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Impact of Digital Transformation Technologies on Egypt Air Sustainability

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Abstract

Recently, sustainability has emerged as a fundamental driving force for the aviation industry. To maintain the desired trends in sustainable aviation, the fast development of fundamentally new and innovative technology and solutions must be reviewed. This research aims to investigate digital transformation technologies and their impact on Egypt Air's sustainability. To achieve this, the study used a descriptive-analytical approach, in which a questionnaire was prepared and distributed to a random sample of 166 aviation industry professionals and Egypt Air employees, using SPSS 25.0, descriptive statistics, reliability analysis, coefficient analysis, Pearson correlation analysis, and regression analysis. The study presented many findings; the most important of these is that there is a significant, moderately positive relationship between the contributions of digital transformation technologies and sustainability efforts at Egypt Air. While regression analysis findings demonstrate that improving sustainability efforts at Egypt Air are influenced by the contributions of digital transformation technologies. The research recommended that Egypt Air should incentivize digital transformation and technological innovation through continued international cooperation.

1. Introduction

Sustainability is another key area that is critical not just for airlines and the travel industry but for the entire world. Airlines are aware of the importance of sustainability and are making strides on multiple levels, with the majority of work concentrated on improving terminal and operational efficiency with the ultimate goal of reducing greenhouse gas emissions. Corporate sustainability performance has been assessed against three main types of organizational responsibility, namely social, environmental, and economic (Zaid et al., 2020).

Recently, one of the driving reasons behind the future of aviation has been the protection of the environment and the energy supply chain. The definition of the goal provided by the Advisory Council for Aeronautics Research in Europe (2011) reads, "In 2050, technologies and procedures will be available to allow a 75% reduction in CO_2 emissions per passenger kilometer to support the Air Transport Action Group (ATAG, 2020) target and a 90% reduction in NOX emissions". The perceived noise output of flying aircraft has been reduced by 65%. These are compared to the capabilities of a typical new aircraft in 2000. Since then, a new area in aviation has also been opened up by the development of game-changing electric and hybrid-electric aircraft. Finally, the phrase "sustainability" has replaced the terms "greening" and "reducing energy consumption" as the most crucial one for evaluating future development (Karakoc et al., 2022: p2).

Digital technology now provides new avenues for addressing environmental challenges (Lock and Seele, 2017; Busch, 2011). Digital transformation technologies are crucial in launching and managing environmental sustainability initiatives. On the one hand, cloud computing and the Internet of Things have offered organizations unprecedented opportunities to engage in environmentally sustainable projects that are inexpensive, simple to use, simple to understand, and simple to implement (El-Kassar and Singh, 2019; Sedera and Lokuge, 2017).

Research Problem

There is still little empirical research connecting factors of digital transformation technology with the sustainability of Egypt Air. The knowledge gap between the two concepts still needs a lot of work. This research seeks to close this gap by conducting an empirical analysis of how the digital transformation affects sustainable development.

Research Aim

The main aim of the research is to investigate digital transformation technologies and their impact on Egypt Air's sustainability. Some objectives were set in order to fulfill the research's main aim:

1. Identifying sustainability efforts in Egypt Air.
2. Exploring the factors positively impacting Egypt Air's pursuit of sustainability through digital transformation technologies.
3. Assessing the effects of digital transformation technologies on Egypt Air's sustainability.
4. Analyzing the contributions of digital transformation technologies to Egypt Air's sustainability
5. Examining the possibility of Egypt Air enhancing its corporate sustainability activities through digital transformation technology using empirical data.

Research questions

RQ1: "What factors influence the relationship between Egypt Air's sustainability and digital transformation technologies?"

RQ2: "What are the positive and negative effects of digital transformation technologies on Egypt Air's sustainability?"

RQ3: “How can Egypt Air's sustainability improve through digital transformation technologies?”

Research Importance

This research presents a small-scale review of the literature on various methodologies and techniques used for the contributions of digital transformation technologies to improve Egypt Air's sustainability, including environmental sustainability components. In addition, many models and approaches to environmental impact assessment for sustainable flight operations are discussed. The approach of this study helps guide strategic and tactical decisions in the aviation industry, support sustainable operations, and mitigate current challenges.

2. Literature Review

The review of literature focuses on the main study question: "Can Egypt Air achieve sustainability during digital transformation technologies?" To answer this question, the research explains sustainability in the aviation industry, digital transformation, and the relationship between aviation sustainability and digital transformation technologies.

2.1. Digitalization and digital transformation definitions

According to Hess et al. (2016) and Li et al. (2018), the term "digital transformation" refers to the transformation brought about by the presence of digital technologies. These fundamental changes have been made to business operations, processes, operational routines, companies' capabilities, and strategies. As a result of the vast number of changes in people, technology, and processes in the digital era, the way organizations manage performance has altered (Kohtamäki et al., 2020; Li et al., 2018; Tekic and Koroteev, 2019). Digitalization is the application of digital technology to modify and enhance an organization. This improvement may be seen as more effective and less expensive than earlier or conventional methods (Denicolai et al., 2021). Because digital technologies enable increased network connectedness, they have an impact on many facets of society and the economy. According to Schallmo and Williams (2018), the definition of digitalization is the use of digital technologies and data to increase revenue transform business models and create a digital information environment for digital enterprises.

Wessel et al. (2020) define digital transformation as a process that tries to enhance an entity by making major changes to its features using a mix of information, computation, communications, and networking technologies. By combining operations and business activities, structures, and processes in digital form, digital transformation swiftly makes firms powerful and efficient (Park and Mithas, 2020). Digital transformation is a new way of doing business that makes use of digital technologies such as cloud computing and the massive data and analytics that come with them.

2.2 Digital transformation technologies

Innovative technology integration can reduce negative environmental effects and support the green aviation industry's long-term growth. Digital transformation technologies and sustainability are connected through several fields (Hilty and Aebischer, 2015). The research focused on the contributions of digital transformation technologies to Egypt Air's sustainability by using several technologies such as big data and analytics, the Internet of Things, artificial intelligence, cloud computing, block chain, augmented reality, virtual reality, D printers, robotics, smart materials, and electric and hybrid aircraft.

2.3 Sustainability in the aviation industry

According to the World Commission on Environment and Development (1987), the concept of sustainable development was first introduced. One definition of sustainable development is a form of development that meets the needs of the present without compromising the needs of future generations. According to Bertoni et al. (2015), the aviation sector may enhance its sustainability by using a variety of viable replacement technologies with a reduced environmental impact.

Sustainable aviation necessitates the creation of climate-neutral aircraft that emit less noise and consume less energy in flight. Less energy per flight may be obtained by lowering drag, which can be accomplished by improving aerodynamics and decreasing aircraft weight. This study covers the fundamental aircraft technology developments that enable sustainable aviation. Technologies addressing the long-term viability of aircraft operations, manufacture, and disposal will be explored. Because they necessitate substantial modifications to all systems and subsystems, these technologies are crucial to the research agenda. The sustainability potential varies by aircraft type, and the advantages of different technology areas are interdependent. Expected benefits are shown for the most appropriate aircraft classifications. The most promising technological advances to make aircraft greener are (Yin et al., 2020):

1. Electrified propulsion and propulsion systems.
2. Hydrogen-powered airplanes.
3. State-of-the-art fuel-efficient aircraft systems.

2.4 The relationship between aviation sustainability and digital transformation technologies

The convergence of sustainability and digitalization is a relatively recent phenomenon, yet it plays a significant role in supporting global business efforts to achieve the Sustainable Development Goals. Whereas digitalization has often been employed to increase productivity and profit margins, it also presents prospects for resource efficiency improvements and significant emissions reductions (Antikainen et al., 2018). The potential of particular types of digitalization to advance sustainability has been widely acknowledged in the literature (Di Vaio et al., 2020; Gebler et al., 2014; Rai et al., 2006; Saberi et al., 2019). Information and communication technologies (ICT) and the Internet of Things (IOT) play fundamental roles in advancing sustainability, improving transparency, or enhancing assessment capabilities, for example, as a result of the contribution of big data analysis and management (Del Ro Castro et al., 2021; Paiola et al., 2021). Furthermore, innovation as a whole is acknowledged as a means of achieving sustainability (Smith et al., 2010), for example, due to the shared value produced through knowledge management systems, accessibility, and organizational design (Chaurasia et al., 2020). However, it should be noted that there is a positive connection between the two components of sustainability and digitization, as the definition of "digital sustainability" (Smith et al., 2010) suggests or implies. Digital transformation through the use of digital technologies can be a powerful tool to promote sustainable development (Seele, 2016; Maffei et al., 2019), and support the Sustainable Development Goals (Sachs et al., 2019).As shown in figure 1.

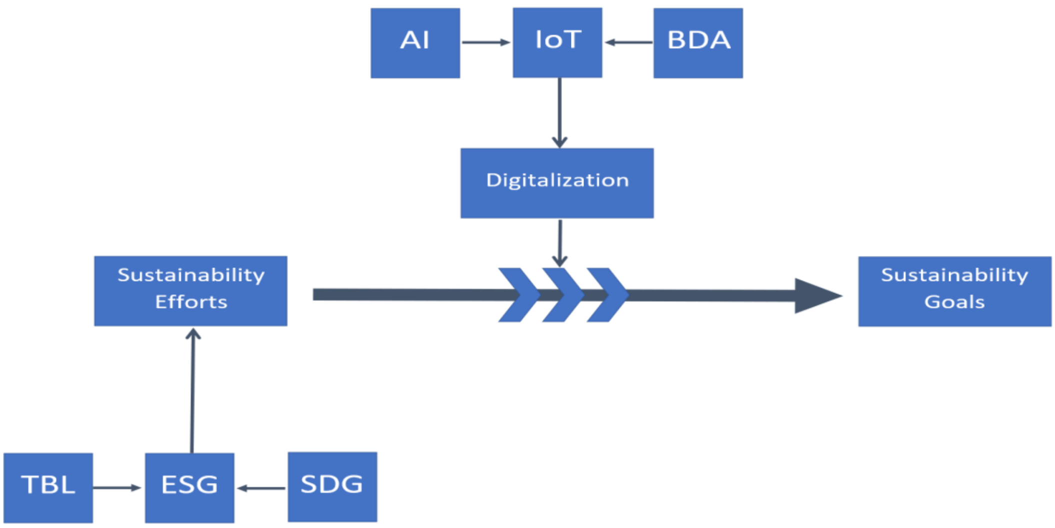

Fig 1: Digital Transformation Towards Sustainable Goals

Source: Christian & Marechal (2022)

2.5 Egypt Air's Sustainability

Egypt Air is determined to provide its services more efficiently and meet the United Nations Sustainable Development Goals. For this reason, the company established its own sustainability committee in 2019 to ensure that environmental goals are at the heart of its services. Egypt Air set the record for the longest flight using sustainable aviation fuel (SAF). Egypt Air launches several awareness-raising activities for its sustainability initiatives. Egypt Air is committed to the sustainability of the industry in conducting its business, the upgrading of Egypt Air's fleet helped cut CO_2 emissions overall and fuel consumption by 20%. The holding group's stakeholders have worked together on collaborative projects to advance sustainable supply chain practices. Egypt Air is making rapid strides in new practices and investing in technology and innovative solutions to improve environmental performance (Egypt Air, 2023).

3. Research Methodology

The research intends to investigate digital transformation technologies and their influence on Egypt Air's sustainability. The researchers used the descriptive analytical method in an effort to present their results. The ideal method for explaining the phenomenon in issue is to describe it, compare, analyze, and explain the data, and then evaluate it in the hopes of drawing significant conclusions that will advance and enlarge our understanding of it.

3.1 Data Collection

This research relied on a field study through an online survey distributed to a random sample of 166 aviation professionals working in the industry and Egypt Air staff of diverse ages, educational levels, years of experience, and employment positions. The survey was designed with an approach that is relevant to the study problem to reduce invalid replies with obligatory or required questions for form completion. The survey was distributed from January to April 2023.

3.2 Measures

The purpose of this study is to examine how digital transformation technologies are affecting Egypt Air's sustainability. To achieve that, this research used a questionnaire instrument with three sections and a descriptive-analytical technique. The first part contains a socio-demographic profile of aviation professionals working in the industry and the Egypt Air staff (gender, age, educational level, years of experience, and classification of participants). The second part contained 39 variables representing the contributions of digital transformation technologies to Egypt Air's sustainability. The third part contained 12 variables representing sustainability efforts at Egypt Air. The survey questions were anchored using a three-point Likert scale: "1 = disagree (D),", "2 = neutral (N),", and "3 = agree (A) ".

3.3. Data Validity and Reliability

3.3.1. Data Validity

The researchers distributed the questionnaire to aviation experts operating in the field as well as Egypt Air employees. To verify the data collection instrument utilized in this study in terms of readability, structure, and capability to assess the study's components. After receiving comments and recommendations from the subject matter experts, the questionnaire instrument was revised and improved. Additionally, the questionnaire instrument's validity was boosted by the experts' interest in it and their interaction with the researchers.

3.3.2 Data Reliability

The instrument's dependability is determined by its level of precision and consistency with whatever it is calculating. Prior to a more in-depth analysis, reliability tests were performed to ensure consistent measurement between the different elements of the questionnaire (Ary et al., 2002). The dependability of the measurement shows the instrument's stability and consistency. Thus, the reliability of the research tool is determined by assessing its internal consistency, i.e., the questions (items) of the questionnaire that are regularly offered. According to Döckel (2003), Cronbach's alpha, which assesses this effect, ranges from 0 (no internal consistency) to 1 (maximum internal consistency). A confidence level of 0.7 or more is considered "acceptable" in most social science research settings (Nunnally, 1978). Cronbach's alpha reliability was determined for two portions, as shown in Table 1. The reliability values for all parts were 0.946, and the accuracy coefficients were 0.973, suggesting that the instrument is useful.

Table (1) Cronbach's Alpha Value

Section	Variables	No. of items	Cronbach's Alpha	Validity Coefficient*
Contributions of digital transformation technologies to Egypt Air sustainability	Artificial intelligence	5	0.947	0.973
	Internet of Things (IOT)	4	0.926	0.962
	Big Data and Analytics	3	0.909	0.953
	Block chain	5	0.886	0.941
	Electric and Hybrid Aircraft	4	0.807	0.898
	Sustainable Aviation Fuels	4	0.825	0.908
	Robotics	3	0.712	0.844
	Cloud Computing	2	0.896	0.947
	Augmented and Virtual Reality	3	0.954	0.977
	Machine learning	2	0.793	0.891
	RFID Reduces Inefficient Transportation	2	0.825	0.908
	Advanced Materials and Manufacturing Techniques	2	0.946	0.973
sustainability efforts	sustainability efforts in Egypt Air	12	0.866	0.931
	Total	51	0.946	0.973

* Validity coefficient = $\sqrt{\text{Reliability coefficient}}$

Cronbach's alpha (1) was used to assess internal consistency and dependability. The scales' reliability was assessed, and the Cronbach's alpha varied from 0.712 to 0.954 for all scales in Table 1, and it was 0.946 for all questionnaire questions. When the Cronbach's alpha value is greater than 0.7, this indicates an appropriate Cronbach's alpha value for each field. It can also be noted that the validity coefficient is 97.30%, suggesting that the tested sample is reliable and valid.

3.4. Data Analysis

The descriptive analytic approach was employed by the researchers to reach the aim of this study. To handle data statistically, the researchers use the Statistical Package for Social Sciences (SPSS). The treatment comprised a number of statistical methodologies, such as frequencies, percentages, means, and standard deviation (SD). In addition, Pearson correlation analysis, regression analysis, and the Cronbach's alpha test were used in the study to evaluate the questionnaire's stability coefficients and the coefficient of stability for each study axis.

4. Results and Discussion

4.1 Descriptive Analysis of Research Variables

First Section: Respondent Demographic Characteristics

Fig. 2 explained that the majority of the respondents were males (92.20%), rather than females (7.80%) in this sample.

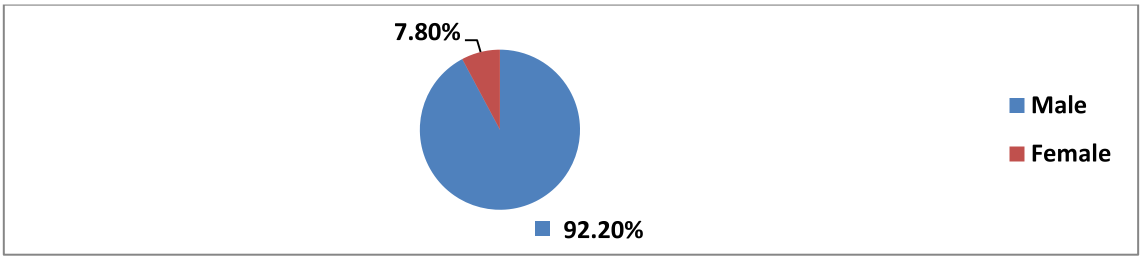

Figure 2: Gender distribution in the sample (%).

Figure 3 displays the respondents' demographic characteristics. Most of the sample (50%) was aged from 41 to 50 years, whereas 20.50% of them were aged from 51 to 60 years.

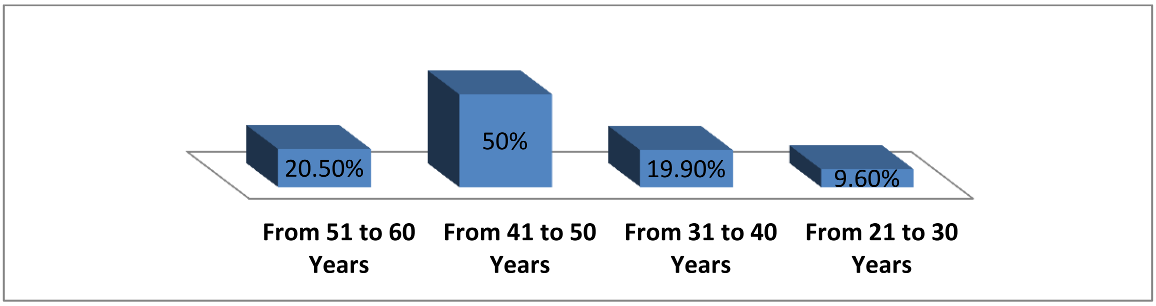

Figure 3: Age distribution of the sample (%)

As shown in Figure 4, the most representative degree was postgraduate (Master's or Ph.D.) with 69.90% of the respondents, followed by higher education with 30.10% of the respondents.

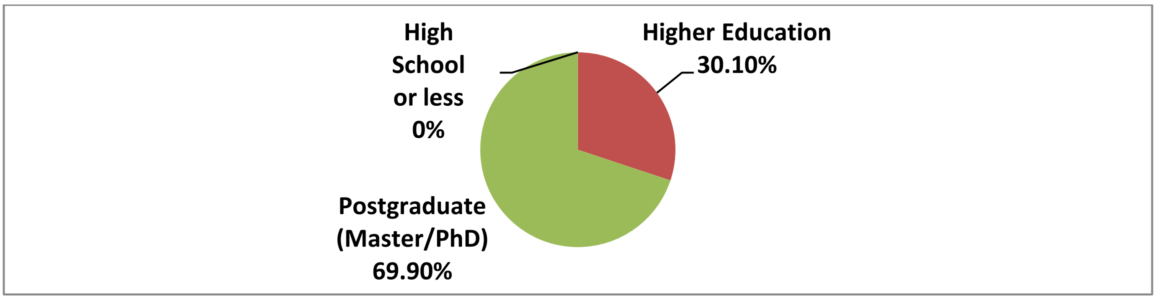

Figure 4: Sample distribution by education level (%)

According to Fig. 5 the majority of respondents in the years of experience groups (80.10%) have more than 10 years of experience, while 10.20% have 7 to 10 years of experience.

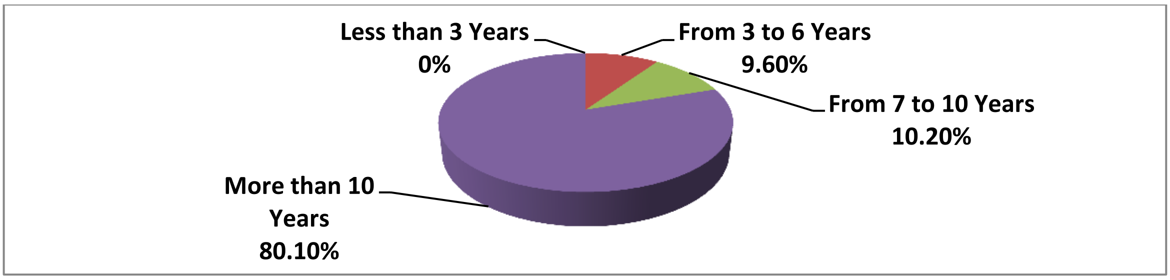

Figure 5: Sample distribution by the Years of experience (%)

The majority of participants were classified as airlines (22.30%), engineers (21.10%), airport services (18.70%), airport planning (13.30%), airport operators (10.20%), handling agents (8.40%), and aircraft designers and manufacturers (6%). In addition, the questionnaire captured the views of other aviation professionals. The full breakdown is shown in Figure 6.

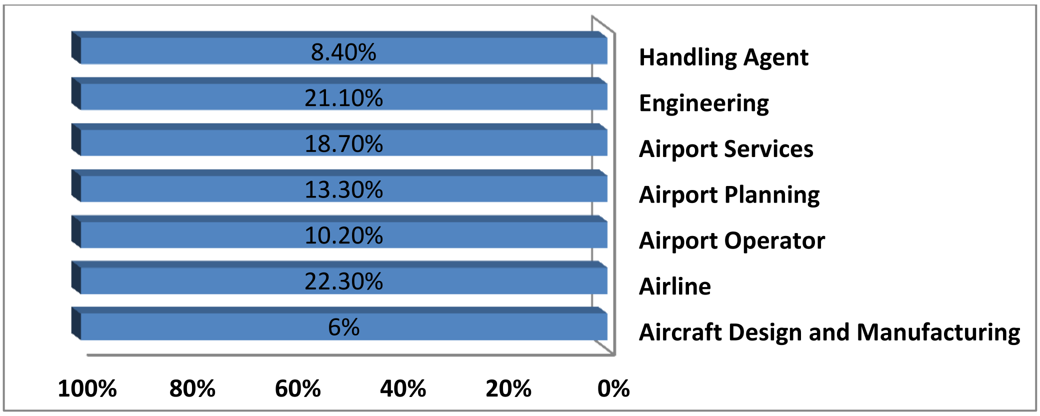

Figure 6: Sample distribution by the classification of participants (%)

Section 2: Contributions of digital transformation technologies to Egypt Air sustainability

Table 2: Descriptive Analysis of Artificial intelligence (AI)

Variables	D	N	A	Mean	SD	Rank	Attitude
AI is used to apply powerful predictive abilities and intelligent grid systems to control the supply and demand of renewable energy.	11.4	18.7	69.9	2.60	.659	3	Agree
AI improves efficiency, reduces costs, and reduces unnecessary carbon emissions.	12.6	16.9	70.5	2.61	.659	2	Agree
AI is used to help decrease emissions through the development of low-carbon technologies, limiting system waste, and enhancing energy efficiency.	9.6	10.3	80.1	2.70	.635	1	Agree
AI is incorporated into the aviation business, and it has a favorable relationship with environmental concerns.	9.6	30.1	60.3	2.51	.667	4	Agree
Airlines utilize AI and machine learning to estimate the optimal amount of fuel needed for a flight.	19.9	10.2	69.9	2.50	.807	5	Agree
Total Mean=2.58							Agree

Table 2 shows the means and Std Deviation for artificial intelligence, which varied from 2.70 to 2.50. In comparison to the overall instrument mean (2.58); the statement "AI is used to help decrease emissions through the development of low-carbon technologies, limiting system waste, and enhancing energy efficiency" achieved the highest ranking (mean = 2.70, SD =0.635). The item "Airlines utilize AI and machine learning to estimate the optimal amount of fuel needed for a flight" came out on the last rank (mean = 2.50, SD =0.807).

Table 3: Descriptive Analysis of Internet of Things (IOT)

Variables	D	N	A	Mean	SD	Rank	Attitude
IOT helps aircraft choose the fastest and most fuel-efficient route.	15.6	44.6	39.8	2.30	.637	4	Neutral
IOT provides aircraft designers and manufacturers with data to improve aerodynamic performance, reducing fuel consumption to fly.	9.6	20.5	69.9	2.60	.659	1	Agree
IOT reduces aircraft weight and carbon footprint.	19.9	20.5	59.6	2.40	.801	3	Agree
IOT uses sensors to collect and store data, benefiting the environment.	12.7	27.1	60.2	2.51	.667	2	Agree
Total Mean=2.45							Agree

Table 3 provided an overview of the attitudes, means, and Std Deviation in relation to the descriptive analysis of the internet of things. The overall mean score (2.45) indicated almost positive attitudes about the contributions of the Internet of Things to Egypt Air's sustainability. Furthermore, the highest mean was for "IOT provides aircraft designers and manufacturers with data to improve aerodynamic performance, reducing fuel consumption to fly" with a value of 2.60 and Std Deviation of 0.659. Whereas, the lowest mean value was for "IOT helps aircraft choose the fastest and most fuel-efficient route" with a low mean value of 2.30 and Std Deviation of 0.637.

Table 4: Descriptive Analysis of Big Data and Analytics

Variables	D	N	A	Mean	SD	Rank	Attitude
Big data and analytics provide real-time decision-making, predictive insights, and beneficial environmental effects.	12.7	17.4	69.9	2.60	.659	3	Agree
Big data and analytics are used to correctly predict the amount of fuel required for every scheduled flight and improve flight routes to enhance energy efficiency.	9.6	19.9	70.5	2.61	.659	2	Agree
Big data and analytics are used to help airlines monitor their aircraft in real-time and spot chances for fuel savings in order to increase energy efficiency, lower fuel usage, and therefore lower carbon emissions.	14.5	10.2	75.3	2.70	.635	1	Agree
Total Mean=2.64							**Agree**

The big data and analytics contributions to Egypt Air's sustainability are shown in Table (4), together with their means and standard deviations. The means varied from 2.70 to 2.60 in comparison to the domain's overall instrument mean (2.64). The item "Big data and analytics are used to help airlines monitor their aircraft in real-time and spot chances for fuel savings in order to increase energy efficiency, lower fuel usage, and therefore lower carbon emissions" ranked first (mean = 2.70, SD = 0.635). The item "Big data and analytics provide predictive insights, real-time decisions, and positive environmental impacts" ranked last (mean = 2.60, SD = 0.659).

Table 5: Descriptive Analysis of Block chain

Variables	D	N	A	Mean	SD	Rank	Attitude
Block chain is used to track airplane lifespans, supply chains, and passenger data.	9.6	60.9	29.5	2.20	.595	3	Neutral
Block chain can help airlines reduce costs and improve efficiency.	0	20.5	79.5	2.80	.405	1	Agree
Block chain can track carbon footprints, greenhouse gas emissions from aircraft, and an airline's overall environmental compliance record.	22.3	48.2	29.5	2.10	.698	5	Neutral
Block chain is used to increase renewable energy deployment.	15.1	25.3	59.6	2.50	.667	2	Agree
Block chain technology is used for environmentally friendly and sustainable supply chain practices.	19.9	40.9	39.2	2.19	.746	4	Neutral
Total Mean=2.36							**Agree**

Table (5) displays the block chain means and standard deviations, which varied between 2.80 and 2.10 when compared to the total mean instrument (2.36). The statement "Block chain can help airlines reduce costs and improve efficiency" reached the first rank (mean = 2.80, SD = 0.405). The item "Block chain can track carbon footprints, greenhouse gas emissions from aircraft, and an airline's overall environmental compliance record" reached the last rank (mean = 2.10, SD = 0.698).

Table 6: Descriptive Analysis of Electric and Hybrid Aircraft

Variables	D	N	A	Mean	SD	Rank	Attitude
Electric and hybrid aircraft contribute to the sustainability of aviation by reducing carbon emissions, improving fuel efficiency, and lowering operating costs.	9.6	41	49.4	2.40	.659	3	Agree
The industry's carbon impact is decreased by using electric and hybrid propulsion systems, which eliminate the need for fossil fuels.	0	30.1	69.9	2.70	.460	1	Agree
All-electric aircraft can reduce CO2 and other air pollutants.	19.9	30.1	50	2.30	.782	4	Neutral
All-electric aircraft have the potential to reduce noise, In particular during takeoff	0	41	59	2.59	.493	2	Agree
Total Mean=2.50							**Agree**

Table 6 provided a concise summary of the attitudes, means, and standard deviation in relation to the descriptive study of the electric and hybrid aircraft. The overall mean value of 2.50 showed nearly positive attitudes about the sustainable contributions of electric and hybrid aircraft to Egypt Air. With a mean of 2.70 and Std Deviation of 0.460, the statement "The industry's carbon impact is decreased by using electric and hybrid propulsion systems, which eliminate the need for fossil fuels" received the highest mean. The statement "All-electric aircraft can reduce CO2 and other air pollutants" had the lowest mean value, with a low mean value of 2.30 and Std Deviation of 0.782.

Table 7: Descriptive Analysis of Sustainable Aviation Fuels (SAF)

Variables	D	N	A	Mean	SD	Rank	Attitude
Sustainable aviation fuels have the potential to cut greenhouse gas emissions.	0	41	59	2.59	.493	2	Agree
Sustainable aviation fuels are essential for the future of aviation.	0	30.7	69.3	2.69	.463	1	Agree
Sustainable aviation fuels are made from renewable resources.	0	50	50	2.50	.502	3	Agree
Sustainable aviation fuels can reduce carbon footprints and promote sustainability.	10.3	30.7	59	2.49	.676	4	Agree
Total Mean=2.57							Agree

The means and standard deviations for sustainable aviation fuels are shown in Table (7), with the means falling between 2.69 and 2.49 in comparison to the domain's overall instrument mean (2.57). When compared to the mean and Std Deviation of all the instruments, the item "Sustainable aviation fuels are essential for the future of aviation" ranked first with a mean and Std Deviation (mean = 2.69, SD = 0.463). The item "Sustainable aviation fuels can reduce carbon footprints and promote sustainability" ranked last reached (mean = 2.49, SD = 0.676).

Table 8: Descriptive Analysis of Robotics

Variables	D	N	A	Mean	SD	Rank	Attitude
Robotics can promote sustainability by combating climate change, recycling, and reducing waste.	10.3	60.2	29.5	2.19	.602	3	Neutral
Robots can reduce emissions by using renewable energy sources.	0	60.2	39.8	2.40	.491	1	Agree
Robotics is used to achieve Sustainable Development Goals by replacing human operations.	10.2	39.8	50	2.40	.669	2	Agree
Total Mean= 2.33							Neutral

Table (8) presents the means and standard deviations of robotics which ranged between (2.40 – 2.19) compared to the mean of all the instruments (2.33). The statement "Robots can reduce emissions by using renewable energy sources" reached the first rank (mean =2.40, SD = 0.491). The item "Robotics can promote sustainability by combating climate change, recycling, and reducing waste." reached the last rank (mean =2.19, SD = 0.602).

Table 9: Descriptive Analysis of Cloud Computing

Variables	D	N	A	Mean	SD	Rank	Attitude
Cloud computing is beneficial for both core and peripheral activities.	9.6	19.9	70.5	2.61	.659	1	Agree
The use of cloud computing for sustainability is straightforward through lowering airlines' carbon footprints	13.9	36.1	50	2.40	.660	2	Agree
Total Mean= 2.51							Agree

The previous table displays the contributions of cloud computing to Egypt Air sustainability items: " Cloud computing is beneficial for both core and peripheral activities.", and "The use of cloud computing for sustainability is straightforward through lowering airlines' carbon footprints" with means of 2.61 and 2.40, respectively, of the respondents.

Table 10: Descriptive Analysis of Augmented and Virtual Reality

Variables	D	N	A	Mean	SD	Rank	Attitude
Technicians use augmented and virtual reality to access aviation components.	9.6	10.3	80.1	2.70	.635	1	Agree
Augmented reality helps pilots gain situational awareness by overlaying real-time data.	13.3	27.1	59.6	2.50	.667	2	Agree
Augmented and virtual reality help reduce environmental damage by lowering greenhouse gas emissions.	12.7	30.7	56.6	2.48	.687	3	Agree
Total Mean= 2.56							Agree

Related to the descriptive analysis of augmented and virtual reality, Table No. 10 summarizes the attitudes, means, and standard deviation. The total mean value (2.56) indicated almost positive attitudes about the contributions of augmented and virtual reality to Egypt Air's sustainability. Furthermore, the highest mean was for "Technicians use augmented and virtual reality to access aviation components" with a value of 2.70 and Std Deviation of 0.635. Whereas, the lowest mean value was for "Augmented and virtual reality help reduce environmental damage by lowering greenhouse gas emissions," with a low mean value of 2.48 and Std Deviation of 0.687.

Table 11: Descriptive Analysis of Machine learning

Variables	D	N	A	Mean	SD	Rank	Attitude
Machine learning can improve energy storage, efficiency, load management, and the reliability of renewables.	0	30.7	69.3	2.69	.463	2	Agree
Machine learning can monitor an aircraft's technical status and perform maintenance tasks.	0	30.1	69.9	2.70	.460	1	Agree
Total Mean= 2.695							Agree

The table shows the contributions of machine learning to Egypt Air sustainability items: "Machine learning can monitor an aircraft's technical status and perform maintenance tasks", and "Machine learning can improve energy storage, efficiency, load management, and the reliability of renewables" with means of 2.70 and 2.69, respectively, of the respondents.

Table 12: Descriptive Analysis of Radio-frequency identification (RFID)

Variables	D	N	A	Mean	SD	Rank	Attitude
RFID can reduce CO2 emissions by eliminating unnecessary truck deliveries.	0	40.4	59.6	2.61	.492	1	Agree
ECO RFID tags reduce carbon emissions and are cost-effective.	10.2	19.9	69.9	2.60	.669	2	Agree
Total Mean=2.605							Agree

According to this table, radio-frequency identification (RFID) contributes to Egypt Air's sustainability initiatives in the following ways: "RFID can reduce CO2 emissions by eliminating unnecessary truck deliveries" and "ECO RFID tags reduce carbon emissions and are cost-effective," with means of 2.61 and 2.60, respectively, of the respondents.

Table 13: Descriptive Analysis of Advanced Materials and Manufacturing Techniques

Variables	D	N	A	Mean	SD	Rank	Attitude
Advanced materials and manufacturing techniques are used for reducing the weight of airplanes, leading to enhanced fuel efficiency and decreased emissions	10.3	30.1	59.6	2.49	.676	2	Agree
Advanced manufacturing techniques, for example, 3D printing, also provide significant advantages in terms of cost, speed, and flexibility	10.2	19.9	69.9	2.60	.669	1	Agree
Total Mean=2.55							Agree

It's indicated in this table that the contribution of advanced materials and manufacturing techniques to Egypt Air sustainability items is: "Advanced manufacturing techniques, for example, 3D printing, also provide significant advantages in terms of cost, speed, and flexibility" and "Advanced materials and manufacturing techniques are used for reducing the weight of airplanes, leading to enhanced fuel efficiency and decreased emissions" with means of 2.60 and 2.49, respectively, of the respondents.

Section 3: sustainability efforts in Egypt Air

Table 14: Descriptive Analysis of sustainability efforts in Egypt Air

Statement	D	N	A	Mean	SD	Rank	Attitude
Egypt Air is better able to a balance between the three dimensions of sustainability thanks to digital transformation	9.6	19.9	70.5	2.61	.659	4	Agree
Egypt Air is improving fuel efficiency, cutting greenhouse emissions, and using more environmentally friendly materials both in the air and on the ground.	0	20.5	79.5	2.80	.405	1	Agree
Egypt Air is focusing their efforts on improving energy usage while optimizing their greenhouse emissions and noise levels.	0	30.1	69.9	2.70	.460	2	Agree
Egypt Air makes a lot of effort to incorporate ecologically friendly and renewable resources in its operations and products.	13.9	26.5	59.6	2.50	.667	6	Agree
Egypt Air goes well beyond the minimum needed by legal authorities to minimize any negative effect of airlines on the environment.	15.7	34.3	50	2.40	.663	9	Agree
Egypt Air recycle all waste	19.3	60.8	19.9	2.01	.628	12	Neutral
Egypt Air has applied for or been awarded a green certification	0	30.7	69.3	2.69	.463	3	Agree
Egypt Air keeps a tight eye on its suppliers to make sure they are environmentally sustainable.	19.9	50.6	29.5	2.10	.698	11	Neutral
Egypt Air's objective to protect the globe and the environment is well-defined.	9.6	39.8	50.6	2.41	.661	7	Agree
Egypt Air are widely recognized as an environmentally friendly airline	16.9	33.1	50	2.40	.660	8	Agree
Egypt Air has a mechanism in place to guarantee that remain focused on environmental protection	15.1	45.1	39.8	2.30	.637	10	Neutral
Egypt air is focusing on initiatives to optimize their operations to decrease weight on-board.	0	40.4	59.6	2.60	.492	5	Agree
Total Mean=2.46							Agree

Related to the descriptive analysis of sustainability efforts in Egypt Air, Table No. 14 summarizes the attitudes, means, and standard deviation. The total mean value (2.46) indicated almost positive attitudes about sustainability efforts in Egypt Air. Furthermore, the highest mean was for "Egypt Air is improving fuel efficiency, cutting greenhouse emissions, and using more environmentally friendly materials both in the air and on the ground" with a value of 2.80 and Std Deviation of 0.405. Whereas, the lowest mean value was for "Egypt Air recycle all waste" with a low mean value of 2.01 and Std Deviation of 0.628.

4.3. Pearson Correlation analysis

Table (15) Correlation between contributions of digital transformation technologies to Egypt Air sustainability and sustainability efforts in Egypt Air

		Sustainability efforts in Egypt Air
Contributions of digital transformation technologies to Egypt Air sustainability	Pearson Correlation	.566**
	Sig. (2-tailed).	.000

According to table (15), there is a significant relationship between contributions of digital transformation technologies and sustainability efforts in Egypt Air (R=.566, $p \leq .01$), which indicates that as contributions of digital transformation technologies increase, sustainability efforts in Egypt Air also increase.

4.4. Regression analysis

Table (16) Simple Linear Regression analysis

	R	R Square	Beta	F	Sig.	Results
Impact Contributions of digital transformation technologies on sustainability efforts in Egypt Air	.566[a]	.321	0.566	77.407	0.000[b]	Accepted

From the results in table (16), contributions of digital transformation technologies affect increasing sustainability efforts in Egypt Air by 32.1%.

5. Summary and Conclusion

This research emphasizes the importance of technological and solution advances in ensuring the future of aviation. It presents a framework for analyzing the overall sustainability of the air transportation system as a whole, recognizing, evaluating, and choosing the emerging technologies and solutions that will shape the future, and detecting major patterns in such developments.

The main aim of this research is to explore digital transformation technologies and their influence on Egypt Air's sustainability. The descriptive-analytical approach was used in the research, and the questionnaire instrument was modified to answer research questions. In this regard, different tests were applied, including the reliability test, the correlation test, and the regression test. Hence, the research produced the following findings: The research sample emphasized the contribution of digital transformation technologies such as artificial intelligence, the Internet of Things, big data and analytics, block chain, robotics, cloud computing, augmented and virtual reality, machine learning, RFID, electric and hybrid aircraft, sustainable aviation fuels, and advanced materials and manufacturing techniques to improve sustainability efforts at Egypt Air.

Furthermore, Pearson correlation analysis revealed a significant, moderately positive relationship between the contributions of digital transformation technologies and sustainability efforts at Egypt Air; whereas the results of regression analysis show that improving sustainability efforts at Egypt Air are influenced by the contributions of digital transformation technologies.

6. Research Recommendations

- Egypt Air should integrate effective environmental measures into its air traffic management system.
- Egypt Air should scale up the supply and use of sustainable aviation fuels (SAF).
- Egypt Air should promote research and identify solutions to address environmental and climate impacts as well as build climate change resilience.
- Egypt Air should incentivize technological innovation through continued international cooperation.
- Egypt Air should foster green airport operations and infrastructure.
- Egypt Air should provide appropriate infrastructure for digital transformation applications that contribute to Egypt Air's sustainability.

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تأثير تقنيات التحول الرقمي على استدامة مصر للطيران

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الملخص

في الآونة الأخيرة ، برزت الاستدامة كقوة دافعة أساسية لصناعة الطيران. للحفاظ على الاتجاهات المرغوبة في مجال الطيران المستدام ، يجب مراجعة التطور السريع للتكنولوجيا والحلول الجديدة والمبتكرة بشكل أساسي. توفر تقنيات التحول الرقمي سبلاً جديدة لمعالجة قضايا الاستدامة في مصر للطيران، وذلك باستخدام تقنيات مثلblock-chain، والذكاء الاصطناعي، والبيانات الضخمة والطائرات الكهربائية والهجينة، والروبوتات ، وإنترنت الأشياء. يهدف هذا البحث إلى استكشاف تقنيات التحول الرقمي وتأثيرها على استدامة مصر للطيران. لتحقيق ذلك ، استخدمت الدراسة المنهج الوصفي التحليلي، حيث تم إعداد استبيان وتوزيعه على عينة عشوائية من مائة وستة وستين (١٦٦) متخصصًا في صناعة الطيران وموظفي مصر للطيران. باستخدامSPSS25.0، الإحصاء الوصفي ، تحليل الموثوقية ، تحليل المعامل ، تحليل ارتباط بيرسون ، وتحليل الانحدار. قدمت الدراسة العديد من النتائج. والأهم من ذلك أن هناك علاقة إيجابية كبيرة معتدلة بين مساهمات تقنيات التحول الرقمي وجهود الاستدامة في مصر للطيران. بينما تظهر نتائج تحليل الانحدار أن تحسين جهود الاستدامة في مصر للطيران يتأثر بمساهمات تقنيات التحول الرقمي. وأوصى البحث بأن تقوم مصر للطيران بتحفيز التحول الرقمي والابتكار التكنولوجي من خلال التعاون الدولي المستمر.