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Industry 4.0 technologies revolutionizing the civil aviation sector: e-services technology adoption in aviation industry

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ABSTRACT

Industry 4.0 technologies have optimized efficiency and effectiveness through the manufacture of sophisticated products and services, which result in enhancement of operations, improvement in safety, time, and cost-saving, and have revolutionized operations in almost all industries and have tremendously transformed the aviation sector. This study aims to examine the passenger travel experience with the implementation of e-services before, during, and after trips, from ticket bookings, self-check-in, smart boarding, in-flight services to baggage tracking after flight. Furthermore, the study seeks to identify the modern technologies with which air passengers are familiar or actively use, and to analyze the factors that influence their acceptance of these e-services. A research model was developed based on the extended Unified Theory of Acceptance and Use of Technology (UTAUT2) and modified to suit the objectives of this study. The study objectives were achieved through a survey, a self-administered online questionnaire from 253 air passengers was obtained, and data was analyzed using SPSS 25 software. The results reveal that performance expectancy, price-value, hedonic motivations, perceived benefits and habit have a positive significant influence on behavioral intention, while social influence, perceived challenges, facilitating conditions and effort expectancy were not supported. The results of the study give insights into how different passengers, different age groups, different geographical locations, and different technological maturity perceive such implementations. This will provide policymakers ideas on how to better manage and enhance e-services.

Introduction

Digitalization has created a major change in daily life, making manual and time-consuming processes more efficient. This change has affected many sectors and the aviation industry has been one of the pioneers in using digital technologies. Through digital technologies, the aviation industry has increased operational efficiency and improved service delivery. This has improved the passenger experience (Korba et al., 2023).

Digitalization has not only made operations more efficient, but has also increased the importance of working smarter and using time more efficiently in the business world. The world is changing rapidly and in order to keep up with this change, digitalization needs to constantly evolve. Therefore, it is of great importance for businesses to develop digital solutions in order to be successful and remain competitive (Hacıoğlu & Sevgilioğlu, 2019).

The incorporation of IoT, big data analytics, and cloud computing which are the base foundation of industry 4.0 technologies to now artificial intelligence, modern robotics have leveraged all dimensions and brought about the possibility of interconnectivity and intelligent systems in all sectors (Tao et al., 2018; Wang et al., 2016; Gilchrist, 2016). In order to keep up with technological developments, business managers need to use modern technologies to adapt to the rapid changes in the digital world (Lumpkin and Dess, 1996). Digitalization offers significant advantages to businesses such as operational efficiency, increasing profits and reducing

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costs (Linlin et al., 2024). Eitrem and Öberg (2018) state in their study that, businesses which employ digital technologies effectively reach their goals, adapt themselves to emerging trends, and obtain advantage compared to their rivals.

The aviation sector steadily growings, considerably enabling financial, social and cultural growth (Munghi, 2020). The industry has undergone a significant transformation thanks to digitalization, which has had a major impact on areas such as passenger experience. By 2037, the number of air passengers is expected to reach 8.2 billion (IATA, 2021), increasing the need for more digital technology and innovative operational strategies to meet growing demand.

Self-service systems enabled by Industry 4.0 technologies, referred to in this study as "e-services", have greatly enhanced the passenger experience in the aviation industry. The aim of e-services is to increase efficiency in travel and provide passengers with more control and convenience. Such technologies range from digital applications for the customers to book flights, providing online checking and transport to airports more comfortably. Passengers can personalize their travel, such as seat selection, ordering meals or special assistance. They can also receive flight information, track flight status and redeem boarding passes electronically via smartphones or tablets. Self-check-in kiosks and smart baggage systems enable passengers to print baggage tags and check in their luggage easily. At security and border controls, biometric systems such as facial recognition help passengers verify their identity quickly and securely. Smart boarding systems enable passengers to scan boarding passes on their own. In addition, in-flight entertainment options such as Wi-Fi and video streaming make passengers' experiences more enjoyable. Finally, smart baggage tracking enables passengers to track their luggage, offering security and convenience. These e-services both increase operational efficiency and give passengers more flexibility and control throughout their journey.

The implementation of Industry 4.0 technologies has dramatically transformed operational processes in many industries. In the aviation industry, these technologies have led to major changes in key areas such as aircraft design, maintenance and flight operations. Aircraft manufacturers are using modern engines to produce more fuel-efficient, safer and environmentally friendly aircraft. These changes are not only seen in flight operations, but also in other areas such as air traffic, passenger experience and connectivity (Valdez et al., 2018). In addition, many airports around the world are using these technologies to improve safety, efficiency and cost management. Thanks to digitalization, the civil aviation sector has moved from outdated and manual processes to digital systems, saving time and costs and improving service delivery. Airlines/airports use some of these technologies in forecasting processes, understanding how individuals perceive their brand through sentiment analysis, tailoring packages and adverts to specific passengers.

While passengers are one of the essential components of the aviation chain, most existing research on the impact of modern technologies in the aviation industry has concentrated on the operational side specifically focusing on how these technologies affect aircraft manufacturers, airlines, and airports (Sharma & Gupta, 2014; Zhu et al., 2012). There is a notable gap in the literature regarding their effects on the passenger experience. There is limited research based on our searches about air passengers' general perception of multiple technology implementations at airports or by airlines from pre travel to post travel (Sharma, 2024; Ćurčić et al., 2024). Also, the era of digitalization has favored mostly the younger generation, who, according to most studies, are more adaptive and curious about exploring new things. However, they are not the only age group that uses air transportation; therefore, for better operation, all ages' perceptions need to be understood and considered in the development of new e-services to suit all passengers. Moreover, studies on passengers were mainly associated with keywords like customer satisfaction, brand loyalty, service quality, brand awareness, etc.

This study aims to investigate the application of digital technologies such as online flight ticket platforms, self-kiosks, automated border control, digital onboard services and luggage tracking systems at the reached destionation to improve customers trip experience. Moreover, the study aims to explore the advantages and drawbacks of these solutions from the perspective of customers. These analyses are crucial to better align the services with the customer expectations, and enable wider exploitation of these solutions.

The second section provides the theoretical framework and a thorough review of the related literature. In section 3, the methodology comprising the preferred approach, data collection and analysis is presented, while the fourth section provides the results and comments on the findings. The section that follows it discusses implications. The paper is concluded by suggesting pathways for future work.

Literature Review

Theoretical and Conceptual Background

In the aviation sector, digital transformation efforts are similar to the Industry 4.0 principles, ranging from adoption of artificial intelligence (AI), the internet of things (IoT), big data analytics, biometrics, and blockchain to enhance operational performance and customer satisfaction (Hacioglu, 2020). There are wide range of digital services, ranging from flight booking, self check-in, automated boarding gates, on-board internet and digital entertainment and baggage tracking after landing. During its early development in aviation, digitalization implementation was mostly at airports or airline levels, where passengers manually completed the entire travel process. Times have changed, and things get extended to the passengers, from the ability to book or reserve their flight to the privilege of self-check-in to access to the internet in the aircraft and many other services. All these have been enhanced through the years with services like self-check-in, smart border control via facial recognition and other biometrics, smart boarding e-gates, baggage tracking, service customization, and more. These have been made possible through the emergence of industry 4.0

technologies (Molchanova et al., 2020). The technological advancements and changes in customer expectations fostered fast adoption of digital services in the aviation sector. Furthermore, the COVID-19 has accelerated the digital transformation more than ever, as contactless and automated services has become a crucial need to ensure safety and minimize physical contact (Kaplan et al., 2024).

The digital transformation solutions are mainly targeting process streamlining, efficiency improvement and higher customer satisfaction. The factors that influence the adoption of digital transformation technologies in this sector is critical to enhance operational efficiency and customer satisfaction. However, wide adoption of the new digital services is dependent on customer acceptance, and the underlying behavioural intention impacted by multiple factors emphasized in the current technology acceptance frameworks. Some of the theories developed to test for user acceptance of technology include the Technology Acceptance Model (TAM) (Davis, 1989), Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1977), Theory of Planned Behaviour (TPB) (Ajzen, 1991), Diffusion Innovation Theory (DIT) (Rogers, 2003), Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). According to Tan (2009), TPB, TRA, and TAM focus more on user perceptions about how certain innovations impact them, while DIT focuses more on users' intentions in adopting new innovations.

The deployment of digital technologies in aviation sector has been investigated through widely known technology acceptance models (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), and its further developed version UTAUT2. These approaches offer a robust understanding perspective about the effects that impact customer acceptance and use of e-services.

Technology Acceptance Model (TAM) (Davis, 1989) identifies perceived usefulness and perceived ease of use as the main factors of technology acceptance. Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) takes into account four main factors: performance expectancy, effort expectancy, social influence, and facilitating conditions. UTAUT2 (Venkatesh et al., 2012) additionally incorporates hedonic motivation, price value, habit, and demographic moderators such as age, gender, and experience.

Empirical Review and Hypothesis Development

Performance expectancy

Performance expectancy is the extent to which a technology user think that use of a specific technology will provide performance imperovement (Venkatesh et al., 2003). In the aviation sector, performance expectancy is mainly related to saving time, operational efficiency, and improved convenience (Harada et al., 2018). Self-kiosks, e-gates and digital check-in applications can considerably decrease the time spent in queus and manual mistakes (Chawla & Joshi, 2019). Customers accept and use technologies such as self check-in devices, digital boarding tickets when they think that these solutions will improve efficiency and decrease the comfort challenges of travel (Venkatesh et al., 2003). In a similar manner, another research approves that performance expectancy positively impacts passenger's motivation to use self-kiosks at smart airports (Samy, 2017). Research on mobile applications for flight services have revealed that the customer's expected usefulness of these solutions foster their motivation to accept and use them (Dwivedi et al., 2023). In, Lien at al., (2021) expected benefits of self-kiosks positively influence traveller's acceptance and use intentions.

Perceived ease of use have influence on traveller's intention to use mobile technologies such as mobile boarding tickets, improving their expected value of the service (Li et al., 2024). In parallel, Chen and Liu (2021) stated that customers accepted automated boarding gates as very beneficial due to its potential of reducing the time and effort spent in the boarding. Therefore, the following hypothesis was formulated:

H1: Performance Expectancy has a positive influence on passenger Behavioral Intention.

Effort expectancy

Effort expectancy is a critical factor that is associated with the ease of use of a technology and influences users' intention to adopt that technology. Especially user-friendly and easy-to-understand designs play an important role in the adoption of technological innovations. Moon and Lee (2022) emphasized that when e-services offered in the aviation industry are found easier and more intuitive by users, the adoption and usage rates of these services increase. This directly increases passengers' preferences for e-services. Similarly, Chen and Liu (2020) found that the perceived ease of use, practicality and usefulness of e-gate systems used at airports positively affect passengers' intention to use these systems continuously. In addition, Taufik and Hanafiah (2019) confirmed that perceived ease of use and usefulness are critical to the adoption of self-check-in kiosks, but passengers' need for human interaction in this process is not a determining factor. Alalwan et al. (2018) showed that passengers attach great importance to intuitive and accessible platforms and that such technologies increase the perception of ease of use, leading passengers to be more oriented towards e-services. In particular, the ease of use and practicality of e-gate systems at airports strengthen passengers' intentions to use these services in the long term. All these findings suggest that effort expectancy plays a decisive role in passengers' behavioral intention. The perception of ease of use and accessibility encourages passengers to adopt aviation e-services and increases their commitment to these services. Thus, we formulated the following hyphotesis:

H2: Effort Expectancy has a positive influence on passenger Behavioral Intention.

Facilitating condition expectancy

Facilitating conditions refer to all the resources, infrastructure and support elements that enable users to adopt new technologies (Venkatesh et al., 2003). In the aviation sector, these conditions include elements that facilitate passengers' access to e-services, such as reliable internet connectivity, user guides, technical support and accessible digital platforms. Passengers are more likely to adopt e-services when they perceive that such support is adequate and provides uninterrupted access to e-services (Venkatesh et al., 2012). Facilitating conditions have been shown to be an important factor influencing users' attitude towards new technologies. Li and Yang (2016) stated that appropriate infrastructure and support elements are decisive in the process of users' adoption of technologies. For example, Singh (2015) found that airline service quality factors such as convenience, speed, and reliability directly affect passengers' satisfaction and perception of service value, which in turn determine passengers' behavioral intentions. Moreover, Premchaiswadi and Porouhan (2012) found that in online e-ticketing systems in Thailand, facilitating conditions significantly increase passengers' intention to use the system. Urumsah et al. (2011) reported that in Indonesian airline e-services, facilitating conditions have an indirect effect on passengers' adoption of e-services through effort and outcome expectancy. Therefore, the subsequent hypothesis was proposed:

H3: Facilitating Condition has positive influence on passenger Behavioral Intention.

Social influence

Social influence, represens the extent to which the potential users of a certain technology think that many important others recommending the use of it, considerably influencing behavioural intention. Travellers usually consider suggestions from their peers or online comments when accepting and using digital services (Hajli, 2015).

Recent research shows that social influence has a critical role in technology acceptance and use (Graf-Vlachy & Buhtz, 2017). Customer’s intention and expectances are influenced by their social network, shaping their behavioural intentions. Peer suggestion can positively influence such motivations by strengthening expected advantages of self-kiosks (Kusumah et al., 2021). Social influence positively impacts first-time adopter’s motivation to accept and use self-service check-in kiosks at airports (Samy, 2017). Thus, we formulated the following hyphotesis:

H4: Social Influence has a positive influence on passenger Behavioral Intention.

Hedonic motivation

Hedonic motivation, the joy and satisfaction of using a technology is an important factor influencing behavioural intention (Venkatesh et al., 2012). In aviation, customers usually adopt e-services not only because of their operational benefits, but also for a better user journey, user-friendliness and personal features. Studies emphasize that hedonic factors, ranging from satisfaction and fun contribute considerable to behavioural intention (Zhu et al., 2022). As an example, gamified aspects, airline apps with high interactivity and personalized content offer a positive emotional experience and encourages consisten use (Mantouka et al., 2019). Alalwan et al. (2018) revealed that hedonic elements in digital services enhance user satisfaction and improve repeated use. Park et al., (2004) stated that travellers satisfied by using airline e-services that improve their overall travel experience, which increases acceptance and use. Therefore, the following hypothesis was formulated:

H5: Hedonic Motivation has a positive influence on passenger Behavioral Intention.

Habit

Habit, represents the behavioural intention due to former use, as a strong factor of technology adoption. Passengers that fly often using airline applications or online check-in services are more likely to continue using those (Lankton et al., 2010). Regular users of a service are more motivated to continue using it due to less mental effort need and their increasing sense of getting used to (Sembiring et al., 2024). Thus, we formulated the following hyphotesis:

H6: Habit has a positive influence on passenger Behavioral Intention.

Price value

The price value, is the user’s evaluation of advantages of a service in terms its costs, considerably impacting their behavioural intentions in the aviation industry. Customers are more likely to accept and use digital services if they think that the cost of using those services is justified by the expected benefits (e.g., convenience, ease of use, price discounts, or extra services). In the aviation sector, online promotions and bundled price discounts are experienced to provide greater value for money, increasing passenger’s intention to adopt digital services (Zeithaml, 1988). Price value strongly influences customer satisfaction, which impacts their behavioural motivation. This shows that, if customers think that they obtain good value for their expenses, they are more tend to continue use of that service (Rajaguru, 2016). Therefore, the following hypothesis was formulated:

H7: Price value has a positive influence on passenger Behavioral Intention.

Perceived benefits

Perceived benefits is the positive outcomes or value the potential users aim to gain by adopting a specific technology (Davis, 1989; Venkatesh et al., 2003). In the aviation sector, perceived benefits cover convenience, saving time, personalized services and an improved passenger experience due to use of e-services such as self-kiosks for check-in, mobile boarding tickets, real-time updates and notifications about flights and loyalty programs. Emprical research have considerably proved that perceived benefits has a significant impact in determining customer's behavioural motivation to adopt digital technologies (Lien et al., 2021). Chen and Liu (2021) stated that perceived benefits, such as perceived ease of use and convenience, strongly impact passenger's behavioural intention to consistent use of automated boarding gate systems. In a similar manner, in a study conducted by Kim et al. (2023) Korean passengers perceived usefulness positively impacts their adoption of e-gates. Based on the prominent studies in the literature, the following hypothesis was formulated:

H8: Perceived Benefits have a positive influence on passenger Behavioral Intention.

Perceived challenges

Perceived challenges represents the barriers or difficulties the users perceive when adopting a new technology or service. Studies showed that perceived challenges can both positively and negatively impact technology adoption. Challenges that may cause negative impact in e-service adoption in the aviation sector may range from technical issues, lack of familiarity with the new digital services, concerns on data privacy or constraints in the digital infrastructure. On the other hand, challengers can also motivate users. Soelasih (2021), revealed that challenges such as delayed flight information, inefficient booking services and long queu times at airport usually drive passengers to adopt digital services such as online booking and self-kiosks for check-in. Improved comfort, reduced time and efficiency these technologies provide are considered as the solutions to the perceived challenges, fostering customer's motivation to adopt them. Passengers tend more to accept and use e-services that provide strong improvements in comfort and efficiency, such a reducing waiting times and improving the overall traveller experience (Humza & Hacioglu, 2023; Farah & Hacioglu, 2024). Technologies that speed-up the procedures such as check-in, provide real-time notifications or offer security procedures directly address overall travel experience, reducing long queues and delays in dissemination information. The perceived benefits of solving such challenges, by offering faster and more seamless flight experience are usually considered as reducing the potential risks or unfamiliarity related to the new services. In this way, customer's behavioural intention to accept and use digital services in stronger, as they prioritize the possible benefits of improved comfort over the uncertainties of adopting a new technology. Thus, the following hypothesis was formulated:

H9: Perceived challenges have a positive influence on passenger Behavioral Intention.

Several studies in the related literature emphasized gender differences in technology adoption (Goswami, Dutta, 2015). For this reasons, experience acts as a strong moderator in technology adoption, bcause it may cange the user preferences over time (Alshehri et al., 2020). More experience with self-service builds positive attitude towards its further use (Curran et al., 2003). Therefore, we proposed that, age, gender and experience of passengers moderate the relationship between Performance expectancy, Effort expectancy, social influence, facilitating conditions, hedonic motivation, price value and Behavioral Intention.

The model developed in this study is structured on the extended Unified Theory of Acceptance and Use of Technology (UTAUT2), to meet the specific goals of the research It includes key constructs from UTAUT2: Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation, Price Value, Behavioral Intention, and Actual Use. The model also takes into account the moderating effects of Age, Gender, and Experience on the relationships among the independent and dependent variables. In addition to the original UTAUT2 constructs, Perceived Benefits and Perceived Barriers/Challenges have been included as new variables to consider additional factors relevant to this study. The final model, shown in the figure below, offers a comprehensive framework for investigating the factors that impact technology adoption and use (Figure 1).

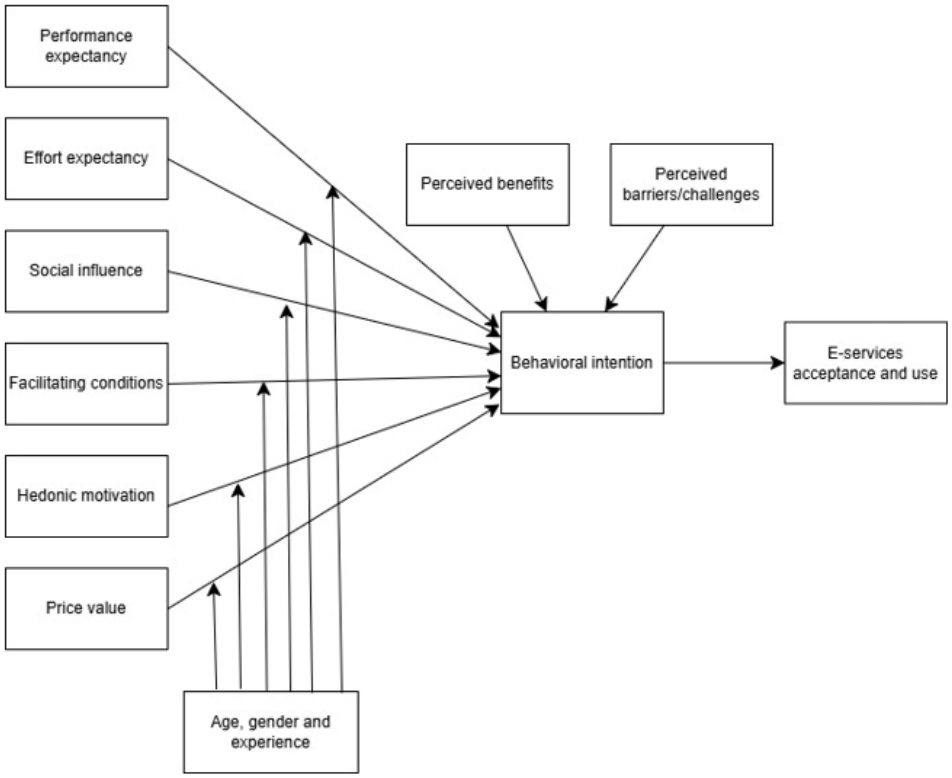

Figure 1: Research model

Research and Methodology

Data collection and sampling

This study targeted air travelers who traveled at least once in the last four years because most of the modern e-services became more popular during and after the COVID-19 pandemic. The method of participant selection was random regardless of continent. Further, a survey method was used to collect data through a self-administered online questionnaire. Studies with large target groups or populations are best believed to use survey methods as many questions can be answered, and statistical techniques can be used to analyze the huge data efficiently within a short span, with less expensive and effective computations (Fitzgerald and Howcroft, 1998).

The efficient service of the web was used for effective communication and dissemination of survey questions to participants. An online self-administered questionnaire was developed and sent via email, WhatsApp, and other social media platforms. A sample size of 450 air travelers was targeted for the study; however, two hundred and fifty-three (253) valid responses were received, which is equivalent to 56. 2% response rate, which is an acceptable number in research, as stated by Roscoe (1975) cited by Tan (2009).

Measurement

The questions were closed-ended, and we included all possible responses related to each question, especially in the demography section. The questions were in sections; the first part was related to demography, air travel experience, and familiarity with e-services. The questions in this section were age, gender, education level, employment status, residence (continent), countries usually travel to (continent), travel frequency in the past four years, flight classes, purpose of travel, airlines/airports, and e-services known or familiar with. In this study, age, gender, and experience are believed to moderate the independent variables; thus, some of these questions were included. The residence and travel destination were intentionally defined and generalized to “continent” to better understand the difference in responses based on places people live and travel to because technological advancement differs in terms of geography. The second and third sections consisted of a total of 31 questions based on passenger perception of e-services used adapted from the UTAUT2 (performance expectancy, effort expectancy, facilitating condition, social influence, hedonic motivation, habit, price value, behavioral intention). Also added perceived benefits and perceived challenges adapted from the studies of Tan (2009); and Awe & Ertemel (2021). Finally, the last part tested the use level of these e-services as one of the research’s aims is to understand the level of familiarity and use of the chosen e-services.

Research ethics

The study aim was stated clearly through a detailed description of what is expected, this was on the first page of the questionnaire. Participation in the study was voluntary; participants voluntarily filled in the forms. Also, the confidentiality of the responses was assured and promised to be used only for the purpose of this study. Further, the estimated time to complete the survey was clearly

stated. Hypotheses were determined before data collection and analysis to avoid manipulation of results, to avoid bias and researcher interference with results, the data was analyzed through statistical software. Finally, the limitation of the study is provided at the end of the research for future studies to take note of.

Analysis

A statistical software Package for Social Sciences (SPSS) 25 was used to analyze the data. Descriptive statistics (mean, standard deviation, frequency, and proportions) were computed to describe the participants' demographics and other variables. The items in each scale were added, and the behavioral intention, performance expectancy, effort expectancy, facilitating condition, social influence, hedonic motivation, habit, price value, perceived benefits, and perceived challenges were computed. Cronbach's alpha value was used to measure the reliability of the scales. Spearman's correlation was conducted between behavioral intention, performance expectancy, effort expectancy, facilitating condition, social influence, hedonic motivation, habit, price value, perceived benefits, and perceived challenges. Linear regression analysis was conducted to examine the association between dependent and independent variables; Coefficients and their 95% CIs were calculated.

Findings

Socio-demographic characteristics results

The demographic and travel-related variables indicate several pertinent outcomes. Age distribution shows a substantial portion of participants falling within the 25-35 age range (62.1%), suggesting a predominant presence of young to mid-adult individuals in the sample. Regarding gender, there is a relatively balanced representation between females 142 (56.1%) and males 111 (43.9%). Educational status highlights a significant proportion of participants holding master's degrees (36%), indicating a relatively high level of education within the sample. Employment status reveals a diverse mix, with private sector employees being the largest group (34.8%), followed by students (23.3%). Residence showcases a varied distribution, with Africa (38.3%) and Europe (23.7%) being the primary continents represented. Africa is the most frequently visited continent, with 55 (21.7%) respondents. This is followed by Europe with 32 (12.6%) respondents and Asia with 31 (12.3%) respondents (Table 1).

Table 1: Demographics results

Variable	Characteristics	Frequency	Percentage
Age	under 25	34	13.4
	25 – 35	157	62.1
	36 – 45	40	15.8
	46 – 55	15	5.9
	Over 55	7	2.8
Gender	Female	142	56.1
	Male	111	43.9
Educational status	High School or Less	18	7.1
	Diploma /College	43	17
	Undergraduate	77	30.4
	Masters	91	36
	Other post-graduate studies	24	9.5
Employment status	Entrepreneur	18	7.1
	Private sector employee	88	34.8
	Public sector employee	57	22.5
	Self-employed	16	6.3
	Student	59	23.3
	Unemployed	15	5.9
Residence (continent)	Africa	97	38.3
	America	54	21.3
	Asia	29	11.5
	Australia	6	2.4
	Europe	60	23.7
	South America	7	2.8
Travel frequency in the last four years	Once	32	12.6
	2 to 4 times	107	42.3

	5 to 7 times	53	20.9
	8 to 10 times	22	8.7
	More than 10 times	39	15.4
Flight Class	Business	33	13
	Economy	207	81.8
	First Class	10	4
	Private	3	1.2
Purpose of trip *	Visiting family/friends	127	50.2
	Business	84	33.2
	Educational	66	26.1
	Leisure tourism	58	22.9
	Religious	9	3.6
	Health	7	2.8
	Other	11	4.3

Validity and reliability of scales

Validity is referred to as the accuracy of the measurement of research, the degree by which hypotheses are measured (Sekaran, 2003). In order to obtain valid research and to be in line with research ethics, the study scales were adapted from the theory that the study's research model is based on and from similar studies related to user acceptance of technology Venkatesh (2013); Awe and Ertemel (2021); Nordhoff et al. (2020); Chu et al. (2022); Tan (2009). Cronbach's Alpha coefficient values were used to calculate the internal consistency of the factors. It is used to measure the reliability of the scale used. In the literature, measurements with a Cronbach's Alpha Coefficient of 0.70 and above are considered adequate. All of our variables have Cronbach's Alpha values above 70% (Table 2).

Table 2: Reliability test results

Cronbach's Alpha	**Cronbach's Alpha Based on Standardized Items**	**N of Items**
.773	.887	11

Correlation analysis

The correlation coefficient determines the direction and strength of the relationship between two variables. This value varies between -1 and +1. As it approaches zero, the relationship weakens, and as it approaches -1 and +1, the relationship increases. Negative values indicate that the relationship is in the opposite direction, while positive values indicate that the relationship is in the same direction.

Spearman correlation analysis was conducted to test for association between the variables, and there was a strong correlation between them. Further, the scales were reviewed in-depth to ensure they align with the research aims, objectives, and questions of this research. Also, the questionnaire was thoroughly reviewed and pretested by friends and colleagues with air travel experience before finally being sent to participants. The researchers made sure to write the questions in simpler English terms and further went on to give definitions or explanations of terms that they presumed may not be familiar to some participants for easy understanding and to ensure correct answering of the questions.

In the Spearman correlation analysis, behavioral intention shows significant positive correlations with performance expectancy (r=.64), effort expectancy (r=.56), facilitating condition (r=.56), social influence (r=.26), hedonic motivation (r=.66), habit (r=.62), price value (r=.31), and perceived benefits (r=.66), while it is negatively correlated with perceived challenges (r= −.35). Performance expectancy, effort expectancy, and facilitating condition are strongly interrelated, with correlations ranging from r=.68 to r=.70. Additionally, hedonic motivation, habit, and perceived benefits are consistently and significantly correlated with most other variables, indicating their central role in shaping behavioral intention. Social influence, while positively correlated with other factors such as hedonic motivation (r=.36) and habit (r=.35), shows no significant correlation with perceived challenges (r=.09). All reported correlations are significant at p<.01 (Table 3).

Table 3: Correlation analysis results

Variables	1	2	3	4	5	6	7	8	9	10
1) Behavioral intention	1									
2) Performance expectancy	.64**	1								
3) Effort expectancy	.56**	.70**	1							
4) Facilitating condition	.56**	.68**	.70**	1						
5) Social influence	.26**	.21**	.26**	.27**	1					
6) Hedonic motivation	.66**	.60**	.59**	.59**	.36**	1				
7) Habit	.62**	.62**	.66**	.75**	.35**	.65**	1			
8) Price value	.31**	.33**	.35**	.43**	.29**	.46**	.41**	1		
9) Perceived benefits	.66**	.63**	.59**	.57**	.40**	.63**	.63**	.49**	1	
10) Perceived challenges	-.35**	-.29**	-.27**	-.34**	0.09	-.27**	-.33**	-.21**	-.26**	1

Linear regression analysis

The research model and hypotheses were tested through linear regression. The overall regression model predicting behavioral intention was statistically significant, F (14, 238) = 49.629, p < .001. Among the predictor variables, performance expectancy (B = 0.17, p = .002), hedonic motivation (B = 0.59, p < .001), habit 44 (B = 0.19, p = .017), price value (B = -0.16, p = .022), perceived benefits (B = 0.32, p < .001), and being under 25 years of age (B = 0.88, p = .011) were significant predictors of behavioral intention. Other variables, including effort expectancy, facilitating condition, social influence, perceived challenges, age groups (36-45, 46-55, over 55), and gender (male), did not show significant association (Table 4).

Table 4: Linear regression results

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics				
					R^2 Change	F Change	df1	df2	Sig.
1	.859[a]	.738	.726	1.746	.738	61.778	11	241	.000

a. Predictors: (Constant), GENDER, PerformancexpeTot, AGE, perceivedchallengesTot, pricevalueTot, socialinfluenceTot, hedonicmotivationTot, facilitatingconditionTot, perceivedbenefitsTot, effortexpectancyTot, habitTot

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	2071.359	11	188.305	61.778	.000[b]
	Residual	734.594	241	3.048		
	Total	2805.953	252			

a. Dependent Variable: behavioralintentionTot; b. Predictors: (Constant), GENDER, PerformancexpeTot, AGE, perceivedchallengesTot, pricevalueTot, socialinfluenceTot, hedonicmotivationTot, facilitatingconditionTot, perceivedbenefitsTot, effortexpectancyTot, habitTot

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.962	.799		4.956	.000
	PerformancexpeTot	.175	.056	.193	3.119	.002
	EffortexpectancyTot	-.018	.082	-.013	-.220	.826
	facilitatingconditionTot	.024	.052	.027	.459	.646

	SocialinfluenceTot	-.023	.051	-.018	-.440	.660
	hedonicmotivationTot	.597	.095	.346	6.286	.000
	HabitTot	.188	.078	.150	2.402	.017
	PricevalueTot	-.177	.070	-.098	-2.513	.013
	PerceivedbenefitsTot	.315	.057	.315	5.558	.000
	perceivedchallengesTot	-.018	.022	-.029	-.804	.422
	AGE	.191	.080	.081	2.396	.017
	GENDER	-.348	.231	-.052	-1.509	.133
a. Dependent Variable: behavioralintentionTot						

From the Table 4, we can see that the overall model is significant, the independent variables significantly influence the behavioral intention and the results of the hypothesis test are presented in Table 5.

Table 5: Hypotheses results

Hypothesis	Relationship	Sig.	Hypothesis Supported
H1	Performance expectancy with Behavioral intention	.002	YES
H2	Effort expectancy with Behavioral intentions	.826	NO
H3	Facilitating condition with Behavioral intentions	.646	NO
H4	Social influence with Behavioral intention	.660	NO
H5	Hedonic Motivation with Behavioral intention	.000	YES
H6	Habit with Behavioral intention	.017	YES
H7	Price Value with Behavioral Intention	.013	YES
H8	Perceived benefits with Behavioral intention	.000	YES
H9	Perceived Challenges with Behavioral Intention	.422	NO

E-services used

The results showed that the e-service most familiar with and used is the "Airline digital platforms," with a mean value of 4.09 out of a 5-point scale. Next is the "In-Flight entertainment (Wi-Fi or video streaming)," with a mean value of 3.71, followed by "Personal device usage to (receive notification or acquire electronic boarding pass)." Next is "Service personalization and customization (mean value of 3.29), e.g., seat selection or request for special assistance;" after is the "self-check-in kiosk" with a mean value of 3.24. After, "I self-track my luggage after a flight in case of delay," "I use airport apps to self-navigate," and" I use smart baggage handle to print and fix the baggage tag myself" were mostly used with mean values (2.96, 2.90 and 2.73) respectively. However, "I use smart security verification through facial recognition or other biometrics by myself," ;"I use smart border control to cross restricted areas by myself via e-gate document scan and biometric verification," and "I use smart boarding to self-board the aircraft by scanning boarding pass and enter via e-gate" were the least used services (Figure 2).

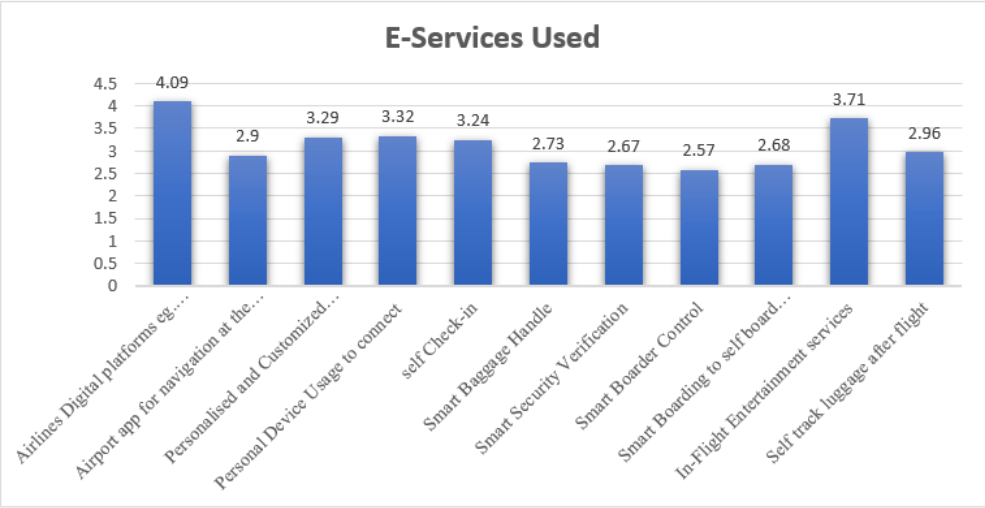

Figure 2: E-Services Used

Conclusion

The needs of humans continue to grow, and for the fact that not everything one needs or wants is within one's immediate geographical space, so travelling continues to be a significant element in people's lives for different purposes. Also, with the changing needs, the high sensitivity of people with time, the desire to be self-sufficient, and the need for privacy, many things have been digitalized and programmed to be self-operated, which are believed to save time/ costs/ and offer privacy which is also the concept behind airlines or airports e-services/ self-service technologies.

Since little study has been conducted regarding general passenger perception from pre-travel to after-flight, the available studies were mostly focused on one or two specific self-service technologies. Thus, this study aimed to understand multiple travel e-services passengers are aware of and which among them they utilize. Further, it investigated their outlook on the said technologies and the reasons for their use or non-use. This study proposed multiple e-services/self-services used in today's aviation industry, from pre-flight to during and post-flight. Additionally, the few studies available were mostly focused on specific airports; thus, one of the motivations for the study was to understand passenger perception in different geographical regions and with different travel experiences using different airlines/airports

The advent of technology has greatly impacted the way operations are carried out now, the output showcased and the convenience and sense of ease it has brought into the lives of people all over the world. Its incorporation into the aviation industry has tremendously brought about differences over the years with its continued upgrades and the introduction of newer innovations, which benefit not only aircraft manufacturers, maintainers, airports, or airlines but passengers as well; thus motivating this study.

The results of our study revealed performance expectancy, effort expectancy, facilitating condition, hedonic motivation, habit, price value, perceived challenges and perceived benefits exhibit strong correlations with behavioral intention, highlighting their critical role in shaping user intention. However, from the proposed hypotheses, performance expectancy, hedonic motivation, habit, price value, perceived benefits, and air travelers around 25 to 45 years of age were identified as significant predictors of behavioral intention to e-services/ self-service technologies. The result indicated most of the selected e-services in the study are not highly utilized and can be tailored to the perceived challenges. Most participants' reports showed that the most notable points where participants agreed most were ("I have security concerns," " e- services adoption is low with the airlines or airports I use"; and "I lack awareness of the perceived benefits of e-services) this may be as a result most participants reside in Africa where most of these technologies are yet to be implemented. The study results indicated that travel destinations accounted for a statistically significant proportion of the variance in behavioral intention; this is in line with the study of Punel, Hasan, and Ermagun (2019) that geographical residence shapes user perspective and accounts for the choice of airline services use thus making experience significant moderator of the independent variables. However, in other questions in the "perceived challenges" variable, the majority of the responses were more disagreed to were ("I don't think there is much difference with traditional services "I have Insufficient technological knowledge to use airlines or airports e-services"). The responses to these answers, if predicted, are highly supported by the demographic results where most participants have higher education, between the ages 20 to 40, so we conclude most of them are technologically aware and would use it if the opportunity is made available.

Theorical implications

The findings of this study provide significant theoretical contributions to the field of e-service adoption in the airline industry. The demographic profile of the participants reveals the importance of generational differences, with millennials and Gen Z, who are typically more open to technological advancements, being the primary adopters of e-services in the airline sector. This aligns with previous research that emphasizes the relationship between younger generations and their adoption of new technologies. The study's result also highlight the geographical influence on technology adoption. People from mature technology-developed areas were more familiar with most of the e-services, and participants from less mature technology were less familiar with most of the e-services. This findings supports the notion that diffusion of technology is not uniform across regions and that geographic factors play a crucial role in the acceptance and use of technological innovations, as suggested by Punel et al. (2019).

Another contribution of this study is the rejection of several hypotheses related to positive influence of effort expectancy, facilitating conditions, social influence and perceived challenges on behavioural intention. Although this result contradicts the findings of many studies (Chen and Liu, 2020; Alalwan et al., 2018; Venkatesh et al., 2012; Li & Yang, 2016), there are also studies that support it. For instance; reseach analysing the influence of performance expectancy, effort expectancy, social influence and attitude toward behaviour on the intention to use digital service providers found that effort expectancy and social influence did not significantly affect users' intention (Rizkalla et al., 2023). This may be due to the population size, and the main factor could be related to the demographic, where most participants' geographical location is in Africa, where most of these technologies have yet to be implemented and the available ones are in the premature stage. Moreover, social influence was not found to have a positive relation with behavioral intention as most participants have higher education and believe in making choices that fit them most, so they'll use an innovation based on their judgments and not peer influence.

The results of the hypotheses indicate that participants perceive usefulness in using the technologies as most of them are literate, so they find these innovations interesting and enjoyable. Most participants positively answered that they would continue to explore the currently used technologies, and they believe that adaptation to newer technologies in the future will be a natural occurrence.

Additionally, they also believed the ones currently used are good value for money and priced within means. This is an indication that people are time and effort-conscious and would pay for convenience as they perceived gains in utilizing them.

Practical implications

The results of the study have given an understanding of what it is like to accept modern services in a broader perspective as it gives insights on different passengers, different age groups, different geographical locations, and different technology maturity in terms of how they perceive such implementations. This study will give decision-makers ideas on how to improve the already introduced self-service technologies to leverage the gap so the different demographic profiles can benefit as the world continues to grow and air travel is projected to continue expanding thus, the need for most operations to be automated, so understanding perception for better improvement and inclusion is crucial. Also, these results will add to the body of knowledge and future studies, especially in areas where this type of study is limited with regard to passenger acceptance and usage of self-service technologies at multiple airports and in different countries. The generalizability of regions and focus on multiple self-services from pre-travel to after-flight will give decision-makers an idea of the different technologies passengers are ready to take on if available, and this will provide solutions on the areas that need improvement for the benefits of airports/ airlines, passengers and the aviation industry at large.

As the outcome of the study is predicted to contribute to the body of knowledge however, it is limited in some ways. Some of the limitations of the study is the number of participants was fair enough, but a larger number would have given better results as air transportation is a worldwide thing. Secondly, the sampling method was a purposive non-probability technique. This method has its limitations, as it is based on research knowledge on who is literate enough to understand the questions, which were self-administered. However, not all travelers can read and understand the questions. Also, there were very few participants from Australia and South America, thus making the results in these regions less generalizable and finally, these e-services implementation cannot be successful if passengers are not aware of them and their benefits because they are yet to be implemented by many airports and airlines in some regions.

Limitations and future researches

The study is based on a cross-sectional survey that captures passengers'perceptions at one point in time. This limits the ability to observe long-term changes. The demographic profile of participants (higher education and younger age groups) may introduce bias, as these individuals are more likely to be familiar with technology and more willing to adopt e-services.

Great observation was made from the analysis and due to the nature of the results, these recommendations are suggested for better implementation or usage of e-services to benefit all parties (airports, airlines and passengers) and to prepare for future changes. First, future studies should consider a larger sample as air transportation is global. Also, they should employ a mixed method approach as some passengers cannot read and some do not understand the English language to comprehend the questionnaire; therefore, they should put this into consideration by having the questionnaire in multiple languages and adding qualitative study through interviews for those that cannot read. Moreover, airlines and airports should study better the passenger usage of these services and conduct more research to understand how passengers perceive these e-services as different people from different works of life with different literacy and technology knowledge use air transportation so these services should have a threshold where almost all passengers should feel comfortable in using them. Airlines, airports, and other stakeholders in aviation should provide sensitization campaigns, using the power of social media or their websites/apps or display screens at airports to give demos on how these e-services / self-services are used and the benefits of using them. Finally, some of these e-services that require extra payments should be made reasonable for passengers to take advantage of their benefits.

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