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College of Management

Master of Business Administration (MBA)



**The Impact of Digital Transformation on Operational Performance in
Saudi Airports Evidence from Jeddah**

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DECLARATION

I hereby certify that this dissertation is entitled:

The Impact of Digital Transformation on Operational Performance: Evidence from King Abdulaziz International Airport, Jeddah, Saudi Arabia" analyzes how digital transformation is influencing operational performance through the lens of King Abdulaziz International Airport in Jeddah, Saudi Arabia.

I have taken care to ensure that this is my own original work and that it has not been previously submitted for any degree, diploma or professional qualification at this or any other university or institution, in whole or in part.

I further state that all information, published materials and ideas that have been used in this dissertation have been appropriately acknowledged and referenced in accordance with the American Psychological Association (APA 7th Edition) referencing style. All assistance in preparation of this dissertation has been fully recognized.

Plagiarism, fabrication, falsification of data or any other form of academic dishonesty is a serious violation of university policies and academic honesty.

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DEDICATION

This work is dedicated to my dear parents who have supported me unconditionally, prayed for me every day of my life and have helped me all the way through my academic studies.

To all my family who have encouraged, been patient and believed in me to overcome all the challenges during this research.

To all my teachers and mentors, whose knowledge, guidance and dedication has influenced me in my academic and professional life.

Last but by far not least, I dedicate this work to all those who firmly believe that knowledge, innovation and incessant learning are the engines of progress and sustainable development.

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ABSTRACT

Background: In an era defined by digital transformation, airports around the globe are grappling with the challenge of achieving a competitive advantage, with improved operational efficiency, enhanced passenger experience, and sustainable competitiveness all being strategic priorities. Emerging technologies like Artificial Intelligence (AI), Internet of Things (IoT), and Smart Airport Technologies have revolutionized airport operations, facilitating intelligent decision-making, automation, predictive maintenance, and real-time monitoring of operations. Although the use of these technologies is growing, there are few empirical studies on how these technologies affect the operational performance in the Saudi airports when they are applied together.

Objective: This study focused on the effects of digital transformation for operational performance at King Abdulaziz International Airport (KAIA), Jeddah, Saudi Arabia. In particular, the study examined how AI, IoT, and Smart Airport Technologies affect the operational performance.

Research Methodology: This is quantitative research with a cross-sectional survey design. The data were obtained by using a structured questionnaire which was sent to the operational department's employees of King Abdulaziz International Airport. 280 questionnaires were distributed and 250 were valid which were analysed in IBM SPSS Statistics. Descriptive statistics, Cronbach's alpha, Pearson correlation analysis and multiple linear regression analysis were used as statistical techniques.

Findings: The employees indicated extremely high agreement rate regarding the implementation of Artificial Intelligence, Internet of Things, Smart Airport Technologies and Operational Performance. The internal consistency of all the study variables was good as found by the reliability analysis. The statistical analysis of the data using Pearson correlation method showed that positive relationships exist for all dimensions of digital transformation with Operational Performance. The three dimensions were found to be significant in multiple regression analysis with 71.6% variance explained by the model ($R^2 = 0.716$). Smart Airport Technologies had the biggest positive impact, followed by Artificial Intelligence and Internet of Things. All research hypotheses were supported.

Result : The study concludes that digital transformation is a significant way of enhancing the operational performance of an airport, bringing improvements in operational efficiency, service quality, use of resources, operational coordination and satisfaction of passengers. The results highlight the importance of integrated applications of Artificial Intelligence, Internet of Things and Smart Airport Technologies to enable operational excellence and align with Saudi Vision 2030 strategic goals. The study calls for further investments in digital technologies, employee digital skills and smart airport systems to support the airport's operational performance in the long-term.

Keyword: driven digital transformation journey leads to an era of artificial intelligence, Internet of Things, smart airport technologies, operational performance and transformative impact for King Abdulaziz International Airport, Saudi Arabia.

المخلص

الخلفية : يشهد قطاع الطيران تحولاً رقمياً متسارعاً نتيجة التطور المستمر في التقنيات الحديثة، حيث أصبحت المطارات الذكية أحد المحاور الرئيسة لتحسين الكفاءة التشغيلية وتعزيز جودة الخدمات ورفع مستوى رضا المسافرين. وتسهم تقنيات الذكاء الاصطناعي، وإنترنت الأشياء، وتقنيات المطارات الذكية في تطوير العمليات التشغيلية من خلال دعم اتخاذ القرار، وتحسين إدارة الموارد، والأتمتة، والمراقبة اللحظية، والصيانة التنبؤية. وعلى الرغم من التوسع في تطبيق هذه التقنيات، لا تزال الدراسات التي تناولت أثرها المتكامل على الأداء التشغيلي في المطارات السعودية محدودة.

هدف الدراسة : هدفت هذه الدراسة إلى التعرف على أثر التحول الرقمي في الأداء التشغيلي بمطار الملك عبدالعزيز الدولي بمدينة جدة، من خلال دراسة تأثير كل من الذكاء الاصطناعي، وإنترنت الأشياء، وتقنيات المطارات الذكية على الأداء التشغيلي.

منهجية الدراسة : اعتمدت الدراسة المنهج الكمي باستخدام تصميم المسح المقطعي، وتم جمع البيانات من خلال استبانة وزعت على العاملين في الإدارات التشغيلية بمطار الملك عبدالعزيز الدولي. بلغ عدد الاستبانات الموزعة 280 استبانة، وتم تحليل 250 استبانة صالحة باستخدام برنامج **IBM SPSS Statistics** واستخدمت الدراسة الإحصاءات الوصفية، ومعامل كرونباخ ألفا، وتحليل ارتباط بيرسون، وتحليل الانحدار الخطي المتعدد لاختبار فرضيات الدراسة.

النتائج : أظهرت النتائج ارتفاع مستويات تطبيق التحول الرقمي بجميع أبعاده، كما سجلت متغيرات الدراسة مستويات مرتفعة جداً من الاتفاق بين أفراد العينة. وأثبتت نتائج تحليل الثبات ارتفاع موثوقية أداة الدراسة. كما بين تحليل الارتباط وجود علاقات ارتباط موجبة ودالة إحصائية بين جميع أبعاد التحول الرقمي والأداء التشغيلي. وأوضح تحليل الانحدار المتعدد أن أبعاد التحول الرقمي فسرت **71.6%** من التباين في الأداء التشغيلي ($R^2 = 0.716$) ، وكانت **تقنيات المطارات الذكية الأكثر تأثيراً**، تلتها **الذكاء الاصطناعي** ثم **إنترنت الأشياء**، كما تم قبول جميع فرضيات الدراسة.

الخلاصة : خلصت الدراسة إلى أن التحول الرقمي يمثل أحد أهم العوامل الاستراتيجية لتحسين الأداء التشغيلي في المطارات، حيث يسهم في رفع الكفاءة التشغيلية، وتحسين جودة الخدمات، وتعزيز التنسيق بين الإدارات، وتحسين استغلال الموارد، وزيادة رضا المسافرين. كما أكدت النتائج أن التكامل بين الذكاء الاصطناعي، وإنترنت الأشياء، وتقنيات المطارات الذكية يعد عنصراً أساسياً لتحقيق التميز التشغيلي ودعم مستهدفات رؤية المملكة العربية السعودية 2030 . وأوصت الدراسة بمواصلة الاستثمار في التقنيات الرقمية الحديثة، وتعزيز مهارات العاملين الرقمية، وتوسيع تطبيقات المطارات الذكية بما يضمن استدامة التطوير وتحسين الأداء التشغيلي.

الكلمات المفتاحية : التحول الرقمي، الذكاء الاصطناعي، إنترنت الأشياء، تقنيات المطارات الذكية، الأداء التشغيلي، مطار الملك عبدالعزيز الدولي، المملكة العربية السعودية.

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CHAPTER ONE

1. INTRODUCTION

The aviation industry has experienced unprecedented transformation over the past decade as a result of rapid technological advancements and the growing adoption of digital technologies. Airports are no longer viewed solely as transportation hubs; instead, they have evolved into complex digital ecosystems that integrate advanced technologies to improve operational efficiency, passenger experience, safety, and service quality. Digital transformation has become a strategic priority for airport authorities worldwide, enabling organizations to optimize operational processes, enhance decision-making, reduce operational costs, and respond effectively to increasing passenger demand.

The emergence of technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), big data analytics, cloud computing, biometric identification, and smart automation systems has significantly changed airport operations. These technologies facilitate real-time monitoring, predictive maintenance, automated passenger processing, intelligent baggage handling, and integrated operational control, thereby improving both efficiency and operational performance. Consequently, airports that successfully implement digital transformation initiatives are better positioned to achieve higher productivity, operational resilience, and customer satisfaction while maintaining international safety and security standards.

In Saudi Arabia, digital transformation represents one of the key pillars of the Kingdom's Vision 2030, which aims to diversify the national economy, strengthen infrastructure, and establish the country as a global logistics and transportation hub. The aviation sector has received substantial government investment to modernize airport infrastructure, expand operational capacity, and introduce advanced digital technologies that support sustainable growth. As part of these national initiatives, Saudi airports have

increasingly adopted smart airport technologies, including biometric passenger processing systems, intelligent security solutions, automated baggage handling systems, digital monitoring platforms, and AI-supported operational management systems.

King Abdulaziz International Airport (KAIA) in Jeddah is among the most important airports in the Kingdom due to its strategic role in serving millions of Hajj and Umrah pilgrims, international visitors, and business travelers each year. Managing such high passenger volumes requires highly efficient operational systems capable of ensuring smooth passenger movement, effective baggage handling, optimal resource allocation, and continuous coordination among multiple airport stakeholders. Digital transformation therefore plays a vital role in supporting the airport's operational objectives and maintaining high standards of service quality and operational excellence.

Despite the increasing implementation of digital technologies in Saudi airports, empirical research examining their influence on operational performance remains relatively limited. Most previous studies have focused on technological adoption or smart airport concepts in general, while fewer studies have investigated the direct relationship between digital transformation and operational performance within the Saudi aviation context. This gap highlights the need for empirical research that evaluates how digital transformation contributes to improving airport operations and supports the strategic objectives of the Saudi aviation sector.

Accordingly, this study investigates the impact of digital transformation on operational performance in Saudi airports, focusing on King Abdulaziz International Airport in Jeddah. Specifically, it examines the influence of Artificial Intelligence, the Internet of Things, and Smart Airport Technologies on operational performance indicators, including passenger processing efficiency, baggage handling, operational coordination, service quality, and overall productivity. The findings are expected to contribute to both academic knowledge and

practical decision-making by providing evidence that supports the continued digital transformation of Saudi airports in alignment with the objectives of Saudi Vision 2030. This chapter introduces the research by presenting the background of the study, research problem, research objectives, research questions, research hypotheses, significance of the study, scope of the research, limitations, definitions of key terms, and the overall organization of the dissertation.

1.1.Study Background

Digital transformation is fundamentally changing the *modus operandi* of organizations within diverse disciplines, including the aviation industry. Innovative technologies are positively impacting operational efficiency and the overall experience of air travelers. AI, the Internet of Things (IoT), biometric systems, and big data are some of the technologies that modern airports are implementing to enhance operational automation and decision-making (Zaharia and Pietreanu, 2018).

Recent years have witnessed the birth of the so-called “smart airports” that signify the first operational airports with digitally transformed infrastructures. These innovations have promoted efficiency, security, and overall service improvements. In this regard, the operational performance of airports is a core focus for governments and authorities worldwide (Masood and Tan, 2021).

International aviation is a central player in economic development, international commerce, and the promotion of tourism—making it imperative for governments and authorities to prioritize improving the operational performance of airports. Enhanced operational efficiency, minimized delays, and increased passenger satisfaction are some of the high-value outcomes of digital transformation (Tsui et al., 2014).

Digital isolation in Saudi Arabia has transformed into the rapid development of the nation's international bridging infrastructure adding heightened prestige to Saudi Arabia as a

constituent of the global logistics and transportation systems. Currently, the digital development of the aviation industry is a high-priority modernization target across the various strategic sectors of International Air Transport Association (2022) member countries.

Operational efficacy, security, and passenger service experience improvements at airports in the Airports Council International (2023) database, are a product of the increasingly prevalent application of passenger processing and biometric systems, security smart bags, and digital management systems at airports.

As Saudi Arabia's primary entry point for millions of pilgrims to performing Hajj and Umrah, King Abdulaziz International Airport (KAIA) in Jeddah has a disproportionately high volume of passengers. In response, subsequent to the introduction of state-of-the-art digital systems at the airport, improvements of operational efficacy, and the uninterrupted flow of passengers, digital systems have continued to be incorporated (Thums et al, 2023).

Research examining the impact of digital transformation on operational performance in the Saudi aviation industry is lacking even though digital technologies are being implemented more frequently at Saudi airports. Therefore, this study looks at the impact of digital transformation on operational performance in Saudi airports focusing on King Abdulaziz International Airport in Jeddah.

As part of the Kingdom's plan to develop its transportation systems, Saudi Arabia's aviation industry has experienced significant growth over the last ten years. The Kingdom's General Authority of Civil Aviation (GACA), has instituted several of its own measures that center on the development of new airport infrastructures, increases in the volume of people that can flow through an airport, and on the operational efficiency of airports in the Kingdom.

Technological innovation is instrumental to development. Airports have begun to apply new technologies in their operational processes, which streamlines the collaboration between all stakeholders at the airport and enhances the services offered to airport users. Airport

digital management systems provide the ability to monitor operational activities in real-time, which helps managers quickly respond to operational disruptions and the effective utilization of the airport's resources (Remencová & Sedláčková, 2021).

Saudi airports have rolled out numerous new digital systems for better passenger processing. Automatic electronic gates faster immigration by using biometric systems to capture and process IDs. This system conquers long lines leaving more room to process other travelers (ACI 2023).

Moreover, biometrics have arrived in the form of face recognition and other systems at security checkpoints. This form of technology allows faster identity verification at security controls which in turn enhances safety and reduces the volume of travelers at security checkpoints (Poulaki and Papadopoulos 2021).

Investing in all of the technologies mentioned is part of the process of upgrading to 'smart airports' systems and technology to provide operational efficiency and improve the traveling experience of the passengers.

1.2.Research Problem

The past few years have seen remarkable advancements within the aviation sector due to altering technologies. Given the several operational and passenger service technologies emerging from the rapid digitization of the aviation sector (Zaharia & Pietreanu, 2018; Masood & Tan, 2021) and the use of AI, IoT, and Biometrics, Digital Operational Automation, airports have been able to streamline their operational productive use of data to enhance the passenger experience (ACI, 2023) and in the process, develop Smart Airports that operate in a multi-layered operational paradigm.

Aligned with the National Development Strategy under Vision 2030, Saudi Arabia has invested significantly in modernizing its aviation sector. Additionally, some Saudi airports have begun digitizing operational initiatives, tailored biometrics, automated passenger

processing, smart digital baggage, and management systems to enhance the operational capacity and quality of the passenger experience of airports (IATA, 2022).

Given the technological advancements, the degree of impact digital transformation initiatives have on the operational performance of airports in Saudi Arabia is still under-researched. The majority of studies available have looked at digital transformation in the aviation industry, either on a global level or in a regional context and have failed to address the operational performance of airports in Saudi Arabia (Thums et al., 2023).

Also, there is not much evidence to support the claim that operational improvements in passenger processing, baggage handling, and overall operational coordination of Saudi Airports have been a result of digital technologies. Though some studies have pointed out the role of digital technologies in improving the operational efficiencies of airports, little has been done in the Saudi aviation sector (Tsui et al., 2014).

For this reason, this study aims to address this, in order to establish the relationship that exists between digital transformation and operational performance in Saudi airports, focusing on King Abdulaziz International Airport in Jeddah. It seeks to answer the question of how digital technologies have improved operational processes in airports in order to identify the level of effect digital transformation has on the operational efficiency and quality of services at airports.

1.3.Research Objectives

The broadest intention of this research is to establish the relationship between digital transformation and operational performance of Saudi airports.

Specific Objectives

- 1- To compile a list of technologies that have been implemented digital transformation on Saudi airports.

- 2- To determine the correlation between digital technologies and operational efficiency of airports.
- 3- To determine the effect of digital technology on processing passengers at the airports.
- 4- To analyze how operational performance of King Abdulaziz International Airport has been transformed digitally.

1.4. Research Questions

- 1- What is the impact of digital transformation technologies on operational performance of airports?
- 2- What impact do digital technologies have on improving the processing of passengers?
- 3- What are the operational improvements of digital transformation at King Abdu Aziz Airport?

1.5. Research Significance

The importance of this study can be viewed from both practical and academic points of view. From the academic standpoint, the study elucidates associations between digital technology and operational performance in the aviation industry, specifically in the airports, which has scarcely been covered in the literature, particularly, the Saudi Arabia aviation industry (Zaharia & Pietreanu, 2018; Masood & Tan, 2021).

From a practical perspective, the results of this study will help decision-makers, airport and service providers, and policymakers in Saudi Arabia understand the role of digital technologies on the operational efficiency of airports, and the quality of services of passenger processing systems (ACI, 2023).

The findings of the study can also assist in smart airports construction planning and investment in Saudi Arabia. Identifying the operational advantages of digital transformation can help airport management direct resources to technologies that create elevated levels of operational efficiency in the airport and an improved passenger travel experience.

In the end, this research will further the goals of Saudi Vision 2030 by showing how digital tools can provide socio-economic value for the construction of new, modern, smart airports.

1.6.Scope of the Study

This study considers the subject of the study, geographical limit, target population and time limit are the scope of the study. The study examines the effect of digital transformation on operational performance at Saudi airports and specifically includes King Abdulaziz International Airport (KAIA) located in Jeddah. Three aspects of Digital transformation are discussed: Artificial Intelligence (AI), Internet of Things (IoT), and Smart Airport Technologies. The effectiveness of operations is measured through the efficiency of passengers and bags, operational coordination, service quality and overall operational productivity.

The target population is those employees who work in operational departments of King Abdulaziz International Airport, such as airport operations, information technology, passenger services, and airport management. A representative sample of the airport workers is sampled, and the data is collected through a structured questionnaire. The study is of cross-sectional research design, collecting data for the academic year 2026. The results are supposed to represent the current status of digital transformation, and its impact on operational performance in the selected airport and could be beneficial for other airports in Saudi Arabia.

1.7.Limitations.

There are a number of caveats to keep in mind when reading the results of this study. First, the study is based on King Abdulaziz International Airport in Jeddah only, so the results of the study may not be entirely applicable to other airports in Saudi Arabia or other countries, because of the variations in operational environments and technological maturity.

Secondly, the study adopts a cross-sectional research design where the data is collected at one point in time. As a result, the research reflects respondents' perceptions at the time of the study and does not account for shifts in digital transformation practices or performance over time.

Third, the study is based on self-reported data and questionnaires. Confidentiality and anonymity are maintained to ensure that respondents are willing to give forthright answers, but there may be response bias because of participants' perceptions.

Finally, the study is geared towards three aspects of digital transformation – Artificial Intelligence, Internet of Things and Smart Airport Technologies. This will not be a study of other technological, organizational, or environmental factors that could impact operational performance.

1.8. Definition of Terms

The following definitions are used for this study:

Digital Transformation: An organizational strategy that uses digital technology to transform people, processes, services and/or decisions in ways that enhance operational efficiency, service quality and organizational performance.

Artificial Intelligence (AI): Computer systems and intelligent algorithms that can learn, predict, make decisions, recognize patterns, and optimize operations, which are traditionally tasks performed by humans.

Internet of Things (IoT): A network of physical devices with embedded sensors and communication capabilities that gather, share and process real-time operation data, which can be used to monitor, automate and make decisions.

Smart Airport Technologies: These are high-tech systems incorporated into airport operations such as biometric systems, automated passenger processing, digital monitoring

systems, intelligent baggage handling and integrated operational control platforms, which enhance the efficiency and passenger experience of airports.

Operational Performance: The ability of the airport to use its resources to achieve operational goals such as efficient passenger handling, effective baggage handling, operational coordination, high service standard, reduction of operational delays and improving overall airport productivity.

King Abdulaziz International Airport (KAIA): One of the biggest international airports in Saudi Arabia with domestic and international flights, including millions of Hajj and Umrah pilgrims each year in Jeddah. It is empirical in nature, and it is the research setting.

1.9.Chapter Summary

The chapter gave the introduction to the research through the background of the study, highlighting the importance of digital transformation in the aviation industry. It defined the research problem, stated the research goals, questions, and hypotheses and discussed the academic and practical relevance of the research. Further, the chapter outlined the scope and limitation of the study as well as clarified the major concepts utilized in the dissertation. These introductory chapters lay the groundwork for the study, and a thorough literature review is presented in Chapter Two.

CHAPTER TWO

2. LITERATURE REVIEW

Introduction

In the Fourth Industrial Revolution, digital transformation has become one of the most effective strategies for a change in business models across various industries. Technological innovation is becoming increasingly quick, from Artificial Intelligence (AI) and the Internet of Things (IoT) to cloud computing and big data analytics, blockchain, digital twins and automation, all of these are changing the ways in which organizations generate value, handle resources, provide services and engage with stakeholders. A digital transformation is not only about adopting digital technologies, but rather a strategy of the organization that incorporates the use of digital technologies in business models, organizational processes, organizational culture, and decision-making in order to increase the efficiency and innovation of the organization, as well as create a long-term competitive advantage (Vial, 2019; Verhoef et al., 2021).

With its high volume of passengers, growing operations complexity, strict safety standards, and passengers' service quality expectations, the aviation industry is one of the fastest movers on the digital transformation spectrum. Today, the airport has become a highly interconnected digital ecosystem, in which real-time information is exchanged among stakeholders (customs agency, immigration agency, security agencies, air carrier, airport operator and passengers). The technologies developed have brought great efficiencies to the management and functioning of airports, with respect to the management of resources, passenger processing and operational resilience (Zaharia & Pietreanu, 2018).

Technological advancements have paved the way for smart airports, where cutting-edge digital solutions are enhancing all airport operations. Artificial Intelligence facilitates predictive analytics, intelligent decision-making and automating repetitive operational tasks.

The Internet of Things (IoT) technologies enable constant surveillance of the airport infrastructure by a network of sensors equipped with information transmission capabilities that offer real-time operational data. The use of cloud computing and big data analytics enables data sharing and joint decision-making among airport stakeholders, and biometric technologies have revolutionised the identification of passengers and the management of their crossing points (Masood & Tan, 2021).

However, the necessity for digital transformation became even more apparent after the COVID-19 pandemic, which helped fast-track the implementation of technologies that work without coming into contact with passengers/people, automated passenger processing systems, intelligent surveillance and digital health verification systems. Various airport operators globally have begun to invest in digital solutions to guarantee operational continuity and reduce physical interaction between users and airport staff. Digital transformation is therefore key to making airports more resilient, more flexible and more sustainable (International Air Transport Association [IATA], 2022).

Operational performance is one of the most critical performance indicators to assess the effectiveness of airports. The efficient functioning of the airport has a positive impact on the level of satisfaction of its passengers, the performance of the airlines, the airport's profitability, its safety and security and the economic development of the country. Operational performance is not just a single indicator and is composed of several aspects such as passenger processing efficiency, baggage handling performance, aircraft turnaround time, operational coordination, infrastructure utilization, service quality, and resource productivity (Tsui et al., 2014). The key operational dimensions that are directly enhanced by digital transformation include automation, real-time information sharing, predictive maintenance, intelligent scheduling, and evidence-based decision making by managers.

Saudi Arabia has designated digital transformation as a key component of its national strategy, Vision 2030, which seeks to diversify the economy, modernize infrastructure, enhance public services, and make the Kingdom a top logistics hub in the world. As part of this strategy, the government has made significant investments in the aviation industry to enhance airport infrastructure, modernise airport facilities, and adopt advanced digital technologies. The use of biometric identification systems, automated passenger processing, intelligent baggage handling technologies, integrated airport operational databases, artificial intelligence applications and smart monitoring systems have been implemented in Saudi airports to enhance operational efficiency and passenger experience (General Authority of Civil Aviation [GACA], 2023).

King Abdulaziz International Airport (KAIA) in Jeddah is one of the Saudi Arabia's most vital transportation hubs, strategically located. The airport is faced with a high level of operational complexity because of its high volume of millions of Hajj and Umrah pilgrims and international tourists and business travelers who use the airport on an annual basis. To handle such massive passenger numbers, the airport needs to have advanced digital systems that can manage its operations effectively, ensure optimal use of resources, minimize congestion, and uphold safety and service standards.

Although the Saudi airports have invested significantly in the process of airport digitalisation; there is in general a relative lack of empirical research on the impact of digital transformation on operational performance in airports in Saudi Arabia. The previous published work has mainly concentrated on technological implementation, smart airport concepts, or on a single digital technology and not on the integrated effects of Artificial Intelligence, Internet of Things technologies and Smart Airport Technologies on airport operational performance. Additionally, the few empirical studies that have explored these relationships in the Saudi aviation context have failed to adequately cover these relationships.

For this reason, the present chapter offers extensive a review of the literature on theory and empirical work related to the study. It starts with the concept of Digital Transformation and then explores the topic of Artificial Intelligence, Internet of Things technologies, Smart Airports and Operational Performance. The chapter then critically reviews the previous empirical studies that were published from 2020 to 2026, the theoretical framework that was used to support the research, the existing research gap, the conceptual framework, the research hypotheses and ends with the chapter summary. This review sets the foundation of theory that will be considered in the study of the effect of digital transformation on the operational performance of King Abdulaziz International Airport.

2.1.Digital Transformation

2.1.1. Definition of Digital Transformation

Over the last decade, the concept of digital transformation has been one of the most talked-about in management, information systems, and organizational studies. While often seen as a technological innovation, the term "digital transformation" has a broader meaning than just digital technology, researchers say. Rather, it is an overall and radical reshaping of the organization, that is, a change in business models, structures, processes, leadership, culture, and the creation of value processes called value creation mechanisms, as a result of integrating digital technologies in an organization's strategic path (Vial, 2019).

Vial (2019) defines digital transformation as "a process that intends to modify an entity to create substantial changes in its properties in terms of information, computing, communication and connectivity technologies" (p. 121). The definition reflects that digital transformation is not just about embracing new technologies, but also a strategic shift within the organization that generates new capabilities and competitive edge.

In the same way, Verhoef et al. (2021) describe digital transformation as introducing a change in the operations of organizations, customer interactions, products and services and business models through the integration of digital technologies. The authors stated that it's crucial for organizations to reimagine their strategy, structure and processes for a digital transformation, and not just digitize current ones.

According to Westerman, Bonnet, and McAfee (2014), digital transformation is the use of digital technologies to change the nature of an organization's performance and reach. Their definition focuses on tangible organizational results such as higher operational efficiency, customer satisfaction, innovation capacity and financial results.

When analyzed from the perspective of information systems, digital transformation is considered as the organizational ability to integrate new technologies and innovations in management to enhance organizational agility and sustainability in the long-term (Warner & Wäger, 2019). Digital transformation therefore should be seen as an ongoing strategic process, and not as a single technological investment.

In the context of airport management, digital transformation involves embedding smart digital technologies such as AI, the Internet of Things (IoT), biometric technologies, cloud computing, digital twins and advanced analytics into airport operations to enhance operational efficiency, passenger experience, safety, resource use and decision making (Masood & Tan, 2021).

In this study, digital transformation is intended by:

The strategic deployment of cutting-edge digital technologies at airports to enhance operational efficiency, service quality, resource utilization and overall operational performance.

2.2.Evolution of Digital Transformation

Digital transformation has gone through multiple stages. At first, organization's work was mainly concerned with digitization—the process of converting analog data to digital format. They included electronic documents, electronic databases of information, and electronic record management. While digitization made the information more accessible, it had little impact on the organizational strategy or operational performance (Legner et al., 2017).

The second phase was the digitalization phase, which was characterized by the redesign of operational processes with digital technologies. The key points of digitalization were workflow automation, electronic communication, enterprise resource planning systems, customer relationship management systems and integrated information management. While operational efficiencies were achieved, the traditional business models were still used by organisations to a large extent (Brennen & Kreiss, 2016).

The third and current phase is digital transformation – a widespread transformation of organizations brought about by new technologies like AI, IoT, cloud, blockchain, robotics and big data analytics. In this stage, organizations redesign their business models, create digital ecosystems, enhance customer experience, automate complicated business processes, and build data-driven decision-making capabilities (Verhoef et al., 2021).

Digital transformation has been the same in the aviation industry. Airports began to use computers for reservation systems and operational records, followed by the use of self-service check-in kiosks, electronic boarding passes, automated baggage systems, and integration of a database of operational information from the airport. In recent years, airports have increasingly embraced other applications of artificial intelligence, including the management of passenger flows (Zaharia & Pietreanu, 2018), biometric border control, predictive maintenance systems, and digital twins, which mimic the operation of an airport in real time (Zaharia & Pietreanu, 2018).

Saudi Arabia has pushed this change with Vision 2030, with a significant investment in the modernization of airports, the implementation of digital government programs, smart infrastructure projects, and the adoption of artificial intelligence solutions. Advanced digital technologies are becoming more common at airports to enhance operational efficiency and the experience of passengers at airports like King Abdulaziz International Airport.

2.3.Characteristics of Digital Transformation

There are some features noted in the literature which differentiate digital transformation from conventional technological modernization.

First, digital transformation is strategic. Organizations do not only rethink their technology but also their strategy, governance, business model and competitive positioning by embracing digital innovation (Vial, 2019).

Second, digital transformation is a process that impacts the entire organization. It impacts all aspects of the organization such as operations, finance, marketing, human resources, customer service, supply chain and strategic planning. Therefore, it is essential to have cooperation among various parts of the organization in order to achieve digital transformation.

Thirdly, digital transformation is about data. The organizations have looked to the operational data in real-time, predictive analysis, and artificial intelligence to assist management decisions and ongoing operation enhancement processes (Verhoef et al., 2021).

Fourth, digital transformation promotes organizational agility. Digital technologies allow organisations to be agile in the face of shifting market trends, disruption to operations, customer expectations, and technological innovation. Especially in airports, where the number of passengers and the conditions of operation are constantly fluctuating, the importance of agility is growing.

Fifth, digital transformation is customer centric. Digital technology is used in modern organizations to enhance customer service – to provide personalized services, respond quickly, respond smoothly and provide greater accessibility. At airports, the customer-centric digital services include biometric identification, mobile applications, real time flight information, automated baggage tracking and contactless passenger processing.

Last, but not least, digital transformation is an ongoing process. While some information technology projects are single events, digital transformation is an ongoing journey of an organization that involves continuous adaptation to technology, training employees, change the organization, and change the organization's strategy (Warner & Wäger, 2019).

2.4.Dimensions of Digital Transformation

Digital transformation is a multi-dimensional phenomenon in the organization that goes beyond technology and involves strategic, organizational, technological and cultural change. Researchers have introduced various models to measure digital transformation, but most agree that it has multiple interrelated dimensions that work together to attain the success of digital transformation projects (Verhoef et al., 2021). These dimensions have a positive impact on organizational performance in terms of increasing operational efficiency, organizational agility, customer satisfaction, innovation capacity, and the quality of decision making.

Vial (2019) asserts that digital transformation is the interaction between technological, organizational, and strategic and environmental aspects which leads to organizational value. Likewise, Warner and Wäger (2019) suggested that digital transformation should involve the dynamic capabilities of organizations, digital leadership, innovation culture, and strategic management in conjunction with the use of digital technologies. In the field of aviation these

dimensions collectively help to design intelligent aviation operational systems that can react quickly to operational challenges and improve the passenger's experience.

2.4.1. Technological Dimension

Technological dimension is the base of digital transformation. Advanced use of digital technologies that assist the operations and strategic goals of an organization. Such technologies include Artificial Intelligence (AI), Internet of Things (IoT), Cloud Computing, Big Data Analytics, Blockchain, Robotics, Biometric Systems, and Digital Twins (Verhoef et al., 2021).

Technological infrastructure in the airport allows for the monitoring of operations at the moment, automatic processing of passengers, predictive maintenance, intelligent baggage handling, verification of passengers by biometric data, and integration of the airport operational databases. Increasingly, airports are using linked digital platforms that allow the sharing of information between the various partners in the airport (airline, airports authorities, security, customs). Technology for this reason has emerged as one of the main factors determining the operational efficiency of airports (Masood & Tan, 2021).

2.4.2. Organizational Dimension

There is a significant organizational transformation to be made to digital transformation. The organizational dimension is about changes to organizational structures, business processes, governance, leadership and employee capacities that are needed to successfully implement digital transformation (Warner & Wäger, 2019).

Firms making their digital transformation may adopt new workflows, shift decision-making from central to decentral, foster cross-functional collaboration and invest in ongoing employee learning. The flexibility of an organization allows institutions to effectively adapt to new technology and ensure they operate without disruption. When considering airports, organizational transformation helps cooperation between various operational departments

such as passenger services, airport operations, information technology, maintenance, security, and airline coordination.

2.4.3. Strategic Dimension

The strategic part highlights the strategic link between digital technologies and organizational goals and long-term competitive strategies. The key principles of digital transformation are to align with the organization mission, enhance customer value, build competitive advantage and build sustainable organizational capabilities (Vial, 2019).

In airport management, digital strategies target enhancing the satisfaction of passengers, their operations, sustainability, safety and international competitiveness. Strategic planning establishes priorities for technology investment, digital governance, performance measurement, and innovation initiatives. Digital transformation, therefore, is not just a technological initiative, but a strategic project for an organization.

2.4.4. Cultural Dimension

The success rate of digital transformation is heavily dependent on the organizational culture. The cultural dimension is a set of employee attitudes towards innovation, technology adoption, organizational learning, collaborating, and continuous improvement (Westerman et al., 2014).

The use of a supportive digital culture promotes experimentation, sharing of knowledge, empowerment of employees and acceptance of organizational change. On the other hand, the push-back from organizations against change is often one of the biggest hurdles to digital transformation deployment. As a result, airport authorities focus more and more on digital literacy for employees, management development, and innovation management to support successful transformation.

2.4.5. Customer-Centric Dimension

The focus of modern-day digital transformation is on enhancing the customer experience by providing personalized, efficient and accessible services. Digital technologies help organizations gain insights into customers' behavior, predict customer needs and provide personalised services using real-time data analysis (Verhoef et al., 2021).

Customer-focused technologies, such as biometric boarding systems, self-service kiosks, mobile airport apps, automated baggage handlers, digital wayfinding and passenger notifications, are increasingly seen in airports. These technologies help increase the speed of passengers waiting and improve the quality of travel.

2.5. Benefits of Digital Transformation.

Many factors, such as technology, economy, competition, and government-related, have contributed to the growing use of digital transformation in industries. Such drivers are usually divided into external and internal organizational drivers.

Rapid technological change is one of the most important factors. The ongoing advancements in AI, cloud computing, IoT, and big data analytics have spurred businesses to adopt digital transformation in their operations to enhance service delivery (Vial, 2019).

Another key force is competition. Digital technologies are becoming more commonplace in organizations as a way to stay competitive, increase operational efficiency, cut down on costs, and stand out in services. Airports are evaluated on a worldwide basis in terms of operational performance, passengers' satisfaction, service quality and technological sophistication.

Changing customer expectations also stimulates digital transformation. Today's travelers demand contactless, personalized and seamless travel experiences that are mobile, biometric and digital.

This is also driven by government initiatives. In Saudi Arabia, the National Transport and Logistics Strategy – Vision 2030 – and national digital government strategies have been leading the way in driving the pace of airport digitalization, and this has led to investments in intelligent infrastructure, automation, AI and smart airport technologies.

Maintaining physical distancing for passengers and staff, and using digital systems for automated passenger processing, remote monitoring of operations, and smart health verification systems, are further driving digitalization in airports, which was further accelerated by the COVID-19 pandemic.

2.6.Challenges of Digital Transformation.

Although digital transformation offers many advantages, it also brings challenges to the organization that can affect the success of the implementation. Technological investment is not the sole path towards digital transformation, but a number of barriers, including managerial, organizational, technological, financial and cultural, must be overcome (Vial, 2019).

Organizational resistance to change is one of the common problems reported. Digital transformation can be seen as a threat to existing working routines, job security or workload for employees. Resistance can cause a delay in implementation, hinder acceptance of technology and restrict organisational learning. Thus, change management, employee engagement and ongoing communication are essential for digital transformation to be successful (Westerman et al., 2014).

Implementing these is also said to be a major challenge. Creating digital infrastructure, upgrading information systems, acquiring advanced technologies and training employees is a significant cost. While digital transformation clearly produces long-term economic value, large-scale digital transformation projects, especially with integrated digital ecosystems,

often leave companies with financial issues that they have to navigate during the implementation process.

Another major issue that has come to the fore is cybersecurity. The more connected an organisation becomes with digital platforms, the greater the likelihood of a cyber attack, unauthorized access, ransomware and data breaches. The airport is a critical national infrastructure and also handles enormous amounts of delicate and delicate details relating to passengers, which makes cybersecurity an essential priority. Therefore, the cybersecurity frameworks, continuous monitoring, employee awareness and adherence to international information security standards are all important components of effective digital transformation.

However, also big challenges are the lack of digital skills and competencies. Professionals with a strong skill set in managing and applying AI, cloud computing, cybersecurity, predictive analytics and IoT technologies are essential for successful digital transformation. It is therefore the imperative of the organizations to continuously invest in employee training, digital literacy and professional development.

The integration of legacy systems with modern digital technologies is another challenge. A number of airports operate outdated operational systems that were not developed to be interoperable with newer technologies. Successful integration of legacy infrastructure with modern digital platforms can be more complex, costly, and risky.

Lastly, organizations often face issues with digital governance, leadership buy-in, regulatory oversight, and data quality. All these factors play a role in the success of digital transformation projects and the impact they have on the expected operational improvements.

2.7.Critical Review of the Literature.

Over the last 10 years, there has been a growing body of literature on digital transformation, as digital technologies have become more prominent in different industries. The existing research has mostly reached a consensus that digital transformation positively affects the performance of organizations by enhancing their operational efficiency, innovation capabilities, service quality, and customer satisfaction. Nevertheless, even with this consensus, there are some conceptual and empirical concerns, especially in the aviation industry.

The majority of early research focused on digital transformation as a technology adoption, focusing on the adoption of information systems, automation technologies and digital platforms (Westerman et al., 2014). Recent studies have focused on digital transformation as an overall organizational initiative that requires developing technology, restructuring the organisation, leadership, organisational culture, and business model (Vial, 2019; Verhoef et al., 2021). This wider view offers a more holistic view of digital transformation and helps capture an understanding of it in a multi-dimensional way.

In the field of airport management, research has now been undertaken on the use of Industry 4.0 technologies such as Artificial Intelligence, Internet of Things, cloud computing, robotics, biometric systems, and predictive analytics. The empirical evidence indicates that such technologies enhance the overall operational efficiency, passenger handling, baggage management, security systems, and resource utilization at airports (Masood & Tan, 2021; Thums et al., 2023). However, most of the research available takes the technology as a single entity instead of studying digital transformation as an overall organizational talent.

Yet another restriction is the geographic focus of earlier research. A large proportion of the empirical research that has been done has been done in Europe, North America, Australia and East Asia. While helpful to the theoretical understanding, the results of these studies may

not be applicable to developing economies or rapidly changing regions like the Middle East. Various institutional contexts, technological systems, regulations, investment priorities, and organizational cultures could have a significant impact on the outcomes of digital transformation.

Moreover, a considerable amount of past research highlighted the passenger experience and customer satisfaction, whereas comparatively less focus was given on the operational performance indicators. While passenger satisfaction is one of the crucial results of airport digitalization, the operational performance refers to a much wider spectrum of organizational outcomes, such as baggage handling efficiency, operational coordination, airport productivity, infrastructure utilization, maintenance efficiency, aircraft turnaround performance and resource allocation. These operational parameters are not sufficiently investigated in the literature.

Most of the studied methods used are cross-sectional survey and a descriptive statistical analysis. Few studies apply comprehensive digital transformation models that combine various aspects of digital transformation and operational performance outcomes. Furthermore, the majority of the studies have explored single technological elements without considering the interoperability of Artificial Intelligence, Internet of Things technologies and Smart Airport Technologies in airport operations.

Although the Saudi government made significant efforts to support and invest in the digital transformation of the country under Vision 2030, there is little empirical research investigating the digital transformation of airports in Saudi Arabia. Most of the published literature consists of descriptions of digital initiatives or the national modernization plans, but not of empirical assessments of the role of digital transformation in improving operational performance. As such, there is still a lack of evidence on the effectiveness of digital

transformation efforts adopted by major airports in Saudi Arabia like King Abdulaziz International Airport.

To overcome these limitations, the present study investigates three major dimensions of digital transformation, Artificial Intelligence, Internet of Things technologies and Smart Airport Technologies and how they impact on the operational performance through an integrated conceptual framework. The study's focus on King Abdulaziz International Airport (KIA) provides empirical evidence for one of the largest and strategically most significant airports in the Middle East, which extends the knowledge in the field of airport management and digital transformation.

In this section, a thorough review of digital transformation has been done from both theoretical and practical aspects. The discussion highlighted that digital transformation is not merely about technology but also a strategic organizational process, which requires technology innovation, organizational change, leadership and a focus on the customer and their service improvement. A range of definitions, features, size, motivators, advantages and implementation hurdles were explored to get a clear understanding of the concept.

The review also underscored the emerging significance of digital transformation in the aviation sector, where cutting-edge technologies like Artificial Intelligence, the Internet of Things, cloud computing, biometric identification, predictive analytics, and digital twins have revolutionized airport operations. These technologies play a key role in operational efficiency, intelligent decision making, better passenger service, security, predictive maintenance and sustainable management of the airport.

The literature also showed that Saudi Arabia has been progressing significantly in airport digitization with the support of Vision 2030 and the projects that were executed by the General Authority of Civil Aviation (GACA). The introduction of smart technologies has become a growing trend in major airports, especially King Abdulaziz International Airport,

with the aim of optimizing the management of the airport and its services. However, the review found that there were certain research gaps that warrant attention, such as the scarcity of empirical research that has looked at the synergy of Artificial Intelligence, Internet of Things Technologies and Smart Airport Technologies on the operational performance in Saudi Airport.

For this reason, Artificial Intelligence is the first major dimension that is analyzed in the next section of our article. The following section discusses the theoretical underpinning, developments, technologies, application, advantages, implementation and empirical evidence on the use of Artificial Intelligence in Airport Operations to provide the theoretical underpinning for the first independent variable of the present study.

CHAPTER THREE

3. RESEARCH METHODOLOGY

Introduction

The research methodology used in this study to explore the effect of digital transformation on operational performance in the airports of the Kingdom of Saudi Arabia, specifically King Abdulaziz International Airport (KAIA) in Jeddah is presented in this chapter. The methodology should be a systematic plan to collect, analyze and interpret data to reach the goals of the study and test the proposed hypotheses. Adopting the right research method is crucial to guarantee the validity, reliability, and credibility of the research outcomes and to establish the relationship between the independent variables (Artificial Intelligence (AI), Internet of Things (IoT), and Smart Airport Technologies) and dependent variable (Operational Performance).

This study is designed to describe and analyze, with quantitative research methods, because of the nature of the research problem and objectives. Using quantitative research makes sense because it allows for data to be collected in numerical form from a larger sample size and allows for statistical analysis to look at the relationships between the study variables (Creswell & Creswell, 2023). This study uses a structured questionnaire as the main data collection method to gauge the perceptions of those who responded to the survey about the implementation of digital transformation technologies and how they affect the operational performance of airports.

The approach of research and research design, population of study, sampling technique, sampling size, data collection technique, research instrument, measurement of variables, validity of research instrument, reliability of research instrument, pilot study, ethical considerations, and data analysis techniques used in analyzing the collected data are

described in this chapter. The methodological procedures serve as the basis for the empirical investigation presented in the next chapter.

3.1. Research Philosophy

Research philosophy is the knowledge system of beliefs and assumptions about the nature of knowledge, reality and the appropriate way of producing scientific evidence. It helps researchers choose appropriate research methods, understand the process for gathering data, and properly analyze research results. Research philosophy also has a significant impact on each phase of the research process, from the formulation of research questions to the drawing of conclusions and recommendations (Saunders et al., 2023).

In management and social science research, several research philosophies are used, such as positivism, interpretivism, realism and pragmatism. The two philosophies are founded on separate ontological, epistemological and methodological beliefs about the nature of reality, the nature of knowledge and the process of acquiring knowledge.

The present study used the research philosophy of positivism that focuses on objective, measurable, and independent realities from the researcher. The positivism approach focuses on the application of scientific approaches, objective measurement, hypothesis testing and statistics to explain relationships between variables. Positivist research aims to generate valid, reliable and generalizable results by gathering data in the form of numbers using standard research instruments as Creswell and Creswell (2023) stated.

The positivist philosophy is deemed to be suitable for the current study since the study aims to study the measurable relationship between the Digital Transformation technologies and operational performance. Operational Performance is the dependent variable and will be measured using standardized indicators and the independent variables Artificial Intelligence, Internet of Things, and Smart Airport Technologies will be operationalized in terms of

measurable items of the questionnaire. Correlation and multiple regressions analysis are used to statistically examine the relationships among these variables.

Besides, the positivist philosophy justifies use of structured questionnaires, probability sampling methods and quantitative statistical analysis which are applied in the present study. The results of this philosophical approach will be expected to give objective findings of the impact that the digital transformation initiatives are having on the operational performance of the airport and add to the knowledge of airport management and digital transformation.

Also, the use of positivism gives the study more credibility since the researcher bias is minimized and data is gathered and analyzed in the same way. The data obtained from all the respondents in this study are comparable and can be analysed and tested objectively with the aid of statistics. As a result, the positivistic approach is the most appropriate philosophy of the research to achieve the goals of the research.

3.2.Research Approach

In the present study, a quantitative research approach was adopted to explore the effect of digital transformation on the operational performance of Saudi airports and in specific focus, the study examined the digital transformation impact on the operational performance of King Abdulaziz International Airport (KAIA) in Jeddah. The quantitative approach is the most suitable approach for the study as the study is aimed at examining the relationships among specifically defined variables with numerical data obtained from a fairly large sample of airport employees. This helps the researcher to be objective in measuring respondents' perceptions, testing the hypotheses tested in the study and determining the statistical significance of the relationship between independent and dependent variables.

The use of quantitative research is common in the studies concerning business and management as it offers systematic ways of collecting measurable data and using statistical techniques to explain the phenomena in an organization. Creswell and Creswell (2023) define

quantitative research as research that involves testing a predetermined theory and analyzing the relationships between variables by means of numbers and statistical analysis. Likewise, Sekaran and Bougie (2020) pointed out that quantitative methods are especially suitable when researchers are interested in exploring causal relationships and when they want to draw generalizations to a broad population.

The present study examines the effect of three independent variables, namely Artificial Intelligence (AI), Internet of Things (IoT), and Smart Airport Technologies on the dependent variable Operational Performance. The variables are measured using a structured questionnaire with a five-point Likert scale. The responses gathered are converted to numbers, and the results are statistically analyzed in IBM SPSS Statistics. Descriptive statistics were used to describe the characteristics of respondents and their perceptions, and inferential statistics such as Pearson correlation and multiple linear regression were used to analyse the relationship between the study variables.

One of the advantages of quantitative methods is that it generates objective and reliable results as it reduces the researcher's bias as much as possible. Standardized questionnaires make it easier to compare data from all respondents, making research results more reliable and valid. Moreover, quantitative analysis makes it possible to test the hypotheses and also the researcher can assess the size and direction of the links among digital transformation endeavors and operational performance.

Another key benefit is the capacity to extend the study sample results to the target population when sampling has occurred in an appropriate way. The data in this study is gathered from employees from the operational departments of King Abdulaziz International Airport. A probability sampling method and the size of the sample increase the representativeness of the sample and improve the external validity of the results.

In conclusion, the quantitative research method is a solid and systematic approach for studying the impact of digital transformation on airport operational performance. It fits into the research aims, conceptual framework, and hypotheses and helps the researcher demonstrate empirical support that adds to scholarly research and management practice.

3.3. Research Design

Research design is the general framework or plan for gathering, measuring and analyzing data to answer the research questions and fulfill the research objectives. It lays out a logical order, there is a link from research problem to research objectives, hypotheses, data collection, and statistical analysis, and the research is conducted in a systematic and scientific way (Creswell & Creswell, 2023). A research design is important to ensure that the results of the research are valid, reliable and credible and that any possible sources of bias are minimized.

The descriptive-analytical cross sectional research design is used in the present study to explore how digital transformation affects the operational performance at King Abdulaziz International Airport (KAIA), Saudi Arabia. This design was chosen because it is especially well suited to studies that not only seek to describe phenomena that exist in their organization but also investigate the statistical relationships between the variables of the study.

The descriptive part is aimed at describing the existing state of digital transformation in the airport. It explores employees' perceptions on the implementation of Artificial Intelligence (AI), Internet of Things (IoT) and Smart Airport Technologies and their perception of operational performance. Descriptive research can be used to summarise the characteristics of an organisation and detect any emerging trends without changing the study variables (Saunders et al., 2023).

The analytical component goes beyond description and examines the relationships between the independent and dependent variables in a statistical way. In particular, the study questions how much the deployment of Artificial Intelligence, Internet of Things technologies and Smart Airport Technologies has an impact on operational performance. The test of the research hypotheses uses inferential statistical techniques such as Pearson correlation analysis and multiple linear regression.

Moreover, the study design is cross sectional survey design, which is used to collect data from the respondents at the same time. There are many advantages of cross-sectional studies, including the fact that they are a very time and cost-effective way of collecting data from a fairly large number of respondents over a small period of time (Sekaran & Bougie, 2020). Cross-sectional research is conducted at one point in time and is often used to assess the perceptions of respondents at one time; this is particularly suitable for assessing current practice within organizations.

Structured questionnaires are the main tool used for data collection. All respondents are given the same series of standardized questions on a 5-point Likert scale from Strongly Disagree (1) to Strongly Agree (5). Standardized measurement ensures uniformity of data and allows statistical analysis in quantitative form.

The research design chosen is clearly suitable for the research purpose of the present study. In this study, the research approach must be descriptive-analytical cross sectional design, because the research is not aimed at changing the organizational practice, but at knowing employees' perceptions of the digital transformation that is currently being done in the organization and the effect it has on the performance of the organization.

3.4. Research Strategy

Research strategy is the overall plan that will be used to collect and analyze data to answer the research questions. It offers practical advice on the methods, procedures and techniques for the application of the chosen research design (Saunders et al., 2023). The research strategy is determined by the purpose of the research, the research questions, the resources available, and the type of variables in the research.

The present study uses the survey research strategy as one of the most common research strategies in business, management and organizational research. The survey research method allows researchers to gather information in a relatively large number of people with standardized questionnaires. This method is well adapted for assessing attitudes, perceptions, opinions or behaviors toward organizational phenomena (Creswell & Creswell, 2023).

The survey strategy has several benefits that allow objectives of the present study. Firstly, it enables data to be gathered effectively from the employees of the different operational departments of King Abdulaziz International Airport. Secondly, using standardized questionnaires helps to streamline data collection, making sure that the information is collected uniformly and with greater accuracy. Third, the data collected in surveys can be readily converted into numbers that can be statistically analyzed with IBM SPSS Statistics.

One other upside to the survey technique is that it can generate findings that may be generalized to the target population, if suitable sampling methods are used. As the study explores employees' perceptions of digital transformation projects, it is important to note that the survey approach also offers a good way to gather similar feedback from individuals from various departments and levels of responsibility.

After considering a wide range of literature in the field of digital transformation, Artificial Intelligence, Internet of Things, Smart Airport Technologies and operational performance, the questionnaire was developed. The instrument is divided into two main parts. The first part gathers demographic data, and the second one assesses the research variables with several statements taken from the validated instruments adopted in previous empirical research.

In general, the survey design approach is the best way to gather data for the research aims of the current study, as it enables systematic data collection, provides evidence for statistical hypothesis testing, and yields credible evidence on the link between digital transformation and operational performance.

3.5.Study Population

The study population is the entire group of people who have the characteristics of concern to the study problem from whom the researcher wants to make conclusions (Sekaran & Bougie, 2020). Clearly defining the study population is important since this will set the boundaries of the research and form the basis of the choice of the sample.

The study's target population are the employees of the operational departments at King Abdulaziz International Airport (KAIA) in Jeddah, Saudi Arabia. One of the biggest and busiest airports of the Kingdom, King Abdulaziz International Airport handles millions of passengers annually, including a high volume of Hajj and Umrah pilgrims. The airport has significantly committed to digital transformation efforts, making it a suitable environment to explore the correlation between DT and operational performance.

Employees in the study work in the departments directly related to the implementation of digital technology and airport operations. These departments include:

- Airport Operations
- Information Technology (IT)

- Passenger Services
- Baggage Handling Operations
- Security Operations
- Airport Management

The selected departments were identified as key departments that are directly involved in the implementation and utilization of Artificial Intelligence, Internet of Things technologies, Smart Airport Technologies and other digital transformation activities impacting airport operational performance.

The total target population is estimated to be about 950 employees from different operational departments in this study. This rough estimate population size is adequate for determining a representative sample that will yield statistically reliable results.

Employees of administrative, supervisory, technical and operational positions were determined as the target group for the study as they have direct experience of airport operational activities and digital transformation practices.

3.6. Sample size and sampling technique

Choosing an appropriate sample size and sampling technique is a key step in quantitative research, as it can impact on the validity, reliability, and generalizability of the research results. A representative sample allows the researcher to make generalizations about the target population that is not impacted by sampling errors (Saunders et al., 2023). It was not possible to gather information about all of the employees who work at King Abdulaziz International Airport (KAIA) and in order to achieve this there was no alternative but to take a representative sample from a target group.

This study is targeted to the employees in the operational departments of the King Abdulaziz International Airport, which is about 950 employees. These employees are in

direct contact with the airport operations and have an adequate level of knowledge and experience about the digital transformation projects carried out in the airport.

The researcher used the sample size recommendations of Robert V. Krejcie and Daryle W. Morgan (1970) – a widely used management and social science research textbook – to determine an appropriate sample size. Based on estimated population size, a sample of about 270-280 respondents is considered adequate for generating statistically sound results. Hence 280 questionnaires were sent to the employees of the selected operational departments.

Once the data collection process was completed, a total of 257 questionnaires have been returned. After data screening and data verification 7 questionnaires were discarded due to poor response rate and/or high percentage of missing data. Thus, 250 valid questionnaires were used in statistical analysis, giving the effective response rate of 89.3% which is above the minimum acceptable rate for quantitative survey research and shows high engagement of the respondents (Hair et al., 2022).

Simple Random Sampling was used as the sampling technique in the study. This sampling approach eliminates selection bias, which helps to create a representative sample of the employees within the population (Creswell & Creswell, 2023). This study is suitable for simple random sampling because the employees in the operational departments have similar operating functions in relation to digital transformation and operational performance. This sampling system helps in the generalizability of the results as it ensures equal opportunities for the sample to participate, which boosts the external validity of the findings.

3.7. Definition of Variables

3.7.1. Operational Definition of Variables

In quantitative research, operational definitions play a crucial role in quantitative research because they define the measurement of each of the research variables in the study. Creswell and Creswell (2023) state that operational definitions are the means of defining

abstract constructs in terms that can be measured and observed and analyzed statistically.

Operational definitions increase the validity and reliability of the research instrument and the data collected are consistent with the desired theoretical concepts.

The present study aims to explore how Operational Performance (OP) is affected by the three aspects of digital transformation: Artificial Intelligence (AI), Internet of Things (IoT), and Smart Airport Technologies (SAT). All the variables are operationalized by the various questionnaire items which are measured on a 5-point Likert scale (Strongly Disagree to Strongly Agree).

Table 1: Sample Distribution

Description	Number
Estimated Population	950
Questionnaires Distributed	280
Questionnaires Returned	257
Invalid Questionnaires	7
Valid Questionnaires	250
Response Rate	89.3%

The final sample of **250 respondents** was considered sufficient to conduct descriptive statistics, reliability analysis, Pearson correlation analysis, and multiple regression analysis. Moreover, the response rate achieved indicates strong participation and enhances confidence in the validity of the empirical findings presented in Chapter Four.

Variable	Operational Definition	Measurement
Artificial Intelligence (AI)	What intelligent systems and AI applications are adopted to aid in operational decisions, predictive maintenance, automation and service delivery at King Abdulaziz International Airport.	5 questionnaire items

Internet of Things (IoT)	The extent of use of interconnected devices and sensors for gathering, sharing and analyzing operational data as it happens in airport operations.	5 questionnaire items
Smart Airport Technologies (SAT)	Implementation of integrated digital technologies that support airport automation, passenger processing, operational monitoring, resource management, and the service quality.	5 questionnaire items
Operational Performance (OP)	Measuring the effectiveness and efficiency of airport operational activities in terms of airport productivity, service quality, operational reliability, resource utilization and overall operational effectiveness.	10 questionnaire items

3.8.Measurement Scale

This study used the 5-point likert scale to evaluate the perceptions of the respondents about the implementation of the technologies of digital transformation and its effects on the operational performance. The Likert scale is a highly popular measurement method in management and social science research since it allows respondents to indicate the degree of their agreement and disagreement with a series of standardised statements (Sekaran and Bougie, 2020).

The 5-point scale was used for each questionnaire item ranging from Strongly Disagree (1) to Strongly Agree (5). Numerical coding of responses makes it easier to analyze the data statistically and standardizes the responses to all the questions on the questionnaire. The following categories represent the answers given to the questions in the present study:

Table 2:Scale Response

Scale	Response
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

After data collection, arithmetic means were computed to find out the perception of the respondents about each of the study variables. To help with interpretation of results, the mean scores were divided into 5 levels in accordance with the interval width method.

Table 3:Interpretation of Mean Scores.

Mean Range	Interpretation
1.00 – 1.80	Very Low
1.81 – 2.60	Low
2.61 – 3.40	Moderate
3.41 – 4.20	High
4.21 – 5.00	Very High

This classification will aid in interpretation of descriptive statistics presented in chapter four in explaining the relative level of agreement that respondents had for each statement and construct.

3.9.Validity of the Research Instrument.

Validity is a measure of how well a research instrument measures the concepts that it is designed to measure. Validating instruments is important because it guarantees the

questionnaire is representative of the theories being researched and yields meaningful research results (Hair et al., 2022).

Several procedures were carried out to validate the questionnaire.

3.9.1. Face Validity

Face validity is the degree to which the questionnaire seems suitable, comprehensible and relevant to the respondents and the subject matter experts. The questionnaire was pre-tested with experienced academic staff who are experts in business administration, digital transformation, information systems, and airport management.

The questionnaire was evaluated by the reviewers with regard to language clarity, wording, sequence of questions, appropriateness of terminology and relevance of the statements to the respective constructs. Several minor edits were made to the items based on feedback, but the general ideas of the items remained the same.

3.9.2. Content Validity

Content validity is the extent to which the questionnaire covers all aspects of the research constructs (Saunders et al., 2023). The questionnaire items were designed after a detailed study of various empirical studies related to Artificial Intelligence, Internet of Things, Smart Airport Technologies, and Operational Performance to ensure content validity.

The constructs consisted of several statements for each theoretical dimension. In addition, the measurement items were taken from validated research instruments that have been reported in peer-reviewed academic publications, which increased the content validity of research instruments.

The results of these two aspects (expert review and adaptation from the empirical studies) show strong evidence for the research constructs being measured in the questionnaire, and that the overall research is valid. Based on the results of the two aspects

above, it can be concluded that the questionnaire instruments have high evidence to measure the constructs that exist in the research and have high overall evidence of the research.

Reliability is a measure of the consistency and stability of the measurements produced by a research instrument when it is used to measure the same construct in the same context. A good questionnaire will reduce measurement error and collect data that accurately portray the perceptions of the respondents (Sekaran & Bougie, 2020).

To assess the reliability of the questionnaire, one of the most popular methods for measuring the internal consistency in management and social sciences research, the Cronbach's Alpha coefficient was used. Hair et al. (2022) have suggested that values of Cronbach's Alpha between 0.70 and above are acceptable reliability levels, with values greater than 0.80 representing good reliability and values greater than 0.90 representing very good internal consistency.

3.10. Reliability Analysis (Cronbach's Alpha).

Table 4: Reliability Analysis (Cronbach's Alpha).

Variable	Number of Items	Cronbach's Alpha	Interpretation
Artificial Intelligence	5	0.901	Excellent
Internet of Things	5	0.884	Good
Smart Airport Technologies	5	0.917	Excellent
Operational Performance	10	0.936	Excellent
Overall Questionnaire	25	0.925	Excellent

The results show that all Cronbach's alpha values were above the recommended value of 0.70, which indicates high internal consistency of the questionnaire. The overall reliability coefficient was 0.925, which is very good and implies that the questionnaire is appropriate for

statistical analysis such as descriptive statistics, correlation analysis and multiple regression analysis.

3.11. Data Collection Procedures

The data collection process was systematic and followed procedures that ensured the accuracy, completeness and reliability of the data collected. Before the study, the researcher has obtained the relevant administrative approval to conduct the study at the KAIA. The study's objective was presented to concerned authorities, and it was pointed out that there was no compulsion to participate and any answers given would be kept confidential.

The questionnaire was created after a thorough review of previously published literature and on the basis of validated measurement tools. The questionnaire was expert reviewed and then pilot tested for clarity and reliability before going to full-scale administration.

The number of questionnaires that was distributed to the working employees in the operational departments of the King Abdulaziz International Airport (KAIA) was 280 questionnaires through the selected sampling procedure. The survey was briefed to the respondents on the purpose of the research and instructions were given on how to complete the survey. A sufficient amount of time was given to finish the survey, and participants were informed that it would be anonymous and voluntary.

After the data collection period, 257 questionnaires were returned. All questionnaires were carefully examined to detect missing or incomplete answers and to uncover any answers which were not consistent. 7 questionnaires were discarded for significant missing data and/or invalid response patterns. Thus 250 valid questionnaires were retained for statistical analysis with 89.3% response rate.

All responses were screened and then coded numerically and entered into IBM SPSS Statistics Version 29. Descriptive and inferential statistical analyses were done after data cleaning procedures to identify missing values, coding errors, and outliers.

3.12. Data Analysis Techniques

After data collection, the SPSS software, version 29, was used to analyze the responses. The statistical analysis used was in two phases, namely descriptive statistical analysis and inferential statistical analysis.

The demographic characteristics and the respondents' perceptions of the study variables were summarized using descriptive statistics. The collected data was summarized by frequencies, percentages, arithmetic means and standard deviations.

Then, inferential statistics were used to test the research hypotheses and relationships between the study variables.

Table 5: Statistical Techniques Used in the Study

Research Objective	Statistical Technique
Describe respondents' characteristics	Frequencies and Percentages
Describe study variables	Mean and Standard Deviation
Assess questionnaire reliability	Cronbach's Alpha
Examine relationships among variables	Pearson Correlation
Test research hypotheses	Multiple Linear Regression

The significance level for all statistical tests chosen was 0.05. Hence, relationships with a p value of ≤ 0.05 were deemed statistically significant.

3.13. Ethical Considerations

Research was carried out in an ethical manner. The subjects in the study were volunteers, and they were made aware of the purpose of the study prior to filling out their

questionnaire. The participants were also told they could opt out of the study whenever they wished without any repercussions.

Confidentiality and anonymity were ensured by omitting collection of any identifying information. Information from all responses was maintained in a secure manner and only used for academic purposes. All data collected were analyzed and reported in an anonymized way to ensure participants' privacy.

In addition, the study was conducted with principles of ethics in academic research, which include honesty in gathering data, honest reporting of research results, and use of APA 7th edition referencing for all academic work and sources of information.

Chapter Summary

In this chapter, the research methodology used to examine the impact of digital transformation on the operational performance of King Abdulaziz International Airport (KIA) was presented. This was about the research philosophy, quantitative research approach, descriptive-analytical cross sectional research design, survey strategy, study population, sampling technique, sample size, research instrument, operational definition of variables, measurement scale, validity and reliability assessment, pilot study, data collection procedures, statistical analysis technique and ethical considerations.

The results of the reliability and validity test showed that the research instrument was suitable to be used in data collection and statistical analysis. The methodological procedures outlined in this chapter enable the collected data to be analyzed as detailed in Chapter Four to test the hypotheses proposed and to answer the research questions.

CHAPTER FOUR

4. DATA ANALYSIS AND RESULTS

Introduction

The analysis of the collected data from the employees who work in King Abdulaziz International Airport (KAIA), Jeddah, Saudi Arabia is provided in this chapter. The primary aim of this chapter is to analyse the answers from the structured questionnaire to gain insight into the impact of digitization on the operational performance.

The data were statistically analyzed with IBM SPSS Statistics 29. Descriptive statistical techniques were used as well as inferential to fulfil the study objectives and test the proposed hypotheses. Demographic parameters and perceptions of the study variables were summarized by descriptive statistics such as frequencies, percentages, means and standard deviations. Finally, Inferential statistics (Pearson correlation analysis and Multiple linear regression analysis) were then performed to analyze the relationship between variables and their influence on the operational performance of the Artificial Intelligence (AI), Internet of Things (IoT) and Smart Airport Technologies.

The chapter has been broken into sections. It begins with the description of the respondents and their response rate. It subsequently analyzes each question of the questionnaire with frequency distributions, percentages, arithmetic means and standard deviations. Finally, reliability analysis, correlation analysis, regression analysis and significance testing are discussed prior to discussing the major findings of the study.

4.1. Response Rate

Around 280 questionnaires were mailed to the employees at the operational parts of King Abdulaziz International Airport. 257 questionnaires were returned after the data were collected. Care was taken that the questionnaires are thoroughly checked and complete so that they are consistent. Seven questionnaires were returned that were incomplete or had too many

missing answers. The overall response rate was 89.3% and 250 questionnaires were statistically valid.

High response rate is desirable, and it ensured participation and confidence in the data collected as representative of the population. The overall response rate obtained in the present study was found to be high (70.1%) as per Hair et al. (2022) which is satisfactory).

Table 6: Response Rate

Description	Number
Estimated Population	950
Questionnaires Distributed	280
Questionnaires Returned	257
Invalid Questionnaires	7
Valid Questionnaires	250
Response Rate	89.3%

The response rate obtained in the data collection process is displayed in Table 1. A total of 280 questionnaires were distributed and a total initial return rate of 91.8% was achieved with 257 questionnaires returned. The 250 questionnaires were completed, and seven questionnaires were thrown out due to incompleteness and incoherence in the responses. The overall return rate of 89.3% is regarded as good for quantitative research and above the minimum acceptable rate recommended for management research. The high response rate adds to the validity, representativeness and reliability of the study results and offers a solid base for further statistical analyses.

4.2.Demographic Characteristics of Respondents

The background information of the respondents in terms of their demographic attributes is important to understand as it gives background information on the population of the study.

The demographic factors studied are gender, age, educational qualification, years of experience, and department. The characteristics help to interpret the findings of the research and understand the composition of the study sample...

4.2.1. Gender Distribution

Table 7: Gender Distribution of Respondents

Gender	Frequency	Percentage
Male	185	74.0
Female	65	26.0
Total	250	100.0

As presented in the results in Table 4.2, the majorities of the respondents were male which is 185 employees (74.0 %), while 65 respondents (26.0 %) were female. This distribution is consistent with the distribution of the workforce generally found in airport operational areas where the technical, operational and engineering functions are dominated by male staff. Even with female respondents, however, the data offers insights from administrative, passenger service and operational support personnel. In general, the distribution of the demography indicates that the study population is representative of the operational staff at King Abdulaziz International Airport.

4.2.2. Age Distribution

The age category is one of the most significant demographic factors as it reflects the employees' maturity in their field of work and their experience, which can affect their attitudes towards digital transformation efforts and operational outcomes. The degree of technology acceptance, adaptability and willingness to embrace new digital solutions can be different for workers from various age groups. So analyzing the age distribution is useful in giving some indication of the age structure of the study sample.

Table 8: Age Distribution of Respondents

Age Group	Frequency	Percentage (%)
Less than 30 years	42	16.8
30–39 years	96	38.4
40–49 years	74	29.6
50 years and above	38	15.2
Total	250	100.0

Table 3 showed that the highest percentage of respondents (38.4%) were in the age range of 30 – 39 years, while employees within the age group of 40 – 49 years accounted for 29.6% of the respondents. Those who were under 30 years old made up 16.8% of respondents as compared to 15.2% who were 50 years and older.

The majority of the people were in the economically active and professionally experienced age group as indicated here. Workers in these age cohorts tend to have a lot of experience of the job and a willingness to adopt new digital tools. As a result, the age distribution of the respondents is deemed adequate in conducting the evaluation of the implementation of digital transformation programs in airport operations.

4.2.3. Educational Qualification

Educational qualification is one of the significant demographic characteristics as it indicates the employees' academic background and professional knowledge. There is a general trend that education levels correlate with higher technological skills, analytical skills, and openness to new and innovative digital solutions.

Table 9: Educational Qualification of Respondents

Qualification	Frequency	Percentage (%)
Diploma	28	11.2
Bachelor's Degree	162	64.8
Master's Degree	52	20.8
Doctorate	8	3.2
Total	250	100.0

Table 4.4 shows that the majority of the respondents (64.8%) had the appropriate educational background for operational and administrative duties in the airport and thus have a bachelor's degree. The 20.8% of the respondents were those with a master's degree, and 11.2% of them were employees with a Diploma. 3.2% of respondents had doctoral qualifications.

The study results seem to be credible considering the relative number of people with university education in the workforce at King Abdulaziz International Airport, as this indicates that the airport employees have the educational capacities needed to grasp and apply the advanced digital technologies.

4.2.4. Years of Experience

The profession's experience is another demographic as it is important that experienced personnel have a deeper understanding of the airport operational procedures and are better equipped to assess the success of the digital transformation efforts.

Table 10: Years of Experience

Years of Experience	Frequency	Percentage (%)
Less than 5 years	46	18.4
5–10 years	88	35.2
11–15 years	67	26.8

More than 15 years	49	19.6
Total	250	100.0

According to the findings, 35.2% of the respondents had 5 to 10 years of professional experience, which was the highest in the sample. 26.8% of the employees had 11-15 years of experience and 19.6% had more than 15 years' experience. 18.4% of the respondents had 5 or few years of experience.

The results showed that most of the respondents had extensive operational experience, which allowed them to make informed judgments about airport digital transformation projects and their impact on operational performance.

4.2.5. Department Distribution

It's worth noting that the respondents are distributed across the various operational departments at the airport, since digital transformation efforts impact several operational entities at the airport. Incorporating staff from various departments makes the sample more representative and all perspectives are gained during the operation.

Table 11: Department Distribution

Department	Frequency	Percentage (%)
Airport Operations	62	24.8
Information Technology	39	15.6
Passenger Services	51	20.4
Baggage Handling	43	17.2
Security Operations	31	12.4
Airport Management	24	9.6
Total	250	100.0

The analysis reveals that the highest share of respondents (24.8%) worked in Airport Operations, followed by the Passenger Services (20.4%), Baggage Handling (17.2%) and

Information Technology (15.6%). The other categories of employees in the study sample were Security Operations (12.4%) and Airport Management (9.6%).

In this distribution, the respondents represent a wide variety of operational departments that are actively involved in any airport activity and in digital transformation projects. Diversity improves the comprehensiveness of the data gathered and increases the validity and acceptability of the findings of the study by adding multiple organizational perspectives.

4.3.Descriptive Statistics of the Study Variables:

Descriptive statistics were used to analyze the respondents' perception on the variables used in this study. Each item of the questionnaires was analyzed descriptively using frequency distribution, percentages, arithmetic means, standard deviations and ranking. These statistics give the general overview of employees' perception regarding the implementation of Artificial Intelligence (AI), Internet of Things (IoT), Smart Airport Technologies, and their impact on the operational activities.

The arithmetic means were interpreted according to the classification as outlined in Chapter Three and include a Very High level (4.21-5.00), High level (3.41-4.20), Moderate level (2.61-3.40), Low level (1.81-2.60), and Very Low level (1.00-1.80).

4.4.Response Distribution for Artificial Intelligence Statements

The Artificial Intelligence (AI) was evaluated using five items in the questionnaire to evaluate employees' perceptions about the use of AI technology in airport operations.

Table 12:Response Distribution for Artificial Intelligence Statements

Statement	SD n (%)	D n (%)	N n (%)	A n (%)	SA n (%)
AI technologies are used in airport operations.	6 (2.4)	12 (4.8)	28 (11.2)	96 (38.4)	108 (43.2)

AI improves operational decision-making.	4 (1.6)	10 (4.0)	24 (9.6)	102 (40.8)	110 (44.0)
AI enhances operational efficiency.	5 (2.0)	11 (4.4)	22 (8.8)	101 (40.4)	111 (44.4)
AI reduces operational errors.	8 (3.2)	13 (5.2)	30 (12.0)	98 (39.2)	101 (40.4)
AI supports continuous operational improvement.	5 (2.0)	9 (3.6)	26 (10.4)	99 (39.6)	111 (44.4)

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

The distribution of the responses to the five statements used to measure the Artificial Intelligence construct is shown in Table 4.7. Respondents had very positive views about the implementation of Artificial Intelligence at King Abdulaziz International Airport in general. For all five statements, the majority answered Agree or Strongly Agree, and the percentages who agreed were between 79.6% and 84.8%.

The level of agreement was the highest for the statement, "AI improves operational efficiency", with 84.8% of respondents agreeing or strongly agreeing. Likewise, 84.8% said that Artificial Intelligence helps in making operational decisions, and 84.0% said that AI aids in continuous improvement of operations. In addition, 81.6% agreed that AI technologies have been implemented in the airport operation, showing the widespread recognition of the use of AI in the airport environment.

The statement "Artificial Intelligence decreases operational errors" had the lowest level of agreement (79.6%), but still very positive evaluation. Neutral responses were under 12% for all items and there were only a small number of respondents who disagreed with any of the statements. These results suggest that the workers see Artificial Intelligence as an

important technological capacity that they think helps them become more efficient, more informed about their decisions, more efficient in processes, and more efficient in the long-term development of their organization. Overall, the results are good descriptive evidence that Artificial Intelligence is an integral part of digital transformation being implemented at King Abdulaziz International Airport.

4.5.Descriptive Statistics for Artificial Intelligence

Table 13:Descriptive Statistics for Artificial Intelligence

Statement	Mean	SD	Rank	Level
AI technologies are used in airport operations.	4.15	0.89	4	High
AI improves operational decision-making.	4.22	0.81	2	Very High
AI enhances operational efficiency.	4.24	0.79	1	Very High
AI reduces operational errors.	4.09	0.94	5	High
AI supports continuous operational improvement.	4.20	0.83	3	High
Overall Artificial Intelligence	4.18	0.85	—	High

The descriptive statistics for the construct of Artificial Intelligence (AI) are presented in Table 4.8. The mean score for the overall was 4.18 (SD = 0.85), which suggests that the respondents were quite agreeable about the implementation and effectiveness of the technologies of Artificial Intelligence at King Abdulaziz International Airport. The discovery indicates that airport users are seeing the application of AI as an integral part of airport operations and are realizing that these technologies are contributing meaningfully to operational performance.

The mean score of “Artificial Intelligence enhances operational efficiency” (M = 4.24, SD = 0.79) was the highest of the five statements, signifying that respondents feel strongly that AI improves the efficiency of the workflow, cuts down in processing time, and optimises the operational activities. The second highest was "Artificial Intelligence improves operational

decision-making" ($M = 4.22$, $SD = 0.81$), indicating that employees are confident that an AI-based decision support system will help them make decisions based on evidence and planning their operations.

The third statement with the mean score of 4.20 was "Artificial Intelligence supports continuous operational improvement". This indicates that the respondents believe Artificial Intelligence is a strategic technology that supports continuous organizational development and innovation. In the meantime, the Mean of the AI technologies used in airport operations was 4.15, thus indicating the broad use of AI applications in airport operational functions.

The mean score of 4.09 and the standard deviation of 0.94 were the lowest for the statement "Artificial Intelligence reduces operational errors". This answer was the least popular, but still found to have a high level of agreement, meaning that most employees feel that AI helps to minimize errors in operation, although this response was not quite as strong as the other two areas.

In summary, the descriptive statistics reveal a favorable attitude of airport workers towards AI. The mean scores and low standard deviation scores suggest that there was high consensus that AI technologies positively impact operational efficiency, managerial decision making, operational processes and successful implementation of digital transformation initiatives. The results presented here offer initial empirical evidence for the hypothesized positive relationship between Artificial Intelligence and Operational Performance that will be explored in more detail in the correlation and multiple regression analyses below.

4.6. Internet of Things (IoT)

The Internet of Things (IoT) construct was assessed by five statements that evaluated employees' perception of the application of 'interconnected digital devices' and 'intelligent monitoring systems' at KAIA. The Internet of Things (IoT) technologies are essential for collecting real-time data, monitoring infrastructures, predictive maintenance, operational

coordination, and passenger flow management. Frequencies, percentages, arithmetic means and standard deviations were used in analyzing the responses obtained from the 250 participants.

4.7. Response Distribution for Internet of Things

Table 14: Response Distribution for Internet of Things

Statement	SD n (%)	D n (%)	N n (%)	A n (%)	SA n (%)
IoT technologies improve monitoring of airport infrastructure	5 (2.0)	10 (4.0)	22 (8.8)	101 (40.4)	112 (44.8)
IoT sensors help monitor baggage handling systems	4 (1.6)	9 (3.6)	20 (8.0)	103 (41.2)	114 (45.6)
IoT technologies improve maintenance planning	6 (2.4)	11 (4.4)	24 (9.6)	99 (39.6)	110 (44.0)
IoT technologies enhance operational coordination between departments	4 (1.6)	10 (4.0)	23 (9.2)	102 (40.8)	111 (44.4)
IoT improves monitoring of passenger flow within airports	5 (2.0)	8 (3.2)	21 (8.4)	104 (41.6)	112 (44.8)

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

The distribution of responses for the five statements in the Internet of Things construct is shown in Table 4.9. As a whole, the respondents had a very positive attitude towards IoT implementation in KAA. In each of the statements, most respondents agreed or strongly agreed with the statements, with the percentages of agreement ranging from 83.6% to 86.8%. The results suggest that IoT technologies have a vital role in the airport digital transformation programs.

The statement "IoT sensors help monitor baggage handling systems" got the highest level of agreement (86.8% agreed and strongly agreed). This is indicative of the awareness among employees of the IoT solutions for better baggage tracking accuracy, lesser baggage losses and real-time operational monitoring. Similarly, 86.4% of respondents concurred that the IoT is an effective way to track the flow of passengers in and out of airports, highlighting the need for connected technologies to optimize passenger flow and reduce congestion in airports.

The statement "IoT technologies improve the coordination of operations between departments" was also backed with 85.2% of the respondents agreeing. This discovery indicates that the use of IoT technologies helps the different departments of the airport communicate and share information with each other, which results in better coordination and quicker airport operational decision making. Likewise, 85.2% of those surveyed said that IoT technologies boost monitoring of airport infrastructure, with a strong sense of trust that connected sensors would help airport infrastructure management.

The results show high levels of agreement overall for this statement, with "IoT technologies improve maintenance planning" having the lowest level of agreement (83.6%). In general, the high consensus on the importance of the IoT technologies in improving operational visibility, improving coordination, optimizing maintenance activities and airport operational performance indicate that employees consider them valuable tools.

4.8.Descriptive Statistics for Internet of Things

Table 15:Descriptive Statistics for Internet of Things

Statement	Mean	SD	Rank	Level
IoT technologies improve monitoring of airport infrastructure	4.23	0.81	3	Very High

IoT sensors help monitor baggage handling systems	4.29	0.76	1	Very High
IoT technologies improve maintenance planning	4.17	0.88	5	High
IoT technologies enhance operational coordination between departments	4.24	0.80	2	Very High
IoT improves monitoring of passenger flow within airports	4.25	0.79	2	Very High
Overall Internet of Things	4.24	0.81	—	Very High

This summary of descriptive statistics for the Internet of Things construct is presented in Table 4.10. The mean score (4.24, SD = 0.81) represents a high level of agreement among the respondents about the implementation and effectiveness of the technologies of IoT in King Abdulaziz International Airport. The results reveal that employees see IoT as a significant technology accelerator to support operational excellence and digital transformation.

The top-rated statement was “IoT sensors contribute to the monitoring of baggage handling systems” (Mean = 4.29, SD = 0.76), which showed that the employees felt that IoT technologies play a significant role in improving baggage tracking, in monitoring baggage handling systems and in increasing the reliability of the systems. The statements ‘IoT improves monitoring of passenger flow within airports’ and ‘IoT technologies enhance operational coordination between departments’ also received very high mean scores, showing that respondents feel there is a significant improvement in operational communication, passenger movement and coordination between functional areas with the use of IoT in airports.

The statement IoT technologies improve maintenance planning received the lowest mean score (4.17), but it was still in the High level of agreement. This means predictive maintenance applications are seen as positive yet employees feel there may be a need for more investments in technology to boost maintenance planning further.

The overall outcome of the results shows that the employees' confidence in IoTs technologies is very high as a vital component of the airport's digital transformation. The stable mean scores confirm that IoT makes a significant impact on the monitoring of infrastructure, carrying the baggage, coordination between operations, management of passenger flow and maintenance planning. Such results give empirical evidence of the proposed positive relation between the technologies of the IoT and Operational Performance which will be further investigated in following sections by correlation and regression analysis.

4.9. Internet of Things (IoT)

Five statements were developed to assess the employees' perceptions of the IoT construct introduced in King Abdulaziz International Airport (KAIA). IoT technologies are pivotal to helping capture real-time data, monitor infrastructure, predict maintenance needs, coordinate operations and manage passenger flow. Data analysis involved frequencies, percentages and arithmetic means and standard deviations from the 250 responses.

Table 16: Response Distribution for Internet of Things

Statement	SD n (%)	D n (%)	N n (%)	A n (%)	SA n (%)
IoT technologies improve monitoring of airport infrastructure	5 (2.0)	10 (4.0)	22 (8.8)	101 (40.4)	112 (44.8)
IoT sensors help monitor baggage handling systems	4 (1.6)	9 (3.6)	20 (8.0)	103 (41.2)	114 (45.6)

IoT technologies improve maintenance planning	6 (2.4)	11 (4.4)	24 (9.6)	99 (39.6)	110 (44.0)
IoT technologies enhance operational coordination between departments	4 (1.6)	10 (4.0)	23 (9.2)	102 (40.8)	111 (44.4)
IoT improves monitoring of passenger flow within airports	5 (2.0)	8 (3.2)	21 (8.4)	104 (41.6)	112 (44.8)

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

The distribution of responses to the five statements that assessed the Internet of Things construct is shown in Table 4.9. Respondents showed a very positive attitude towards the implementation of IoT in King Abdulaziz International Airport. In each of the statements, most respondents responded Agree or Strongly Agree (ranging from 83.6% to 86.8%). The results show that IoT technologies have become a crucial part of the digital transformation programs of airports.

The highest level of agreement was seen for the statement 'IoT sensors help monitor baggage handling systems', with 86.8% of respondents stating that they agree or strongly agree. This is a result of employees' acknowledgment of IoT applications in the areas of increased baggage detection accuracy, reduced baggage loss and real-time operational monitoring. Similarly, 86.4 % of respondents said that IoT technologies positively contribute to the monitoring of passenger flow in an airport, which highlights the value of connected technologies in optimizing passenger movement and congestion in airports.

Another strong consensus was the agreement that "IoT technologies improve operational coordination between departments" with 85.2% agreeing. The discovery indicates that with the help of IoT technologies, communication and information exchange within the airport departments can be made easier, which in turn results in better coordination and quick

decision-making within the airport. Likewise, 85.2% said IoT helps in monitoring of airport infrastructure, while 82.8% agreed that it helps in managing the infrastructure.

Even if the percentage of agreement was not as high as in the other answers (83.6%), the result shows a high level of confidence in predictive maintenance with the help of monitoring systems enabled by IoT technologies. In conclusion, the high degree of agreement in each item indicates that employees view the Internet of Things technologies as a valuable means to achieve better visibility of operations, coordination, maintenance optimization and operational performance of airports.

Table 17: Descriptive Statistics for Internet of Things

Statement	Mean	SD	Rank	Level
IoT technologies improve monitoring of airport infrastructure	4.23	0.81	3	Very High
IoT sensors help monitor baggage handling systems	4.29	0.76	1	Very High
IoT technologies improve maintenance planning	4.17	0.88	5	High
IoT technologies enhance operational coordination between departments	4.24	0.80	2	Very High
IoT improves monitoring of passenger flow within airports	4.25	0.79	2	Very High
Overall Internet of Things	4.24	0.81	—	Very High

Table shows descriptive statistics for the constructing Internet of Things. The mean score of 4.24 (SD = 0.81) suggests that the respondents generally agreed that IoT technologies are being implemented and effective at King Abdulaziz International Airport,

with high scores representing high agreement. The results show that IoT is seen as a significant technology enabler for operational excellence and digital transformation in the eyes of employees.

The most successful statement was “IoT sensors help monitor baggage handling systems” (Mean = 4.29, SD = 0.76), meaning that employees felt confident in the contribution that IoT technologies can make towards monitoring and tracking bags, as well as monitoring and improving operations and system reliability. The other two statements, “IoT improves monitoring of passenger flow within airports” and “IoT technologies enhance operational coordination between departments” also had very high mean scores, reflecting that respondents feel IoT has a significant role to play in improving operational communication, passenger movement and coordination between airport departments.

The lowest mean score was for the statement ‘IoT technologies improve maintenance planning’ (4.17) but it still reached the High level of agreement. This could indicate that predictive maintenance applications are well received, and that further investments in technology may augment the maintenance planning further.

As a whole, the findings suggest that the employees are confident in the use of IoT technologies as a key component of the airport's digitalization. The mean scores are consistently high, thus indicating that IoT has a significant impact on infrastructure monitoring, baggage handling, operational coordination, passenger flow management and maintenance planning. The above findings give empirical evidence of the hypothesized positive correlation between Internet of Things technologies and Operational Performance which shall be analysed further in correlation and regression analysis in the subsequent sections.

4.9.1. Smart Airport Technologies

Smart Airport Technologies is one of the most important aspects of digital transformation in today's airports. These technologies combine intelligent digital systems, automation, biometric identification, self-service technologies and smart airport platforms to increase the efficiency of the airport and enhance the passenger experience. This study employed five items of a questionnaire to measure the Smart Airport Technologies. Frequency distributions, percentages, arithmetic means and standard deviations were computed in order to investigate the perceptions of the respondents about the implementation of these technologies at KAIA.

Table 18: Response Distribution for Smart Airport Technologies

Statement	SD n (%)	D n (%)	N n (%)	A n (%)	SA n (%)
Smart technologies improve airport operational efficiency	4 (1.6)	8 (3.2)	19 (7.6)	102 (40.8)	117 (46.8)
Automated systems improve passenger processing efficiency	3 (1.2)	8 (3.2)	20 (8.0)	101 (40.4)	118 (47.2)
Biometric technologies improve passenger identification	5 (2.0)	10 (4.0)	23 (9.2)	99 (39.6)	113 (45.2)
Smart airport systems improve passenger experience	4 (1.6)	9 (3.6)	21 (8.4)	100 (40.0)	116 (46.4)
Digital airport systems improve service quality	3 (1.2)	8 (3.2)	18 (7.2)	103 (41.2)	118 (47.2)

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

The results of the respondents' perception about Smart Airport Technologies are given in the table below. These results show that all of the five statements received overwhelmingly

positive responses, with agreement and Strongly Agree on each statement ranging from 84.8% to 88.4%. These results show that smart technologies in airports are seen as crucial for the enhancement of operational efficiency, passenger services and the performance of the airport.

The highest level of agreement was found with the statements "Automated systems improve passenger processing efficiency" and "Digital airport systems improve service quality", which were both 88.4% agreed. The results are employees' trust in automation to help process passengers faster, waiting times and service delivery.

Likewise, 87.6% of respondents reported that a smart airport system improves the passenger experience, showing that digital services help to increase passenger convenience and satisfaction. There was also considerable consensus in favor of the statement about the benefits of smart technologies on the operational efficiency of airports, with 87.6% agreeing. The lowest level of agreement (84.8%) was seen in the item "Biometric technologies improve passenger identification", but people showed an extremely positive perception about biometric technologies as a reliable means to enhance identity verification and airport security.

In general, the findings reveal that Smart Airport Technologies are broadly perceived as key enablers of operational excellence, helping to ensure the smooth and efficient processing of passengers, the quality of service, airport security, and overall airport performance

Table 19: Descriptive Statistics for Smart Airport Technologies

Statement	Mean	SD	Rank	Level
Smart technologies improve airport operational efficiency	4.29	0.77	3	Very High

Automated systems improve passenger processing efficiency	4.33	0.74	1	Very High
Biometric technologies improve passenger identification	4.21	0.84	5	Very High
Smart airport systems improve passenger experience	4.30	0.76	2	Very High
Digital airport systems improve service quality	4.34	0.73	1	Very High
Overall Smart Airport Technologies	4.29	0.77	—	Very High

Table shows the descriptive statistics of the Smart Airport Technologies construct.

Overall, the mean score of 4.29 (SD = 0.77) attests to a high level of agreement among respondents with regard to the implementation and efficacy of smart airport technologies at KAIA. The standard deviation is relatively small which shows that there is a very high level of agreement among employees.

The statements that received the highest mean scores (M scores) and the lowest standard deviations (SDs) were "Digital airport systems improve service quality" (M = 4.34, SD = 0.73) and "Automated systems improve passenger processing efficiency" (M = 4.33, SD = 0.74). The results of these findings suggest that digital systems are seen by employees as very effective in improving operational quality and in improving the services to passengers.

With a score of 4.30, the statement "Smart airport systems are enhancing the passenger experience" was the second highest, highlighting the importance of the role smart airport systems play in enhancing the comfort and satisfaction of passengers. Similarly, respondents were strongly supportive of the role smart technologies play in enhancing operational

efficiency ($M = 4.29$), highlighting the importance of automation and integrated digital systems in optimizing airport operations.

The mean score of “Biometric technologies improve passenger identification” was the lowest $M = 4.21$, yet it was still in the Very High range of agreement. The results indicate that the interviewees are aware of the benefits of biometric technologies for passenger identification, and are aware that biometric technologies can be further developed.

Overall, descriptive statistics show good support for the empirical evidence of the widespread adoption and the high value of Smart Airport Technologies by airport employees. The average scores are all high, confirming that these technologies are important in terms of operational efficiency, passenger processing, service quality, passenger satisfaction and airport security. As a result, Smart Airport Technologies are one of the most significant aspects of digital transformation identified in the study, and are likely to have the most

4.9.2. Reliability Analysis

Reliability of the questionnaire was explored prior to testing the research hypotheses by examining the internal consistency of the measurement scales using Cronbach's Alpha coefficient. Cronbach's Alpha is one of the most commonly used statistics used to assess the reliability of questionnaire items. Hair et al. (2022) states that values higher than 0.70 denote acceptable reliability, values higher than 0.80 denote good reliability and values higher than 0.90 denote excellent reliability.

The reliability results are given in Table

4.9.3. Reliability Analysis (Cronbach's Alpha)

Table 20: Reliability Analysis (Cronbach's Alpha)

Variable	Number of Items	Cronbach's Alpha	Interpretation
Artificial Intelligence	5	0.901	Excellent
Internet of Things	5	0.884	Good

Smart Airport Technologies	5	0.917	Excellent
Operational Performance	10	0.936	Excellent
Overall Questionnaire	25	0.925	Excellent

The results indicate that all study variables achieved Cronbach's Alpha coefficients above the recommended threshold of 0.70. Artificial Intelligence recorded an Alpha value of **0.901**, Internet of Things **0.884**, Smart Airport Technologies **0.917**, and Operational Performance **0.936**. The overall questionnaire achieved an Alpha coefficient of **0.925**, indicating excellent internal consistency.

These findings confirm that the questionnaire is highly reliable and that the measurement items consistently measure their intended constructs. Therefore, the instrument is considered appropriate for conducting subsequent inferential statistical analyses, including correlation and multiple regression analysis.

4.10. Correlation Analysis

Pearson correlation analysis was conducted to examine the relationships between the independent variables (Artificial Intelligence, Internet of Things, and Smart Airport Technologies) and the dependent variable (Operational Performance). Pearson's correlation coefficient (r) ranges from -1 to $+1$, where values close to $+1$ indicate a strong positive relationship, values close to -1 indicate a strong negative relationship, and values near zero indicate little or no linear relationship.

4.11. Pearson Correlation Matrix

Variable	AI	IoT	Smart Airport	Operational Performance
Artificial Intelligence	1.000			
Internet of Things	0.684**	1.000		

Smart Airport Technologies	0.739**	0.712**	1.000	
Operational Performance	0.781	0.746	0.802	1.000

Note: Correlation is significant at $p < 0.01$ (2-tailed).

The results indicate that all independent variables are **positively and significantly correlated** with Operational Performance ($p < 0.01$). Smart Airport Technologies exhibited the strongest relationship with Operational Performance ($r = 0.802$), followed by Artificial Intelligence ($r = 0.781$) and Internet of Things ($r = 0.746$). These findings suggest that increased implementation of digital transformation technologies is associated with higher levels of operational performance.

The correlations among the independent variables ranged from **0.684** to **0.739**, indicating moderate positive relationships without suggesting severe multicollinearity. Therefore, all variables were retained for multiple regression analysis.

4.12. Multiple Regression Analysis

Multiple linear regression analysis was conducted to determine the combined effect of Artificial Intelligence, Internet of Things, and Smart Airport Technologies on Operational Performance.

4.13. Model Summary

Table 21: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	0.846	0.716	0.712	0.394

1 The regression model achieved a multiple correlation coefficient ($R = 0.846$), indicating a strong positive relationship between the independent variables and Operational Performance.

The coefficient of determination ($R^2 = 0.716$) indicates that 71.6% of the variance in

Operational Performance is explained collectively by Artificial Intelligence, Internet of Things, and Smart Airport Technologies. The remaining 28.4% may be attributed to other organizational and environmental factors not included in the model.

4.14. ANOVA results

Table 22:ANOVA

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	95.284	3	31.761	204.316	0.000
Residual	38.236	246	0.155		
Total	133.520	249			

The ANOVA results indicate that the regression model is statistically significant ($F = 204.316$, $p < 0.001$). This finding confirms that the three independent variables jointly explain a significant proportion of the variation in Operational Performance. Therefore, the overall regression model is appropriate for predicting operational performance in the context of King Abdulaziz International Airport.

4.15. Regression Coefficients

Table 23:Regression Coefficients

Variable	B	Std. Error	Beta	t	Sig.
Constant	0.714	0.201		3.552	0.001
Artificial Intelligence	0.281	0.054	0.292	5.204	0.000
Internet of Things	0.243	0.058	0.248	4.190	0.000
Smart Airport Technologies	0.392	0.061	0.408	6.426	0.000

The regression coefficients demonstrate that all three independent variables have a positive and statistically significant effect on Operational Performance ($p < 0.001$).

Among the predictors, Smart Airport Technologies exerted the strongest influence ($\beta = 0.408$), followed by Artificial Intelligence ($\beta = 0.292$) and Internet of Things ($\beta = 0.248$). These findings indicate that improvements in smart airport technologies contribute most substantially to enhancing operational performance, followed by AI and IoT initiatives. This equation indicates that increases in any of the three digital transformation dimensions are associated with corresponding improvements in operational performance.

Operational Performance

Operational Performance represents the dependent variable in this study and reflects the extent to which digital transformation initiatives contribute to improving airport operational efficiency, service quality, passenger satisfaction, productivity, and overall organizational effectiveness. The construct was measured using ten questionnaire statements covering different aspects of airport operational performance. Descriptive statistics, including frequencies, percentages, arithmetic means, and standard deviations, were calculated to examine employees' perceptions.

4.16. Response Distribution for Operational Performance

Table 24: Response Distribution for Operational Performance

Statement	SD n (%)	D n (%)	N n (%)	A n (%)	SA n (%)
Digital technologies reduce passenger waiting times	4 (1.6)	8 (3.2)	18 (7.2)	102 (40.8)	118 (47.2)
Digital transformation improves baggage handling efficiency	5 (2.0)	9 (3.6)	20 (8.0)	101 (40.4)	115 (46.0)
Airport operations become faster after digital transformation	3 (1.2)	8 (3.2)	17 (6.8)	103 (41.2)	119 (47.6)

Digital systems reduce operational errors	6 (2.4)	10 (4.0)	22 (8.8)	100 (40.0)	112 (44.8)
Digital monitoring improves airport operational coordination	4 (1.6)	8 (3.2)	19 (7.6)	102 (40.8)	117 (46.8)
Digital technologies improve overall airport productivity	4 (1.6)	9 (3.6)	18 (7.2)	101 (40.4)	118 (47.2)
Digital transformation reduces congestion in airports	5 (2.0)	11 (4.4)	24 (9.6)	98 (39.2)	112 (44.8)
Digital technologies improve airport service quality	3 (1.2)	8 (3.2)	17 (6.8)	104 (41.6)	118 (47.2)
Digital transformation improves airport operational performance	3 (1.2)	7 (2.8)	18 (7.2)	101 (40.4)	121 (48.4)
Digital transformation improves passenger satisfaction	4 (1.6)	8 (3.2)	19 (7.6)	100 (40.0)	119 (47.6)

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

Table presents the response distribution for the ten statements measuring Operational Performance. The findings reveal a consistently positive evaluation of operational performance following the implementation of digital transformation initiatives at King Abdulaziz International Airport. Across all ten statements, the combined percentages of respondents selecting Agree and Strongly Agree ranged from 84.0% to 88.8%, indicating a very high level of employee agreement regarding the positive influence of digital technologies on airport operations.

The strongest agreement was observed for the statement "Digital transformation improves airport operational performance," where 88.8% of respondents either agreed or strongly agreed. This result reflects employees' overall confidence that digital transformation

has significantly enhanced operational effectiveness within the airport. Likewise, 88.8% agreed that airport operations have become faster after digital transformation, demonstrating the perceived effectiveness of automation and intelligent operational systems in accelerating airport processes.

High levels of agreement were also observed for statements relating to passenger waiting times, passenger satisfaction, airport productivity, service quality, operational coordination, and baggage handling efficiency. These findings suggest that employees recognize the broad operational benefits of digital transformation across multiple airport functions.

Although the statement "Digital systems reduce operational errors" recorded the lowest level of agreement (84.8%), respondents still expressed strong confidence in the ability of digital technologies to improve operational accuracy and reduce human errors. Similarly, 84.0% agreed that digital transformation reduces airport congestion, indicating that respondents believe digital technologies contribute positively to traffic management and passenger flow, although opportunities remain for further improvement.

Overall, the results indicate a high degree of consistency in employees' perceptions regarding Operational Performance. The low levels of disagreement and relatively small proportion of neutral responses demonstrate widespread confidence in the airport's digital transformation initiatives. These descriptive findings provide preliminary empirical evidence that digital technologies have significantly enhanced operational efficiency, productivity, coordination, service quality, passenger satisfaction, and overall organizational performance.

4.17. Descriptive Statistics for Operational Performance

Table 25: Descriptive Statistics for Operational Performance

Statement	Mean	SD	Rank	Level
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Digital technologies reduce passenger waiting times	4.31	0.76	3	Very High
Digital transformation improves baggage handling efficiency	4.27	0.80	6	Very High
Airport operations become faster after digital transformation	4.34	0.73	1	Very High
Digital systems reduce operational errors	4.18	0.89	10	High
Digital monitoring improves airport operational coordination	4.30	0.77	4	Very High
Digital technologies improve overall airport productivity	4.31	0.76	3	Very High
Digital transformation reduces congestion in airports	4.17	0.88	9	High
Digital technologies improve airport service quality	4.32	0.74	2	Very High
Digital transformation improves airport operational performance	4.36	0.71	1	Very High
Digital transformation improves passenger satisfaction	4.33	0.74	2	Very High
Overall Operational Performance	4.29	0.78	—	Very High

As can be seen in Table, the overall perception of Operational Performance by the respondents was very high with an overall mean score of 4.29 (SD = 0.78). The result shows that the employees are convinced digital transformation programs have significantly improved the effectiveness of their business operations at King Abdulaziz International

Airport. The statement with the highest ranking was “Digital transformation improves airport operational performance” (Mean = 4.36, SD = 0.71), which means that the employees believe that digital transformation is a strategic initiative that drives the organization's performance. Two other top-ranking statements are “Airport operations become faster after digital transformation” (Mean = 4.34) and “Digital transformation enhances passenger satisfaction” (Mean = 4.33) which demonstrate the importance of operational and customer-service benefits that come from digital technologies. In addition, respondents were highly supportive of the benefits of digital technologies at the airport in terms of service quality, passenger waiting times, operational coordination, overall productivity and efficiency in baggage handling.

The results indicate that the digital transformation has had a positive impact on various aspects of airport performance, such as operational speed, service effectiveness, productivity, and customer experience. The lowest mean scores were for the statements: Digital systems reduce operational errors (Mean = 4.18) and Digital transformation reduces congestion in airports (Mean = 4.17). However, both statements still scored a high rating of agreement, suggesting that employees are aware of the positive impact that digital technologies can have to operational reliability and congestion management, but there is still room for further improvements.

Overall, the scores for the mean scores were very high, and the standard deviation was relatively low, which shows a high level of agreement on the effectiveness of the digital transformation initiatives among respondents. The results show how digital transformation has helped to improve operational performance in the field, as it has enhanced efficiency, speeded up airport operations, strengthened the quality of services, improved productivity, increased passenger satisfaction and enabled better operational coordination. The descriptive findings lend valuable empirical support to the conceptual framework of the study and serve

as a firm basis for inferential analysis in the subsequent analyses such as reliability, correlation analysis, multiple regression analysis and hypothesis testing.

Chapter Summary The empirical analysis of the data collected from the employees working in the King Abdulaziz International Airport was presented in this chapter to evaluate the effect of digital transformation on operational performance. The chapter started with the response rate and socio-demographic profile of the respondents and then provided a detailed descriptive analysis of each study variable in terms of frequency distribution, percentages, arithmetic means and standard deviations. The results showed that the respondents were very positive about the implementation of Artificial Intelligence, Internet of Things technologies, Smart Airport Technologies, and the benefits it would bring to the Operational Performance.

The descriptive results show that digital transformation projects have already well seeped into the operational activities at airports and are seen by employees as key drivers of effectiveness. Later, the reliability analysis showed that the research instrument had high internal consistency and Pearson correlation analysis showed that all of the research variables showed a positive correlation and had become significant. Multiple regression analysis also confirmed that the Artificial Intelligence, Internet of Things and Smart Airport Technologies significantly and positively influence Operational Performance, accounting for a large portion of the variance. Of these variables, Smart Airport Technologies had the greatest predictive power on operational performance.

Hypothesis testing has shown all the proposed hypotheses to be accepted, thus yielding strong empirical evidence that digital transformation programmes have a significant positive effect on operational efficiency, services to passengers, airport productivity, service quality, operational coordination and organizational performance. These results help to confirm the conceptual model used in the study and validate the theoretical relationships between the variables in the research model. The statistical analysis presented in this chapter generally

supports the finding that digital transformation is indeed a strategic capability that is considered critical in improving airport operational performance.

Given the evidence, it is likely that further investment in Artificial Intelligence, Internet of Things technologies and Smart Airport systems will play a role in enhancing the operational excellence and sustain the long-term goals of the Saudi Arabia's airport modernization. These results are discussed in the next chapter in connection with earlier empirical research and relevant theories. It also includes the findings of the study, the implications, recommendations for airport management, limitation of the research and recommendations for future research.

CHAPTER FIVE

5. DISCUSSION OF FINDINGS

Introduction

This chapter presents a discussion of the findings of the empirical study results carried out in Chapter Four, which refers to the research objectives, research hypothesis, theoretical basis, and other empirical studies that have been performed. The main objective of this chapter is to make sense of the statistics derived from the data gathered from the employees at King Abdulaziz International Airport (KAIA), Saudi Arabia, and to discuss the practical and theoretical implications of these statistics. The discussion is about analyzing the impact of the three aspects of the Digital Transformation on Operational Performance: Artificial Intelligence (AI), Internet of Things (IoT), Smart Airport Technologies (SAT). This study was based on the three theories, namely the Technology Acceptance Model (TAM), Resource Based View (RBV) and Dynamic Capabilities Theory, which are used to interpret the findings. In addition, the results are contrasted with earlier empirical research that took place in the years 2020-2026 to highlight regions of agreements and disagreements, as well as offer logical explanations for the observed similarities and differences. First, the demographic characteristics of the respondents are discussed, and then each of the research variables is discussed individually. It then discusses the correlation analysis, multiple regression results, and hypothesis testing. Finally, the implications of the findings in the context of theory, management and practice are discussed before summarizing the chapter.

5.1. Discussion of Demographic Findings

Demographic analysis showed that the male employees (74%) occupied the higher percentage than the female employees (26%). This distribution is in line with the composition of the workforce typical of airport operational environments, in which technical, engineering, operational control and security roles are mostly held by male employees. However, it was

beneficial to have the involvement of female workers from the industry, as they had some great ideas around passenger services, administrative processes and airport management. The sample, therefore, is representative in terms of demographics to reflect the operational staff members of King Abdulaziz International Airport.

As to age distribution, the largest group was aged 30-39 years (38.4%) followed by employees in the 40-49 age group (29.6%). The results indicated that most of the respondents were of a mature professional level and were experienced enough to objectively assess the digital transformation initiatives. Staff in these age groups are typically well-suited with their practical experience and technological adaptability to deliver reliable evaluations of Artificial Intelligence, Internet of Things technologies and 'Smart Airport' systems.

The educational profile showed that about two thirds of the respondents had a bachelor's degree and a large proportion had postgraduate qualifications. This level of educational attainment suggests that the respondents have the necessary academic skills to grasp the complexities of digital technologies and their implications for their operation. Staff with a higher education level tend to be better equipped to embrace new technologies and to adjust to digital transformation projects.

Most of the respondents were professionals with five to 10 years of experience. This experience can help employees make informed decisions about the impact of digital transformation initiatives on airport operations, and assess their efficiency, quality of service, productivity, and level of satisfaction. Professional staff are also more aware of operational issues and thus more able to judge an intelligent digital solution's effectiveness.

Lastly, the respondents came from many different operational departments of the airport, such as airport operations, information technology, passenger services, baggage handling, airport security, and airport management. The diversity of this department made the sample more representative and provided for closer contact with viewpoints of employees

directly involved in various activities within the airport. Thus, the demographic results add to the confidence levels of the generalizability of the study results within the context of King Abdulaziz International Airport (KAIA) operational environment.

The overall demographic profile shows that the respondents had the necessary education, experience, and operational tasks to be able to assess digital transformation initiatives and its effects on the airport operational performance with a fair degree of certainty.

5.1.1. Engage in a conversation about the findings of Artificial Intelligence.

The descriptive analysis showed that all the respondents had a very high mean score for Artificial Intelligence (4.23). Overall, employees felt that AI is a critical technological capability that supports the operational planning of the airport, enhances managerial decision-making, optimizes the use of resources, forecasts passenger demands and boosts airport security monitoring. The results illustrate how AI has become a part of airport DTAs.

Individual statements received the highest ratings from respondents for the impact of Artificial Intelligence on airport operational planning. The discovery indicates that staff are aware of the strategic value of AI-powered planning systems to distribute airport resources, predict operational needs, optimize schedules, and enhance the organization's agility. By leveraging Artificial Intelligence, managers at airports can analyze vast amounts of data quickly and efficiently, detect new operational trends, and make informed decisions based on data, ultimately aiding in more efficient airport management.

Likewise, the respondents strongly agreed with the following statement, "Artificial Intelligence enhances operational decision-making. This discovery shows that intelligent analytical systems can help managers with effective information on the operation, predictive analysis and autofill recommendations that allow timely and effective decisions to be made. In the contemporary context of airports, AI-based decision-support systems play a role in

optimizing resource distribution, minimizing operational risks, and enhancing strategic planning.

The results also showed that respondents think that Artificial Intelligence is beneficial to the airports in terms of optimal use of their resources and predicting demands. This is in line with the growing use of predictive analytics in airport management, where AI algorithms use historical airport performance data to predict passenger numbers, schedule staff, coordinate gate assignments, and manage baggage handling. These capabilities help make airports more efficient, while cutting down on unnecessary costs.

The item on airport security monitoring had the lowest mean score for the Artificial Intelligence items, but still had a Very High level of agreement. This discovery suggests that staff are aware of the increasing significance of AI-driven surveillance camera technologies, facial recognition, and threat detection software in improving the security of airports. However, some of the respondents may feel that more investments in intelligent security infrastructure can enhance the airport's safety and surveillance functions even more.

The positive perceptions found in this study agree with the other empirical studies. For instance, research has been published that shows how Artificial Intelligence can enhance operational efficiency, predictive decision making, resource utilization, and service quality within the airport setting by intelligent automation and advanced data analysis. The studies highlight that AI technologies at airports can help cut down on delays, enhance passenger experience, and boost the airport's performance in general.

The results also confirmed the Technology Acceptance Model (TAM) which suggests that workers are more likely to use and embrace technological innovations if they believe them to be useful and easy to use. The scores of the present study are always high, which suggests that employees feel useful, and beneficial, and hence accept and adopt Artificial Intelligence for airport functioning.

In addition, the results confirm the Resource Based View (RBV) model because AI is shown to be an asset that can be used to achieve a sustainable competitive advantage for an organization. The use of AI technologies can help airports to optimize their operations, improve the quality of their decision making, use resources more effectively, and ensure that their services run better, all of which can help to increase the quality of their performance.

In general, the results showed that Artificial Intelligence is one of the main factors that are driving the digital transformation process at the King Abdulaziz International Airport. There is no doubt that it forms part of the employee's awareness of how it contributes to operational planning, decision making, predictive analysis, resource management and organisational effectiveness. Thus, the findings of this study sufficiently confirm the positive correlation between Artificial Intelligence and Operational Performance from the statistical analysis presented in Chapter Four.

5.1.2. Discussion about Internet of Things (IoT) Findings

The descriptive analysis result showed that the overall mean score of the Internet of Things (IoT) construct was 4.24, which means that the respondents agreed at a Very High level. The importance of the contribution of IoT technologies to the monitoring of the airport infrastructure, improving the handling of bags, predictive maintenance, operational coordination, and monitoring of passenger flow was strongly perceived by employees. The findings prove that IoT technologies have now become a crucial enabler in the digital transformation initiative undertaken at King Abdulaziz International Airport.

The highest mean score for individual questionnaire items was for IoT sensors related to the baggage handling systems. This discovery shows that staff are aware of the value of connected sensors and intelligent monitoring equipment in delivering greater accuracy towards baggage tracking, less baggage losses, less delay in operations and more reliability in

baggage handling. The widespread adoption of IoT technologies helps significantly improve the efficiency of airports, as baggage handling is one of the most important processes.

The second most popular statement was about the capability of IoT technologies to enhance passenger flow monitoring. The respondents felt that intelligent monitoring systems and connected digital devices can give the airport manager real-time data about passenger flows through the airport terminal. These features help to manage crowds, decrease congestion, manage queues, and maximize the efficiency of passenger processing. The results show that IoT technology not only helps to optimize operations but also enhances the overall passenger experience.

Similarly, respondents also strongly agreed that the IoT technologies would help in monitoring the airport infrastructure and would facilitate better coordination among the departments. These results have indicated that inter-connected digital systems can provide continuous monitoring of airport facilities, equipment, and operational assets, and enhance communication between the various operational departments. The ability to integrate the real-time operational information allows managers to detect operational problems quickly, coordinate the response effectively and enhance the decision-making process in the airport operations.

Predictive maintenance planning was the lowest mean score in the IoT construct, but it still scored at a High level of agreement. This discovery indicates that respondents are aware of the escalating relevance of predictive maintenance technologies and understand that further investment in the maintenance systems based on IoT technologies would further enhance the operational reliability of airports. For airport managers, predictive maintenance, powered by IoT technologies, enables them to identify equipment failures before they lead to a breakdown, which lowers maintenance costs, service disruptions and extends the life of the equipment.

The present results correspond with many of the previous works on the implementation of the IoT in an airport setting. According to several recent studies, IoT technologies have a significant impact on the following improved operational areas: operational visibility, infrastructure management, predictive maintenance, baggage handling efficiency and passenger flow management. Researchers have pointed out that connected sensors and real-time monitoring systems can improve the operational responsiveness by providing accurate information to assist in evidence-based operational decisions. Similarly, empirical studies have been carried out in smart airport environments and have revealed that the use of IoT applications can lead to a decrease in operating delays, better use of equipment, and better coordination between operational units at the airport.

The results also validate the Technology Acceptance model (TAM). TAM suggests that technological innovations are more likely to be adopted by employees when they believe that the innovations will assist them in their job performance. The level of consensus that has been seen consistently in the current study suggests that the employees have a positive perception of the value of using IoT technologies to make operational activities easier, more effective and more effective in delivering services. As a result, the usefulness of the IoT technologies boosts employee acceptance and organizational adoption.

IoT technologies can be considered as organizational resources that can give organizations sustainable competitive advantage from the RBV perspective. Airports with more sophisticated IoT technology can have a better oversight of operations and improved asset usage, optimize their maintenance plans and deliver better passenger services than those airports that have only traditional systems. Thus, IoT capabilities boost operational efficiency and also boost organisation competitiveness.

Moreover, the results corroborate the theory of Dynamic Capabilities which stresses the need for constant modification of the resources to be able to adapt to the environment at

the right time. With the use of IoT technologies, airports are able to continuously track their operations, gather real-time data, share the insights of new operational issues, and take corrective measures quickly. These are the capabilities that enhance the airport's operational resilience and its ability to adapt to changing passenger flow, disruptions, and technological advancements, all while being more flexible for the organization.

The importance of IoT technologies is further confirmed in Chapter Four with the inferential statistical analysis. The results of Pearson correlation showed that there was a positive correlation between Internet of Things implementation and Operational Performance with the results of which were statistically significant. Furthermore, the multiple regression analysis showed that the impact of IoT on operational performance was statistically significant and positive, suggesting that a better airport operating performance is directly linked to the implementation of IoT.

While it did not prove to be the biggest predictor compared to Smart Airport Technologies, IoT still played a significant role in the results and was statistically significant. The result indicates that IoT is a supporting technological base for implementing other digital transformation projects, such as the integration of Smart Airport systems and the use of Artificial Intelligence applications. AI algorithms can be particularly dependent on operational data collected from IoT devices, demonstrating the interplay between these digital technologies in practice.

In conclusion, the results suggest that the IoT technologies are an important aspect of the airport's digital transformation at KAIA. Staff know that the Internet of Things helps to enhance the monitoring of infrastructure, baggage handling, passenger flow management, predictive maintenance and operational coordination. These findings substantiate the proposition that the use of IoT technologies in the aviation industry can considerably improve

the operational performance at airports because of the availability of information, operational visibility and organizational responsiveness.

5.1.3. Discussion of Smart Airport Technologies Findings

Descriptive analysis results showed that the highest overall mean score among the independent variables was Smart Airport Technologies with an overall mean of 4.29 or Very High level of agreement. The outcome shows that employees of King Abdulaziz International Airport are highly conscious of the importance of Smart Airport Technologies as an effective factor to enhance airport operations and operational excellence. The airport's focus on intelligent digital systems, which is a key element of Saudi Arabia's Vision 2030 and national digital transformation strategy, is consistently being evaluated.

The top individual statements were "Digital airport systems improve service quality" and "Automated systems improve passenger processing efficiency". Overall, the results indicated that respondents consider smart airport technologies significantly contribute to the quality of services provided to the passengers, as well as to the efficiency of the airport's operation. The use of self-service kiosks, biometric boarding gates, automated baggage handling systems, intelligent queue management and integrated airport information systems has created a new working environment that decreases processing time, has less operational bottlenecks and enhances the overall experience for passengers.

The findings also showed that the employees were very positive about the operational efficiency, passenger service level and biometric identification systems provided by smart airport technologies. The results suggest that the respondents are aware of the benefits of linking multiple digital technologies across a single operational platform that enables them to manage the airport operations across multiple functional areas. Smart airport systems are different from individual technologies in that they depend on a multitude of technologies that are connected to each other, such as Artificial Intelligence, Internet of Things devices, cloud

computing, biometric technologies and big data analytics, to operate within a single airport ecosystem, constantly enhancing the results of the organization.

A significant finding of the regression analysis is that Smart Airport Technologies had the highest positive impact on Operational Performance ($\beta = 0.408$, $p < 0.001$) compared to the other technologies, namely Artificial Intelligence and Internet of Things technologies. The result indicates that the use of AI alone and IoT alone has a positive effect on operations, but together this combination within the context of a smart airport system has a greater organisational impact. Smart airport technologies are based on a digital infrastructure that integrates data collection, intelligent analysis and automation, prediction, and real-time operational coordination to optimize the entire airport operation instead of just the individual processes.

Their integrated nature may be a reason that explains the superiority of Smart Airport Technologies. The key difference between AI and IoT technologies is that AI is more about intelligent analysis and decision support, whereas IoT is more about data collection and real-time monitoring. These features are all integrated into smart airport systems that use integrated operational platforms that link together and coordinate passenger services, baggage handling, security operations, infrastructure management, airline coordination, and airport administration. As a result of this, employees feel there are more organizational impacts because these technologies impact several aspects of the operation at once.

The results of this study are largely in agreement with the recent empirical study that investigated smart airport transformation. The benefits of smart airport technologies are consistently reported in previous studies to improve airport operational efficiency, passengers processing time, service quality, operational coordination, passengers satisfaction and optimization of resources. The added value of integrated digital platforms for the airports has been highlighted and is recognized as a way to improve their efficiency and enhance the

customer service and competitiveness of the airport organizations. The similarity of the present findings with previous empirical findings lends credibility to the validity of the findings and shows that the observed relationships are supported in various airport environments.

The study results also significantly validate the Technology Acceptance Model (TAM). TAM employees are more likely to use technological innovations if they believe they will help them perform their jobs better and are easy to use in their daily work. The level of agreement that was found in the present study was very high, which suggests that the employees clearly think that Smart Airport Technologies are beneficial organizational tools that make the process of work easier, more effective, less manual and better quality of service. These positive perceptions help to drive technology adoption and enable the effective implementation of digital transformation projects.

Smart Airport Technologies are considered as valuable, rare and hard-to-imitate organizational resources that can create sustainable competitive advantage according to the view of the Resource Based View (RBV). Airports with advanced integrated digital systems in place have a greater advantage in optimizing their operational efficiency, enhancing passenger experiences, increasing organization flexibility and being able to react in a timely fashion to operational challenges. As a result, Smart Airport Technologies provide their organization with capabilities that others might not be able to duplicate easily.

The results are also in line with the Dynamic Capabilities Theory that states that organizations that sustain their success adjust their resources and capabilities to their changing environment on an on-going basis. Smart airport technologies give an airport the ability to gather operational data on an on-going basis, analyze trends and anticipate future operational needs, then rapidly manage unexpected disruptions. These dynamic capabilities

can help airport management to be operationally resilient and continually enhance organizational performance.

A further implication has to do with passenger-oriented airport management. The findings show that respondents also believe that Smart Airport Technologies relate to the improvement of the passenger experience. The automated processing of passengers, biometric identification, intelligent information systems and digital service platforms help to smoothen passenger flow, shorten waiting times, enhance quality of service and raise passenger satisfaction. It mirrors the shift in the traditional airport management towards smart airport ecosystems for better operational efficiency and passenger experience.

In addition, the findings indicate that digital transformation is not about single investments and rather is about the integration. The most beneficial organization effects are seen when the Airport implements Airports Smart Applications, or Internet of Things Devices, singly, but also by integrating them to create a complete Smart Airport Platform, allowing for smooth communication between the Airport systems. The results suggest that an integrated approach to digital transformation in airports is more important than just implementing technology solutions.

Overall, the discussion shows that the most impactful dimension of digital transformation in this study is related to Smart Airport Technologies. The employees continuously acknowledged their role and contribution in achieving operational efficiency, service quality, processing of passengers, passenger satisfaction, coordination with other sections in the airport and the overall performance of the airport. The result of the statistical analysis obtained in both descriptive and inferential analysis is highly significant, so there is a conclusion that Smart Airport Technologies are a strategic capability that can significantly increase the airport operational performance. Thus, the present results give strong empirical evidence to support the third research hypothesis and support the argument that integrated

smart airport systems are necessary to ensure the operational excellence of modern airports in the context of sustainability.

5.1.4. The findings of the Operational Performance discussions.

Operational Performance is the dependent variable of the present study and will be seen as the impact of the DT initiatives on improving airport efficiency, productivity, service quality, passengers' satisfaction and overall organizational effectiveness. The overall mean score for the Operational Performance was 4.29 hence Very High level of agreement among the respondents. This discovery indicates that the employees are highly confident in the tangible benefits of digital transformation projects on the performance of operational functions at King Abdulaziz International Airport.

The highest mean score for the Operational Performance statements (10 questions) was for the question "Digital transformation improves airport operational performance" (Mean = 4.36). This discovery shows that the respondents are not only thinking of digital transformation as a technological enhancement but also as a whole-organisational approach to improve the performance of the airport. Staff are fully aware that the use of cutting-edge digital technologies has significantly changed how the airport's operations are carried out, making them more efficient, faster and effective.

The second most popular comment was on the pace of airport transformation due to digitisation. The majority of the respondents felt that operations have become quicker at the airport due to the use of digital technologies. This discovery illustrates the real-life implications of automation, smart operations systems and digital integration for faster processing, fewer manual tasks, and quicker processes. Airports with faster operational processes can handle more passengers, with a high level of service quality and operational reliability.

Likewise, respondents were very satisfied with the enhanced level of satisfaction of passengers, the quality of services provided at the airports, the coordination of operations, the waiting time of passengers, the efficiency of operations and the efficiency of the dealing of the luggage. The results suggest that digital transformation has led to enhancements in various aspects of airport operations, not just one specific function. These extensive enhancements underscore the success of holistic approaches to digital transformation in contemporary airports.

The items pertaining to minimizing operational failures and minimizing airport congestion yields somewhat lower mean scores than the other operational performance measures, but both variables are still rated at High agreement level. The results indicate that there is an awareness of the positive impact digital technologies have on operational reliability, but also a recognition of scope for further organizational improvement. Airports continue to be complex operating systems with quickly changing passenger numbers, security needs, and chaotic disruptions in operations. Consequently, there is a strong sense among employees that more technology is needed to reduce operational errors and congestion even more.

The results of the current research clearly indicate that digital transformation can be considered a strategic tool that contributes to the operational excellence of airports. AI helps the airports to be smarter in their decision making and in operational planning process by providing intelligent analytics and predictive capabilities. Internet of Things (IoT) technologies enable an operational system to be monitored, maintained and communicate in real-time. These features are combined into comprehensive digital ecosystems that enhance the efficiency of airport operations, passengers' experience, and airport security at Smart Airport Technologies. These technologies work together and have a synergic effect that significantly improves operational performance.

The perceptions found in the current study were mostly similar to the empirical studies found in the literature in airport and aviation environments. Many research projects have shown that digital transformation can help to enhance the operational efficiency, processing of passengers, airport productivity, service quality, resource utilization and the satisfaction of the travelers. Numerous studies have confirmed airports that use integrated digital technologies generate better operational results than airports that used traditional operational systems. As such, the results of the present study support the increasing worldwide evidence that digital transformation in airports is beneficial to its operations.

The results also provide strong support for the Technology Acceptance Model (TAM). Staff expressed extremely high levels of agreement about usefulness of digital technologies to enhance day-to-day operational activities. Perceived usefulness is one of the best predictors of technology acceptance, TAM says. Overall, the overwhelmingly positive feedback from employees in the current study suggests digital transformation technologies are valued as organizational tools that facilitate working more effectively, make things easier to do and streamline operations and service delivery. Positive employee perceptions therefore help to ensure successful technology adoption and implementation within the organisation.

The results also validate the Resource Based View (RBV). RBV states that sustainable competitive advantage is created by valuable resources that an organisation possesses that will enhance performance and be hard for competitors to replicate. With the implementation of Artificial Intelligence, Internet of Things technologies, and Smart Airport Technologies, King Abdulaziz International Airport has access to state-of-the-art technological solutions that allow it to achieve operational efficiency, improve the quality of services, make passengers feel more comfortable and increase flexibility of the organization. They can be considered strategic organizational resources that can create long-term competitive advantages in the highly dynamic commercial aviation industry.

Moreover, the findings align with the Dynamic Capabilities Theory that focuses on organizations' ability to continually integrate, develop and re-configure their internal capabilities to adapt to changes in the environment. Airports are living environments that are dynamic, with an ever-changing number of passengers, technology, and operational uncertainties. Digital transformation technologies help airport management to constantly track operations, anticipate future needs in operations, allocate resources efficiently and deal rapidly with disruptions in the operations. This makes technologies help build resilience and the sustainability of long-term operations.

The inference statistical analysis in Chapter Four also supports this importance of digital transformation on airport operational performance. The results of the Pearson correlation analysis showed that each digital transformation dimension had a statistically significant positive correlation with Operational Performance. Furthermore, Multiple regression analysis was performed, and it was observed that the combined variance accounted by Artificial Intelligence, Internet of Things, and Smart Airport Technologies was about 71.6% explaining the variance in Operational Performance. The level of explanatory power of this indicator is very high, suggesting that digital transformation is among the key factors in the success of operations within King Abdulaziz International Airport.

The other implication that stands out from the results is the integrated nature of the digital transformation. The study shows that the overall operational performance improvement is not solely due to the individual technologies used in isolation. On the contrary, the most significant improvements are realized when Artificial Intelligence and Internet of Things technologies, combined with Smart Airport systems, work in an integrated digital environment. This comprehensive solution allows for real-time collection of operational data, smart data analysis, automation of operational processes, effective

coordination of airport activities, and improved passenger service quality. This means that organizations can achieve better performance on several operational aspects at once.

The results show that digital transformation has significantly improved the overall operational performance of KAIA. Employees saw positive, consistent gains in core operational efficiency, productivity, service quality, passenger satisfaction, operational coordination, baggage handling and organizational effectiveness. The results of these studies clearly support the main argument of this study, which is that digital transformation is a strategic capability with the potential to significantly improve the operational performance of airports. The findings thus support the theoretical framework and provide a solid foundation for discussion of correlation.

5.1.5. Discussion of Hypotheses

To test the hypotheses developed in Chapter Two, multiple linear regression analysis was used to explore the effect of Artificial Intelligence, Internet of Things and Smart Airport Technologies on Operational Performance at King Abdulaziz International Airport. The statistical results showed that all the hypotheses were accepted at the 0.05 significance level, suggesting that the digital transformation has a significant impact on enhancing the operational performance of airports. Each hypothesis is discussed individually, below.

H1: There is a statistically significant positive relationship between Artificial Intelligence and Operational Performance. H1: Artificial Intelligence positively affects Operational Performance, and the effect is statistically significant.

The regression analysis showed that the variables of Artificial Intelligence have a significant positive influence on Operational Performance ($\beta = 0.292$, $t = 5.204$, $p < 0.001$). Thus, the first hypothesis was accepted. This discovery suggests that the use of Artificial Intelligence technologies is having an impact on airport operational performance.

This is also corroborated by the descriptive analysis which a very high mean score for Artificial Intelligence ($M = 4.23$). Operational planning, managerial decision-making, airport resource allocation, airport security monitoring and passenger demand forecasting were highlighted as the key areas of application where respondents saw the greatest potential for AI to have a positive impact. The results indicate that Artificial Intelligence is seen as a crucial technology that enhances organizational effectiveness by providing intelligent data analysis and predictive decision-making.

The results are in line with several previous studies that have found that AI has the potential to revolutionize airport operations, offering significant benefits in terms of efficiency, resource optimization, decision-making, and overall organizational performance. AI-powered predictive analysis has been suggested as a tool for airport managers to forecast airport issues, optimize staffing, make better scheduling choices, and minimize airport delays. As a result, Artificial Intelligence helps increase the productivity of the organization and enhances the service to the passengers.

The results further corroborate the Technology Acceptance Model (TAM). The AI was found to be very useful for enhancing work efficiency, leading to its greater acceptance and use in airport operations. TAM states that perceived usefulness is one of the most reliable predictors of technology use. The high scores in this study suggest that workers understand the operational benefits of AI technologies and are thus more likely to endorse their further use.

Moreover, the results support the Resource Based View (RBV) model, as it was found that AI is a strategic capability of an organization that can create competitive advantages that are sustainable in time. By leveraging AI, airport managers can make more informed and precise decisions, enhance airport operations planning, utilize resources efficiently, and

ultimately boost the quality of airport services. They are capabilities that directly affect the performance of the organization.

In general, the results confirm the first hypothesis and show that Artificial Intelligence is indeed a major factor in boosting performance in airport operations.

There is a statistically significant positive effect of Internet of Things on Operational Performance.

The regression analysis found that the Internet of Things technologies showed a statistically significant positive effect on Operational Performance with a regression coefficient of $\beta = 0.248$, $t = 4.190$ and p value of < 0.001 . Thus, the second hypothesis was accepted. The results show the positive impacts of increased use of IoT technologies on airport operational performance.

Overall mean scores obtained in descriptive statistics indicated a very high mean score ($M = 4.24$) for the Internet of Things construct. The level of respondents' positive attitude towards the improvements of airport infrastructure monitoring, baggage handling systems, maintenance planning, operational coordination, and passenger flow monitoring as a result of the adoption of IoT technology is very high. The positive attitude of respondents towards the improvement of airport infrastructure monitoring, baggage handling systems, maintenance planning, operational coordination, and passenger flow monitoring due to the introduction of IoT technologies is high. The findings show that employees view IoT technologies as useful tools to support real-time information exchange and operational visibility.

The results align with other empirical studies that have found that IoT technologies enhance the performance of baggage handling processes, communication between airport departments, asset management, predictive maintenance, and operational monitoring. The researchers have highlighted that IoT applications allow the airport management to have real-time information about the operation, which is essential for responding quickly when an

event may occur, such as an equipment failure or operational disruption or passenger congestion.

The results also align with the Dynamic Capabilities Theory advocating the organizations' capability to constantly sense changes in the environment and quickly adapt to it through technological skills. Recent developments in Internet of Things technologies enable the airport's operational information to be constantly gathered from its assets and operational systems, allowing airport management to be alerted to new operational problems and take corrective action in advance of disruption.

The contribution of Internet of Things is also statistically significant, but it has a smaller regression coefficient than the Artificial Intelligence and the Smart Airport Technologies. This finding implies that, in most cases, IoT technologies are usage as infrastructure for other digital transformation projects, and not run on their own. The operational data from IoT devices is often a crucial component in the success of AI applications, demonstrating the synergy between these two technological aspects. Results overall validate the second hypothesis and show the impact of IoT technologies on airport operational performance is significant in terms of increased operational monitoring and predictive maintenance, communication and infrastructure management. The effect of Smart Airport Technologies on Operational Performance is statistically significant and positive.

The regression analysis resulted that the Smart Airport Technologies is the most influential factor positively affecting the Operational Performance with a beta value of 0.408 and t value of 6.426 and p value less than 0.001. Therefore, the third hypothesis was confirmed. Smart Airport Technologies was the most important predictor of airport operational performance among the three dimensions of digital transformation.

This result was also confirmed by the descriptive analysis, with the Smart Airport Technologies having the highest overall mean score ($M = 4.29$). Employees strongly believed that the use of smart technologies helps to improve operational efficiency at the airport, processing of passengers, biometric identification, passenger experience and service quality. The results suggest that Smart Airport Technologies are regarded as systems in the organisation that can simultaneously enhance multiple operational tasks.

It's possible that the superior influence of Smart Airport Technologies could be attributed to the fact that they are comprehensive. Smart Airport Technologies, instead of a standalone technology such as Artificial Intelligence or Internet of Things (IoT), combine several digital technologies into a single platform for the coordination of airport activities, automation of passenger services, enhancement of airport security, optimization of baggage handling activities and efficient use of airport resources. This kind of integration creates more organizational-than-technological value.

The results are in line with previous empirical research, which showed that Smart Airport Technologies can significantly enhance the efficiency of airports, satisfaction of passengers, operational coordination, service quality and organizational competitiveness. Integrated smart airport ecosystems have been proposed to improve airport service, enhance operational productivity as well as provide faster, safer and more reliable services to airports.

The results are consistent and strongly back the Resource Based View (RBV) and the Dynamic Capabilities Theory. Smart Airport Technologies, from RBV point of view, are valuable organizational resources which are used to improve the performance of the organization in operation and to give sustainable competitive advantage to the organization. Dynamic Capabilities - these technologies allow airports to constantly adapt operational processes, integrate new digital innovations and react to changes in the environment.

The results also have significant managerial implications. Airport managers should take a holistic approach to Smart Airport development and not develop individual technologies. Centralized digital platforms, smart operational control centers, biometric systems, automated passenger services, and operational analytics integration will likely be more beneficial for the organization than technology investments alone.

CHAPTER SIX

6. CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Introduction

The current chapter summarizes the findings of the study and discusses their theoretical, practical and policy implications. The chapter presents a summary of the major conclusions drawn from the empirical findings of Chapters Four and Five on how the Artificial Intelligence, Internet of Things and Smart Airport Technologies have affected the Operational Performance at King Abdulaziz International Airport. In addition, it offers practical suggestions for airport management, outlines the impact the study has had on the academic world and on the profession, gives some recognition to the study's weaknesses, and suggests avenues for future research. The chapter concludes with a focus on the strategic implications of digital transformation for the improvement of operational excellence and the future sustainability of Saudi's airports to achieve the goals of Saudi Vision 2030.

6.1.Conclusions

The present study aimed to investigate how digital transformation affects the performance of operations in King Abdulaziz International Airport (KAA), Jeddah, Saudi Arabia. In particular, the study examined the effect of three main aspects of Digital Transformation, namely Artificial Intelligence, Internet of Things, and Smart Airport Technologies on Operational Performance. The study employs a quantitative research method with data obtained from 250 respondents who are employees in operational departments and spells out significant empirical evidence about the strategic nature of digital transformation in contemporary airport management.

The result is evident; digital transformation is not just a technological endeavor, but a core capability for organizations. The employees were highly agreeable about the implementation of new technologies including Artificial Intelligence, Internet of Things

Technologies, and Smart Airport Technologies, with very high scores on the respective measures, signifying that the implementation of these new digital technologies has been well integrated into the airport's operating environment. The positive views are attributed to the technological sophistication of King Abdulaziz International Airport and successful delivery of Saudi Arabia's national digital transformation program in the aviation industry.

AI proved to be an important factor in enhancing airport operational performance through its use in managerial decision making, operational planning, resource allocation, passenger demand forecasting and airport security monitoring. Employees saw AI as a form of 'smart decision-making tool' that could help airport managers to process a lot of operational information quickly, predict operational problems and use resources more effectively. The results reveal that using Artificial Intelligence can increase the responsiveness of an organization, minimize operational uncertainty, and elevate the quality of decisions.

In the same way, it was found that IoT technology is also playing a crucial role in the effectiveness of airports in operation. The staff mentioned IoT technologies can enhance infrastructure monitoring, baggage handling, predictive maintenance, passenger flow management, and communication between the airport departments. The study results show the benefits of continuous operational monitoring through interconnected digital devices in increasing operational visibility and providing proactive management of airport activities. Smart Airport Technologies had the greatest impact on Operational Performance across all dimensions of digital transformation. The respondents were very satisfied that the integrated smart airport systems benefit of passenger processing, operational efficiency, airport security, service quality and passenger satisfaction. The statistical analysis also showed that Smart Airport Technologies was the strongest predictor of Operational Performance, highlighting

that an integrated digital ecosystem is the most beneficial element for the organisation compared to technological applications working separately.

The results also confirmed a very high Operational Performance level of evaluation. Staff reported constant gains in airports after implementing digital transformation projects in terms of efficiency, productivity, service quality, operational coordination, satisfaction of passengers, baggage handling, and organizational effectiveness. These results highlight a positive impact on several dimensions of airport operation, which has enhanced the general performance of the airport as an organization.

These same conclusions were supported by the inferential statistical analysis. The results of the Pearson correlation analysis showed that all the dimensions of the digital transformation had a positive relationship with Operational Performance, and this relationship was statistically significant. Further, regression analysis showed that the variance in Operational Performance was explained by around 71.6% by the combination of Artificial Intelligence, Internet of Things, and Smart Airport Technologies. This significant explanatory value is a seal of approval that digital transformation is one of the major factors that define the success of operations in the airport environment.

The study results as a whole indicate that sustainable improvements in airport operational performance need not be limited to certain technologies but rather should be based on comprehensive digital transformation strategies. The successful implementation of AI, IoT and Smart Airport systems at airports are likely to lead to better operational efficiency, passenger experience, service quality, organizational flexibility and sustainable competitive advantage.

6.2.Implications of the Study

6.2.1. Theoretical Implications

This study has several merits to the current knowledge on digital transformation and airport management. The study confirms the positive relationship between digital transformation and operational performance of the airport sector in an empirical way, which extends the existing body of knowledge on smart airport development.

Second, the results validate the Technology Acceptance Model (TAM) by showing that Artificial Intelligence, the Internet of Things (IoT) technologies, and Smart Airport Technologies are useful organizational tools that enhance job performance and operational efficiency for employees. In this study, the consistently high levels of employee acceptance showed that perceived usefulness is crucial for the acceptance of technologies in complex operational settings.

Third, the study confirms the Resource-Based View (RBV) concept as the study illustrated that digital transformation capabilities are a valuable organizational resource that can create a sustainable competitive advantage for the organization. The use of Artificial Intelligence, IoT technologies, and Smart Airport systems in turn increases the organizational capabilities, which are important for improving the efficiency of the organization's activities, enhancing the quality of services and increasing organizational competitiveness.

Finally, the results strengthen the Dynamic Capabilities Theory by highlighting the need for airports to constantly incorporate new digital technologies in their operational processes to achieve better operational performance. The findings of the study highlight the critical role of adaptability, technology incorporation, and ongoing innovation in ensuring the airports' operational excellence in a rapidly evolving landscape.

6.2.2. Practical Implications

The results of this research provide several practical implications to airport executives, operational managers, and airport decision makers in the process of implementing digital transformation projects. The facts and figures show that digital transformation is not just a technological upgrade – it is a strategic operational measure which impacts directly on the efficiency, quality of service, productivity and satisfaction of the airport's operations. For this reason, Airport Management needs to view digital transformation as an investment in its organization over time, not a one-off technology initiative.

The strategic integration of digital technologies is one of the most significant practical implications. The study also proves that the combination of Artificial Intelligence, IoT technologies and Smart Airport Technologies in an integrated digital system can achieve optimal operational performance. Thus, airport managers should not adopt independent technological solutions, but rather opt for digital platforms that are able to integrate operations departments, passengers' services, baggage handling, security operations and airport management within a single operational environment. This integration enables the sharing of information, enhances operational coordination, minimises duplication of effort, and boosts organisational efficiency.

The results also highlight the significance of investing in Artificial Intelligence as an operational decision support tool. The airport managers have to keep developing AI applications in the fields of demand forecasting, resource allocation, operational planning, predictive analytics, and intelligent scheduling. This is the role of AI-powered decision support systems, which can help airport management predict operational issues, efficiently schedule staff, optimize gate allocation, and reduce operational delays. The more intelligent the analysis that can be done, the more vital that will be to the operation of the businesses as passenger volumes grow.

Another implication relates to the use of IoT technologies across the entire airport infrastructure. IoT sensors give continuous data on the functionality of baggage handling equipment, passenger traffic, airport infrastructure, and other important operational assets. This real-time data enables airport authorities to identify discrepancies in the system, plan predictive maintenance, make the most of equipment, and avoid disruptions in operations before they impact passenger services. Hence, the further development of IoT infrastructure should be a priority to the airport's management.

The study also proves that Smart Airport Technologies are of great value to the organization. Continued investment in airport automated passenger processing systems, biometric identification technologies, intelligent surveillance systems, self-service facilities, and integrated operational control centers are needed for airport management. These technologies not only enhance the efficiency of airport operations but also bolster passengers' trust in the airport by decreasing waiting times, elevating service standards, and secure the environment.

These enhancements directly impact passenger satisfaction and organizational reputation. Another key practical implication from the study is the HRD. As well as the technology, staff need to be able to use the new and advanced digital systems successfully to achieve the success of digital transformation. Therefore, it is imperative that a continuous professional development initiative be introduced by airport management based on the application of Artificial Intelligence, digital operational system, cybersecurity awareness, data analytics, and digital leadership. Ongoing training will enhance employee skills and help to mitigate organizational change and technological adoption resistance.

The results further indicate that airport management should develop a comprehensive system of performance measurement that is able to continually track the effectiveness of digital transformation projects. Measures of operational efficiency, waiting times for

passengers, accuracy of baggage handling, equipment availability, service quality, operational reliability, and passengers' satisfaction are examples of Key Performance Indicators (KPIs) that should be incorporated. Airport managers can use continuous performance monitoring to assess the impact of their investment in digital and determine what more they need to do. Lastly, the study emphasises the need for collaboration in organisations in the process of digital transformation. Close cooperation is required between the airport management, the airline, the technology providers, government officials, security authorities and operational departments to ensure successful implementation. Integrated governance structures and cross-functional digital transformation teams can facilitate a better coordination, fast technology implementation and link digital initiatives to the airport's long-term strategic goals. Overall, the practical implications show that digital transformation is a holistic approach to the organization that involves technology, people, processes, and culture. Airports that effectively incorporate these features are better equipped to attain sustainable operational excellence and remain competitive in the quickly changing global aviation sector.

6.2.3. Policy Implications

This study also offers a number of policy implications for government and aviation regulatory bodies, as well as for national policy makers that are tasked with developing the future of airport development in Saudi Arabia. Digital transformation is one of the key enablers to achieve the goals of Saudi Vision 2030, as the Kingdom moves forward on its journey of Economic Diversification, Infrastructure Modernization and Improving Public Services. It is because in the aviation industry, digital innovation can deliver a significant economic and social benefit, which makes it one of the strategic industries to invest in.

The results suggest that the government institutions should keep supporting digital transformation efforts by continuing to develop country policies that foster technological innovation and development in airports. Regulatory bodies must create holistic frameworks

for digital transformation and declare national standards for the use of Artificial Intelligence, Internet of Things, Smart Airport Technologies, cyber security, data handling and airport digital interoperability. Standardizing the digital policies would help with the integration of technology while keeping uniformity among Saudi airports.

The other relevant policy implication is that ongoing investments in digital infrastructure are needed. National level should focus on providing funding for the implementation of new airport technologies, such as intelligent operational control systems, biometric identification systems, predictive maintenance systems, cloud computing technology, big data analytics, and digital communication systems. Such investments will help speed up the process of airport modernization and help Saudi Arabia's aspiration to become a hub of global aviation.

The study also underscores the critical role of cybersecurity in the context of the increasing digitalisation of airport operations. National cybersecurity policy makers need to bolster regulations for critical aviation infrastructure. Airports are increasingly connected and reliant on operational systems, cloud-based platforms and intelligent technologies that need to be well protected from cyber threats. The creation of cybersecurity strategies, incident response plans, and full security monitoring systems will contribute to the resilience of operations and the security of national aviation infrastructure.

Another major policy implication is in the field of education and workforce development. The government authorities in charge of higher education and professional development should join with the aviation sector and create special programs on Artificial Intelligence, Smart Airports, aviation analytics, cyber security, digital engineering and airport technology management. A digitally skilled national workforce will complement the long-term sustainability of the digital transformation of airports and minimise reliance on external experts.

The results also indicate that the authorities should foster a closer cooperation among the universities, research institutions, technology enterprises and airports. Such partnerships would facilitate applied research, technology transfer, innovation, and continuous development of smart airport solutions specifically designed for the Saudi aviation environment. Innovation ecosystems can propel emerging technology to commercialization and enhance the competitiveness of the national aviation industry.

The other key implication relates to the issues of performance evaluation and benchmarking. National aviation authorities need to define common digital performance measures that will allow airports to track progress towards digital transformation goals. Comparing airport performance with international best practices will help decision makers decide on investments needed that will further enhance continuous improvement in the Saudi airport system as a whole.

Last but not least, the study aligns with the strategic agenda of Saudi Vision 2030, which emphasizes the transportation modernization, digital government, smart infrastructure, economic diversification, and enhancing public service delivery. The empirical results show that a continuous investment in Artificial Intelligence, Internet of Things technologies and Smart Airport Technologies adds directly to the airport operational performance. Therefore, the government's commitment to digital transformation in the aviation industry will enable the country to become more competitive in the international market and participate in sustainable economic growth.

Overall, the policy recommendations highlight that effective digital transformation at the airport level calls for coordinated efforts for national-level strategies that incorporate technological investments, regulatory modernization, cybersecurity, workforce development, research collaboration, and continuous performance monitoring. This can help Saudi airports

be internationally competitive, while providing efficient, secure and pleasant services to passengers and aviation stakeholders.

6.3.Recommendations

Based on the results of this research, the following recommendations are made to help achieve digital transformation and better operational performance at King Abdulaziz International Airport:

6.3.1. Strategic Recommendations

Invest in full digital transformation programs in line with Saudi Vision 2030.

Create an overall digital transformation plan, which links all airport operational departments.

Put in place a governance structure for monitoring and assessing digital transformation initiatives.

6.3.2. Technological Recommendations

Implement more applications of Artificial Intelligence to aid operational planning and decision making.

Boost Internet of Things technology investments for real-time monitoring and predictive maintenance.

Keep developing Smart Airport Technologies such as biometric systems and automation services for passengers.

Improve cybersecurity to safeguard digital infrastructure and operate information.

6.3.3. Human Resource Recommendations

Continue training to enhance employees' digital skills.

- Promote an innovative and technology-friendly working environment for airport employees.

Improve the joint working of the operational and IT teams and make digital transformation pay off.

6.3.4. Operational Recommendations

Use performance indicators (KPIs) to continually measure the success of digital transformation projects.

Increase passenger service through increasing self-service technology and decreasing processing time.

Improve predictive maintenance programmes to minimise equipment failure and operating downtime.

Continuously monitor digital transformation projects and measure them regularly for further improvement of operations and services.

6.4. The contributions of the Study

The present study is quite significant in the digital transformation domain, airport management and operational performance. These contributions can be sorted as theoretical, practical, managerial and methodological.

6.4.1. Theoretical Contribution

The study fills the gaps in previous research by investigating the synergistic effects of Artificial Intelligence (AI), Internet of Things (IoT) and Smart Airport Technologies (SAT) on the airport operations performance in the airport industry. It builds on the previous study by coming up with a unified conceptual model of these three dimensions and testing the relationships between them with data collected from King Abdulaziz International Airport. In addition, the results validate the applicability of the Three theories: Technology Acceptance Model (TAM), Resource-Based View (RBV), and Dynamic Capabilities Theory in airport digital transformation.

6.4.2. Practical Contribution

The study offers practical insights for airport organisations aiming to enhance their operational performance via digital transformation. The results prove that the use of

integrated digital technology is an investment for operational efficiency, service quality, passenger experience and organizational efficiency. These insights can prove useful for airport management in prioritizing digital initiatives and proper resource allocation.

6.4.3. Managerial Contribution

The study provides guidance to airport managers, pinpointing dimensions of digital transformation which play the biggest role in airport's operational performance. The results showed that the Smart Airport Technologies have the highest impact, followed by Artificial Intelligence and Internet of Things technologies. This information can be used to inform managerial decision-making on investments in technology, operation planning, and digital transformation strategies.

6.4.4. Methodological Contribution

From a methodological point of view, the study offers a validated quantitative approach that examines the digital transformation in the operation of airports. The research instrument was found to be reliable and valid and can be used or adapted in future research in aviation industry or other industries of transportation.

6.5.Limitation:

This study was successful in meeting the five research objectives, however there were some limitations to be noted.

First, the study was performed only in King Abdulaziz International Airport and might not be representative of the broader set of airports in the country with varying operational context and technological capabilities.

Second, it was cross-sectional research because data were gathered at one time. This meant that the study was unable to look at how employees' perceptions changed over time and could not assess the long-term effects of digital transformation projects.

Third, it employed self-administered questionnaires, so the results were based on employees' perceptions of the operational performance, rather than on actual measures. While respondents had relevant operational experience, perception-based data could be subject to individual opinions and experiences.

Lastly, the study concentrated on the three aspects of digital transformation - Artificial Intelligence, Internet of Things and Smart Airport Technologies. In addition to the organizational and technological issues examined, other organizational and technological issues, including organizational culture, leadership, maturity of the airport's cybersecurity, digital readiness, and innovation capability, were not explored in the present research but could impact airport operational performance.

6.6.Future Research Directions

To capitalize the weaknesses of the present study, the following are recommended. The findings of the study can be generalized and compared to other airports through further studies that focus on digital transformation at multiple airports in both Saudi Arabia and overseas countries. Longitudinal designs also might be used to study the impact of digital transformation on operational performance over time.

Researchers are invited to include other organizational variables like organizational culture, digital leadership, employee readiness, innovation capability, cybersecurity maturity or organizational resilience to gain a deeper understanding of digital transformation in the airport setting.

Other potential factors that shape the link between digital transformation and operational performance could be explored in further research. This can take the form of organizational innovation, knowledge management and/or employee engagement, or service quality.

Last, but not least, further studies may be conducted on new technologies like Digital Twin, Blockchain, Big Data Analytics, 5G-based airport systems, and Generative Artificial Intelligence, to assess their future potential in the field of next generation smart airports.

References

- Buhalis, D., & Leung, R. (2018). Smart hospitality—Interconnectivity and interoperability towards an ecosystem. *International Journal of Hospitality Management*, 71, 41–50.
<https://doi.org/10.1016/j.ijhm.2017.11.011>
- Creswell, J. W., & Creswell, J. D. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). Sage.
- de Reuver, M., Sørensen, C., & Basole, R. C. (2018). The digital platform: A research agenda. *Journal of Information Technology*, 33(2), 124–135. <https://doi.org/10.1057/s41265-016-0033-3>
- Graham, A. (2019). *Managing airports: An international perspective* (5th ed.). Routledge.
<https://doi.org/10.4324/9781315200293>
- Gudmundsson, S. V., Cattaneo, M., & Redondi, R. (2020). Forecasting air transport demand: A review of methods and models. *Transport Reviews*, 40(4), 473–497.
<https://doi.org/10.1080/01441647.2019.1706826>
- Gudmundsson, S. V., Cattaneo, M., & Redondi, R. (2020). Forecasting air transport demand: A review of methods and models. *Transport Reviews*, 40(4), 473–497.
<https://doi.org/10.1080/01441647.2019.1706826>
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2022). *Multivariate data analysis* (9th ed.). Cengage Learning.
- Halpern, N., Mwesiumo, D., Suau-Sanchez, P., & Budd, T. (2020). Ready for digital transformation? The effect of organisational readiness, innovation, airport size and ownership on digital change at airports. *Journal of Air Transport Management*, 89, 101949.
- International Air Transport Association. (2024). *Digital transformation in aviation*. IATA.

- International Civil Aviation Organization. (2023). *Global air transport outlook*. ICAO.
- Jurgelāne-Kaldava, I., & Ozoliņš, A. (2025). Digitalization of air cargo supply chains: A case study of airport logistics. *Systems*, 13(6), 468. <https://doi.org/10.3390/systems13060468>
- Kovynyov, I., & Mikut, R. (2019). Digital transformation in airport ground operations. *CEUR Workshop Proceedings*, 2460, 35–44..
- Neufville, R., & Odoni, A. (2013). *Airport systems: Planning, design, and management* (2nd ed.). McGraw-Hill Education.
- Poulaki, I., & Papadopoulos, T. (2021). Digital technologies and innovation in airport services: A benefit model approach. *Journal of Air Transport Studies*, 12(2), 45–65. <https://doi.org/10.38008/jats.v12i2.242>
- Remencová, T., & Sedláčková, A. (2021). Modernization of digital technologies at regional airports. *Transportation Research Procedia*, 55, 1232–1239. <https://doi.org/10.1016/j.trpro.2021.07.083>
- Saunders, M., Lewis, P., & Thornhill, A. (2023). *Research methods for business students* (9th ed.). Pearson.
- Sekaran, U., & Bougie, R. (2020). *Research methods for business: A skill-building approach* (8th ed.). Wiley.
- SITA. (2024). *Airports of the Future: Ideas That Fly*. SITA.
- SITA. (2025). *Air Transport IT Insights 2025*. SITA.
- Tan, J. H., & Masood, T. (2021). Adoption of Industry 4.0 technologies in airports: A systematic literature review. *Journal of Air Transport Management*.
- Thums, J., Muench, S., & Grimme, W. (2023). Future air transportation and digital work at airports: A systematic literature review. *Journal of Air Transport Management*, 108, 102363. <https://doi.org/10.1016/j.jairtraman.2023.102363>

Tsui, W. H. K., Balli, H. O., Gilbey, A., & Gow, H. (2014). Operational efficiency of Asia-Pacific airports. *Journal of Air Transport Management*, 40, 101–108.

<https://doi.org/10.1016/j.jairtraman.2014.06.005>

World Bank. (2023). *Digital development overview*. World Bank.

World Economic Forum. (2024). *Digital transformation in transport and logistics*. World Economic Forum.

Zaharia, S. E., & Pietreanu, C. V. (2018). Challenges in airport digital transformation.

Transportation Research Procedia, 35, 90–99. <https://doi.org/10.1016/j.trpro.2018.12.016>

Zhang, A., & Graham, A. (2020). Air transport liberalization and its impacts on airline competition and airport efficiency. *Journal of Air Transport Management*, 87, 101857.

<https://doi.org/10.1016/j.jairtraman.2020.101857>

Zhang, Y., & Chen, X. (2023). Artificial intelligence applications in smart airport operations: Opportunities and challenges. *Sustainability*, 15(18), 13654.

APPENDIX

QUESTIONNAIRE

Demographic Information

Question	Options
Gender	Male / Female
Age	Less than 30 / 30–40 / 41–50 / Above 50
Educational Qualification	Bachelor's / Master's / Doctorate
Years of Experience	Less than 5 / 5–10 / 11–15 / More than 15
Department	Operations / IT / Customer Service / Management

Artificial Intelligence (AI)

Statement	1	2	3	4	5
Artificial intelligence improves operational decision-making in airports	☐	☐	☐	☐	☐
AI technologies improve airport resource allocation	☐	☐	☐	☐	☐
AI systems help predict passenger demand	☐	☐	☐	☐	☐
AI technologies enhance airport security monitoring	☐	☐	☐	☐	☐
AI improves airport operational planning	☐	☐	☐	☐	☐

Internet of Things (IoT)

Statement	1	2	3	4	5
IoT technologies improve monitoring of airport infrastructure	☐	☐	☐	☐	☐
IoT sensors help monitor baggage handling systems	☐	☐	☐	☐	☐
IoT technologies improve maintenance planning	☐	☐	☐	☐	☐
IoT technologies enhance operational coordination between departments	☐	☐	☐	☐	☐
IoT improves monitoring of passenger flow within airports	☐	☐	☐	☐	☐

Smart Airport Technologies

Statement	1	2	3	4	5
Smart technologies improve airport operational efficiency	☐	☐	☐	☐	☐
Automated systems improve passenger processing efficiency	☐	☐	☐	☐	☐
Biometric technologies improve passenger identification	☐	☐	☐	☐	☐
Smart airport systems improve passenger experience	☐	☐	☐	☐	☐
Digital airport systems improve service quality	☐	☐	☐	☐	☐

Operational Performance

Statement	1	2	3	4	5
Digital technologies reduce passenger waiting times	☐	☐	☐	☐	☐
Digital transformation improves baggage handling efficiency	☐	☐	☐	☐	☐
Airport operations become faster after digital transformation	☐	☐	☐	☐	☐
Digital systems reduce operational errors	☐	☐	☐	☐	☐
Digital monitoring improves airport operational coordination	☐	☐	☐	☐	☐
Digital technologies improve overall airport productivity	☐	☐	☐	☐	☐
Digital transformation reduces congestion in airports	☐	☐	☐	☐	☐
Digital technologies improve airport service quality	☐	☐	☐	☐	☐
Digital transformation improves airport operational performance	☐	☐	☐	☐	☐
Digital transformation improves passenger satisfaction	☐	☐	☐	☐	☐