Big Data Analytics in Airlines: Opportunities and Challenges

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ARTICLE INFO   ABSTRACT

Big data refers to the huge amounts of information in the structured and unstructured form that cannot be processed using traditional data systems. Big data technology facilitates the utilization of high volumes of external and internal data to create new products, services and improve business operations. In the era of big data, airlines can provide services that are more satisfying to customers and to stay competitive in their fierce marketplace. Airlines can reap many benefits from big data, but many challenges still remain. This study illustrates how airlines successfully adopt big data technology. The paper also explores the opportunities and challenges of big data in the airline industry. Based upon the qualitative approach, 27 semi-structured interviews with employees and experts at airlines in Egypt were conducted. The findings reveal that big data has a great importance in providing broad opportunities for airspace management, enhancing flexibility in dealing with each passenger, boosting problem solving, supporting decision, providing safe flights, boosting predictive maintenance, and improving performance. The findings illustrate a range of challenges that airlines may face when dealing with big data, such as shortage of qualified human resources, absence of data-driven culture, dealing with and processing huge amounts of data, as well as data privacy and security issues. Finally, implications for practice as well as future researches are discussed.

1. Introduction

With the advent of digitalization, more enterprises are adopting big data and business analytics to analyze available data in order to improve their products, services and sustain smart decision-making (Maroufkhani et al., 2019). The development of big data management research has generated a range of analytical tools that could be utilized to better respond to such sudden 'black swan' risks, like COVID-19 pandemic (Ienca and Vayena, 2020). Big data was described as the massive volume of both structured and unstructured data, difficult to process using common software techniques or by using traditional statistical methods (Baggiom, 2016). Big data is being generated through different sources including internet traffic, mobile

transactions, user generated content, and social media (George et al., 2014). There are also sources of big data such as the content captured through sensor networks, business transactions, and many other domains such as bioinformatics, healthcare, and finance (George et al., 2014). Big data provides promising opportunities for modern societies and companies (Fan et al., 2014). It helps companies understand the purchasing behavior of the customers to create more efficient marketing strategies (Sternberg et al., 2018). It may also lead to more accurate analysis, more valuable decision-making, and greater operational efficiencies (Song and Liu, 2017). Extracting insights from big data includes two main sub-processes (Gandomi and Haiderm, 2015): data management and data analytics. Data management comprises processes and supporting technologies to acquire and store data and to prepare it for analysis (Larsen, 2013). On the other hand, data analytics refers to techniques used to analyze and acquire intelligence from big data. Big-data analytics is the process of examining huge amounts of data of a variety of types to discover hidden patterns, indefinite correlations as well as other useful information (Larsen, 2013).

Airlines described big data as the "third wave ", after traditional databases and web-based content (Hausladen and Schosser, 2020). The airline industry is characterized by low profit margins, frequent entry of new players, disruptive competition, fierce airfare wars, severe legal and safety requirements (Chen et al., 2016; Kastur et al., 2016). The adoption of big data technology can transform the organizational airline operations in different ways (Odarchenko et al., 2019); 1- ground handling preparations are faster due to a reduction in the processing cycle time, 2- data analysis offers the ideal solutions in the field of airspace management, which in turn increase efficiency; 3- data analysis allows airlines to discover an individual approach to each passenger. Besides, big data offers unique advantages for airlines in achieving new sources of competitive advantage, including optimizing operations, customer intelligence, innovation in products and services, personalized marketing, better pricing and cost reductions (Fan et al., 2014; Chen et al., 2017; Lee, 2017; Sternberg et al., 2018; Odarchenko et al., 2019). Big data is also imperative for improving the predictive analysis of ground operations, load control, aircraft turn-around operations, staff management and aircraft maintenance that are critical parts of providing a great end-to-end customer experience (Chen et al., 2017). However, the airline industry does not seem able to fully exploit data information for lack of technological skills and infrastructure (Izzo, 2019). The major obstacles for using big data analytics in aviation industry are the lack of time, resources, skills, tools and systems that are needed to derive value from the data (Izzo, 2019). There are also challenges regarding the analysis, capture, search, sharing, storage, transfer, security and information privacy of big data (Hashem et al., 2015).

There are few studies of big data technology in the airline industry; the present study attempts to contribute to the debate on this topic. This research adopts a qualitative approach to explore the application of big data analytics for airlines in Egypt. The objectives of this study are to discover the airlines' concept of big data, and to determine the different opportunities and challenges of big data in this context. The following section introduces the literature review on big data followed by the

methodology and results section. Finally, the discussion, conclusion and future research avenues are illustrated. The current paper addresses the following questions:

- What are the main applications of big data technology in the airline industry?
- What are the sources and types of big data in airlines?
- What are the opportunities that airlines can reap from adopting big data?
- What are the challenges that airlines can face in adopting big data?

2. Literature Review
2.1. Big Data: Definitions and Characteristics

Big data is considered a driving force that can enhance economic growth, prosperity and solve societal problems (Mayer-Schönberger and Cukier, 2013; Verhoef, et al., 2016). Big data comprises an array of modern analytical technologies and business possibilities (Mikalef et al., 2018). These new systems handle a wide range of data, from sensor data to Web and social media data that enhances business agility by fostering automated real-time actions and immediate decision making (Mikalef et al., 2018). Moreover, big data is a cultural and technological phenomenon that stands on the interaction of (1) **Technology**: maximizing computation power to gather, analyze, link, and compare large datasets. (2) **Analysis**: to identify patterns in order to make economic, social, technical, and legal claims. (3) **Mythology**: large datasets offer a higher form of intelligence and knowledge that can provide insights that were previously unfeasible (Boyd and Crawford, 2012). Big data represents the information assets characterized by such a high volume, velocity and variety to require specific technology and analytical methods for its transformation into value (De Mauro et al., 2015). In sum, it is a larger-scale and complex data that traditional data processing applications and software tools are insufficient to capture, curate, manage, and process it within a reasonable period of time (Snijders et al., 2012).

Big data is commonly described by the three "Vs", volume, velocity and variety of data (Laney,2001; McAfee and Brynjolfsson, 2012). Most definitions of big data include the three main characteristics of volume (amount of data), velocity (speed of data in and out), and variety (range of data types and sources)   (Song and Liu,2017). Volume refers to the sheer amount of data available for storage, processing, and analysis (Hausladen and Schosser, 2020). This includes all data sources from aircraft, airports, and institutions strongly connected to them, which could be databases of maintenance centers, weather stations, satellite networks, and the Internet (Yin and Kaynak, 2015; Kasturi et al., 2016). Velocity refers to the speed at which data are generated and processed (Lee, 2017). Variety refers to the different types and sources of data collected (Akter, 2016). In aviation, very large amount of flight data is generated and there is an essential need to analyze such data in real time (Kasturi et al., 2016). Technological advances allow firms to use various types of structured, semi-structured, and unstructured data (Lee, 2017). Structured data refers to the tabular data found in spreadsheets or relational databases (Gandomi and Haider, 2015). Text, images, audio, and video are examples of unstructured data, Extensible Markup Language (XML), a textual language for exchanging data on the Web, is a typical example of semi-structured data (Gandomi and Haider, 2015). Some data types of aircraft parameter may be structured some may not (Kasturi et al., 2016).

Those data sets cannot be integrated easily, due to different structures, schema, and the problem of merging sources, such as schedules of different airports, weather, and radar data or pilot-assistant systems (Kasturi et al., 2016). Researchers proposed another two features; veracity and value (Manyika et al., 2011; Beyer and Laney, 2012; Chen et al., 2014). Veracity is related to the reliability, validity and completeness dimension of the data (Akter, 2016; Mariani et al., 2018). Wamba et al. (2015:236) define value as "the extent to which big data generates economically worthy insights and or benefits through extraction and transformation". Moreover, SAS (2013) added two additional dimensions to big data: variability and complexity. Variability refers to the variation in data flow rates (Gandomi and Haider, 2015). Complexity refers to the different number of data sources (Lee, 2017).

2.2 Big Data Analytics

There has been considerable attention from both academics and practitioners on the value that organizations can derive from the use of big data analytics towards the attainment of organizational goals (Mikalef et al., 2019). Big data analytics was regarded as the leading future for innovation, competition, and productivity (Manyika et al., 2011). Big data analytics is defined as a collection of data and technology that accesses, integrates, and reports all available data by filtering, correlating, and reporting insights (Jifan Ren et al.,2017). Big data analytics is considered a new generation of technologies, designed to extract value from very large volumes of a wide selection of data, by enabling high velocity capture, discovery and/or analysis (Mikalef et al, 2017). The airline industry is pioneered in adopting big data analytics (Sternberg et al., 2018). Big Data analytics could increase the business performance (McAfee and Brynjolfsson, 2012). According to Labrinidis and Jagadish (2012), Bendre and Thool (2016) and Burmester et al. (2018), big data analytics revolve through the following five stages:

1. **Data generation or integration:** Large amounts of data can be gathered from different applications such as publishing factual data, search engine pages, world events, social media graphs, analysis of natural language content, BBC online content, etc., with different types for future analytics (Sikos, 2015).

2. **Data acquisition or management:** It is the process of gathering, filtering and cleaning large amounts of data (Lyko et al., 2016).

3. **Data storage:** The platform with a clustered network of servers and community hardware are used to store the data (Bendre and Thool, 2016).

4. **Data analytics:** It is the process of examining useful information from the huge data storage using complicated machine learning and data mining techniques (Chen et al., 2014).

5. **Data visualization or knowledge presentation:** The graphical format representation of data can easily be understood and represented in a simple way (Bendre and Thool, 2016).

In addition, the following techniques represent a significant subset of the tools available for big data analytics (Gandomi and Haiderm, 2015; Bendre and Thool, 2016):

- **Text analytics:** refers to techniques that extract information from textual data. Social network feeds, emails, blogs, online forums, survey responses, corporate documents, news, and call center logs are examples of textual data.
- **Multimedia data analytics:** It is a process of finding useful insights from images, audio files, and videos.
- **Web data analytics:** It is a process of measurement, collection, analysis, reporting and viewing of web data.
- **Social media analytics:** social media analytics refer to the analysis of structured and unstructured data from social media channels.
- **Mobile analytics:** It refers to analyzing data collected from user's different activities such as websites visits, install–uninstall applications, play online games, make online transactions and so many discussions through mobile phones.

Rajaraman (2016) also classifies types of data analytics to be: **Descriptive analytics**: This essentially describes what happened in the past and presents it in an easily understandable form. **Predictive analytics**: It extrapolates from available data and reports what is expected to happen in the near future. One major use of predictive analytics is in marketing by comprehending customers' needs and preferences. **Exploratory or Discovery analytics**: Collection of data from a variety of sources and analyzing them provides additional opportunities for insights and unforeseen discovery. **Prescriptive analytics**: based on data gathered, opportunities to optimize solutions to existing problems. One obvious example is in airlines' pricing of seats based on historical data of travel patterns, popular origins and destinations, major events, holidays to maximize profit.

2.3. Applications of big data in the airline industry
With the advent of big data era, modern aviation industry can find solutions for their major challenges of safety and performance improvement (Dou, 2020) because big data can provide multidimensional, adequate, and real-time information (Lee, 2017) and improve the predictive and preventive capabilities of aviation flight risks (Nikolopoulos and Petropoulos, 2018). Big data will effectively improve the technical performance and operating conditions of aircraft, avoid various adverse external environmental conditions, and reduce manual errors, to enhance aviation safety (Dou, 2020). By adopting big data technology, fuel consumption, crew deployment, and flight operations could be optimized; maintenance could anticipate when parts need replacing; air congestion could be reduced; flight routes could be altered well in advance of takeoff to avoid storms and passengers could be kept informed about schedules from the minute they leave their home for the airport (Izzo,2019). The airline industry makes use of primary data sets that come from many different parameters such as flight tracking data, airport operations data, weather conditions, airline information, market information, passenger information, aircraft data and air safety reports (Larsen,2013; Sternberg et al., 2018). Big data analytics can also be

used to analyze transaction activities in real time, detect fraudulent activities, and notify clients of potential issues immediately (Lee, 2017).

Advanced data analytics techniques enabled airlines to engage in more accurate real-time customer intelligence which in turn improves personalized marketing and price discrimination (Knorr, 2019). The most important practices of big data analytics in airlines are predictive maintenance that aims to reduce costs and minimize maintenance (Badea et al., 2018). Improving customer interaction and revenue management is the motive for using big data (Chen et al., 2017). Short-term forecasting and handling of irregular operations can be also the ultimate goal for airlines (Chen et al., 2017). Furthermore, air carriers use big data technologies for many other different purposes (Odarchenko et al.2019). The low-cost Ryanair applies big data for targeted advertising. KLM and SWISS use "large data" to improve the quality of customer service. British Airways collects information about passengers using its own application, such information is then used to provide personalized services to customers. American Airline Delta has an application that allows its customers to track luggage (Odarchenko et al., 2019). In terms of some flight services with the most complaints from passengers, some companies use big data to design a real-time application (Chang and Arami, 2019). Passengers can keep track of their flights and any related updates in adavance, particularly in-flight delays caused by air traffic control, bad weathers and other uncontrollable factors (Chang and Arami, 2019). Such an application can greatly alleviate conflicts caused by flight delays (Wang, 2014). Hu (2017) assures that using big data can predict flights delay and explain its benefits for both airline companies and passengers. Lufthansa identified big data value in four major areas (Chen et al., 2017):

1. Personalizing the customer experience
2. Handling irregular (IRREG) situations
3. Predicting departure delays and being proactive in IRREG recovery
4. Implementing predictive and preventive aircraft maintenance

According Rachman and Arviansysh (2019) and Dou (2020), there are multiple types of big data analytics in airlines. These include the following :

Big data for aircraft design and performance improvement. This includes both the big data reflecting the internal health and performance of aircraft and the big data reflecting external environment and services.

Big data for aircraft operating conditions and malfunction and maintenance. These are platforms and information systems of aircraft operating conditions, malfunction and maintenance include data collection and data analysis.

Big data for route planning and air traffic management. This includes both the big data of available route status and the big data of real-time route usage.

Big data for flight environment and safety. This refers to the data such as cabin pressure, altitude and fuel consumption.

Big data for flight and airport management. This refers to big data and its information systems for flight and airport management at national and global levels.

Big data for crew and cabin passenger service management. Its role is to facilitate the intelligent and automated management of crew and cabin passenger service to reduce management costs and operational errors and improve management performance (Gupta et al., 2018). Rachman and Arviansysh (2019) explained that big data is also collected from various databases of diverse enterprise applications, as follows:

a) **Schedule Planning System (SPS)**, the application for supporting flight scheduling and fleet assignment.

b) **Operation Control System (OCS)**, this is the main application for aircraft maintenance and routing, including determination of flight delay, postpone, divert, reroute, or even cancelation.

c) **Crew Management System (CMS)**, this is the main application for crew planning, including pairing construction, crew rostering and scheduling.

d) **Aircraft Communications Addressing and Reporting System (ACARS)**, this service helps pilots receive vital information in real-time. In terms of flight data, it provides aircraft movement, the pilot in charge, and fuel information.

e) **Aircraft Performance System (APS)**, this application is used to calculate aircraft weight and balance by considering several factors such as payload, fuel load, passenger, cargo, runway length, and airport contour and limitation.

f) **Passengers Service and Departure Control System (DCS)**. This application is used for handling aircraft load, including passengers, cargo, and fuel.

g) **Flight Data Monitoring System (FDM)**, this system receives all information about flight and aircraft attitude during flight. It will be used for flight analysis and safety evaluation purpose.

As for many modern technologies, big data comes with not only benefits but but with specific risk as well. These risks can be grouped into data quality risks, analytical risks, and managerial or organizational risks (Grover et al., 2018). Chen et al. (2017) indicated that the challenges and risks are greater in big data system development because of the following reasons:

1. The technical difficulty arising from the 4Vs of big data (volume, variety, velocity, veracity)
2. The rapid explosion and evolution of big data technology
3. The organizational agility required to extract value from big data.

Additionally, Samara et al. (2020) identified the challenges of big data as follows:
Technical challenges Data storage is an important challenge, which occurs when data are not collected into one place and instead are isolated in different systems, compromising market coverage, data quality and accuracy.

Financial and business challenges It refers to cost concerns, return on investment (ROI) and commercial challenges.

Regulatory challenges It refers mainly to privacy, individuality and safety concerns.

Socio-ethical challenges the fear of job loss is an obvious example for this type.

Furthermore, big data creates significant managerial and organizational challenges such as data privacy and security, the required infrastructure and data investments, and the organizational reluctance towards big data (Raguseo, 2018). Many studies have determined the lack of required skills (Grover et al., 2018), reluctance towards technology (Günther et al., 2017) and appropriate organizational structures (Günther et al., 2017) to be the main factors. Big Data are characterized by high dimensionality and large sample size (Fan et al., 2014). These two features raise the following unique challenges: (1) high dimensionality brings noise accumulation and incidental homogeneity; (2) high dimensionality combined with large sample size creates issues such as heavy computational cost and algorithmic instability (Fan et al., 2014). Lee (2017) also considered challenges in adopting big data to be:

Data quality It refers to the fitness of data according to a specific purpose of usage.

Data security Weak security systems create user resistance to the adoption of big data. It also leads to financial loss and damage to a firm's reputation.

Privacy Protecting privacy is important to both firms and customers.

Investment justification Many big data projects have unclear aims and use emerging technologies without logic vision.

Data management Few firms would be able to invest in data storage for all big data collected from their sources.

Shortage of qualified data scientists the staff shortage will extend from data scientists to data architects and experts in data (IDC, 2015).

3. Methodology

Due to the exploratory nature of the research; the most appropriate method is to conduct an inductive study (Leavy, 2014). We chose the qualitative method based on the use of interviews has been chosen for its ability to provide an in-depth understanding of the participant's own experience, perceptions, and information about challenges and opportunities of big data in airlines. The qualitative approach was a proper way to gather a relatively large amount of information about the research topic and to answer the research questions (Veal, 2018). It focuses mainly on experiences and emotions and is designed to be probing in nature, thus encouraging participants to introduce concepts of importance from their perspective (Altinay and Paraskevas, 2008). Qualitative research is generally appropriate when the primary purpose is to explore, describe, or explain (Leavy, 2017). Interviews with employees and experts in airlines have been performed to get an in-depth understanding of the study subject and to inductively develop an empirically grounded theory (Glaser and Strauss, 1967; Veal, 2018). The grounded theory approach is a method for discovering theories, hypotheses, concepts, and assumptions directly from data rather than from a priori propositions, current theoretical frameworks, or other research (Taylor et al., 2016). Moreover, the grounded theory approach has been chosen because of the importance of the study topic for aviation industry, and because of the multilateral nature of the research method, which has enabled the researchers to explore and detect new ideas that have not been planned or expected (Charmaz, 2011).

3.1 Data Collection

Data was collected by conducting semi-structured interviews either face-to-face or through online (Zoom Cloud Meetings) with 27 employees in different airlines in the Arab Republic of Egypt between July and September 2021 until data saturation was achieved (Gill, 2014). In grounded theory research, the sample size may be specified by the process of 'saturation', that is, the point at which additional interviews stop producing new insights, themes, issues or theoretical categories (Strauss and Corbin, 1998; Charmaz, 2006: 113); in that case the sampling process is closely linked to the analysis process. While 27 would be a relatively small sample in quantitative studies, it would be considered rather large for a qualitative sample, with some studies having between one and four interviews (Lepkowska-White and Parsons, 2019). Intensive semi-structured interviews have been chosen as data collection instrument. Purposive sampling was used and the majority of interviewees held multiple positions in airlines ranging from flight attendant to general manager with many years of experience in the aviation sector (see Table 1). Purposive sampling is significant when the researcher intends to construct a historical reality, describes a phenomenon or develops something about which only a little is known (Kumar 2014). The primary consideration in purposive sampling is the researcher's judgment as to who can provide the best information to achieve the study objectives (Kumar, 2014). Airlines were chosen as a sample for this research because of the huge amount of data that airlines deal daily, including data related to reservations, customers, appointments, boarding, maintenance, investment, revenues, marketing offers, ground and logistics services, and even during the flight. Besides, airlines arguably produce more customer data than any other industry. Within this information lies large amounts of valuable and beneficial intelligence that affects operations, procedures, efficiency, and service; which makes big data analytics can give airlines a huge advantage over competitors. An interview guide (Appendix A) was designed to reflect the main questions which the research attempts to investigate.

Table 1

Participants' Profile

ID	Gender	Age	Educational Level	Current Profession	Airline Name	Years of Experience
1	Male	26-35	Bachelor degree	General Manger	Egyptair	11-15
2	Male	36-45	Master's Degree	Traffic officer	Egyptair	6-10
3	Male	26-35	Bachelor degree	Cabin Crew	Saudi Arabian Airlines	Less than 5 Years
4	Male	26-35	Bachelor degree	Business Development Manager	Egyptair	6-10
5	Male	46-55	Doctorate Degree	Business Intelligence & Data Science	Saudi Arabian Airlines	16-20
6	Male	26-35	Doctorate Degree	Cabin crew	Egyptair	11-15
7	Male	18-25	Bachelor degree	Station Officer	Nile Air	Less than 5 Years

8	Male	46-55	Bachelor degree	Trainer Manager of International and Internal Relations	Egyptair	16-20
9	Male	46-55	Bachelor degree	Business Development Manager	Gulf Air	16-20
10	Male	46-55	Bachelor degree	General Manager	Lufthansa	16-20
11	Male	36-45	Bachelor degree	Sales Manager	Turkish Airlines	16-20
12	Female	36-45	Bachelor degree	Sales Manager	Kuwait Airways	11-15
13	Male	36-45	Bachelor degree	Sales & Marketing Manager	Saudi Arabian Airlines	16-20
14	Male	More than 55	Bachelor degree	General Manager	Egyptair	Above 21 (34 Years)
15	Female	26-35	Bachelor degree	Cabin Crew	Kuwait Airways	6-10
16	Male	26-35	Bachelor degree	Senior Station Officer -Ground Operations	Nile Air	6-10
17	Male	More than 55	Bachelor degree	Operations and Airport Services	Lufthansa	Above 21 (38 Years)
18	Male	36-45	Master's Degree	Manager Data Analysis	Etihad Airways	16-20
19	Female	36-45	Bachelor degree	International Flight Attendant	Egyptair	11- 15
20	Male	36-45	Bachelor degree	General Manager	Turkish Airlines	11- 15
21	Male	26-35	Master's Degree	Data science and Optimization	Emirates Airlines	6-10
22	Male	More than 55	Doctorate Degree	General Manager	Egyptair	Above 21 (25 years)
23	Female	26-35	Bachelor degree	Flight Attendant	Egyptair	6-10
24	Female	36-45	Bachelor degree	Cabin Crew,	Emirates Airlines	11-15
25	Male	36-45	Master's Degree	Planning Specialist	Egyptair	16-20
26	Female	26-35	Bachelor degree	Flight Attendant	Egyptair	11-15
27	Female	26-35	Master's Degree	Employee in Aviation Department	Egyptair	Less than 5 Years

3.2. Data Analysis

The data was analyzed using inductive qualitative analysis, which involved a process of data determination, coding, and data reduction together under related order themes (Mac Con Iomaire et al., 2020). The transcription stage concerns information on recording and transcription of interviews (Kvale, 2007). In order to guarantee comparability, reliability, and consistency; all interviews were conducted, recorded, and transcribed verbatim (Figure1) at the end of each interview. According to Strauss and Corbin (1998), open and axial coding were adopted to analyze the data. Open coding was used to specify the characteristics and dimensions of the concepts in the dataset. Axial coding was used for intersection and relating concepts/categories to each other and for identifying the best category and theme. During and after data analysis, specific codes were created, others were canceled; some data parts were recorded, some were considered a better appropriate for a different theme than the one to which they had initially been dedicated. Finally, an analytic interpretation is presented with verbatim quotes from the interviewees (Gill, 2014).
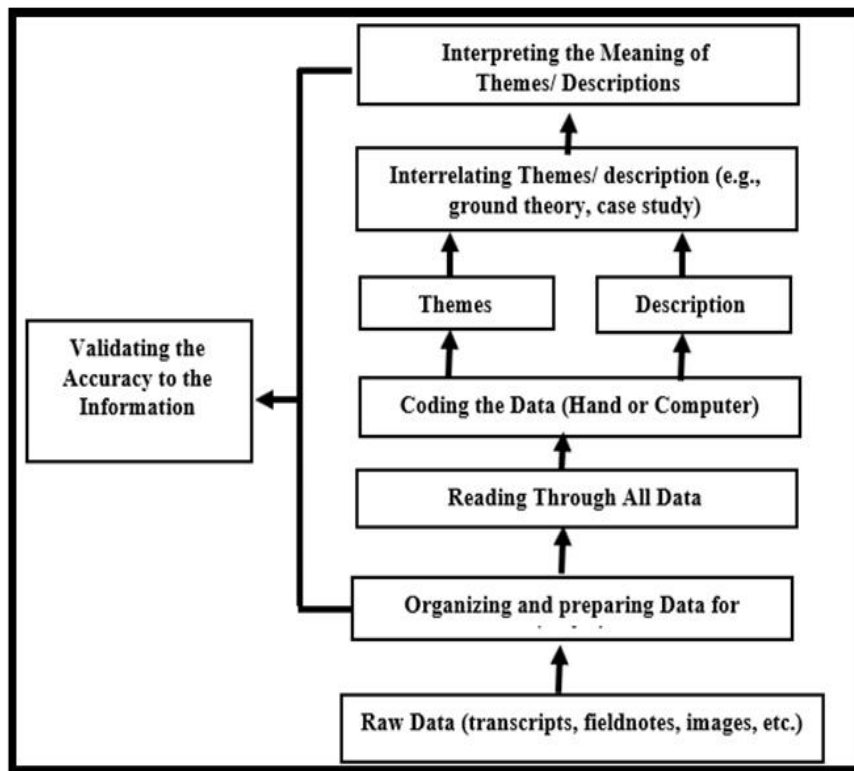
Fig.1. Data analysis in qualitative research by Creswell and Creswell (2018)

3.3. Validity, reliability, and transparency

To enhance the credibility, validity, and reliability of the category, the themes, and the sub-themes obtained, coding was made independently. Two academics who did not participate in the interviews and two experts in airlines who participated in the research were contacted to review and test the inter-rater agreement. These people were given a sample of the data and were asked to develop themes and sub-themes

until the data is ready for analysis. The research applied most of the transparency criteria that was identified by Aguinis and Solarino (2019). The grounded theory approach, purposive sampling was used, the methodological design, saturation degree discussed, the level of detail in transcription, data coding by various coders and inter-rater-reliability (Tracy, 2013; Aguinis and Solarino, 2019).

4. Findings

As shown in Table 1, Male constituted (74.1%) of the sample while female accounted for (25.9%). The majority of the participants were aged between 26-35 years (37%), followed by 36-45 years (33.1%). As for their educational level, the vast majority of them held at least a bachelor degree (70.4%). The sample represented many jobs and specializations within the airlines between management, marketing and sales, cabin crew, data science and analytics, international and internal Relations, Business Development, ground Operations and airport services, Flight Attendant, and traffic and station officer. The sample also represented 8 airlines (Egypt Air, Saudi Arabian Airlines, Nile Air, Gulf Air, Lufthansa, Turkish Airlines, Kuwait Airways, Etihad Airways, Emirates Airlines). The participants' years of experience in aviation industry ranged between less than 3 years (11.1%), 6-10 years (22.2%), 11-15 years (25.9%), 16-20 years (29.6%), and more than 21 years (11.1%).

4.1. Concept of big data

Based on three main characteristics: volume, velocity and variety, big data are usually defined (Kitchin, 2013; McAfee and Brynjolfsson, 2012), to which Veracity and Value have also been added (Chen et al., 2014; George et al., 2014; Goes, 2014; Opresnik and Taisch, 2015). The respondents observe that the concept of big data in airlines relates to customer information, means of contacting them, and the destinations they prefer to travel to.

Big data involves names of passengers, phone numbers, social media accounts, their favorites, and their destinations.   *(ID1)*

While others reported that the concept of big data is related to all matters of the traveler's flight before, after and during travel in order to improve the service.

All data from pre-flight to post-flight operations, including Users search, ticket purchase, seat selection, luggage, boarding, ground transportation, etc.   *(ID4)*

Collecting customers' information in order to improve services.   *(ID13)*

Growth in the size of data has been joined by a fast rise in computer software (Kambatlaet al., 2014) that makes it possible to winnow, structure, analyze and model very large data sets in the right time and cost in order to improve firm performance (Wamba et al., 2017:3; Wang et al., 2017). This is what the interviewees pointed out that the large and complex volume of big data requires the need to deal with it in a way that enables airlines to solve their problems and improve their performance.

It is a large set of airline data that can be collected, analyzed, stored, and then converted into information and data for use.   *(ID 27)*

Big data is larger, more complex data sets, especially from new data sources. But these large data can be used to handle problems you wouldn't have been able to solve before.

(ID 21)

While others have regarded the concept of big data in airlines revolve around decision-making related to the company's goals.

It is the most important source for the decision maker, provided that you have a professional team has the vision, experience and tools to achieve the objectives of the airline. *(ID 14)*

4.2. The importance of big data in airlines

Odarchenko et al. (2019) stated that big data analytics has an effective role in changing the organization of airlines' operations for three reasons. First, with the advent of big data, ground preparations are faster due to reduced response time. Second, big data provides broad data-based solutions in the field of airspace management, which is the driving force for increased efficiency. Third, allowing great flexibility to deal with each passenger both at the level of registration, cancellation, which supports customer loyalty and the airline's brand. One of the interviewees illustrates the same meaning:

When the data you own provides you with daily information about the airport, airline, stakeholders, ground and operational operations, and improving the quality of work......... then that data becomes important. *(ID12)*

The importance of data is limited to the value that such data provides for the decision maker to rely on. Data has substantial value. But it won't be feasible until that value is discovered. Today, big data has become capital, with a large portion of the value that the world's largest companies provide comes from their data (Oracle, 2021). Big valued data that is constantly analyzed helps airlines to provide more solutions, develop new products, and make accurate and purposeful decisions. The interviewees assured that the importance here lies in the usefulness of the data and not in its size:

> *The importance of big data isn't about how much data you have, but what you can do with it.* *(ID19)*

According to some interviewees, the importance of big data revolves around addressing all problems related to ground services, airport and maintenance operations, and data analysis has an important role in this processing.

Airport data analytics is an important factor to provide a multitude of key information and knowledge that will help address many areas related to nearly every aspect of airport operation, from operational processes, such as improving airport resource utilization, maintenance and airport capacity to increasing revenues and maximize the passenger experience. *(ID17, ID14)*

While other interviewees consider that big data has great potentials in providing powerful solutions to improve and develop performance, which is strongly reflected in the strong return of airlines in the market and competition.

Big data has the ability to solve the problems of airlines and improving and developing its performance.   *(ID 6)*

Big data can build and impose the airline in the market within short time and can recover any situation and strengthening the airline's competitive position.   *(ID 13)*

One interviewee remarked the importance of big data as being a skeleton for the airline on which it relies for all of its decisions.

It's the skeleton of any airline; each decision at any departments depends on how many data you have.   *(ID 14)*

4.3. Big data types and sources in airlines

Huge amounts of data are circulated daily in the aviation industry, from information about existing and potential customers to flights and transactions. They change so rapidly that it is impossible to analyze them in the traditional way (Odarchenko et al., 2019). The interviewees suggested many themes for the types and sources of big data in airlines, through which a huge database can be collected in order to help airlines improve and develop operations, solve problems, increase profits and make right decisions in a timely manner. The most important of these types and sources are related to customers, airline operations, multimedia, competitors, documentation, and some other data. The types and sources of big data for airlines are classified in Figure 2 based on the responses of the interviewees.
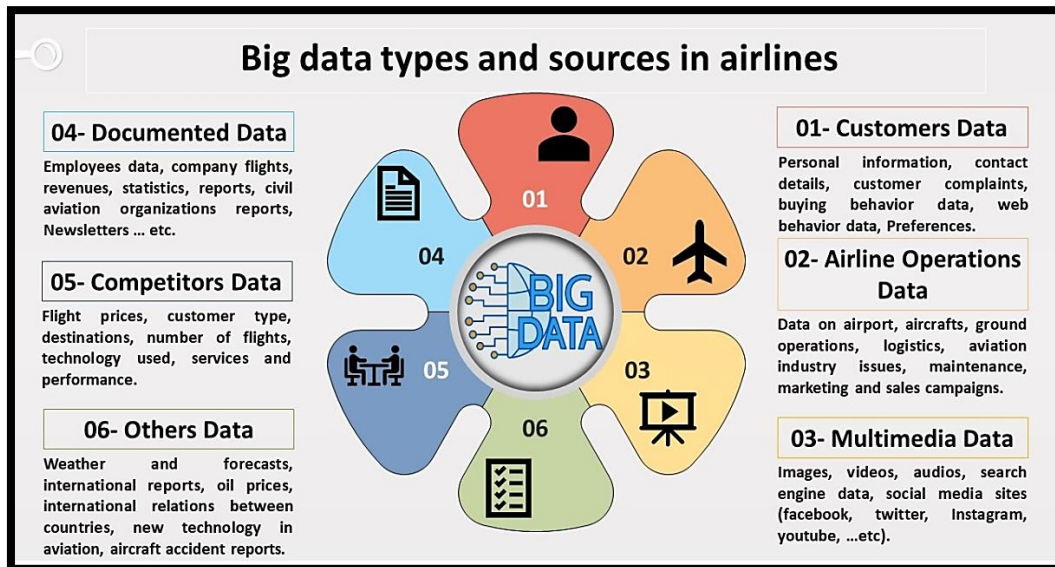

Fig.2. Big data types and sources in airlines

4.4. Big data analytics opportunities for airline success

In the age of digital data, the opportunities to use big data are increasing. Khan (2018) reported that within 2014 to 2019, the annual growth rate of big data technologies increased by 36%, with global income for business analytics and big data increasing by 60%. Many advanced data analysis techniques can turn big problems into small problems and can be used to make better decisions, reduce costs, and enable more

efficient processing (Hariri et al., 2019). The General Manager at Egypt Air mentioned during his interview that big data provides huge opportunities for the present and the future of the aviation industry as:

It is the bones, blood and flesh of the airline. (ID 14)

4.4.1. Improve services and product development

Big data analytics can also help airlines enhance customer service. By identifying passengers' buying habits and collect historical information, airlines can predict customer behavior to create personalized offerings. This not only increases ticket sales, but also boosts retail opportunities, such as baggage fees and onboard refreshments (Feliu, 2020) and to plan, produce, and launch new products.

Detecting new routes and cross-selling are considered as opportunities from customers' booking behavior insights. This leads to the provision of new services and products to travelers. (ID 11)

4.4.2. Customer experience and loyalty

Airlines around the world have recourse to big data analytics technologies. They assist in doing many matters that a person cannot do, such as, help to merge the internal systems of plane with the airport system, obtain real-time weather information, provides information on each passenger, which enables the airline to carry out targeted marketing campaigns that enhance customer loyalty to the brand (Odarchenko et al., 2019).

By obtaining passenger data from airline tickets, social media, and their contact data, and by analyzing that data, the airline can provide value services that enhance customer experience and loyalty. (ID 25)

4.4.3. Predictive maintenance

Adopting the big data analytics helps airlines in real-time plane monitoring and predictive maintenance. Using big data analysis airlines can determine fuel consumption, which accounts for 17% of all airlines' operating costs, on a per-flight basis. For example, Southwest Airlines provided a range of sensors embedded in the plane to measure temperature data, wind speed and weight of the plane along with fuel consumption. In addition, Boeing analyzes 2 million cases across 4,000 aircraft daily in order to plan maintenance and support preventive action. This saves the company $300,00 annually in-flight delays and repair costs (Feliu, 2020). All these procedures and analyzes aim to achieve maximum security in order to provide a safe travel experience.

It is very necessary in the field of aviation to provide accurate and sufficient information about any defect in the aircraft that needs to be repaired, modified or checked for any part of the aircraft before the flight, and I believe this is one of the vital roles of big data analysis, which provides a safe travel experience. (ID16)

..... Also, big data analysis plays a pivotal role to predict the maintenance date, providing information about the parts that have been serviced, the availability of the part that needs maintenance in the stock, the year and model of parts, the time of

maintenance and repair, the next maintenance date, how often Aircraft maintenance and its malfunctions, the number of previous flying hours of the aircraft. **(ID 17)**

4.4.4. Safe flights

The respondents indicated that big data procedures and analytics are intended to achieve the highest levels of security and safety in the aviation industry in order to provide a safe travel experience.

Reviewing aircraft disaster data and analyzing the causes of aircraft accidents allow the aviation industry to discover potential hazards, resulting in fewer accidents and safe travel for passengers. **(ID 3, ID 22)**

4.4.5. Support decision making

In the era of rapid change and development, companies are looking for the best way to take advantage of data for decision making. By managing and analyzing big data, decision makers can use data, information, and knowledge that are useful for problem-solving and decision-making at the individual and organizational levels (Visinescu et al., 2017). Big data analytics can improve decisions about financial and planning issues. It can also be used to support decision-making in line with existing market demands.

Big data analytics allows you to get a complete picture of information, which means a different approach to improving decision-making. **(ID 8)**

The right decision in any single step at any departments depends on the data you have internally and externally. **(ID 14)**

4.4.6. A Personalized customer experiences

Personalization, as a familiar concept in marketing, is gaining importance in aviation industry. It strives to identify current and potential customers and offer them the required services at the right time, price and conditions (Klein and Loebbecke, 2003).The majority of interviewees indicated that due to the huge amount of data that airlines deal with daily, especially with regard to customer data, which can be obtained from many sources, such as ticket reservation data, social networking sites, contact data, customer service data, and travel reviews data, customers' past travel history.... etc. All this information and data, and through its processing, provide great opportunities for the airline to provide services and offers that suit the wishes and needs of its customers, which represents a unique personal experience for each customer and supports his loyalty to the airline.

Today airlines collect tons of information about their customers. Crunching this information enables airlines not just to segment passengers better, but also to provide a personalized experience to each customer. It is a one-to-one relationship between the airline and the passenger that increases customer satisfaction and builds extraordinary loyalty. **(ID 4)**

Knowing the types of passengers and their needs will facilitate the process of reaching them and meeting their needs. **(ID 1)**

4.4.7. Differential pricing strategy

Differential pricing strategy is a common strategy to distinguish prices based on customer characteristics, such as personal characteristics, purchase histories, zip codes, or behavior patterns are offered different prices. Similarly, prices based on group often depend on categories like 'domestic or foreign citizenship', 'age' or 'social status' (Klein and Loebbecke, 2003). Big data processing allows the airline to select customers according to their needs and desires, one customer may be time-sensitive, another may be price-sensitive, another is looking for services and facilities, and other customers are not interested in these details. Therefore, airlines can segment their customers and create various offers to meet the needs of different segments. Depending on the offer, airlines can price their tickets and services. This differential pricing strategy helps in maximizing revenues from each customer (TechVidvan, 2021).

Opportunity to provide competitive prices for each customer based on the airline's customer database.   *(ID 17)*

..... Moreover, the price flexibility provided by data analysis allows customers a wide base of choice and purchase decision.   *(ID 13)*

4.4.8. Anticipate future supply and demand

The development of big data, sensor technologies, predictive analytics, processing capacity, connectivity and storage present big challenges, as well as providing opportunities for airlines and customers. Advances in big data and analytics are expected to assist airlines predict and adjust to changes in supply and demand in real-time (IATA and SOIF, 2018).

I see that by analyzing passengers' data every period of time, we can expect an increase or decrease in demand, as well as an increase or decrease in the number of flights to a particular country.   *(ID 12)*

4.4.9. Evaluating current routes and opening new routes for flights

According to the personal interviews, participants believed that once the airline has a comprehensive database for flights, the number of customers per flight, their data, desires and preferences; this provides an opportunity for the airline to conduct an analysis of the current travel behavior of customers and based on the results of that analysis, the airline can predict the most important routes Which generate income for the company, as well as the most important future paths that the company can open to achieve many profits.

The tourist service is very faulty, every empty seat on the plane is lost forever, so by knowing what are the reasons that led to not filling the seat, is marketing the reason or the flight path does not have a demand, or the size of the plane is large and the demand on this path is little or what? Therefore, analyzing that data and knowing the reasons is reflected in the decisions to reduce the number of flights for this route, cancel it or open a new route.   *(ID 17)*

4.4.10. Developing creativity

Now, big data is pushing airlines towards a more, new innovative future (Feliu, 2019). Airlines must deal with big data in an innovative, new ways that enable them to retain and control their businesses and customers. They have to completely change the way they operate by making use of big data techniques and analytics to be the leader in the field of information technology, as it has led the way in IT in the past electronic reservation systems at a time when banks were still doing manual ledgers (IATA, 2018). As cited in Mei Chen et al. (2016: 5099), Roland Schütz, CIO, Lufthansa stated that "Aircraft and new applications are now considered to be of equal priority; we can only move forward by improving IT capabilities. We believe that this is the only opportunity to survive the coming competition."

The Answer is, how to think out of the box??? This question for the responsible person can make him Reach to the goal, so what is the market need to Success ... this destination for Airlines can achieve the target of Sales Finally all these points is analysis.   *(ID 7, ID 13)*

How does the analysis of your data affect your services, service delivery, customer complaints resolution, regular trips, employee and customer satisfaction, and winning the competition? This is creativity.   *(ID 10)*

4.4.11. Cabin Crew and Staff Management

With a complete database of airline big data, the company can make new applications for pilots, crew and other employees. At the time, cabin crew and ground control play a critical role in monitoring flight performance and maintenance. Weather data and maintenance reports will help pilots choose the best safe flight path to avoid unwanted accidents. The database also helps cabin crew and airline staff improve passenger boarding on and off the plane, thus decreasing ground time. Some data may be shared with passengers to make them feel better about safety considerations (Nagarajan et al., 2017).

In every flight, we deal with a huge amount of data and reports related to operation, testing, maintenance, warning, control, communications, air control and others. When analyzed closely, this data can simplify operations and improve safety.
                                                            (ID 15, ID 24, ID 19)

Providing us with any information, even if it is simple, about any matter related to the flight, which makes a lot of difference in the flight path.   *(ID 6)*

When the exchange of data and information is available quickly and flexibly on the plane, this provides us with safety before the passenger and helps us to act well in emergency situations.   *(ID 23, ID 3, ID 19)*

4.4.12. Benchmarking and performance measurement

With the help of big data analytics, airlines can effectively analyze performance measurement through the analysis of data for each flight such as number of passengers traveling, profit per passenger, average revenue, operating cost, average flight occupancy, overbooking (TechVidvan, 2021). This data is used by the company to take some corrective actions or increase incentives and rewards for employees.

..... I often use numbers and statistics to shortlist the operations, costs, and any crises specific to a flight or customers, so we can use them on the next trip, and compare ourselves to others.   *(ID 10)*

The most important thing is to understand the meaning of the data that you are processing, so that it is easy to direct it to the right place and person to fill any gaps or shortcomings in the performance of the work.   *(ID 18, ID 25)*

4.5. Challenges of big data in airlines
With big data, airlines not only encounter numerous appealing opportunities but also face challenges. These challenges must be overcome to maximize big data benefits because the amount of data and information surpasses the airlines' harnessing capabilities (Khan et al., 2014).

4.5.1. The huge amount of data
The amount of data generated every day is dramatic. In 2018, the amount of data generated every day was 2.5 quintillion bytes (Marr, 2018). Formerly, the International Data Corporation assessed that the amount of produced data will multiply every two years (McAfee and Brynjolfsson, 2012). Moreover, Google processes more than 40,000 searches per second (Marr, 2018). There are 1.91 billion people on average log onto Facebook daily and are considered daily active users for June 2021 (Zephoria, 2021). Every 60 seconds, Facebook users upload 300 million photos, 510,000 comments, 293,000 status updates, and 4 million posts are liked (Osman, 2021). As a result, this enormous amount of data needs techniques to analyze and understand, as it is a big source from which to deduce valuable information (Hariri et al., 2019).

The respondents argued that the volume of huge data that airlines deal with daily in light of the rapid and successive developments in the global aviation market makes the process of storing data a challenge for global airlines.

Availability of places to store the huge amount of data of daily flight operations can be a big challenge for us.   *(ID 5, ID 20)*

This imposes on specialists in the field of data science and analysis the need to search for valuable and useful data more than collecting a large number of unhelpful data for the airline, which wastes time, effort and money.

..... Then the process of sorting, classifying and analyzing data related to customers and the company operations is an important matter that helps in solving the problem of storing a huge amount of data.   *(ID 21, ID 5)*

4.5.2. Organizing and managing Data
The interviewees stated that the huge amount of daily data generated by the aviation industry, whether technical, operational or related to customers and others, needs to be organized and managed in a way that allows airline employees easily access to any data or information in real time and supports the decision-making process.

There is an important rule in management science that it is more important than owning data is that you can organize and manage that data and provide it to the

decision maker in real time, without organizing and managing data, your data becomes inaccurate and the company will not benefit from it.   (ID 22)

4.5.3. Data processing technology

In fact, it is difficult to deal with the huge amount of data using traditional management tools. Accordingly, big data processing programs are relied on for data extraction, storage, data sharing, and data visualization, in order to provide a data framework including tools and techniques used to investigate and transform data (Tyagi, 2020). The data type also significantly influences the selection of the most suitable technological software and the pre-processing is, in many cases, the most urgent side of the entire process (Papagiannopoulos, 2021). Data processing software is widely associated with other technologies such as machine learning, deep learning, artificial intelligence and the Internet of Things that are being enhanced on a large scale (Tyagi, 2020).

After Hadoop, Apache Spark, new AI technologies and numerous programming languages have emerged to deal with big data, and over the coming years keeping up big data technology will be a constant challenge.   (ID 21, ID 10, ID 22)

The aviation industry needs technologies that merge and enhance a large number of data types, formats, and structures in real time. It is also important to have technologies developed specifically for the needs of aviation.   (ID 5)

The biggest challenge at this point lies in creating a unique technology to process big data and cannot be imitated by competitors and this does not conflict with the experience of new technologies. But many are afraid to implement new methods and techniques for fear of failure.   (ID 21)

4.5.4. Lack of knowledge

The respondents indicated that there is lack of awareness of the concept of big data among some employees in different departments in airlines, and this is one of the challenges that may lead to the absence of a culture of data importance, handling and analysis. As it is necessary for every individual in the airline to deal with every data or information as a valuable asset, how it contributes to the fulfillment of work, and how to direct it to the right place for supporting decision-making.

One of the most important difficulties is the lack of knowledge of airline some employees about the concept of big data and its importance.   (ID 15, ID26, ID 3)

4.5.5. Data Privacy and security

As data analytics is customer-focused, data privacy and security are major challenges for airlines. The issue of customer data privacy and security has always been of great importance to any customer, which may require airlines to guarantee the privacy and security of their customers' data. On the other hand, the issue of data privacy and security is not only related to customers, but also to all data, transactions and revenues of airlines, which requires airlines to secure this data from piracy and hackers, especially those related to big data processing software.

When it comes to big data analytics, data privacy and security is also a big challenge.
(ID 14)

Airlines also have concerns about saving data and handling or transferring data in cloud-based systems, such as social media sites. *(ID 9)*

...... policies that include all customer privacy concerns should be promoted, and customer data should not be misused or infiltrated. *(ID 10)*

4.5.6. The need for Data-Driven Culture

Literature on data-driven organizations often focuses on the tools and technological development that have made data storage, processing, and analysis faster and cheaper. Despite of this, for many airlines, a strong data-driven culture still remains elusive, and data is rarely the basis for decision-making (Waller, 2020).

The majority of airline managers don't think about how to use big data to improve performance - which is a big problem. *(ID 9)*

An organizational culture based on data enhances the use of data in decision-making. It treats data as a strategic asset for the airline by making data widely available and accessible. It focuses on collecting, refining, and organizing meaningful data from across the airline. It is a culture with a high level of data literacy that promote repeated experimentation for learning and improvement and the belief that data helps everyone perform better (Vachhrajani, 2020). A successful big data analytics approach needs time and the desire to test, evaluate and cultivate the developed models. Big data analytics should, therefore, be considered part of the core business operations for the airline (Papagiannopoulos, 2021).

Without a data culture, dealing with data would be randomly. *(ID 17)*

Airlines need leaders who understand the importance and power of data to differentiate themselves from the competitors. *(ID 18, ID 25)*

Airlines that understand the importance of data can generate meaningful data that everyone in the company can access and use in their decisions. *(ID 17)*

.... In addition, airline employees need to work in a collaborative environment that clarifies how to deal with big data and how to use it in the context of their role. *(ID 5)*

4.5.7. Lack of qualified human resources in data science

Big data is not only about analyzing it. But it is a whole process that requires insightful analysts, business users, and executives, who ask the right questions, recognize patterns, make assumptions, and predict behavior (Oracle, 2021). The interviewees frequently referred to the challenges related to the lack of qualified individuals in the field of data analysis, as traditional skills for dealing with data are insufficient in the case of big data.

The majority of local, regional and international airlines suffer from a shortage of qualified personnel in the field of data science and analysis. Despite job announcement for these Specialties, there are very few or no qualified applicants. *(ID 10, ID 8)*

This shows the importance of training employees to deal with and analyze data and spread that culture among all company employees, which may represent a solution for this challenge.

Some airlines deal with this by training some of their employees how to analyze and display data. *(ID 8)*

If you have the qualified staff, under a supervision of high qualified management and they have the power to achieve the targets of the airline according to the airline strategic plan. If so, it's more than enough. If the airline does not have qualified person, it will need to recruit, or gets the data from outsourcing companies. *(ID 14)*

In the following context, the participants were asked whether it is better for airlines to recruit a company that is specialized in big data analysis? or hire someone responsible for this task? The interviewees highlighted that outsourcing an external company specialized in data analysis and processing is better, as they will be more capable and efficient in dealing with big data due to their specialization and field of work in data science.

Outsourcing will become more capable and efficient in analyzing customer data.

(ID1, ID7, ID 15, ID 24, ID 26)

Definitely hire specialized company responsible for this task. Data analytics can be done more proficiently with the availability of distributed it to decision maker.

(ID 2, ID 7, ID 11)

On the other hand, other participants believed that it would be better to employ an individual to be responsible for analyzing and processing data, as he/she would be more able to access accurate and airline-related data and information, in addition to maintain the confidentiality of the company's data, and that will support his loyalty to it.

It is better to appoint a responsible person to obtain more accurate and efficient results. *(ID5, ID 8, ID 13, ID 21)*

Hire someone responsible for this task to get his / her loyalty to organization. *(ID 27)*

The respondents also suggested that the airline could appoint a person responsible for analyzing and processing data, and outsource an external company specialized in data science in the event that it was not possible to obtain any data related to some non-specialized business such as marketing data, industrial data or any data far from the field of aviation, but airlines may need it in their business.

Definitely a person in airline with someone who is an expert in the area. *(ID 6)*

Mainly you can't get all the data by yourself easily, especially, the data for marketing. In that case you have to depend on outsourced company. *(ID 14)*

5. Discussion and conclusions

Big data as a new technology paradigm for data that is generated at high velocity and high volume, and with high variety, has captured the attention of both researchers and practitioners. Davis (2014) describes big data as expansive collections of data (large volumes) that are updated quickly and frequently (high velocity) and that exhibit a huge range of different formats and content (wide variety). Big data analytics is a process of examining information and patterns from huge data. The airline industry is

interesting because of its importance to the global economy, international presence and fierce competitive environment (Sternberg et al., 2018). The current paper is one of the studies that inductively explain the challenges and opportunities that big data can provide to airlines. For this purpose, an inductive qualitative analysis based on intensive semi-structured interviews have been conducted with employees and experts at airlines in Egypt (N=27). The findings provide several insights into the main challenges that airlines may encounter as well as the opportunities they may capture in the aviation industry, which has enabled the development of a theoretical framework explaining these challenges and opportunities and other issues related to big data in airlines (see Figure 3). The results advocated that the concept of big data from the point of view of airline employees differs from one individual to another. The interviewees considered big data as all data related to the customer from personal data, contact data, customer's profile on social networking sites and e-mail, while others highlight that big data in airlines relates to all data related to the flight from reservation data and data related to ground and operational services as well as services provided before, during and after the flight. This difference may be due to their work affiliation, as each of them observes the concept of big data according to his position in the airline and the type of data he deals with.

Additionally, the interviewees reported that big data is the primary and first source in the airline to deal with problems and support decision-making, and this view revolves around the importance of the role that big data plays in the ground operations of airlines. The results indicated that big data has a great importance in providing broad solutions for airspace management and flexibility for dealing with each passenger (Odarchenko et al., 2019) and maintenance operations. The findings also revealed that interviewees often attach big data analytics with the value of decision-making, faster ground operations, as well as improved performance. These findings are particularly important because they shed light on how these different aspects as a result of big data analytics can provide solutions to customer problems, strengthen the airline's competitive position, and support brand and loyalty. This is in line with the findings of Saggi and Jain (2018) and Shamim et al. (2019) who reported that big data analytics can provide various types of decision making namely data mining, data visualization, predictive modeling, optimizing modelling, prescriptive methods, and performance management. Whereas, by using the results of big data analytics, airline employees have positive tools on the effectiveness of valued decision-making, as well as improving the quality of the company's work performance (Wamba et al., 2017).The study identified many types and sources of big data that airlines deal with on a regular basis (Figure 2), which are related to customer data, flight data, multimedia data, documented data, competitors' data, and some other data related to the aviation industry, international reports, oil prices, political relations between states and others.
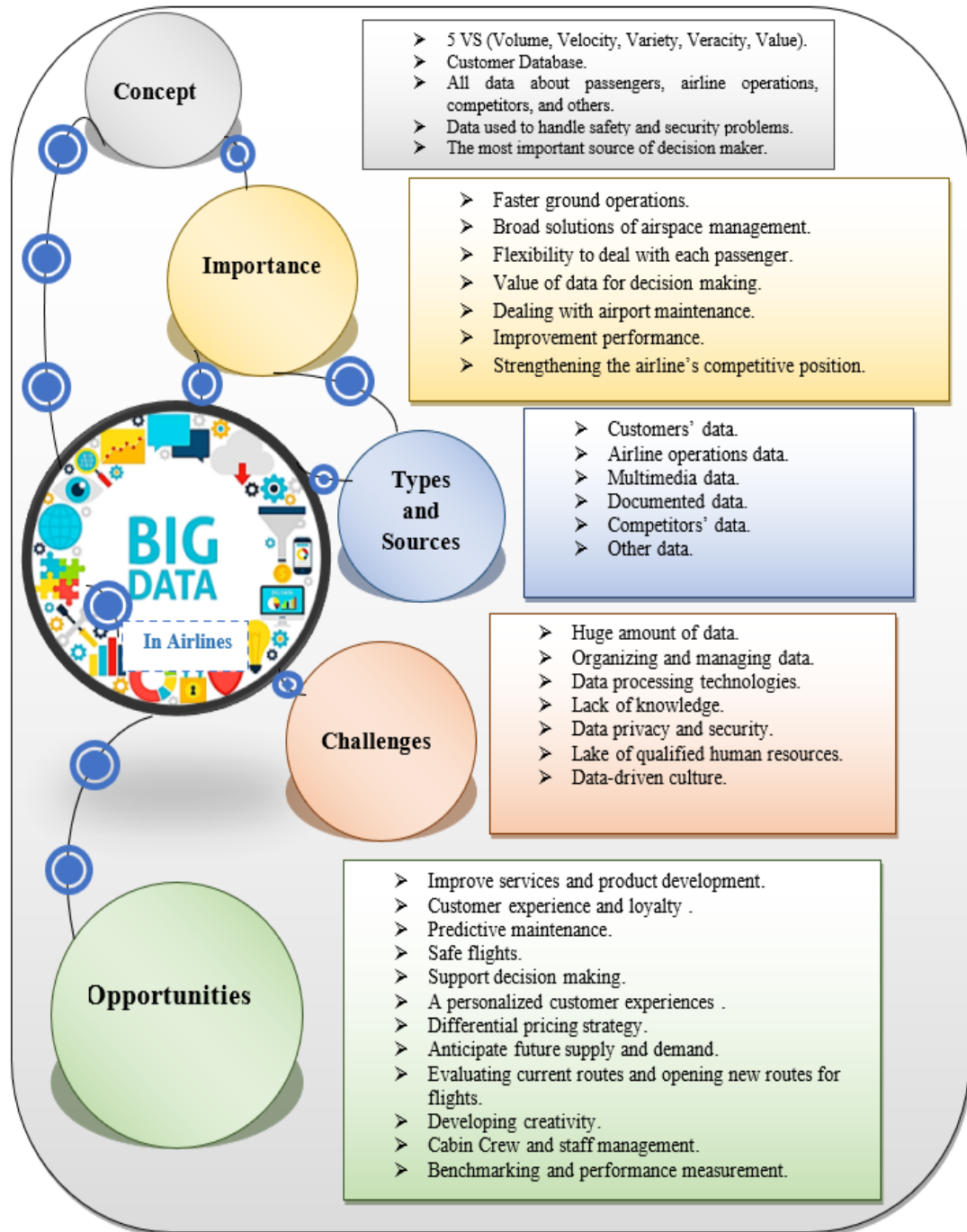
Fig.3. Theoretical framework for big data in airlines

The results also demonstrated that big data presents a plenty of promising opportunities for the aviation industry. Big data provides airlines with modern insights that can invent new business models (Oracle, 2021). Through big data analytics, airlines can improve services and product development, support customer experience and loyalty, obtain predictive maintenance, provide safe flights, personalize customer experience, provide differential price for each customer and

groups, anticipate future supply and demand, cut costs, support decision makers, evaluate current routes and open new ones, develop creativity in customer services and technology, and affective management for cabin crew and staff. Big data also assists airline companies to optimize the process of booking, ordering and luggage tracking. Furthermore, big data can help airlines to have a better understanding of their customers. They can identify each customer's behavior, keep track of their preferences, and predict future demands. The airlines can also promote their businesses and marketing campaigns, enabling them to achieve success and superiority in a strong competitive market. With a huge stock of data at their disposal, big data technology can change the way airlines do work. By giving a priority to data collection and analysis, they can react to customer needs, desires, and market trends with accurate and fast (Feliu, 2019). In this vein, there are many opportunities that can be obtained through adopting big data technology, including increasing operational efficiency, informing strategic direction, developing better customer service, identifying and developing new products and services, identifying new customers and markets (Chen and Zhang, 2014) In fact, big data from airlines, airports, aircrafts, aviation service providers, alongside with open linked data (e.g., for weather, environment, customers, etc.), have the opportunities to the aviation industry by predicting early failures and maintenance issues, improving flight routes, rescheduling paths, improving operational and logistic services, protecting the environment and controlling safety and risk threats (like pandemics and terrorist attacks) (Papagiannopoulos, 2021). Big data can also help airlines in predicting estimated arrival times, weather conditions and flight information which improve flight scheduling (McAfee and Brynjolfsson, 2012). Big data can lead to business knowledge and guide the managerial practice in order to achieve a sustainable competitive advantage (Chen et al., 2014). The airlines will be able to distinguish themselves from competition and stay at the top of the market by their ability to stock and manage big quantities of data both from inside and outside (Sumathi et. al., 2017).

The findings illustrate a range of challenges that airlines may face when dealing with big data. One of the important challenges that can face big data in the airlines is the shortage of skills. Airline can eliminate this by including big data technologies, regards, and decisions are added to airline IT governance program (Oracle, 2019). Airlines can address this problem through training, training of trainers' programs, and specialized companies in the field of data science, in addition to hiring new employees in this field. Hence, it may be better for the airline to have its big data analysis system link and integrate the relevant data together, and support it with many summaries, tables and figures that lead to better conclusions. Through data analysis, different types and sources of data can be linked to form specific relationships that end with meaningful value decisions. This challenge is also related to a lack of knowledge and absence of organizational culture based on the importance of data in airlines. Many challenges related to big data are more likely to be related to organizational culture and not to data or technology (Alharti et al., 2017). Organizational culture in the field of big data is often referred to as organizational learning, which is a pivotal side of big data process (Gupta and George, 2016;

Mikalef et al., 2017; Jeble et al., 2018). We suggest that airlines' leadership should adopt a vision for the change based on a data-driven culture in entire airline processes (Lunde et al., 2019). This finding is consistent with the study of Duan et al. (2020) which stated that there is clear evidence that explains the significant role of data-driven culture as an arising organizational culture in the field of big data.

In addition, the findings depict that the huge amount of big data and how to store and deal with it is a true challenge for airlines, keeping in mind the procedures of collecting and storage restriction, huge volume of data, and delayed process fulfillment. This is in agreement with the study of (Saggi & Jain, 2018; Chen et al. 2014; Chen and Zhang, 2014). Moreover, the airlines could not fully exploit the data information due to lack of time, resources, technological skills and infrastructure (Sumathi et al., 2017). In order to deal with this challenge, airlines should develop a set of software and technological applications to deal with the processing of big data (Zhao et al., 2009; Taheri et al., 2013; Buza et al., 2014), which in itself represents a new challenge for airlines. Data processing technology programs represent another challenge for airlines, which means choosing a data processing program that matches the company's goals and the skills of its employees, and can analyze the relationships between the various data that the airline deals with daily and present it in the form of meaningful information to the decision maker. This finding is in line with the study of Bhadani and Jothimani (2016) which reported that the advantages and applications of big data analytics are being realized in various sectors. This requires many companies to introduce data analysis technology into their operations and to choose the technological applications that suit them according to their field of work, as the huge amount of data processing programs currently make the process of analyzing big data a reality that is difficult for any airline to lag behind.

6. Implications and future research areas
Big data analytics is expected to become increasingly important in the near future. The unmatched volume, diversity and affluence of aviation data that can be obtained, created, stored and managed provides unique capabilities for aviation-related industries (airlines, passengers, airports, product and service providers, manufacturers, local authorities, etc.) and more of values that remains to be opened. In aviation industry, big data are important issue for both manufacturers and airline companies. For manufactures, the advantages are represented in the domains of engineering, supply chain, aftermarket, and program management. For airlines in the other hand, benefits are identified in the areas of flight operations, fleet management, maintenance, inventory management, pilot and crew management (Izzo, 2019). The current research findings have important implications for both theory and practice. Theoretically, the study provides many new insights and opinions regarding the concept, importance, sources and types, opportunities and challenges that big data presents to airlines. In addition, the inconclusive findings thus far regarding the different effects of developing an organizational culture based on the priority of dealing with data. In this vein, the study has shown that airlines that adopt and have data analytics-driven culture may have great opportunities to benefit from such analytics. Hence, more research is needed to link the role of organizational culture

and organizational learning and big data analytics. There is also a need to conduct more research with a quantitative approach to study the capabilities of big data for airlines and their impact on performance improvement, decision making, customer satisfaction, and customer loyalty. Practically, our findings introduce many important implications for airlines. The study presented some challenges and more promising opportunities for airlines that adopt big data technology. Therefore, leaders are urged to embrace such opportunities to improve airline performance, achieve customer satisfaction and loyalty, support decision-making, and achieve competitive advantage. On the contrary, companies that will not catch up with the implementation and adoption of big data technology will lag behind their peers and may lose their competitive positions as well as their customers. Against the previous findings, we recommend airline leaders to organize periodical training programs for all employees on big data analytics, data visualization, data mining, and data processing programs. It is also important for airlines to use big data in the way that aligns with their goals and vision. Based upon the previous results, the study recommends implications for airlines;

1- Identifying a strategic plan with clear vision of the aims of big data technology. The main concern is not the adoption of an advanced big data system but to assure that it really serves the company.

2- Optimizing the application of big data analytics techniques. Data analytics can reduce costs and identify innovative services.

3- Recruiting qualified data specialists or experts with the appropriate knowledge of the airline business environment. Firms will have to offer highly competitive salaries to qualified data scientists and may need to develop data analytics training programs for their current employees.

4- Developing a data culture, based on an integrated approach of data sourcing, models expansion and organizational transformations. Careful assessment of the big data technology is a must. The implementation of big data technologies requires a change in management processes to minimize the associated organizational risks.

5- Establishing a data quality control system to evaluate data quality and repair any data errors.

6- Paying more attention to the privacy and security concerns. Relevant laws and regulations are required to protect the user information. Installing proper security data management techniques such as detection systems, encryptions, and firewalls is needed to consider.

To date, several studies have discussed the technical aspects of big data, but fewer focused on the organizational outcomes of big data technology especially in the tourism industry. It is also significant to understand the mechanisms and processes through which big data can add business value to tourism enterprises. Future studies need to be addressed for the previous domains. Besides, further studies can address the modern technology techniques and their impacts on the tourism and aviation

industry. It is suggested that further research explores more opportunities and challenges in big data technology, and its relations with blockchain, cloud computing, artificial intelligence "AI", machine learning "ML", and the Internet of Things "IOT" applications.

Acknowledgements

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Appendix "A" interview Guide

Concept

From your point of view, what is the concept of big data in airline industry?

Importance

What is the importance of big data for airlines?

What do you believe about the value of big data analytics for your airline?

Types and Sources

What types and sources of big data that airlines dealt with?

Outsourcing or Hiring

How many people with data analytics skills work in the airline?

In which department of the airline do they work?

From your point of view, is it better for airlines to outsource the big data analytics process to a specialized company? Or hire someone responsible for this task? and why?

What are the training programs suggested to your employees?

Opportunities

How can big data analytics provide opportunities for airline success? How do your airline benefit from it?

How do big data create value in the airline? How can it affect the decision-making?

Do you think that there is a data-driven culture in your airline?

Challenges

What are the challenges of big data analytics in airlines? How to deal with it?

Participants' Profile:

Name: …………...   (optional)

Gender: …………...   Age: …………...

Educational Level: ………….   Current Profession: ……………

Airline Name: ……………………   Years of Experience: …………

تحليلات البيانات الضخمة في شركات الطيران: الفرص والتحديات

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معلومات المقالة	الملخص
	تشير البيانات الضخمة إلى الكميات الهائلة من المعلومات في شكل منظم وغير منظم والتي لا يمكن معالجتها باستخدام أنظمة البيانات التقليدية. تسهل تقنية البيانات الضخمة استخدام كميات كبيرة من البيانات الخارجية والداخلية لإنشاء منتجات وخدمات جديدة وتحسين العمليات التجارية. في عصر البيانات الضخمة، يمكن لشركات الطيران تقديم خدمات أكثر إرضاءً للعملاء وتظل قادرة على المنافسة بقوة في الأسواق. يمكن لشركات الطيران أن تجني الكثير من الفوائد من البيانات الضخمة، ولكن لا تزال هناك تحديات كثيرة. توضح هذه الدراسة كيف تتبنى شركات الطيران تكنولوجيا البيانات الضخمة بنجاح. تستكشف الورقة أيضًا فرص وتحديات البيانات الضخمة في صناعة الطيران. باستخدام المنهج النوعي، تم إجراء عدد 27 مقابلة شبه منظمة مع الخبراء والعاملين بشركات الطيران في مصر. تكشف النتائج أن البيانات الضخمة لها أهمية كبيرة في توفير فرص واسعة لإدارة المجال الجوي، تعزيز المرونة في التعامل مع كل راكب، دعم اتخاذ القرار وحل المشكلات، توفير رحلات آمنة، تعزيز الصيانة التنبؤية، وتحسين الأداء. توضح النتائج مجموعة من التحديات التي قد تواجهها شركات الطيران عند التعامل مع البيانات الضخمة؛ مثل نقص الموارد البشرية المؤهلة، وغياب الثقافة القائمة على البيانات، التعامل مع ومعالجة الكمية الهائلة من البيانات، فضلاً عن قضايا خصوصية وأمن البيانات. أخيرًا تمت مناقشة الآثار المترتبة على الممارسة وكذلك الأبحاث المستقبلية.