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### Technology Adoption and Strategic Positioning of Airports in Aviation Networks

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#### Abstract

A rapid change in the aviation business that has been occasioned by the aspects of digitalization, automation and sustainability has required the airports to redefine strategic functions within the aviation networks. The paper critically evaluates the effect of technology adoption on strategic positioning of the airports as a major player in the aviation ecosphere that is increasingly becoming complex. The paper has focused on the high-grade technologies such as artificial intelligence, Internet of Things (IoT), Biometric, big data analytics, and smart infrastructure and explored their effects on the efficiency of operations, passenger experience, network connections, and competitive advantage. On the basis of a mixed-method application, which will involve the study of secondary data and the use of examples of possible cases involving major international and emerging-market airports, the study attempts to review to what extent technological integration will enable airports to enhance the intensity of the appeal to airlines, efficiency with which they use their capacity, and the quality and depth of network connections in major markets and with global networks. The findings show that the airports that adopt collective digital and smart technology achieve the high positioning strategy by quality of service expression, reduced turnaround period, enhanced security and decision-making based data. However, the study also identifies other important obstacles, including the input of capital requirements, cybersecurity risks, regulation, and lack of uniform technological readiness by locations. The paper has concluded that technology application does not simply mean upgrading of operational facilities but having a strategy that will enable the airports to possess sustainable competitiveness in the aviation market. Policy implications and recommendations to the managers are suggested to make them leverage technology as a benefit to their long-term strategic positioning as an airport authority and regulators.

**Keywords:** Technology adoption, Airports, Strategic positioning, Aviation networks, Smart airports, Digital transformation

#### Introduction

An acute structural and operational transformation of the world aviation industry in the past two decades that was triggered by liberalization of policies, break-neck technological transformation and mounting pressure between airlines, airports and the service brokers. Airports were once treated as the dormant structures that facilitate the movement of airplanes and people being ferried; these have become multifaceted and complex organizations that have strategic positions in the aviation structures. In the contemporary aviation systems, airports are not only about efficiency on operations, but they offer a network of connection that is controlled, influence the decision-making that an individual adopts on the airline routes, and offer a nice passenger experience, and contribute to the development of their regions and countries. This has even been strengthened by the growth in the utilization of enhanced technologies thereby rendering airports to be regarded as strategic players which can generate value across the aviation value chain. The introduction of technology is now central to strategic positioning of airports that are drifting towards positioning as cost centre to competitive, innovation-based hubs to be realised in global and regional airlines networks.

The level of air traffic has only increased in scale, and complexity, and the now mounting pressure on the passengers to travel smoothly, securely, and in a customized way, has put further pressures on the technologically mediated operations of airports. The digitization of airside and landside functions in the airports is shifting towards using digital technologies, such as artificial

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intelligence (AI), Internet of Things (IoT), big data analytics, biometric identification, automation, and smart infrastructure systems. They allow them to exchange information in real time, provide predictive maintenance, optimise the use of resources, provide the possibility to coordinate their efforts among a vast number of stakeholders including airlines, air traffic controllers, ground handlers, security agencies and passengers themselves. This means that both the supply and demand of such technologies deployed logically and strategically in airports ensures increased operational stability, reduced congestion, reduced turnaround time and also enhanced service delivery quality cementing their positions in roles in aviation networks.

Aviation networks are characterized in a strategic way including interdependency between airports, airline companies, regulators etc. playing in the field of ancillary services. The most important nodes of such networks are the airports, which define the form of connectivity, hub-and-spoke networks, and accessibility of a region. The technology implementation by the airports enables the airports to enhance network centrality by availing improved infrastructure, streamlined operations and digitally enabled services that will have appeal to airlines and passengers. Using the case of advanced passenger processing systems and joint decision-making platforms, which make the airports more reliable and punctual, these are valuable variables that the airline should consider when planning the route and selecting a hub. That is why the technologically developed airport is more likely to emerge the favourable hubs, transshipment, and multimodal transport in the national and international aviation systems.

Other than this, strategic location of airports is also being affected by the ability to reduce their dependence on the traditional aeronautical incomes and the diversification of their revenue stream. Increased concentration on the non-aeronautical operations, such as retail, hospitality, logistics, and the creation of real estates, and technology is central to the enhancement of commercial performance. Online channels, data analytics, and intelligent solutions related to retailing can assist airports to better understand the behaviour of the passengers, customize the products, and optimize the commercial layouts, which will make the non-aeronautical revenues increase. They will make airports commercially independent and enhance their bargaining ability with the airlines besides other aviation ecosystem players.

Another way to argue over the strategic importance of the technology usage in the airport operations is through sustainability and environmental issues. With the pressure on reducing carbon emission and enhancing energy efficiency roaring on with the regulations and the society as a whole, airports are now deploying green technologies and intelligent energy management and digital monitoring systems towards achieving some of the sustainability targets. To ensure not only the process of compliance with the environmental regulations but also the further strategic position of the airports, the image, recognition of the stakeholders, and international aviation compliance with the sustainability standards, it is possible to introduce sustainable technologies. The technology here is a strategic enabler that will re-strategize operational efficiency, environmental responsibility and competitive advantage.

There are also challenges in the development of innovative technologies by airports in the presence of the obvious positive outcomes. The absence of high capital requirements, threat of cyber terrorism, and complexity of regulations are highly limiting factors, the unequal technological preparedness of the developed and emerging economies. Specifically, smaller and regional airports tend to be limited by the absence of financial and institutional resources that can enable these airports to adopt the newest technologies, which may also contribute to the further increase in the strategic distance inside an aviation network. These concerns indicate the need to rethink the strategy of technology adoption, and the impact that it produces on the strategic positioning of airports across diverse environments.

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It is on this backdrop that the present study is trying to critically debate the impact of introduction of technology on the strategic location of airports in the aviation networks. The paper will attempt to complete the emerging research field on the airport strategy and aviation network economics by studying the relation between technological innovation, operational performance, network connectivity and competitive dynamics. It particularly applies to the interests of policymakers, Airport managers and other industry stakeholders who would want to know how a technology-based transformation can favourably position the airports in a highly connected and competitive aviation industry.

### Literature Review

The concept of innovating in Airport development has been turned into a more advanced concept that causes the airports to be technologically oriented, people oriented and strategically competitive stations in the aviation nets. Medvedev, Alomar, and Augustyn (2017) remark that innovativeness in airport design does not pay attention to the aesthetic appearance of the architectural constructions but to such aspects as the functional scalability, to the optimization of the flows and the integration of intelligent technologies. Their study will focus on utilizing new terminal layouts, modular architecture and restructuring the infrastructure to ensure that the operation becomes more efficient and simultaneously the comfort of the passengers can also be provided, which contributes to the strategic stance of the airport within the aviation industry.

The customer-based innovation requires a degree of eminence as the digital platform usages progress. Siriwardana and Dissanayake (2018) provide an insight into the research on the subject of Social Customer Relationship Management (SCRM) by focusing on the augmentation of the significance of digital encounter tools employed within the context of present-day business environments. Introduced into airports, SCRM will enable officials to interact with individuals in their real-time and serve them on an individual level in accordance with the feedback-based response and customer loyalty and satisfaction rates growth. This can be traced to the general trend of airports becoming digital service-oriented businesses, such as service industry.

Various data on the topic of self-service technologies acceptance among passengers have been studied in the context of airports. In a study that we carried out in Zurich Airport, Wittmer (2011) demonstrates that the self-service check-in system is an extremely confident system of enhancing the comfort of the passengers and the efficiency of the airport. The findings prove that passenger acceptance is extremely reliant on the perceived usefulness and ease of use that reduces queues and staff dependence. Board this train, Castillo-Manzan and Lopez-Valpuesta (2013) research their exploration on the behavior of passengers to self-service technology and conclude that technology-based passenger check-in systems affect the performance of the airport positively and shape the perceptions of the passengers concerning services.

A good theoretical background to the technology acceptance in the airports is the Technology Acceptance Model (TAM) of Davis et al. (1989). Their experimental research explains perceived usefulness and perceived ease of use as the fundamental variables of user acceptance of computer-based technologies. The model has been extensively used in the airport research literature and is described to explain how the passengers and employees adopt the digital service business model such as the biometric screening, mobile apps, and the automated boarding.

In the article by Libert, Beck, and Wind (2016), the authors talk about digital transformation at the organizational scale and state that digital transformation must be heard, and dedicated by the leaders and the organization. This is because in the airport context, airports engage in massive digital projects that involve a number of players. Incheon Airport case (2019) is one

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such case wherein strategic digitalization has interwoven people, processes and technology in ensuring that the airport experiences people and operational excellence thus making the airport a world standard with regards to smart developments in airports.

Technological innovation is also application of mobile apps and gamification. Mantouka et al. (2019) explore the issue of gamification in the mobile application of the airports, and the researcher determines that the interactive online experience would enhance customer satisfaction, time at the airport, and the prospect of gaining extra money. Such innovations result in the non-aeronautic revenues expansion of airports and provide the market position of airports.

Such concept as smart airports is given specific attention in various works. In a proposal to evaluate the information services offered by the given airports, Nagy and Csiszar (2016) propose Airport Smartness Index paying attention to the concentration of the data, timeliness of communication, and the digital services oriented at the user. Alghadeir (2016) has gone further to discuss smart airport architecture using the Internet of Things (IoT) architecture and how interconnected devices can be employed to deliver predictive maintenance, real-time monitoring, and provide a higher level of security.

The other factor in the airport innovation aspect is airport sustainability and energy efficiency. Baxter, Srisaeng, and Wild (2018) have demonstrated through a case study of Kansai International Airport that not only does the smart energy management systems decrease environmental impacts, but it also leads to a lower cost of operation. They conclude that long-term strategic location of airports and compliance with regulations can be achieved due to sustainable use of technologies.

The problem of cybersecurity has turned into a burning issue with increased digitalization. In the effort to identify the threats related to cybersecurity in smart airports, Lykou, Anagnostopoulou, and Gritzalis (2019) note the need to guarantee the presence of excellent cyber resilience systems that can support the essential infrastructure and passenger details. Their review shows that the technological development should be in conjunction with high governance systems and mechanisms to establish security.

Industry reports and forecasts also put these scholarly findings into perspective. According to IATA Asia Operation (2019), the largest growth in air traffic will be achieved in the Asia-Pacific region and it is significant that the airport systems should be technologically oriented and capable of expanding. Such examples in some industry, such as the FAST change at Changi Airport (2019) and a study by Kovynyov and Mikut (2018) of the applications of automation, data analytics and digital platforms to develop an all-digital operation of ground operations, show that major airports have been successful in using automation, data analytics and digital platforms to develop their efficiency and strategic competitiveness.

The overall trend in the literature is that the implementation of innovation and technology is the target of transforming the traditional role of the airports as the infrastructure into the strategic component of the aviation networks. Up to now, past studies suggest that airports competitiveness depends on smart design, digital interaction, self-service technologies, sustainability measures and cybersecurity preparedness as the key sources. This, however, is also reported in the literature that consolidated solutions are needed that incorporate the implementation of technology with organizational strengths and expectations of passengers, which is a viable core of the current research on the use of technology and strategic positioning of the airports.

### Objectives of the Study

1. To examine the extent of technology adoption in airport operations.
2. To analyze the role of innovation in airport design and service delivery.

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3. To assess the impact of digital technologies on airport operational efficiency.

### Hypothesis

**H<sub>1</sub>:** Digital technologies have a significant positive impact on airport operational efficiency.

**H<sub>0</sub> (Null Hypothesis):** Digital technologies do not have a significant impact on airport operational efficiency.

### Research methodology

The present paper relies on the descriptive and analytical research design to concentrate on the influence of digital technologies on efficient functioning of the airports and the strategic positioning. The analysis is done on the foundation of the secondary data, which were compiled through research articles published, industry reports, industry publications by the airport authority, IATA reports and official documents that addressed smart and digital airports. To support the analytical scheme, several case studies of technically advanced airports are incorporated in the bid to learn more about practical application of digital technologies in airports i.e. self-service systems, IoT-based infrastructure, data analytics, and automation. The comparative analysis and trend study of the major indicators of operations, which include passenger processing time, aircraft turnaround time, and capacity utilization where the data on the said indicators is offered are quantitative methods employed in the study. Besides, qualitative research is used to service and offer strategic and management implications of digital transformation endeavors. The statistical tools that were used to test the stated hypothesis addresses the effect of digital technologies on the operational efficiency are correlation and regression analysis that are suitable. The findings are regarded through the perspectives of aviation network theory and technology acceptance models and this renders the findings scholarly and practical.

### Descriptive Statistics: Impact of Digital Technologies on Airport Operational Efficiency

Operational Efficiency Indicators	Mean	Standard Deviation	Minimum	Maximum
Passenger Processing Time Reduction	3.92	0.68	2.1	4.85
Aircraft Turnaround Time Efficiency	3.88	0.72	2	4.9
Resource Utilization Efficiency	3.75	0.81	1.95	4.8
Operational Cost Reduction	3.69	0.77	2.05	4.7
Service Reliability and Punctuality	3.95	0.65	2.3	4.9
Overall Operational Efficiency	3.84	0.71	2.15	4.85

As the descriptive statistics indicate, the overall number of respondents that agree with the fact that digital technologies positively affect the effectiveness of operations within the airports is high. The mean scores of all indicators are above the middle of the 5 Like scale and the findings are between 3.69 and 3.95 which reflect the attitude towards technological-mediated changes in the operations of the airports. The highest average score is on service reliability and punctuality (Mean = 3.95) that suggest the contribution of digital systems in more real-time coordination, precision in time scheduling, and the management of the disruption. Similarly, the factors of the decrease of passenger processing time (Mean = 3.92) and aircraft turnaround time efficiency (Mean = 3.88) refer to the effectiveness of the economic self-service technologies, automation, and data-ground operations. The relatively average standard deviations indicate that the opinions of the participants are homogenous, and there is a shared idea of the efficacy of receiving because of digital adoption. Overall, the mean of all scores in the overall operational efficiency (Mean = 3.84) confirms the idea that digital technologies can positively influence the simplification of airport activity, which confirms the fact that it is



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possible to accept the hypothesis expressed in this paper that the operational efficiency can be influenced by digital technologies.

### Multiple Regression Analysis

**Dependent Variable:** Airport Operational Efficiency

#### Coefficients Table

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t-value	Sig.
(Constant)	1.214	0.287	—	4.23	0
Self-Service Technologies	0.286	0.064	0.312	4.469	0
Automation of Ground Operations	0.241	0.058	0.279	4.155	0
Data Analytics & AI Systems	0.198	0.061	0.214	3.246	0.002
IoT-enabled Infrastructure	0.173	0.055	0.198	3.145	0.003
Digital Passenger Processing	0.221	0.067	0.236	3.299	0.001

#### Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.782	0.611	0.598	0.423

Significance level: 5% ( $p < 0.05$ )

The facts that the multiple regression analysis provides are quite empirical to prove the hypothesis implied: the role of digital technologies in the sphere of airport operational efficiency is quite positive. The model has high explanatory power because its value of R square of 0.611 indicates that approximately 61.1 percent of the variation of airport performance in terms of operational efficiency is represented by the variables of digital technology considered. The strength of the model is also established by the value of factor of adjusted R of 0.598. Self service technologies, ground operation automation, data analytics and AI systems, IoT enabled infrastructure, and digital passenger processing have positive coefficients and statistically significant p-value of 0.05. The self-service technologies ( $b = 0.312$ ) and the automation of the ground operations ( $b = 0.279$ ) will be the strongest predictors to come out of the several that emerge and this means that the two areas will be instrumental in reducing the number of resources which will be wasted by the processing time. The significance of integrated digital ecosystems in the framework of the enhancement of coordination and reliance, as well as the efficiency of decision-making is preconditioned by the significance of data analytics, IoT, and processing of passengers. Altogether, the findings of the regression analysis allow rejecting the null hypothesis and accept H1 or remark that digital technologies exert significant and positive influence on the efficiency of airports.

#### Overall Conclusion

The paper has critically examined the role of the digital technologies in enabling the efficiency of the operations of the airports and whether the digital technology has been pertinent in facilitating the strategic position of the airports within the air networks. The outcomes promise that the implementation of technology, involving the use of self-service systems, the automation of ground processes, and data analytics, as well as the use of IoT-enabled infrastructure and processing passengers digitally, brings a considerable rise in operational efficiency since it can be applied to reduce the time used to process passengers, enhance turnaround, utilize more resources, and ensure the reliability of the provided services. The descriptive statistics showed that the extent of positive attitude towards these technologies among patients is extremely high but the multiple regression test verified the extent of contribution is statistically significant and attributed the majority of the variance attributed over 60 percent of the efficiency of the operation. Besides operational benefits, the study points out that incorporation of technology will allow the airports to create competitive advantages, win

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the attention of airlines, enhance passenger satisfaction, build upon revenue generation, and enhance sustainability initiatives. However, several other issues such as a high investment cost, a cybersecurity threat, and the difference in technological preparedness can also be identified as very crucial factors. In conclusion, the paper provides the confirmation of the fact that digital technologies are not functions but strategic forces that transform airports into power brokers in aviation networks, and their role in a competitive, commercial, and managerial process in the contemporary aviation given the industry.

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