IBN HALDUN UNIVERSITY
SCHOOL OF GRADUATE STUDIES
AIR TRANSPORT MANAGEMENT

MASTER THESIS

THE EFFECT OF BLOCKCHAIN AWARENESS ON PASSENGERS' INTENTION TO USE BIOMETRIC TECHNOLOGIES AT ISTANBUL AIRPORT

İBRAHİM HAKKI GÜNTAY

THESIS SUPERVISOR
ASSOC. PROF. ALİ OSMAN KUŞAKCI

ISTANBUL, 2023

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by

İBRAHİM HAKKI GÜNTAY

A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Science in Air Transport Management

THESIS SUPERVISOR
ASSOC. PROF. ALİ OSMAN KUŞAKCI

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APPROVAL PAGE

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Air Transport Management.

Thesis Jury Members

Title - Name Surname	Opinion	Signature

This is to confirm that this thesis complies with all the standards set by the School of Graduate Studies of Ibn Haldun University.

Date of Submission Seal/Signature

ACADEMIC HONESTY ATTESTATION

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name:

Signature:

ÖZ

BLOCKCHAIN FARKINDALIĞININ İSTANBUL HAVALİMANINI KULLANAN YOLCULARDAKİ BİOMETRİK TEKNOLOJİLERİ KULLANMA NİYETİNE ETKİSİ

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Bu çalışma, İstanbul Havalimanı'nı kullanan yolcuların biyometrik teknolojileri kullanma niyetlerini ve blockchain teknolojilerine yönelik farkındalığın bu niyet üzerindeki etkisini ölçmektedir. Biyometrik teknoloji, insan biyolojisini kullanarak bir kişiyi tanımlama teknolojisi olarak ifade edilir. Biyometrik teknolojiler bu bilgileri toplayabilir ve bir kişinin doğal kimlik kartını oluşturabilir. Biyometrik teknolojilerin oluşturduğu bu bilgiler daha gerçek, daha güvenli ve daha doğrudur. Bu teknolojiler hassas bilgileri topladıkça, bu teknolojilerin güvenliği de bir o kadar önemli hale gelmektedir. Bu noktada bu teknolojilerin güvenliğini sağlamak için Blockchain öne çıkmaktadır. Bu amaçla çalışmada havalimanlarında biyometrik uygulamalar ve örnekleri ile bu uygulamaların geliştirilmesi üzerinde durulmuştur. Ardından Blok zincir teknolojisinin biyometrik uygulamalardaki yeri ve önemi üzerinde durulmuştur. Kullanıcıların bu teknolojileri kullanma niyetlerini ölçmek için İstanbul Havalimanı'nda bir anket çalışması yapılmış ve sonuçlar değerlendirilmiştir. Bilgi teknolojileri ile bunları kullanma niyetleri arasındaki bağlantıyı anlamak için geliştirilmiş birkaç model vardır. Bunlardan Venkatesh et al. (2012) UTAUT2 modeli genel bir kabul görmüştür. Bu araştırma UTAUT2'ye göre oluşturulmuş Morosan'ın (2016) modeline dayanmaktadır. Buna göre biyometrik teknolojilerin performans beklentisi, biyometrik teknolojilerin kullanma kolaylığı beklentisi, yolcuların mahremiyet kaygıları, hava yolcularının bilgi duyarlılığı, hava yolcularının yaşamlarına uyumluluğu, hava yolcularının blok zincir hakkındaki bilgileri sorulmuştur. Bu kaygıların biyometrik teknolojileri kullanma niyeti üzerindeki etkileri değerlendirilmektedir. Bu bilgiler ile niyet arasındaki ilişkiyi değerlendirmek için yapısal eşitlik modellemesi kullanılmıştır.

Anahtar Kelimeler: Biometrik Teknolojiler, Blok Zincir, İstanbul Havalimanı, Niyet.

ABSTRACT

THE EFFECT OF BLOCKCHAIN AWARENESS ON PASSENGERS' INTENTION TO USE BIOMETRIC TECHNOLOGIES AT ISTANBUL AIRPORT

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This study measures the intention to use biometric technologies of passengers using Istanbul Airport and the effect of awareness about blockchain technologies on this intention. Biometric technology can be described as the technology to identify a person using biology. Biometric technologies can collect this information and create a person's natural identity card. This information created by biometric technologies is more natural, safer, and more accurate. As these technologies collect sensitive information, the security of these technologies has become just as important. At this point, blockchain comes to the fore to ensure the safety of these technologies. For this purpose, biometric applications in airports, their examples, and the development of these applications are emphasized. Afterward, the place and importance of blockchain technology in biometric applications are emphasized. In order to measure the users' intention to use these technologies, a survey study was conducted at Istanbul Airport, and the results were evaluated. There are several models developed to understand the link between individual acceptance and the use of information systems. Venkatesh et al.'s (2012) UTAUT2 model has been widely accepted. The model used in this research is based on Morosan's (2016) model created according to UTAUT2. Accordingly, it is asked about the performance expectancy of biometric technologies, the effort expectancy of biometric technologies, the privacy concerns of passengers, air travelers' information sensitivity, air travelers' compatibility, and air travelers' knowledge about blockchain. The effects of these concerns on the intention to use biometric technologies are evaluated. In order to assess the relationship between this information and intention, structural equation modeling is used.

Keywords: Biometric Technologies, Blockchain, Intention, Istanbul Airport.

DEDICATION

It is dedicated to my family.

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I would like to express my gratitude to my supervisor, Ali Osman Kusakci, who guided me throughout this thesis. I would also like to thank my friends and family who supported me and offered deep insight into the study. I wish to acknowledge the help provided by the technical and support staff in my company, Turkish Airlines. I would also like to show my deep appreciation to my superiors and the Board of Directors who created this opportunity for me.

İbrahim Hakkı GÜNTAY

BUCHAREST, 2023

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LIST OF SYMBOLS AND ABBREVIATIONS

API	Advance Passenger Information
AVE	Average Variance Extracted
BC	Blockchain
BT	Biometric Technology
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CMIN/DF	Chi Squared Per Degree of Freedoms
CR	Construct Reliability
DLT	Distributed Ledger Technology
DNA	Deoxyribonucleic Acid
GDPR	General Data Protection Regulation
GDS	General Distribution System
HTMT	Hetero-Trait-Mono-Trait
ID	Identity
IFI	Incremental Fit Index
IS	Information System
IATA	International Air Transport Association
ICAO	The International Civil Aviation Organization
KLM	Royal Dutch Airlines
MaxR(H)	Maximal Reliability
MSV	Maximum Shared Variance
NEXTT	The New Experience Travel Technologies
NFI	Normed Fit Index
PNR	Passenger Name Record
PNRGOV	Passenger Name Record to Governments
RFI	Relative Fit Index
RMR	Root Mean Squared Residual
RMSEA	Root Mean Square Error of Approximation
SITA	Société Internationale de Télécommunications Aéronautiques
SRMR	Standardized Root Mean Squared Residual
TLI	Tucker-Lewis Coefficient
UTAUT	Unified Theory of Acceptance and Use of Technology
UTAUT2	Unified Theory of Acceptance and Use of Technology 2
WEF	World Economic Forum

CHAPTER I

INTRODUCTION

Biometric technology (BT) can be defined as the technology used to identify an individual by using his biological and anthropometric features. It is known that human biology contains a wide variety of unique information. This information is private for each person. One of the most precise methods that can be used to identify a person is to collect this information through specific technologies. Fingerprints, the iris, face recognition, vascular distributions, gene sequences in DNA, and voices can be given as examples of this information. Biometric technologies can collect this information and create a person's natural identity card. It is possible to see biometric technologies in all areas of life. These technologies are used not only in public spaces but also in our daily personal work, which is worth every person's life. The fingerprint we use to enter our mobile phones, the iris scan we use to enter our office, and the voice we use to verify when using a call center are examples of these technologies in daily life.

Natural Identity (ID) cards created by biometric technologies are more authentic, safer, and more accurate than traditional ID cards. Therefore, the use of biometric technologies in areas where identity verification is required is becoming more common day by day. One of these areas is the airline industry and the areas that this industry touches. The risks in the airline industry, various negative events experienced in the world, and the damage caused by the risk of fraud due to the relatively high prices of products or services cause the stakeholders of this industry to use these technologies. The places where the identity of the passenger must be confirmed at the airports are the main check-in areas, security gates, passport control, and boarding gates. Especially the significant risk factor due to malicious use of air transport reveals that security and verification in these areas are crucial.

The increase in the use of these technologies affects users from various angles. The most critical issue these technologies causes is a safety concern. This security concern includes whether the data is processed securely, whether this data will fall into the hands of malicious individuals or institutions, and whether this data can be destroyed after use. The convenience brought by these technologies has also brought with it the difficulty of protecting the information obtained by such technology. In order to overcome this difficulty, biometric technologies develop infrastructures that provide data security. At this point, blockchain technology, which we have seen frequently in daily use in recent years, seems to be a solution for protecting, storing, and securely transmitting this data.

Blockchain is an information recording system. Since information is stored in one or some places in classical systems, fraud or malicious applications in the recorded area of this information may cause this information to be changed or used in bad faith. However, considering that this information is reproduced and recorded in all computer systems on the blockchain and that the authenticity of this information must be verified in all of these systems, it can be said that cheating or malicious intent cannot occur on the blockchain. It is possible to define the blockchain as a digital ledger storing all the information. Every transaction on the blockchain is recorded in blocks, and every transaction is added to every participant's ledger. "The decentralized database managed by multiple participants is known as Distributed Ledger Technology (DLT). Blockchain is a type of DLT in which transactions are recorded with an immutable cryptographic signature called a hash" (*Euromoney*, 2022).

Although blockchain technology is rarely used in daily life, we will see it in the information transfer of biometric technologies and many other applications in the near future. At this point, both the approach of users to biometric technologies and the adoption of blockchain by users will increase the rate of use of these technologies. The intention of users to use such technologies will affect their spread, especially in the airline industry, where sensitive data is processed. Therefore, security is kept at a very high level, especially in airports.

For this purpose, in our study, biometric applications in airports, their examples, and the development of these applications are emphasized. Afterward, the place and importance of blockchain technology in biometric applications are addressed. In order to measure the users' intention to use these technologies, a survey is conducted at

Istanbul Airport, and the results are evaluated. Airport capacity problems lead service providers to use these technologies by incentivizing passengers. However, the effect of this technology usage is vital to assess these facilities' success. Passengers' intention to use such technologies may give clear views for service providers' improvement. Therefore, it is expected that this study will contribute to the literature in terms of showing the importance of biometric technologies in the aviation industry and the relevance of blockchain technology for biometric identification systems in airports from the perspective of passengers.

In order to test the results mentioned above, a series of questions will be evaluated.

- How the performance expectancy of BT affects the intention to use BT in airports
- How the effort expectancy of BT affects the intention to use it in airports
- How the information sensitivity of users has effects on this intention. Accordingly, the privacy concerns of users are also asked. The compatibility of BT in users' lives is also evaluated to determine their intention to use it. Lastly, it is also requested about blockchain information and its effects on this intention.

CHAPTER II

LITERATURE REVIEW

There are several models developed to understand the link between individual acceptance and the use of information systems (IS). Venkatesh et al. (2003) developed the unified theory of acceptance and use of technology (UTAUT) model, which was formed by the combination of eight theories and models created to understand the individual's intention to use information systems. To develop this mainstream model, Venkatesh et al. (2012) have created a new model based on UTAUT, which is called UTAUT2. According to Morosan (2016), UTAUT and the more recent version which is UTAUT2 can explain this relationship between intentions and IS. The model used in this research is based on Morosan's (2016) model created according to UTAUT2.

2.1. Related Works

The UTAUT2 model has been used in many studies measuring the intention to use information systems. These studies have been developed to evaluate information systems used in many different fields and to measure users' intentions.

Mobile app-based shopping in India was predicted with the UTAUT2 model (Juliarti, Nugraha, Suryono, & Sensuse, 2021; Tak & Panwar, 2017). The studies used the following variables: performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit.

The measurement model of behavioral intention to subscribe to Youtube channel content using the UTAUT2 model is checked by Marietta, Nandika, Megawati, & Lilik Noor (2019). This study evaluated the relationships between performance expectancy, effort expectancy, social influence, facilitating condition, hedonic motivation, habit, e-lifestyle, promotion, behavioral intention to use, usage behavior, and intention to subscribe.

In order to test behavioral intention to adopt technology among entrepreneurship students, the UTAUT2 model was used in a recent study (Handoko, 2020). According to the study, performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit are essential variables.

Another work was about internal social media acceptance in government organizations. According to Juliarti et al. (2021), there is a meaningful relationship between performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, and intention to use these media. In this work, the original model was extended with two variables: trust and capability.

The technology acceptance model analysis of MBanking was checked using the UTAUT2 method (Putri, Paramaeswari, & Sarno, 2021). This model considered performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit factors in behavioral intention.

Mansyur & Ali (2022) tested the adoption of Sharia fintech among millennials in Indonesia using UTAUT2. Islamic financial literacy is added as a variable instead of a habit. According to the study, Islamic financial literacy significantly influences the preference for the use of Islamic financial products or services. Still, it is also shown that as a moderating variable, it has a positive but non-significant effect on moderating the relationship between social influence and hedonic motivation (Mansyur & Ali, 2022). Similarly, factors affecting the use of e-money in the millennial generation were researched by Alfansi & Daulay (2021), and only the variable of trust was added to the basic UTAUT2 model.

Kašparová (2022) studied the effect of business intelligence methods on the decision-making process, which was tested according to the UTAUT2 model. This study observed the effects of performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit factors on behavioral intention.

Ratnawati, Durachman, & Saputra (2022) analyzed the effect of performance expectancy, effort expectancy, social influence, hedonic motivation, price value, and habit on the intention to use mobile fintech applications, specifically free interbank money transfer, Flip. They added two variables to the UTAUT2 model: trust and perceived security.

Osei, Kwame, Kwateng, Kofi, & Boateng (2022) addressed e-learning adoption in the era of the COVID-19 pandemic with the help of the UTAUT2 model and tested personality traits, perceived relatedness, perceived autonomy, and perceived competence in addition to performance expectancy, effort expectancy, facilitating condition, price value, and habit.

Performance expectancy, effort expectancy, social influence, facilitating condition, hedonic motivation, perceived value, perceived credibility, and habit are also tested in the study by Yuliana & Aprianingsih (2022) to see factors involved in adopting mobile banking for the Sharia banking sector by using UTAUT2.

The factors influencing the use of virtual reality head-mounted display devices were studied in a recent work (Norizan, Hafiz Faizal Mohamad Kamil, & Khalid, 2022). The authors addressed personal innovativeness and perceived risk variables within the UTAUT2 acceptance model.

2.1.1. Related Works in Aviation

Morosan (2016) discussed the effects of information sensitivity, performance expectancy, effort expectancy, privacy concerns, and compatibility on the intention to use biometric e-gates in a sample of US air travelers. According to the study, all the hypotheses were supported.

Singh & Matsui (2017) added trust and the long tail effect to UTAUT2 model variables and tested these effects and other variables like performance expectancy, effort expectancy, social influence, facilitating condition, hedonic motivation, price value, and habit on online shopping behavior. This study is performed in Japan for two product categories, i.e., airline tickets and books.
Another study related to the aviation sector was about the technology acceptance of Indonesian Gen Z in ticket booking platforms like the Fly Garuda App from Garuda

Indonesia Airlines and the BetterFly Citilink Mobile App from Citilink Indonesia Airlines (Fefayosa, Tarigan, & Al Makky, 2022). The main dimensions of the model were performance expectancy, effort expectancy, social influence, facilitating condition, hedonic motivation, price value, and habit.

2.2. Hypothesis Development

Performance expectancy is one of the essential factors for IS and reflects its success. Accordingly, performance expectancy is a core part of the UTAUT2 model (Venkatesh et al., 2012a). "The literature overwhelmingly supports that IS characterized by high performance is likely to increase users' intentions to adopt such systems" (Morosan, 2016). Accordingly, the following hypothesis is developed:

H1. There is a positive relationship between air travelers' performance expectancy toward biometric technologies and their intention to use them in airports.

Effort expectancy is also considered one of the most critical elements of using an IS (Morosan, 2016). Understandably, different efforts spent using systems will result in different reactions or acceptance of such systems. The concept of effort expectancy originates from the term "ease of use" (Morosan, 2016). Therefore, this factor has been considered one of the core independent variables to understand the meaningful relationship between effort expectancy and biometric technologies. Accordingly, the following hypothesis is developed:

H2. There is a positive relationship between air travelers' effort expectancy toward biometric technologies and their intention to use them in airports.

Several studies based on technology acceptance models show a "significant link between IS ease of use (e.g., effort expectancy) and usefulness (Morosan, 2016)". In this study, we also address the relationship between effort expectancy and performance expectancy. Accordingly, the following hypothesis is developed:

H3. There is a positive relationship between air travelers' effort expectancy and their performance expectancy toward biometric technologies in airports.

Due to their nature, biometric technologies require biometric information from users in order to process the data and transfer it to related systems. In this regard, privacy concerns impact the intention to use these technologies. The users’ concern about the safety of IS and the data given to IS is defined as privacy concerns (Morosan, 2016). Also, cultural, economic, religious, or environmental factors may affect users’ intentions without such IS (Kim et al., 2008).

The recent literature documents conceptualizations of privacy concerns, especially as such concerns take two forms: (1) general privacy concerns, reflecting users’ concerns about their privacy in general (H. Li et al., 2011), and (2) system-specific privacy concerns, reflecting the privacy concerns of users vis-à-vis a specific IS (Paine et al., 2007). Therefore, this study considers the second type of privacy concern because biometric technology is defined as a specific IS. Accordingly, the following hypothesis is developed:

H4. There is a negative relationship between air travelers’ privacy concerns and their intentions to use these technologies in airports.

Users’ privacy concerns may differ according to information sensitivity. While using such technologies, the user may provide different types of data, such as financial, medical, educational, and biological data, which can also be described as biometric data. A user's most fundamental possession is biology, anthropometry, and biometrics. Thus, processing this information requires critical decision-making, directly affecting the intention to use IS within the identification process (Morosan, 2016). Accordingly, the following hypothesis is developed:

H5. There is a positive relationship between air travelers’ information sensitivity and privacy concerns toward biometric technologies in airports.

The sensitive information may also affect performance expectancy for IS. According to Morosan (2016), there is a negative relationship between information sensitivity and performance expectancy because sensitive information may cause vital risks in such systems. Accordingly, the following hypothesis is developed:

H6. There is a negative relationship between air travelers' information sensitivity and their performance expectancy toward airport biometric technologies.

Users' compatibility with new technologies is one of the most significant factors in using them. Furthermore, they use these technologies according to their lifestyles or daily needs. Therefore, the compatibility of these technologies and users may change the intention levels of using them. Also, this relationship has been revealed by various studies on this subject (Morosan, 2016). Accordingly, the following hypothesis is developed:

H7. There is a positive relationship between air travelers' compatibility with biometric technologies and their intentions to use such technologies in airports.

In this study, the effect of blockchain technology is also examined. Although it is a very new technology for the end user, many technology companies have started using blockchain in their service infrastructure. The effects of blockchain-based systems have been researched and correlated with the intention to use a specific IS (Miraz et al., 2020). Blockchain systems are developed in order to secure data. Thus, we propose that the intention to use IS may differ if users know about this technology. However, blockchain may still be a foreign term for the end user. The use of the blockchain in the distribution of cryptocurrencies may have an adverse effect due to their perception worldwide. The current level of perception of cryptocurrencies may not lead to a thorough understanding of blockchain. Thus, the impact of blockchain knowledge on the intention to use it may be more effective when its relation to the cryptocurrency is unknown. On the other hand, more knowledge of blockchain may have a cumulative effect on intention (Strebinger & Treiblmaier, 2019). Accordingly, the following hypothesis is developed:

H8. There is a positive relationship between air travelers' knowledge of blockchain and their intentions to use biometric technologies in airports.

This study explores the relationship between these variables and users' intentions to use biometric technologies in airports. After developing the core theoretical foundation, the model is depicted in Figure 2.1.

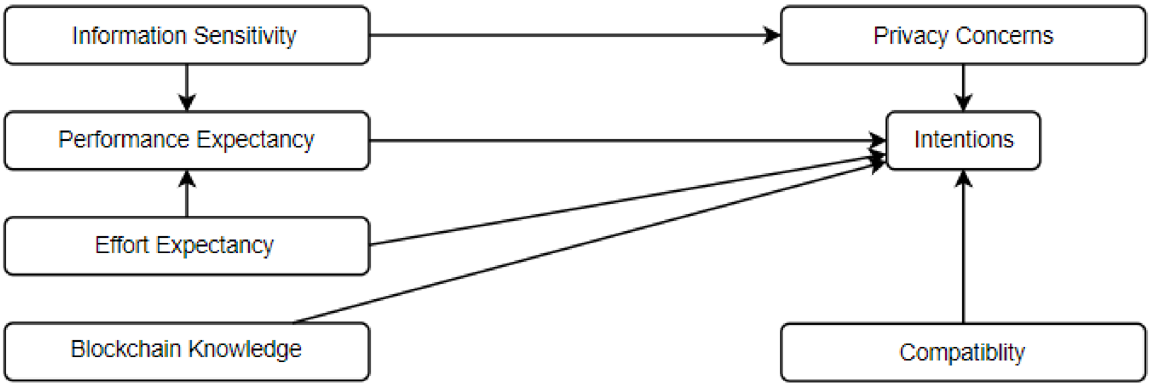

Figure 2.1. Conceptual Research Model

The survey items of this thesis can be formulated as follows:

Table 2.1. Items

Items		Factors	Reference
1	I find biometric technologies in my daily life.	Performance Expectancy	Venkatesh et al., 2012
2	Biometric technologies help me accomplish things more quickly.	Performance Expectancy	Venkatesh et al., 2012
3	Biometric technologies increase my productivity.	Performance Expectancy	Venkatesh et al., 2012
4	Learning how to use biometric technologies is easy for me.	Effort Expectancy	Venkatesh et al., 2012
5	My interaction with biometric technologies is clear and understandable.	Effort Expectancy	Venkatesh et al., 2012
6	I find biometric technologies easy to use.	Effort Expectancy	Venkatesh et al., 2012
7	It is easy for me to become skillful at using biometric technologies.	Effort Expectancy	Venkatesh et al., 2012
8	I do not feel comfortable with the type of information these technologies request from me.	Information Sensitivity	Morosan, 2016
9	I feel that these technologies gather highly personal information about me.	Information Sensitivity	Morosan, 2016
10	The information I provide to these technologies is very sensitive to me.	Information Sensitivity	Morosan, 2016

Table 2.1. (cont.)

11	I have privacy concerns about using biometric technologies.	Privacy Concerns	Morosan, 2016
12	Using biometric technologies would make me personally uncomfortable.	Privacy Concerns	Morosan, 2016
13	Using biometric technologies fits well with my lifestyle.	Compatibility	Kim and Qu, 2014
14	Using biometric technologies is compatible with my needs.	Compatibility	Kim and Qu, 2014
15	Using biometric technologies fits well with the way I like to get things done.	Compatibility	Kim and Qu, 2014
16	I believe blockchain technology will be used in everyday life.	Blockchain Knowledge	Miraz et al., 2020
17	I am familiar with Blockchain technologies.	Blockchain Knowledge	Miraz et al., 2020
18	Blockchain technology took my attention.	Blockchain Knowledge	Miraz et al., 2020
19	I am fascinated with Blockchain technology.	Blockchain Knowledge	Miraz et al., 2020
20	I intend to continue using biometric technologies in the future.	Intention	Venkatesh et al., 2012
21	I will always try to use biometric technologies in my daily life.	Intention	Venkatesh et al., 2012
22	I plan to continue to use biometric technologies frequently.	Intention	Venkatesh et al., 2012

CHAPTER III

APPLICATIONS OF BIOMETRICS AND BLOCKCHAIN IN AVIATION

There are several applications for biometric systems in different parts of the aviation sector. Most of these technologies are used in airports. Iris scans, fingerprints, and facial recognition are the most common ways to collect data from passengers and use it to facilitate and ease the customer experience in airports. Even though these applications ease the customer experience, security and safety concerns are the primary motivators for implementing such technologies.

Globalization affects air transport. The increase in international trade, tourism, and fast passenger circulation undoubtedly affects the number of passengers. According to International Civil Aviation Organization (ICAO) market data, the number of passengers worldwide, which was 1.67 billion in 2000, reached 4.56 billion in 2019 (World Bank, 2022). One of the biggest problems in the aviation sector, with a growth rate of approximately 300%, is that the existing infrastructure cannot meet this growth. However, this is a vital issue, as an airport's limited capacity can negatively affect passengers' experiences at the airport. Accordingly, ultra-large airports are built, like the recently built Beijing Daxing International Airport and Istanbul Airport. The use of systems that can make existing airports more efficient has also been discussed. From this point of view, technologies that allow passengers to move more comfortably and efficiently at airports have started to be used. At the same time, the increasing number of passengers negatively affects the security of customs and borders (Khan & Efthymiou, 2021). However, it is one of the priority issues of countries, especially with today's increasing immigration wave and the risk of terror attacks. At this point, biometric technologies offer practical solutions to these problems. According to Dave Bakker, President of Société Internationale de Télécommunications Aéronautiques (SITA) Europe, automated controls at the border will be inevitable for faster traveler processing and uncompromised security (Bakker, 2015). According to Bakker (2015), the main problem at the border is an insufficient workforce. In order to solve this problem, e-gates and kiosks will become necessary with the use of biometric technologies.

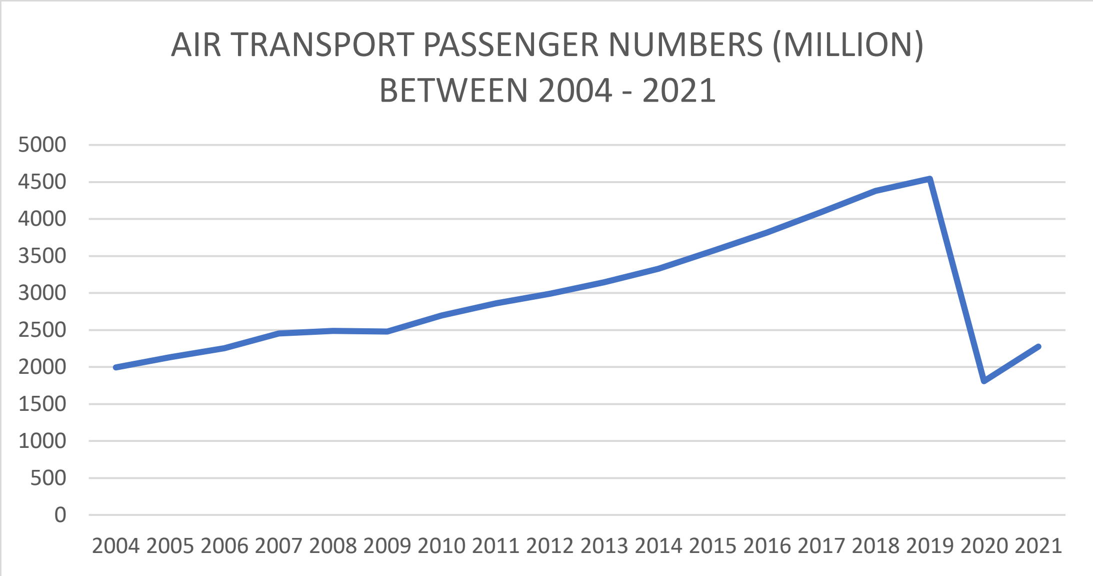

Figure 3.1. Passenger Carried in the World (Million)

Source: World Bank, 2022

On the other hand, the passengers' preference to move faster at the airports is evident. According to International Air Transport Association (IATA) data, passengers do not want to wait in airport lines for more than 10 minutes. To avoid waiting, passengers prefer various applications that minimize this waiting time, such as self-check-in or self-bag-drop (Khi, 2020). Airport authorities also pressure airlines to reduce waiting times to improve the airport experience and attract more passengers, which turns into airport revenue. Furthermore, the pandemic may cause biometric technologies to become widespread, reducing touch. Schultz & Soolaki (2021) argue that biometric technologies can play an essential role in increasing touchless airport applications.

In the modern concept of travel, air transportation starts with a passenger leaving home and ends when they reach their final destination. From this point of view, this journey includes the transport to the airport, the experience with the luggage until the airport, the arrival at the airport and check-in, baggage drop, passport control, and boarding at the source station, the processes at the airport after the flight, and even the travel from the airport to the final destination. From this point of view, air travel is only a part of the whole journey.

In this process, carrying the luggage with the passenger in the shortest amount of time is undoubtedly one of the most critical factors that will increase the efficiency of the trip. Biometric technologies come to the fore to increase safety and efficiency. Airlines, airports, and service providers develop various applications in order to improve the passenger's experience. For example, baggage delivery or check-in applications within the city have started to be used by airlines. Passengers can spend more time in the city by checking in or delivering their baggage to the airline while still in the city, thus leaving the airport without baggage. At the same time, the development of different transportation alternatives by airports can be given as an example. In the coming period, service providers will implement these practices more in order to improve the passenger experience. These travel concepts will become a natural part of travel. The digital transformation of these processes will increase passengers' comfort and reduce the airport's intensity and pressure. A mechanism will enable all aspects of air travel, which increases efficiency for each stakeholder and redesigns every step of passenger spending time on air travel.

3.1. NEXTT and One ID

IATA is the most significant trade association for the world’s airlines, representing 290 airlines from 120 nations or 83% of total air traffic. IATA is developing an initiative called New Experience Travel Technologies (NEXTT) in order to use these technologies outside of airports. The association anticipates that this technology will increase efficiency and safety in the aviation industry. "IATA and Airports Council International (ACI) have launched the NEXTT vision to ensure the transport of passengers, baggage, and cargo benefits from the latest technology developments to improve customer experience, reliability, and efficiency (IATA, 2022)". In this concept, which aims to initiate the management of customs and border procedures during ticket reservation, data exchange between customers, regulatory authorities, and service providers is carried out before the passenger arrives at the airport. In this process, as changes occur, all stakeholders are informed. This will not only increase the passenger's time but also provide a reassuring experience for the passengers and enable the risk-free evaluation of the necessary physical checks (IATA, 2022). This system, which aims to eliminate the need for paper documents, seeks to create a digital identity during reservation and activate processes outside the airport by benefiting from biometric technologies. Biometric technologies are also planned to be used without creating the identity of the luggage or cargo and connecting it with the passenger. NEXTT is an automation mechanism that allows these digital identities created using biometric technology to be used by stakeholders both outside and inside the airport. With this automation, security scans will be fast and free from human errors. At the same time, screening checks can be carried out at an early stage of the journey, i.e., outside the airport. All relevant authorities can use the scan images to report risk assessments for a passenger, baggage, or cargo shipment. Five case studies were conceptualized as part of the NEXTT initiative, three of which are in use. These are the One ID Service Platform at Hongqiao Airport, door-to-door baggage service by China Southern Airlines, the Airport Digital Transformation Program at Shenzhen Bao'an International Airport, door-to-door baggage delivery at Shenzhen Bao'an International Airport, and the Virtual Queuing Program at Seattle Tacoma International Airport. The One ID Service Platform at Hongqiao Airport can be considered one of the best implementation cases using biometric technologies.

Basically, two different types of passenger data are shared between stakeholders in the aviation industry. The first piece of data is called the passenger name record (PNR), created at the time of reservation on the airline’s reservation system. PNR consists of different information like the itinerary, fare conditions, special service requests, credit card information, and passenger details such as name, date of birth, nationality, country of residence, travel document numbers, and contacts (To, 2020). This data should be shared with border control authorities after flight departure with a standard message called PNRGOV in order to control and secure customs and borders. The second type of passenger data is called Advance Passenger Information (API), which includes passengers’ verified biometric identification details and essential flight information. "When a passenger checked in at the airport, the self-service kiosk or check-in agent would extract API data from passports or other government-issued travel documents. API is beneficial for border control authorities to match against watch lists and risk profiles, as well as identify inadmissible travelers (To, 2020)." In order to facilitate this process, IATA launched One ID in 2016 by aiming for an end-to-end passenger experience that is secure, seamless, and efficient. One-ID not only allows passengers to experience airports easily and efficiently but also gives governments a way to manage passenger data more securely. Governments use API data in order to secure their borders. With the help of One-ID, this data will be more accurate.

Creating an interoperable system between various partners and service providers on a flight journey is a critical goal of One ID. This fact is stated by IATA as follows:
"One ID introduces an opportunity for the passenger to further streamline their journey with a document-free process based on identity management and biometric recognition. Passengers will be able to identify themselves at each airport touchpoint through simple biometric recognition. The objective is to achieve truly interoperable system coordination between airports, airlines, and governments" (IATA, 2022).

3.2. Applications of One ID and Other Applications of Biometric Technologies

Some stakeholders came together as a workgroup, called the One ID Advisory Group, and provided directions and guidance in order to apply this project. These group members are Airports Council International, Kempegowda International Airport, Dubai Airports, Emirates, Government of Aruba, Heathrow Airport, International Airlines Group (IAG), Koninklijke Luchtvaart Maatschappij (KLM), Lufthansa, Government of the Netherlands, Qantas Group, Sydney Airport, Transport Canada, United States Customs and Borders Protection, World Travel & Tourism Council, World Economic Forum, Australian Government, and Schiphol Amsterdam Airport. As seen, airports, airlines, governments, and industry associations seek efficient passenger travel experiences using biometric technologies.

At Hongqiao Airport, the One ID Service Platform has been applied as a case study of NEXTT. The details of the application are presented as follows:

Hongqiao Airport has worked with TravelSky to build its own platform based on the One ID concept that will enable contactless touchpoints in the airport thanks to biometric recognition (hereinafter referred to as Hongqiao Airport's One ID Platform or the One ID Platform). The platform applies biometric identification and other advanced technologies through passenger touchpoints in Terminal 2, covering check-in, bag drop, security check, and boarding. Through collaboration with the deployment of SAE cloud computing, Hongqiao Airport's One ID platform provides efficient and consistent identity verification service and information service for passengers passing through the airport and collaborates with other airports, airlines, and government agencies to improve passengers' passing through efficiency, and experience, boost airport service efficiency, and enhance civil aviation safety on the basis of ensuring system and data security. As a core system of future passenger travel, the Hongqiao Airport's One ID platform will totally change the existing travel mode of passengers when completed (IATA, 2022).

With this application, significant results that affect the passenger experience have emerged, and the waiting time for passengers decreased from 40 minutes to 20 minutes. It also improved the utilization efficiency of the check-in counters and reduced the amount of public space required due to the long queues. Customer satisfaction has increased, and travel safety concerns are fulfilled due to the touchless process. Especially during the pandemic, this process has made passengers feel more secure (IATA, 2022).

Dubai Airport's Smart Tunnel Project is about new fast-track passport control services using face and iris recognition. According to the project, 122 smart gates at the arrival and departure terminals will be deployed in order to replace manual passport control. The new system aims to finish passport control within fifteen seconds (Dubai OFW, 2022).

Kempegowda International Airport in Bengaluru has started an initiative with the help of the Ministry of Civil Aviation in India. In 2019, Vistara Airlines passengers began to use the One ID biometric platform, aiming for an enhanced digital experience for air travelers (Business Traveller, 2022). The biometric data collected from passengers is used to authenticate and verify passengers for boarding. The process also includes the deletion of passenger data after usage.

Amsterdam Airport Schiphol and KLM launch another example of the OneID application. Passengers at Schiphol Airport can board their flights without showing their boarding pass or passport by using special gates. This application uses facial recognition, and the data is collected with biometric technology (Future Travel Experience, 2022).

In Istanbul Airport, the biometric-enabled Proof of Concept (PoC) was conducted by SITA. In a six-month trial, passengers are directed to a low-touch experience, yielding a 30% reduction in boarding times. Using standard check-in counters developed by SITA, passengers can scan their faces at every part of the journey, like security checks, lounge access, and boarding. In order to use it, passengers should be enrolled by Turkish Airlines handling agents (Future Travel Experience, 2022).

The Transportation Security Administration (TSA) recently conducted several biometric technology applications in different USA airports. For example, in collaboration with the State of Arizona and Apple, the TSA created a new mobile application for identity verification that State of Arizona citizens can use at Phoenix Sky Harbor International Airport's (PHX) security checkpoints. "Arizona-resident travelers can now verify their identity using their state-issued mobile driver's license or mobile identification card issued in Apple Wallet on iPhone or Apple Watch (Future Travel Experience, 2022)".

Korean Air self-boarding at Seoul Gimpo Airport, Austrian Airlines' Star Alliance biometric platform at Vienna Airport, Delta Airlines' end-to-end digital identity experience at Atlanta Airport, Lufthansa Group's one-step biometric boarding process utilizing facial recognition at eight airports in the US, Rome Fiumicino Airport's biometric boarding facility for Delta passengers, Tokyo Haneda Airport's biometric technology for passenger processing, United Airlines & SITA's low-touch enabled biometric trials at San Francisco, Malaysia Airports collaboration with Vision-Box to build biometric digital identity management system at Kuala Lumpur International Airport are other examples of the application of biometric technologies recently. Both airlines and airports have seen the importance of using biometric technologies.

3.3. Blockchain in Aviation Sector

Blockchain technology can be used in all areas where there is a contract. These contracts can be for airlines and service providers, airlines and passengers, airports and passengers, government authorities and airlines, and airlines and cabin cockpit crews. Considering that the blockchain makes all contracts smart and ensures the security and verification of these contracts in a decentralized way, it should be accepted that the blockchain still has a bright future in the aviation field.

As with biometric technologies, IATA has taken various steps to apply blockchain technology to the aviation industry. IATA has issued a token called IATA Coin to facilitate and standardize the payments of stakeholders. This token is used in IATA settlement systems, especially in the IATA clearing house system, allowing payments to be made in a single currency (Goudarzi & Martin, 2018). The Digital Certification Authority (DCA) concept developed by IATA aims to take advantage of emerging technologies such as blockchain, artificial intelligence, and biometrics, facilitating information flow and digital identity management between stakeholders (Goudarzi & Martin, 2018).

Peng (2021) shows six scenarios of blockchain applications in civil aviation, including passenger identity racking, baggage handling and indemnity, ticket selling, aircraft maintenance records, passenger privacy and security, and opaque examination and approval of airline resources. Within these areas, passenger identity, privacy, and security are also related to biometric technologies. In addition to these areas, frequent flyer programs (FFP) are also improved with blockchain technology by enabling tokens to earn, spend, and reconcile travel miles (Lopes et al., 2021). Considering that 11% of data theft in 2017 was done to loyalty programs, it can be seen that blockchain is critical in this field (Ahmad et al., 2020). Another important issue in civil aviation is crew certification. Because civil aviation requires many procedures and certifications, blockchain technology may also secure the security or verification of these papers or contracts (Ahmad et al., 2020).

Airlines started to use blockchain technologies on the payment side. For example, Air France and KLM have jointly developed a blockchain strategy with Switzerland-based start-up Winding Tree to reduce the number of intermediaries. Lufthansa has also cooperated with Winding Tree to help its customers make cheaper travel arrangements. Etihad is also looking for different blockchain technologies to distribute products and services without needing third parties, such as a Global Distribution System (GDS).

Similarly, JSC Siberia Airlines has also focused on the payment side of its operations and developed a blockchain platform for payment processing in cooperation with a bank (Lopes et al., 2021).

3.3.1. Recent Blockchain Applications in Aviation Sector

Today, many companies or start-ups have started implementing applications for the aviation industry.

3.3.1.1. Aeron

Aeron is an Ethereum-based initiative created by some industry professionals aiming to keep the flight logs of pilots and thus securely record the contracts made between pilots and aircraft owners or airlines. It improves aircraft safety by managing the pilot's flight logs, aircraft maintenance history, and spare parts components (Ahmad et al., 2020).

3.3.1.2. Loyyal

Loyyal is a blockchain system that aims to manage the rewards and incentives created for customers and increase the efficiency of airline loyalty programs offered to their customers.

3.3.1.3. Ozone

Ozone is a blockchain platform that combines airlines, car rental companies, and hotels under one roof and enables secure transactions between these companies. The expensive, complicated, non-transparent, and centralized structure of existing systems is ineffective in finding an alternative market for users. Ozone provides a less expensive approach for both parties by connecting the end user and related companies.

3.3.1.4. FlightChain

SITA has published a study called FlightChain, working with British Airways, Heathrow, Geneva Airport, and Miami International Airport (SITA, 2022). FlightChain gives a single and synchronized view of flight data to collect data from multiple flights, authenticate the provenance of data, and merge verified data to decide the truth (Ahmad et al., 2020).

3.3.1.5. TravelBlock

TravelBlock is a distribution system that aims to be an alternative to global distribution systems and provides cost savings, security, and transparency to its users by using the blockchain infrastructure (Goudarzi & Martin, 2018).

3.3.1.6. TravelChain

TravelChain is an open-source blockchain system that aims to bring together all stakeholders in the industry. In addition to the services it provides to its users, it is foreseen to have provisions that will provide ratings and transparency.

3.3.1.7. TripBit

Tripbit is an online booking and purchasing platform allowing users to find the best deals on airlines, hotels, and car rentals. However, it enables non-refundable tickets sold in secondary markets (ICObench, 2022).

3.3.1.8. TrustaBit

TrustaBit is a platform that enables the management of coupons created to be given to passengers during flight delays or cancellations. In this way, it ensures the security and control of coupons and aims to improve the passenger experience (TrustaBit, 2022).

3.3.1.9. Winding Tree

Winding Tree offers solutions that provide inventory management for airlines and hotels. It facilitates the distribution of these inventories. At the same time, it aims to establish a market where these inventories will be presented to the market by using this decentralized blockchain system. In particular, it seeks to minimize the costs arising from traditional distribution systems (Goudarzi & Martin, 2018). The company seeks to connect travelers directly with service providers like airlines, hotels, and tour guides with its LIF token.

3.4. Blockchain Usage with Biometric Applications in Aviation

While biometric applications aim to improve passengers' travel experiences, they also prioritize ensuring safety by minimizing human errors. Reducing the risks, especially in customs and border security, is very important in terms of eliminating human-related errors. But at this point, a secondary security problem arises. Although biometric systems offer safer travel, the security of data collected through biometric technologies becomes a problem for passengers and service providers collecting this data. The distribution of the collected data among the stakeholders also makes the security of these distribution processes important. At this point, blockchain technologies and applications have started to be used by aviation stakeholders to eliminate this problem. The use of blockchain technologies in aviation is not limited to the applications mentioned above but manifests in all kinds of transactions.

The spread of biometric applications also brings some problems. In particular, the emergence of different applications or systems makes it difficult for these systems to communicate with each other or necessitates the use of various tools and technologies in this process. In the case of widespread use of biometric technologies, it will be challenging to integrate the applications, each of which is designed with its unique systems, with each other. Integration and the trust of stakeholders using these systems in this process become important. To summarize, data standardization and verification become the essential points of this process (Khi, 2020). Although ICAO introduces a standard for biometric data to eliminate this situation, not every country implements it (Khi, 2020). The absence of such a standard causes stakeholders not to trust each other's data. Even if biometric data from different systems are shared, the insecurity of sharing this data is another problem. In other words, even if the stakeholders accept each other's data as correct, the security problems experienced in sharing the data will again question the accuracy of this data.

The biggest shortcoming of the One ID application is that stakeholders are still concerned about the security risks that will occur in this process. The secure and transparent transmission of information is the most critical frontier for companies while adopting new technologies (X. Li et al., 2021). For example, while stakeholders at an airport using the same application can rely on this information transfer, how can another airport stakeholder using a different application ensure the security of the data coming from the partnering airport? In addition, the legal systems in force today, such as the General Data Protection Regulation (GDPR), make it difficult to securely store and share this data (Khi, 2020). Theft and misuse of this digitally stored data further increase the distrust of stakeholders. At this point, the blockchain stands out for the verification and secure transmission of this data. Khi (2020) argues that blockchain will be the ideal and crucial solution for data verification and security with standardized protocols. Khi (2022) goes as follows:

Using blockchain, tech companies can create innovative decentralized solutions that can secure passenger data. Then, assuming international standardization and regulation, the reputational score of the data could become the basis of shared insights between airlines and governments, who would in turn be able to trust that the validation and re-validation are accurate. As a result, wherever in-person checks still have to be performed, the data verification process will allow airlines and government agencies to focus on screening passenger behavior rather than verifying biographic/ passport data, making the checking process at airports and borders much more efficient (Khi, 2020).

In its study, To (2020) argues the importance of blockchain when transferring data between stakeholders. To (2020) illustrates a generic blockchain-based solution by creating a digital ID for passengers created by a government by gathering biometric information about a passenger. The government tokenizes this unique information and signs it with a private key. The digitally signed token can then be kept on a blockchain and shared with authorities, airlines, and airports. The passenger may also keep the token as a digital ID. Whenever the passenger goes for check-in or border control, all information can be easily checked and matched with the passenger's digital ID. With the help of blockchain, the data cannot be lost or damaged. Also, the security of transferring data like PNR or API can be provided via blockchain.

Peng (2021) hypothetically creates a digital app to facilitate the passenger experience securely. Even though it is a hypothetical application, blockchain technology has the power to do these processes securely.

First of all, passengers should make a registration after downloading the specific app, among which the APP will firstly collect the passenger's facial image, then encode the image, and at last, record the image characters into the chain. After that, the passenger inputs their name, e-mail, and phone number, and then the APP generates the externally owned account for the passenger and creates the corresponding public-private key pair. Account on the blockchain can invoke a smart contract, which is actually some code fragments running on the blockchain. Without any human intervention, the smart contract executes independently and automatically in a prescribed manner. Applications, including identity information tracking, aircraft ticket purchase, baggage sorting, and others, are implemented by calling the smart contract. Alliance chain ensures the information privacy of passengers. Although the information of passengers in the externally owned account is recorded in clear text, only the relevant nodes operating the blockchain can see the identity information of passengers. Furthermore, for private information such as flight records, the smart contract encrypts those records, which can only be decrypted and viewed by special departments such as public security organs or National Security (Peng, 2021).

Sometimes, passengers lose their passports, or their passports may be damaged during the journey. In this case, airlines must receive an okay-to-board message from the destination country to accept this passenger. The arrival of this message depends on the acceptance of this passenger by the state authorities. This process takes place within a time constraint, and the relevant notice is often not received on time. The reason for this is the manual operation of the systems, where the state authorities will verify this passenger information, or this information cannot be trusted without a passenger. In order to ensure that this message arrives quickly and automatically, digital identity cards can be created for each passenger, biometric data can be stored on these cards, and this data can be transferred securely to the relevant units with the help of the blockchain (Ahmad et al., 2020). Digitizing passports with biometric technologies will help minimize the risk of passport damage or loss.

The most critical application in this regard has been developed with the World Economic Forum and Accenture. Accenture developed the Known Traveler Digital Identity System to speed up the security process, aiming to reduce waiting time at airports. It has also partnered with the World Economic Forum (WEF) to develop the travel industry. It aims to collect the information of frequent travelers using the blockchain and share it with airport stakeholders. It aims to improve airport passenger experiences by accelerating data flow. The created digital identities are secured with the blockchain, allowing stakeholders to manage airport processes more quickly (System Initiative on Shaping the Future of Mobility, 2018).

CHAPTER IV

METHODOLOGY AND RESULTS

4.1. Instrument Development

Online and face-to-face survey instruments were used in this study. The scale for performance expectancy is adapted from the work of Morosan (2016), which relied on Venkatesh et al. (2012b). The scale consists of three items. We adopted the effort expectancy scale from Morosan (2016), which includes four items. Privacy concerns are considered to have a negative relationship with intention. This construct contains four items, of which two have lower loadings. Accordingly, these two items are dropped, and the model is respecified. These items were adopted from Kim et al. (2008). Information sensitivity has three items, and the scale is adapted from the same source (Morosan, 2016). The scale for compatibility is adapted from Morosan (2016) and includes three items. Because there is not enough literature about the relationship between blockchain knowledge and intention, four items were created, according to Miraz et al. (2020). Lastly, the intention scale has three items (Morosan, 2016). All items are measured using a five-point Likert scale: 1 (strongly disagree) to 5 (strongly agree).

The instrument has two parts: demographics and latent constructs scaling each item. At the beginning of the survey, demographic information is collected with five questions. After demographic questions, participants were asked if they had used biometric technologies before and which ones they used. After these questions, observers were asked 22 questions. At the end of the survey, respondents were asked to share their contact information to send the work results.

4.2. Sampling and Data Collection

Data were collected in April and May 2022 at Istanbul Airport, face-to-face and online, through Google Forms. All participants were selected from passengers who used Istanbul Airport six months before the study. 420 responses were collected, and after data cleaning, 412 of them were used in the analysis.

4.3. Model and Tools

The structural equation model (SEM) is used for the research analysis of given hypotheses. In order to test the model, SPSS AMOS software is used. The reflective measurement model is chosen between observed variables and latent variables.

4.4. Demographics and Behavioral Profile

The demographic of respondents (Table 4.1) shows the sample includes more males (66%) than females (34%). According to the data, most respondents (56%) are between 31 and 45 years old. Respondents older than 61 years old are only 1% of the total participants. Income distribution is seen as not being biased. However, it is not distributed normally. 38% of respondents earn between $10,000 and $25,000, and almost all have a bachelor's degree or higher. Only 6% of respondents got an education in high school.

The behavioral profile (Table 4.2) of respondents shows that most (61%) travel more than once a year. Only 6% of these respondents travel once a week or more. Biometric technology usage is an important variable to evaluate in the sample for hypothesis analysis. 93% of the total respondents have used biometric technologies before.

Table 4.1. Demographic Profile

Variable	Percent
Gender	
Female	34%
Male	66%
Age	

Table 4.1. (cont.)

16-30 Years Old	32%
31-45 Years Old	56%
46-60 Years Old	12%
More than 61 Years Old	1%
Annual Household Income	
Less than $10,000	16%
$10,000 - $25,000	38%
$25,000 - $50,000	9%
$50,000 - $100,000	18%
$100,000 - $500,000	19%
Education	
High School	6%
Bachelor's Degree	51%
Master's Degree or higher	43%

Table 4.2. Behavioral Profile

Variable	Percent
Frequency of Air Travel	
Once a year	11%
More than once a year	61%
Once a month	22%
Once a week or more	6%
Biometric Technology Usage	
Yes	93%
No	3%
Maybe	3%

In order to look at specific BT usage (Table 4.3), it is shown as numbers instead of percentages. Respondents are asked to choose several BTs, including fingerprint, face, voice, and iris recognition. Most of the respondents (361) used fingerprints. After fingerprint technologies, face recognition is the most commonly used biometric technology among the sample. Only eight respondents had not used biometric technologies before, according to Table 4.3.

Table 4.3. Usage of Biometric Technology

Most Biometric Technology Usage	Total Number
Fingerprint	361
Face recognition	323
Voice recognition	223
Iris recognition	124
Other	34
Not Used Before	8

4.5. Measurement Model Analysis

The collected data must pass tests before analyzing the selected sample. First, to confirm the model's theory (Hair et al., 2021), the reflective measurement model was used between the latent variables and the observed variables or items. The SPSS AMOS v.26 software program was used to test this model.

The structure in Figure 4.1 was established to make a confirmatory factor analysis (CFA), test the relationship of all latent variables with each other and the relationship of observed variables with the latent variable, and assess the chosen measurement model. It allows for evaluating the relationship between latent and observed variables, which gives an idea of how the model works with collected data (Mueller & Hancock, 2001). In the first stage, all items were added to the model, and the result was evaluated. The procedures were applied sequentially. First, factor loadings showing the importance of related factors or items were examined. It was determined that the factor loading values in the Privacy Concerns variable were less than 0,5, as shown in Table 4.4. According to Hair et al. (2006), factor loadings bigger than 0,5 show a meaningful relationship between the observed variable and the latent variable.

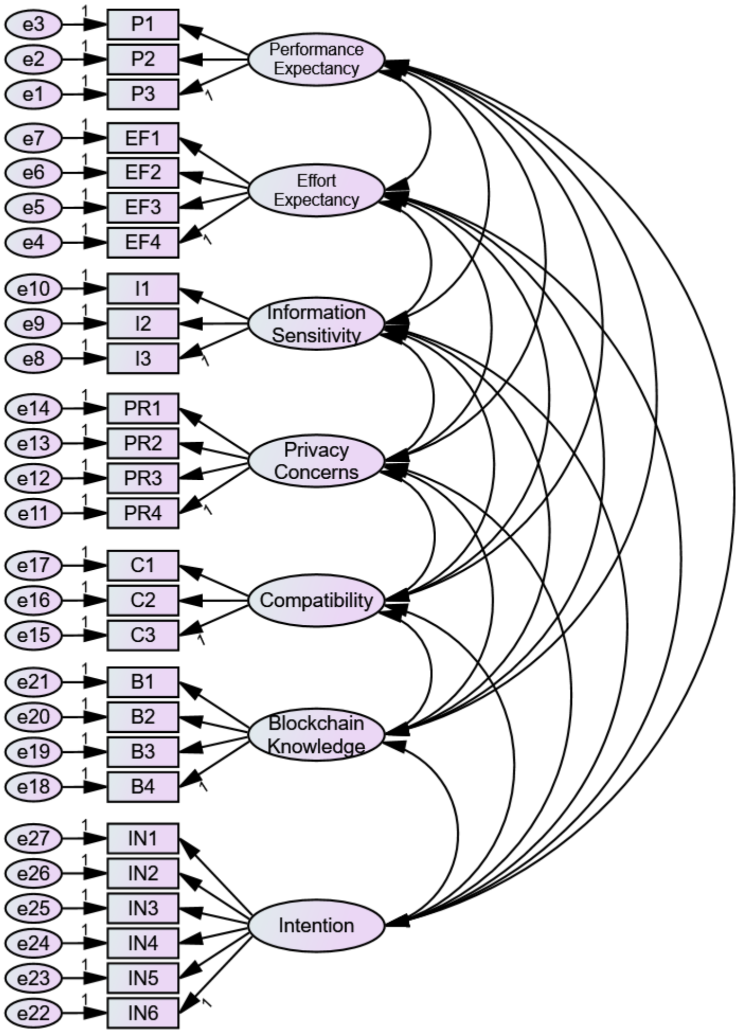

Figure 4.1. Reflective Measurement Model Before Tests

The structure in Figure 4.2 was established and tested again by removing the first and second items from Privacy Concerns. It was seen that the factor loading values were bigger than 0.5 for the third and fourth items (see Table 4.5).

Table 4.4. Factor Loadings Before Model Fit

			Estimate
P3	<---	PerformanceExpectancy	0,883
P2	<---	PerformanceExpectancy	0,884
P1	<---	PerformanceExpectancy	0,71
EF4	<---	EffortExpextancy	0,775
EF3	<---	EffortExpextancy	0,863
EF2	<---	EffortExpextancy	0,886
EF1	<---	EffortExpextancy	0,856
I3	<---	InformationSensitivity	0,556
I2	<---	InformationSensitivity	0,748
I1	<---	InformationSensitivity	0,704
PR4	<---	PrivacyConcerns	0,326
PR3	<---	PrivacyConcerns	0,334
PR2	<---	PrivacyConcerns	-0,826
PR1	<---	PrivacyConcerns	-0,898
C3	<---	Compatibility	0,94
C2	<---	Compatibility	0,947
C1	<---	Compatibility	0,854
B4	<---	BlockchainKnowledge	0,809
B3	<---	BlockchainKnowledge	0,884
B2	<---	BlockchainKnowledge	0,829
B1	<---	BlockchainKnowledge	0,634
IN6	<---	Intention	0,688
IN5	<---	Intention	0,704
IN4	<---	Intention	0,659
IN3	<---	Intention	0,937
IN2	<---	Intention	0,919
IN1	<---	Intention	0,911

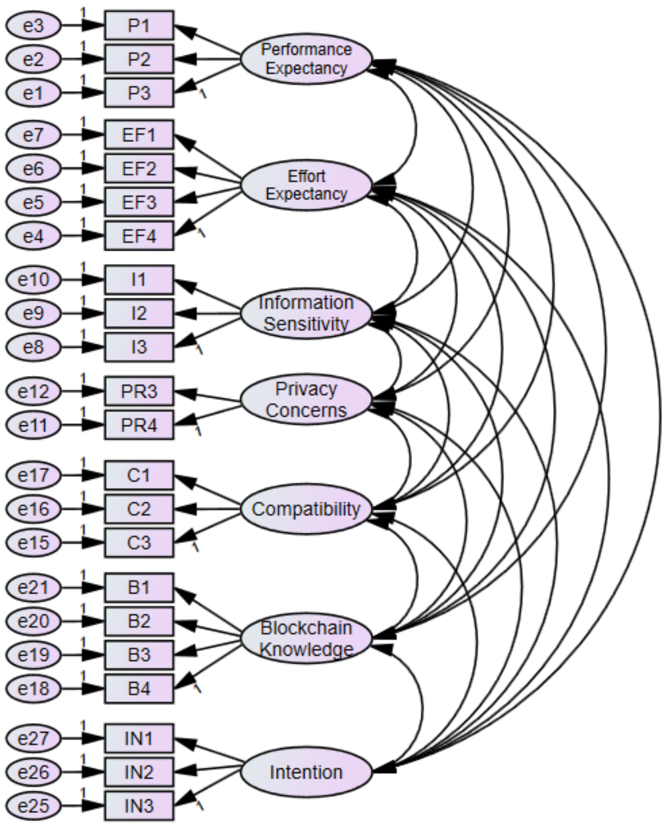

Figure 4.2. Reflective Measurement Model After Tests

Table 4.5. Factor Loadings After Model Fit

			Estimate
P3	<---	PerformanceExpectancy	,882
P2	<---	PerformanceExpectancy	,884
P1	<---	PerformanceExpectancy	,711
EF4	<---	EffortExpectancy	,775
EF3	<---	EffortExpectancy	,863
EF2	<---	EffortExpectancy	,886
EF1	<---	EffortExpectancy	,856
I3	<---	InformationSensitivity	,632
I2	<---	InformationSensitivity	,724
I1	<---	InformationSensitivity	,667
PR4	<---	PrivacyConcerns	,708
PR3	<---	PrivacyConcerns	,759
C3	<---	Compatibility	,943
C2	<---	Compatibility	,945
C1	<---	Compatibility	,851

Table 4.5. (cont.)

B4	<---	BlockchainKnowledge	,806
B3	<---	BlockchainKnowledge	,890
B2	<---	BlockchainKnowledge	,827
B1	<---	BlockchainKnowledge	,630
IN3	<---	Intention	,955
IN2	<---	Intention	,933
IN1	<---	Intention	,910

Table 4.6. Baseline Comparisons Before Model Fit

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	,880	,858	,907	,890	,907
Saturated model	1,000		1,000		1,000
Independence model	,000	,000	,000	,000	,000

Before rebuilding the measurement model, model fit is also checked to see if the model fits the theory. There are some indices to evaluate the model fit. It is observed that the Normed Fit Index (NFI) is less than 0,9 (see Table 4.6). NFI was defined by Bentler & Bonett (1980) and should be close to 1,0. The relative fit index (RFI) should be greater than 0,9, according to Meyers et al. (2013). RFI is less than 0,9, according to Table 4.6. Tucker-Lewis Coefficient (TLI) is also considered closer to 1,0 for a good model fit (Bentler & Bonett, 1980). In this study, the mentioned coefficient is less than 0,9, as shown in Table 4.6. According to Kline (1998), the Chi-Squared Per Degree of Freedoms CMIN/DF value should be less than 3,0. However, in this model, it is more than 3,00 (see Table 4.7). In order to improve the model, the covariances of errors in the same latent variables were checked. It is seen that Intention error terms have higher covariances. Accordingly, items with smaller factor loadings in this variable were removed from the model. The intention variable's 4th, 5th, and 6th items were removed from the model, and the model was rebuilt, as seen in Figure 4.2.

Table 4.7. CMIN Before Model Fit

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	71	1016,951	254	,000	4,004
Saturated model	325	,000	0		
Independence model	25	8487,552	300	,000	28,292

The new model shown in Figure 4.2 produced NFI, RFI, and TLI values greater than 0,9 (see Table 4.8). Similarly, the CMIN/DF value became less than 3,00, as shown in Table 4.9. Also, Incremental Fit Index (IFI) and Comparative Fit Index (CFI) are bigger than 0,9 in Table 4.8. According to Fan et al. (1999), a CFI bigger than 0,9 is considered an acceptable fit. Likewise, values close to 1,0 indicate a good fit for IFI (Bentler & Bonett, 1980).

CMIN should be reported if the sample size is between 100 and 200 (Tabachnik & Fidell, 1996). In this model, the CMIN value became bigger as the sample size was more than 200 (see Table 4.9). The P value is also reported in Table 4.9.

Table 4.8. Baseline Comparisons After Model Fit

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	,928	,911	,952	,941	,952
Saturated model	1,000		1,000		1,000
Independence model	,000	,000	,000	,000	,000

Table 4.9. CMIN After Model Fit

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	65	527,579	188	,000	2,806
Saturated model	253	,000	0		
Independence model	22	7318,256	231	,000	31,681

It is suggested that the Root Mean Square Error of Approximation (RMSEA) value should be less than 0,05 for a proper fit (MacCallum, Browne, & Sugawara, 1996). However, it is acceptable if the value is between 0,05 and 0,08 (Fabrigar, MacCallum, Wegener, & Strahan, 1999). In this model, the RMSEA value is 0,066, as shown in Table 4.10. So, it appears to be an acceptable fit.

Table 4.10. RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	,066	,060	,073	,000
Independence model	,273	,268	,279	,000

According to Hu & Bentler (1999), the Standardized Root Mean Squared Residual (SRMR) is recommended to be less than 0,08. Table 4.11 shows the Root Mean Squared Residual (RMR) as 0,087. The standardized RMR is 0,0692, which is also acceptable.

Table 4.11. RMR

Model	RMR	GFI	AGFI	PGFI
Default model	,087	,897	,861	,666
Saturated model	,000	1,000		
Independence model	,422	,221	,146	,201

In order to assess the reliability of the model, it is recommended that the Construct Reliability (CR) be bigger than 0,7 (Lerdpornkulrat et al., 2017). The model's CR for each latent variable satisfies this condition, as shown in Table 4.12. Furthermore, each construct's Maximal Reliability (MaxR(H)) is bigger than 0,7, as shown in Table 4.12. Based on these two measures, CR is established.

In order to assess the convergent validity, the Average Variance Extracted (AVE) should be bigger than 0,5 (Hair et al., 2006). Therefore, the model satisfies the condition. Also, for discriminant validity, Maximum Shared Variance (MSV) value should be less than AVE (Fornell & Larcker, 1981). In this model, all MSV values are less than AVE, as shown in Table 4.12. All Hetero-Trait-Mono-TraiT (HTMT) values in the model are less than 0,9, establishing discriminant validity (Fornell & Larcker, 1981), as given in Table 4.13.

Table 4.12. Reliability and Validity Analysis

	CR	AVE	MSV	MaxR(H)
Performance Expectancy	0,868	0,688	0,675	0,89
Effort Expectancy	0,909	0,716	0,5	0,915
Information Sensitivity	0,715	0,543	0,49	0,72
Privacy Concerns	0,7	0,539	0,356	0,703
Compatibility	0,938	0,836	0,812	0,95
Blockchain Knowledge	0,871	0,631	0,121	0,895
Intention	0,953	0,87	0,812	0,956

Table 4.13. Reliability and Validity Analysis – HTMT Analysis

	Performance Expectancy	Effort Expectancy	Information Sensitivity	Privacy Concerns	Compatibility	Blockchain Knowledge	Intention
Performance Expectancy							
Effort Expectancy	0,705						
Information Sensitivity	0,078	0,031					
Privacy Concerns	0,106	0,112	0,894				
Compatibility	0,782	0,63	0,192	0,165			
Blockchain Knowledge	0,313	0,296	0,087	0,031	0,365		
Intention	0,824	0,64	0,21	0,253	0,89	0,387	

4.6. Research Model Analysis

The structure in Figure 4.3. was established in SPSS AMOS v.26 software to evaluate hypotheses constructed according to the model.

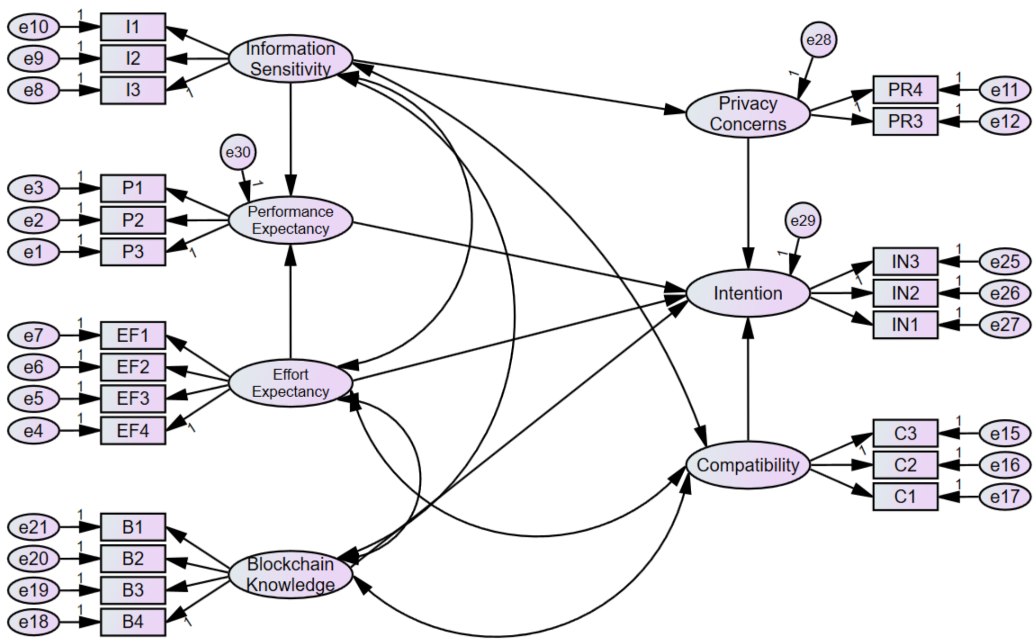

Figure 4.3. Structural Model Assessment After Tests

Table 4.14. Regression Weights

			Estimate	S.E.	C.R.	P
PrivacyConcerns	<---	InformationSensitivity	1,109	0,12	9,416	***
PerformanceExpectancy	<---	InformationSensitivity	-0,127	0,05	-2,432	0,02
PerformanceExpectancy	<---	EffortExpextancy	0,914	0,07	13,71	***
Intention	<---	PrivacyConcerns	-0,084	0,03	-2,686	0,01
Intention	<---	Compatibility	0,752	0,04	17,13	***
Intention	<---	BlockchainKnowledge	0,052	0,03	1,948	0,05
Intention	<---	EffortExpextancy	-0,063	0,07	-0,854	0,39
Intention	<---	PerformanceExpectancy	0,379	0,05	7,333	***

According to the results, almost all relationships between independent and dependent variables are significant, except for the blockchain knowledge effect on intention and the effort expectancy effect on intention.

Because the p values of relations between dependent and independent variables shown in Table 4.14 are less than 0,05 and significant, the results support six hypotheses: H1, H3, H4, H5, H6, and H7. However, the results do not support H2 and H8.

4.7. Results and Discussion

The primary purpose of this study was to measure the attitudes of the passengers using the airports towards BT, how they met these technologies, and their intentions to use them when they encountered them. Especially today, protecting sensitive data and its secure distribution among stakeholders are thought to affect users' intentions when exposed to these technologies. For this reason, the effect of blockchain technology, a very new technology for almost every business area, was tried to be measured.

First, performance expectancy and effort expectancy from the UTAUT2 model, information sensitivity, privacy concerns, and compatibility from Morosan's (2016) study were evaluated to measure this. Then, by adding blockchain knowledge to these variables, passengers' intentions to use BT were investigated.

The main findings of this study show that performance expectancy, information sensitivity, privacy concerns, and compatibility have a significant effect on the intention to use BT. One of the main findings of this study and its contribution to the literature in this area is that blockchain knowledge had an almost significant impact on the intention to use BT in Istanbul Airport. On the other hand, the study shows effort expectancy is not substantial enough for this intention.

As Venkatesh et al. (2012) show in their study, performance expectancy is one of the most critical factors affecting intention to use IS. The aviation industry is a technology-dependent sector and closely follows technological developments. There is visible competition in the aviation industry, especially in evaluating and applying the technological developments in recent years in the sector. The most important feature of these improvements is to provide passengers with a perfect travel experience. For this reason, the effect of performance expectancy on the intention to use BT parallels and supports the improvements the industry is currently trying to make and the travel experiences it offers passengers. Thus, the ease of use of these technologies is considered one of the vital issues. Time constraints are one of the most critical factors affecting the passenger's experience from the beginning of the journey to boarding. In particular, airports try to reduce the time the passengers' procedures take to board the plane, including check-in, baggage drop, customs control, security checks, boarding, etc., leading passengers to spend more time inside the airport. Accordingly, ease of use in the developments in technology made is highly critical not only for passengers but also for airports. The positive effect of the effort expectancy on the intention to use BT and the performance expectancy is a result that will contribute to the sector's applications. As Morosan (2016) shows in his study, performance expectancy and effort expectancy have a positive effect on the usage of IS. Still, only effort expectancy’s effect on intention is not confirmed by this study.

Contrary to other sectors, the aviation industry is where sensitive or personal data is shared the most. When purchasing airline tickets, information such as name, phone number, passport information, e-mail, credit card information, and date of birth is shared with sales channels. In addition, some applications at airports collect such information. As a result of increasing digitalization, personal data is shared more and more and is exposed to malicious uses. At this point, it is known that passengers are naturally sensitive to the misuse or malicious use of personal data.

On the other hand, biometric technologies collect data that is much more sensitive for each passenger, such as fingerprint, iris, and face recognition. Therefore, sensitivity to personal data has a negative effect on using these technologies. While the result of the study supports this situation, it also provides data for airports to take more responsibility in this regard. The sensitivity of the information collected further increases this effect, or, in other words, the sensitivity of personal data positively affects these concerns, which is also shown by this study. On the other hand, it can be predicted that the performance expectancy of the BT in which this sensitive information is used will be lower. For this reason, sensitive information will inevitably have a negative impact on performance expectations, and research has proven this to be true. Studies like Morosan (2016) and Paine et al. (2007) say privacy concerns impact intention, and there is a positive relationship between information sensitivity and privacy concerns. The relations among such variables are as mentioned in such studies, and they are significant enough to evaluate. On the other hand, the information sensitivity effect on performance expectancy is negative, as Morosan (2016) shows.

Developments in the field of technology today have increased the number of technological products and services, and the customization that previously occurred in normal goods or the acceptance of the product by the user and the compatibility of the product with the user have become important in the creation of the products and services. Undoubtedly, this change is also happening in the aviation industry. Especially airlines and airports evaluate this factor in their customers' products or services. In this study, it is seen that a factor that positively affects intention is compatibility. Reaching more users of the offered service or product increases the efficiency of the relevant service provider's workflows. Efficiency gains even more importance when the impact of airport congestion, time constraints, and the complexity of security processes on passengers are considered. The positive effect of compliance on intention provides essential data for airports. Our results also prove the positive relationship between the intention to use IS and compatibility studied by Morosan (2016).

Blockchain technologies and their effect on usage intention are an area examined in this study that is very new in the literature. BC has closed a severe gap in data protection. Although the use of these technologies in the aviation industry is not widespread, it is seen that service providers operating in the field of technology in the aviation industry have started to use this technology in almost every sector. The study measured both the familiarity of passengers with technology and the effect of this familiarity on intention. It is shown that BC knowledge positively affects the intention to use BT. Although it is thought that BC technology will be helpful in storing, processing, and sharing biometric data, it is predicted that users will use BT more easily if they know BC. According to the results, a positive relationship was found between this variable and intention, but it was observed that this relationship was not significant enough. From this point of view, it can be concluded that BC technology is not fully known or that users do not have information about how it stores or protects biometric data. However, it can be understood from the reports that the effect of the BC on intention will be beneficial if an investment is made in this area. When the negative effect of privacy concerns about their personal data on the intention is also calculated, it is seen that the BC will become more critical over time. What Miraz et al. (2020) suggest is evaluated in this work is that BC-based systems are researched and correlated with the intention to use a specific IS. Also, BC knowledge has a cumulative effect on intention, according to Strebinger & Treiblmaier (2019). Even though the relation is not significant enough, it is seen that the positive correlation between BC knowledge and intention to use BT is constructed.

The aviation industry will take some time to return to its old days after the pandemic. We have a few more years to reach the figures reached in 2019 regarding seats supplied and the total number of flying passengers. After this stage, the previously discussed issues will reappear on the agenda. Studies will be carried out on the more effective use of airports, increasing passenger experience, protecting passenger information, preventing abuses, and increasing the fluidity of passenger information. Projects implemented before the pandemic will gain popularity again or renew themselves and be presented to passengers differently. At the heart of all these developments is storing and distributing information collected from passengers, which plays a key role. As the study shows, passengers tend to use these technologies after considering various variables. One way to implement these technologies more quickly and practically will be their integration with BC technology.

CHAPTER V

CONCLUSION

Technological developments are accelerating, especially in some areas related to information processing. BT is also at the forefront of these areas. The uniqueness of the biometric information shared using BT is an issue that institutions working in this field should be careful about. Many legal procedures, like GDPR, are also being produced to protect this information. Governments enforce more and more regulations. The sensitiveness of stored, processed, and shared information is also essential for customers using these technologies. It affects their intention to use them.

Airports use BT to regulate the increasing passenger traffic and make the facility more functional. Existing airport infrastructure and terminals had become unable to meet the growing demand before the pandemic. Although there has been a dramatic decrease in passenger traffic during the pandemic period, this traffic will inevitably return to 2019 figures after the pandemic. On the other hand, airports have started to implement different practices that facilitate the travel experience of passengers in order to regulate the increasing passenger traffic. The most important of these is undoubtedly the use of BT at airports.

The primary purpose of this study was to measure how passengers act when they encounter these technologies at airports. Therefore, the passengers using Istanbul Airport were studied.

In order to measure the passengers' intention to use these technologies, the literature was searched. The UTAUT2 (Venkatesh et al., 2012) model was chosen. Performance expectancy, effort expectancy, privacy concerns, information sensitivity, compatibility, and BC knowledge were determined as variables affecting the intention to use BT. The effect of these variables on intention has been examined, and the results are aligned with the literature. As observed, performance expectancy, effort expectancy, and compatibility positively affect intention. On the other hand, privacy concerns and information sensitivity have negative effects. Besides these variables, BC knowledge is not significant, even though it positively correlates with intention.

Although these results have emerged, some issues will come to the fore in future studies. The data collected in the survey conducted during the preparation of this thesis has been carefully reviewed. For the collected data to be healthy, care was taken to ensure that the respondents were not in a particular group, such as a specific age range or gender. However, Istanbul Airport, where the survey was conducted, is generally an airport used by Turkish passengers, and it is assumed that most of the respondents are Turkish. Although the nationality of the passengers was not asked during the survey, this is seen as a significant limitation of the current study.

Another point to be considered while conducting the survey is that it was primarily directed at passengers at the airport. Thus, the time constraint at the airports may also apply to the answers of the surveyors. The fact that passengers do not want to waste time while conducting the survey may affect the results.

When the literature is scanned, it is seen that there are studies specific to BT, but it should not be forgotten that most of the studies have been done recently. Accordingly, we claim that the literature is not mature in this sense. Besides, the relationship between BC and BT was a very new subject. Thus, one may question whether the UTAUT2 model suits this. Another issue related to BC is that the relationship of BC knowledge with information sensitivity or privacy concerns is not examined. The fact that BC knowledge is a new variable for the UTAUT2 model has necessitated looking only the effect of this variable on intention. However, BC knowledge may correlate with privacy concerns and information sensitivity. Although it is thought that the impact of the items used on the related variable is positive, two items used while measuring the privacy concerns variable may be insufficient to measure the variable. From this point of view, it is essential to create models by considering other variables in order to measure BC knowledge more accurately in future studies.

Another limitation of this study related to the UTAUT2 model is how appropriate the questions asked during data collection are for the relevant variables. Although these questions, which are prepared according to the UTAUT2 model, are general, asking different questions may also differentiate the results. Therefore, the number of questions asked or their relationship with the variables should be discussed and how the questions are formulated may significantly affect the outcome.

It is believed that this study will contribute to the literature and enable more similar studies, especially in the aviation industry. It is thought that it is important to apply scientific methods to solve the existing airport problems and benefit from scientific studies while determining these methods.

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APPENDIXES

APPENDIX A

Ethics Committee Permission Certificate obtained by the student regarding the questionnaire for the thesis is attached.

Evrak Tarih ve Sayısı: 11.05.2022-13351

T.C.
İBN HALDUN ÜNİVERSİTESİ
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Sayı : E-71395021-020-13351 11.05.2022
Konu : İbrahim Hakkı GÜNTAY-Etik Kurul Kararı

İLGİLİ MAKAMA

Kurulumuza başvuran İbrahim Hakkı GÜNTAY'ın "The Effect of Blockchain Awareness on Passengers' Intention to Use Biometric Technologies in Istanbul Airport" isimli projesi; amaç, araştırma türü, veri toplama araçları, süreç ve işlemler, veri analizleri dikkate alınmak suretiyle 19.04.2022 tarihinde değerlendirilerek 2022/04-4 karar numarası ile etik açıdan uygun bulunmuştur.

Bilgilerinizi arz/rica ederim.

Prof. Dr. Alev ERKILET
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