The Digital Maturity levels of African airports: A departure point for the Digital Transformation journey

Tshegofatso Mosehlane

313954

313954@students.wits.ac.za 083 9851128

A research report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Management in the field of Digital Business

Johannesburg, 2020

(Version 2019-2020)

ABSTRACT

Background: The study aims to investigate Digital Maturity levels within the African airport industry. The correlation between Digital Maturity and the following airport performance indicators; total revenue growth, total departing passenger growth and Airport Service Quality (ASQ), was investigated to establish whether any such relationships exist.

Objectives: To determine the as-is Digital Maturity levels as input into Digital Transformation Strategy development and to understand whether there exists a relationship between high Digital Maturity levels and an increase in company performance.

Method: A literature study of fourteen Digital Maturity models was performed to determine the qualitative dimensions of the Digital Maturity Model used in this study. An online survey set up in a Likert scale format (1 = *strongly disagree* to 5 = *strongly agree*), was subsequently developed. Frameworks by De Bruin, Rosemann, Freeze, and Kulkarni (2005) and Maier, Moultrie, and Clarkson (2012), were used for the development of the Digital Maturity Model. The reliability of the Digital Maturity model was tested using Cronbach's alpha (α) test (Gilem & Gilem, 2003). The survey was sent to African airport employees via email. Responses were quantitatively measured by allocating weightings (1 to 5) to Digital Maturity sub-dimensions, enabling the calculation of maturity levels per Digital Maturity dimension for each airport. Descriptive studies were further conducted to understand the distribution of the collected data. The second part of the study investigated the correlation between Digital Maturity levels and company performance indicators (Remane, Hanelt, Wiesboeck, & Kolbe, 2017).

Results: The study found that African airports display low maturity levels, ranging between 1.39 and 2.96. With South African and Ghanaian airports being on the higher end and Nigerian airports being on the lower end of the Digital Maturity scale. Most of the airports fall on the higher end of the scale, above Digital Maturity level 2.7. Furthermore, all the airports experienced a decline in total revenue and an increase in total departing passenger numbers over 3 years. The airports with the higher Digital

Maturity levels experienced lower total revenue declines and higher total departing passenger growth, compared to the airport with the lowest Digital Maturity level. Additionally, the airport with the highest Digital Maturity level, experienced the most considerable decline in ASQ. Whereas the airport with the lowest Digital Maturity level, experienced an improvement in ASQ over the 3 years.

Conclusion: Digital Maturity levels at African airports are low and to remain competitive, airports need to define strategies to assist them in progressing to higher levels of Digital Maturity. The features and outputs of the Digital Maturity Model survey should be used to inform the Digital Transformation Strategies. The study found a positive relationship between Digital Maturity and growth in total revenue and total departing passengers, and a negative relationship between Digital Maturity and ASQ. Organisations should decide on the Digital Maturity dimensions that will be a priority for them to remain competitive. These priority dimensions should be used to offer a differentiated experience to passengers and customers per the organisations' refreshed Digital Transformation Strategy.

Keywords: Digital Maturity, Digital Transformation, Maturity Model, Fourth Industrial Revolution, 4IR, Industry 4.0, African Airports, Airport 4.0

DECLARATION

I, Tshegofatso Mosehlane, declare that this research report is my own work except I have explicitly indicated otherwise. I have followed the required standards in referencing the work, thoughts and ideas of others. This research is submitted in partial fulfilment of the requirements for the degree of Master of Management in the field of Digital Business at the University of the Witwatersrand, Johannesburg. I confirm that research report has not been submitted before, in this or any other university.

Name: Tshegofatso Mosehlane Signature: 

Signed at Polokwane

On the 11th day of November 2020

DEDICATION

This research is dedicated to my family and friends who have supported me every step of the way. They have given me the much-needed encouragement along this process. More specifically, I would like this to be a motivation to my children and siblings, for them to know and believe that they can achieve whatever they put their minds to achieving. Finally, to God be the glory, for carrying me through this journey. I am because He is!

ACKNOWLEDGEMENTS

I would like to acknowledge the following people and organisations, Professor Brian Armstrong, the Head of Chair in Digital Business at the Wits Business school, for your teachings. To Dr Joachim Vermooten, who was my research supervisor during this study. I would like to thank you for your guidance and support during the duration of this study. To Ayanda Magida, your never-ending patience and assistance was much appreciated. You support many students, but your ability to provide individualised feedback and assistance was amazing.

To Refilwe Simankane, my friend and colleague, your continual motivation, support and understanding. If it were not for you, I probably would not have made most of the timelines I needed to make to complete this study. To Hlumelo Dokoda, my friend and manager, your understanding and support has been incredible. Thank you for affording me the time I needed, when I had to focus on my studies. To my employer, thank you for sponsoring me in every way that was required.

To the ACI Africa team, for their support and assistance during the data collection process. A special mention to Yacine Kebe for connecting me with all the relevant stakeholders. A special thank you also goes to Pieter Du Plessis, for opening up the ACI Africa network to me. Additionally, to all the African airports that took part in the study and more importantly to the employees who heeded the call to participate in the survey, I appreciate the time you took out of your busy schedules to assist me in this process.

Last but not least, to the MMDB full-time class of 2019 and all the syndicate groups I was part of, thank you for the learning journey. The plethora of ideas, the openness to sharing, and the support throughout the year made this an enriching experience. Thank you!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

4IR: Fourth Industrial Revolution

ACI: Airports Council International

ASQ: Airport Service Quality

B2B: Business to business

B2C: Business to consumer

CAPEX: Capital expenditure

CIO: Chief Information Officer

CPSS: Cyber-Physical Production System

DM: Digital Maturity

EBIT: Earnings before interest and taxes

IATA: International Air Transport Association

NEPAD: New partnership for Africa's development

RFID: Radio-frequency identification

RO: Research Objectives

1 INTRODUCTION

1.1 Purpose of the study

This study was a mixed-method study to investigate the Digital Maturity levels of six African airports. The correlation between Digital Maturity and the following airport performance indicators; total revenue growth, total departing passenger growth and Airport Service Quality (ASQ), was investigated to establish whether any such relationships exist.

1.2 Context of the study

The airport industry has seen a high penetration and implementation of digital technologies at airports across the world (Halpern, Budd, Suau-Sanchez, Brathen, & Mwesiumo, 2019). Some of the airports have done well in adopting digital technologies to transform their airports, evolving into smart airports digitally, dramatically improving the passenger journey experience like; Schiphol (Aulman, 2018), Heathrow (Martin-Domingo & Martin, 2016) and Abu Dhabi Airports (African Aerospace, 2019).

Smart airports have implemented technologies such as smart security, self-service gates with facial recognition (Aulman, 2018) and automated bag drops, digital signage, (Kovynyov & Mikut, 2018) and RFID baggage tracking (Aulman, 2018; African Aerospace, 2019)

Some of the stated drivers for implementing Digital Transformation strategies are; improving passenger experience (Kalakou, Psaraki-Kalouptsidi, & Moura, 2015), achieving process efficiencies (Kovynyov et al., 2018), improving security (Kalakou et al., 2015), driving collaboration amongst airport stakeholders, cost benefits, (Halpern et al., 2019) and creating new business models (Kovynyov et al., 2018). Judging by the above benefits to business, there is a clear business case for airports to adopt digital technologies to enable Digital Transformation. In their study Halpern et al.,

(2019), state that there is increased interest for airports to transform and thus reach Digital Maturity.

As stated by Berghaus and Back (2016), business-to-consumer (B2C) businesses will be most impacted by Digital Transformation than companies that are business-to-business (B2B). Airports find themselves in a position where they are both B2Cs, through the provision of non-aviation services to passengers and B2Bs, through the provision of aviation services to airlines, making them even more vulnerable to this evolution. They are faced with changing passenger and airline expectations. This position presents an opportunity for integration, agility, and improvement across the entire value-chain (Schumacher, Erol, & Sihn, 2016; Ganzarain & Errasti, 2016).

Industry stakeholders, such as Airports Council International (ACI) have developed guidelines for Airport Digital Transformation Best Practice (Airports Council International [ACI], 2017) to aid airport executives in digitally transforming and building a digital culture across their organisations. The notable involvement of Industry stakeholders in supporting member airports is a testament to the great impact that Digital Transformation will have on the airport industry.

1.3 Research problem

The advent of new digital technologies resulting from the Fourth Industrial Revolution has caused pressure on organisations to transform digitally. Organisations are feeling the pressure to adapt their business models (Remane, Hanelt, Wiesboeck, & Kolbe, 2017), to ensure continuous process improvement and to provide unique customer experiences (Issa, Hatiboglu, Bildstein, & Bauernhansl, 2018).

Organisations, such as those in the manufacturing industry rarely understand what technologies need to be adopted and implemented, how much investments need to be dedicated to this adoption (Schumacher et al., 2016) and the skills required to assist with implementation. Secondly, they lack clarity over the digital solutions that will deliver the most value for their businesses (Schumacher et al., 2016). The third dilemma is with regards to how they could successfully transform their organisations while achieving their performance objectives (Issa et al., 2018). A Digital

Transformation journey needs to have a starting point, where the company understands its' as-is maturity level. This understanding, includes understanding the adoption levels of digital technologies or the ability to transform digitally, referred to as digital readiness (Schumacher et al., 2016).

A Digital Maturity model can be used to help African airports understand their as-is maturity level. Furthermore, the Digital Maturity model helps identify gaps between as-is and to-be Digital Maturity levels, as they embark on their Digital Transformation journey (Berghuas et al., 2016). A roadmap needs to be crafted to contain the sequence of steps that will be taken. Digital Maturity analysis enables an understanding of the current Digital Maturity level and identification of the gaps that exist to allow the airports to remain competitive (Halpern et al., 2019). An understanding of current maturity levels will result in the development of the Digital Transformation Strategy – the roadmap.

The impact of Digital Maturity on organisational performance indicators has been researched by Remane et al., (2017). This study contributes to this area of research by investigating the impact on airport-specific indicators, i.e. total revenue growth, total departing passenger growth and ASQ.

1.4 Research objectives

The study investigated the following research objectives (RO)

RO1: To investigate the Digital Maturity levels of African airports using a Digital Maturity model

It was unclear whether a relationship exists between an increase in Digital Maturity and improvements in company performance. This led to the next research objectives, where the relationships were investigated.

RO 2: To analyse the relationship between Digital Maturity levels and total revenue growth over 3 years

RO 3: To analyse the relationship between Digital Maturity levels and passenger growth over 3 years

RO 4: To analyse the relationship between Digital Maturity levels and ASQ results of airports over 3 years

1.5 Significance of the study

This study contributes to discussions on the adoption of digital technologies within the Fourth Industrial Revolution. The study adds to the body of work of Digital Maturity models. Furthermore, the study provided a relationship between Digital Maturity and airport performance indicators. It determined the organisation's current Digital Maturity status (Berghuas et al., 2016), to aid organisations in embarking on their Digital Transformation journeys.

The relationship between customer perceptions and Digital Maturity levels of organisations remains unexplained (Chanias & Hess, 2016). This study investigated the relationship between ASQ (customer perception of the airport) and Digital Maturity. Furthermore, the study provided insights on Digital Transformation in the African context and more specifically within African airports.

1.6 Delimitations of the study

The study aimed to collect data from six African airports, with annual passenger numbers of 2 million and above. Smaller African airports were excluded from this study. The study did not investigate the detail of adopted digital technologies. Instead, it evaluated the readiness of the airport (considering organisational practices) and the success of previous technological adoptions to determine the level of Digital Maturity. Digital Maturity measurement was based on the organisational practices and not only on operations at the airport. The study did not review Digital Maturity models, not used in academic research, such as those developed by consulting firms even though these maturity models are used in practice (Felch, Asdecker, & Sucky, 2019). Academia, analysts, consultants and the airport industry can benefit from the outcomes of this

study. This study contributes to the use of Maturity Models to measure the Digital Maturity of airports.

1.7 Definition of terms

Airport Service Quality: A measure of passengers' satisfaction with airports (Pabedinskaite & Akstinaite, 2014).

Capability: An area within a specific domain which provides more details on the components of that domain, (De Bruin et al., 2005) to enable the measurement of changes in maturity of the domain being evaluated (Kohlegger, Maier, & Thalmann, 2009). According to (Maier et al., 2012), it can also be defined as the degree of difference in organisational performance.

Competency: Qualitative attributes used to classify an object into a specific class/es (Kohlegger et al., 2009).

Digital Maturity: A measure of the status of an organisation in terms of its ability to adopt digital technologies or the state of an organisation's Digital Transformation (Chanias et al., 2016). In literature, the terms Digital Maturity and digital readiness are used interchangeably (Schumacher et al., 2016; Remane et al., 2017; Issa et al., 2018). In the context of the study, the term Digital Maturity was used.

Digital Maturity Levels: The extent of Digital Maturity of an organisation customarily measured as cumulative steps on a scale from low to high (De Bruin et al., 2005).

Digital Maturity Model: A tool used to measure the status of an organisation in terms of its ability to adopt digital technologies or the state of an organisation's Digital Transformation (Chanias et al., 2016).

Digital Technologies: Digital technologies in the context of this study refer to those technologies that relate directly to the 4th Industrial revolution, such as big data, artificial intelligence, augmented reality, and internet of things.

Digital Transformation: The transition of an organisation from the current state of Digital Maturity to the predefined state of to-be Digital Maturity. Alternatively, the

process of change due to the increased use of technology (Chanias et al., 2016) to ensure that the organisation sustains a competitive advantage in the future. Digital Transformation can also be referred to as digitalisation (Schwer, Hitz, Wyss, Wirz, & Minonne, 2018). In the context of the study, the term Digital Transformation was used.

Digital Transformation Strategy: A strategy used in support of the broader organisational strategy to aid the organisation in making strategic decisions with regards to the adoption of digital technologies and in guiding decisions around Digital Transformation priorities.

Fourth Industrial Revolution: Advances in technology where the internet and associated technologies are the backbone to the integration. Including the integration of physical objects, humans, smart machines, processes, and production lines across organisational boundaries (Schumacher et al., 2016) that require a new level of organisation and control (Ganzarain et al., 2016).

Maturity Model: A tool used to measure the maturity levels of an organisation against set criteria or dimensions. A maturity model represents stages of increased quantitative or qualitative competency improvements of a maturing component, to assess its progress in a defined focus area (Kohlegger et al., 2009) or, evolutionary process (Mettler & Rohner, 2009).

Passenger Growth: An increase in the number of passengers facilitated through the airport (Halpern et al., 2019).

Revenue Growth: An increase or decrease in company income.

Smart Airports: Airports that have entirely digitised their operations and passenger touchpoints, to ensure optimised processes and enhanced passenger experience where the passenger is aided by intelligent infrastructure and their mobile device (Nagy & Csiszar, 2016).

Sophistication levels: The extent of maturity (Mettler, 2009) or reaching a predefined level of maturity (Mettler et al., 2009).

Strategic Objectives: The performance measures or key performance indicators defined by an organisation, to measure its performance against achieving the organisational strategy.

1.8 Assumptions

Firstly, it was assumed that respondents in the research had a similar understanding of the concepts being evaluated in the survey. This assumption was made because the target audience were senior employees of airports expected to have a good knowledge of maturity concepts. Next, the study assumed that the respondents would provide honest responses about the level of maturity of the dimensions being evaluated. This assumption was made because of the anonymity promised to respondents surveyed. Finally, the study assumed that the airport performance data would be accessible, as the airports in this study are government organisations whose data should be readily available.

2 LITERATURE REVIEW

2.1 Introduction

A literature study of the research objectives of this study was performed to provide concepts to investigate the research hypotheses.

2.2 Background discussion

Maturity models have been developed in the following areas; capability (Paulk, 1995), business process (De Bruin et al., 2005; Van Looy, De Backer, & Poels, 2010), Information Technology (Becker, Knackstedt, & Poppelbuss, 2009) and more recently Digital Maturity (Chanias et al., 2016; Berghuas et al., 2016).

This study was theoretically underpinned by the Capability Maturity Model (CMM) developed by the Software Engineering Institute, which focused on measuring the maturity of software companies with regards to software process implementation (Paulk, 1995). The CMM defines five levels of maturity, and it is different from the model used in this study because it only focuses on improving software development processes (Halpern et al., 2019).

2.3 Digital Maturity at African airports

2.3.1 *The utility of maturity models*

The context and content of the maturity models differ, a common feature of these models is in prescribing several stages (Klotzer & Pflaum, 2017) to determine the current as-is state. Prescription of stages is done as a method of either; performance improvement, benchmarking (Gokalp, Sener, & Eren, 2018) or, gap identification to progress to higher levels of maturity (Becker et al., 2009; Kohlegger et al., 2009; Maier et al., 2012; Van Steenbergen, Bos, Brinkkemper, Van De Weerd, & Bekkers, 2010).

Furthermore, maturity models measure several attributes of an organisation:

- Competency (De Bruin et al., 2005; Kohlegger et al., 2009),
- Capability (De Bruin et al., 2005; Kohlegger et al., 2009; Maier et al., 2012),
- Sophistication levels (De Bruin et al., 2005; Mettler et al., 2009).

Maturity is described on an ordinal scale from *not mature* – lowest level, to *mature* – highest level (De Bruin et al., 2005; Becker et al., 2009). Critics have been analytical of maturity models, arguing that maturity models prescribe maturity to be a linear and stepwise progression which is inflexible. Also, studies argue that this linear assessment does not provide an adequate measurement of maturity in complex areas of study (De Bruin et al., 2005). On the contrary, De Bruin et al., (2005) state that representing maturity as cumulative steps from high to low is a widely accepted design practice. This practice has also been stated by other researchers (Maier et al., 2012; Mettler et al., 2009).

Maier et al., (2012) argued that it was a preconceived expectation that an organisation finds itself at the maximum maturity level; otherwise, it was not performing to expected standards. While Remane et al., (2017) state that, organisations will not be impacted in the same way and to the same extent by Digital Transformation. Consequently, it will not be desirable for all to reach the ultimate level of maturity. An organisation can differentiate itself by achieving a higher maturity level in an area or maturity dimension of choice (Valdez-de-Leon, 2016), enabling the organisation to define its desired maturity path to meet expectations and remain competitive. A maturity model can be used as a tool to balance internal needs and external market expectations, of customers and stakeholders (Mettler et al., 2009). As noted by Chanias et al., (2016), Digital Maturity assessments should be used as reference points for new digital initiatives, areas of improvement and should help inform potential action steps (Chanias et al., 2016). The oversimplification might lead to wrong management decisions (Remane et al., 2017). Awareness of an organisations' maturity level enables reflection of current strategies (Schumacher et al., 2016) to close identified maturity gaps, to progress through maturation to subsequent levels.

2.3.2 *Digital Maturity*

Digital Maturity considers the readiness of an organisation, the environment within the organisation, organisational capabilities and the support that exists for the organisation to transform digitally. Within the practice of measuring maturity, there is a need to consider various dimensions of maturity, to enable a richer view of the organisation's as-is situation to enable foresight in roadmap and strategy development (De Bruin et al., 2005).

Most Digital Maturity models are naturally linear (Remane et al., 2017), with different dimensions and methodological approaches (Chanias et al., 2016). Similarly, Remane et al., (2017) argue that the description of Digital Transformation as linear is an oversimplification of the complex phenomenon. Chanias et al., (2016) state that single dimension models are not enough and that multidimensional maturity models are better suited to understand to the full extent - the Digital Maturity of an organisation. An aspect of multidimensionality is the inclusion of all the variables that measure the maturity of a specific area. Since Digital Maturity is defined as the extent of implementation of digital technologies (Chanias et al., 2016), the technology dimension is one of the aspects that should be included in the measurement of maturity. Maturity models reviewed, address various aspects of technology; information technology (Berghuas et al., 2016), complementary IT systems, (Klotzer et al., 2017) and Information systems (Schuh, Anderl, Gausemeier, Hompel, & Wahlster, 2017).

2.3.3 *Development of the Digital Maturity model*

Researchers have contributed by suggesting frameworks for the development of maturity models (De Bruin et al., 2005; Kohlegger et al., 2009; Maier et al., 2012; Mettler et al., 2009; Van Steenbergen et al., 2010). Though critics argue that there is limited, documented research on how most of the existing maturity models have been developed (Becker et al., 2009). Literature studies of maturity models revealed the following:

Out of the fourteen Digital Maturity models reviewed,

- Four calculated their Digital Maturity levels through a software or some complex mathematical calculation (Berghuas et al., 2016; Remane et al., 2017; Schumacher et al., 2016; Schumacher, Nemeth, & Sihn, 2019).
- Two models neither outlined the Digital Maturity dimensions, nor the process for calculating Digital Maturity (Halpern et al., 2019; Weber, Konigsberger, Kassner, & Mitschang, 2017).
- One model did not provide details of its Digital Maturity Dimensions (Ganzarain et al., 2016).
- Three models did not outline the process for calculating Digital Maturity scores (Chanias et al., 2016; ACI, 2017; Issa et al., 2018).

Only models by Valdez-de-Leon (2016), Klotzer et al., (2017), Schuh et al., (2017) and; Gokalp et al., (2018) had comprehensively documented the dimensions and levels they were using to measure Digital Maturity. In addition, they had indicated the process for calculating the Digital Maturity scores. Maier et al., (2012) state that the measurement of maturity will always be subjective rather than objective. Given the same area of study or capability, different authors employed different descriptors for the maturity dimensions (Maier et al., 2012). Thus, the definition of maturity dimensions should be stipulated, so their contents are clear. Similarly, perspectives from other practitioners should be considered as input, when developing maturity dimensions, as was done in this study.

The Digital Maturity dimensions and levels of all the fourteen Digital Maturity models were used in the compilation of the Maturity Model for this study to ensure that the Digital Maturity Model is comprehensive and that the Digital Maturity dimensions are objective. This approach was selected to overcome subjectivity (Maier et al., 2012) in the compilation of the Digital Maturity Model. Four development frameworks were studied and considered for adoption in the development of the Digital Maturity Model - detailed in Table one.

Table 1

Reviewed Development Frameworks for the consideration in the Development of the Maturity Model

Maturity Model Development frameworks	Phases/Steps	Observations
De Bruin, Rosemann, Freeze, and Kulkarni (2005)	• Scope: decide the stakeholders and domain the maturity model is being developed for • Design: determine model architecture, i.e. means and drivers of assessment as well as maturity levels and target respondents • Populate: determine the content of the model, i.e. domain components and sub-components • Test: test the validity, reliability and generalisability of the model and its constructs • Deploy: deploy to entities independent to model development • Maintain: track model evolution and development	Framework outlines detailed steps for maturity model development and can be applied to developing a model in any domain

Kohlegger, Maier, and Thalmann (2009)	• Preparation:
	  ○ Predefine items for analysis
	  ○ Define what maturity means
	  ○ Define maturing element
	  ○ Define the features of the model and how the model will be used
	  ○ Describe categories
	• Coding: review and analyse findings and re-work findings into the categories of the model
	• Concluding: format results
		Only high-level detail of the development process has been provided, making it difficult to follow the framework

Mettler and Rohner (2009)	• Design: define maturity model dimensions • Specification of levels: identify the stages of the maturity model • Configuration parameters: conduct situational analysis to configure the model for specific scenarios • Proof of concept: assess the practical application of the maturity model	Framework allows for dynamic customisation of the model as a result of responses received from the participants, which requires real-time system configuration during data collection

Maier, Moultrie, and Clarkson (2012)	• Planning:
	  ○ Define users and improvement entities for the model
	  ○ Define the aim of the model
	  ○ Decide domain the maturity model is being developed for
		Framework outlines detailed steps for maturity model development and can be applied to developing a model in any domain

- Define success-criteria for the model
- Development:
  - Select process areas
  - Select maturity levels
  - Formulate maturity sub-dimensions
  - Decide the assessment method
- Evaluation: validate and verify the maturity model
- Maintenance:
  - Benchmark and adjust model
  - Maintain a database of results
  - Document development and evolution of model

Observations made during the review of the maturity model development frameworks, led to the adoption of the frameworks by De Bruin et al., (2005) and Maier et al., (2012) for use in this study. The frameworks provided enough detail of the steps that are followed for the development of a maturity model, thus were useful for adoption. The *Design* and *Populate phases* by De Bruin et al., (2005) as well as the *Development phase* by Maier et al., (2012) were modified to guide development steps of the Digital Maturity Model.

2.3.3.1 ***Development phase.***

Detailing the (modified) Digital Maturity Model development steps.

Step 1: Selecting Digital Maturity dimensions (process areas and components)

The elements of the fourteen Digital Maturity models were grouped into similar Digital Maturity themes. The Digital Maturity themes were then used to define the Digital Maturity dimensions.

Digital Maturity Dimensions: seven Digital Maturity dimensions were developed for the Digital Maturity Model.

Organisational Culture: Measures the organisations' culture and innovation practices, also looking into the collaboration amongst employees and their level of involvement in digital initiatives.

Strategy: Measures the extent of organisational readiness, alignment and investment for digital implementation. Additionally, the dimension considers the definition of requirements from an overall resources and roles perspective.

Organisation and Governance: Measure the organisations' approach to governing Digital Transformation, level of leadership commitment, organisational structure agility and the coordination of digital activities.

Leadership and People: Measures leadership support and ownership, people practice alignment, employee skills, competencies and capabilities as well as employee behaviour.

Process Management: Measures the organisations' approach to business process modelling, improvement and automation as well as the results of these interventions. Moreover, this dimension measures the level of visibility and accessibility of processes within the organisation.

Customer: Measures the collection and usage of customer data to ensure customisation and personalisation of the customer experience. Furthermore, this dimension investigates the customer interaction tools and platforms as well as the use of self-service technology.

Technology and Data: Measures the organisations' management and storage of data, technology project management, technology and system architecture maturity. Additionally, this dimension measures the extent of emerging technology implementation, cybersecurity implementation and the role of the Information Technology (IT) department in the Digital Transformation process.

Step 2: Selecting Digital Maturity levels (rating scale)

The Digital Maturity levels for the Digital Maturity Model were developed on an ordinal scale in numeric order, from level 1 to level 5 (Becker et al., 2009; De Bruin et al., 2005). The definition for each level is outlined below.

Digital Maturity Levels: five Digital Maturity levels identified as stages of maturity, to inform the rating scale for the Digital Maturity Model.

Level 1: Digitally unconscious

At Digital Maturity level one, the organisation does not have a clear vision on Digital Transformation priorities, and it has low readiness to transform digitally. Organisations found at this level range between having no awareness, to having minimal awareness on what is required to transform digitally, i.e. to operate as a fully digital organisation, implementing 4IR strategies.

Level 2: Digitally aware

At Digital Maturity level two, the organisation is starting to develop strategies, identify gaps and explore initiatives required to transform digitally. Organisations found this level to range between having limited awareness, to being aware of what is required to transform digitally.

Level 3: Digitally prepared

At Digital Maturity level three, the organisation displays the required readiness and has identified the gaps it needs to address, to transform digitally. Organisations found at this level range between being very aware and knowing what is required to transform digitally.

Level 4: Digitally intentional

At Digital Maturity level four, the organisation has invested in, and implemented strategies that are progressing it to transforming digitally. Organisations found at this level range between knowing what to do and doing what is required to transform digitally.

Level 5: Digitally transformed

At Digital Maturity level five, the organisation is operating as a digitally transformed organisation, and all its processes and practices support the digitisation. Organisations found at this level range between having parts of their organisations, and having the entire organisation being fully transformed digitally.

Step 3: Selecting Digital Maturity sub-dimensions (sub-components)

A top-down approach was used to identify the Digital Maturity sub-dimensions (Maier et al., 2012). Where the Digital Maturity dimensions were identified, and the Digital Maturity sub-dimensions were subsequently grouped under the dimensions they belonged to. De Bruin et al., (2005) describe the top-down approach as one that first determines "what" represents maturity, before it determines "how" maturity can be measured. Others describe the approach as one that begins by identifying definitions and then fitting assessment items to the identified definitions (Mettler et al., 2009) This approach is further illustrated in *Figure 2*, in section 3.2.1.

The Digital Maturity sub-dimensions were used to develop prescriptive questions under each Digital Maturity dimension for the online survey, to enable the definition of actions and improvement areas (Berghuas et al., 2016). The Digital Maturity sub-dimensions are listed in section 4.3.1.1.

Step 4: Defining administration mechanisms

In their study, Maier et al., (2012), describe two research methodologies, i.e. paper-based and electronic survey. This study made use of an electronic survey to administer the survey. This choice was made to reach a wider variety and larger target audience (Maier et al., 2012).

2.3.4 *African Airports*

Aviation on the African continent has, for a long time lagged other continents (Abate, 2014), notwithstanding, the steady growth in passengers carried, flights performed, and aircraft deployed on the African continent (Wilson, 2019). This growth contributed to the development of new airport infrastructure and increased airport capital expenditure (CAPEX) investments in South Africa (African Aerospace, 2019), Kenya (Ondiege, Moyo, & Verdier-Chouchane, 2013), Nigeria (Pirie, 2019) and Ghana (African Aerospace, 2019). Conversely Irandu and Rhoades (2006) observed that there were some investment limitations for airport development in Kenya. The future

growth in passenger traffic is expected to put further pressure on airports (Halpern et al., 2019).

Aviation provides economic opportunities for African countries through access to the global market, enhancing regional integration, improving tourism, and contributing to mobility (Irandu et al., 2006; Abate, 2014). Developing African economies pose opportunities because they are not locked in legacy technology, systems, and infrastructure and NEPAD (New Partnership for Africa's Development) has identified a need to improve Information, Communication and Technology (ICT) infrastructure (Britz, Lor, M, & Bester, 2006). Historically the continent lagged in the adoption of expensive new technologies and innovations, and this might have been because of the lack of existence of laws to govern electronic strategies (Britz et al., 2006). Most African economies, however, leapfrogged legacy fixed-line telephone networks by the rapid adoption of newer technologies in mobile technology (Britz et al., 2006).

Salient challenges currently faced by African airports include increased passenger growth, the pressure to become commercially focussed, globalisation, (Akwei, Tsamenyi, & Sa'id, 2012) and safety and security (Wilson, 2019). These challenges can benefit from the implementation of Digital Transformation strategies. Studies demonstrated that the adoption of digital technologies improved passenger flow management, reduced queuing times, minimised lost baggage, and increased speed of passenger facilitation (Aulman, 2018). Understanding current Digital Maturity levels assists African airports in setting priorities and investment requirements to transform digitally.

The following hypothesis is made based on stated investment limitations for airport development (Irandu et al., 2006) and limited existence of laws to govern electronic strategies on the African continent (Britz et al., 2006). Furthermore, an observation that African countries might find it difficult to keep pace with emerging technologies and the need to improve Information, Communication and Technology (ICT) infrastructure on the continent (Britz et al., 2006) imply that implementation of emerging technologies is low.

H1: African airports display low levels of Digital Maturity

2.4 The relationship between Digital Maturity and company performance

2.4.1 *Digital Strategy and Performance*

The concepts of strategy development and implementation have been well researched in academia (Porter, 1996). Strategy outlines the roadmap to achieve specific performance measures or key performance indicators that an organisation had set out to achieve. A strategy is vital to track the progress of performance and to enable improvement in performance (Henderson, 1989). Competitive advantage is also assured by Strategy (Henderson, 1989; Porter, 1996).

A Digital Transformation strategy adds another dimension to the traditional concept of strategy, in defining the use of available digital technologies by an organisation (Berghaus et al., 2016). Ensuring that the organisation remains competitive into the future and avoids disruption by competitors in their markets. Digital Transformation includes the practical management of transformation, organisational change, as well as technology-driven changes required in the development of the strategy (Chanias et al., 2016; Issa et al., 2018).

Although organisations are using and adopting digital technologies, studies indicate that there is often no clear strategic plan to transform, as many grapple to come up with a Digital Transformation strategy (Berghaus et al., 2016; Schumacher et al., 2016). As a result, both the Market-based and Resource-based concepts of strategy need to be considered to balance internal and external requirements (Mettler et al., 2009).

Internal strategic objectives of an organisation should drive decision making and be the basis for Digital Transformation strategy development (Schuh et al., 2017). Ganzarain et al., (2016) argue that the Industry 4.0 vision of an organisation needs to be integrated into its organisational strategy. While Issa et al., (2018) iterate that the organisation needs to achieve alignment between the business and information technology strategies before investment decisions are made. Thus, organisations

should not be investing in digital technologies for the sake of doing so, but strategic decision-making and foresight needs to be applied before any investments are made.

The performance indicators of an organisation support the strategy the organisation has agreed, to achieve its performance objectives and targets. Thus, the measurement of performance is typical to the industry and organisation involved. Adding the dimension of performance, to the measurement of Digital Maturity, allows for the Digital Maturity model to be tailored to meet the specific needs of the unique industry under analysis.

The literature review conducted in this section demonstrates that Digital Transformation should be driven from a strategy point of view and this study theorises that strategic objectives, that are unique to an organisation drive the selection of performance indicators. Therefore, this study investigated the relationship between Digital Maturity of an organisation and how well it performs against its stated performance indicators, represented by the correlation between Digital Maturity level and performance on priority indicators. This study concludes that a well-developed Digital Transformation strategy, should contribute to, and form part of the broader organisational strategy towards achievement of strategic objectives or company performance.

2.4.2 *Airport Performance*

In recent times airports are expected to operate on a commercial basis, paying more attention to their performance and benchmarking themselves against other airports around the world (Graham, 2005). Air travellers now have more choice on which airport to use. Airports need to become competitive by differentiating their service levels from other airports (Pabedinskaite et al., 2014). Airports' performance drives the economies of countries and cities, where they are located (Humphreys & Francis, 2002; Luke & Walters, 2010). Moreover, managers require performance information, so they can address performance gaps and ensure improvement (Humphreys et al., 2002; Strycekova, 2011), as well as to enable investment and development decisions (Akwei et al., 2012).

Graham (2005), stated that airport performance could be evaluated from operational, marketing and financial perspectives. Examples of operational performance are infrastructure capacity utilisation and the average waiting time, whereas marketing performance refers to passenger perception of the airport environment, i.e. comfort and signage (Akwei et al., 2012). Financial performance considers financial ratios and airport-specific economic indicators such as aeronautical revenue and passenger traffic (Graham, 2005).

A relevant driver of airport performance is technical innovation (Humphreys et al., 2002). Technical innovation relates to the implementation of the latest technologies in the airport environment. Nwankpa and Roumani (2016) found a positive relationship between Digital Transformation and company performance. Their finding demonstrated the relationship between Digital Maturity and performance indicators. This study investigated these relationships in the African airport industry.

2.4.2.1 ***Revenue generation at airports.***

Commercial focus of airports leads to increased focus on financial performance measures (Humphreys et al., 2002). Humphreys et al., (2002) identified the metric of *non-aeronautical revenue per passenger* as the most important financial measure - indicating the drive for airports to become commercially focused.

Airports that seek to increase non-aeronautical revenue should ensure passengers satisfaction (Halpern et al., 2019). Furthermore, they should ensure quicker facilitation through passenger touchpoints to increase leisure time and thus increase the likelihood of making a purchasing decision (Castillo-Manzano, 2010). An increase in non-aeronautical revenue increases the viability of an airport commercially, making it less dependent on revenue generated from aeronautical activities – a position in which every airport should find itself.

Previous Digital Maturity studies have shown positive correlations between digital readiness and financial performance indicators, i.e. annual revenue and EBIT margins - see *Figure 1* (Remane et al., 2017).

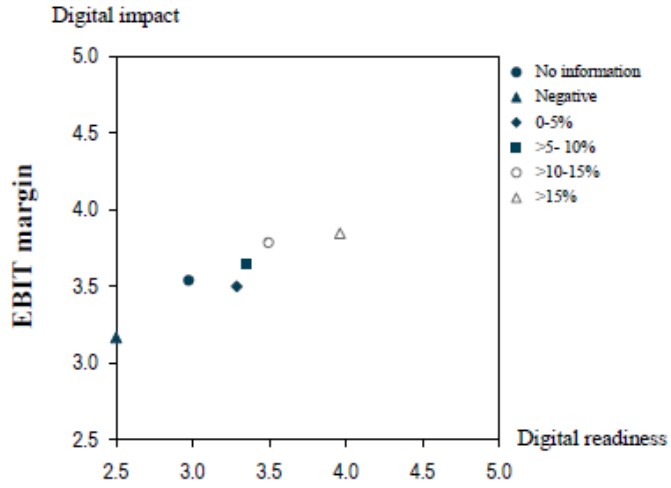


Figure 1. Mean values for profitability (EBIT Margin) along two dimensions of Digital Maturity (Remane et al., 2017)

Organisations with higher EBIT margins are considered as digitally more mature (Remane et al., 2017). A positive correlation between profitability, i.e. EBIT Margin and digital readiness, i.e. Digital Maturity, in the context of this study can be observed in *Figure 1*. It was found that those organisations with the highest Digital Maturity achieved a greater than 15% profitability. This study investigated this notion using total revenue growth at African airports.

The following hypothesis is made.

H2: There is a positive correlation between Digital Maturity levels and total revenue growth over 3 years.

2.4.2.2 ***Passenger growth at airports.***

Airports have different input and output measures. The measure of throughput number of passengers (traffic) is classified as an output measure for airports (Strycekova, 2011).

Once traffic, specifically passenger traffic increases, an airport becomes a hub where airlines and other service providers base their operational and commercial activities. The associated passenger throughput creates an opportunity for the airport to generate non-aeronautical revenue (Castillo-Manzano, 2010). Castillo-Manzano (2010) concluded that airports generate significantly higher non-aeronautical revenue, if the traffic throughput is derived from a greater number of trips (higher frequency of flights) than with the same number of passengers carried on lower frequencies with larger aircraft.

It is predicted that over the next couple of years, air passenger traffic in Africa is going to increase by 40%-90% (NEPAD, 2014). The increased traffic will demand a discerning retail experience, swifter passenger facilitation using digital technologies and overall improved passenger experience.

The following hypothesis is made.

H3: There is a positive correlation between Digital Maturity levels and passenger growth at airports

2.4.2.3 *Airport service quality.*

ASQ is a key performance area that airlines use to make judgements on which airport to base their hub of operations (De Nicola, Gitto, & Mancuso, 2013). Furthermore, Suarez-Aleman and Jimenez (2016) state that passenger satisfaction is a key performance area at airports. Meeting passenger expectations can be a competitive advantage and a differentiating factor for airports (Tsai, Hsu, & Chou, 2011), which are measured through ASQ.

The measurement of ASQ is challenging to conduct because of the various variables that are included within its measurement (De Nicola et al., 2013; Saurez-Aleman & Jimenez, 2016). Variables range from passenger satisfaction, operational efficiencies, productivity, as well as the quality of airport services to airlines (Pabedinskaite et al., 2014). Furthermore, academic literature lacks a consensus on how to measure ASQ (Pabedinskaite et al., 2014). This study uses the widely used ASQ data published by

the ACI, in which passengers are surveyed at ACI member airports (Humphreys et al., 2002).

De Nicola et al., (2013) found a positive relationship between a deterioration in airport productivity and lack of technology improvement and low quality of service. This finding suggests that implementing digital technologies, transforming the airport digitally and having high levels of quality can lead to increased levels of productivity. This study used the ACI ASQ data to investigate the relationship between Digital Maturity and passenger satisfaction.

The following hypothesis is made.

H4: There is a positive correlation between Digital Maturity levels and ASQ results of airports

2.5 Conclusion of Literature Review

This study focussed on the use of a Digital Maturity model as a method of gap identification to measure capability, competency and sophistication levels. The model was designed on an ordinal scale as it is the most feasible and widely accepted practice (De Bruin et al., 2005)

Based on the reviewed literature, the below hypotheses are made, to address the research objectives.

H1: African airports display low levels of Digital Maturity made in section 2.3.5

H2: There is a positive correlation between Digital Maturity levels and total revenue growth over 3 years made in section 2.4.2.1

H3: There is a positive correlation between Digital Maturity levels and total departing passenger growth at airports over 3 years made in section 2.4.2.2

H4: There is a positive correlation between Digital Maturity levels and ASQ results of airports over 3 years made in section 2.4.2.3

3 RESEARCH METHODOLOGY

This section outlines the research methodology, starting with the approach followed, as well as how the research was designed. Additionally, the selected data collection methods, sample, profile of respondents, research instrument, and limitations to the study are discussed. This section concludes with a discussion on the data analysis approach and ethical considerations of the study.

3.1 Research approach

A mixed-method approach was used to investigate the research objectives outlined for this study.

The data for this study was collected through surveying. The collection method was selected to reach a wider audience across the African continent and enable quick turnaround on data collection. The surveying method allowed the research to cover both English-speaking and French-speaking members of the target audience, as the survey was made available in both languages.

3.2 Research design

The dimensions of the developed Digital Maturity model were used to compile survey questions to determine the Digital Maturity levels of airports under study. The survey was used to determine the perceptions of senior leaders and employees who work for airports.

The research was designed to minimise the impact of linearity as described by critics of maturity models (De Bruin et al., 2005). Linearity was minimised by investigating the relationship between Digital Maturity levels and the airports' performance indicators. The Digital Maturity model was tested for reliability using the data collected from the online survey.

Administering the survey to audiences at different airports, across different African countries and with differing priorities, i.e. employees vs. leaders, added to the

generalisability of the Digital Maturity model (De Bruin et al., 2005). An online survey was used to reach the target audience for this study. The survey was the most appropriate tool because it allowed for the collection of data from participants who are in different locations. The study made inferences where a representative sample was achieved.

3.2.1 *Instrument for measuring Digital Maturity*

The Digital Maturity model was derived from those models reviewed in this study as described under the Digital Maturity section – section 2.3.3 of this study.

The Digital Maturity themes and dimensions are illustrated in *Figure 2* below. The Digital Maturity themes were used to come up with 66 questions (Digital Maturity sub-dimensions) across seven Digital Maturity dimensions. See appendix C for the online survey questionnaire.

It was acknowledged that challenges with translation might be experienced where the meaning is lost through direct translation of terminology used to describe concepts. The translation risk was minimised through the inclusion of an introduction section in both English and French languages. This opening section aimed to set the context for the concepts under study to enable participants to cross-reference the concepts using the English context as a base.

The survey in this study was structured on a five-point format (Likert scale). It measured the extent to which the survey participants agree or disagree (Gilem et al., 2003) with the implementation of the 66 Digital Maturity sub-dimensions within their airports. The five points on the Likert scale were.

1 = *strongly disagree/definitely not,*

2 = *somewhat disagree/probably not,*

3 = *neither agree nor disagree/might or might not*,

4 = *somewhat agree/probably yes,*

5 = *strongly disagree/definitely yes.*

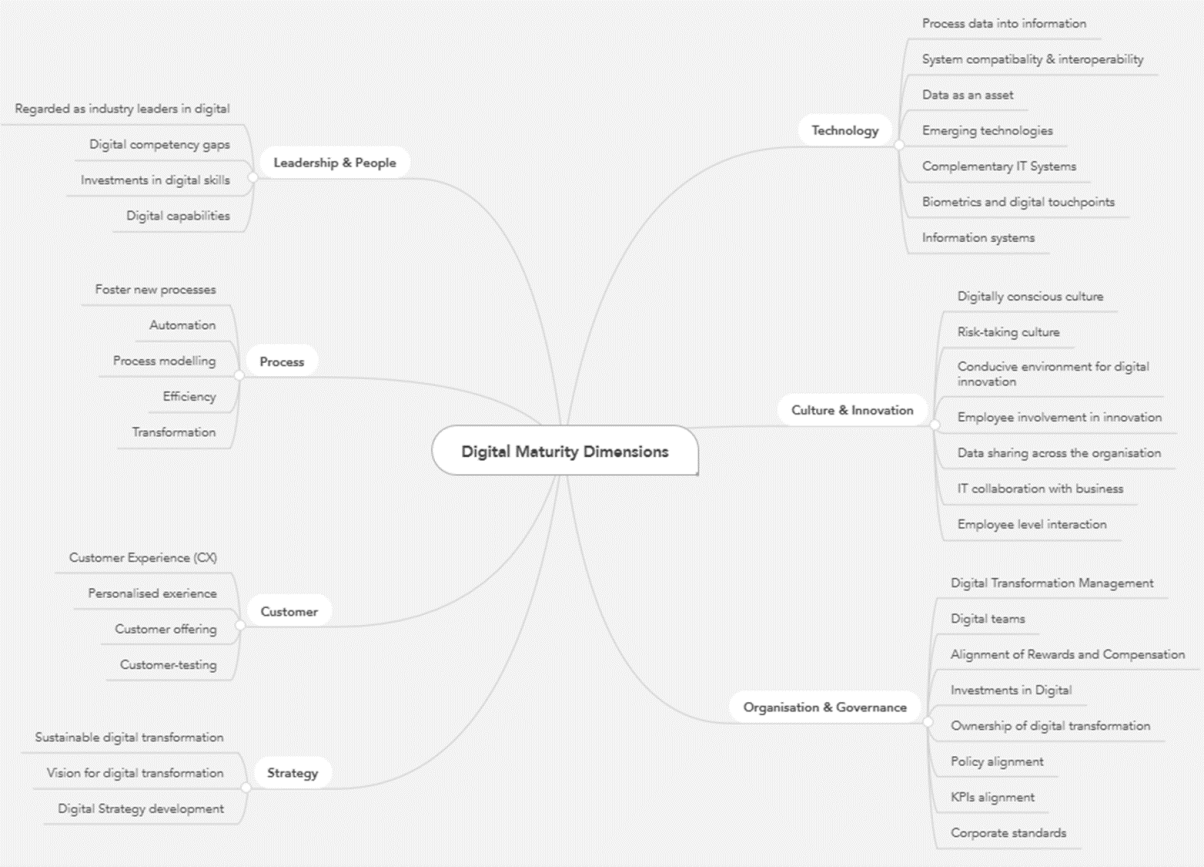


Figure 2. Mind map of Digital Maturity dimensions and themes

3.3 Data collection methods

3.3.1 *Online Survey*

The data collection process relied on snowball sampling to get responses from online surveying. An online survey was administered to an audience of employees working for airports in the African continent.

3.3.2 Company Performance Data

Passenger data was sourced from internet databases and the airports themselves. Revenue data and ASQ results for each airport were sourced from the respective

airports. Due to the sensitivity of performance data, permission was sought, to use the data.

3.4 Population and sample

3.4.1 *Sample and sampling method*

The study focused on collecting data from eight African airports, that facilitate over 2 million passengers a year; the rest of the African airports were excluded from this study. Airports that met the above criteria but did not participate in the ACI ASQ survey were also excluded, because it would be impossible to conduct ASQ correlation studies for those airports. A sample of eight airports out of a possible 28 airports that facilitate over 2 million passengers annually in Africa, were considered. The sample was deemed as sufficiently representative of African airports, representing 29% of the target population size.

Table 2

List of Airports included in the Study

African Region	Country	Airport Pseudonym
Southern	South Africa	Airport A
Southern	South Africa	Airport B
Southern	South Africa	Airport C
Western	Ghana	Airport D
Western	Nigeria	Airport E
Western	Nigeria	Airport F

African Region	Country	Airport Pseudonym
Northern	Morocco	Airport G
Eastern	Kenya	Airport E

The study aimed to achieve a minimum of 30 survey responses per airport in the study, to enable inferential statistics to be conducted, producing a total of 240 responses for the eight airports. Online survey links were sent to participants via email, asking them to participate. The study also depended on snowball sampling, as a result of the senior leaders sending the link to colleagues at their companies.

Table 3

Profile of Respondents

Participant Grouping	Participants	Survey Mode	Number to be sampled
Employees who work for African airports	• Airport Managers • Chief HR Officers • Chief Technology or IT Officers • Chief Operations Officers • General Employees	Online Survey	240

3.5 The research instrument

A Digital Maturity model, in the form of a survey, was used as a diagnostic tool for this study. The dimensions employed in this model were developed from the reviewed Digital Maturity models. The Digital Maturity dimensions comprehensively covered the elements that impact the ability of an organisation to transform digitally. Furthermore,

calculation of Digital Maturity levels from the outcomes of the Digital Maturity Model did not employ complex mathematical-statistical computation.

See appendix A for a table of reviewed Digital Maturity models. The components of the Digital Maturity Model applied in this research, are set out in section 2.3.3, and its results are reproducible, promoting more extensive use of the Digital Maturity model (Chanias et al., 2016).

3.6 Procedure for data collection

The survey was sent to participants via email.

The online survey was not only available in English but was translated into French using Google Translate. The outlined data collection process allowed for reaching a wider audience.

3.7 Data analysis and interpretation

The initial outcomes from the survey were analysed to calculate the maturity level for each airport. A simple quantitative approach was used to calculate the maturity level based on responses from the 66 maturity sub-dimensions in the online survey. Equal weighting was applied to each maturity sub-dimension.

The data was analysed to ensure that there was a statistically significant representation of participants from each airport to ensure that comparisons can be made between airports. Three grouped scatterplots are generated in section 4.7, to investigate the relationship between Digital maturity level scores and the performance indicators, to enable regression analysis to be conducted to answer the research objectives (Field, 2009).

3.8 Limitations of the study

The below limitations were identified, and the measures that were put in place to resolve them, are discussed below.

- Limitation 1: The inability to get a fair representation of African airports that facilitate more than 2 million passengers

  The limitation was addressed through using the ACI Africa network to connect to the target airports. A list of contact details for the target airports was attained, where a minimum of one contact was provided per airport. Emails were sent to introduce the research study and the online survey to the contacts. Contacts were asked to share the survey link with a minimum of thirty colleagues from their airports.
- Limitation 2: Not getting a good representation of the different departments, i.e. IT vs. Operations.

  The limitation was addressed by asking senior HR leaders at the African airports to forward the online survey to senior colleagues and other employees within their airport. The survey received a satisfactory representation of participants from different departments, as illustrated in *Figure 4*.

- Limitation 3: Non-responsiveness from the online survey

  The limitation was addressed by sending the link to airport employees via email and WhatsApp messaging, as well as weekly reminders to encourage responsiveness. The survey, still experienced non-responsiveness from some of the target airports, regardless of the emails and reminders sent. Other unforeseen macro challenges were encountered during the data collection process, that could have been attributed to the low response rate. The data collection happened during the COVID-19 outbreak, which affected most countries and airports across the world. The financial impact of many airlines being grounded and flights from risk countries being banned, posed a competing priority for survey completion. During this time airport leaders and employees were inundated with airport operational requirements that were necessary for business continuity and for curbing of the COVID-19 pandemic.

3.9 Validity and reliability

3.9.1 *External validity*

Generalisability of the study was met by reaching 50 responses across six airports. Limitations to meeting the initial target of 240 are outlined in section 3.8 above; thus, population validity (Onwuegbuzie, 2000) could not be maximised.

3.9.2 *Internal validity*

Since the study analysed the data at a group level and not on an individual participant level, this resulted in the loss of statistical power, though counteracted by the fact that group data was free from contamination (Onwuegbuzie, 2000). Careful consideration was applied at data interpretation phase to ensure that threats of confirmation bias do not influence the interpretation process. This was done by avoiding data manipulation.

3.10 Reliability

Different reliability tests exist, and according to Cortina (1993), the decision for which test to use in a study should be driven by the sources of variance that a researcher is interested in investigating. In the case where the variance attributed to elapsed time or stability (Heale & Twycross, 2015) between administration of scales is of interest, then test-retest reliability tests should be used (Cortina, 1993). Alternatively, in the case where variance attributed to sub-dimensions and interrelatedness between sub-dimensions is of interest. Cronbach's alpha (α) tests, which are internal consistency estimates, should be used (Cortina, 1993). This study was interested in investigating the variance between Digital Maturity sub-dimensions within a Digital Maturity model and the interrelatedness of these sub-dimensions. This study also used a multiple-item research instrument, i.e. 66 Digital Maturity sub-dimensions, and according to both Gilem et al., (2003) and Tavakol and Dennick (2011), Cronbach's α was suitable for measuring reliability in multiple-item research.

Furthermore, the survey in the study was structured in a Likert scale format, which was a format compatible with the use of Cronbach's α (Gilem et al., 2003). Based on

the above discussions, the most suitable test for reliability in this study was Cronbach's α. Reliability and internal consistencies of the Digital Maturity model were tested using Cronbach's α.

3.11 Demographic profile of respondents

The study collected data through the online survey from six out of a target of eight airports. The eight airports were selected to ensure that each of the four African regions (North, East, Southern and West) were represented in the targeted responses. Responses were only received from the Southern and West African regions.

The target sample size was 240 for eight airports, because responses were only received from six airports, the target sample size was re-calculated to 180 responses. The study managed to achieve a total response rate of 50. None of the six airports met the target (30 responses) set per airport. Small sample sizes were received from the West African airports, and inferential studies could not be performed, thus hypothesis one, two and three could not be investigated for those airports. The study achieved a fair representation of employees from different categories (*Figure 3*) and departments (*Figure 4*) within the organisations.

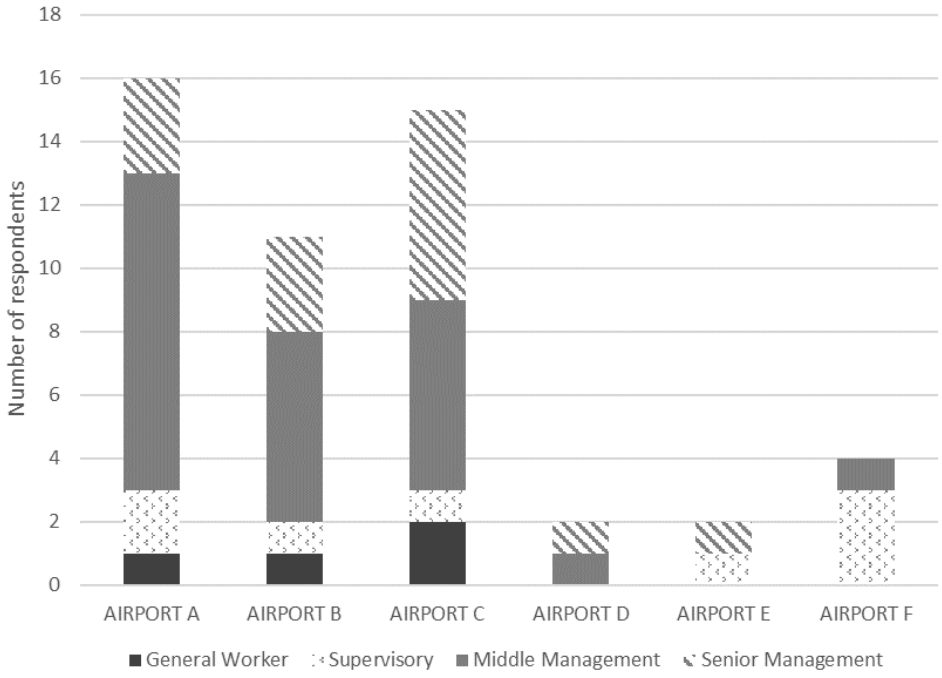


Figure 3. Employee category representation of respondents by airport

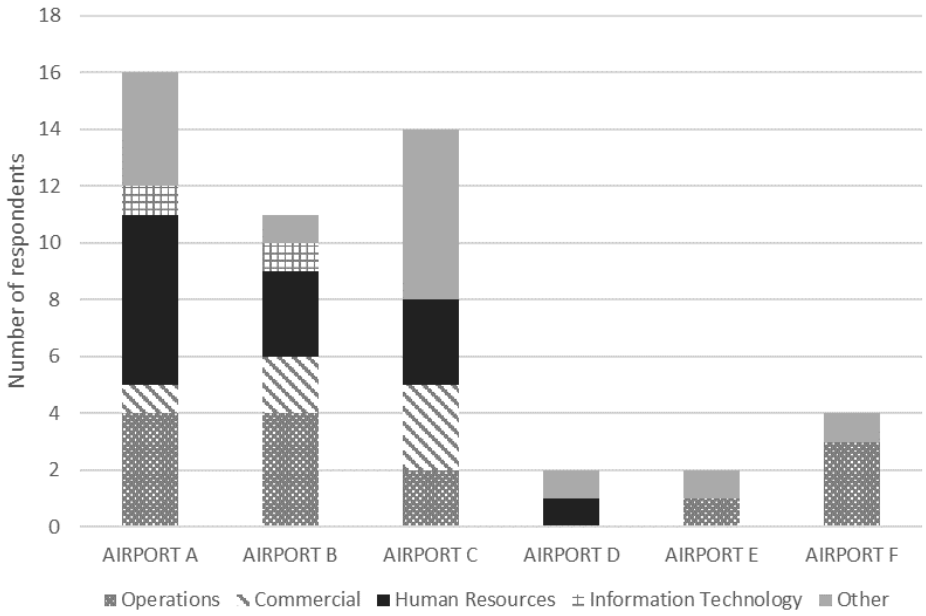


Figure 4. Departmental representation of respondents by airport

3.12 Ethical considerations

Confidentiality was maintained for the survey. Moreover, participation in the survey was voluntary. No incentives were offered for participation, apart from sharing of the completed research report with those who had requested. The only demographical data that was requested from the participants was data required to assist in answering the research questions. Demographics that were required are listed below.

- Name of Airport
- Employee category – see *Figure 3*
- Department – see *Figure 4*
- Email addresses – for those participants who wanted to receive the report once research had been concluded.

Organisational permission from airports that were part of the study was attained for the use of their responses and airport performance data, i.e. ASQ scores, revenue data and passenger growth data. Organisation-unique and competition-relevant data was anonymised to ensure confidentiality of participating airports.

4 RESULTS AND DISCUSSIONS

4.1 Introduction

In this section, the results from the reliability test set out in section 4.3, and Digital Maturity level results of the Digital Maturity model is presented in section 4.4. Section 4.6 presents and discusses company performance results for the airports. Section 4.7 outlines the correlation studies investigating Digital Maturity levels and their relationship to company performance indicators, i.e. total revenue growth, total departing passenger growth and ASQ. The results will be followed by discussions, per hypothesis. The section will end with a summary and conclusion of the results and discussions.

4.2 Presentation of results

A Digital Maturity model was developed to measure Digital Maturity at African airports. Reliability of the Digital Maturity model was determined in section 4.3, using Cronbach's α tests. Tests were used to ensure accurateness and repeatability of results obtained from the model, and its' defined Digital Maturity dimensions (De Bruin et al., 2005). Cronbach's α tests were run per Digital Maturity dimension to determine homogeneity of sub-dimensions (Berghuas et al., 2016). In their study, Tavakol et al., (2011) indicate that Cronbach's α results ranging between 0.7 and 0.95 are acceptable values. Gilem et al., (2003) classify values of >0.7 as acceptable, values of >0.8 as good, and values of >0.9 as excellent. The tests were conducted for both the data collected from South African airports and the comprehensive data including South African, Ghanaian and Nigerian airports, i.e. African data. All the Digital Maturity Model sub-dimensions produced good Cronbach's α results of >0.8.

4.3 Reviewing the Digital Maturity Model

4.3.1.1 *Determining the reliability of the Digital Maturity model*

4.3.1.1.1 **Organisational Culture.**

The organisational culture dimension measured the organisations' culture and innovation practices, also studied the collaboration amongst employees and their level of involvement in digital initiatives. The Cronbach's α results for the South African and African airports' data set were 0.856 and 0.897, respectively.

Maturity Dimension	Maturity Sub-dimension	Cronbach's α (South Africa)	Cronbach's α (Africa)
Organisational Culture (OC)	• Digital culture (OC1) • Employee collaboration (OC2) • Innovation (OC3) • Employee involvement (OC4) • Digital initiatives (OC5) • Product/service innovation (OC6) • Agile ways of work (OC7) • Agile frameworks (OC8) • Use of data analytics (OC9)	0.856	0.897

4.3.1.1.2 **Strategy.**

The strategy dimension measured the extent of organisational readiness, alignment and investment for digital implementation. Furthermore, the dimension considered the definition of requirements from an overall resources and roles perspective. The Cronbach's α results for the South African and African airports' data set were 0.964 and 0.918, respectively.

Maturity Dimension	Maturity Sub-dimension	Cronbach's α (SA)	Cronbach's α (SA incl. Other)
Strategy (S)	• Digital Transformation vision (S1) • Digital readiness (S2) • Strategy alignment (S3) • Requirements definition (S4) • Resource and assets audit (S5) • Roles and responsibilities (S6) • Process, people and technology (S7) • Financial investments (S8) • Goal setting and measurement (S9) • Digital return on investment (S10) • Digital strategy socialisation (S11)	0.964	0.918

4.3.1.1.3 **Organisation & Governance.**

The organisation and governance dimension measured the organisations' approach to governing Digital Transformation, level of leadership commitment, organisational structure agility and the coordination of digital activities. The Cronbach's α results for the South African and African airports' data set were 0.901 and 0.800, respectively.

Maturity Dimension	Maturity Sub-dimension	Cronbach's α (SA)	Cronbach's α (SA incl. Other)
Organisation & Governance (OG)	• Digital governance (OG1) • Management commitment (OG2) • Central coordination (OG3) • Policy adaptation (OG4) • Communication (OG5) • Cross-departmental roles (OG6) • Organisational structure (OG7)	0.901	0.800

4.3.1.1.4 **Leadership & People.**

The leadership and people dimension measured leadership support and ownership, people, practice alignment, employee skills, competencies, and capabilities as well as employee behaviour. The Cronbach's α results for the South African and African airports' data set were 0.956 and 0.911, respectively.

Maturity Dimension	Maturity Sub-dimension	Cronbach's α (SA)	Cronbach's α (SA incl. Other)
Leadership & People (LP)	• Support and ownership (LP1) • Industry leadership (LP2) • People impact (LP3) • Digital competencies and capabilities (LP4) • Employee Re/Up-skilling (LP5) • Digital technology affinity (LP6) • Digital skills recruitment (LP7) • Organisational behaviour (LP8) • KPI alignment (LP9) • Rewards and compensation alignment (LP10)	0.956	0.911

4.3.1.1.5 **Process Management.**

The process management dimension measured the organisations' approach to business process modelling, improvement and automation as well as the results of those interventions. Furthermore, this dimension measured the level of visibility and accessibility of processes within the organisation. The Cronbach's α results for the South African and African airports' data set were 0.926 and 0.935, respectively.

Maturity Dimension	Maturity Sub-dimension	Cronbach's α (SA)	Cronbach's α (SA incl. Other)
Process Management (PM)	• Process automation (PM1) • Analytics-enabled process improvement (PM2) • Agile process modelling (PM3) • Process visibility (PM4) • Efficiency and cost reduction (PM5) • New process (PM6) • Automated quality control (PM7)	0.926	0.935

4.3.1.1.6 **Customer.**

The customer dimension measured the collection and usage of customer data to ensure the customisation and personalisation of the customer experience. Furthermore, this dimension investigated the customer interaction tools and platforms as well as the use of self-service technology. The Cronbach's α results for the South African and African airports' data set were 0.916 and 0.946, respectively.

Maturity Dimension	Maturity Sub-dimension	Cronbach's α (SA)	Cronbach's α (SA incl. Other)
Customer (C)	• Self-service technology (C1) • Engagement tools (C2) • Customer insights usage (C3) • Adaptation to customer behaviour (C4) • Customised interaction (C5) • Individualised content (C6) • Digital channels (C7) • Analytics-enabled CX (C8) • Behavioural economics (C9)	0.916	0.946

	• Data-driven decision making (C10) • 360º view of customer (C11) • Customer channels (C12) • Digital services (C13)

4.3.1.1.7 **Technology & Data.**

This dimension measured the organisations' management and storage of data, technology project management, technology, and system architecture maturity. Additionally, this dimension measured the extent of emerging technology implementation, cybersecurity implementation, and the role of the Information Technology (IT) department in the Digital Transformation process. The Cronbach's α results for the South African and African airports' data set were 0.933 and 0.954, respectively.

Maturity Dimension	**Maturity Sub-dimension**	**Cronbach's α (SA)**	**Cronbach's α (SA incl. Other)**
Technology & Data (TD)	• Emerging technology implementation (TD1) • Architecture gap analysis (TD2) • Agile project management (TD3) • IT as advisor (TD4) • Data management (TD5) • Data and information accessibility (TD6) • Cloud usage (TD7) • Data as an asset (TD8) • Automated data collection (TD9) • Technology maturity (TD10) • Technology uptake (TD11) • System interfaces (TD12)	0.933	0.954

- Cybersecurity (TD13)
- Systems update (TD14)

The process followed and frameworks adopted by De Bruin et al., (2005) and Maier et al., (2012) to develop the Digital Maturity model for this study have based on the above results for the Cronbach alpha results, shown to have resulted in a Digital Maturity Model that is reliable (Gilem et al., 2003) with satisfactory internal consistency estimates (Cortina, 1993).

4.3.2 *Defining Digital Maturity levels*

Each dimension of the maturity model was assessed across five levels of maturity on a Likert scale. Participants were asked to rate the extent to which they agreed with a statement or the extent of implementation of a Digital Maturity element. Responses were then allocated a score between 1 (*lowest*) and 5 (*highest*).

Maturity levels between level 1 and level 2.99 were classified as low maturity, levels between level 3 and level 3.99 were classified as medium maturity, and levels between level 4 and level 5 were classified as high maturity.

It should be noted that the developed Digital Maturity Model, included five stages of maturity. The Digital Maturity Model was composed of seven Digital Maturity dimensions, which implied its multidimensional nature. The Digital Maturity dimensions can be evaluated individually to ascertain the desired levels of maturity per dimension by an organisation.

4.4 African airports' Digital Maturity levels

4.4.1.1 *Calculating Digital Maturity levels for African airports.*

Results from the surveys received from airport participants (from West and Southern Africa) are presented in Table four below. Overall average Digital Maturity level for all the airports in the study, overall individual Digital Maturity per airports, as well as average Digital Maturity level by dimension were calculated to investigate the different levels of Digital Maturity at African airports.

The following formula was used to calculate airport Digital Maturity (DM) levels:

$$\boldsymbol{DM}x = \frac{sumx(digital\ maturity\ item\ scores)}{countx(digital\ maturity\ items)}$$

DM = Digital Maturity level

x = Digital Maturity dimension

Example: Calculation illustration of Organisational culture at Airport A

$$\boldsymbol{DM}organisational\ culture(oc) = \frac{sum(oc1, oc2, oc3, oc4, oc5, oc6, oc7, oc8, oc9)}{count(oc1, oc2, oc3, oc4, oc5, oc6, oc7, oc8, oc9)}$$

$$\boldsymbol{DM}organisational\ culture(oc) = \frac{(37 + 42 + 46 + 36 + 43 + 54 + 40 + 38 + 44)}{(16 + 16 + 16 + 16 + 16 + 16 + 16 + 16 + 16)}$$

$$\boldsymbol{DM}organisational\ culture(oc) = \frac{380}{144}$$

$$\boldsymbol{DM}organisational\ culture(oc) = 2.64$$

Table 4

Digital Maturity Level Results of African Airports by Digital Maturity Dimension

		Digital Maturity Dimensions						
		Organisational Culture	Strategy	Organisation & Governance	Leadership & People	Process Management	Customer	Technology & Data	**Overall Digital Maturity Level**
South Africa	**AIRPORT A**	2,64	3,22	2,63	2,83	2,19	3,32	2,30	2,73
	AIRPORT B	2,82	3,03	2,71	2,58	2,46	3,29	2,57	2,78
	AIRPORT C	3,22	3,45	3,05	2,87	2,49	3,06	2,57	2,96
Ghana	**AIRPORT D**	3,89	2,86	3,64	3,54	1,07	3,88	1,68	2,94
Nigeria	**AIRPORT E**	1,33	1,32	1,58	1,58	1,50	1,42	1,00	1,39
	AIRPORT F	2,22	3,00	1,93	1,92	1,00	1,04	1,00	1,73
		2,69	2,81	2,59	2,55	1,79	2,67	1,85	**2,42**

Descriptive studies were conducted to investigate the results from African airports, including those with small sample sizes, to understand better, the distribution of the data collected, the descriptive studies are outlined in Table five. The mean of 2.42 provided an estimation value of the whole data set, placing the African airports between level 1 and level 2.99, as described in section 4.3.2, at this level maturity was classified as low. Furthermore, both the minimum (1.39) and maximum (2.96) values

of the data set fell within level 1 and level 2.99, further emphasising the low maturity levels of African airports. However, all airports except for Airport E, displayed medium maturity levels of between 3.03 and 3.89 at the Digital Maturity dimension level, with *Strategy, Organisational Culture* and *Customer* being the highest scoring dimensions, on average. More detail on the highest rating Digital Maturity dimensions per airport, are found in sections 4.4.1.3 to 4.4.1.8 below. The whole data set produced a low standard deviation, indicating that the maturity levels across each African airport within this study, were close to the mean of 2.42. This observation was the case even though relatively lower maturity levels were observed for two Nigerian airports in comparison to the three South African airports and one Ghanaian airport in the study, and this can be seen in Table four above.

Table 5

Statistical Analysis of Digital Maturity Level Results from African Airports under Investigation

Minimum	Maximum	Mean	Std Deviation	Variance
1.39	2.96	2.36	0.5	0.90

4.4.1.2 ***Reviewing the Digital Maturity levels of airports.***

The results received from the data collection process in this study, as seen in Table four, indicate that the overall maturity levels for the airports under study ranged between 1.39 and 2.96. This range described maturity between level 1 and level 2.99.

Figure 5 illustrates the comparison between the airports under study. The Radar Chart can be interpreted by looking at the distance of the line, representing each airport, from the centre of the chart. The closer a point in the line was to the edge, the higher the Digital Maturity level of the dimension found at that part of the Radar Chart.

Figure 5. Radar Chart comparing Digital Maturity levels of African Airports

The Radar Chart served as a benchmarking tool that the airports could use to differentiate themselves from the other airports in the African market. Each airport could consider the internal and external factors, needs and expectations (Mettler et al., 2009) that were important to them as they define their Digital Transformation strategies. This process enabled the airport to determine for themselves, the dimensions that would be a focus. The dimensions of focus could then be used as competitive differentiators (Valdez-de-Leon, 2016; Remane et al., 2017).

4.4.1.3 ***Digital Maturity at Airport A.***

The overall Digital Maturity level at Airport A was found to be 2.73. At this maturity level, the airport was digitally aware and ranged, between having limited awareness to being aware of what was required to transform digitally. The radar chart in *Figure 6*, illustrates that Airport A's overall Digital Maturity level was higher than the average overall Digital Maturity level for the African airports. It was also observed that Airport A, had higher Digital Maturity levels for all the Digital Maturity dimensions compared

to the overall average for the dimensions, except for *Organisational Culture*, which was lower than the average.

The lowest rating Digital Maturity dimensions were *Process Management* and *Technology & Data Management.* With the highest rating dimensions being *Customer* and *Strategy.* The overall Digital Maturity level of this airport was classified as low maturity, because it was between level 1 and level 2.99. The airport should consider putting plans in place to improve the lowest scoring dimensions, i.e. *Process Management* and *Technology & Data*, this would ensure that they achieve higher overall Digital Maturity levels.

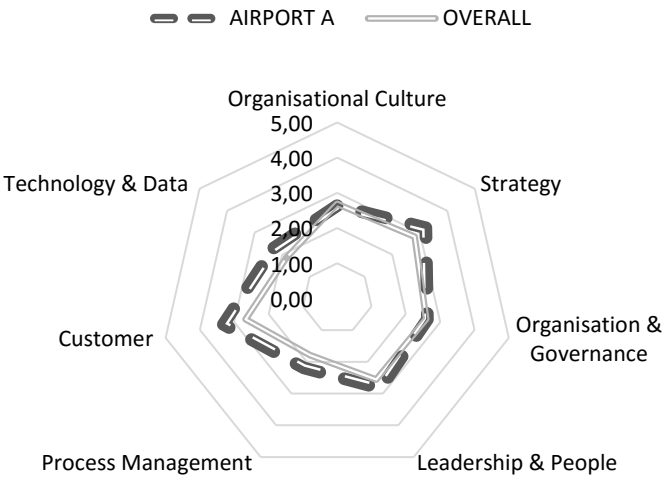


Figure 6: Radar chart illustrating Airport A's Digital Maturity in comparison to the overall Digital Maturity for African Airports

4.4.1.4 ***Digital Maturity at Airport B.***

The overall Digital Maturity level at Airport B was found to be 2.78. At this maturity level, the airport was digitally aware, and ranged, between having limited awareness to being aware of what was required to transform digitally. The radar chart in *Figure 7*, shows that Airport B's overall Digital Maturity level was higher than the average overall Digital Maturity level for the African airports. Furthermore, Airport B had higher

Digital Maturity levels for all the Digital Maturity dimensions compared to the overall African airports' average.

The lowest rating, Digital Maturity dimensions were *Process Management* and *Technology & Data.* With the highest rating dimensions being *Customer* and *Strategy.* The overall Digital Maturity level for this airport was classified as low, because it was between level 1 and level 2.99. The airport should consider putting plans in place to improve the lowest scoring dimensions, i.e. *Process Management* and *Technology & Data*; this would ensure that they achieve higher overall Digital Maturity levels.

Figure 7: Radar chart illustrating Airport B's Digital Maturity in comparison to the overall Digital Maturity for African Airports

4.4.1.5 ***Digital Maturity at Airport C.***

The overall Digital Maturity level at Airport C was found to be 2.96, making it the highest maturity level of the airports that were part of this study. At this maturity level, the airport was digitally aware and ranged, between having limited awareness to being aware of what was required to transform digitally. It is observed in the radar chart in *Figure 8* that Airport C's overall Digital Maturity level was higher than the average overall Digital Maturity level for the African airports. It was also observed that Airport C had higher Digital Maturity levels for all the Digital Maturity dimensions, compared to the overall African airports' average.

The lowest rating, Digital Maturity dimensions were *Process Management* and *Technology & Data.* With the highest rating dimensions being *Organisational Culture* and *Strategy.* The overall Digital Maturity level for this airport was classified as low maturity, because it was between level 1 and level 2.99. The airport should consider putting plans in place to improve the lowest scoring dimensions, i.e. *Process Management* and *Technology & Data*, this would ensure that they achieve higher overall Digital Maturity levels.

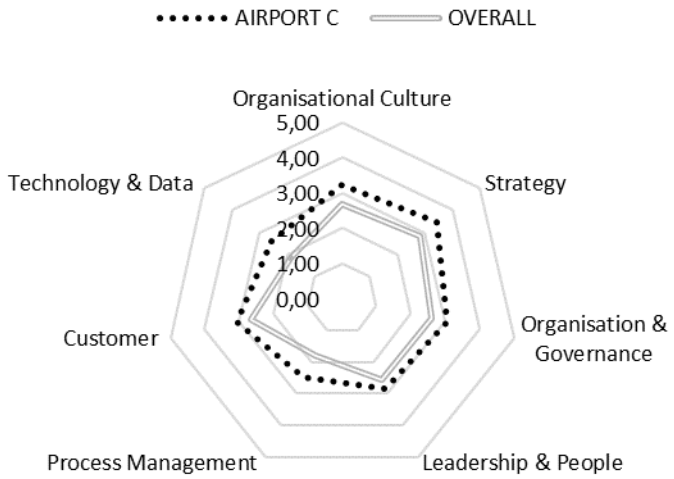


Figure 8: Radar chart illustrating Airport C's Digital Maturity in comparison to the overall Digital Maturity for African Airports

4.4.1.6 ***Digital Maturity at Airport D.***

The overall Digital Maturity level at Airport D was found to be 2.94, making it the second-highest maturity level of the airports that were part of this study. At this maturity level, the airport was digitally aware and ranged, between having limited awareness to being aware of what was required to transform digitally. *Figure 9* illustrates that Airport D's overall Digital Maturity level was higher than the average overall Digital Maturity level for the African airports. It was also observed that Airport D had higher Digital Maturity levels for all the Digital Maturity dimensions compared to the overall African airports average. With *Process Management* and *Technology &*

Data being the exceptions, at lower Digital Maturity levels than the overall African average.

The lowest rating, Digital Maturity dimensions were *Process Management* and *Technology & Data*. The highest rating dimensions being *Organisational Culture* and *Customer*. The overall Digital Maturity level for this airport was classified as low maturity because it was between level 1 and level 2.99. The airport should consider putting plans in place to improve the lowest scoring dimensions, i.e. *Process Management* and *Technology & Data*, this would ensure that they achieve higher overall Digital Maturity levels.

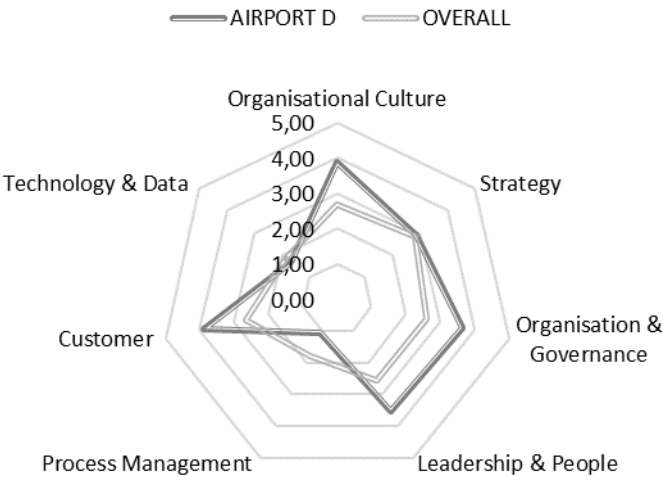


Figure 9: Radar chart illustrating Airport D's Digital Maturity in comparison to the overall Digital Maturity for African Airports

4.4.1.7 ***Digital Maturity at Airport E.***

The overall Digital Maturity level at Airport E was found to be 1.39, making it the lowest maturity level of the airports that were part of this study. At this maturity level, the airport was digitally unconscious, and it ranged between having no awareness, to having minimal awareness on what was required to transform digitally. The chart in *Figure 10*, illustrates that Airport E's overall Digital Maturity level was lower than the average overall Digital Maturity level for the African airports. It was also observed that

Airport E had lower Digital Maturity levels for all the Digital Maturity dimensions compared to the overall African airports average.

The lowest rating, Digital Maturity dimensions were *Strategy* and *Technology & Data*. The highest rating dimensions being *Organisation & Governance* and *Leadership & People*. The overall Digital Maturity level for this airport was classified as low maturity because it was between level 1 and level 2.99. The airport should consider putting plans in place to improve all the Digital Maturity dimension levels because they received a score of less than 2 for all the dimensions.

Figure 10: Radar chart illustrating Airport E's Digital Maturity in comparison to the overall Digital Maturity for African Airports

4.4.1.8 ***Digital Maturity at Airport F.***

The overall Digital Maturity level at Airport F was found to be 1.73. At this maturity level, the airport was digitally unconscious, and it ranged between having no awareness, to having minimal awareness on what was required to transform digitally. It was observed in *Figure 11* that Airport F's overall Digital Maturity level was lower than the average overall Digital Maturity level for the African airports. It was also observed that Airport F, had lower Digital Maturity levels for all the Digital Maturity dimensions compared to the overall African airports average for the Digital Maturity dimensions. Excluding the *Strategy* dimension, which had a higher overall Digital

Maturity level than the overall African average for the dimension. It was recommended that the airport uses the *Strategy* dimension as a point of differentiation, since it was already performing well at it.

The lowest rating, Digital Maturity dimensions were *Process Management* and *Technology & Data*. The highest rating dimensions being *Organisational Culture* and *Strategy*. The overall Digital Maturity level of this airport was classified as low maturity because it was between level 1 and level 2.99. The airport should consider putting plans in place to improve all the Digital Maturity dimension levels because they received a score of less than 2.50 for all the dimensions, except *Strategy.*

Figure 11: Radar chart illustrating Airport F's Digital Maturity in comparison to the overall Digital Maturity for African Airports

4.4.1.9 ***Overall Digital Maturity of African Airports.***

The *Process Management* and *Technology & Data* dimensions had the lowest Digital Maturity levels across most of the six African airports in the study. The highest scoring dimensions across most of the airports were the *Strategy,* followed by the *Organisational Culture* and *Customer* dimensions. Airport B and C had higher, overall Digital Maturity in all the Digital Maturity dimensions. While, Airport A and D had higher overall Digital Maturity in most of Digital Maturity dimensions, apart from *Organisational Culture* for Airport A and *Process Management* and *Technology & Data*

for Airport D. Airport E and F had overall lower Digital Maturity in all the Digital Maturity dimensions, except for the *Strategy* dimension for Airport F. It should be noted that the results presented for Airport D and E are the views of only two respondents from each airport, respectively.

Based on the results from the data collected, the airports in the study had maturity levels that ranged between 1.39 and 2.96. The overall average Digital Maturity level for African airports being 2.42. This level placed the maturity levels between level 1 and level 2.99 on the Digital Maturity Model.

Furthermore, this level was classified as low maturity within this study. Two conditions of low maturity level, both at an airport level and at a continent level were satisfied. Thus, hypothesis one (H1) was supported.

4.5 Using the Digital Maturity Model output as input into the Digital Transformation Strategy

The Digital Maturity Model developed in this study, was developed to assist organisations in understanding where they are in the process of transforming their organisations digitally. To enable them to put interventions in place to transform. The different features of the model should be used to close the knowledge-intervention gap, referred to as the knowing-doing gap by Mettler et al., (2009).

The features of the Digital Maturity Model are the; Digital Maturity dimensions and Digital Maturity levels. The outputs of the Digital Maturity Model, i.e. Digital Maturity scores, overall scores and dimension scores, should also be used to address the knowledge-intervention gap.

The following approaches should be used to address the knowledge-intervention gap:

- Organisations should use the knowledge of low versus medium and high scoring Digital Maturity dimensions to inform interventions that are required to improve or sustain the as-is levels, within Digital Maturity dimensions of their choice.

- Knowledge of the organisations' Digital Maturity level should be used to enable the development of a Digital Maturity path or roadmap. The prescriptive questions of the Digital Maturity Model should be used to assess the requirements required for the next level of maturity. The assessment should consider that the requirements of the higher-level builds on the requirements of the previous lower level within the Digital Maturity dimensions.
- Additionally, both the knowledge of the Digital Maturity dimension levels and the overall Digital Maturity levels, should be used to guide decisions on which Digital Maturity dimensions are of priority to the organisation, to inform resource and investment allocation.

These approaches will enable leaders to provide input into the development or review of a Digital Transformation Strategy to enable their organisation to move to a higher Digital Maturity to-be state.

4.6 Reviewing company performance over 3 years

This study reviewed airport performance across three performance indicators: two financial indicators, i.e. total revenue growth and total departing passenger growth, as well as one marketing indicator, i.e. ASQ.

Performance indicators were classified to gain an understanding of the airport performance indicators investigated in this study and their contribution to aeronautical versus non-aeronautical revenue generated, as follows:

- Total revenue growth is made up of both aeronautical and non-aeronautical revenue (Battal & Bakir, 2017).
- Total departing passengers contribute to aeronautical revenue generated (Humphreys et al., 2002).
- ASQ contributes to non-aeronautical revenue generated, as implied by Halpern et al., (2019).

If this was the case, then an increase in total departing passengers and an increase in ASQ should have resulted in a positive contribution to total revenue growth. Below, the study discusses the findings with regards to the statement as mentioned above.

4.6.1 *Airport A's performance over 3 years*

Over the 3 years, Airport A observed a total revenue decline of 10.38%, despite having a 2.22% increase in the number of total departing passengers and an increase of 3.82% in the ASQ score. These results indicated that the airport needed to do more to improve both their aeronautical and non-aeronautical revenue generated; thus, their total revenue generated. An increase in the total departing passenger numbers and the ASQ score were not enough to assist the airport in avoiding a revenue decline.

The dimensions of the Digital Maturity Model should be used to craft alternative strategies and new business models to improve the total revenue generated through Digital Transformation. Strategies should be developed to improve the lowest scoring Digital Maturity dimensions, i.e. *Process Management* and *Technology & Data*. The improvement and automation of processes could lead to quicker facilitation of passengers, thus increasing the opportunity to make a purchasing decision (Castillo-Manzano, 2010), improving the likelihood of generating non-aeronautical revenue. The implementation of emerging technologies, i.e. technical innovation, has been shown to drive airport performance (Humphreys et al., 2002).

Consequently, strategies should also be developed to maintain their highest-scoring Digital Maturity dimensions, i.e. *Customer* and *Strategy*. It was interesting to note that the airport observed an increase in ASQ and had a high Digital Maturity score on the *Customer* dimension. From the results, it was concluded that the efforts Airport A had put in place to drive the customer experience using technology, had benefitted the ASQ score.

4.6.2 *Airport B's performance over 3 years*

The results from investigating Airport B's performance showed a 5.63% decline in total revenue over the 3 years despite a 5.57% increase in total departing passengers. The ASQ score decreased by 2.15% over the 3 years.

It should be noted that Airport B observed a less negative decline in revenue than Airport A over the period. The less negative decline could be attributed to a 3.35% (i.e. 5.57 minus 2.22) higher increase in total departing passengers, than Airport A. Though Airport B observed an ASQ score decrease, where Airport A observed an ASQ score increase.

As recommended for Airport A, Airport B should also improve both their aeronautical and non-aeronautical revenue generated, to avoid future decline in total revenue generated. Decisions on which Digital Maturity dimensions to prioritise for improvement, could be used to transform digitally and thus improve company performance (Nwankpa et al., 2016). The same lowest and highest scoring dimensions were found for Airport B, as was for Airport A; thus, the same recommendations should be applied for the lowest scoring dimensions.

For the highest-scoring dimensions, i.e. *Customer* and *Strategy,* the airport should investigate the discrepancies between a high Digital Maturity level score for the *Customer* dimension versus a decline in its ASQ scores over the 3 years. Airport B should verify that the implemented customer experience strategies are resolving the pain points that customers (passengers) are experiencing. This verification should ensure that the airport invests in fit-for-purpose customer solutions and technologies, that add value to passenger satisfaction, this could result in improved ASQ scores.

4.6.3 *Airport C's performance over 3 years*

Airport C observed a 7.34% decline in total revenue over the 3 years, a 6.74% increase in total departing passengers and a 2.33% decrease in its ASQ scores. Airport C similarly observed a decline in total revenue and an increase in total departing

passengers as was seen for Airport A and Airport B. Furthermore, Airport C observed a decrease in ASQ scores, as did Airport B.

To summarise, the airport saw a decline in two out of the 3 performance indicators, making it the airport with the second-highest total revenue decline. Despite having the highest overall Digital Maturity level of 2.96. The same lowest scoring dimensions were found for Airport C, as was for Airport A and Airport B; thus, the same recommendations should be applied for the lowest scoring dimensions.

The airport had the highest number of dimensions (four), scoring above a Digital Maturity level 3. The four dimensions were *Organisational Culture* and *Strategy,* as well as *Customer,* and *Organisation & Governance.* The airport should investigate the discrepancies between the decline in company performance and the relatively high Digital Maturity dimension scores. Based on the results from the four highest-scoring dimensions, the airport had begun to put measures in place to transform their operations digitally. Though these efforts had not shown consequent improvements in company performance except for an improvement in total departing passengers.

For the *Customer* dimension, the same recommendations as suggested for Airport B should be applied. The *Organisational Culture*, *Strategy*, and *Organisation & Governance* dimensions are inward-looking and focus more on improving internal organisational practices and processes, that should inherently translate into what the customers (passengers) experience when they go through the airport. Based on the results observed, this was not the case, and a possible disconnect may have existed between Digital Transformation interventions and the resulting customer experience. The airport needs to review its Digital Transformation Strategy, or put one in place, to ensure that efforts align to the felt customer experience and Digital Transformation outcomes. As stated by Berghuas et al., (2016), organisations battle to develop viable Digital Transformation strategies. The identification of the gaps that existed using a Digital Maturity model could help with addressing the gaps and consequently increasing the viability of these strategies.

4.7 Digital Maturity and company Performance

The relationship between Digital Maturity and company performance data, namely, total revenue growth, total departing passengers facilitated and ASQ score, was investigated. Performance data for three financial years, i.e. 2016, 2017 and, 2018, was used to calculate the percentage increase or decrease of the three indicators over the 3 years.

Due to the small sample sizes received from the Ghanaian and Nigerian airports, correlations could not be made for those airports; thus, inferential statistics were only investigated for the South African airports, where higher sample sizes were achieved. This decision was made based on findings by Rosseel (2020), their study indicated that results from small sample sizes might not provide enough information to answer research questions due to statistical limitations. Thus, data collected from the Ghanaian and Nigerian airports was not used to investigate hypothesis two, hypothesis three, and hypothesis four. Only data collected from the South African airports were used to investigate these three hypotheses.

The percentage growth/decline of performance indicators was then compared to the Digital Maturity level per airport, for airports where correlations could be investigated, as seen in Table six below.

Table 6

Company Performance Data by Airport

	Overall Digital Maturity Level	% Total Revenue growth rate	% Total departing passengers change	% ASQ score change
Airport A	2,73	-10,38	2,22	3,82
Airport B	2,78	-5,63	5,57	-2,15
Airport C	2,96	-7,34	6,74	-2,33

Airports that had marginally higher maturity levels of 2.96 and 2.78 experienced a total revenue decline of 7.34% and 5.63% respectively. Where the airport with a lower maturity level of 2.73, had a total revenue decline of 10.38%. Additionally, the airport with the highest Digital Maturity level experienced the highest total departing

passenger growth of 6.74%, compared to a total departing passenger growth of 5.57% and 2.22% for the other two airports. The airport with the highest Digital Maturity level, experienced the greatest decline of 2.33% in ASQ over the 3 years. While the airport with the second-highest Digital Maturity level experienced a 2.15% decline in ASQ over the same period. This was observed although, the airport with the lowest Digital Maturity level, experienced an improvement of 3.82% in ASQ.

4.7.1 *Correlation between Digital Maturity levels and total revenue growth over 3 years*

Table six indicates the percentage annual total revenue growth for the airports in the study, over 3 financial years, i.e. 2016, 2017 and 2018. It was observed that revenue for all three airports declined over the 3 years. When the correlation between Digital Maturity and the total revenue growth was investigated, a positive correlation was observed between the two variables, with an *R* of 0.3506 (*Figure 12*). The *R*-value indicated that there was a correlation between the two variables.

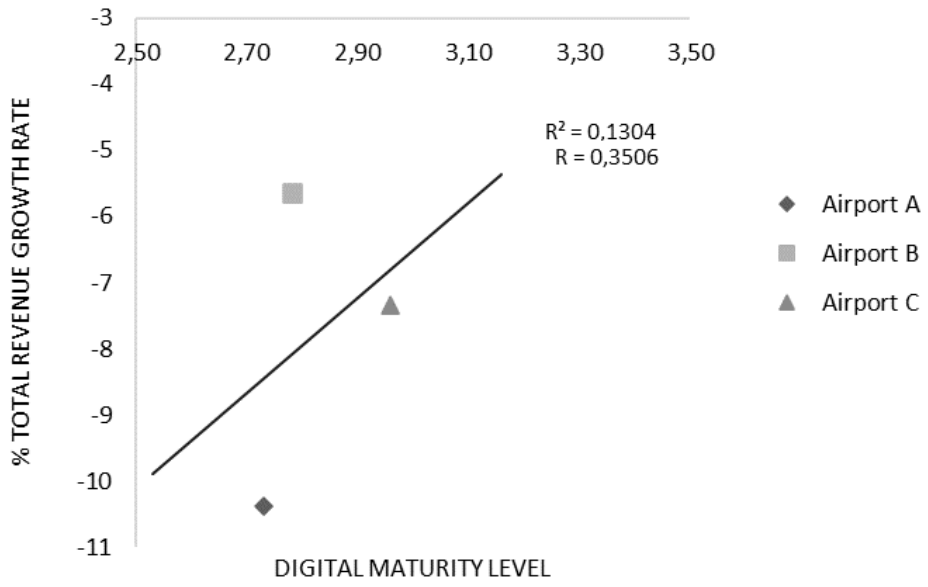


Figure 12. Digital Maturity versus total revenue growth rate

This finding was similar to the research by Remane et al., (2017). In their study, organisations with excellent financial performance showed better digital readiness levels ranging between 2.5 and 4, as observed in *Figure 1*.

Based on the data, the second hypothesis (H2) was thus supported by the findings because airports with higher Digital Maturity levels tended to have a better performance in total revenue growth, i.e. less decline in revenue. Moreover, even though all the three airports saw a decline in revenue growth, the airports that observed the least total revenue loss had higher Digital Maturity levels than the airport that observed the highest revenue loss of 10.38%.

4.7.2 *Correlation between Digital Maturity levels and departing passenger growth at African airports*

Total departing passengers grew at different rates for all the airports under the study, over the 3 years. A positive correlation between Digital Maturity levels and the total percentage growth of departing passengers facilitated through the airports over the 3 years was observed (*Figure 13*). An *R* of 0.8260 was observed; this showed a high positive correlation between the two variables.

It was concluded that airports that saw an increase in passenger growth rate year on year, also saw a higher Digital Maturity. Therefore, the third hypothesis (H3) of the study was supported.

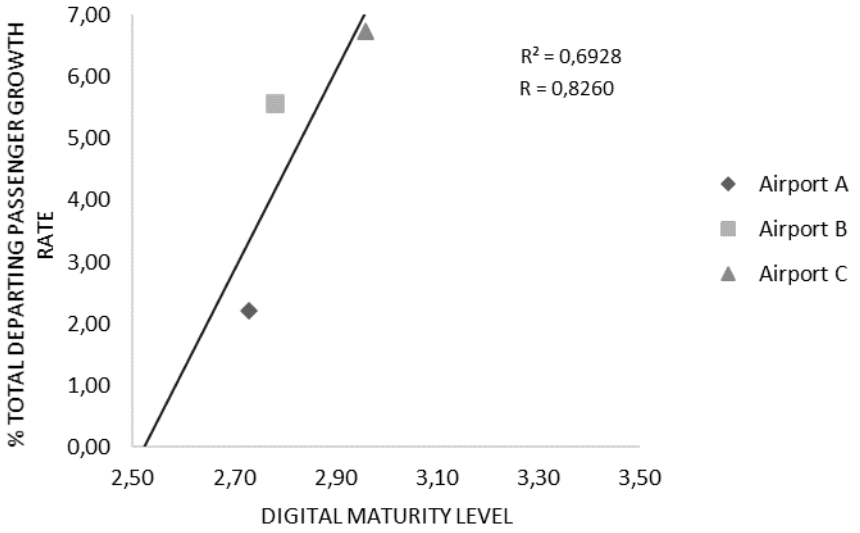


Figure 13. Digital Maturity versus total departing passenger's growth rate

4.7.3 *Correlation between Digital Maturity levels and ASQ results of African airports*

This study further investigated the correlation between Digital Maturity and customer perception, i.e. ASQ. As discussed in their study, Chanias et al., (2016) observed that customer feedback is neglected during Digital Maturity model development. Furthermore, their study indicated that performance indicators were also not considered. As much as customer perceptions were taken into account within the *Customer* dimension, correlations between Digital Maturity and ASQ were further investigated.

Upon investigation, a negative correlation was found between Digital Maturity and the annual ASQ score percentage change (*Figure 14*). The correlation showed an *R* of 0.6529, indicating a high negative correlation between the two variables. Although, all the airports achieved a Digital Maturity score of above level 3 for the *Customer* dimension. The data indicated that, as Digital Maturity increased, service quality scores, i.e. customer perceptions on airport operations, decreased.

The fourth hypothesis (H4), was not supported based on the findings in the study.

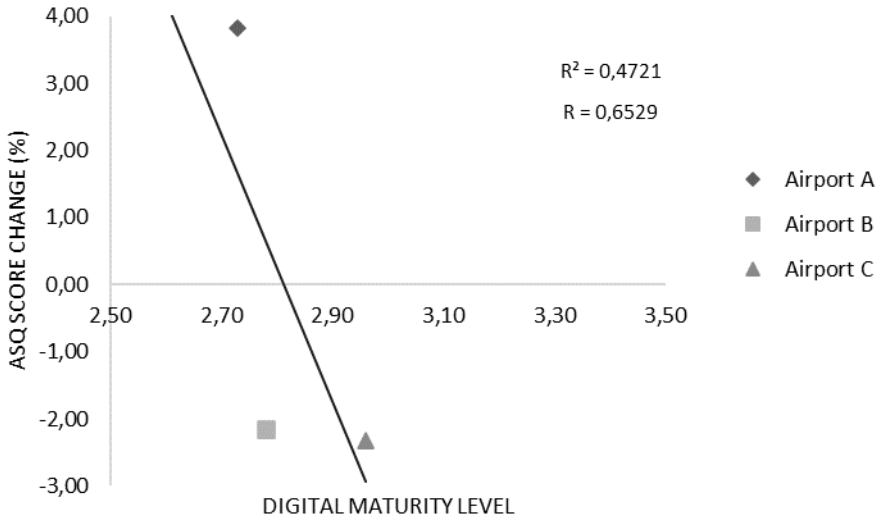


Figure 14. Digital Maturity versus ASQ score change

The literature study showed that for an airport to increase its non-aeronautical revenue, it had to increase its passenger satisfaction (Halpern et al., 2019), thus its ASQ score. The study by Halpern et al., (2019) further stated that passenger satisfaction could lead to increased revenue generation. These findings by Halpern et al., (2019) implied the existence of a positive relationship between revenue generation and passenger satisfaction, or in the case of this study, ASQ. This positive relationship was intriguingly only observed at Airport A, within this study. Another study by Tsai et al., (2011), indicated that passenger satisfaction could be a competitive advantage and a differentiating factor for airports. Based on these reasons, airports should aim to increase their ASQ scores.

4.8 Summary of results

Due to the small sample sizes received from other African airports, inferential studies were only conducted for the South African airports, whereas descriptive studies for the whole data set. Though there are considerable advantages to using online surveys for data collection, such as cost-effectiveness and in the context of this study - reaching audiences in other African countries. The challenge of low responsiveness was

encountered during the data collection process. Though sufficient response rates were achieved for the South African airports, and this could have been attributed to the networks and connections that existed in South Africa. Additionally, an approximately higher number of leaders within South African airports were asked to distribute the survey link to their colleagues. The opposite was true for the airports outside of South Africa. In this case, the study had access to a maximum of two leaders at each airport that was part of the study.

Furthermore, other researchers (Fan & Yan, 2010) noted a challenge with not achieving representative sample sizes from an online survey. In their study Fan et al., (2010) listed amongst other challenges, that surveys distributed from popular survey platforms encountered a higher probability of being blocked by spam filters, if survey links were sent via email. Limited internet access could also pose a challenge to high participant responsiveness.

The study investigated four hypotheses. Based on the results observed from the data collected, three of the hypotheses, i.e. hypothesis one, hypothesis two, and hypothesis three were supported, and hypothesis four, was not supported. It was summarised that African airports within the study, displayed low levels of Digital Maturity. Furthermore, there was a positive relationship between Digital Maturity and total revenue as well as total departing passengers. Airports with a higher maturity level, observed a less negative performance on total revenue growth and an increase in total departing passengers facilitated through their airports, over the 3 years. It was further concluded that there was a negative relationship between Digital Maturity levels and changes in ASQ scores. The airport with the highest Digital Maturity level, experienced the highest decrease in ASQ scores, over the 3 years. While the airport with the lowest Digital Maturity level, experienced the highest increase in ASQ scores, during the same period.

5 Conclusion and Recommendations

A multidimensional Digital Maturity model, consisting of seven Digital Maturity dimensions, was developed to investigate the Digital Maturity levels at African airports. The African continent has previously lagged in the adoption of technology. Thus, the Digital Maturity Model aimed to provide African airports with knowledge of their current Digital Maturity status, as input into the development of their Digital Transformation Strategies. The Digital Maturity Model, compiled from a survey questionnaire, helped organisations understand where they are in the process of transforming their organisations digitally, to enable them to transform and move to the next level of Digital Maturity. The Digital Maturity Model was tested for reliability using Cronbach's α, where all the Digital Maturity dimensions in the model achieved a Cronbach's α of >0.8. Guaranteeing, the reliability of the Digital Maturity Model.

The different features of the Digital Maturity model could be utilised to address the knowledge-intervention gap, referred to as the knowing-doing gap by Mettler et al., (2009). This gap was found where organisations did not have an awareness and appreciation of their as-is Digital Maturity status and thus did not know where to begin with their Digital Transformation journeys. Additionally, organisations that found themselves in the knowledge-intervention gap did not know the interventions that they needed to put in place, to transform digitally, to move their organisations to the next level of Digital Maturity. The understanding of the current Digital Maturity level and subsequent development of a Digital Transformation strategy could help leaders and their organisations to further transforming digitally.

Digital Maturity levels at African airports were found to be low, between level 1 and level 2.99, on a five-point scale. Actual Digital Maturity levels for the African airports ranged between levels 1.39 and 2.96, with South African and Ghanaian airports at the upper end and Nigerian airports at the lower end of the Digital Maturity scale. However, most airports showed medium maturity levels of between 3.03 and 3.89 at the Digital Maturity dimension level. The highest scoring dimensions across most of the airports were *Strategy,* followed by the *Organisational Culture* and *Customer* dimensions. The *Process Management* and *Technology & Data* dimensions had the

lowest Digital Maturity levels across most of the airports in the study. It should be noted that the results presented for Airport D (Ghanaian) and Airport E (Nigerian) are the views of only two respondents from each airport, respectively.

Based on the results of this study, the following recommendations were made to address the knowledge-intervention gap:

- Firstly, organisations should use the knowledge of low versus medium and high scoring Digital Maturity dimensions to inform interventions that would be required to improve or sustain the as-is levels, within Digital Maturity dimensions of their choice. This approach would enable organisations to move to a higher Digital Maturity to-be state.
- Secondly, knowledge of the organisations' Digital Maturity level should be used to enable the development of a Digital Maturity path or roadmap. Where the organisation decides on the target or ideal Digital Maturity level and defines plans and actions to reach the target level. The prescriptive questions of the Digital Maturity Model could be used to assess the requirements required for the next level of maturity. The assessment should consider that the requirements of the higher-level builds on the requirements of the previous lower level within the Digital Maturity dimensions. These maturity paths should serve as input into the development or review of a Digital Transformation Strategy.
- Thirdly, both the knowledge of the Digital Maturity dimension levels and the overall Digital Maturity levels, should be used to guide decisions on which Digital Maturity dimensions are of priority to the organisation, to inform resource and investment allocation.

Detailed recommendations to address the knowledge-intervention gap, are provided for, for each airport in sections 4.4.

The second part of the study used correlation studies to investigate relationships between Digital Maturity levels and company performance indicators, which were collected for 3 years. These studies were conducted to investigate whether a link exists between Digital Maturity and company performance to solidify the business

case for Digital Transformation. This study concluded that airports with a higher maturity level, observed a less negative performance on total revenue and observed an increase in total departing passengers facilitated through their airports. During the 3 years, all three airports for whom correlation studies were performed, experienced a revenue decline. However, airports that had marginally higher maturity levels of 2.96 and 2.78 experienced a less negative total revenue decline of 7.34% and 5.63% respectively. Whereas the airport with a lower maturity level of 2.73, had a total revenue decline of 10.38%. Additionally, the airport with the highest Digital Maturity level experienced the highest total departing passenger growth of 6.74%, compared to a total departing passenger growth of 5.57% and 2.22% for the other airports.

Furthermore, it was concluded that there was a negative relationship between Digital Maturity levels at airports and changes in ASQ. As Digital Maturity increased, service quality scores, i.e. customer perceptions on airport operations, decreased. The airport with the highest Digital Maturity level, experienced the most considerable decline of 2.33% in ASQ over the 3 years. While the airport with the second-highest Digital Maturity level experienced a 2.15% decline in ASQ over the same period. This observation was although, the airport with the lowest Digital Maturity level, experienced an improvement of 3.82% in ASQ.

Airports should investigate discrepancies in the relationship that may have existed between company performance and Digital Maturity. To ensure that Digital Transformation interventions and efforts that were put in place resulted in improved company performance and higher Digital Maturity levels. The study found a positive relationship between Digital Maturity and growth in total revenue and total departing passengers, and a negative relationship between Digital Maturity and ASQ. The study investigated correlation relationships and not cause and effect relationships. Thus, it did not conclude that higher Digital Maturity levels resulted in better company performance. It is recommended that the cause and effect relationships between Digital Maturity and company performance be investigated in future studies.

Airports should consider the Digital Maturity dimensions that would be a priority for them to remain competitive. This consideration would enable them to define maturity paths to improve these Digital Maturity dimensions and use them to offer a

differentiated experience to passengers and customers, e.g. airlines, per their refreshed Digital Transformation Strategy. Development of the Digital Transformation Strategy should not be done in isolation but should be developed in support of the overall organisational strategy. Moreover, Digital Transformation Strategy should be developed in line with the strategic objectives and key performance indicators that the organisation is working towards achieving. This approach would allow progress against Digital Maturity interventions and improvement in Digital Maturity levels to be linked back to company performance, to show business value for the Digital Transformation process.

To avoid giving business leaders an incomplete view of Digital Maturity gaps that exist within their organisations and leading them to the wrong decisions on interventions to implement. The study recommends that future Digital Maturity development should comprehensively measure all the variables that constitute the Digital Maturity of an organisation, to satisfy the principle of multidimensionality. An adaptation and addition of more dimensions to the Digital Maturity model developed in this study is recommended, where future studies deem it necessary as the concept of Digital Maturity evolves and academia gains a better understanding of the area of study.

Finally, it is recommended that the Digital Maturity model be tested in other industries. To investigate applicability, replicability and generalisability of this study.

6 References

Abate, M. (2014). Economic Effects of Air Transport Market Liberalization in Africa. *Air Transport Research Society Conference.* Swedish National Road and Transport Research Institute.

Airports Council International. (2017). *Airport Digital Transformation Best Practice.* Airports Council International.

African Aerospace. (2019, May 30). *African Aerospace*. Retrieved from Tracking bags drive 66% improvement in baggage delivery: https://www.africanaerospace.aero/tracking-bags-drive-66-improvement-in-baggage-delivery.html

African Aerospace. (2019, May 22). *Kotoka terminal lightens the load*. Retrieved from African Aerospace: https://www.africanaerospace.aero/kotoka-terminal-lightens-the-load.html

African Aerospace. (2019, February 14). *O.R Tambo International unveils first phase of Western Precinct development*. Retrieved from African Aerospace: https://www.africanaerospace.aero/o-r-tambo-international-unveils-first-phase-of-western-precinct-development.html

Akwei, C., Tsamenyi, M., & Sa'id, H. (2012). Deregulation, competition and performance measurement of an African airport: The case of Kotoka International Airport of Ghana. *Wiley Periodicals*, 537-550.

Aulman, J. N. (2018). Meeting airport capacity demand using new technologies and innovations. *Journal of Airport Management, 13*(1), 57-63.

Battal, U., & Bakir, M. (2017). The Current Situation and Change in Airport Revenues: Research on The Europe's Five Busiest Airports. *International Journal of Academic Research in Business and Social Sciences, 7*(7), 287-303.

Becker, J., Knackstedt, R., & Poppelbuss, J. (2009). Developing Maturity Models for IT Management – A Procedure Model and its Application. *Business & Information Systems Engineering, 3*, 213-222.

Berghuas, S., & Back, A. (2016). Stages in Digital Business Transformation: Results of an Empirical Maturity Study. *MCIS 2016 Proceedings*, 22. Retrieved from http://aisel.aisnet.org/mcis2016/22

Britz, j. j., Lor, P. J., M, C. I., & Bester, B. C. (2006). Africa as a knowledge society. *The International Information & Library Review, 38*(1), 25-40. Retrieved from https://doi.org/10.1080/10572317.2006.10762700

Castillo-Manzano, J. I. (2010). Determinants of commercial revenues at airports: Lessons learned from Spanish regional airports. *Tourism Management*, 788-796.

Chanias, S., & Hess, T. (2016). How digital are we? Maturity models for the assessment of a company's status in the digital transformation. *Management Report*.

Cortina, J. M. (1993). What is Coefficient Alpha? An Examination of Theory and Applications. *Journal of Applied Psychology, 78*(1), 98-104.

De Bruin, T., Rosemann, M., Freeze, R., & Kulkarni, U. (2005). Understanding the Main Phases of Developing a Maturity Assessment Model. *Australasian Conference on Information Systems.* Sydney.

De Nicola, A., Gitto, S., & Mancuso, P. (2013). Airport quality and productivity changes: A Malmquist index decomposition assessment. *Transportation Research Part E, 58*, 67-75.

Fan, W., & Yan, Z. (2010). Factors affecting response rates of the web survey: A systematic review. *Computers in Human Behavior, 26*, 132-139.

Felch, V., Asdecker, B., & Sucky, E. (2019). Maturity Models in the Age of Industry 4.0 – Do the Available Models Correspond to the Needs of Business Practice? *52nd Hawaii International Conference on System Sciences*, (pp. 5165-5174).

Field, A. (2009). Grouped Scatterplot. In A. Field, *Discovering statistics using SPSS* (pp. 119-120). California: SAGE Publications Inc.

Ganzarain, J., & Errasti, N. (2016). Three stage maturity model in SME's toward industry 4.0. *Journal of Industrial Engineering and Management, 9*(5), 1119-1128. Retrieved from http://dx.doi.org/10.3926/jiem.2073

Gilem, J. A., & Gilem, R. R. (2003). Calculating, Interpreting, and Reporting Cronbach's Alpha Reliability Coefficient for Likert-Type Scales. *Midwest Research to Practice Conference in Adult, Continuing, and Community Education.* Columbus.

Gokalp, E., Sener, U., & Eren, E. (2018). Development of an Assessment Model for Industry 4.0: Industry 4.0-MM.

Graham, A. (2005). Airport benchmarking: a review of the current situation. *Benchmarking*, 99-111. Retrieved from http://www.emeraldinsight.com/10.1108/14635770510593059

Halpern, N., Budd, T., Suau-Sanchez, P., Brathen, S., & Mwesiumo, D. (2019). Towards Airport 4.0: Airport Digital Maturity and Transformation. *23rd Air Transport Research Society World Conference.* Amsterdam. Retrieved from https://www.researchgate.net/profile/Nigel_Halpern/publication/335015282_Towards_Airport_40_Airport_Digital_Maturity_and_Transformation/links/5d4aa138299bf1995b6ab1c8/Towards-Airport-40-Airport-Digital-Maturity-and-Transformation.pdf

Heale, R., & Twycross, A. (2015). Validity and reliability in quantitative studies. *Evidence Based Nursing, 18*(3), 66-67.

Henderson, B. D. (1989). *The Origin of Strategy.* Retrieved from Havard Business Review: https://hbr.org/1989/11/the-origin-of-strategy

Humphreys, I., & Francis, G. (2002). Performance measurement: a review of airports. *International Journal of Transport Management*, 79–85.

Irandu, E., & Rhoades, D. L. (2006). The Development of Jomo Kenyatta International Airport as a regional aviation. *Journal of Air Transportation, 11*(1). Retrieved from https://ntrs.nasa.gov/search.jsp?R=20060046467

Issa, A., Hatiboglu, B., Bildstein, A., & Bauernhansl, T. (2018). Industrie 4.0 roadmap: Framework for digital transformation based on the concepts of capability maturity and alignment. *Procedia CIRP*, 973–978.

Kalakou, S., Psaraki-Kalouptsidi, V., & Moura, F. (2015). Future airport terminals: New technologies promise capacity gains. *Journal of Air Transport Management, 42*, 203-212.

Klotzer, C., & Pflaum, A. (2017). Toward the Development of a Maturity Model for Digitalization within the Manufacturing Industry's Supply Chain. *50th Hawaii International Conference on System Sciences*, (pp. 4210-4219). Retrieved from http://hdl.handle.net/10125/41669

Kohlegger, M., Maier, R., & Thalmann, S. (2009). Understanding Maturity Models Results of a Structured Content Analysis. *Proceedings of I-KNOW '09.*

Kovynyov, I., & Mikut, R. (2018). Digital Transformation in Airport Ground. *arXiv:1805.09142*.

Luke, R., & Walters, J. (2010). The economic impact of South Africa's international airports. *Journal of Transport and Supply Chain Management, 4*(1), 120-137.

Maier, A. M., Moultrie, J., & Clarkson, P. J. (2012). Assessing Organizational Capabilities: Reviewing and Guiding the Development of Maturity Grids. *IEEE Transactions on Engineering Management, 59*(1), 138-159.

Martin-Domingo, L., & Martin, J. C. (2016). Airport mobile internet an innovation. *Journal of Air Transport Management, 55*, 102-112.

Mettler, T., & Rohner, P. (2009). Situational Maturity Models as Instrumental Artifacts for Organizational Design.

Nagy, E., & Csiszar, C. (2016). Airport Smartness Index – evaluation method of airport information services. *OSTERREICHISCHE ZEITSCHRIFT FUR VERKEHRSWISSENSCHAFT*, 25-30.

New Partnership for Africa's Development. (2014). *Africa Transport Sector: Outlook 2040.* African Union.

Nwankpa, J. k., & Roumani, Y. (2016). IT Capability and Digital Transformation: A firm performance perspective. *Thirty Seventh International Conference on Information Systems.* Dublin.

Ondiege, P., Moyo, J. M., & Verdier-Chouchane, A. (2013). Developing Africa's infrastructure for enhanced competitiveness. *The African competitiveness report*, 69-92.

Onwuegbuzie, A. J. (2000). Expanding the framework of internal and external validity in quantitative research. *Association for the Advancement of Educational Research.* Florida: Educational Resources Information Center.

Pabedinskaite, A., & Akstinaite, V. (2014). Evaluation of the airport service quality. *Procedia - Social and Behavioral Sciences, 110*, 398-409.

Paulk, M. C. (1995). The Evolution of the SEI's Capability Maturity Model for Software. *Software Process - Improvement and Practice*, 3-15.

Pirie, G. (2019). China and aviation in Africa: context, thrust, novelty. *African Geographical Review*, 2163-2642. Retrieved from https://doi.org/10.1080/19376812.2019.1599294

Porter, M. E. (1996, November). *What is Strategy?* Retrieved from Havard Business Review: http://innovationinthebox.com/clientresources/articles/Strategy/CLASSIC-What%20is%20strategy%20HBR.pdf

Remane, G., Hanelt, A., Wiesboeck, F., & Kolbe, L. (2017). Digital Maturity in Traditional Industries – An Exploratory Analysis. *Twenty-Fifth European Conference on Information Systems.* Portugal.

Rosseel, Y. (2020). Small sample solutions for Structural Equation Modelling. In R. van de Schoot, & M. Miočević, *Small sample size solutions: A Guide for Applied Researchers and Practitioners* (pp. 226-238). New York: Routledge.

Saurez-Aleman, A., & Jimenez, J. L. (2016). Quality assessment of airport performance from the passengers' perspective. *Research in Transportation Business & Management, 20*, 13-19.

Schuh, G., Anderl, R., Gausemeier, J., Hompel, M., & Wahlster, W. (2017). *Industrie 4.0 Maturity Index.* Acatech.

Schumacher, A., Erol, S., & Sihn, W. (2016). A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises. *Procedia CIRP, 52*, 161 - 166.

Schumacher, A., Nemeth, T., & Sihn, W. (2019). Roadmapping towards industrial digitalization based on an Industry 4.0 maturity model for manufacturing enterprises. *Procedia CIRP, 79*, pp. 409-414.

Schwer, K., Hitz, C., Wyss, R., Wirz, D., & Minonne, C. (2018). Digital maturity variables and their impact on the enterprise architecture layers. *Problems and Perspectives in Management, 16*(4), 141-154. doi:10.21511/ppm.16(4).2018.13

Strycekova, I. (2011). Approaches towards airport economic performance. *Transport Problems*, 111-118.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2*, 53-55.

Tsai, W., Hsu, W., & Chou, W. (2011). A gap analysis model for improving airport service quality. *Total Quality Management, 22*(10), 1025–1040.

Valdez-de-Leon, O. (2016). A Digital Maturity Model for Telecommunications Service Providers. *Technology Innovation Management Review, 6*(8), 19-32.

Van Looy, A., De Backer, M., & Poels, G. (2010). Which maturity is being measured? A Classification of Business Process Maturity Models. *Conference on Enterprise Information Systems*, (pp. 7-16).

Van Steenbergen, M., Bos, R., Brinkkemper, S., Van De Weerd, I., & Bekkers, W. (2010). The Design of Focus Area Maturity Models. *Conference enterprise Information Systems*, (pp. 17-19).

Weber, C., Konigsberger, J., Kassner, L., & Mitschang, B. (2017). M2DDM – A Maturity Model for Data-Driven Manufacturing. *Procedia CIRP, 63*, 173-178.

Wilson, C. (2019, August 12). *It's good to talk why collaboration is the name of the game*. Retrieved from African Aerospace: https://www.africanaerospace.aero/it-s-good-to-talk-why-collaboration-is-the-name-of-the-game.html

APPENDIX A: Reviewed Digital Maturity Models

Location	Year	Authors	Article Title	Purpose of study	Method used (Design, Sample and Place)	Maturity Levels	Maturity Model Dimensions	Key Findings
Norway	No Date	Halpern, Budd, Suau-Sanchez, Brathen and Mwesiuomo	Towards Airport 4.0: Airport Digital Maturity and Transformation	To apply the concept of maturity models to digital transformation of airports	Literature review of maturity models, for application in the airport industry	• 1.0 Analogue • 2.0 Digitising • 3.0 Digitalising • 4.0 Transformed	Not available	Conceptual framework for airport Digital Maturity model has been developed
Munich	2016	Chanias and Hess	How digital are we? Maturity models for the assessment of a company's status in digital transformation	To show a broad range of Digital Maturity models and to evaluate the overall potential for approximating a company's digital transformation status	Literature review comprising 35 models in total out of which 20 were shortlisted, against defined design parameters	Maturity level scoring process not detailed MIT Center for Digital Business and Capgemini Consulting • Digital Intensity • Transformation Management Intensity IWI-HSG and Crosswalk • Level 1: Testing • Level 2: Establishing • Level 3: Consolidating	Maturity level scoring process not detailed MIT Centre for Digital Business and Capgemini Consulting • Fashionistas • Digiratis • Beginners • Conservatives IWI-HSG and Crosswalk • Customer Experience • Product Innovation • Strategy • Organisation	Maturity models differ in content and methodology. The study argues that these models apply vague general classifications of maturity are somewhat vague. Some models focus only on the technology side, and they use complex mathematical computation for determining scores, which is questionable

Location	Year	Authors	Article Title	Purpose of study	Method used (Design, Sample and Place)	Maturity Levels	Maturity Model Dimensions	Key Findings
						• Level 4: Structuring • Level 5: Optimising	• Process Digitisation • Collaboration • ICT Operations and Development • Culture and Expertise • Transformation Management	
Switzerland and Germany	2016	Berghaus and Back	Stages in Digital Business Transformation: Results of an Empirical Maturity Study	To derive typical stages in a digital transformation process from empirical data, to determine how organisations prioritise different courses of action	Sixty items of Digital Maturity were presented in an online questionnaire. Rasch-algorithm and cluster analysis were used to analyse the data. Internal dimension consistency tested using Cronbach's alpha. Mean achievement was used to determine the level of difficulty of	Maturity level scoring process qualitatively determined and allows for quantitative scoring via 3rd Party consulting firm and JMetrik software • Level 1: Promote and Support • Level 2: Create and Build • Level 3: Commit to transform • Level 4: User-centered and elaborated processes	• Customer experience • Product innovation • Strategy • Organisation • Process digitisation • Collaboration • Information technology • Culture and expertise • Transformation management	While digital affinity and experimenting with technology are prevalent, a strategically planned transformation and use of data analytics to improve customer experience is less prevalent

Location	Year	Authors	Article Title	Purpose of study	Method used (Design, Sample and Place)	Maturity Levels	Maturity Model Dimensions	Key Findings
					achieving dimension.	• Level 5: Data-driven enterprise		
Austria	2016	Schumacher, Erol and Sihn	A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises	To propose an empirically grounded model and its implementation to assess the maturity of enterprises in discrete manufacturing	Three-step model development of maturity model involving semi-structured interviews, literature review and definition of maturity items, levels and characteristics. This resulted in 62 items across 9 dimensions. Maturity level determined using the weighted average of maturity items within its dimension	Maturity level scoring process qualitatively determined and allows for quantitative scoring via software tool Level 1: Not distinct to Level 5: Very distinct	• Strategy • Leadership • Governance • Culture • People • Products • Customers • Operations • Technology	To enable assessment of all 5 levels of maturity, relative understanding is required. Strategy dimension scored the lowest, whereas the Products dimension scored highest.

Location	Year	Authors	Article Title	Purpose of study	Method used (Design, Sample and Place)	Maturity Levels	Maturity Model Dimensions	Key Findings
Spain	2016	Ganzarain and Errasti	Three Stage Maturity Model in SME's towards Industry 4.0	Suggestion of a stage process model to guide organisations identify opportunities for diversification within Industry 4.0	Three-stage process model	Maturity level scoring process qualitatively determined • Level 1: Initial • Level 2: Managed • Level 3: Defined • Level 4: Transform • Level 5: Detailed Business Model	• Envision • Enable • Enact	Few companies use a holistic Industry 4.0 methodology, and there Is a need for guided support Industry 4.0 strategies, vision and project planning
Canada	2016	Valdez-de-Leon	A Digital Maturity Model for Telecommunications Service Providers	To develop a Digital Maturity model to help Telecommunication companies embark on their transformation journeys	Three-stage approach applying the Delphi method to maturity model development	Maturity level scoring process qualitatively determined and allows for quantitative scoring • Level 1: Initiating • Level 2: Enabling • Level 3: Integrating • Level 4: Optimising • Level 5: Pioneering	• Strategy • Organisation • Customer • Ecosystem/Value chain • Operations • Technology • Innovation	The Ecosystem and Innovation dimensions came out as essential but their contribution to achieving digital transformation were shown as having been underestimated
Germany	2017	Remane, Hanelt, Wiesboeck and Kolbez	Digital Maturity in traditional industries – An exploratory analysis	To propose two scales for describing organisational maturity (a more accurate description of a	Literature review and analysis of digital transformation survey data	Maturity level scoring process quantitively determined Five (5) clusters	• Digital Impact • Digital Readiness	Derivation of a classification scheme for Digital Maturity archetypes and calculation of Digital Maturity clusters

Location	Year	Authors	Article Title	Purpose of study	Method used (Design, Sample and Place)	Maturity Levels	Maturity Model Dimensions	Key Findings
				firm's maturity level) and to demonstrate the usefulness of these scales through derivation of maturity clusters				
Germany	2017	Klotzer and Pflaum	Toward the Development of a Maturity Model for Digitalization within the Manufacturing Industry's Supply Chain	Development of a maturity model for digital transformation within the Manufacturing industry's supply chain	Grounded theory research coupled with in-depth interviews for maturity model development	Maturity level scoring process qualitatively determined (Radar diagram) • Digital Awareness • Smart networked products • Service-oriented enterprise • Thinking in service systems • Data-driven enterprise	Smart product realisation (external and customer-centric) and Smart product application (internal and organisation-centric) • Strategy Development • Offering to the customer • "Smart" product • Complementary IT system • Cooperation • Structural organisation • Process organisation	Dimensions and maturity levels of the developed maturity model display granularity of the digital transformation model. The two perspectives of maturity enable leaders within organisations to identify focus areas specific to their organisations and benchmark internally and externally.

Location	Year	Authors	Article Title	Purpose of study	Method used (Design, Sample and Place)	Maturity Levels	Maturity Model Dimensions	Key Findings
							• Competencies • Innovation culture	
Germany	2017	Schuh, Anderl, Gausemeier, Hompel and Wahlster (Acatech Study)	Industrie 4.0 Maturity Index: Managing the Digital Transformation of Companies	To provide a means of determining a company's' current Digital Maturity status, to identify concrete actions to achieve higher maturity	Case studies and workshops were used to analyse real-life examples of how organisations have undertaken digital transformation	Maturity level scoring process qualitatively determined (Radar diagram) Six (6) Stages	• Organisational Structure • Culture • Resources • Information Systems	Companies need to transform their Organisational structure and culture to become a learning and agile organisation to enable tailored digital transformation
Germany	2017	Weber, Konigsberger, Kassner and Mitschang	M2DDM – A Maturity Model for Data-Driven Manufacturing	To develop a maturity model for IT architectures for data-driven manufacturing	Literature review	Maturity level scoring process unavailable • Level 0: Non-existent IT integration • Level 1: Data and System integration • Level 2: Integration of cross-life-cycle data • Level 3: Service-orientation • Level 4: Digital	Not available	Advanced analytics and edge analytics allow for self-learning in manufacturing to create smart factories and should be integrated with the digital twin platform

Location	Year	Authors	Article Title	Purpose of study	Method used (Design, Sample and Place)	Maturity Levels	Maturity Model Dimensions	Key Findings
						Twin • Level 5: Self-optimising factory		
Global	2017	Airports Council International	Airport Digital Transformation: Best Practice	Present a framework to guide leadership at airports in digitally transforming		• Level 1: Non-Operational deployment • Level 2: Limited rollout (Digitally enabled) • Level 3: Full-scale deployment (Full Digital) • Level 4: Rolled out (NextGen Digital)	• Infrastructure • Open Data • Personalised Passenger Experience • Biometrics and Digital Touchpoints • IoT, Virtual control room and Operational efficiency • Digital Transformation and Innovations • Internal Digital Transformation Activities	Digital Transformation Best Practice and survey have been developed to assist airports understand their digital requirements and plans

Location	Year	Authors	Article Title	Purpose of study	Method used (Design, Sample and Place)	Maturity Levels	Maturity Model Dimensions	Key Findings
Turkey	2018	Gokalp, Sener and Eren	Development of an Assessment Model for Industry 4.0: Industry 4.0-MM	To determine the extent to which current Digital Maturity models accurately measure maturity for adoption of Industry 4.0	Systemic literature review	Maturity level scoring process qualitatively explained • Level 0: Incomplete • Level 1: Performed • Level 2: Managed • Level 3: Established • Level 4: Predictable • Level 5: Optimising	• Asset Management • Data Governance • Application Management • Process Transformation • Organisational Alignment	None of the reviewed Digital Maturity model satisfy the defined criterion; thus a SPICE-based Digital Maturity model is developed
Germany	2018	Issa, Hatiboglu, Bildstein and Bauernhansl	Industrie 4.0 roadmap: Framework for digital transformation based on the concepts of capability maturity and alignment	To introduce a framework to guide and assist organisations with the implementation of Industry 4.0	Literature review and empirical validation case study	Maturity level scoring process not explained • Level 1: No Industry 4.0 or only “ad-hoc.” • Level 2: Departmental level • Level 3: Organisational level • Level 4: Inter-organisational level	• Technology • Organisation • Process	Outcomes of the digital assessment were aligned with the organisations’ perspective of required digital transformation activities. Another outcome was that the maturity level score was of little significance to the SME’s as they were more interested in what their focus area should be
Austria	2019	Schumacher, Nemeth and Sihn	Road-mapping towards industrial organisation	To provide an approach to realising Industry	Expert interviews and literature	Maturity level scoring process quantitively	• Technology • Products • Customers and	A systemic model is developed to guide the journey from initiation to

Location	Year	Authors	Article Title	Purpose of study	Method used (Design, Sample and Place)	Maturity Levels	Maturity Model Dimensions	Key Findings
			digitalisation based on an Industry 4.0 maturity model for manufacturing enterprises	4.0 benefits and overcome the challenges of digitally transforming	review	determined with Tableau software • Level 1 - Lowest • Level 2 • Level 3 • Level 4 – Highest	Partners • Value Creation processes • Data and Information • Corporate Standards • Employees • Strategy and Leadership	realisation of Industry 4.0 action items

APPENDIX B: Participant Information Sheet

Good day

My name is Tshego Mosehlane, and I am a Masters student in Digital Business at the University of the Witwatersrand, Johannesburg. As part of my studies, I am investigating the Digital Maturity of African airports. This research project aims to find out the extent of Digital Maturity at African airports, and its relationship to airport performance indicators, i.e. revenue growth, passenger growth and Airport Service Quality score.

As part of this project, you are invited to take part in this survey. This activity will take approximately 15minutes to complete. Your participation in the survey will be regarded as consent for the use of the data you provide. The first part of the survey explores the level of Digital Maturity, and the second part explores airport performance.

You will not receive any direct benefits from participating in this research, and there are no disadvantages or penalties for not participating. You may withdraw at any time or not answer any question if you do not want to. The survey will be completely confidential, and your input will be held securely and not disclosed to anyone else.

Responses to the survey will be analysed at the airport level using a pseudonym (fictitious name) to represent participating airports in the final research report.

If you have any questions during or afterwards regarding this research, feel free to contact myself or my supervisor on the details listed below. Should you wish to receive a summary of this report, include your email at the end of the survey.

If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee, telephone +27(0) 11 717 1408, email Shaun.Schoeman@wits.ac.za

Yours sincerely,

Tshego Mosehlane
Researcher: Tshego Mosehlane, 313954@students.wits.ac.za, +27(0) 83 985 1128
Supervisor: Dr J Vermooten, joachimvermooten@gmail.com, +27(0) 83 468 2111

APPENDIX C: Survey Questionnaire

Q1 **Airport Name -** Select your airport from the below options

---

Q2 **Division/Department -** Select the option that best describes your department within the airport

- Operations
- Commercial
- Information Technology
- Human Resources
- Other (please indicate) _____

Q3 **Position/Role -** Select the option that best describes your position/level within the airport

- Executive
- Senior Management
- Middle Management
- Supervisory
- General Worker
- Other (please indicate) _____

Q4 **Organisational Culture -** Describe the extent to which you agree with the below statements as they relate to the organisational culture at your airport

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Employees within the organisation have a digitally conscious culture, are willing to take risks and there is "no blame" culture	○	○	○	○	○
There is seamless employee level interaction, networking and knowledge-sharing	○	○	○	○	○
The organisation has a platform for employees to contribute innovative ideas and has a conducive environment for innovation	○	○	○	○	○
Culture of innovation entrenched across all parts of the organisation	○	○	○	○	○
Digital initiatives incorporate employees from different parts of the organisation	○	○	○	○	○
The organisation employs technology and digital innovation to current service/product offerings	○	○	○	○	○
Employees work in an autonomous way and work arrangements have been reorganised to enable agile ways of work	○	○	○	○	○
Organisation supports innovation through the use of Agile methodologies and frameworks i.e. SCRUM, Kanban, Lean etc.	○	○	○	○	○
Data analytics underpin innovation processes	○	○	○	○	○

Q5 **Strategy** - Rate the extent of implementation of the below digital strategy elements within your airport

	Definitely not	Probably not	Might or might not	Probably yes	Definitely yes
The organisation has articulated a need for digital transformation	○	○	○	○	○
The company displays a high level of readiness for digital transformation	○	○	○	○	○
There is clear alignment between company strategy and digital strategy	○	○	○	○	○
Internal requirements for sustainable digital transformation have been defined	○	○	○	○	○
Key resources and assets that will be part of the digital ecosystem have been identified	○	○	○	○	○
Roles and responsibilities to deliver on digital initiatives are widely distributed across the company	○	○	○	○	○
The digital strategy is not only focusing on technology advancement, but encompasses people, process and technology	○	○	○	○	○
Financial investments in digital initiatives/technologies are guided by the digital strategy	○	○	○	○	○
The organisation has defined digital transformation goals and continuously measures progress against goals	○	○	○	○	○
The organisation is realising a return on investment (ROI) as a result of implementing the digital strategy	○	○	○	○	○
Digital strategy is widely shared with all stakeholders including industry partners	○	○	○	○	○

Q6 **Organisation & Governance -** Select the statement that best describe your organisational structure

1. The organisation has a hierarchical structure with rigid governance structures and decision-making processes
2. The organisation has plans to review parts of the organisation structure to enable "agile ways of work"
3. Certain departments in the organisation have agile organisational structures that enable digital transformation
4. The entire organisation has adopted agile organisational structures and data driven decision making processes
5. The organisation continuously adapts its agile organisational structure to enable digital transformation and employs data driven processes

Q7 **Organisation & Governance -** Describe the extent to which you agree with the below statements as they relate to management of digital transformation within your organisation

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Clearly defined governance processes for management of the digital transformation and supporting initiatives	○	○	○	○	○
Management displays commitment and responsibility for the digital transformation journey	○	○	○	○	○
There is central coordination of digital activities	○	○	○	○	○
Policies are adapted to align to the digital strategy	○	○	○	○	○
There is company-wide communication regarding digital initiatives the organisation is undertaking	○	○	○	○	○
Digital is not confined to a single team, but is inherent in all departmental strategies	○	○	○	○	○

Q8 **Leadership & People -** Rate the below statements as they relate to your airports' approach to leadership and people practices

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Leadership support and ownership for the digital transformation is highly visible in every department	○	○	○	○	○
Organisational leaders are pioneers and viewed as subject matter experts in the field of digital transformation within the airport industry	○	○	○	○	○
The organisation has begun to identify roles that will be impacted and introduced as a result of digital transformation	○	○	○	○	○
The organisation has identified digital competency and capability gaps within the current workforce	○	○	○	○	○
Line managers have been up skilled on digital skills and use of emerging technologies	○	○	○	○	○
The organisation has implemented a formal program for re-skilling and up-skilling its employees in preparation for the future of work	○	○	○	○	○
Employees have an affinity to, and are familiar with digital technologies	○	○	○	○	○
Digital competencies are an important criterion in recruitment	○	○	○	○	○
There are intentional and targeted investments in acquiring or outsourcing employees with digital skills	○	○	○	○	○
Employees display the required organisational behaviours to enable digital transformation	○	○	○	○	○
Employees are measured on clear KPIs (key performance indicators) that are aligned to the digital strategy	○	○	○	○	○
Company rewards and compensation is aligned to the company digital strategy	○	○	○	○	○

Q9 **Process Management -** Rate the management of business processes as it pertains to your airport

	Below average		Average		Above average	
	0	1	2	3	4	5
There is end-to-end process automation for real-time data flow, decision making and planning						
Business processes are updated and continually introduced based on data and analytics						
Business process modelling is a standardised agile process						
There is end-to-end visibility of all business processes						
Continuous process improvement to achieve efficiencies and cost reduction						
Development of new processes to foster digital innovation						
Quality control is automated						

Q10 **Customer -** Describe the extent to which you agree with the below statements as it relates to customer experience within your airport

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The organisation enables the customer to shape their own journey through self-service technology i.e. self-check-in, baggage drop-off, biometrics	○	○	○	○	○
The organisation has implemented customer engagement tools to support the customer journey	○	○	○	○	○
Insights and data derived from customer interaction is used to improve the customer journey e.g. offering value-added	○	○	○	○	○

services based on customer data					
The organisation adapts to customer behaviour and expectations through various strategies e.g. dynamic pricing	○	○	○	○	○
The organisation offers customisation through personalised customer communication and interaction	○	○	○	○	○
The organisation adapts content to individual users e.g. delivery of location and context-aware communication	○	○	○	○	○
Customer interaction is enabled via digital channels	○	○	○	○	○
The organisation uses analytics to improve the customer experience	○	○	○	○	○
Customer experience is proactive and utilises behavioural economics e.g. automated nudges	○	○	○	○	○
Customer data is acted upon in real time, to support data-driven decision making	○	○	○	○	○
Organisation integrates all customer information into one platform creating 360 views to be used to enhance and personalise the customer experience	○	○	○	○	○

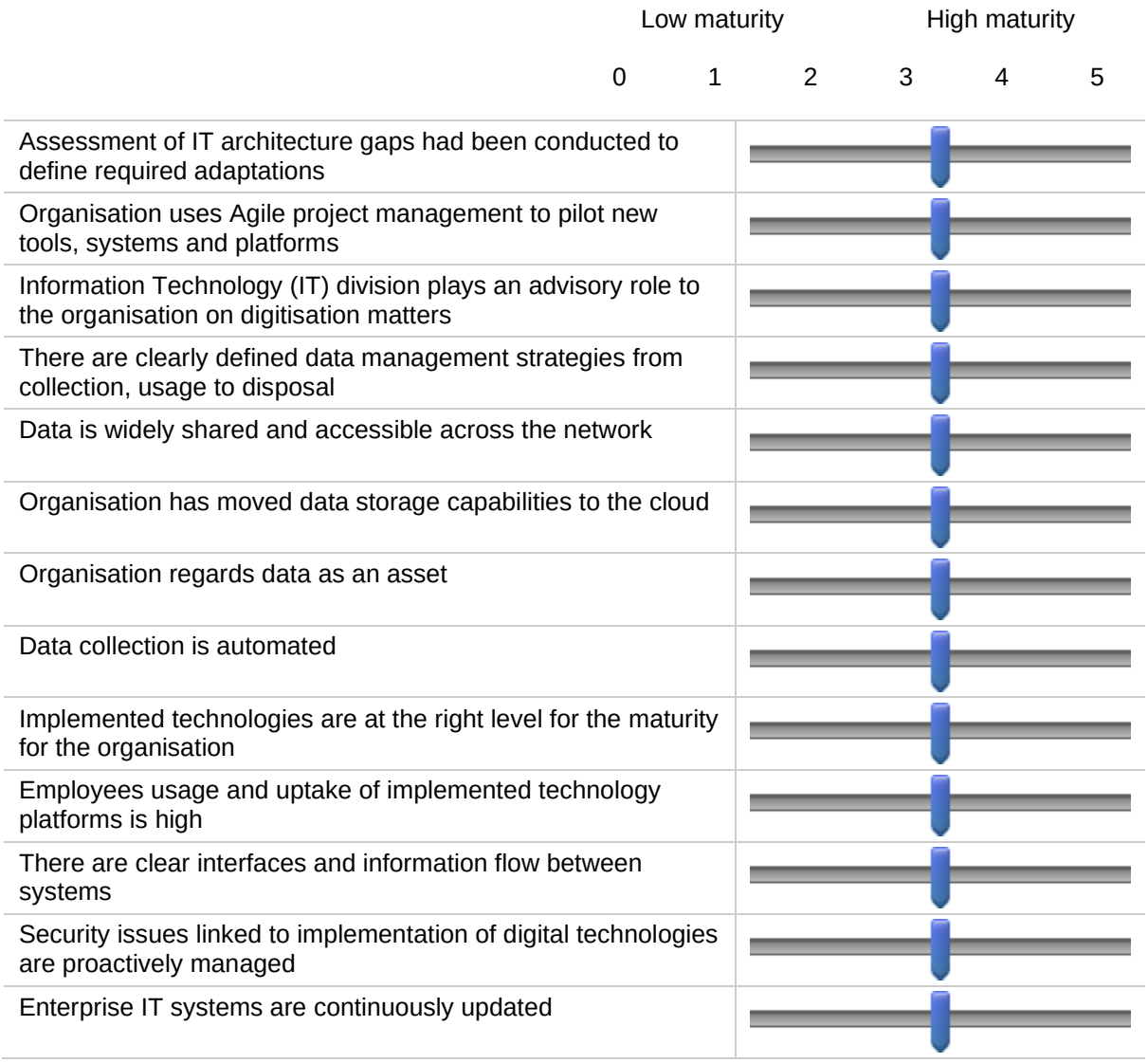
Q11 **Customer -** Which statement best describes your airports' management of customer channels?

1. Organisation does not collect customer data across any of its channels. Customer experience across the various channels is inconsistent
2. Organisation has a plan in place to begin collecting data across its various channels. Customer experience is consistent across some of the channels
3. Organisation collects customer insights and data across some of the channels and customer experience is consistent across most of the channels
4. Organisation collects data across all their customer channels and the customer experience is consistent across all channels
5. Organisation integrates cross-channel data and insights onto one channel (omni-channel) to enable a personalised customer experience. Customer experience is consistent across all channels

Q12 **Customer -** Which statement best describes your airports' digital services maturity?

1. No plans to develop and implement new digital services
2. Plans are in place to develop new digital services
3. New digital services have been developed and are in the process of being introduced to the market
4. New digital services are being made available to customers and are contributing to revenue generation
5. Machine learning or other digital technologies are used to identify customer behaviours to develop services entirely new to the industry - enabling new business models e.g. For generation of non-aeronautical revenue. Digital services contribute to a significant portion of revenue

Q13 **Technology & Data -** Rate your airports maturity as it pertains to management of technology and data.



Q14 **Technology & Data -** Which statement best reflects the implementation of emerging technologies within your airport? i.e. machine learning, Internet of things, big data, augmented reality and robotics

1. Organisation has not identified the need to implement emerging technologies
2. Organisation is exploring the use of emerging technologies
3. Organisation has put infrastructure in place to accommodate implementation of emerging technologies
4. Usage and implementation of emerging technologies is becoming a norm in the organisation
5. Emerging technologies are used widely across the organisation

Q15 If you would like to receive the outcomes of the research please indicate your email address.