

An assessment of South African airlines' growth in the era of Fourth Industrial Revolution technologies: the unexplored dimension

South African airlines' growth

19

Received 12 July 2022
Revised 17 September 2022
2 December 2022
Accepted 25 February 2023

Clinton Ohis Aigbavboa

*SARChI in Construction Management and Leadership in the Built Environment,
Faculty of Engineering and the Built Environment,
University of Johannesburg, Auckland Park, South Africa*

Andrew Ebekoziem

*SARChI in Construction Management and Leadership in the Built Environment,
Faculty of Engineering and the Built Environment,
University of Johannesburg, Auckland Park, South Africa;
Department of Quantity Surveying, Auchu Polytechnic, Auchu, Nigeria and
School of Sciences, Universiti Sains Malaysia, George Town, Malaysia, and*

Nompumelelo Mkhize

*SARChI in Construction Management and Leadership in the Built Environment,
Faculty of Engineering and the Built Environment,
University of Johannesburg, Auckland Park, South Africa*

Abstract

Purpose – Aerospace is a demanding technological and industrial sector. Several regulations and policies via innovative digital transformation have been integrated to impact production systems and supply chains, including safety measures. Studies demonstrated that the Fourth Industrial Revolution (4IR) technologies could enhance productivity growth and safety measures. The 4IR role in influencing airlines' growth is yet to receive in-depth studies in South Africa. Thus, this study aims to investigate the role of 4IR technologies in influencing airlines' growth in South Africa.

Design/methodology/approach – This research used a qualitative research method. Primary data were compiled via 56 face-to-face semi-structured interviews with major stakeholders. The study achieved saturation. A thematic method was used to analyse the collected data.

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Special thanks to the participants for providing knowledgeable contributions to enhance the findings of this paper. Also, the authors appreciate the comments, suggestions, and recommendations provided by the anonymous reviewers, which collectively helped hone and strengthen the quality of this manuscript during the blind peer-review process.

Funding: Faculty of Engineering and the Built Environment and CIDB Centre of Excellence (05-35-061890), University of Johannesburg, South Africa.



Journal of Facilities Management
Vol. 23 No. 1, 2025
pp. 19-33
Emerald Publishing Limited
1472-5967
DOI 10.1108/JFM-07-2022-0076

Findings – Findings reveal the nine major factors influencing South African airlines' growth in the 4IR era. This includes investment in ergonomics applications and research, governance is driven by 4IR, collaboration and incorporation of 4IR concepts, partnership with drone technology and high precision and efficiency with 4IR. Others are reskilling and upskilling, investment in 4IR software, policies to promote 4IR usage in the industry and policies to reduce human interface.

Originality/value – Understanding the relative significance of 4IR technologies' role in airlines' growth can assist critical stakeholders in promoting innovative policies and regulations tailored towards digitalised aerospace. Thus, the study contributes to strategies to improve digital innovation, airline growth and safety as components of the air travel demands in South Africa.

Keywords Aerospace, Airline, Digital technology, Fourth Industrial Revolution, South Africa

Paper type Research paper

1. Introduction

The airline sector is part of the transportation system. The 21st-century airline sector has provided its customers with large-scale comfort and safety aspects to their customers (Wu and Liao, 2014). Hawkins and Orlady (2017) affirmed that in the latter half of the 20th century, the reliability and safety of air transport improved. This is evidence of the increase in the volume of traffic. Aviation plays a critical role in developing the economy in most countries, including South Africa (De Gove, 2019). However, despite the success of civil aviation, there have been concerns about aerospace technology development, especially in African countries. The International Air Transport Association (IATA) (2014) projected that the African airline sector will continue to increase in commuter numbers at an annual average rate of 4.7% by 2034. It will be faster than regional markets in Europe and North America, whose growth is 2.7% and 3.3%, respectively. There is an increase in national carriers such as Ethiopian Airlines, Kenya Airlines and South African Airlines (Paolo and Vilakazi, 2016). To meet this demand, innovative technology may play a critical role. The Fourth Industrial Revolution (4IR) technologies intend to enhance the vanguard for innovative digitalisation in the aviation sector to succeed. This is one of the study's motivations. Chen and Chen (2012) and Liou (2012) affirmed that technological advancement and sophisticated equipment have made the airline industry capital-intensive.

The 4IR technologies are driving changes in every system (economic, political, social and environmental) across the globe. The South African Presidential Commission on the 4IR (PC4IR, 2020) described it as “*an era where people are using smart, connected and converged cyber, physical and biological systems, and smart business models to define and reshape the social, economic and political spheres*” (p. 25). Alexander (2021) asserted that countries' abilities to adapt digital innovation and systems would influence the nations' future development and growth. The businesses' capacity to adapt and create digital innovation and mechanisms can be regarded as being influenced by the attributes of national innovation systems (Alexander, 2021). Ebekozi and Aigbavboa (2021) avowed that 4IR technologies could improve urban public services. This includes road construction, housing provision, telecommunications, etc. Advanced digital technology is a revolution branded by a fusion of technologies. They are “*blurring the lines between the physical, digital, and biological spheres*” (Schwab, 2016, p. 1). Aerospace is one demanding technological and industrial sector. Several regulations and policies via innovative digital transformation have been integrated to impact production systems and supply chains, including safety measures.

In South Africa's context, the 4IR may enhance the airlines' production systems, supply chains and safety measures via digital transformation to mitigate possible challenges. The 4IR role in influencing airlines' growth is yet to receive in-depth studies in South Africa. This is a knowledge gap because the desired study's findings are absent. It is one of the

study's motivations. Besides a few studies either addressed airline issues (Barros and Wanke, 2015; Bourguignon and Darpeix, 2016; Paelo and Vilakazi, 2016; De Gove, 2019; Babatunde, 2020; Nyatumba, 2021) or 4IR issues (Alexander, 2021; Mhlanga *et al.*, 2021), not from the perspective of key participants via a qualitative approach as adopted in this study. Barros and Wanke (2015) used the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) to rank the finite set of units based on the minimisation of distance and evaluate the relative efficiency of African airlines with a focus on South Africa. Babatunde (2020) affirmed that inadequate infrastructure, including airports, has hampered Africa's economic growth. Nyatumba (2021) focused on selected African airlines and their corporate turnaround strategies implementation. Thus, this study will fill the existing methodological and population gaps. Also, apart from contributing to the existing knowledge emphasising airlines growth, the study will fill the literature gap regarding 4IR role in influencing airlines' growth in South Africa. This intends to promote policy reforms tailored towards best global practices and sustainable airlines growth in a developing setting like South Africa. Thus, the study seeks to investigate the role of 4IR technologies in influencing airlines' growth in South Africa through the following objectives:

- to examine the factors influencing airlines' growth in South Africa; and
- to investigate the factors influencing South African airlines' growth in the era of 4IR technologies.

2. Literature review

2.1 Airlines growth

The aerospace sector is one industry that involves the application of scientific disciplines. The technological advancement in aerospace is fast and stands as the vanguard of recent industrial and societal developments. The airline sector exists in a competitive market. About 1,300 airlines linking not less than 3,600 airports (in Gudmundsson and Rhoades's study, as cited in Hamad *et al.*, 2021). Air transport development is a factor and a pointer to economic growth, especially with the rapid population in Latin America, the Middle East, Asia and Sub-Saharan Africa (Bowen, 2013). IATA (2019) reported that airlines require 40,000 new aircraft over the next two decades, valued at US\$7tn. This implies that the sector needs to be regularly profitable. The aviation sector is not exempted from challenges. It is a factor of progress as it simplifies transportation within extended nations. A flourishing aviation sector represents development. This is because its volume depends on the level of economic activity and the prosperity of the people. Also, it is an indicator of the shape of economic growth, especially for developing countries. The IMF (2012) affirmed that developing countries represent 85.1% of the global population and account for 48.9% of GDP. Dobbs *et al.* (2015) and Upadhaya *et al.* (2018) asserted that developing countries are fast-growing, contrasted to their advanced counterparts. Many investors see developing countries as strong growth engines. This is one reason foreign investors are investing in these countries. Bourguignon and Darpeix (2016) avowed a dynamic connection between economic growth and air transport demand. It implies that increased air transport demand will significantly lead to economic growth. Van De Vijver *et al.* (2014) opined that aviation transport development might influence economic growth via various routes and promote investments in innovative infrastructure. Ozcan (2013) asserted that aviation transport contributes to employment opportunities generation and increased household incomes. Bowen (2013) found that the continued expansion of the airlines industry will mitigate the intimidating encumbrances open up new prospects for developing countries in today's aviation industry.

Patel (2014) opined that Africa is the least connected continent, as evidenced by the 2012 National Aeronautics and Space Administration (NASA) satellite image of the earth. Thus, weak

infrastructure has contributed to the fate of Africa's economic growth (Babatunde, 2020). The airline industry is one of the drivers of economic and social progress (ATAG, 2016). PwC (2011) claimed that airline firms have one of the major stakeholder alliances compared to other sectors. ATAG (2016) found that apart from 54% of foreign tourists travelling by air, the sector creates 62.7 million jobs globally and contributes 3.5% to the world's GDP. IATA (2016) reported that world expansion of air travel has averaged around 5% annually for the past 30 years. The role of the aviation industry is significant, especially in the context of countries such as South Africa (Paelo and Vilakazi, 2016). In South Africa, the national carrier [South African Airways (SAA)] operated from 1934 to 1990, following domestic market liberalisation and deregulated in the early-1990s (Goldstein, 1999). Barros and Wanke (2015) discovered network size-related and economies of scope as the most significant variables for explaining levels of efficiency in the African airline industry. Oosthuizen (2013) found that most new airlines had difficulty contending with SAA. SAA, at that point, held at least 95% of the market share. This was a threat to others to survive in the industry. After deregulation, the first airline to enter the market was Flitestar (Goldstein, 1999). Table 1 presents a summarised history of major airlines in South Africa, landmark events and the year.

2.2 Fourth Industrial Revolution technologies background

This sub-section presents a brief background from the First Industrial Revolution to the 4IR. The first IR was driven by steam power and water to automate production around 1760 (the end of 18th century) (Schwab, 2017). The second IR used electric energy to generate mass production around 1890. The third IR used information technology and electronics to mechanise mass production around 1960s. It gave rise to semi-conductors and the spread of computers and the internet. The 4IR builds on the third IR via an advanced digital revolution (Ebekozien *et al.*, 2021). The process from the 3IR to the 4IR has been taking place since the mid-last century (Schwab, 2017). The 4IR is characterised by a fusion of advanced technologies blurring the lines between digital, physical and biological spheres. Schwab (2017) identified three features that stand this 4IR out as not just an advancement of the third IR. This includes velocity, scope and systems impact. The current trend of daily breakthroughs has no historical pattern. People's potentials linked by mobile gadgets, with extraordinary processing power, access to knowledge and storage capacity, are limitless. This is one aspect of the 4IR technologies. Others are artificial intelligence, robotics, the internet of things (IOT), digital fabrication technologies, autonomous vehicles, 3D printing, materials science, big data, simulation model, energy storage and quantum computing (Ebekozien and Aigbavboa, 2021). With artificial intelligence, self-driving cars, drones were developed (Schwab, 2017).

2.3 Fourth Industrial Revolution technologies' role in airlines' growth

Across all sectors, there is evidence that advanced digital technologies that reinforce the 4IR influence businesses across the supply chains (Oesterreich and Teuteberg, 2016; Schwab, 2016, 2017; Ebekozien and Aigbavboa, 2021). Many sectors, including the airline sector, view the introduction of advanced technologies that develop innovative approaches to serving current needs and substantially disrupt the present sector value chains (Schwab, 2017). Disruption flow from agile, advanced technologies, improving speed, quality or price at which value is delivered. Schwab (2017) affirmed that the technology lowers the barriers for businesses, including airline companies and individuals, to generate wealth, altering staffers' personal and professional environments. Organisational forms, customer expectations, product enhancement and collaborative innovation were identified as the major impact of 4IR on business. Ebekozien and Aigbavboa (2021) found that physical products and services may be improved with digital facilities that enhance their value. It makes assets more stable and resilient.

Year	Event
1934	SAA was established
1949	Comair was established as a private airline
1978	Link Airways began operations (later known as SA Airlink) in 1978 (secondary routes)
1979	Bop Air began operations (later known as Sun Air)
1990	The industry was deregulated, but the private sector allowed a one year grace period to prepare itself before re-entering international routes
1991	Flitestar was the first airline to enter after deregulation
1992	Comair began operating the main domestic routes starting with Johannesburg-Cape Town. SA Airlink started operations in 1992, following the collapse of an alliance between Magnum Airlines, Border Air and City Air, operating as Link Airways, due to financial problems
1993	SA Airlink formed an alliance with SAA
1994	Flitestar ceased business in April when it went bankrupt Phoenix Air began operations in December 1994 and focused on Johannesburg, Durban and Cape Town routes SA Airlink formed an alliance with SA Express
1995	Phoenix Air ceased operations due to failure to pay its debts Nationwide Airlines was established
1996	Comair entered into a franchise agreement with British Airways (18% shareholding) Sun Air enters the market
1998	Interlink Airlines began operations
1999	Sun Air ceased operations when taken over by SAA
2001	Kulula, a subsidiary of Comair, entered the market as the first LCC
2002	Intensive Air went bankrupt and ceased operations
2004	I Time entered the industry
2006	Mango, a subsidiary of SAA, entered the market as a low-cost carrier
2008	Nationwide ceased operations due to bankruptcy
2010	Interlink Airlines went into liquidation and ceased operations
2011	Velvet Sky entered the market in October on the Johannesburg-Cape Town route Santaco Airlines launched with a publicity flight but failed to commence commercial flights
2012	Velvet Sky ceased operations due to failure to repay its debts I Time ceased operations when it went bankrupt
2013	CemAir launches full-service domestic scheduled flights (mainly to smaller towns and cities in RSA)
2014	FlySafair began operations
2015	Skywise, Fly Go Air, and Fly Blue Crane began operations

Sources: Modified from [Paelo and Vilakazi \(2016\)](#) and [Aigbavboa et al. \(2023\)](#)

Table 1.
A summarised
history of major
airlines in South
Africa

The 4IR technologies may enhance the airlines' growth because of the constant advancements in aircraft, internet, communication satellites and worldwide positioning systems ([Deloitte, 2012](#); [Sanjog et al., 2015](#)). The 4IR technologies may enhance efficiency augmentation in aviation industries via adopting ergonomics systems. [IEA \(2000\)](#) described ergonomics as the scientific discipline about the interaction among human beings and other elements of a system, data and the method to design to optimise performance. [Chaffin \(2005\)](#) avowed that simulations developed via a digital human model (DHM) and digital mock-up are more economical than the conventional ergonomic process. Also, a human being's complex physical, cognitive aspects can be developed and represented via DHM, known as three-dimensional (3D) ([Sanjog et al., 2015](#)). [Li \(2009\)](#) opined that DHM enables the inclusion of human considerations in engineering decisions. The model is an inevitable tool for remote and unsafe environments where testing with living humans is unsafe and wrong. The model is an advanced technology for ergonomic assessment of products or workstations in the

virtual environment and is on the verge of developing an integral part of computer-aided engineering and ergonomics. This strengthens the reason for the study.

However, statistics from the NASA showed that 70% of aviation crashes could be due to the ineffective performance of human beings (Zheng and Fu, 2011). This is of great concern to the stakeholders. Thus, it signifies the need to integrate digital innovation to mitigate these human factors in the airlines sector from the viewpoint of engineering design. Berninger (1991) affirmed that aviation's human error is the main cause of about two-thirds of airplane crashes. This is a threat to the airline industry if not checked in this era of advanced technology. Studies revealed that the possibility of mistakes, distress and fatigue is high, though pilots can cope with physically conflicting design (Chang and Wong, 2012). Also, the role of social media in airlines' growth may be pertinent. Social media is a group of internet-based applications that builds on the technological ideology of Web 2.0 to allow the exchange of user-generated content (Kaplan and Haenlein, 2010). This includes blogs, microblogs such as Twitter, media-sharing sites (YouTube), social networking sites (Facebook) and wikis (Wikitravel) (Zhang, 2011). It is an online platform that allows social interaction. Airline companies could use it to improve two-way communication with their fans and customers and indirectly grow their business (Baghirov *et al.*, 2019). This mechanism is not without challenges, such as internet speed, inadequate infrastructure, digital knowledge and social media usage differences, especially in developing countries (Baghirov *et al.*, 2019).

3. Research method

This study used a qualitative research approach. It is entrenched in interpretivism (Chandra and Shang, 2019). Ebekoziem (2021) affirmed that interpretivism is intuitively a social variable, and the researchers intend to understand the meanings of human actions. This aligned with Upadhaya *et al.* (2018) and Hamad *et al.* (2021). Upadhaya *et al.* (2018) used the same semi-structured interviews supported by relevant documentary evidence to evaluate the social responsibility of the airline industry in Nepal. Hamad *et al.* (2021) conducted interviews with Qatar Airways managers and analysed them to define airline strategies to rebrand globally. The study adopted a phenomenological perspective. Phenomenological derived the meaning of the scenario by interrogating a group of people (Paley, 2016; Ebekoziem *et al.*, 2022). The study's objectives were achieved via the phenomenology approach, an unexplored dimension regarding airlines' growth and 4IR era. The primary data were collected via semi-structured face-to-face interviews. This aligned with Creswell and Creswell (2018). The study use a purposeful sampling technique. Purposeful sampling targets participants who are considered knowledgeable in the subject matter (Ebekoziem, 2020).

Fifty-six face-to-face semi-structured interviews from selected South African Civil Aviation Authority (SACAA) (P1-P2), South African Tourism Industry (SATI) (P3-P4), executives of state-owned airlines (ESOA) (P5-P6) and regular passengers (P7-P56) were engaged, as presented in Table 2. Ethical clearance was approved on 20 February 2021, and

Item	Categorisation of interviewees	Code of interviewees	No. of interviewees
1	South African Civil Aviation Authority	SACAA (P1-P2)	2
2	South African tourism industry	SATI (P3-P4)	2
3	Executives of state-owned-airlines	ESOA (P5-P6)	2
4	Regular passengers (economy)	PASSENGERS (P7-P56)	50
	Total number of interviewees		56

Source: Aigbavboa *et al.* (2023b)

Table 2.
Summary of
interviewees'
description

the interview lasted from March 2021 to May 2021. An average of 45 min were spent on each interview, and saturation was achieved. The interviewees identified though hidden were considered knowledgeable about 4IR technologies and airlines' growth in South Africa. The interviewees' responses were presented in an anonymous form. The interviewees had background knowledge of 4IR technologies and South African airlines.

Concerning the analysed data via a thematic approach, words and sentences were assigned a label to enhance the generation of the study's concepts in line with the stated objectives. Hence, an open coding system of coding was used in the transcription of interview data. Emotion, narrative, *in vivo* and themeing coding techniques were used (Corbin and Strauss, 2015). Sixty-four codes were generated and re-organised based on frequency, occurrence and reference in line with the coding. From the 64 codes, four categories were derived and re-mapped into two themes. The concerns of findings' validity were eased through the triangulation of the data collection approach adopted (Tajeddini and Mueller, 2009).

4. Findings and discussion

This section presents the results and discussion in line with the study's objectives. The growth of the aviation industry is pertinent, knowing that it is a capital-intensive sector. Thus, investigating the role technology can play in growing the sector is germane in the era of advanced digital technology. This is because current literature shows that digitalised technology belongs to the 4IR. As discovered, it works as an end-to-end innovative and digitalised mechanism across the value chain, including the aviation sector.

4.1 Theme 1: factors influencing airlines' growth

Theme 1 proffers answers to the study's objective (to examine the factors influencing growth within the South African airline industry) from the participants' perspective. Participant P1 says, "[...] *the central government must institute a legislative instrument at the governmental level to create a conducive environment for growth [...]*" this is pertinent because a sound legislative structure within the aviation sector will improve and encourage sanity. One of the possible outcomes will be growth within the sector. Findings show that instituting feasible rules at the governmental level would bring growth. Findings agree with Jones *et al.* (2007) and suggest prioritising economic and policy governance via establishing institutions with a strong development state with peace and stage building. Practicable rules create an enabling environment for growth, including in the airline sector. Participants (P8, P17, P34 and P56) suggest that airlines operating within the sector should always introduce innovations that would attract passengers, thereby leading to growth in the airline fraternity. "[...] *novelty in the airline sector influence growth in the South Africa airline industry [...]*" said Participant P2. Findings reveal that novelty in all aspects of an organisation is imperative if growth is maintained. This is because novelty is associated with practical benefits in the context of an organisation. These practical benefits include increased competitiveness, reduced costs and improved productivity. Others are improving the brand, value, profitability, recognition, increased turnover and new partnerships and relationships. Findings agree with Jeevan (2015), and it was found that careful empirical attention is required to understand the drivers of Africa's growth.

Moreover, findings across the board agree that growth within the industry could be influenced when the airlines embark on an aggressive mission to understand their customers' need. This is pertinent, thereby influencing growth within the sector. For growth to be consistent and sustainable, airline operators must comprehend their operating sector (P2, P4 and P5). The national and individual airline operators must understand the sector and its dynamics. This is one of the drivers that can influence growth within the sector. Findings agree with Agenda 2063, where African people, including South Africans, aspire to "a prosperous Africa based on

inclusive growth and sustainable development” (Gowreesunkar, 2019). So, the industry requires a model that will fit the type of passengers the airline intends to fly (P15, P24, P33, P34, P44 and P54). Understanding passengers/customers’ needs is germane for business growth. Participants (P3, P6, P12, P23, P34, P44, P51 and P54) identify the ability of airlines to be prompt regarding scheduled time as one of the drivers of growth. The influence of airline industry growth impacts the national economy with adequate management structures (P1).

Participant P4 says, “[...] *ensuring the airline has attractive flight packages for tourists would bring growth* [...]”. Findings show that attractive packages for such airlines can influence the airlines’ growth. The outcome may influence the value chain of the tourism industry and increase partnerships with airlines (P5, P34 and P45). Growth would be influenced by thorough competition among the sector players (P3, P22, P31 and P45). The degree of competition among the key players will encourage innovation, especially in customer experience. Sustainable regulatory guidelines drive airlines’ growth within the sector (P5, P6 and P29). Findings agree with Gowreesunkar (2019) and IATA (2019). Gowreesunkar (2019) found that African countries need to align their tourism plans with the aspirations projected to attract tourists. IATA (2019) discovered that policy and regulatory environment could either be a key driver of the industry or an impediment if not well evaluated before implementation. Consistent and sustainable tourism via the airline industry’s growth cannot be over-emphasised. In summary, sustainable regulatory guidelines, a legislative instrument to be instituted by the government, airliners innovations, airliners novelty and understanding of customers’ needs emerged as the drivers that can influence airlines growth in South Africa’s aviation sector. Others include airlines operators who should comprehend the sector, airliner prompt in scheduled time, attractive flight packages and competition within the airlines, as presented in Figure 1 and Table 3.

In summary, regarding Objective 1 findings, the emerged factors influencing airlines’ growth in South Africa are sustainable regulatory guidelines, competition within the airline sector, attractive flight packages for tourists (incentives), government needs to institute a legislative instrument and airline operators should comprehend the sector. Others are: airlines always need to introduce innovations, novelty in the airline sector, understand passengers/customers’ needs and airliner prompt in scheduled time.

4.2 Theme 2: drivers influencing South African airlines’ growth in the era of Fourth Industrial Revolution technologies

This sub-section proffers answers to the study’s Objective 2 (factors influencing South African airlines’ growth in the era of 4IR technologies) from the participants’ perspective. Findings show that majority of the factors identified in the previous sub-section can be improved if engaged with 4IR technologies within the airlines’ operations. “[...] *the aviation sector must collaborate and incorporate the concepts of the 4IR in their operations*. [...]” said P1. Findings show that governance is one major challenge relative to the 4IR. Participants P2, P3 and P6 suggest adopting ergonomics principles in the aviation industry. Computer-aided ergonomics through digital human modelling promote 4IR technologies such as simulations using digital mock-up and DHM (Chaffin, 2005). Most people perceive 4IR as the automation of business processes (P23, P33, and P45). Findings agree with Oesterreich and Teuteberg (2016) and discovered that BIM-based platforms and cloud computing could improve collaboration, reduce human interface, reduce production cost and better customers services delivery with real-time schedule (P3, P5 and P39). Some participants, such as P12, P17, P29, P46 and P53, affirm that 4IR may threaten the airline industry by replacing human activities with computerisation systems. To facilitate growth within the airline, one vital concept for the aviation industry is to partner with drone technology, a typical 4IR concept

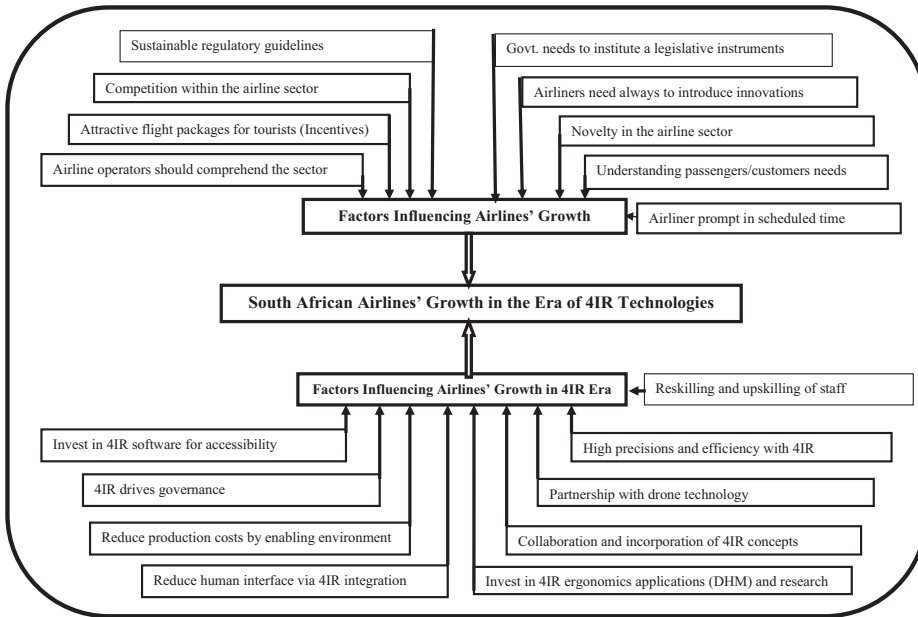


Figure 1. Thematic network of South African airlines' growth in the era of 4IR technologies

Source: Aigbavboa *et al.* (2023b)

(P4, P6, P23 and P44). “[...] *high precisions and efficiency associated with the fourth industrial revolution would bring about an overwhelming number of products.* [...]” said P4. Regulatory policies should encourage digital human modelling technology in the airline sector. The technology can proffer easy answers to issues such as security checks, passenger luggage, on-board passenger service, reception and services offered to customers, including those with special needs (Sanjog *et al.*, 2015). Findings agree that the social media platform can influence airlines' growth if well used by the operators (P23, P35, P45 and 55). Findings agree with Baghirov *et al.* (2019), and it was found that social media platforms can improve two-way communication between passengers and airlines operators.

Findings reveal that 4IR technologies will mitigate human interface with a replacement of aerial systems, which are remotely operated and produce reliable outcomes (P2, P3, P4, P6, P23 and P45). Participant P3 says, “[...] *4IR has associated benefits of cost reduction in communication, logistical and transportation...*”. It implies that the logistics and supply chains will become more efficient. Findings align with Bruemmer (2016) and asserted that automation of labour-intensive events such as robotics results in a cost decrease. From the tourism perspective, it could bring about innovative activities such as technological innovation. The outcome will be a long-term gain in efficiency and productivity (P33, P39 and P50). “[...] *reskilling and upskilling in the era of 4IR cannot be over-emphasised if we want to experience positive growth in the airline sector. It should be all-inclusive training* [...]” said P4. Findings show that artificial intelligence, robotics, digital human modelling autonomous vehicles, 3D printing and simulation require special skills. Findings agree with Schwab (2017), and it was found that exponential increases in computing capacity drive these digital technologies. Digital human modelling is key in the airline industry because it

Theme	Sub-theme	Code
Theme 1: factors influencing airlines' growth	Government-related factors	Sustainable regulatory guidelines (P1, P3, P5, P6, P13, P15 and P29) Legislative instruments from government (P1, P3, P13 and P15) Novelty in the airline sector, e.g. 4IR compliance (P2) Policy to create enabling environment (P8, P17, P34 and P56)
	Employer/airlines-related factors	Attractive flight packages for tourists (P4, P5, P34 and P45) Competition within the airline sector (P3, P22, P31 and P45) Airline operators comprehend the sector (P2, P4 and P5) Innovation from airliners (P5, P6 and P29) Understand passengers/customers' needs (P15, P24, P33, P44 and P54) Airliner prompt in scheduled time (P3, P6, P12, P23, P34, P44, P51, and P54)
Theme 2: Drivers influencing South African airlines' growth in the era of 4IR	Government-related measures	Invest in 4IR software (cut across participants) 4IR drives governance (P23, P35, P45 and P55) Reduce production costs by enabling environment (P3, P5, P33, P39 and P50) Collaboration and incorporation of 4IR concepts (P1, P2, P3 and P6)
	Employer/airlines-related measures	Invest in 4IR ergonomics applications (DHM) and research (P1, P2, P3 and P6) Invest in 4IR software (cut across participants) Reduce human interface via 4IR integration (P2, P3, P4, P6, P23, P33 and P45) Reskilling and upskilling of staff (P2, P4 and P13) High precisions and efficiency with 4IR (P3, P4, P5 and P39) Partnership with drone technology (P4, P6, P23 and P44) Collaboration and incorporation of 4IR concepts (P1, P2, P3 and P6) Invest in 4IR ergonomics applications (DHM) and research (P1, P2, P3 and P6)

Table 3.
Matrix of main findings

Source: Aigbavboa *et al.* (2023b)

can facilitate the inclusion of persons' considerations in engineering decisions and offers design help (Li, 2009). Findings show that the technology can be used to combine additive manufacturing, computational design and materials engineering to invent the buildings we inhabit. Participants P1, P2, P4 and P6 suggest more investment in ergonomics application and research in airlines sector to use the 4IR to the optimal. Accident may drastically reduce because 4IR technology will mitigate human interfaces. Findings agree with Berninger (1991) and Zheng and Fu (2011). Berninger (1991) reported that two-thirds of aircraft accidents were linked to human errors. Zheng and Fu (2011) found that about 70% of aircraft accidents could be due to human inefficiency. In summary, investment in

ergonomics applications and research governance is driven by 4IR, collaboration and incorporation 4IR concepts, partnership with drone technology and high precisions and efficiency with 4IR emerged as the drivers that can influence airline's growth in South Africa's aviation sector in the era of 4IR. Others are reskilling and upskilling (P2, P4 and P13), investment in 4IR software, policies to promote 4IR usage in the industry and policies to reduce human interface, as presented in [Figure 1](#) and [Table 3](#).

In summary, regarding Objective 2 findings, the emerged factors influencing South African airlines' growth in the era of 4IR technologies are investing in 4IR software for accessibility, 4IR driving governance, reducing production costs by enabling the environment, reducing human interface via 4IR integration and reskilling and upskilling. Others are high precision and efficiency with 4IR, partnership with drone technology, collaboration and incorporation of 4IR concepts and investing in 4IR ergonomics applications (DHM) and research.

5. Implication and benefit of this study

This research promotes implementing 4IR technologies in the airline industry in South Africa. It has far-reaching benefits to the stakeholders, especially the operators, because of the possible growth via 4IR technologies usage. Apart from the economic boost of the airlines' growth in the era of 4IR technologies, the 4IR technologies can perform vision analysis for pilots, simulate airflow and evaluate the comfort of airplane passenger seats, and workstations in virtual environments. Achieving this requires all-inclusive mechanisms and policies driven strategies. Thus, encouraging 4IR technologies in the airline sector cannot be over-emphasised across South African airports. Examples of the 4IR technologies connected with the airline sector include digital human modelling, 3D, simulation model, computer-aided engineering, automation, artificial intelligence, mobile computing, cloud computing, BIM-based platform and IOT. Literature about South Africa's airline sector's growth in the 4IR era has been strangely quiet. This theoretical gap, among others, has been filled in the study. Also, the developed thematic network of the major results, as shown in [Figure 1](#), emphasising sustainable regulatory guidelines, legislative instruments and governance driven towards 4IR is part of the study's theoretical implications. This aligns with [Salim *et al.* \(2021\)](#) and [Ibrahim *et al.* \(2022\)](#) that adopted their study's thematic network as part of the theoretical implication.

Concerning the study's practical contribution, findings will support and provide a better view of the factors that determine the airlines' growth in the 4IR era in South African airports. The study intends to stir up airline operators and policymakers regarding influencing factors determining airlines' growth in the 4IR era. The positive relevance of 4IR technologies emerged in this study as recognised by international organisations such as the United Nations ([United Nations News Centre, 2018](#)). One outcome is to encourage the engagement of 4IR within the airline operations. It will improve services and product delivery within the airline sector. Taking advantage of the 4IR technologies to grow the sector, especially the social media platform, cannot be over-emphasised.

The benefits of this study to airlines' growth in the 4IR era have reawakened policymakers and operators to re-examine the level of investment in 4IR technologies within the aviation sector. This is germane for better efficiency and service delivery to passengers. The study established that most factors influencing airlines' growth can be improved if integrated with 4IR technologies. The use of 4IR technologies in airline operations can play an important role. Besides reducing aircraft accidents caused by man's errors, virtual human simulation can be used to maintain airplane systems and design upgrades using DHM ([Ianni, 2011](#)).

6. Conclusion

This study highlights a collective perception of the factors influencing airlines' growth and the 4IR technologies' role in improving airlines' growth in South Africa. The study highlighted nine factors influencing airlines' growth in the 4IR era. This includes investment in ergonomics applications and research, governance driven by 4IR, collaboration and incorporation of 4IR concepts, partnership with drone technology and high precision and efficiency with 4IR. Others are reskilling and upskilling, investment in 4IR software, policies to promote 4IR usage in the industry and policies to reduce human interface. This research contributes to educating stakeholders, including policymakers and researchers in the airline industry, regarding how 4IR technologies could be used to enhance productivity in the sector. The awareness includes how digital technology such as digital human modelling, automation, robotic, mobile computing, simulation, cloud computing, BIM-based platform, IOT, among others, could improve service delivery within the airline sector in South Africa. South Africa's airline sector has experienced rapid growth over the past few decades and can do better via 4IR. The sector is recognised as one of the important drivers contributing to the nation's economic growth.

This research can recapitulate some contributions to guide researchers, policymakers and other stakeholders in the airline industry about how the 4IR technology era can enhance productivity and growth in the sector. The presidential commission on the 4IR is one critical decision from the South African Government to drive innovative technology to the fast-growing economy. More policies and programmes are needed to improve the enabling environment for stakeholders to embrace 4IR technologies in their operations, including airline operators. The study is not without some limitations. Firstly, the researchers used a qualitative research design. The study recommended a mixed-methods research design to accomplish generalisability for future research. Secondly, an investigation into the level of compliance to 4IR technologies in the operational activities within the airline sector is germane. It will assist in driving policies and programmes tailored towards compliance and motivation across South African airports. Also, the developed constructs (factors influencing airlines' growth in the 4IR era) can be further investigated to achieve empirical validation .

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About the authors

Prof Clinton Ohis Aigbavboa is a Professor in the Department of Construction Management and Quantity Surveying, University of Johannesburg, Johannesburg, South Africa. He is the author/co-author of many peer-reviewed journal articles.

Dr Andrew Ebekozi is a Senior Research Associate/Post-Doctoral Research Fellow in the Department of Construction Management and Quantity Surveying, University of Johannesburg, Johannesburg, South Africa. He is the author/co-author of many peer-reviewed journal articles. Andrew Ebekozi is the corresponding author and can be contacted at: ebekoandy45@yahoo.com

Nompumelelo Mkhize is a Doctoral student in the Department of Construction Management and Quantity Surveying, University of Johannesburg, Johannesburg, South Africa.

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