Analysis of Challenges in the Adaption of Technology in Aviation Procedures for the Attainment of Sustainability.

BS Aviation Management

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Abstract

Technological adaptation has been shown to be a major driver of various types of issues and procedures. The challenges associated with the adaptation of technology within the systems in the aviation method will assist the sector in learning how they can bring more sustainable elements.

Purpose: This paper aims to present the research trends and identification of future research agendas regarding the digitalization of airport procedures and insight into the sustainability domain. The study employed by quantitative systematic literature review (SLR) method to achieve the research objective. A deductive approach has been used with developing a hypothesis based on an existing theory, and after that designing a research strategy to test the hypothesis. The technique used for sampling is convenient and snowball sampling. In research, the study was limited to the Pakistan Civil Aviation Authority (PCAA).

Findings: Challenges such as Digital doubles, Current aviation digital system regulations, Ease of access to any digital asset, and the Low literacy rate in Pakistan regarding aviation technology have a neutral response for being the utmost reason to be considered as a challenge. Cyber insurance couldn't be identified as an element of managing aviation cyber risk. Analyzing the result research study can exploit to future directions moving toward other aspects such as maintenance and reliability process in operations.

Keywords: Sustainability, Digitalization, Cyber issues, Digital procedures, Threats, Aviation Technology

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Table of Contents

List of Tables and Figures

1 Introduction

1.1 Background

Technological adaption is proven to be an important driver of different types of challenges and procedures especially related to Co2 emissions. The economic crisis in Pakistan is a huge challenge for every sector to grow its roots. The technology could help reduce the issues of overstaffing implications at the airport. Through a review of certain emerging technologies, it could be deduced that necessary challenges and procedures are needed to be exposed for the management of feasible energy. Several barriers have prevented the deployment of technology ranging from social, economic, and technical amid growing concern about greenhouse gasses. Despite these, there remain several challenges unaddressed for the implementation of such a stratagem. To recognize the importance of security and international technology market barrier there is a need the establish a framework to make technology a more accepted and needed platform in the current and future aviation market of Pakistan (Tushar, Saha et al. 2020).

Digitalizing the airport airline procedures requires transforming the business into a digital alliance. For smooth transformation, there are challenges while integrating various systems and partners such as services provided by security. The fact that many airports are interested in introducing intelligent technologies to their business but it's a slower and more intensive process in sense of investment as well. The complexities behind every fusion in system technology so that it would be feasible to surround require many blocks of knowledge for its transition into digital lines (Ukwandu, Ben-Farah et al. 2022).

In the era of technology, maintaining sustainability was a major challenge because of several threats to technology and advancements procedures, especially in aviation the industry. Focusing on the aviation industry and analyzing challenges that were faced in the past was complex in the attainment of sustainability. As the aviation sector becomes digitized and increasingly dependent on wireless technology, so does its appeal to cyber attackers, including nation-state actors and terrorists. Before implementing the technology, it must know what value the integrating technology is having and would be creating in future aspects. The innovation cluster's performance works on a high level of safety, digitalization, exchanging data, and adapting new levels of automation (Pereira 2022).

To address this sustainable aviation sector multiple factors linked, that were faced for achieving. Organizations that want to implement sustainable development are faced with the problem of choosing between countless options that were same faced by the aviation industry. Before the implementation of digitalization and technology procedures, a bunch of threats were there and even after introducing the advancement in different sectors of aviation much more threats came with it that hit the sustainability procedures. Meanwhile, for developing a two-stage data-driven analysis to identify which sustainable development

alternatives are most likely to succeed, based on careful examination of sustainable aviation cases. For the attainment of sustainability, multiple factors were considered in the past, which were slowly developed in a better way for the successful implementation of procedures in the industry (Wu and Yang 2021).

1.2 Problem Statement

Technology in every industry has its role and with improvements, it is also bringing some major issues too. In the aviation industry of Pakistan, technology is at a crawling speed. The International airports have only on latest technology i.e., explosive detectors. Unknown reasons that Pakistan Airports and even international airports do not have the new and improved technological infrastructure. Neglected factors that do not help raise awareness for sustainability through technology and technology bring a problem for its adoption as it brings new threats while it's improving. So far, the researchers have found about the cyber threats to technology and their solution through models' approach to existing technology only, which is many years old and still could be hacked with new attacks. In this context, the research is focused on finding new challenges posed to adoption and cyber security through a combination of technology improvement, segmentation, and complexity of cyber robust systems and this type of research hasn't been done yet in Pakistan (Ukwandu, Ben-Farah et al. 2022).

1.3 Questions

i. Does improving digitization and connectivity, and adversaries have a significant effect on technological system security?
ii. Does technology adoption in aviation a challenge for sustainable development?

1.4 Research Objectives

i. Improving digitization and connectivity, adversaries do have a significant effect on technological system security.
ii. Technology adoption in aviation is a challenge for sustainable development.

1.5 Significance

Analyzing the challenges and threats associated with the technology or improvement in technology can help aviation researchers to find a solution before a problem could occur. Challenges associated with the adaption of technology within the systems in aviation procedure will help the industry to get to know how they could bring more sustainable aspects while interaction between passenger, technology, and the agent, between the agent and technology, within the technological tools in the environment and between technology and aviation procedures. It would help to know which type of

technology is adaptable in the airports of Pakistan(Bican and Brem 2020). There is no benefit of high-tech tools in the industry if the handlers aren't capable of operating the systems. The past crisis has led the aviation industry to move toward more technology-adapted ways so that in such cases without any due interaction the procedures would not stop. The study would help to know, Is technology the solution of it or if it's bringing more challenges and threats with it, combining the increased danger for the aviation industry in both sustainability and security impacts. The research is focused on finding the challenges that could prevent a technology to be adopted at Pakistan airports. At Lahore Allama Iqbal International airport, any type of new or important technology cannot be seen operating but why, while being an international airport, it should be the first one to adopt new technology to move toward sustainability or it is thought that upbringing technology would reduce sustainability(ElMassah and Mohieldin 2020). Highlighting the problems in airport procedures and finding a solution for them could bring the Pakistan Aviation industry to at least, a competitive world level. Addressing the cyber threats in present and future technology could help the industry to be careful before taking any major steps towards it because a disruption in the technological system could destroy the safety of different cross countries associated with it. In 2020, airlines were targeted in 65% of cyber-attacks leading to financial loss in 55% of cases and theft of personal data in an additional 34% of cases (Ukwandu, Ben-Farah et al. 2022). Validating and reasoning that cyber-attacks are preventing technology adaption could remove a hurdle for the adaption of technology and will let researchers find more sustainable and less costly solutions to cope with the attacks.

2 Literature Review

2.1 Digitalization

With the unstoppable development of technology in the Internet and communication, the era is giving birth to some tremendous inventions. But as time passes with development, there is a rise in complexity as well. Through the internet, there is a free flow of data between millions of people throughout the humungous world. Through surfing, searching, and exchanging information through newsgroups and email internet is being widely used. The internet traffic, the cookies, and downloading could bring damaging viruses and dangerous codes which can interface the entire network. The principal means of communication such as email brings a vast number of viruses and Trojans. A subsequent flow of these viruses coming along the spreadsheet could impact productivity leading to distorted network performance and huge loss of materials, money, and, especially time too (Mukherjee 2008).

The digital framework does bring new possibilities to a multinational business but it brings risk awareness with it as well. Digital interdependence, the complexity of regularity, and information security are the major risk drivers. Threats arising with an

increasingly digitizing environment require the need for more comprehensive study, opening a space of important questions for the research community to explore. The supply disruption, the ripple effect of information breaching, cybercrimes because of over-dependency, and other digital breakdowns. These threats are also not confined to a country or region but are global in nature(Arnold and Casullo 2021). How much a region is exposed to the threats depends upon the intensity of usage of IT, platform participation, geographic diversity, and firms' strategy implementation. Digital globalization makes international companies dependent more on each other magnifying the impact of external shock caused by unexpected breakdowns of digital interconnectivity. Managing the threats and risk constitute to be a central discussion but it is always based on assumptions of tangible nature form of technologies rather than intangible sources such as data flow between partners (LUO 2022).

Cybersecurity challenges can increase in frequency and severity as they spread digitalization. It is one of the main challenges in the implementation of digitalization as Machine learning in aviation procedures brings more challenges for the industry because it offers other ways of cybersecurity in terms of increase of data and velocity(Hedberg and Šipka 2021). Data collection and transforming data for digitalization procedures at airports is one of the main challenges that can be faced because it relies on the physical infrastructures of the sensor poor structures for managing data can be a hindrance. Although for setting up procedures investment is a huge challenge for sensor technology (Lamb 2018).

2.2 Challenges

Aviation faces a unique set of challenges when it comes to digitalizing procedures with the advancement of technology. Inflight entertainment and other services are already being digitalized, and the real-time ticket booking and check-in process have been introduced. Many airlines are using smartphone apps with personalized interfaces and a unique experience for customers. Digital technology has an impact on the passenger experience in the seat of an aircraft to an airline operation and from infrastructure to support and services. (Lamb 2018) Ensuring large access to big data means the creation of infrastructures that do not yet exist, there is a need to develop sufficient access to various sectors which are already working on infrastructure development. When data is available it does not mean that it is complete and reliable, quality assurance is also a major part of smart airports with the main technical and cultural challenges to overcome. Decision-making systems will require data from many sources which will also increase the risk of data incompletion or nonexistent (Kuisma 2018).

Traditional training techniques will be replaced by modern and complex systems which will cross the manuals and handbooks used in aviation procedures training of such systems will be difficult and is itself a challenge. From a digital point of view, solutions

that enhance the customer experience are associated with entertainment, digital platforms, and a self-service boarding system. Which will require new qualifications and jobs for the digitalization of airports will be needed. Digital transformation requires a professional pathway with proper demands and skills which will follow the general education and training process in aviation (Zaharia and Pietreanu 2018).

Airport managers have to face solutions to provide a common platform for mobile applications, the passengers who are willing to use more than one app for their travel information. Real-time notifications of flight and airline policies and information about parking fees will be a considerable decision for the managers shortly. Revealing a gap between management and technology indicates low digitalization and demonstrates to the staff it is not trained to face new challenges of new technology. As the competition is growing rapidly among low-cost carriers and the lack of quality suppliers, the cost structure for the airlines is the major reason behind the significance of implementing a solid digital strategy(Noussan, Hafner et al. 2020). The large fixed cost is a vital risk to consider at the early stages of investing huge amounts of capital as these costs will be difficult to regain shortly. The digital technologies that are potentially influencing the cost of airlines include 3D printing and internet-based solutions. These technologies will potentially increase gross margins and reduce costs. Blocked chain technologies also have the potential to serve as a technological foundation for pavements, tokens, exchange currencies, and smart contract transmissions. The risk affiliated with blockchain technology is acquiring trust in transactions and increasing the risk of fraud and treachery. Blockchain permits a real-time clearance of any record transaction which will reduce the transfer times of the fund. Blockchain technology has its own risk and benefits both for passengers and airlines which have a lifetime value (Heiets, La et al. 2022).

Big data is defined as data that is largely complex that cannot be managed saved or processed by any software to an extent. The data of customers, flight cancellations and delays, ticket booking, and pre-booking management. It is hard to save and encrypt big data in an inventory for more than three days. The risks accosted with big data are data theft, hacking, privacy encroachment, and leakage of personal information. By evaluating and comparing the current state of digital transformation a huge risk is associated with big data as new software and infrastructures are required (Kuisma 2018).

2.3 Threats

The safety and security of any digital system are the first concern in the industries like aviation, medical transportation logistics, etc. thoroughly analyzing the threats due to not only system failure, but also external conditions. A technique named fault tree analysis (FTA) is most popular in such scenarios and is also to apply this technique in NextGen simulation. Security is about protecting organizational assets from any outside danger or threat. In this revolving world, multiconnected and interconnected computing systems

such as cybersecurity are leading the interest of any organization. Security threats also include communication failures, and wrong or incorrect message transmissions which can be caused by changing the concept of the message. These threats are due to missing authorization systems. Also for safety, identify the set of security requirements which are focusing on potential hazards and impacting communication (Kornecki and Liu 2013).

Attacks by outsiders and insiders include privacy violations, trojan horses, other cyber integrity attacks, physical attacks such as cutting cables, and electromagnetic interferences. Other attacks include wiretaps and electric waves dropping perhaps, assessing this information's useful for subsequent attacks. The problems of digitalizing are worldwide; security, safety, and reliability are separate very difficult problems. Carefully controlling the procurement of the system and development and fulfilling the requirements and continuous control throughout the whole operation. Easy solutions are very risky (Neumann 1997).

As airports are the frontiers of technological advancements, due to the continuous air travel passengers. Staying ahead of continuously evolving cyber threats and securing airports smartly is the shared responsibility of every department in the aviation industry. Many threats occur intentionally or unintentionally, cyber security threats are mainly focused on intentional/malicious intentions. Each of these attacks may cause security accidents confidential breaches, integrity, and attack on any asset of the airport(Ukwandu, Ben-Farah et al. 2022).

Many smart airports apply good practices and find those security gaps which are not been revealed before. Also, the rapid advancement of the technologies causes a slow pace of the regulatory bodies, which may lead to many serious legal and malicious threads in these smart airports. Airport management should prioritize cybersecurity initiatives to maintain a higher level of security and safety operations for passengers, the public, and airlines. These threats and risks will continue to grow along with technology and the relationship between safety and security will become more interdependent (Lykou, Anagnostopoulou et al. 2018).

The aviation sector particularly is under great pressure. This is mainly due to cost Industry structure, safety, and competitiveness. The Commercial sector can greatly improve efficiency Security-related performance, cost, and flexibility through the use of digital technology (Gillen, Oum et al. 1990). In the development of digitalization procedures in aviation, it will give rise to several challenges that may run intuition in many sectors if it moves towards digital operations and integration, data challenges such as interoperability are among the main technical tasks in the aviation industry followed by the system of the security where the danger is of violation is severe, in terms of implantation of digitalization procedures several challenges will overcome whereas

changing in management procedures and social outcomes as well investment challenges faced will be considered (Lamb 2018).

2.4 Sustainability

The definition of sustainability has been the subject of much research and debate, and remains a hotly debated topic due to its multifaceted nature. Sustainability remains a difficult issue when it comes to business models, as there is no definitive design for sustainable organizational operations. This is because organizational design is difficult to keep up to date and the value proposition, defined as the willingness of customers to purchase products, is constantly changing. Despite the promise that better service will extend product lifecycles, the reality is that the average product lifecycle is getting shorter and shorter. This is partly because innovation programs encourage product replacement, and partly because planned obsolescence reduces product utility. Highly volatile products and services require higher levels of institutional knowledge for organizations to keep up with extreme dynamics(Vu, Le Bui et al. 2022). This requires constant coordination between the organization and its stakeholders to deliver value to the organization and its stakeholders. The product perspective so far raises interesting questions about sustainability and other concepts such as the bioeconomy, green economy and circular economy (CE). Sustainability is cited as one of the main benefits of Industry 4.0, citing increased productivity and automation of knowledge and learning as examples. It is ensured that the increased value creation of Industry 4.0 by more sustainable companies will soon become visible due to its enormous potential and the importance of considering this linkage (Ordieres-Meré, Prieto Remon et al. 2020).

Artificial intelligence (AI), big data analytics, mobile technologies, the Internet of Things (IoT), and social media platforms are examples of digital technologies that have a positive impact on society and business. Digital technologies are being used more and more to enhance environmental sustainability. Businesses are increasingly launching brand-new platforms and products built on digital technologies that improve environmental sustainability. Nowadays, businesses rely on AI, IoT, and big data analytics to implement sustainable business strategies that involve lowering carbon emissions and reducing other environmental waste. Applications of big data analytics are revolutionizing how environmental effect is evaluated and mapped. In a similar vein, blockchain is regarded as a technology with huge promise for achieving sustainability in commercial and industrial activities. Blockchain has the potential to increase resource efficiency, lengthen product life cycles, and more (Feroz, Zo et al. 2021).

In order to increase financial benefits through technological performance enhancements, complementary assets, a reduction in environmental impacts, and the provision of extra value to passengers, airlines, airports, and civil aviation chains should support innovation as a source of value creation. The pressing need for fresh, sustainable

advances, more individualized services, and the creation of a safer and more secure environment are further reasons why innovations add value. Technical techniques have formed the foundation of earlier research on air transport innovation. In addition, little is known about how these innovations affect the sector to shift the industry towards a more sustainable paradigm, despite the fact that innovation is regarded to be important in lowering aviation macro concerns. This research is useful in this context because it emphasizes the significance of leading innovations in products, services, and procedures in the adoption to create value aviation sector (Pereira, Lohmann et al. 2022).

2.5 Hypothesized Model

H0: Implementation of digital procedures does not impose positive impacts on sustainability.

H1: Implementation of digital procedures imposes positive impacts on sustainability.

H0: An increase in digitalization does not increase the severity of cyber threats.

H2: An increase in digitalization increases the severity of cyber threats.

H0: Challenges in the aviation industry does not have a positive impact on sustainability.

H3: Challenges in the aviation industry have a positive impact on sustainability

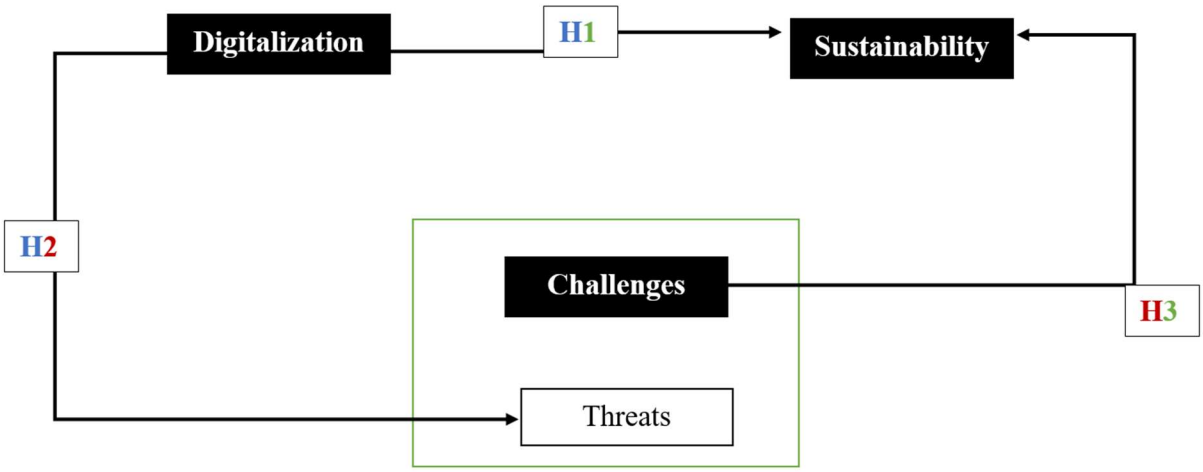

Figure 2.1 - Hypothesized Model

3 Research Methodology

3.1 Research Type

As indicated earlier, this paper aims to present the research trends and identification of future research agendas regarding the digitalization of airport procedures and insight into the sustainability domain. The study employed by quantitative systematic literature review (SLR) method to achieve the research objective. SLR has been an effective research method for identifying trends and defining future research opportunities. This paper has followed a step-by-step process for the identification of research articles and analyzing them as per the procedures of SLR. In this regard, the guidelines are used from the previous research studies on doing a systematic literature review (Chen, Despeisse et al. 2020).

3.2 Research Approach

A deductive approach is used with developing a hypothesis based on an existing theory, and after that designing a research strategy to test the hypothesis. Deductive means reasoning from the particular to the general and the design might test to obtain the relationship on general circumstances (Newman 2000). Using this approach will help to explain casual relationships between the variables and the concepts and also will allow to measure concepts quantitatively to generalize research findings to a certain extent. The research consists of three variables where Challenges *(Constructs: Threats)* is an independent variable and Digitalization, Sustainability are dependent variables. The questions that were used for the survey of this research study were from previously conducted research studies (Referenced in "Appendix A").

3.3 Sampling Technique

The technique used for sampling is convenient and snowball sampling. The reason for choosing these sampling techniques is that through snowball, a pool of participants would be created through referrals by individuals who share the specific characteristic of interest with the target population. It would make it quicker to find samples and would be cost-effective as referrals are obtained from primary data sources. While with convenience sampling, would speed up the research process and will help save time and cost.

3.4 Sample Population

In research, the study is limited to the Pakistan Civil Aviation Authority (PCAA). The unit of analysis used is "PCAA employees". The target population is the employees of PCAA. The population size would be employees of airlines and airports.

3.5 Sample Size

The sample for this research purpose was taken from Pakistan Civil Aviation, different airports and airlines, with a range of employees working there through the Non probability convenience sampling technique. Male and female were both included in research domain.

The data was collected from the Airports and airlines; it was convenient sampling. The data was taken from 141 employees from all the departments of the airports. And 5 respondents are set per question to conduct better research. The determination of minimum sample size was according to Hair et al. (1998) rule of thumb i.e., 5 responses per question (Hair, Anderson et al. 1998). The questionnaire consists of 21 questions so total responses would be 21*5 = 105 (Lai 2018).Participants were provided with questionnaires at their convenience. Participants were asked to fill out the consent and then questionnaires as the confidentiality were ensured to each participant through the consent sheet in the survey form wherein the determination of the study was explained to them.

3.6 Research Tools

The questionnaire consists of Likert scale of agreement, in which given choices are 1 (Strongly disagree), 2 (Disagree), 3 (Neutral), 4 (Agree), 5 (Strongly Agree). The questionnaire was circulated through email on google forms as well as through approaching the research subjects. For the interpretation of data SPSS tool is used. The data is screened and hypothesis is tested using the SPSS software. The factors analysis was done, mostly used to develop the questionnaire. Factor analysis attempts to bring inter-correlated variables together under more general, underlying variables. The goal was to decrease the dimensionality of the original space and to give an interpretation to the new space.

In *SPSS*, where the variables must be used in the analysis. Linear regression is the next level up. When predicting the value of a variable based on the value of another variable, this technique is utilized. The dependent variable is the one that must be predicted. The descriptive analysis is also performed in this research, in which the central tendency (the "center" or expected value) and dispersion (the distribution of the *variable's* responses) of a variable are both described by descriptive statistics. After doing all the factor and test analysis in SPSS, the results are interpreted.

4 Data Analysis

As indicated earlier, this paper aims to present the research trends and identification of future research agendas regarding the digitalization of airport procedures and insight into the sustainability domain. For the interpretation of data, the SPSS tool is used. The data is screened and the hypothesis is tested using the SPSS software. The factors analysis is done, mostly used to develop the questionnaire.

In SPSS, where the variables must be used in the analysis. Linear regression is the next level up. The descriptive analysis is also performed in this research, in which the central tendency (the "center" or expected value) and dispersion (the distribution of the variable's responses) of a variable are both described by descriptive statistics. After doing all the factor and test analyses in SPSS, the results were interpreted.

4.1 KMO and Bartlett's Test

Table 4.1 - KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.607
Bartlett's Test of Sphericity	Approx. Chi-Square	443.405
	df	210
	Sig.	.000

KMO (Kaiser-Meyer-Olkin) is a test to examine the strength of correlation defining how the factors are explaining each other. KMO values closer to 1.0 are considered ideal and values less than 0.5 are unacceptable. (Dewi and Rusilowati 2021). The result indicates the KMO value of 0.607 dictating that the degree of information among variables overlap is less likely than average. i.e., the partial correlation is relatively weak but not unacceptable so it is reasonable to conduct factor analysis. This shows that the sample used in data interpretation is adequate to an acceptable level(Shrestha and Statistics 2021).

The Bartlett's test is used to test the alternatives and null hypothesis with an identity matrix. An identity matrix means the variable is not ideal for factor analysis. A significant test (usually less than 0.05) shows that the matrix is not an identity matrix. The test above is significant as the value is less than 0.05 proving that the matrix is not an identity matrix. Hence the results show a considerable correlation between data. The test result has shown the significance of variables for conducting further analysis i.e., results are significant at 0.000.

4.2 Factor Analysis

Table 4.2 - Factor Analysis

Variables	Extraction (Factor Loading)	Mean	Cronbach's Alpha
Challenges		**3.3660**	**0.374**
CH1-Current aviation digital system regulations are effective for managing cyber challenges	0.648		
CH2-Ease of access to any digital asset may invalidate the technology adoption at Pakistan Airports.	0.645		
CH3-Digital double of people represents an additional vulnerability to procuring technology	0.550		
CH4-Creating a rich and positive dialogue about digital sway will accelerate the understanding of protentional challenges and solutions	0.611		
CH5-Low literacy rate in Pakistan regarding aviation technology is a major motive for no/less use of digital platforms at airports	0.622		
Threats		**3.3783**	**0.334**
TH1-It is not possible to 'hack' aviation systems	0.608		
TH2-Within aviation, adequate cyber threats relevant data is captured, protected, and available for analysis	0.541		
TH3-Good faith cybersecurity researchers are a positive thing for the aviation industry	0.510		
TH4-The use of approved, independent companies to objectively assess the cyber threats of aviation products and services is useful to gain insight into risk	0.560		
TH5-PCAA includes cyber insurance as an element of managing aviation cyber risk.	0.762		
TH6-Cyberattacks against aviation organizations appear to be increasing after the implementation of automation procedures.	0.668		
Digitalization		**3.4993**	**0.232**
DG1-Digitalization is insufficiently popular because many employees prefer traditional manual services	0.680		

DG2-PCAA is planning on investing more in digitalization	0.611		
DG3-The importance of proactive challenges and transparency in digitalization throughout the lifecycle of aviation products, services, and software is critical	0.628		
DG4-Ensuring less energy consumption may restrict the adaption of digital procedures at Pakistan Airports.	0.645		
DG5-Digitalization is seen as a key to delivering incremental value to end customers	0.614		
Sustainability		**3.4170**	**0.508**
SU1-Non-standard digital solutions are the trajectory of sustainable economic growth	0.561		
SU2-Transition of enterprises of PCAA to cloud digital models, to remain competitive, inflates sustainability	0.606		
SU3-Reduction in the human interface through digitalization enhances sustainability	0.629		
SU4-The process of transition from an environmentally hazardous business model to a sustainable economy challenges digitalization	0.635		
SU5-The aviation sector protects passenger privacy, it must be a proactive and transparent dialogue.	0.489		

Factor Analysis is a technique that is used to reduce a large number of variables into fewer numbers factors. The extraction of maximum common variance from all the variables and set them into a common score and the score is used further for analysis. The values in the extraction column show how much each variable is explained by factors. The closer the communality to 1, the better the variable is explained. A good way to measure factor analysis is to have a commonality of at least 0.40. The initial value for each variable is 1.00 or 100% by default as in the beginning none of the information has been extracted (Bujang, Omar et al. 2018).

4.2.1 Descriptive Statistics

Mean indicates the average across all observations. It is the most widely used measure of central tendency.

For “Challenges” the mean is 3.36 which is 3. According to responses gathered, 3 is “Neutral” which means most people neither agree nor disagree on certain statements. Challenges such as Digital doubles, Current aviation digital system regulations, Ease of access to any digital asset, and the Low literacy rate in Pakistan regarding aviation technology have a neutral response for being the utmost reason to be considered as a challenge. It may be because of the possible reason fewer concepts regarding technology in internal systems of Airports. Employees may find it unsuitable to be adaptable to new procedures in a certain time to deliver optimal efficiency.

For “Threats” the mean is 3.37 which is 3. According to responses gathered, 3 is “Neutral” which means most people neither agree nor disagree on certain statements. Cyber-attacks and less encrypted systems could be possible main threats, employees are neutral toward such response because of fewer aspects of problems appearing in systems, as systems are not that digitally empowered compared to other airport systems. Less or no Knowledge about cyber issues and other technical threats may be a reason employee are neutral toward such issues.

For “Digitalization” the mean is 3.49 which is 3. According to responses gathered, 3 is “Neutral” which means most people neither agree nor disagree on certain statements. Employees understand the concept of less energy consumption but are not concerned about transitioning the environmental hazard system to a digital system at the required level. This could be because of a lack of interest in the growth of the industry in these fields. IT is considered to be a growing industry in Pakistan. Collaborating with Pakistan Aviation Industry benefits both, most employees are less concerned about it because of fewer resources and unsuitable growth strategies.

For **“**Sustainability” the mean is 3.41 which is 3 indicating that most people neither agree nor disagree on certain statements. Non-standard digital solutions, Reduction in the human interface may inflate sustainability, employees have neutral responses towards it. The reason could be because of the low literacy rate of new technology. Many employees prefer manual procedures as they don’t find digital procedures understanding enough for operations. The PCAA is concerned about sustainability but at least level when it comes to digitalization because it will incur a lot of costs in training and soft structures.

From the result, the minimum amount of information is 48.9% by SU5 indicating a 51.1% loss of information. The maximum amount of information is 76.2% by TH5

indicating a 33.8% loss of information. The average amount of information is 60.66% by all variables indicating that 39.34% of information is lost.

4.2.2 Reliability Analysis

Cronbach's alpha is a measure used to assess the reliability or internal consistency indicating how closely related a set of items are as a group. A high value of alpha does not necessarily mean that measure is unidimensional. It is most commonly used when you have multiple Likert questions in a survey checking the reliability of items/variables formed through the survey (Taherdoost, Sahibuddin et al. 2022).

Cronbach's alpha coefficient ranges from 0 to 1.0 with higher values denoting increased reliability. The Coefficient of Challenges is 0.374 indicating no consistency between variables. It indicates that internal reliability between variables is weak. Challenges such as Digital doubles, Current aviation digital system regulations, Ease of access to any digital asset, and Low literacy rate in Pakistan regarding aviation technology are less contributing towards the adaption of technology in Pakistan's Aviation industry. The employees (Airline, cargo, Vigilance, etc.) do not consider these challenges as more important challenges contributing toward the insufficient growth of Pakistan's Aviation Industry in terms of technology .

The co-efficient of Threats is 0.334, indicating no reliability. The value shows that internal reliability between variables measuring threats towards adapting technology is weak. The employees of the Pakistan Aviation Industry consider Hacking, and cyber-attacks, non-adequate capturing of related data may not to be the only major reasons for changing procedures from manual to technical. Cyber insurance couldn't be identified as an element of managing aviation cyber risk. There could be more extensive systematic reasons for the efficient adaption of technology at Pakistan Airports.

The co-efficient of Digitalization is, 0.232 indicates a cause of concern for no internal reliability. The Aviation industry of Pakistan prefers traditional manual services. Not understanding the concept of transparency in digitalization plays a major role in Aviation Industry not being technically competent. Digitalization is not proven sufficient enough for Pakistan Aviation Industry to deliver incremental value to end customers (Passengers, third-party, etc.).

The co-efficient of Sustainability is 0.508, indicating less poor reliability between variables as compared to other variables but at acceptable levels. The transition of enterprises of PCAA to cloud digital models is not considered satisfactory enough to remain competitive in the industry, Reduction in the human interface by Artificial intelligence may inflate sustainability but not in every aspect of the Aviation Industry. It is considered as an imbalance in sustainability because of not enough understanding of procedures for the transition from an environmentally hazardous business model to a

sustainable economy. The aviation sector does not have proactive dialogues about protecting passenger privacy to the end encryption as described by employees Aviation Industry of Pakistan.

4.3 Correlation

Table 4.3 - Correlation Matrix

		CH	TH	DG	SU
CH	**Pearson Correlation**	1			
TH	**Pearson Correlation**	0.245**	1		
DG	**Pearson Correlation**	0.172**	0.186**	1	
SU	**Pearson Correlation**	0.425**	0.324**	0.280**	1

***Correlation is significant at the 0.01 level (2-tailed)*

The numbers in Pearson correlation measure the strength and direction of the linear relationship between two variables. The correlation coefficient can range from -1 to +1, with -1 indicating a perfect negative correlation, +1 indicating a perfect positive correlation, and 0 indicating no correlation at all. The confidence interval in Pearson Correlation is 90% with a 10% probability of being insignificant. On average there is less than a weak positive relationship between variables (Taber 2018).

The relationship between Threats (TH) and Challenges (CH) is 0.245 indicating a weak positive relationship between the respective two variables. The relationship between se Digitalization (DG) and Challenges (CH) is 0.172 indicating a very weak positive relationship between the respective two variables. The relationship between Digitalization (DG) and Challenges (TH) is 0.186 indicating a very weak positive relationship between the respective two variables.

The relationship between Sustainability (SU) and Challenges (CH) is 0.425 indicating a less-than-average positive relationship between the respective two variables. The relationship between Sustainability (SU) and Threats (TH) is 0.324 indicating a weak positive relationship between the respective two variables. The relationship between Sustainability (SU) and Digitalization (DG) is 0.280 indicating a very poor positive relationship between the respective two variables.

4.4 Hypothesis Testing

Table 4.4 - Hypothesis Testing

Hypothesis Statement	P-Value	Result
H1: Implementation of digital procedures imposes positive impacts on sustainability	**0.001** P<0.05	Supported
H2: An increase in digitalization increases the severity of threats	**0.027** P<0.05	Supported
H3: Challenges have a positive impact on Sustainability	**0.001** P<0.05	Supported

For Hypothesis testing**,** through regression analysis, the ANOVA test is used. The test indicates whether there is a significant difference between two or more groups being tested or not. The confidence interval in the test is another way to describe the probability that the population parameter will fall between sets of values. In hypothesis testing, the confidence interval is 95% with a 5% probability of being incorrect

The P-value measures the probability of obtaining the observed results, assuming that the null hypothesis is true. The lower the P-value the greater the statistical significance of the observed difference. A p-value of 0.05 or lower is generally considered statistically significant (Bujang, Omar et al. 2018).

Hypothesis H1 bearing a p-value of 0.001 < 0.05 indicates that the hypothesis is supported stating that "Implementation of digital procedures imposes positive impacts on sustainability", rejecting the null hypothesis. Sustainability is considered a more promising and important factor to be pondered upon whenever there is a required change overall or there is an expansion in certain activities at Pakistan Airports. Through analysis, it could be concluded that by implementing digital changes in Airports in Pakistan may foster the growth of Pakistan's Aviation industry. Revenue streams can show an incremental value because of less cost being incurred by manual procedures.

Hypothesis H2 bearing a p-value of 0.027< 0.05 indicates that the hypothesis is supported stating that an **"**Increase in digitalization increases the severity of threats", rejecting the null hypothesis. While with the concern of sustainability, the cons also linger side by side. With the new technology, it may cause certain problems that further require extensive solutions. Data privacy and protection could be eliminated because of not enough security or end encryption models being encrypted easily by hackers. The threats of cyber-attacks may increase which in term increase the vulnerability of systems to be operational at time of crisis. Spam and other data-capturing threats could pose a possible danger to employee and passenger privacy.

Hypothesis H3 bearing a p-value of 0.001< 0.05 indicates that the hypothesis is supported stating that **"**Challenges have a positive impact on Sustainability", rejecting the null hypothesis. Challenges increase as there is increase ina the procedures for operations to be sustainable more and more. Certain challenges may pose a barrier to sustainability such as energy consumption through digital technology while maintaining cost and efficiency simultaneously.

4.5 Histogram

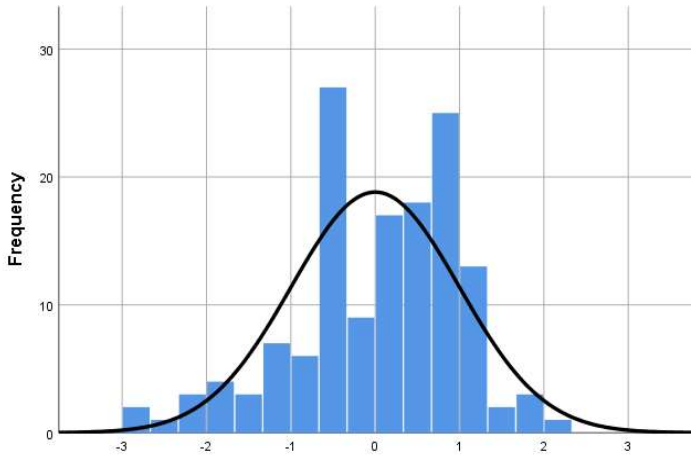

Figure 4.1 - H1 Histogram

Figure 4.1 shows the Histogram of H1 that DG has a positive impact on SU. The curve in the above figure is more on the right side which shows that there is a positive association between DG and SU. It means that digitalization has a positive impact on sustainability and improving digitalization will increase sustainability and it will be easy for the employees to maintain procedures accordingly.

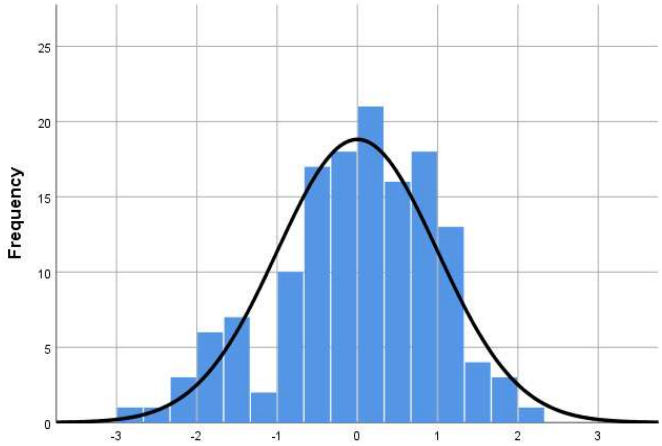

Figure 4.2 - H2 Histogram

The histogram of H2 in Figure 4.2 demonstrates how positively DG affects TH. The curve in the above figure is skewed more to the right, which indicates that DG and

TH have a good relation. It implies that risks are positively impacted by digitization and that threats will become more serious as digitalization advances.

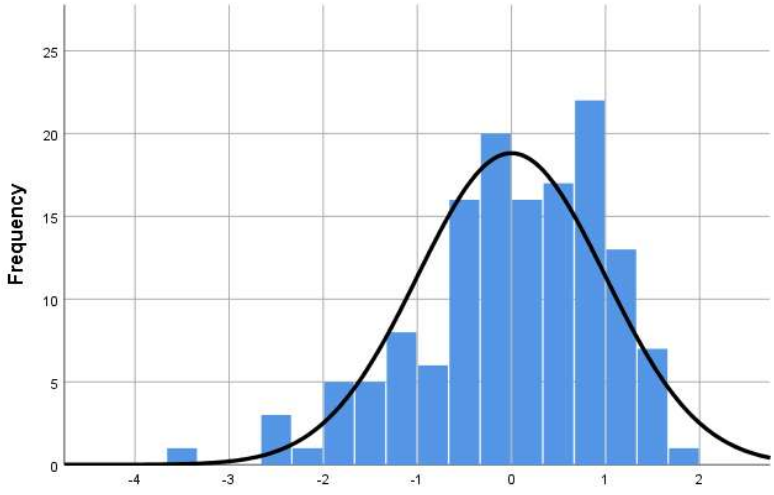

Figure 4.3 - H3 Histogram

The histogram of H3 in Figure 3 demonstrates how CH has an advantageous effect on SU. The above curve is skewed more to the right, which indicates that CH and SU have a favorable relationship. It implies that the challenges brought on by digitalization have a good effect on sustainability and that the challenges brought on by furthering digitalization will grow.

5 Discussion and Conclusion

In light of earlier literature, this section presents the research's primary findings. It also includes ideas for further research as well as the research's advantages and criticisms. The main goal of this study was to find out challenges contributing in technology adoption in aviation for sustainable development while also enhancing connection, digitization, and system security.

The multiple dangers to technical breakthroughs and practises, notably in the aviation sector, make sustainability very challenging to maintain in the age of technology. Prior to the introduction of digitalization and technology procedures, there were many risks, and even with the introduction of breakthroughs in several aviation sectors, there were many more threats that had an impact on sustainable practises (Obilor, Amadi et al. 2018). Sustainability is viewed as a more promising and major factor to be taken into consideration when there is a need for a general change or for a specific activity to be expanded in the Pakistan Aviation Industry. Through research, it was feasible to come to the conclusion that adding digital upgrades to Pakistan's airports might promote the growth of the nation's aviation industry (Tobias and Carlson 1969).

The environmental problem coexists side by side with the drawbacks. The use of new technology could raise some problems that require more comprehensive solutions. Data privacy and protection may be lost due to a lack of security or end encryption models that are easily cracked by hackers. Risks of cyberattacks could increase, increasing the likelihood that systems will malfunction in an emergency. The privacy of employees and passengers may be compromised as a result of spam and other data collecting issues. Some problems, such as how much energy digital technology uses while maintaining cost and efficiency, may make sustainability more difficult.

Through result it also could be concluded that there is less awareness about technical literature in aviation sector specifically in Pakistan Civil Aviation as most of the employees don't know about technological advancement with growth of industry. The research findings of this study are consistent with previous literature that there exist frequent challenges such as cyber issues, less awareness and sustainability issues for adoption of technology and advancing the technology in Pakistan Aviation Industry, concluding that there is need of promising solutions that could resolve the combine effect of these challenges.

Despite the fact that the results of the current investigation confirm the hypotheses that were put to the test, it is important to recognize that the study had certain limitations. The fact that the data sample is exclusively representative of the aviation sector in Pakistan and that the findings of this study might not apply to other aviation industries throughout the world is a significant restriction. The target population that was utilized in this study was "PCAA employees". This could be expanded to other operators of the Pakistani Aviation industry to increase the applicability of the research.

5.1 Theoretical Implications

This paper's conclusions represent a detailed outline that highlights the key points of the issues presented. These findings mostly confirm previous findings, indicating that digitalization has an impact on every industry and can provide significant benefits when addressed appropriately and integrated into the company's strategic focus, but they also provide some dissenting perspectives due to the broad scope of this topic in general. These opposing viewpoints mostly concern the difficulties of digitalization adaptation and the potential risks of using specific digital components. Previous study may have understated these problems, and hence there is lots of room for future research that focuses on the various themes such as cyber risks concerning sustainability in greater depth. The nature of this ever-changing topic, together with the findings of this research, suggests that new breakthroughs and trends such as digital procedures in reliability and maintenance are likely to develop. These trends may be developing now, although they have not yet received literary recognition. Similarly, current trends implementing digitalization in

administrative activities of Pakistan Civil Industry that are considered relevant may fade or evolve into new directions, adding to the potential for considerable future research.

5.2 Practical Implications

In order to overcome the challenges of the digital transition, this exploratory study offers a variety of practical implications for policy makers, administration, and organizations in Pakistan Aviation Industry. The findings of this study generally point out difficulties in promoting digitalization. The dynamics of digital change require cutting-edge infrastructure and services. However, understanding how to make use of technology, the benefits of big data, and how to apply AI to data analysis is insufficient. As a result, developing the requisite knowledge and abilities should be viewed as a fundamental quality to successfully navigate the digital revolution. When considering single stakeholders, the results on challenges advise authority to reconfigure their business models by acquiring a new mentality oriented towards a medium- to long-term perspective. This study urges policymakers in the regional innovation system to develop the system so that it is capable of promoting digital literacy, raising awareness of Internet dangers, and developing stakeholder engagement to explore potential learning routes. Policymakers should make additional financial resources available. More funding is required to encourage digital transformation processes as much as feasibility in the activities of stakeholders.

5.3 Future Research Directions

The current study supports aviation using common variables (digitalization, challenges, threats and sustainability) to examine the implications of technology, mostly on the administrative side. The combination of these variables can intrigue further future questions, other than the ones that have been discussed in this research. It could be beneficial to extend digitalization studies to all large medium and small sized airports across Pakistan. There is a need for an in depth research, exploring the technological variables in a mediating effect with the major motives of the aviation industry of Pakistan i.e. sustainability. Additionally, this research does not provide any elaborated guidelines such as “how any threats related to digitalization can cause vulnerability to factors playing a role in sustainable environment” and instead works with a general framework. Future research could address the individual digital trends such as Reliability process, maintenance and infrastructure development of airports in Pakistan. Data gathered from various airlines and organizations at airports might lead to new discoveries in the field of study.

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Appendix A

Questionnaire: "*Analysis of challenges in the adaption of digitalization in aviation procedures in the attainment of sustainability*"

Challenges

1. Current aviation digital system regulations are effective for managing cyber challenges

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

2. Ease of access to any digital asset may invalidate the technology adoption at Pakistan Airports.

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

3. Digital double of people represents an additional vulnerability to procure technology.

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

4. Creating a rich and positive dialogue about digital sway will accelerate the understanding of protentional challenges and solutions .(BAGARİC and FRANCA 2021).

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

5. Low literacy rate in Pakistan regarding aviation technology is a major motive for no/less use of digital platforms at airports

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

Threats

6. It is not possible to 'hack' aviation systems.

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

7. Within aviation, adequate cyber threats relevant data is captured, protected and available for analysis.

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

8. Good faith cybersecurity researchers are a positive thing for the aviation industry

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

9. The use of approved, independent companies to objectively assess the cyber threats of aviation products and services is useful to gain insight to risk

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

10. PCAA includes cyber insurance as an element of managing aviation cyber risk. (Zaharia and Pietreanu 2018).

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

11. Cyberattacks against aviation organizations appear to be increasing after implementation of automation procedures? (Polishchuk, Kulinich et al.)

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

Digitalization

12. Digitalization is insufficiently popular because many employees prefer traditional manual services.

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

13. PCAA is planning on investing more in digitalization

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

14. The importance of proactive challenges and transparency in digitalization throughout the lifecycle of aviation products, services, and software is critical.(Cooper 2019).

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

15. Ensuring a zero-carbon footprint and reducing energy consumption may restrict the adaption of digital procedures at Pakistan Airports.

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

16. **Digitalization** is seen as a key to delivering incremental value to end customers

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

Sustainability

17. Non-standard digital solutions are the trajectory of sustainable economic growth

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

18. Transition of enterprises of PCAA to cloud digital models, in order to remain competitive, inflates sustainability.

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

19. Reduction in the human interface through digitalization enhances sustainability

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

20. The process of transition from an environmentally hazardous business model to a sustainable economy challenges digitalization.

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

21. The aviation sector protects passenger privacy, it must be a proactive and transparent dialogue.

(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree