the conventional boarding procedure.	
		3.03 (0.748)	Using biometric security is in line with my values.	
	Compatibility (3)	3.17 (0.864)	Biometric security is not much different from the conventional boarding system.	
		2.69 (0.770)	Introducing the biometric security procedure to the current boarding system is not a big problem.	
		2.41 (0.781)	If I could try biometric security right now, I think it would make me more open to the idea of using it in the future.	
	Trialability (3)	2.42 (0.847)	If airlines or airports hold events about using biometric security, it would definitely motivate me to use the system in the future.	
		2.28 (0.796)	If there are more types of biometric security in the future, it would be helpful for us to use the system with ease.	
Initial Use Intention (3)		2.60 (0.869)	I would use biometric security for my airport security procedure.	Lee
		2.77 (0.807)	Using biometric security for dealing with my airport security procedures is something I would do.	
		2.65 (0.808)	I would see myself using biometric security for dealing with my airport security procedure.	
Repeat Use Intention (3)		2.35 (0.893)	I plan to continue using biometric security for airport security procedures.	
		2.39 (0.865)	I consider biometric security to be my first choice for airport security procedures in the future.	Chiu, Wang, Fang and Huang
		2.26 (0.830)	It is likely that I will continue using biometric security in the future.	

3.3 Measures

If we have predictors X and responses Y, along with projections T of X and Y and projections U of P and Q, errors E and F are assumed to be unbiased random normal variables that are uniformly distributed.

Decomposing X and Y would help achieve the highest covariance between T and U .
We developed two formative second-order constructs, namely perceived risk and perceived benefit. The former consists of four dimensions (temporal risk, social risk, physical risk, and functional risk), while the latter includes three dimensions (relative advantage, compatibility, and trialability). The repeated indicator approach was utilized for these formative second-order constructs . Furthermore, the research applied latent variable scores to test the final research model. The flooding-out effect may occur when using second-order formative constructs due to repeated indicators. However, in this study, the research model effectively accounted for second-order formative constructs without experiencing any flooding-out effects through the implementation of a two-stage approach .

4. Results

Prior to conducting the main analysis, a single-factor analysis was used to address potential method biasAll the data samples were reported by the individuals themselves. The test findings revealed that the factor explained a significant percentage, accounting for 29.8% of the variance, which is less than 50%. Therefore, there was no significant impact from common method bias in the sample.

4.1. Assessing the First-Order Constructs

First and foremost, the first-order constructs were assessed for their reliability and validity. The Cronbach's Alpha index is commonly employed to assess construct reliability. If the index exceeded 0.600, the construct could be considered satisfactory; otherwise, it should be revised, such as by removing one or more items from the construct . As depicted in Table 3, the research model's internal consistency was assessed using Cronbach's α, with values ranging from 0.726 to 0.885. Furthermore, composite reliability scores varied from 0.811 to 0.962, and the average variance extracted was also validated (Fornell & Larcker, 1981), evaluated ranged from 0.644 to 0.813 in order to assess the convergent validity of the construct level. The results depicted in Table 3 indicate that all obtained variances are above 0.5 .

Table 3. Reliability and Validity of the First-order Constructs.

Construct		Cronbach's α	Composite Reliability	AVE
PR	TI	0.8	0.882	0.714
	SO	0.762	0.863	0.679
	PH	0.828	0.897	0.745
	FU	0.781	0.873	0.697
	RA	0.763	0.863	0.68
PB	CO	0.726	0.844	0.644
	TR	0.81	0.887	0.724
IUI		0.775	0.868	0.689
RUI		0.885	0.929	0.813

The Fornell-Larcker criterion was then employed to assess discriminant validity for the primary constructs. This criterion, which utilizes average variance extracted, is a commonly applied statistical measure. The AVE can be calculated based on the variance captured by constructs including measurement errors (Fornell & Larcker, 1981). Hence, the square root of the AVE for each construct should be larger than the inter-construct correlations below the diagonal line . The analysis findings, as demonstrated in Table 4, confirm the discriminant validity among the constructs .

Table 4. Discriminant Validity.

Construct		TI	SO	PH	FU	RA	CO	TR	IUI	RUI
PR	TI	0.845.								
	SO	0.6	0.824							
	PH	0.453	0.541	0.863						
	FU	0.346	0.331	0.43	0.835					
	RA	-0.119	-0.262	-0.151	-0.089	0.825				
PB	CO	-0.111	-0.275	-0.198	-0.243	0.29	0.803			
	TR	-0.253	-0.447	-0.301	0.346	0.475	0.45	0.851		
IUI		-0.351	-0.543	-0.485	-0.332	0.397	0.392	0.463	0.83	
RUI		-0.486	-0.611	-0.532	0.277	0.352	0.289	0.672	0.672	902

4.2. Assessing the Second-Order Constructs

Next, we assessed the importance of the secondary formative constructs through a bootstrap analysis involving 1000 samples to examine the upward dimensional impacts The findings showed that all initial factors incorporated into the second-level formative constructs have considerable impact with statistically significant t-values as shown in Table 5.

Table 5. Dimension Effect for the Second-order Formative Constructs.

Construct		Original β	Mean β	STDEV	t-Value	p-Value
PR	TI → PR	0.335	0.332	0.022	15.49	0
	SO→PR	0.39	0.395	0.027	14.684	0
	PH→PR	0.355	0.353	0.02	18.098	0
	FU→PR	0.265	0.264	0.018	14.64	0
	RA→PB	0.422	0.421	0.031	13.715	0
PB	CO→PB	0.423	0.421	0.031	13.829	0
	TR→PB	0.559	0.56	0.041	13.59	0

Next, as Marakas, , and recommend, latent variable scores for the top-level constructs were created to construct the ultimate structural equation model following validation of the dimensional impact of second-order constructs. Once the final model, depicted in Figure 2, was formed, we assessed discriminant validity using the heterotrait–monotrait ratio. The results from Table 6 confirmed that yielded values below 1.00 for discriminant validity as per recommended criteria.

4.3. Assessing the Final Research Model

Hypothesis 1 revealed that the perceived risks have a significant negative impact on passengers' initial intention to use biometric security ($\beta = -0.428$, $p < 0.000$) in the departure hall. Moreover, hypothesis 2 also demonstrated that these risks significantly influence passengers' repeat intention to use biometric security ($\beta = -0.428$, $p < 0.000$). In addition to the findings of hypothesis 1, the results of hypothesis 2 also demonstrate a significant negative effect on security ($\beta = -0.363$, $p < 0.000$). These outcomes suggest that perceived risks such as temporal, social, physical, and functional concerns act as psychological obstacles to passengers' intention to use biometric security ($\beta = -0.363$, $p < 0.000$). These two findings suggest that perceived risks, such as the various aspects of biometric security procedures - temporal, social, physical, and functional risk - act as psychological barriers that deter passengers from using them. Conversely, the perceived benefits yielded a result opposite to that of the perceived risks. Regarding the use of biometric

security by passengers, hypothesis 3 revealed that perceived benefit positively influences passengers' initial intention to use it (β = 0.377, $p < 0.000$).
perceived hazards. In the context of passengers using biometric security, hypothesis 3 revealed that Additionally, the test results for hypothesis 4 showed that perceived benefits also have a significantly positive impact on passengers' willingness to repeatedly use biometric security (β = 0.200, $p < 0.001$). These results Suggest that perceived advantages strongly motivate passengers to adopt biometric security in airport processes. Moreover, passengers' initial inclination to use biometric security significantly influences their intention to use it again, according to the findings of hypothesis 5 (β = 0.357 $p < 0.000$). This implies how the initial acceptance of biometric security by passengers affects their future intentions to use it. The findings in Figure 3 and Table below present a summary of the results from analyzing structural equations and testing hypotheses, demonstrating the significant influence of perceived benefits in promoting passenger adoption of biometrics. Furthermore, the mediation effect analysis reveals noteworthy mediation effects for both PR → IUI → RUI (β = −0.154, $p < 0.000$) and PB → IUI → RUI (β = 0.136, $p < 0.000$). Conversely, no significant impact was found from the four control variables.

Table:6 Overall Results of Hypotheses Tests

Hypothesis		Results
H1	Perceived risk influences passengers' initial use intention of biometric security negatively.	Accepted
H2	Perceived risk influences passengers' repeat use intention of biometric security negatively.	Accepted
H3	Perceived benefit influences passengers' initial use intention of biometric security positively.	Accepted
H4	Perceived benefit influences passengers' repeat use intention of biometric security negatively.	Accepted
H5	Perceived benefit influences passengers' repeat use intention of biometric security positively	Accepted

5. Conclusion

5.1 Discussion and Implications

In this research, we explored the correlation between perceived risk, perceived benefit, initial and repeated intention to use biometric security measures at airports. The primary goal of implementing biometric security technology is to enhance aviation security and passenger facilitation for sustainable airport management. However, there are still some airport personnel who seek to embrace the innovative technology solely for its potential benefits.
However, there are still some airport personnel who are only interested in gaining a better understanding of passengers' needs. This uncommitted approach from airport operators could negatively impact not just the successful implementation of the service, but also sustainable airport management. Therefore, this study sounded an alarm about such lackadaisical attitudes by offering valuable insights for airport operators to develop a suitable strategy for implementing biometric security procedures.
Practical implications have been identified to help airport operators implement biometric technologies more effectively. Passengers' perceived benefits and risks significantly influence their intention to use biometric security measures, so airport practitioners should take these factors into consideration when

creating value and addressing the associated risks. The study found that perceived benefit is a key factor affecting passengers' intentions to use biometric security services, highlighting the importance of providing value to users. For example, airports could promote the advantages of biometric security processes to passengers, such as reducing contact with security agents and lowering the risk of disease transmission like COVID-19.

The study's main finding was that perceived risk had a greater impact on passengers' intention to use airport services, both initially and repeatedly, compared to perceived benefit. This underscores the importance for airport staff to prioritize efforts in reducing risk factors to encourage passenger uptake of the service. For example, as a countermeasure to minimize perceived risks, airport operators should focus on alleviating passengers' concerns about disease transmission (e.g., COVID-19) by regularly sanitizing biometric security devices. It is essential for passengers to be informed through promotional materials that these devices are frequently cleaned. Furthermore, informing them about reduced contact with security agents and potential implementation of thermal scanning for fever detection on biometric security devices could help shift their perception from risks towards benefits during this pandemic period.

Furthermore, this research indicated that the initial usage experience was crucial for encouraging passengers to repeatedly use biometric security procedures. By providing a positive and enjoyable first encounter with biometric security, passengers are less likely to have negative perceptions of the trial and more inclined towards perceiving the benefits outweighing any risks. This positive engagement has the potential to lead to greater success in implementing biometric security technology.

5.2. Limitations & Suggestions for Future Studies

Despite the mentioned implications, this study still has limitations. Initially, it only used self-reported cross-sectional data samples, which could potentially be affected by standard method variance. To address this bias, acquiring a longitudinal dataset from third-party measures may be necessary. Furthermore, the research's implications could have broader generalizability with longitudinal datasets that can apply to airports not only in Korea but also around the world.

Additionally, biometrics could potentially be used throughout the entire airport boarding process to improve operational efficiency for sustainable airport management (Negri et al., 2019),, This research solely concentrated on the security protocol. Biometric technologies have the potential to streamline the tedious process of presenting identification documents and flight tickets at different areas of the airport, similar to how it works at the security checkpoint. However, considering that there are additional operational factors in various parts of the airport, passengers may have varying concerns and willingness to use biometric services beyond just security checkpoints. In essence, further investigation is necessary for incorporating biometric technologies across the entire airport to enhance overall airport management flow by enhancing aviation security and operational efficiency simultaneously.Future research should aim to acquire longitudinal data samples and extend the range of areas suitable for biometric applications in airports. The use of biometrics could be expanded beyond pre-boarding procedures to other areas such as check-in, bag-drop, boarding gate operations, departure and arrival identification processes, and even duty-free shops as a unified service. By utilizing longitudinal data samples and exploring various compatible applications, future studies can uncover more impactful insights that go beyond the findings of this study to support sustainable airport management.

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