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PWM Controlled Servomechanism

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Abstract

Precise control of aircraft flight control surfaces by the pilot is critical to flight safety. The joystick and control surface positions must be detected accurately and quickly, and the motion mechanism must be operated in such a way as to ensure synchronization between them. The analogue voltage value taken from the potentiometer, which is used as a position sensor in many small aircraft, can be used directly or by converting to digital.

In this applied study, the analogue position knowledge received from the potentiometer on the joystick was converted into a PWM signal with an oscillator circuit. The PWM position signal applied to the IR (InfraRed) LED in the transmitter unit is sent as infrared light. The PWM position knowledge detected by the photodiode in the receiver unit was passed through the LPF (Low Pass Filter) and the voltage value of the joystick potentiometer was obtained again. With the mechanism controlled according to the difference between the potentiometer values of the joystick and the control surface, the synchronization between the joystick and the control surface is ensured. In this study, a wireless and stable servomechanism connection is obtained by transmitting PWM position knowledge as IR.

1. Introduction

The ability of an aircraft to fly safely depends on the full control of the flight control surfaces by the pilot. For full control, it is very important that the synchronization between the control handle used by the pilot and the flight control surface is uninterrupted and instantaneous. When a sudden maneuver is required during flight, an accident is inevitable if the command given by the pilot with the joystick is not completely and accurately transferred to the control surface. For this reason, a stable and correctly functioning servomechanism system is one of the most important equipment for an aircraft. In a well-functioning servomechanism, the positions of the control lever and control surface must be detected accurately and the control surface must be moved according to the control lever position.

Servomechanism can be defined as the mechanism that automatically adjusts the movement of a mechanical device according to the feedback signal from the sensor in the device. There are basically two types of servomechanisms used for position and speed control. In engine speed control, speed knowledge can be obtained analogously with a tacho generator or digitally with an incremental encoder connected to the engine shaft. This speed knowledge is compared with the reference value determined for the speed, and control signal is applied to the motor driver circuit so that the difference between the motor speed and the desired speed is minimal. Some types of speed limiting servomechanisms, called "governors", which work completely mechanically, have been used in the steam engines in the past (Wikipedia, 2023).

In the servomechanism used for position control, it is very important to correctly detect the position of both the joystick and the controlled mechanism (control surface). Position knowledge can be obtained as analog with a magnetic sensor or potentiometer, and digitally with an absolute encoder. Although the potentiometer has some disadvantages such as inaccurate value due to contamination and wear over time, it is cheap and simple to use, making it frequently preferred in many low-cost small UAV applications.

The movement of the control surface can be electrical, pneumatic or hydraulic. The servo motor used in the electrically driven unit provides motion with a gear set to produce high torque. The driver of the servo motor used is controlled by the servomechanism circuit. In the case of a pneumatic or hydraulic system, the valve that controls the fluid velocity is adjusted by a low-power electric motor controlled by a servomechanism. Hydraulic or pneumatic actuators are used, especially in large-scale aircraft that are exposed to high forces, and hydraulic or pneumatic fluid is controlled by a servomechanism.

In the literature, some examples of servomechanisms performed in many different fields and with different methods can be briefly summarized. Lang at al. proposed an electro-hydraulic servo system with pressure control valve and used two methods to compute the whole system natural frequency in frequency domain. In the study, in which the system dynamic response was increased, the natural frequency of the

system was calculated by creating an electro-hydraulic actuator model. (Jang, 2009). An electronic-mechanical actuator, used IEEE-1394B bus to interact aircraft network is integrated in aircraft remote control unit. In the system where pre-distribution broadband technology is used to transmit commands, DSP + FPGA is used for decoupling control. DRV8301 was used as power conversion and motor driver for a complete protection strategy (Hu, 2021). Discrete-type position sensors for precision control at high temperature is proposed for aerospace systems by Kim at al. By using micro electro-mechanic system technology in the position sensor design, a resistive element was made with MoSi2 and multilayer metallization containing TiN, Ti, Pt was performed on the Si layer. (Kim, 2018). A microcontroller-based tester was designed for Electro-Hydraulic Actuators at fly-by-wire aircrafts. The algorithm sends a pass or fail message according to the Electro-Hydraulic Actuator pressure and position sensor signal. The Electro-Hydraulic Actuator response capability is then tested for a proper dynamic response evaluation. (Lucena, 2007). Another work is focus on Brushless Alternating Current (BLAC) motor and control algorithms, for intelligent actuators based electrical servo drivers. In the study where incremental encoder and Hall magnetic sensor were used for rotor position, the speed control algorithm and accuracy were simulated. (Toman, 2014). A stepper motor actuator is used to adjusting cabin pressure by controlling pressure valve. For correct positioning, angular displacement was achieved by controlling the number of pulses according to the stepper motor type and thus the aircraft cabin pressure was adjusted. (Zhou, 2018). A position control system using PMDC motor was designed by utilizing MATLAB based PID controller. Angular calibration data of the PMDC motor, linearity and reliability of the control system were examined. (Bandyopadhyay, 2016). In this study, a piezo actuator-based linear actuator is electrostatically controlled. The sliders in the electrostatically controlled linear actuator are driven by the electrostatic clutch mechanism and the piezo actuator, providing gradual movement of the sliders (Nguyen, 2013).

An unmanned aerial vehicle (UAV) has been produced, with the necessary designs for the transition from passive to active flight. In order to achieve maximum performance, the appropriate wing and tail structure was designed, and liquid fuel engines were used for higher power and operating times. (Coban et al. 2023). In the study, where the effects of drone use in the field of logistics on the sector were investigated for current and future situations, literature research was also conducted. When the tables created according to the research results were analyzed with the DEMATEL method, market share was the most important factor, while security problems were the least important factor. (Düzgün, 2021). In many cases, it is undesirable to notice unmanned aerial vehicles (UAVs) in the sky. In this study, a lighting system was placed on the underside of UAVs to make visual tracking difficult by the enemy. With the lighting adjusted according to the amount of light in the environment, the UAV's visibility in the sky has become difficult (Konar, 2021). Unmanned aerial vehicles (UAVs) that navigate using the global navigation satellite system (GNSS) may deviate from the target if the connection with the satellite is lost due to environmental factors. By using infrared and ultrasonic sensors data, a study was conducted to prevent the UAV from deviating from the target even in such closed environments where the connection may be lost (Y. Dalkıran, 2021). It is extremely important to know the maximum flight time and distance of an unmanned aerial vehicle (UAV) so that it can be used safely for a specific mission. In this study, the prognostic method is discussed to obtain the necessary data set to calculate flight time and distance (Erşen, 2023). The block diagram of the autopilot used in the study investigating the state space analysis and control system for the unmanned aerial vehicle (UAV) was modeled with MATLAB / Simulink. The autopilot system was later updated to minimize the cost function created by takeoff, flight time and overwork (Coban, 2018). In sport aviation, long distances can be traveled using natural air currents. One of the most important indicators for the pilot during flight is the device called variometer, which gives the vertical speed change. In the study, a low-cost Arduino-based variometer was designed and produced (Kekec, 2020). Maximum performance of an unmanned aerial vehicle depends on its aerodynamically suitable structure. In the study, four UAVs with different body structures were designed and, according to the analysis, the highest performing model was produced (Koç, 2020). There may be significant differences in the hardware of the unmanned aerial vehicle (UAV) depending on the area of use. The most important part of the UAV, which is designed according to features such as distance, carrying capacity and speed, is the engine that provides thrust power for flight. In the study, the advantages and disadvantages of different engine types used in UAVs were examined and compared (Çoban, 2018).

In the past, potentiometers were used in many analog electronic circuits to adjust quantities such as volume, light intensity and speed. In many electronic circuits today, such quantities are adjusted digitally. However, the potentiometer is still used as a position sensor because it produces an analog voltage value depending on the amount of mechanical movement. When used as a position sensor, the analog voltage value taken from the middle end of the potentiometer must be delivered to the comparison circuit without changing. Otherwise, the potentiometer will be perceived as standing in a different position. The most important factor that cause to change the analog value which express position knowledge is the cable and contact resistance, especially when it comes to long distances. The voltage drops on the resistor in the transmission line cause to change the voltage value at the end of the line. One of the most practical ways to solve this problem is to convert the analog value on the potentiometer into digital form and transmit it. Analog-digital conversion can be done using many different methods. These methods may have some advantages and disadvantages compared to each other in terms of number of bits and conversion time. In addition, converting position knowledge into digital form using an analog digital converter (ADC) causes some system complexity and extra costs.

In this study, a simple and stable servomechanism was produced. The potentiometer position knowledge on the joystick was converted into a PWM signal simply and quickly by using an oscillator instead of using an ADC. This PWM signal containing position knowledge can be transmitted to the receiver via wire or wirelessly as in this study. The PWM signal was applied to the IR LED and sent as IR light to the receiver side, then detected by the photo diode at the receiver side and converted back into an electrical signal. The electrically obtained PWM signal was passed through the LPF and converted into an analog voltage value expressing the joystick position knowledge. Then, the control surface was moved so that this value was equalized with the control surface potentiometer value.

2. Materials and Methods

Analog position knowledge received from the potentiometer on the joystick was converted into digital form using an oscillator instead of ADC By using the oscillator circuit, a square wave (PWM) signal whose duty-cycle ratio varies depending on the potentiometer position is obtained as seen in Figure 1. Since the duty-cycle ratio of the produced square wave signal changes proportionally to the position of the potentiometer, the position of the potentiometer can be understood by measuring this ratio. Since the position information is transmitted as a PWM signal, the analog voltage value is no longer important and the position information is not affected by the cable resistance. Additionally, when position knowledge is converted into a PWM signal, it can be easily transmitted wirelessly as RF or IR as in this study. When the position information arrives the comparator circuit as IR in the form of a PWM signal, it is converted to a small voltage level by a photo diode. The PWM signal at the millivolt level was amplified to level between zero volts and +Vcc. Since the average value of the PWM signal is proportional to the duty cycle, this PWM signal was passed through the LPF and the voltage level proportional to the potentiometer position was obtained again. Instead of using LPF, position information can be obtained digitally with a processor by measuring the "0" and "1" times of the PWM signal, but LPF was used in this study due to its simplicity. Synchronization was achieved by driving a DC motor so that the difference between the analog value obtained from the PWM signal and the analog value coming from the potentiometer on the control surface was minimal.

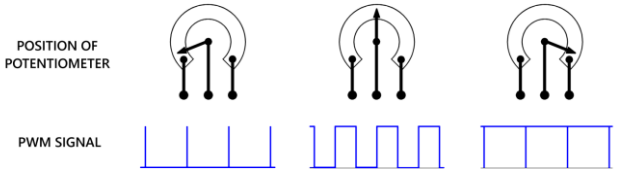

Figure 1. Changing the duty cycle of the PWM signal according to the potentiometer position.

In this servomechanism system, whose block diagram is given in Figure 2, the analog value in the potentiometer, whose value changes depending on the joystick position, is converted into a PWM signal. The PWM conversion is performed with a low cost and fast response 555 oscillator circuit. If the position knowledge received from the potentiometer is transmitted directly as an analog voltage, the position knowledge can be corrupted due to factors such as cable and contact resistance at the transmission line. When the position knowledge is transmitted as PWM, it is converted into a two-level (0.1) digital signal with varying duty cycle, and it can be easily used in the wired or wireless transmission environment.

In the transmitter unit, the PWM signal applied to the IR LED was sent as infrared light and after being detected by the photodiode in the receiver unit, it was passed through the LPF so that the joystick potentiometer value was obtained again. This value is compared with the analog value on the potentiometer on the mechanism and the differential voltage is applied to the motor driver. The DC motor, which run forward or backward according to this difference voltage, moves the mechanism and ensures that the control surface is in the same position as the joystick.

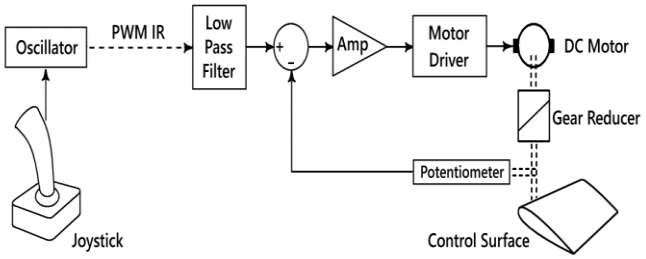

Figure 2. PWM controlled servo mechanism

2.1. Generation of Position Knowledge as PWM

The 555 integrated circuit, which can generate square wave signals in a wide frequency range, is a very stable and low-cost oscillator. The output becomes logic "1" or logic "0" according to the access time in which the capacitor voltage of C1 in Figure 3, changes between two different reference values. The lower reference voltage values are one-third of the supply voltage (Vcc/3), while the upper reference voltage values are two-thirds (2Vcc/3) of the supply voltage.

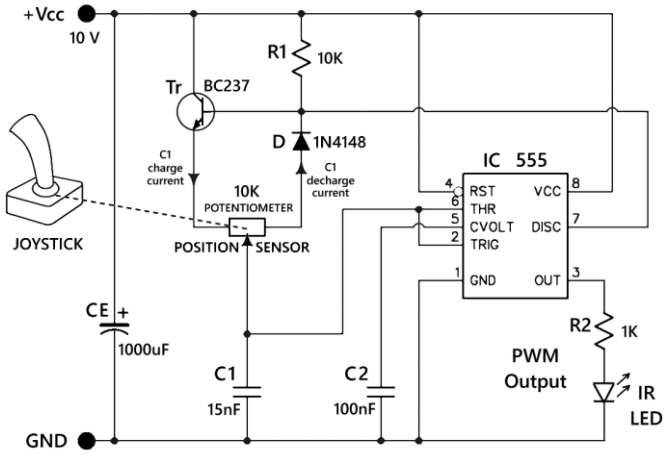

Figure 3. PWM IR transmitter circuit

While the capacitor is being discharged (Vo = “0”), when the voltage value of the capacitor drops below the lower reference value, the output becomes “1” and at the same time, since the open collector discharge (pin 7) pin current is cut off, the capacitor starts to charge through the resistor connected to it in series. When the voltage value of the capacitor rises above the upper reference value, the output becomes “0” again and the capacitor starts to discharge through pin 7 and the 555 continues to work as an astable multivibrator.

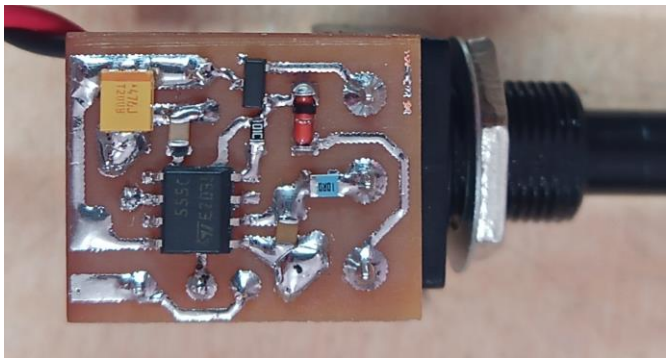

Figure 4. PWM IR transmitter photographic view

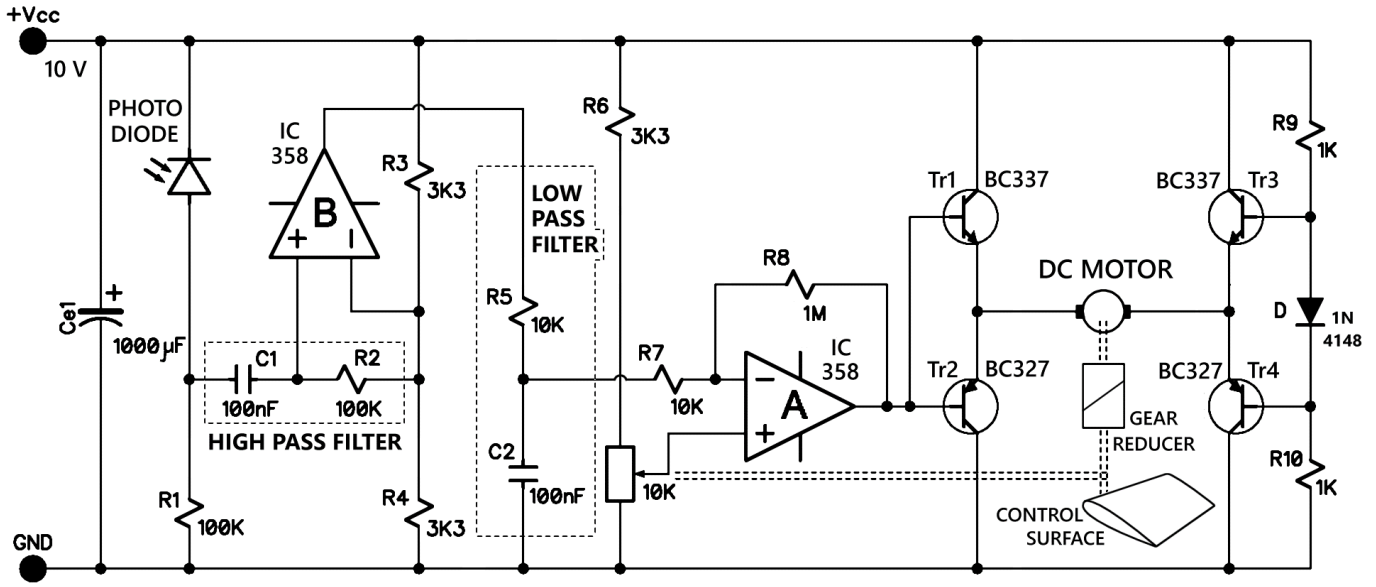

Figure 5. IR receiver and servo control circuit

The duty cycle of the square wave signal at the output of the 555 oscillator depends on the time it takes for the capacitor voltage to reach these two reference values during charging or discharging. This time changes with the RC time constant. The duty cycle can be changed from %0 to %100 with the transistor circuit added to the standard 555 circuit. The capacitor is charged between middle end of the potentiometer and the transistor and discharged between middle end of the potentiometer and the diode. Potentiometer wiper moving does not change the frequency of the PWM signal because the resistance of the part with the charging current increases while the resistance of the part with the discharge current decreases (or vice versa). In this application, although the frequency value is not very critical, approximately 10 KHz is used as the operating frequency. The produced transmitter circuit is seen in Figure 4.

2.2. Motion of Mechanism according to PWM Knowledge

When the joystick position knowledge sent in the form of IR light arrive the photo diode, it causes the diode leakage current to increase. When the PWM signal is "1", the leakage current is maximum and when it is "0", the leakage current is minimum. In this case, the voltage on the R1 resistor in Figure 5 varies according to the leakage current, that is, the PWM signal. This voltage at the millivolt level must be applied to the LPF after it is strengthened. However, the light in the environment affects the leakage current of the photodiode. Even when there is no signal, the voltage on R1 increases when the environment is bright and the voltage on R1 decreases when the environment is dark. A HPF (High Pass Filter) consisting of C1 and R2 was used to protect the PWM signal against bias voltage caused by ambient light. In this way, high-speed light changes such as the PWM signal (10 KHz) arrive Op-Amp B and are amplified.

The DC motor, which provides the movement of the mechanism (control surface), is driven by the feedback Op-Amp circuit. The feedback circuit produces output according to the difference between the signal (voltage level) coming from the potentiometer on the control surface and the PWM signal coming from the joystick. For this reason, the PWM signal must be converted to an analog value proportional to the duty cycle. This is possible with a simple LPF since the average value of the PWM signal changes proportionally with the duty cycle of the signal. As seen in Figure 5, the PWM signal was applied to the Op-Amp circuit after passing through the LPF.

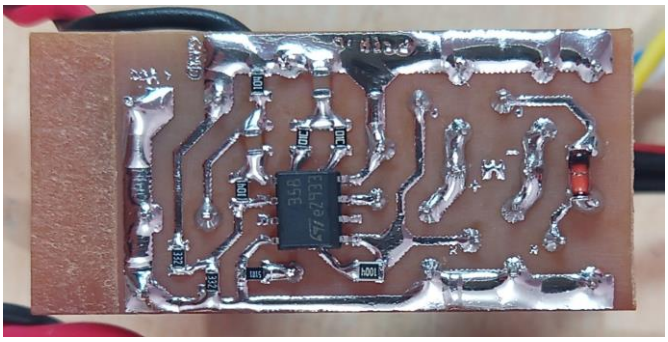

Figure 6. PWM IR receiver photographic view

Control surface movement is provided by DC motor connected to Op-Amp output. The torque on the shaft of the DC motor is not sufficient for the movement of the control surface. For this reason, by connecting a gear reducer to the DC motor shaft, the torque was increased and the surface movement speed was reduced to a reasonable level. In the reducer, which is a gear mechanism, the small gear connected to the motor shaft rotates a large number of times, while the large gear driven by the small gear rotates a small number of times.

The control surface position information was taken analogously with a potentiometer connected to the surface and applied directly to the comparator circuit. The difference between the voltages from the control surface and the joystick is amplified by Op Amp A and applied to the DC motor. Op Amp A output is positive or negative according to the difference between the input voltages. The DC motor drives the mechanism by rotating it forward or backward to equalize the two input voltages. This movement provides synchronization between the joystick and the control surface. The produced receiver circuit is seen in Figure 6.

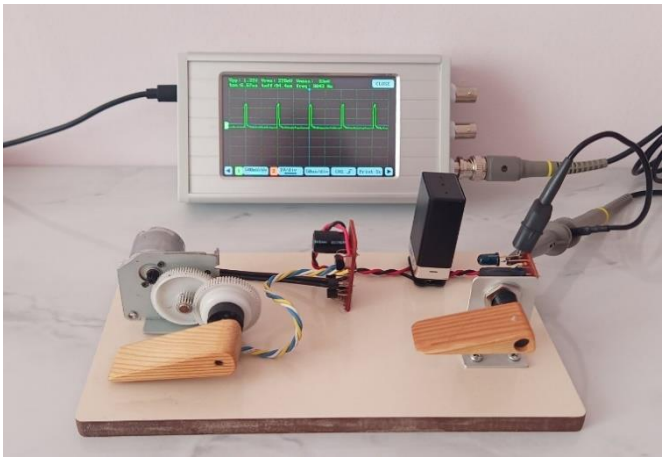

Figure 7. Synchronization between joystick and control surface in case of minimum pulse width.

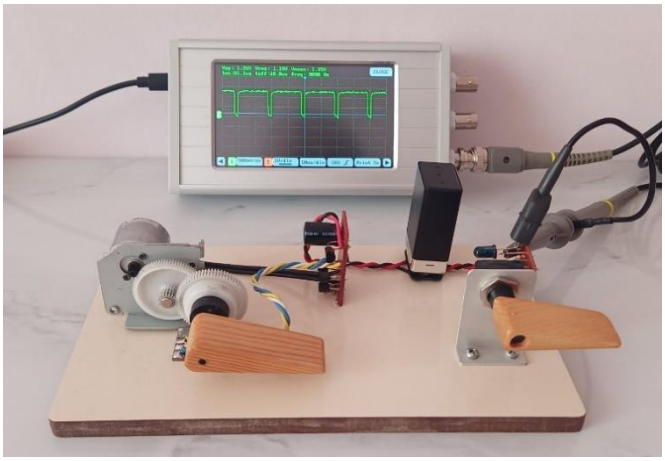

Figure 8. Synchronization between joystick and control surface in case of maximum pulse width.

3. Result and Discussion

The fact that a servomechanism system is stable and fast, as well as simple and low-cost, significantly affects its applicability. A simple and reliable servomechanism, with its uncomplicated structure, allows easier detection and repair of system malfunctions, especially in low-budget applications. In many low-budget servomechanisms, since the potentiometer used as a position sensor produces analog output, there may be some difficulties in its use depending on the cable line through which the position knowledge is sent. An impedance change in the cable line between the joystick and the control surface can easily cause the analog position knowledge to be corrupted.

The distance between the joystick and the control surface can be too large. For example, while the distance between the joystick (sidestick or yoke) in the cockpit and the control surface in a passenger aircraft can be tens of meters, it is hundreds of meters in the case of a UAV (unmanned aerial vehicle). In the aircraft, the servomechanism connection can be provided with a cable. However, in case of direct transmission of position knowledge as analog voltage in wired connection, position knowledge may change on the receiver side due to cable and contact resistance. In this case, it is not possible for the control surface to move synchronously with the joystick. If the analog position knowledge is converted to digital with ADC and transmitted, some conversion time is required and the system cost increases. In addition, a high-speed processor is required for the transmission and processing of digital angle knowledge with a certain number of bits, which increases the system cost also. This applied study can be used as an alternative method for low-cost small systems.

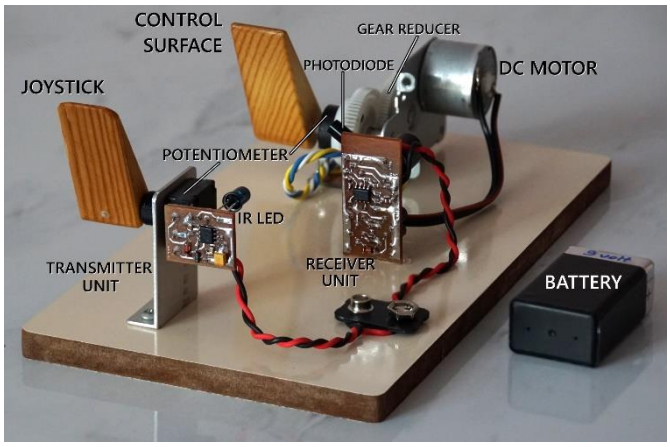

Figure 9. Photographic view of the PWM controlled servomechanism

The PWM signal has different pulse widths for different angles of the joystick. While Figure 7 shows the joystick position at the minimum pulse width, Figure 8 shows the joystick position at the maximum pulse width. At the joystick positions between maximum and minimum, the PWM signal pulse width also takes values between maximum and minimum. The perspective view of the entire servomechanism system is seen in Figure 9. The application video of this study can be watched from the link below.
https://youtu.be/DLkvDwn7EFA

4. Conclusion

In this study, analog position knowledge is transmitted by converting it to PWM signal with a simple and low-cost oscillator circuit. In this way, a simple and stable servomechanism assembly has been obtained by using the minimum number of circuit elements. This servomechanism assembly, in which the joystick position knowledge is transmitted as PWM, can be used with a wired connection between the cockpit and the flight control surface, or with a wireless connection in the UAV. In this applied study, a simple and stable servomechanism was obtained by using the PWM transmission method.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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The Psychological Impact on Chinese Pilot Students During the Pandemic – The Lesson Learned

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Abstract

This study was intrigued by routine onsite observation among pilot students who were concerned about the market downturn during the pandemic and career uncertainty in the post-pandemic time. The purpose of this study was to discover how COVID-19 affected pilot students and how they reacted and were accustomed to the pandemic regulations. Human Factors, psychological issues, and the status of safety culture were also surveyed. Purposive sampling was used to select two Chinese Civil Aviation Regulation (CCAR) Part 141 flight schools to participate in an online survey. The Cronbach's alpha, and Spearman's Correlation Coefficient were calculated. The findings exemplify the emergence of Human Factors and psychological issues, while the flight school's safety culture remains strong. Simultaneously, the result of this study provides a reference for stakeholders at flight training institutes for coping with future similar crises.

1. Introduction

The advent of the COVID-19 pandemic has presented formidable challenges to the worldwide aviation industry. Due to the substantial reduction in flights between 2020 and 2022, many aviation professionals faced job insecurity or were furloughed for an uncertain length of time that has resulted in income reduction and financial hardship (Flight Safety Foundation [FSF], 2020 May). Giuntella, Hyde, Saccardo and Sado further reported that the impact of COVID-19 on professionals of air transportation could include psychological/mental health issues such as worry, anxiety, uncertainty, pressure, helplessness, sadness, and loneliness just to name a few (Giuntella, Hyde, Saccardo & Sadoff, 2021).

2. Literature Reviews

To better control the pandemic in China, the National Health Committee (NHC) has required people to wear a face mask, keep a physical distance, wash their hands frequently to prevent virus spread, and has encouraged the public to get vaccinated to avoid potential severe illness or death. However, a study by Dattel, Lubner, Gao, and Xie (2021) showed that pilots seemed to be averse to wearing a face mask during flight training due to inconvenience, discomfort, or lack of oxygen. Also, face masks could become a barrier to effective and clear communication regardless of the advocacy from Aircraft Owners and Pilots Association (AOPA) (2020). In addition, China's NHC also adopted the "Dynamic COVID-Zero" strategy in 2021 until February 2023 that took comprehensive measures to deal with localized COVID-19 cases, hoping to quickly disconnect the transmission chain, and diminish the communicable disease promptly (Liu, Liu & Liang, 2022). The aforementioned protocol automatically applied to all Chinese flight schools where visitors must also provide a negative Polymerase Chain Reaction (PCR) test report and the result must be done within 48 hours before their arrival (Shandong Nanshan International Flight Co. Ltd, 2021).

Not surprisingly, the pandemic has significantly delayed pilot students' training progress and believed that their flight skills have decreased due to the unpredictable lockdowns and consequently reduced training slots (Wu & Shila, 2021). Research on Tertiary education in Australia's undergraduate pilot students shows that the COVID-19 pandemic has even caused some students to voluntarily deviate from their original pilot career path (Miani, Kille, Lee, Zhang & Bates, 2021). The pandemic restrictions and subsequent quarantines resulted in a dearth of training activities, potentially leading to a decline in flight proficiency. Consequently, the lack of flight proficiency

could weaken a student's confidence and intensify the mental and cognitive process during the training activities (Brynes, Rhoades, Williams, Arnaud, & Schneider, 2022; IATA, 2020 Oct.; Olaganathan & Amihan, 2021; Schaper, 2021).

Looking back to 2020, IATA alerted that health protocols, restrictions, and quarantine policies could impose burdens (physical and psychological) on able workers due to the sudden manpower shortage (IATA, 2020 June). This has been echoed by EASA - Safety Issues, published on August 4, 2021 (EASA, 2020) and Ed Johnson of Bloomberg (Johnson, 2021 Oct.). According to Hilditch and Flynn-Evans (2022 May), the quarantine protocols and duty restrictions has increased an able worker's workload, and thus fatigue emerged.

Fatigue has been a repeated human factor affecting operational safety. Fatigue leads to distraction, fixation, tardiness, poor communication and teamwork, and loss of situational awareness (SA) (FAA, 2010). Like drugs and alcohol, fatigue slows down reaction time, decreases awareness, and impairs judgment and the decision-making process (Boyd, 2021, Caron, 2020; FAA, 2010; Jin & Lu, 2019; Keller, Mendonca & Cutter, 2019; Kilic, 2019). Mental fatigue causes distractions that could be stemmed from family issues, policy changes, economic downturns, social relationships, or even personal financial hardship (IATA, 2022).

Besides fatigue, ICAO identifies other Human Factors that could contribute to unsafe operations during the COVID-19 period, including lack of communication, weak company support, and pressure (Masrani, n.d.). According to Wiegmann and Shappell, the Human Factors Analysis and Classification System (HFACS) categorizes human errors into four (4) levels and 18 categories including unsafe acts of operators, preconditions for dangerous acts, unsafe supervision, and organizational influences (Wiegmann and Shappell, 2003, p.71). James Reason states that pilots would exhibit decision errors, skill-based errors, perceptual errors during flight operations attributed to fatigue (Reason, 1997), and occasionally flight rule violations (Tisdall, Zhang & Zhang, 2021). Not only fatigue, but all emerging Human Factors could endanger the necessary vitality for an industry or organization to be safe, productive, and sustainable (Kim, Wong, Han, & Yeung, 2022; Vink, 2021).

Fortunately, airlines and flight schools are recommended to offer psychological and mental support to address Human Factors such as fatigue, stress, distress, pressure, and anxiety in many aspects (Vuorio & Bor, 2020) as some Chinese pilots experience elevated anxiety and depression during the unprecedented COVID-19 pandemic time (Wang, Cheng, Yue, & McAleer, 2020). It is plausible to professionally deal with social and psychological difficulties in the early stage of flight training to avoid operational errors or unintentional mistakes. Amid the pandemic ordeal, many pilot training schools voluntarily create a platform of mutual support for pilot students to ensure their mental wellness (FSF, 2020) as well as organizational safety culture (Civil Aviation Administration of China [CAAC], 2017). There is no doubt that pilot training schools believe that a promising safety culture is pragmatically desired. And the Safety Management System (SMS) would need to be continuously active to improve the safety culture (Beckman Siao, Smith & Corns, 2019; Lu, Bos, & Caldwell, 2007; Lu, Camp, Dalal, & Tasswar, 2022). It is simply because the cognitive perception of safety culture should be deeply rooted in an organization's policies, risk assessment programs, safety assurance plans, managerial supports, and continuous promotion activities (Adjekum & Tous, 2020; Leib & Lu, 2014; Lu, Wang & Jin, 2020).

The purpose of this study is to understand the emerging issues that could have affected pilot students during the pandemic. Lessons learned could generate a reference for managing a similar crisis in the future. The research questions of this study are:

1. What emerging Human Factors impact pilot students' flight training during the pandemic?
2. What psychological factors influence pilot students amid the pandemic, and how do they cope with the resulting effects?
3. What was the pilot students' perception of safety culture during the pandemic time?

3. Methods

Medical professionals utilize a variety of instruments to assess mental health and well-being. Those tests help professionals screen the presence or absence of common mental health conditions, make a formal diagnosis, judge symptom severity and abnormality, and monitor the outcomes across the course of therapy. The common psychological problems related to pilots include pressure, anxiety, depression, fatigue, or eating disorders. Generalized Anxiety Disorder (GAD) assesses people's action frequencies influenced by anxiety feelings (Spitzer, Kroenke & Williams, 2006). Hamilton Anxiety Rating Scale (HAM-A) (Salkovskis, Rimes, Warwick, & Clark, 2002) concentrates on intellectual problems and insomnia. Zimmerman et.al. (2008) designs the Clinically Useful Depression Outcome Scale (CUDOS) to measure a person's feelings of depression caused by imminent factors. The items of the questionnaire of this study are synthetically selected from leading psychological assessment tools such as fear, anxiety, uncertainty, stress, distress, pressure, emotion, fatigue, and other influential factors. Thus, survey questions in the questionnaire are specifically extracted from the following assessment instruments: Generalized Anxiety Disorder 7-item (GAD-7), the Hamilton Rating Scale of Anxiety, the Clinically Useful Depression Outcome Scale (CUDOS) (Buysse Reynolds, Monk, Berman, & Kupfer, 1989). The questionnaire has been pilot tested twice by voluntary pilot students. Purposive sampling is used and two major CCAR Part 141 flight schools in China are invited to participate in this study. The process of research execution is provided below (See Figure 1).

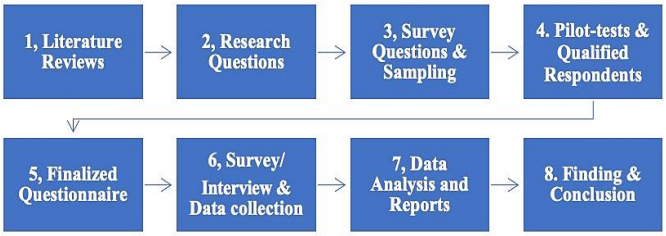

Figure 1. Flow-chart - Project Execution

The IBM SPSS Statistics software is selected to calculate the reliability/consistency of the feedback and demonstrate pictorial results accordingly. Cronbach's alpha is used to coin data consistency and the formula is presented as follows:

$$\alpha = \frac{K}{K-1}\left(\frac{S_y^2 - \sum S_i^2}{S_y^2}\right) \quad (1)$$

K: number of the questions
S_y^2: variance of the total score (the variance of the sum of each respondent's answers for all questions)
$\sum S_i^2$: sum of the individual variance of each question

4. Results

4.1 What emerging Human Factors impact pilot students' flight training during the pandemic?

95 respondents indicated that they have encountered distinct Human Factors during the COVID-19 pandemic time. The result shows that among respondents, "pressure" (58/95, 61.05%), "fatigue" (30/95, 31.57%), and "distraction" (30/95, 31.57%) are three dominant Human Factors followed by "stress" (28/95, 29.47%), "lack of resources" (27/95, 28.42%) and "lack of communication" (27/95, 28.42) (See Figure 2).

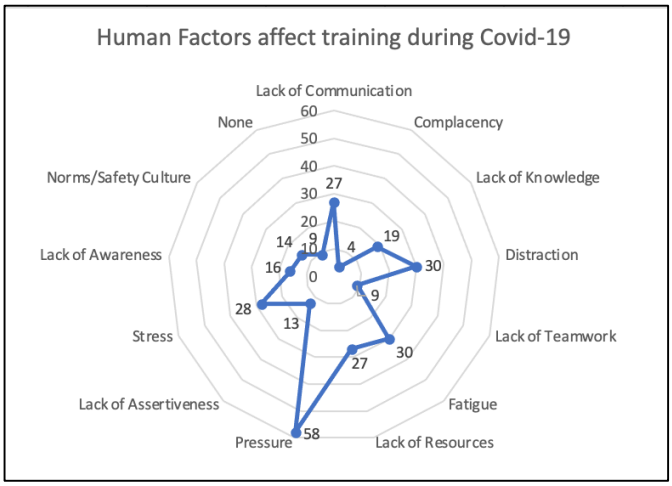

Figure 2. Human Factor Issues Presented in Flight Training During COVID-19

The factor of "pressure" stands out as the most critical concern among respondents. In the specific open-ended question, respondents encounter "pressure" from different spectrums of aspects that lead to (1) the lack of rest, (2) irregular work shifts, and (3) work-life imbalance. Ultimately, pressure indirectly forms a fallacious precursor of fatigue. Not surprisingly, respondents indicate that "fatigue" could lead to pilot distraction, which could also result in low-quality operations, erroneous procedures, or poor decisions in the cockpit. Fortunately, only 4.2% (4/95) respondents indicate "complacency" and 10.5% (10/95) state "none" regarding encountered Human Factors during the survey.

4.2. What psychological factors influence pilot students amid the pandemic, and how do they cope with the resulting effects?

Questions of this section are designed to obtain respondents' psychological and mental well-being during COVID-19 using Likert Scale (1: Strongly Disagree, 5: Strongly Agree). In this section, the authors evaluate internal data consistency by using Cronbach's alpha of the two Likert Scale questions related to psychological factors. The Cronbach's alpha is 0.710, which affirmatively helps researchers to realize respondents' attitudes toward mental or psychological health consultant service and their overall self-assessment of mental health conditions (See Table 1).

Table 1. Cronbach's Alpha of Psychological Factors Section

Number of Likert Scale Questions (K)	**2**
Number of Responses	95
Sum of individual questions variances ($\sum S_i^2$)	3.396
Variance of the total score (S_y^2)	5.209
Cronbach's alpha (α)	0.710

Respondents indicate that "Uncertainty" (38/95, 40%) and "tress" (34/95, 35.79%) are two prevailing psychological factors they have perceived. Additionally, many respondents express their feeling of "anxiety" (26/95, 27.37%), "worry" (25/95, 26.31%), "financial hardship" (22/95, 23.15%), followed by "fatigue" (20/95, 21.05%) and "distress" (20/95, 21.05%). The "poor social relationship" (15/95, 15.79%) is not significant but highlights the necessity for well-prepared social activities at the training bases (see Figure 3).

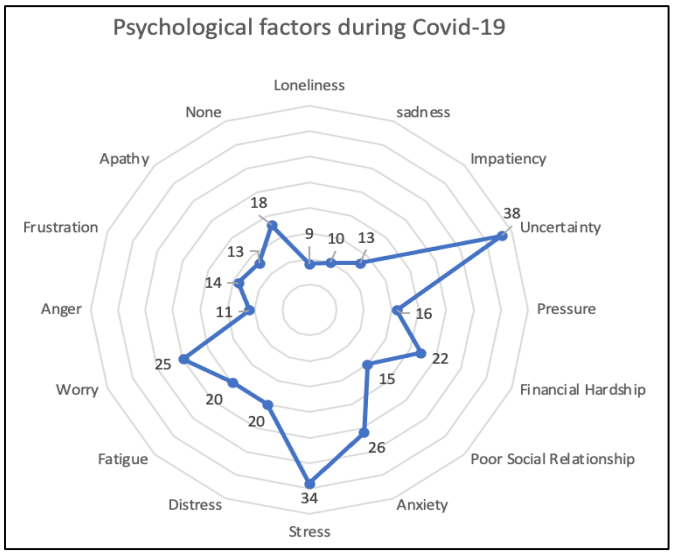

Figure 3. Psychological Factors Students Encountered during COVID-19

When inquiring respondents' opinions on getting mental/psychological health consultant service, 73 (76.84%) respondents agree that flight schools need to provide such service. There were 67 (70.52%) respondents who are aware that their flight schools do provide consultant service and 32 (33.68%) take part in the service including twenty (20) respondents who respond that it is helpful and worthwhile. Among the remaining 35 respondents who do not participate in the consultant service, 68 (71.57%) of them are willing to take the service when deemed necessary. Lastly, for the 28 students whose flight schools do not provide consultant service, 22 of them advocate initiating a similar psychological/mental health service in place (See Table 2).

Table 2. Descriptive Statistic of Flight School Mental Health Consultant Need and Service

Questions			Average or %
It is important to seek mental/psychological health support/consultant if there is a need.			4.05
My flight program provides mental health consultant.	Yes (%) 67 (70.53%)	No (%) 7 (7.37%)	Not sure (%) 21 (22.11%)
I have been to mental health consultant service during COVID-19. (Note: For 67 respondents who selected "Yes" in Q.4.3)	Yes (%) 32/67 (47.76%)	No (%) 35 /67 (52.24%)	
			Average
I think my flight department need to have a comprehensive mental health consultant service. *(Note: Based on 28 respondents who select "No" (7) or "Not Sure" (21) in Q.4.3)*			3.93
I think the consultant service is useful. *(Note: Based on the 20 out of 32 respondents selected "Yes" in Q.4.4)*			3.69
I am willing to go to the consultant service in the future *(Note: Based on the 35 respondents selected "No" in Q.4.4)*			4.09
I believe my overall mental health condition is good during COVID-19 *(For all 95 respondents)*			3.67

4.3. What was pilot students' perception of safety culture during the COVID-19 pandemic time?

This section is designed to measure the ongoing safety culture during the pandemic. The Cronbach's alpha is 0.9752 which reflects on the consistency of answers concerning the four (4) subcultures of the safety culture. The average score of 4.03 shows a promising safety culture during the COVID-19 pandemic time. The Cronbach's alpha of each subculture concerning just, reporting, informed, and learning cultures is very strong (See Table 3).

To further analyze, while safety remains the operational priority during the pandemic, routine safety committee meetings are held periodically resonating with the high score of reporting, just, informed, and learning cultures. Remarkably, reporting culture and informed culture yield the highest Spearman Correlation Coefficient, 0.89. There is a strong relationship between reporting culture and routine safety meetings with a 0.83 Correlation Coefficient indicating that most respondents support the hazard reporting system also recognize the benefit of routine safety meetings. The Correlation Coefficient between the reporting culture and learning culture is 0.83, showing that pilot students acknowledge the importance of a reporting system as well as the learning culture. Diagram 1 below illustrates the Spearman Correlation Coefficient among safety culture questions. Overall, the Spearman Correlation Coefficient varies between 0.735 to 0.910 (See Diagram 1).

Table 3. Descriptive Statistics of the Likert Scale - Questions in the Safety Culture Section

Questions	Average	Cronbach's alpha if deleted from this section
Safety remained the core value at my flight training institute during COVID-19.	4.22	0.972
My flight training program conducted safety meetings periodically or whenever is necessary during COVID-19.	4.09	0.97
I have been willing to report hazards regardless of COVID-19.	4.05	0.97
I trust that the review of a hazard report has been effective and fair.	4.02	0.975
My institute has routinely informed me the safety status regardless of COVID-19.	4.01	0.971
I can adapt to new safety standards and changes regardless of COVID-19.	3.97	0.971
The top executives of my institute showed strong supports to safety during COVID-19.	4.03	0.971

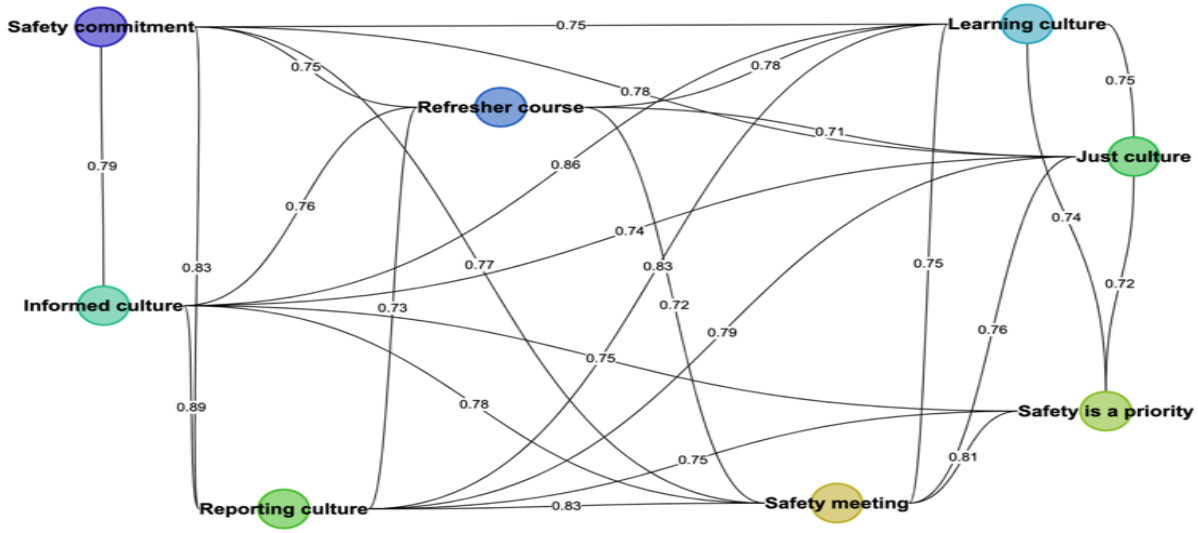

Diagram 1. Spearman Correlation Graph of the Likert Scale Questions in the Safety Culture Section

In addition, regarding the learning culture and refresher courses, respondents indicate that pilot students are adaptable to learning from the new standards and policies while advocating the need for refresher courses. The Correlation Coefficient is 0.63 between safety priority and safety commitment, which shows top executives of the flight schools do accentuate the importance of flight safety during the pandemic time by making an administrator's commitment appealing.

Diagram 1 presents that all Spearman Correlation Coefficients are greater than 0.6 and show that reporting, just, learning, and informed culture have been highly intercorrelated underpinning the school's Safety Management Systems (SMS) amid the pandemic challenges.

4.4. Discussion

Emerging Human Factors. Pressure, fatigue, and distraction are the three top Human Factors perceived by the respondents. The fatigue problem that Chinese pilot students faced is truly associated with the high pressure brought about by the pandemic, especially, in a closed campus/base with limited social interaction and open activity. When people live in a confined space for an extended period, some could encounter difficulties in making new friends or adapting to the rapidly changing community. Persistent concerns in their minds prevent students from getting proper rest and therefore fatigue emerged. In addition, mandatory COVID-19 obedience could lead to pressure, stress, distraction, lack of teamwork and skills, work-life imbalance, and ultimately erroneous decisions during flight training, which unquestionably could affect flight safety.

Psychological/Mental Health Problems Pilot Students Encountered. Due to the unpredictable development of the COVID-19 pandemic between 2021 and 2022, the recovery of the aviation industry was unsure. Most respondents choose "uncertainty" as the leading psychological issue followed by "stress", "anxiety" and "worry." The result mirrors Air Line Pilots Association (ALPA) research results confirming the existence of psychological impacts during the COVID-19 pandemic (Freeze, 2022). By the time of this study, Chinese flight schools were still under strict pandemic control. The finding of "anxiety" from respondents aligns with Wang and Zha''s research outcome despite the Chinese airlines' guaranteed hire (Wang & Zhao, 2020).

Furthermore, an extended period of the campus lockdown could lead to severe mental impacts on students as they are reframed from in-person interaction and thus feel stressed, vulnerable, and lonely under such strict pandemic measures (Wang, Cheng, Yue & McAleer, 2020).

Important Mental Health Consultation Services. The surveyed flight schools do proactively provide consultation services to assist pilot students in improving mental health so as to strengthen their confidence, psychological integrity, and self-esteem similar to the findings from the studies of Carleton, Norton, and Asmundson in 2007 and Cox, Holden, and Sagovsky in 1987. Respondents believe that getting consultation services is beneficial, and most of them prefer to visit consultants soon. It should be specifically noted that not all respondents are aware of the existence of the consultation services.

Safety remains the top priority during COVID-19 in spite of the interrupted routine training. Flight training institutes in China persistently reiterate safety by conducting safety workshops and group meetings and collecting hazard reports to continue supporting the mandatory SMS. From the survey result, the four sub-cultures (reporting, informed, just, and learning cultures) are strongly intact.

5. Conclusion

This study surveys pilot students in China regarding the impact of the COVID-19 pandemic. Besides the strict pandemic protocols that respondents must abide by, this study discovers Human Factors and psychological issues perceived by pilot students during the pandemic. Pressure, fatigue, and distraction are the three top Human Factors and uncertainty is the leading psychological issue according to respondents. With flight training being interrupted to a great extent while the recovery of the aviation industry is unsure, psychological issues affecting mental well-being cannot be ignored. Practical consultation services are offered to help improve students' confidence, self-esteem, and integrity. It is worth noting that safety culture remains persistent during this unusual pandemic time. Even if the risk of COVID-19 has been downgraded to the endemic category, lessons learned from COVID-19 remain robust and enduring for managing the future similar etiological emergency. The findings of this study are meaningful to practitioners, readers, interested researchers, and stakeholders as a quick reference when encountering a similar crisis. This study is equally important to pilot students to remain resilient and maintain a healthy personality by identifying precursors of mental health as well as psychological issues during the early stage of their flight career development.

6. Future Study

Given the time constraints, the forthcoming study should include all Chinese flight schools so as to increase the generalizability and practicality of the research finding. In addition, flight students in the United States could also be included to enable a comparative analysis concerning students' perception of psychological impact, human factor issues, and safety culture during the pandemic crisis.

Ethical approval

Not applicable.

Conflicts of Interest

There is no conflict of interest regarding the publication of this paper.

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Customised Holiday Experiences through Artificial Intelligence: Case Studies from the Aviation and Hospitality Sectors

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Abstract

This article explores the impact of artificial intelligence (AI) on the aviation and hospitality industries, both of which are rapidly evolving due to technological advancements. It aims to understand the increasing importance of artificial intelligence by examining the various ways in which it is used in these sectors through qualitative research. The research included an analysis of online sources such as airport and hotel websites, booking platforms, and social media accounts of travel-related businesses. This comprehensive data collection provides insight into the various applications of artificial intelligence in tourism. Thematic analysis was then used to categorise the data according to similar uses, providing a detailed understanding of the role of AI in these areas. It compares and examines artificial intelligence applications adopted by aviation and hospitality organisations, evaluating their effectiveness and differences. The study reveals the various ways in which AI is being integrated into these industries and highlights its significant contributions across various dimensions. It also highlights how AI can deliver competitive advantage, improve customer experiences, and introduce innovative paradigms to the aviation and hospitality industries. One important aspect of the research is its ability to provide a deeper understanding of emerging AI trends in these sectors and lay a strong foundation for future research. Ultimately, this study provides valuable insight to stakeholders in aviation and hospitality, equipping them with an informed perspective on leveraging AI for growth and long-term sustainability in their respective industries

1. Introduction

The tourism sector is currently undergoing a rapid transformation on a global scale, characterised by new dimensions emerging due to the influence of technological advancements. This transformation has been prominently highlighted by Benckendorff et al. (2019), Gövce (2020), Popkova et al. (2021) and Rezaei et al. (2022). As underscored by Shin and Perdue (2022), stakeholders within the tourism industry are demonstrating a steadfast commitment to harnessing innovation and technology as catalysts for comprehensive sector-wide transformation. This unwavering commitment is rooted in the urgent need not only to meet the increasing demand for tourism but also to enhance and personalise the overall visitor experience while simultaneously strengthening their competitive position in the market. In this context, as noted by Doborjeh et al. (2022), advanced technologies like artificial intelligence contribute significantly to the transformation and growth processes of the tourism sector.

In recent years, there has been a noticeable increase in the impact and importance of artificial intelligence (AI) applications in the aviation and hospitality sectors. This phenomenon has been extensively studied by researchers, with contributions from Iranmanesh et al. (2022), Sridhar and Bell (2022), Nam et al. (2021), and Kumar and Thakur (2012), among others. These sectors, which are an integral part of the broader tourism industry, have undergone transformative changes as they adopt AI technologies to streamline their operational processes. Simultaneously, this study particularly investigates how businesses in aviation and accommodation, essential components of the tourism industry, adopt artificial intelligence technologies and enhance their operational processes. It is well known that tourism stakeholders enhance customer experiences and gain competitive advantages by integrating artificial intelligence into their business strategies (Samara et al., 2020). Furthermore, the broad-ranging contributions of artificial intelligence applications to the tourism sector, along with future strategies and the potential for sustainable growth, are crucial (Saydam et al., 2022).

The innovations and advantages generated by artificial intelligence applications in the tourism sector have the potential to enhance operational efficiency, elevate customer satisfaction, and offer personalised experiences for businesses (Gündüz et al., 2023; Knani et al., 2022; Li et al., 2021). The significance of this study lies in contributing to the understanding of the transformation of the tourism sector in terms of growth and competitiveness and shedding light on the role of artificial intelligence in this transformation.

Most of the existing research has separately addressed aviation and accommodation (Tepylo et al., 2023; Limna, 2022; Garcia et al., 2021; Molchanova, 2020; Yang et al., 2020; Gündüz & Gündüz, 2017). What sets this study apart

from similar works in the literature is its focus on different tourism components, amalgamating sectors like aviation and accommodation to explore how the utilisation of artificial intelligence differs across these industries. Additionally, by considering the potential benefits and challenges of artificial intelligence applications from the perspective of businesses and tourists, the study offers a comprehensive outlook.

Studies show that artificial intelligence is a candidate to be a decisive competitive factor for the tourism sector in the future (Bhatia et al., 2022; Pérez-Campuzano et al., 2021; Ercan, 2020). In the following sections of the article, various aspects and effects of artificial intelligence applications in the tourism sector are examined in depth, especially focusing on how they enable transformation in the aviation and accommodation sectors. Additionally, the study underlines the critical role that artificial intelligence can play in promoting sustainable growth and development in the tourism sector and offers recommendations for future research and applications. Ultimately, this study aims to provide a comprehensive perspective that enriches our understanding of the potential of artificial intelligence to shape the future of the tourism industry.

2. Materials and Methods

This research adopts a qualitative research design to investigate the utilisation of innovations, particularly artificial intelligence (AI), within the aviation and hospitality industries. Qualitative research is chosen as the preferred method due to its capacity to facilitate in-depth comprehension, exploration of phenomena, and detailed examination of specific topics (Ritchie & Lewis, 2003). This research approach centres on the analysis of textual, visual, or audio data rather than the quantitative analysis of numerical data (Ilgar & Ilgar, 2014). The primary objective of this study is to extract valuable insights pertaining to the intricate integration of AI within the aviation and hospitality sectors.

The central aim of this research is to provide a comprehensive elucidation of the utilisation of artificial intelligence tools within the aviation and accommodation sectors based on the information available on websites. In this context, the chosen research methodology is web content analysis. Web content analysis is recognised as a qualitative research approach that systematically and quantitatively assesses textual content in an objective manner (Wimmer & Dominick, 2013). To accomplish this, the researcher extensively engages with a diverse range of online resources, including the websites of airlines and airports, hotel websites, official social media accounts of travel-related businesses, reservation platforms, industry reports, and scholarly articles. This thorough approach involves a comprehensive investigation of artificial intelligence applications in both the aviation and hospitality sectors. The study involves the analysis of data collected from 55 companies operating within these industries. These companies were identified as users of artificial intelligence through internet scans and subsequently became subjects of analysis in this research.

The collected data underwent thematic analysis. Thematic analysis, a sub-branch of qualitative research known as content analysis, is employed to derive meaning from complex textual data. Researchers identify recurring patterns, significant themes, and meaningful relationships by thoroughly examining texts pertaining to a specific topic (Terry et al., 2017).

In the initial phase, the researchers scrutinised the data for repetitive patterns and themes associated with AI applications. These themes encompass topics such as common use cases, benefits, and evident trends. After identifying these themes, the researchers categorised AI applications based on their functional and effective similarities. This approach facilitated a structured and systematic analysis of diverse AI utilisation patterns within the aviation and hospitality industries.

The categorised themes were subjected to a more in-depth analysis in order to pinpoint significant patterns and emerging trends in the integration of artificial intelligence (AI). Pattern recognition, in this context, refers to the process of identifying recurring and unique structures, arrangements, or connections within the data. This process finds utility in various domains, including data mining, artificial intelligence, image processing, and natural language processing (Murty & Devi, 2015). The objective of this analytical phase was to identify recurrent patterns, such as enhancing customer service, utilising data analytics, and providing personalised recommendations. A total of 10 different themes were identified and presented in Table 6.

Multiple researchers carried out the cross-validation of categorized themes and identified patterns. Any discrepancies were meticulously addressed to enhance the credibility of the analytical process. The findings were then interpreted within the context of existing literature. The outcomes underscored AI's pivotal role in tackling challenges within the aviation and hospitality sectors, enhancing customer experiences, and driving innovation.

Consequently, this adopted methodology has facilitated a thorough exploration of AI applications within the aviation and hospitality industries. By rigorously categorising and adeptly recognising patterns through the amalgamation of diverse online resources, researchers have gained a deeper comprehension of AI's transformative impact. This approach not only enhances our understanding of emerging AI trends but also establishes a robust foundation for further academic exploration and informed decision-making within the industry.

3. Result and Discussion

In this section of the study, we provide a thorough analysis of how various industries utilize collaborative artificial intelligence (AI) applications to achieve a competitive edge. Specifically, we present a breakdown of AI applications employed by airlines, airports, the hotel industry, online reservation platforms, and price comparison websites in tabular format for clarity and reference. Later, these applications were analysed thematically and presented as main themes and sub-applications. The analysis delves into their strategies for increasing operational efficiency, enhancing customer experience, and other goals. This research provides important insights into how AI is reshaping industries, shedding light on both commonalities and distinguishing features, and shaping a clearer understanding of evolving environments. The names of the companies discussed in the study are given in the form of a "unique company code" in order not to cause copyright problems.

3.1. Artificial intelligence applications in airline companies

One of the sectors where artificial intelligence has been used the most in recent years is airlines (Abeyratne & Abeyratne, 2017). Companies in the airline sector are leveraging a range of AI applications to improve their operations and the customer experience. In Table 1, artificial intelligence applications of 13 airline companies are given. For example, AA uses chatbots to improve customer service, while BA analyses passenger requests to optimize routes and fuel

efficiency. QA uses AI for flight predictions and delay analysis to improve operational efficiency, and SQ uses passenger behaviour analysis to manage safety and maintenance.

Table 1. AI Applications in Airline Companies

Serial No	Company Code	AI Applications
1	AA	-Automatic flight tracking and management systems / Customer service with chatbot support / Price optimisation and analysis
2	BA	-Systems analysing passenger requests and preferences / Route optimisation and fuel efficiency
3	AF	-Use of AI in baggage tracking and management / Personalisation of customer experience
4	QA	-AI for flight predictions and delay analysis / Automation in human resources processes
5	SQ	-Systems analysing passenger behaviour to provide recommendations / Cabin maintenance and security management
6	CP	-Sentiment analysis applications for analysing passenger complaints / Internal efficiency and process automation
7	ANA	-Route optimisation and flight tracking systems / Analysis of sensor data in aircraft maintenance
8	AC	-AI applications for baggage and passenger management / Air traffic analysis and predictions
9	EY	-Dynamic pricing systems based on passenger preferences / Personalization in-flight services
10	THY	-Dynamic Pricing / Chatbot Service / Baggage Tracking and Optimisation / Recommendation Engines
11	QR	-Use of AI in flight safety and risk analysis / Chatbot-assisted reservations
12	FR	-Price optimisation and predictions / Flight demand analysis and scheduling
13	WN	-AI for monitoring and improving operational efficiency / Staff management automation

AC uses AI for passenger and baggage management, and EY employs dynamic pricing based on passenger preferences to provide personalised travel experiences. FR gains a competitive edge through price optimisation and demand analysis, while WN uses AI to improve operational efficiency. THY uses artificial intelligence applications in a wide range of areas, from dynamic pricing to chatbot service, from baggage tracking to personalised travel recommendations, to improve customer experience, optimise operational processes, and improve maintenance forecasts. Carrier and Fiig (2018) also underlined in their study that airlines use artificial intelligence to guide their pricing strategies and increase profitability. In addition, Gupta and Jain (2023) stated that artificial intelligence has begun to be used with ethics and confidentiality for personalised customer service. The airline industry primarily leverages personalised customer experiences, one of the most widely used AI applications, to stand out while simultaneously capitalising on varying applications to gain a competitive edge.

3.2. Artificial intelligence applications in airports

Artificial intelligence is currently used in many airports on key issues such as flight delays, airport environment, airport operational management, and airport security (Huang & Zhu, 2021; Ivanov & Webster, 2019). Airports are adopting a wide variety of AI applications to streamline passenger flow and optimise operational processes. In Table 2, artificial intelligence applications used by 12 international airports are presented. Accordingly, ICN facilitates fast transitions through passenger flow management and waiting time forecasts, while FRA improves the guest experience using artificial intelligence in baggage and cargo management. LHR analyses passenger movements through artificial intelligence at security controls, and HND improves efficiency in baggage and passenger management through automation and analytics.

Table 2. AI Applications in Airports

Serial No	Company Code	AI Applications
1	ICN	-Passenger direction and waiting time prediction systems / Baggage tracking and optimisation
2	FRA	-AI systems for baggage and cargo management / Personalization of passenger experience
3	LHR	-Use of AI in security checks / Analysis of passenger movements
4	HND	-Automation and analysis in baggage and passenger management / Enhancement of passenger experience
5	PEK	-Air traffic predictions and management / Terminal operations and staff direction
6	LAX	-Smart systems for baggage and security checks / Passenger direction and experience applications
7	DXB	-AI-assisted systems for baggage and passenger management / Air traffic analysis and management
8	ZRH	-Analysis of passenger movements for flight predictions and waiting times optimisation
9	HKG	-Smart systems for customs processes acceleration / Baggage tracking and security analysis
10	MUC	-Personalisation applications enhancing passenger experience / Passenger demand analysis and route management
11	IST	-AI systems tracking and directing passenger movements / Security and baggage analysis
12	CDG	-AI applications for tracking and optimising passenger movements / Route predictions

PEK utilises AI to forecast air traffic and manage terminal operations, and DXB employs AI-driven systems in baggage and passenger management. IST, on the other hand, uses artificial intelligence systems that monitor and direct passenger movements and artificial intelligence technologies for security and baggage analysis. Tang et al. (2022) also stated that artificial intelligence techniques are used to improve air traffic management in their studies.

Airports extensively employ artificial intelligence applications, particularly passenger movement analysis, to enhance transit efficiency. Nevertheless, as indicated in Table 2, the utilisation of artificial intelligence within airport operations is predominantly centred on baggage handling and passenger security. This observation is substantiated by the research findings of Koroniotis et al. (2020), Akcay & Breckon (2022), and Garcia et al. (2021).

3.3. Artificial intelligence applications in hotels

The hotel sector utilises a wide array of AI applications to enhance guest experiences and streamline operational processes. In Table 3, artificial intelligence applications used by 12 hotels are given. For example, HYT balances demand through dynamic room pricing, and WYN customises guest experiences, utilising predictive analytics for demand and inventory management. RAD stands out by optimising business processes, while BW enhances reservation management and customer service through guest preference analysis.

Table 3. AI Applications in Hotel Industry

Serial No	Company Code	AI Applications
1	HYT	-Dynamic room pricing systems / Analysis of guest requests
2	WYN	-Personalisation of guest experience / Demand predictions and inventory management
3	RAD	-AI applications optimising hotel operations / Human resources management
4	BW	-Analysis of guest preferences / Reservation management and customer service
5	CHC	-Recommendation systems based on guest preferences / Price optimisation and guest experience
6	IHG	-Developing marketing strategies using guest data / Room cleaning scheduling
7	SHA	-Personalised services based on guest preferences / Restaurant and spa management
8	MEL	-Smart systems optimising in-hotel operations / Workforce management and hotel efficiency
9	ACC	-Dynamic pricing and analysis of hotel prices and demand / Hotel marketing strategies
10	MRT	-Guest preference analysis for personalised recommendations / Room cleaning management
11	HIT	-Guest experience enhancement through AI applications / Room service and request management
12	FRS	-Personalised experiences based on guest preferences / Luxury service management

CHC enhances guest experience through recommendation systems based on preferences, and IHG tailors marketing strategies to guest data. The hotel industry primarily uses customised services, one of the most extensively used AI applications, to compete effectively, while simultaneously focusing on various applications to maximise efficiency.

Artificial intelligence has significantly transformed the hospitality industry, with two particular applications standing out in terms of their widespread adoption: room pricing optimisation and the enhancement of customer preferences. Notably, in-depth research conducted by Manigandan & Raghuram (2022), Nam et al. (2021), and Yang et al. (2020) concurs with this observation, further solidifying the prominence of these AI-driven functionalities in the hotel sector.

3.4. Artificial intelligence applications in reservation platforms

The landscape of booking platforms has been significantly reshaped by the integration of artificial intelligence, ushering in a new era of travel planning and deal optimization (Lv, et al., 2022). In Table 4, information is given about the artificial intelligence tools used by reservation applications. In this context, notable AI applications such as AGD and PCL work in tandem to tailor recommendations according to individual user preferences, while HTLS takes a different route, leveraging guest reviews to steer reservation decisions. Additionally, platforms like HOME and VRBO extend their capabilities by aiding users in comprehensively assessing rental preferences and a myriad of accommodation options.

Table 4. AI Applications in Booking Platforms

Serial No	Company Code	AI Applications
1	AGD	-Recommendation systems based on user preferences / Price comparisons and predictions
2	PCL	-Price predictions for flexible date searches / User behaviour analysis
3	HTLS	-Analysis of guest reviews / Directing hotel reservation requests
4	HOME	-Analysis of rental requests and preferences / Price comparisons
5	VRBO	-Chatbots facilitating communication between hosts and renters / Price analysis
6	EXP	-Analysis of travel trends / User demand predictions and price optimisation
7	BOOK	-Recommendations based on user preferences / Hotel ratings
8	ORBT	-AI applications comparing flight and hotel prices / Reservation management
9	TRVLC	-Travel package recommendations and price analysis / User feedback analysis
10	ABNB	-Personalisation of accommodation options / Rental price predictions and demand analysis
11	TRPD	-Sentiment analysis of hotel and restaurant reviews / Travel trend predictions
12	KYK	-Comparing different travel options / Price trends and predictions

Within the domain of travel and lodging reservations, the ubiquity and transformative impact of artificial intelligence are unmistakable. Platforms such as EXP have harnessed the capabilities of AI to meticulously analyse prevailing travel trends, thereby endowing them with the capacity to proactively anticipate and address user requirements. In parallel, the distinctiveness of TRVLC emerges not solely from its adeptness at delivering curated travel package recommendations but also from its adept utilisation of intricate price analytics, thereby significantly enriching the decision-making landscape.

A pivotal arena of competitive differentiation among reservation platforms resides in the realm of AI-fuelled personalised recommendations—a strategic thrust heavily contingent upon discerning user predilections. Notably, the orchestration of this strategy is underpinned by an eclectic amalgamation of methodological approaches, adeptly calibrated to harmonise with the nuanced idiosyncrasies of user demands.

A comprehensive scrutiny of Table 4 underscores a preponderance of AI applications gravitating towards comparative analysis and personalized tailoring within the repertoire of these booking platforms. This thematic alignment corroborates the salient findings accentuated in Table 3, wherein analogous AI-driven interventions were observed within the purview of hotels, specifically oriented towards the

customization of their room typologies in consonance with individual proclivities. Evidently, the empirical insight gleaned from Popesku's (2019) empirical investigation articulates the discernible evolutionary trajectory of AI applications in the tourism sector, progressively converging towards a pronounced emphasis on bespoke personalization. A congruent sentiment reverberates in the scholarly discourse elucidated by Pinheiro et al. (2021), which underscores the instrumental role of artificial intelligence in predicting reservation cancellations—an affirmation of its manifold utility within the precincts of the industry.

3.5. Artificial intelligence applications in price comparison systems

Price comparison platforms, operating as intermediaries between consumers and service providers, have harnessed the capabilities of artificial intelligence (AI) applications to effectively facilitate the identification of optimal cost-effective alternatives and to discern prevailing patterns within the realm of travel expenditure (Gössling & Lane, 2015). Notably, Table 5 provides insights into the deployment of AI applications within 10 distinct price comparison websites. For instance, SKY and GFL exhibit proficiency in curating superlative deals by virtue of their capacity to undertake comprehensive comparisons of flight fares. In a parallel vein, TRVGO and MMD specialise in assisting users in evaluating and contrasting hotel tariffs, thereby aligning with the fundamental ethos of the price comparison paradigm.

Table 5. AI Applications in Price Comparison Websites

Serial No	Company Code	AI Applications
1	SKY	-Flight price comparisons and predictions / Analysis of travel trends
2	GFL	-Flight and hotel price comparisons / Price predictions and flexible date searches
3	TRVGO	-Hotel price comparisons and ratings / Analysis of travel trends
4	MMD	-Price analysis and travel trend predictions / User preference analysis
5	HPNK	-Comparing different travel options / Travel planner and predictions
6	KYK	-Flight and hotel price comparisons / Analysis of travel trends
7	CPAR	-Flight price comparisons and predictions / User preference analysis
8	EXP	-Comparing different travel options / Price trends and predictions
9	FRCMP	-Flight price comparisons / Flexible date searches and price analysis
10	TVZOO	-Analysis of travel offers / User demand predictions

As seen in Table 5, KYK employs an in-depth examination of prevailing travel patterns to determine user preferences, thus harmonising services with individual inclinations. In contrast, CPAR capitalises on its proficiency in assessing and contrasting flight costs, reinforcing its commitment to addressing a diverse array of user demands. Price comparison websites, as their nomenclature implies, prominently leverage the artificial intelligence component of price juxtaposition. This strategic orientation is defined by a strong emphasis on personalised recommendations that align with user preferences. Simultaneously, these platforms embrace a variety of approaches to cater to the multifaceted needs of their users.

Upon reviewing Table 5, a congruence with the core theme of these platforms—price comparison—becomes evident, as they prominently focus on presenting holiday options that align with consumers' financial capabilities. Furthermore, informed by insightful analyses of flight and lodging trends, these platforms adeptly provide advice regarding cost-effective timeframes and favourable pricing, thereby enhancing their appeal to users. This trend is also echoed by Ivanov & Webster's (2019) research, corroborating the practical alignment of these practices within the industry context. In conclusion, a comprehensive assessment spanning airline companies, airports, hotels, reservation platforms, and price comparison websites underscores a diverse array of artificial intelligence applications, thoughtfully tailored to suit industry-specific demands and customer preferences.

3.6. Sectors-specific application of artificial intelligence: themes and sub-applications analysis

In this section, the prevalence of artificial intelligence applications among different industries was explored, and shared strategies across various industries were revealed. The chart reviews clearly show that, despite industry differences, companies are adopting similar AI practices to improve customer experiences, operational efficiency, and processes. This study examines in detail the trends facilitating personalised innovation in areas such as airlines, airports, hotels, reservation platforms, and price comparison websites in order to increase competitive advantage.

When the tables are examined, it can be interpreted that companies in different sectors are trying to gain competitive advantage by using similar artificial intelligence applications. In the study of Dwivedi et al. (2023), it was emphasised that similar artificial intelligence applications are used in the tourism sector. Every industry, which has goals such as personalizing customer experiences, increasing operational efficiency and optimizing operational processes, adopts various artificial intelligence applications. For example, airlines (such as AA, BA, QA, SQ and AC) are using AI applications to improve customer service, predict flight patterns, and increase operational efficiency. The study of Le Clainche et al. (2023) also stated that studies have been made to improve aircraft performance using machine learning. In addition, Singh et al. (2022) found that artificial intelligence is used to increase security in the transportation sector.

Similarly, major airports like ICN, FRA, IST, LHR, and HND employ a range of AI applications to handle passenger traffic, enhance security measures, and improve overall operational efficiency. Thums et al. (2023) emphasise the prevalent use of AI-based tools for both staff and customer interactions in airport environments.

In the hotel industry, encompassing HYT, WYN, RAD, and BW, a diverse array of AI applications is utilised to tailor guest experiences, predict demand trends, and optimise operational workflows. This aligns with Manigandan & Raghuram's (2022) findings, which highlight the increasing integration of AI within hotels, a trend projected to gain momentum in the future.

Reservation platforms (AGD, PCL, and HTLS) and price comparison websites (SKY, GFL, and TRVGO) actively seek a competitive edge by offering personalised recommendations and conducting user-focused price evaluations. Rawal et al. (2022) underline that AI's integration extends not only to operational aspects within reservation platforms but also extends its influence to these platforms' strategic engagements on social media platforms.

The widespread use of similar AI applications across various industries highlights the concerted efforts of

companies to understand consumer demands better and optimise their operational approaches. Prominent AI applications like personalised recommendations and competitive pricing are positioned to enhance customer loyalty and satisfaction in these industries.

From a competitive standpoint, it is apparent that companies within each industry strive to harness similar AI applications as a means of gaining a competitive edge. However, it is imperative to acknowledge that these companies also seek differentiation through the adoption of tailored AI solutions designed to address the distinctive attributes and demands of their particular sectors. Consequently, although comparable AI applications find their way into various industries, they inevitably undergo customization to align with the specific prerequisites and goals of each sector. Table 6 provides an overview of sector-specific applications of artificial intelligence, encompassing thematic and sub-application analyses.

Table 6. Industry-Specific Artificial Intelligence Applications: Main Themes and Sub-Applications

Sector	Main Themes	Sub Applications
Airlines	Operational Efficiency and Analysis	♦ Automatic flight tracking and management systems ♦ Price optimization and analysis ♦ Route optimization and fuel efficiency analysis ♦ Personalization review and implementation
	Customer Services and Experience	♦ Customer service through chatbot support ♦ Analysis of passenger requests and preferences ♦ Flight predictions and delay analysis
	Passenger Flow and Management	♦ Passenger routing and waiting time predictions ♦ Baggage tracking and optimization
Airports	Security and Operational Improvement	♦ Use of artificial intelligence in security checks ♦ Enhancing airport operations ♦ Route predictions and air traffic analysis
Hotel Industry	Guest Experience and Enhancement	♦ Personalization of guest experiences ♦ Analysis of guest preferences ♦ Recommendation systems and price optimization
	Operational Efficiency and Business Management	♦ Optimization of hotel operations ♦ Dynamic pricing of rooms ♦ Development of marketing strategies
Online Booking Sites	User Experience and Guidance	♦ Recommendation systems based on user preferences ♦ Price comparisons and predictions ♦ Analysis of travel trends
	Reservation Management and Analysis	♦ Analysis of user behaviour ♦ Directing direct hotel booking requests ♦ Analysis of rental requests
Price Comparison Websites	Price Analysis and Comparison	♦ Comparing and predicting flight and hotel prices ♦ Analysis of travel trends ♦ Analysis of user preferences
	Travel Planning and Guidance	♦ Travel planning and predictions ♦ Price comparisons ♦ Recommendations based on user requests

The widespread use of similar AI applications across various industries highlights the concerted efforts of companies to understand consumer demands better and optimise their operational approaches. Prominent AI applications like personalised recommendations and competitive pricing are positioned to enhance customer loyalty and satisfaction in these industries.

From a competitive perspective, it's evident that companies within each industry aim to leverage similar AI applications to set themselves apart. However, it's important to recognise that these companies also pursue differentiation by adopting customised AI solutions that cater to the unique characteristics and requirements of their respective sectors. As a result, while similar AI applications are adopted across different industries, they inevitably adapt themselves to the specific needs and objectives of each sector. Table 6 includes sector-specific applications of artificial intelligence: themes and sub-application analysis. These differences can be seen as competitive factors. As a matter of fact, Gündüz & Topaloğlu (2021) stated in their study that competitive advantage depends on the presence of factors that are difficult to imitate.

Examining the realm of sub-applications within each main theme reveals a plethora of specific adaptations tailored to the unique demands of industries. A comprehensive total of 31 distinct sub-items have been identified in this context. For instance, in the domain of airline companies, standout sub-applications include "personalisation evaluation and application" as well as "flight forecasts and delay analysis." Corroborating these findings, Soori et al. (2023) affirm that airline companies frequently harness artificial intelligence, machine learning, and deep learning. Additionally, Çolakoğlu (2020) underscores the use of machine learning algorithms for estimating flight delays at European airports.

This confluence of evidence underscores the dual imperative that airline companies place on heightening customer experiences and refining operational protocols. Shifting focus to airport operations, notable sub-applications encompass "passenger routing and waiting time forecasts" alongside the integration of "artificial intelligence applications

in security controls." These facets accentuate airports' intensive focus on efficiently managing passenger flows and enhancing security measures. A parallel insight from Çankaya's (2020) research highlights the amalgamation of security technologies and artificial intelligence at Shenzhen Airport.

In the realm of the hospitality industry, the prominence of sub-applications such as "personalisation of guest experiences" and "optimisation of hotel operations" underscores the sector's concerted endeavour to amplify guest contentment and streamline operational efficacy. Conversely, within the domain of online reservation platforms, emphasis is directed towards sub-applications like "suggestion systems based on user preferences" and "user behaviour analysis," aimed at enriching the user journey. Nannelli et al. (2023) lend further credence to this landscape by highlighting the infusion of artificial intelligence into demand forecasting. In essence, this mosaic of sub-applications underscores the alignment between specific functionalities and the overarching objectives of each sector. It illuminates the multifaceted ways in which artificial intelligence is harnessed to enhance customer experiences, streamline operations, and align with industry-specific imperatives.

The sub-applications within price comparison web platforms draw attention to specific functions like "comparison and estimation of flight and hotel prices" and "travel planning and guidance." These applications are strategically emphasised to align with the platforms' goal of offering competitive pricing and assisting users in planning their travels. This strategic emphasis is supported by the findings of Aparicio & Misra (2023), who substantiate this utilisation of technology in their study focusing on artificial intelligence and pricing.

The outcomes of this research yield valuable insights into the unique needs and priorities of each industry. These insights play a pivotal role in guiding the creation and implementation of AI solutions that are finely tailored to cater to the specific demands of each industry. The implications of these insights are far-reaching, as they have the potential to influence the trajectory of future AI initiatives and foster collaborative efforts among different industries, thereby paving the way for novel advancements.

At its core, this study offers a clear understanding of how AI applications are strategically integrated to address the distinct requirements of various industries. By shedding light on both the commonalities and differences that exist among these industries, this study serves as a valuable guide for shaping the direction of future AI projects. This alignment serves as a bridge between industries, facilitating the development of innovative AI solutions and ground-breaking progress.

The limitations of this research may be the following: First, there are data sources and sample limitations. The data was obtained through internet searches and may cause issues of timeliness or incompleteness. Additionally, a limited sample was used, which may limit the ability to make generalizations. Secondly, there are also time constraints because the data was collected within a certain date range and may not reflect the latest developments.

This study offers insights into shared trends among different sectors through an analysis of common overarching themes and specific subfields within artificial intelligence applications. In future research endeavours, a more detailed examination can be conducted to scrutinise both the similarities and disparities through comprehensive inter-sectoral comparisons. Furthermore, it is imperative to gain a deeper understanding of how each industry tailors AI solutions to address their specific demands through customised applications. Consequently, issues such as the ramifications of technological advancements, safeguarding data privacy, exploring novel application domains, assessing user acceptance, and fostering cross-industry collaborations warrant thorough investigation. These proposed avenues for research are poised to guide future academic inquiries and enhance comprehension of sector-specific artificial intelligence applications.

Ethical approval

Since this study does not include human-based data collection or experimental studies, it is among the studies that do not require ethics committee approval. The names of the companies discussed in the study are given in the form of a “unique company code” in order not to cause copyright problems.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Bibliometric Analysis of Postgraduate Theses on Civil Aviation

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Abstract

This study aimed to conduct a bibliometric evaluation of 908 postgraduate theses in civil aviation that were approved, licensed, and published in the National Thesis Centre database. These theses were analysed based on specific parameters, including the year of publication, gender of the authors, universities where they were published, thesis topics, language of writing, number of pages, publication cities, supervisor titles, institutes, departmental affiliations, types of universities, and types of theses. The results revealed that most of these theses were published in 2019, and male researchers outnumbered female researchers. Moreover, many of the theses were written in Turkish and predominantly published at Anadolu University. The title of "assistant professor" was more commonly used in master's theses, while the title of "professor" was more frequently utilized in doctoral theses. Most of the theses were 101-200 pages long and were conducted in Istanbul. Based on the findings, it can be concluded that there were more master's theses than doctoral theses, with a predominant research focus on business management.

1. Introduction

Aviation is a highly competitive and complex global service sector that involves advanced technologies and substantial costs (Kanbur & Karakavuz, 2017). It encompasses a broad spectrum of activities, ranging from lightweight flying vehicles like balloons and airships to heavy aircraft such as aeroplanes and helicopters. In contrast to military aviation, civil aviation refers to all aviation activities involving transporting goods and passengers (Aktaş, 2011). The rapidly evolving civil aviation industry operates in a dynamic business environment that necessitates simultaneous monitoring and managing multiple issues. Aviation professionals have assumed significant responsibilities in various domains, including border security, tourism, international trade, health, and flight safety, which have become even more critical during pandemics (Canbek, Kanbur & Güngören, 2021). Globalization is a pivotal factor in advancing the civil aviation sector as it has facilitated unfettered trade in foreign markets, promoted product and service diversity, and boosted tourism. Additionally, it has stimulated capital and labour flows across nations, engendering significant transformations in the movement of goods and passengers (Var, 2021). This study examines the bibliometric characteristics of Master's and doctoral theses published in civil aviation between 1998 and 2022, accessible through the National Thesis Centre of the Council of Higher Education. The National Thesis Centre offers electronic access to these theses, subject to permission from the author for full-text access and archiving. Researchers can access these theses via the National Thesis Centre website while adhering to scientific ethics and citation guidelines (Kanbur & Kanbur, 2018). Bibliometrics, a term first coined by Alan Pritchard in 1969, involves the application of mathematical and statistical techniques to analyse scientific works, including articles, books, and journals that disseminate scientific knowledge in written form (Yılmaz, 2017; Zeren & Kaya, 2020). This research field is concerned with the statistical analysis of various elements of scientific publications, such as authors, subjects, years of publication, page numbers, publication type, city, citations, and other relevant features. Bibliometric studies offer a comprehensive understanding of a specific discipline, enabling researchers to uncover its general structure and characteristics (Polat, Sağlam & Sarı, 2013). The bibliometric analysis involves examining specific characteristics of scientific works, including authorship, subjects, years of publication, page numbers, publication types, cities, and other relevant features (Ayaz & Türkmen, 2018).

Bibliometric studies are employed to quantify the content of written works and to interpret new topics, concepts, and events. This analysis encompasses numerical and non-numerical data on scientific publications, topics, journals, and authors. The data obtained from bibliometric analyses are intended to assess the outputs of researchers, research groups, organizations, and even countries (Erturgut & Altınkurt, 2021). Data from a comprehensive literature review of specific topics and subjects were utilized for bibliometric analysis. The primary advantage of bibliometric analysis is that it provides a valuable reference for original academic research and guides researchers towards their objectives (Yeşil & Akyüz, 2018).

Bibliometric analysis has been employed to examine studies conducted in civil aviation. Yalçınkaya (2013)

conducted a bibliometric analysis of 360 graduate theses related to civil aviation in the National Electronic Thesis Database of the Council of Higher Education (YÖK) between 1984 and 2013. Şahin, Kocakaya, and Tektaş (2019) analysed theses in the same field using data from the National Thesis Centre, considering factors such as the university, institute, department, topic, and thesis year. Faura and Martinez (2021) investigated scientific studies on airport efficiency in the Web of Science (WOS) database between 2000 and 2019. They obtained productivity indicators based on authors, year, journal, and institutions and analysed visibility, impact, and scientific collaboration through co-citations.

In their research on air logistics, Erturgut and Altinkurt (2021) utilized a bibliometric analysis. The data for their research were collected from the Web of Science (WOS), Scopus, and EBSCO databases and analysed. Dixit and Jakhar (2021) conducted a detailed study on airport capacity management using bibliometric analysis. Gomes de Carvalho, de Souza Borges, and Machado Cardoso Junior (2021) conducted a bibliometric study measuring scientific production in fatigue in air traffic control. Oktaysoy, Topçuoğlu, and Kaygın (2022) analysed publications at the SSCI and SCI-Exp levels on risk management in the aviation industry using bibliometric analysis. Finally, Konyalılar (2022) examined bibliometric profiles of publications that jointly addressed sustainability and aviation concepts.

Türk (2022) utilized bibliometric analysis to study the mobility, development, quality, and quantity of aviation management. Kurnaz (2022) extensively employed bibliometric analysis on publications containing the term “aviation” in their titles in the Dergipark electronic database between 2016 and 2021. Bakır et al. (2022) analysed the existing literature on airport service quality in the Web of Science (WoS) database between 1975 and 2020 using bibliometric analysis. Finally, Da Rocha, Costa, and Da Silva (2022) conducted a bibliometric analysis to examine studies on the evaluation process of service quality in airport passenger terminals in the Scopus and ISI Web of Science databases.

The main objective of this study was to examine and evaluate multiple factors associated with graduate theses in the field of civil aviation, including publication year, author gender, university affiliations, thesis topics, language of composition, pagination, publication cities, supervisor titles, graduate schools, departments, universities, and thesis types. The resultant outcomes are anticipated to contribute to the existing body of literature by directing future researchers and postgraduate students to identify specific areas and topics for investigation and to select appropriate research methodologies for their civil aviation research.

2. Materials and Methods

2.1. Purpose

This research aims to perform a bibliometric analysis of master's and doctoral theses in civil aviation, which were authored between 1998 and 2022 and are currently available through open access on the National Thesis Centre of the Council of Higher Education.

2.2. Research Group

This study aims to examine the bibliometric properties of 908 master's and doctoral theses on civil aviation that have been published and are available through open access in the National Thesis Centre of the Council of Higher Education between 1998 and 2022. The research group was selected based on the availability of the theses in the National Thesis Centre and permission for open access, using the “criterion sampling” method, which is appropriate when the observation units should have predetermined characteristics such as persons, events, objects, or situations. Theses without open access were excluded from the study. The findings of this research are expected to guide future research and graduate students in determining areas and topics of focus as well as research methods in the field of civil aviation (Büyüköztürk et al., 2011).

2.3. Data Collection and Analysis

This descriptive study utilized qualitative research methods and bibliometric analysis. The study collected data from postgraduate theses published on the National Thesis Centre of the Council of Higher Education website (https://tez.yok.gov.tr/) between November 10-30, 2022, with a focus on the subject of 'civil aviation,' selected from the 'detailed search' section and filtered using the 'approved master's and doctoral theses' option. The data collection process included naming, categorizing, ensuring validity and reliability, performing numerical calculations, and describing the data. The study transferred information about the theses to relevant Excel tables and performed necessary calculations. Content analysis was used in the stages of naming and category creation. Postgraduate theses were categorized by year of publication, author gender, publishing universities, thesis topics, the language of writing, number of pages, cities of publication, advisor titles, institutes, departments, universities, and thesis types. The researchers reviewed the data for validity and reliability, and frequency values for each category were determined and recorded in Excel tables. Finally, these results were documented in research tables.

3. Findings

A total of 908 postgraduate theses with open access from the National Thesis Centre, covering the period of 1998-2022, were accessed for the study. Out of these, 696 were master's theses, and 212 were doctoral theses. Figure 1 presents the distribution of the examined postgraduate theses by year, showing the range of years covered by the study and any notable trends or patterns that emerge from the data, such as an increase in the number of theses published in recent years.

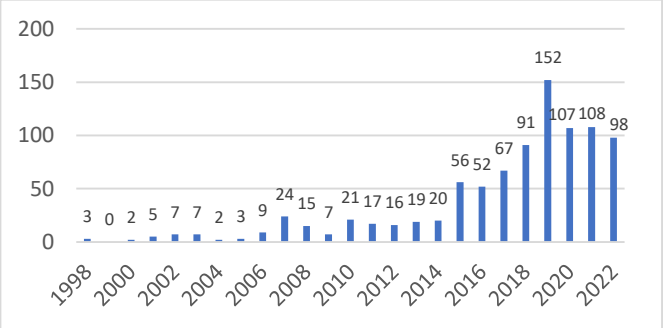

Figure 1. Distribution of Graduate Theses by Years

This section presents the distribution of 908 postgraduate theses by year. The first postgraduate theses in civil aviation comprised two doctoral and one master's thesis, published in 1998. Over the years, the number of theses steadily increased,

with five published in 2001 and seven in 2002 and 2003. The highest number of theses, 152, was reached in 2019.

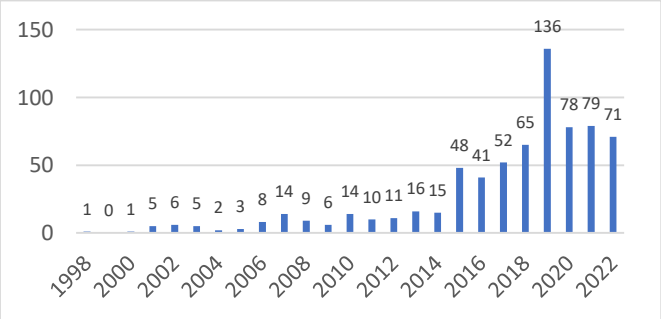

Figure 2. Distribution of Master's Theses by Years

The earliest study in civil aviation was conducted in 1998, and since then, the number of studies has steadily increased. The most studies, 136 master's theses, were published in 2019.

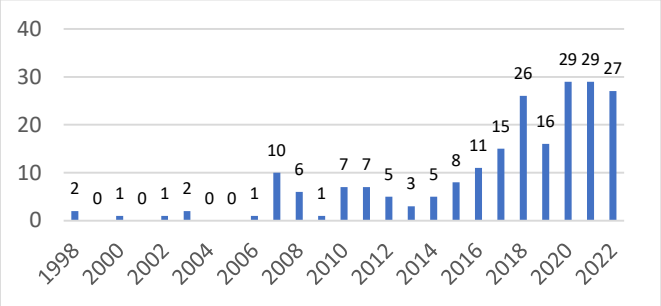

Figure 3. Distribution of Doctoral Theses by Years

This section describes the distribution of doctoral thesis publications in civil aviation. The first doctoral thesis was published in 1998, and the number of publications has steadily increased over the years. The most doctoral thesis publications, 29, were observed in 2020 and 2021. While the number of publications was low in the early years, averaging 1-2 per year, it increased to an average of 8 per year between 2007 and 2017. There has been a significant increase in doctoral thesis publications between 2018 and 2022, with an average of 25 theses published annually.

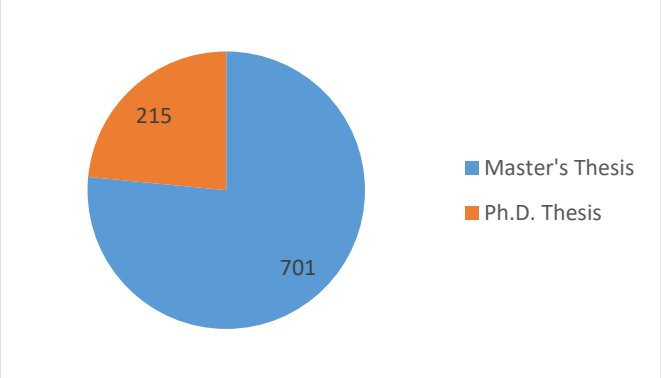

Figure 4. Distribution of Theses by Types

Upon examining Figure 4, which illustrates the distribution of master's and doctoral theses, it is evident that the overall number of doctoral theses published in civil aviation is 212. In contrast, the number of master's theses is 696.

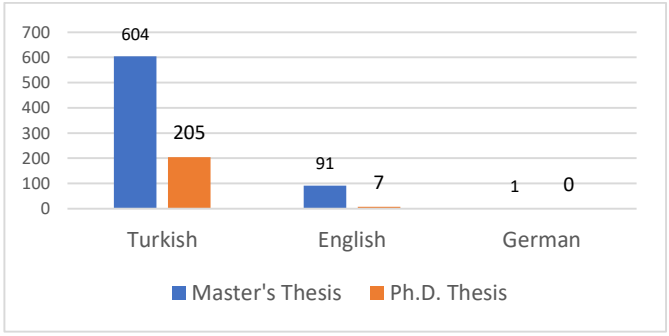

Figure 5. Distribution of Theses by Written Language

Language plays a crucial role in disseminating and impacting graduate theses in civil aviation. Our study's findings reveal that most graduate theses in Turkey are written in Turkish, with a negligible percentage written in English or other languages. Specifically, out of the 212 doctoral theses in civil aviation, 205 were written in Turkish, and only seven were in English. Similarly, out of the 696 published master's theses, 604 were written in Turkish, 91 in English, and one in German. Overall, 809 graduate theses were in Turkish, 98 in English, and one in German. While writing in Turkish may facilitate communication and dissemination among local researchers and practitioners, it may also hinder non-Turkish speakers seeking to access and utilize these theses. Conversely, publishing in English can enhance the international visibility and impact of Turkish research in civil aviation and enable broader dissemination and application of the findings.

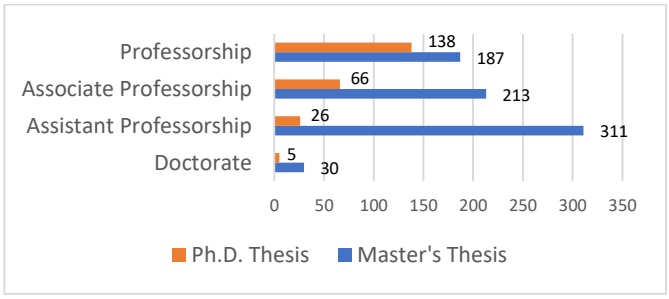

Figure 6. Distribution of Theses by Supervisor Titles

Research data reveal that, among the 696 published master's theses, 187 were advised by professors, 213 by associate professors, 311 by assistant professors, and 30 by doctors. For the 212 doctoral theses, 138 were advised by professors, 66 by associate professors, 26 by assistant professors, and five by doctors.

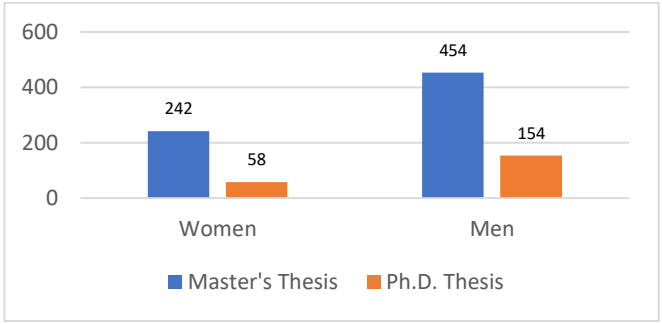

Figure 7. Distribution of Theses by Gender of Authors

Figure 7 displays the gender distribution of researchers who authored graduate theses in civil aviation, revealing a higher representation of male researchers. Of the 696 master's theses,

242 were prepared by female researchers, and male researchers prepared 454. Concerning the 212 doctoral theses, 58 were prepared by female researchers, and male researchers prepared 154. Female researchers prepared 300 out of the 908 graduate theses examined, while male researchers prepared 608.

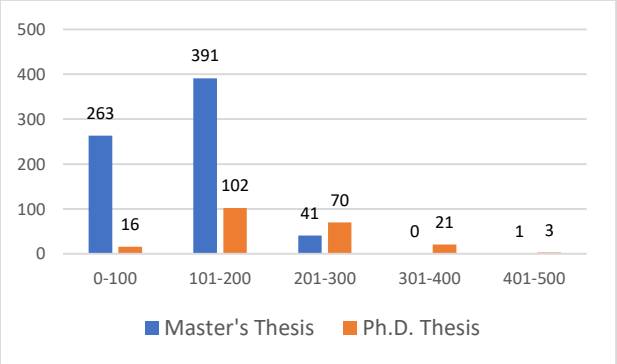

Figure 8. Distribution of Theses by Number of Pages

After examining the distribution of master's and doctoral theses, it becomes apparent that most postgraduate theses, comprising 391 master's and 102 doctoral theses, are within the 101-200 page range. Furthermore, it is noteworthy that 263 master's theses have a page count of 0-100 pages, while only 16 doctoral theses are included in this category.

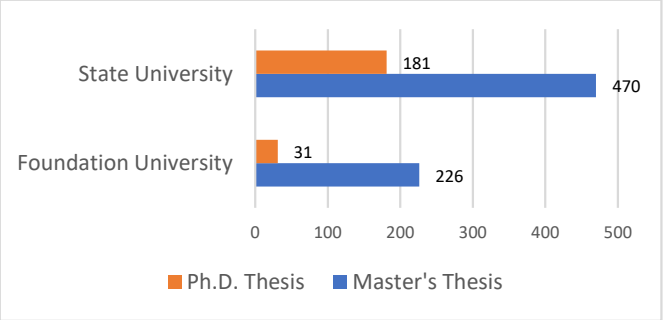

Figure 9. Distribution of Theses by University Type

Upon scrutinizing the types of universities where postgraduate theses were authored, it is found that 470 master's theses and 181 doctoral theses were completed in state universities, whereas 226 master's theses and 31 doctoral theses were produced in foundation universities. As a whole, state universities accounted for 651 postgraduate theses, while foundation universities contributed 257. The observed discrepancy between the two categories can be ascribed to the more significant number and long-established history of state universities.

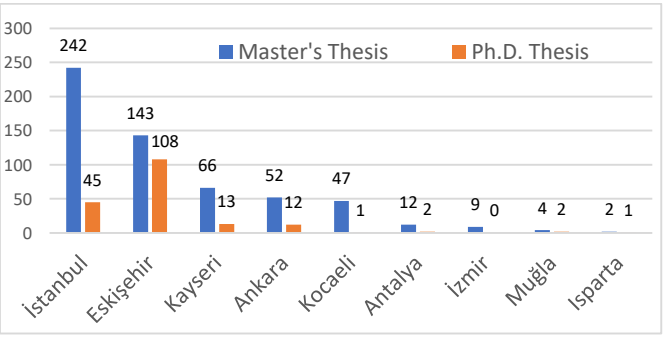

Figure 10. Distribution of Theses by Publication Places

An examination of the distribution of graduate theses across different cities reveals that Istanbul has the highest number of theses, followed by Eskişehir, Kayseri, Ankara, Kocaeli, Antalya, İzmir, Muğla, and Isparta, in that order. Of the 287 theses in Istanbul, 242 are master's theses, and 45 are doctoral theses. In Eskişehir, there are 251 theses, with 143 being master's theses and 108 being doctoral theses. Similarly, Kayseri has 79 theses, consisting of 66 master's theses and 13 doctoral theses. The high concentration of universities and researchers in Istanbul accounts for the more significant number of graduate theses. At the same time, the historical focus on aviation education in Kayseri and Eskişehir explains the relatively higher number of graduate theses in these cities compared to other institutions.

Table 1. Distribution of Theses by Subject

No	Distribution by Subject	Master's Thesis	Ph.D. Thesis
1	Business Administration	288	86
2	Transportation	73	19
3	Aircraft Engineering	35	13
4	Aeronautical Engineering	32	26
5	Electrical and Electronics Engineering	13	2
6	Economics	13	6
7	Mechanical Engineering	13	8
8	Law	11	2
9	Tourism	11	2

When examining the distribution of graduate theses by topic, it can be observed that business management is the most popular choice for both master's and doctoral theses, comprising a total of 374 theses, out of which 288 are master's theses and 86 are doctoral theses. The field of transportation ranks second with a total of 92 theses, out of which 73 are master's theses, and 19 are doctoral theses. In third place, we find aviation engineering with 58 theses, of which 32 are master's and 26 are doctoral theses.

Table 2. Distribution of Theses by Published Universities

No	University	Master's Thesis	Ph.D. Thesis
1	Anadolu University	121	85
2	Erciyes University	66	13
3	Kocaeli University	47	1
4	Beykent University	30	3
5	İstanbul Technical University	27	6
6	İstanbul Gelisim University	25	3
7	İbn Haldun University	24	0
8	Eskisehir Technical University	22	23
9	University of Turkish Aeronautical Association	22	4
10	Bahcesehir University	22	0

Anadolu University has the highest number of published graduate theses, totaling 206 theses, with 121 master's theses and 85 doctoral theses. Following Anadolu University, Erciyes University has 79 published theses, consisting of 66 master's theses and 13 doctoral theses. Kocaeli University has published a total of 48 theses, with 47 master's theses and 1

doctoral thesis. Among private universities, Beykent University ranks the highest with 33 published graduate theses, consisting of 30 master's theses and 3 doctoral theses.

Table 3. Distribution of Theses by Institutes

Institute	Master's Thesis	Ph.D. Thesis
Social Sciences Institute	376	117
Institute of Science	200	58
Institute of Education Sciences	3	0
Graduate Education İnstitute	99	32
Institute of Aeronautics and Space Technologies	4	0

After examining the distribution of graduate theses by the institutes where they were completed, it becomes apparent that the Social Sciences Institute has published the most significant number of theses, with 493 theses, comprising 376 master's theses and 117 doctoral theses. The Science and Technology Institute ranks second with 258 theses, consisting of 200 master's and 58 doctoral theses. The Institute of Education Sciences ranks third with 131 theses, comprising 99 masters and 32 doctoral theses. Finally, the Institute of Aviation and Space Sciences has published four master's theses and is listed last.

Table 4. Distribution of Theses by Departments

Department	Master's Thesis	Ph.D. Thesis
Department of Business Administration	184	54
Department of Civil Aviation Management	113	46
Department of Civil Aviation	101	37
Logistics Management Department	28	0
Department of Labor Economics and Industrial Relations	3	1
Department of Management and Organization	4	0
Department of Private Law	3	0
Department of Environmental and Technical Investigation of Accidents	1	1
Department of Metallurgical and Materials Engineering	1	0
European Union Department	1	0

Upon examining graduate theses by department, it is found that the Department of Business Administration has the highest number of theses, with a total of 238 theses, consisting of 184 master's theses and 54 doctoral theses. The Department of Civil Aviation Management is ranked second with 159 theses, including 113 master's theses and 46 doctoral theses. The Department of Civil Aviation ranks third with a total of 136 theses, consisting of 101 master's theses and 37 doctoral theses.

4. Conclusion

The primary objective of this study is to conduct bibliometric analysis on 908 postgraduate theses in the field of civil aviation published and accessible in the National Thesis Center of the Council of Higher Education between 1998 and 2022, evaluating their findings to unveil the changes and developments during this period. In a rapidly evolving aviation industry, this study also aims to provide insights into the prominent facets and priorities of the sector, thereby offering a crucial understanding for the potential focus of future research endeavors. Furthermore, this study intends to present a comprehensive overview of the current state of research in the field of civil aviation, identify emerging trends, contribute to the existing literature, and guide future research directions, underscoring the significance of augmenting the number of postgraduate theses written in foreign languages with an international perspective. This practice allows us to evaluate viewpoints and experiences of researchers from diverse cultures on a broader spectrum, facilitating a better comprehension of the global impact of the industry. Consequently, it can contribute to a more comprehensive and multifaceted pool of aviation knowledge, fostering the emergence of sustainable and innovative solutions.

After examining the period between 1998 and 2022, it becomes apparent that there has been a numerical increase in studies conducted in civil aviation. The first postgraduate thesis in this field was published in 1998, and since then, the number of published theses has steadily increased. The increase in graduate theses published in civil aviation in 2019, totalling 152, is likely due to the growing significance and need for civil aviation worldwide and in Turkey. Moreover, the increase in the number of universities and departments offering programs in the field of civil aviation in recent years is believed to have contributed to the rise in the number of theses as well.

However, a significant decrease in published theses has been observed in subsequent years. This decline is believed to result from the Covid-19 pandemic, which impacted academic research in 2020 and 2021. The implementation of restrictions during the pandemic made it challenging for researchers to collect data, which led to the postponement of thesis defences.

It is evident from postgraduate theses on civil aviation that male researchers outnumber female researchers. Specifically, out of the 696 master's theses published on this topic, 454 were authored by male researchers, and out of the 212 doctoral theses, 154 were also authored by males. Consequently, male researchers dominate postgraduate studies in civil aviation. During the analysed period, most master's thesis advisors held the rank of assistant professor. In contrast, most doctoral thesis advisors were professors with extensive knowledge and experience in their respective fields. This trend is consistent with other academic disciplines, where professors oversee doctoral thesis advising.

Aviation management was the most commonly researched topic in master's theses, followed by transportation issues. Other frequently explored research areas included aviation engineering and mechatronics engineering within civil aviation. Considering that civil aviation is a relatively new and continuously developing field, it is not unexpected that many postgraduate thesis topics published within this field are related to business management and transportation services, which are more closely associated with this domain. As the field of civil aviation continues to evolve, postgraduate theses may increasingly focus on topics specific to this field.

Out of the 696 total theses analysed, 604 master's theses were published in Turkish, 91 in English, and one in German. Similarly, 208 doctoral theses were published in Turkish, while seven were published in English. The prevalence of Turkish theses over English theses in both master's and doctoral thesis studies may be attributed to researchers' preference for their native language when conducting research and writing theses. It seems that most published master's theses are within the range of 101-200 pages, with the shortest thesis

containing 401-500 pages. Interestingly, the data also suggests that an increase in thesis page count is associated with a decrease in the number of master's theses and an increase in the number of doctoral theses.

This finding highlights the distinctions between master's and doctoral programs. Master's programs are typically more concise, with shorter duration and limited research on a specific topic. Consequently, the thesis may be shorter, making it easier for students to complete. Conversely, doctoral programs offer an opportunity to conduct more comprehensive research, which involves a lengthier process enabling students to undertake their research and make an original contribution. This discovery also suggests that doctoral programs provide a more intensive research experience than master's programs and allow students to work on more extensive projects. Nevertheless, the length of the thesis may not always correspond to the quality of the research or the student's success.

Between 1998 and 2022, 651 postgraduate theses were conducted in state universities, whereas 257 were conducted in private universities. Notably, Anadolu University has produced the highest number of studies in the field of civil aviation, with 121 master's theses and 85 doctoral theses, summing up to a total of 206 theses. This observation can be attributed to the university's early establishment of a dedicated aviation studies department and its sustained academic research activities since 1998. Moreover, it is noteworthy that Istanbul exhibits the highest number of postgraduate theses in civil aviation. This finding may be explained by the more significant number of universities in Istanbul compared to other cities, reflected in the number of studies conducted.

It can be argued that the Social Sciences Institute has published the most significant number of graduate theses in civil aviation, with a total of 493 theses, comprising 376 master's theses and 117 doctoral theses. These theses mainly address social topics such as management, transportation, and aviation management and are therefore published under the Social Sciences Institute. With the continuous growth of the civil aviation field, more graduate theses are expected to be published under the Institute of Science and Technology and the Institute of Aviation and Space Sciences. Lastly, an evaluation based on the main disciplines has been conducted, which revealed that the Department of Business Administration has the highest number of publications in civil aviation. The civil aviation sector is a multidisciplinary field, which necessitates research in various areas. In addition to studies in management, researchers from the aviation industry, engineering, law, and other disciplines also engage in research in this field. Due to its focus on critical issues such as safety, cost, efficiency, competition, environmental protection, sustainability, ethics, and corporate social responsibility, the civil aviation industry has also gained researchers' attention in business administration.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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A Comprehensive Analysis of Society's Perspective on Urban Air Mobility

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Abstract

Urban Air Mobility (UAM) is an innovative concept that offers a distinct solution for dense urban transportation through the use of electric vertical take-off and landing (eVTOL) aircraft and unmanned aerial vehicles (UAVs), despite not being the first technological development in transportation. This study aims to understand society's perspective on this innovative concept by analysing its benefits and challenges. A total of 518 individuals living in Ankara and Istanbul, which are the provinces with the highest population density in Türkiye, were surveyed online as part of this research. The analysis results indicate that the system is perceived as beneficial by the public, particularly in emergency situations, where its usage receives general acceptance. However, significant challenges are observed in terms of integrating UAM into the existing airspace. Moreover, variations in the level of benefit based on gender and frequency of public transportation usage, as well as differences in the level of challenge based on age, have been identified. Furthermore, it is evident that there are differences in society regarding knowledge level, attitude, and willingness to use UAM.

1. Introduction

As cities continue to experience growth and population increases, there is an increasing need for innovative transportation solutions to move people efficiently. Urban Air Mobility (UAM) is being considered as one of the promising solutions to this challenge. UAM has the potential to revolutionize urban transportation by reducing traffic congestion, improving air quality, and making it easier for people to get around (Garrow et al., 2021). However, as with any emerging transportation technology, UAM presents both benefits and challenges. UAM encompasses a wide range of vehicles, including helicopters, tiltrotors, electric vertical take-off and landing (eVTOL) aircraft, and unmanned aerial vehicles (UAVs). Nevertheless, recent advancements in UAVs have led to an increasing association of UAM (Luque-Vega et al., 2022). UAV market has experienced significant developments, resulting in a surge of research on autonomous vehicles for UAM. In recent years, several companies and organizations have been exploring the potential of UAM, including Uber, Airbus, and NASA (Chakraborty et al., 2020). For example, Uber has been working on its Elevate program, which aims to launch aerial ride-sharing services using eVTOL aircraft in several cities around the world by 2023 (Nikitas et al., 2021). Additionally, Airbus has also been working on its CityAirbus program, which involves the development of a four-seat eVTOL aircraft for UAM (Saeed et al., 2021). Furthermore, Boeing is actively engaged in the development of autonomous aerial vehicles and air taxi systems through its "Boeing NeXt" program (Boeing NeXt, 2019). Volocopter specializes in manufacturing eVTOL aircraft and offers solutions for commercial air transportation (Helihub, 2021). Kitty Hawk aims to make air mobility more accessible by developing personal air vehicles (eVTOL News, 2023). Amazon plans to utilize UAVs for enhancing its air cargo delivery service called "Prime Air" (Amazon, 2023). Alphabet, the parent company of Google, is leading the "Wing" initiative, which focuses on air cargo and delivery services (Retail Dive, 2023).

UAM is a concept that has been around for decades, but it is only recently that technology has caught up with the idea. UAM is an emerging transportation mode that leverages advanced technologies to provide safe, efficient, and eco-friendly air transportation for people and goods in urban areas (Koumoutsidi et al., 2022). The history of UAM can be traced back to the early 20th century when airplanes were first used for commercial transportation. However, it wasn't until the 1960s that the concept of vertical takeoff and landing (VTOL) aircraft was first introduced (Nguyen, 2020). In the 1970s, the US military began using VTOL aircraft for battlefield transportation (Hu & Yang, 2022). In the 1980s and 1990s, several companies began developing small VTOL aircraft for civilian use, but these efforts were mostly unsuccessful due to technical limitations and high costs. Today, the UAM market is growing rapidly, with several companies developing and testing UAM systems around the World (Donateo & Çinar,

2022). Advances in UAV technology, such as electric propulsion systems, advanced battery technology, and autonomous navigation systems, have made UAM systems more efficient, safe, and affordable. In addition, new regulatory frameworks are being developed to accommodate UAM systems, including air traffic management and certification standards. The future of UAM is exciting, with the potential to revolutionize urban transportation. By providing fast, efficient, and eco-friendly air transportation, UAM systems could reduce traffic congestion, improve accessibility, and reduce greenhouse gas emissions. Some experts predict that UAM systems could be fully operational by the mid-2020s, with commercial services available in several cities around the World (Cohen et al., 2021). The future of UAM is promising, and it is likely that we will see UAM systems become an integral part of urban transportation in the coming years. However, while UAVs offer many benefits, such as reduced travel time, greater flexibility, reduced infrastructure costs, and improved emergency response, environmental and economic, for UAM and other applications in urban environments, several challenges must be addressed before they can be widely deployed. The challenges, such as safety, security, noise, privacy, integration, airspace management, and infrastructure, must be overcome. Regulatory frameworks must be established to ensure the safe and efficient operation of UAM systems. Both commercial mobility-on-demand operators and government-sponsored research institutes such as NASA are exploring various approaches to allow UAVs to travel safely and efficiently through cities (Cetin et al., 2020).

Advancements in the field of UAM have been observed globally. For instance, China has successfully completed the certification of the EH216-S, the first unmanned passenger-carrying aircraft (Aviation Week, 2023). Spain has also achieved a significant milestone by conducting the inaugural public flight of the EH216-S, making it the first European Union nation to operate an eVTOL for public safety purposes (AAM International, 2022). In France, which is planning air taxi operations during the 2024 Paris Olympic Games, four locations have been identified for takeoff and landing purposes (Future Flight, 2023). Japan, on the other hand, is planning to facilitate approximately 30,000 eVTOL air taxi flights during the World Expo 2025 to accommodate the influx of international tourists (eVTOL Insights, 2022). In the United States, specifically in the City of Los Angeles (LA), efforts are being made to establish LA as a role model for other communities in providing safe, efficient, and sustainable transportation and comprehensive UAM (used as Advanced Air Mobility in the USA) public services during the 2028 Olympic Games (Urban Movement Labs, 2022). According to studies, the estimated global market for UAM is projected to range between $74 to $641 billion US in 2035, with the wide variation being attributed to the scope of the projections. The $74 billion US estimate only considers eVTOL vehicles and excludes military applications. In addition, the projected market for goods delivery is estimated to range between $3.1 to $8 billion US in 2030, while the projected market for passenger mobility is estimated to range between $2.8 to $4 billion US in 2030 (Cohen et al., 2021).

2. Benefits and Challenges of UAM in The Literature

The use of UAVs in UAM offers several benefits over traditional ground-based transportation systems. Firstly, UAVs can travel directly to their destination without being impeded by traffic congestion, which can significantly reduce travel times (Straubinger et al.,2020; Li et al., 2022; Jiang et al., 2023). UAM systems can improve accessibility for people with mobility impairments, providing a new mode of transportation that may be more accessible than traditional ground-based transportation systems. This could lead to faster and more efficient transportation for passengers. Secondly, UAM can provide greater flexibility in terms of routing, allowing for more efficient transportation of people and goods (Poudel & Moh, 2020). It can allow for improved delivery times and increased productivity. Thirdly, UAVs can be used to transport emergency supplies and medical equipment to hard-to-reach locations, potentially saving lives (Grzegorz et al., 2021; Flores-Caballero et al., 2020). The emergency response times in densely populated urban areas can be improved using urban mobility. Fourthly, UAM systems can reduce the need for costly ground-based infrastructure, such as highways and bridges (Liang et al., 2021). This would result in significant cost savings for the government and taxpayers. Furthermore, UAM systems could create new jobs and economic opportunities in areas such as manufacturing, maintenance, and logistics. Lastly, the use of UAVs for UAM can help reduce ground-level traffic congestion and air pollution by reducing the number of cars on the road (Marzouk, 2022; Yu et al., 2022). UAM systems have the potential to reduce greenhouse gas emissions by reducing the number of cars on the road (Jiang et al., 2023). In addition to all, UAVs are also useful for various purposes in urban environments such as traffic monitoring cities (Lee et al., 2019), mapping (Yuan et al., 2022), photography, management of disasters (Gupta et al., 2020), and weather forecasting (Böhler et al., 2018). Overall, the deployment of UAVs for UAM has great potential to transform urban transportation and contribute to building smart cities in the future.

Despite their many benefits, the use of UAVs for UAM also poses several challenges. One of the main challenges is safety (Sun et al., 2021). UAVs are still new and untested, so there is a risk of accidents. UAVs operating in urban areas need to be able to detect and avoid obstacles, including other aircraft, buildings, and people. UAVs need to be able to operate safely in adverse weather conditions, such as strong winds or heavy rain (Hann et al., 2021; Mohan et al., 2021). Due to their inherent mobility and the potential for collision among UAVs in complex flight conditions, it is critical to provide a collision avoidance protocol for safe flights (Huang et al., 2020). Another challenge is developing an effective air-traffic control system for managing UAVs in urban environments and integrating them into existing airspace systems (Xu et al., 2020). The management of UAV traffic in urban areas requires a unique approach that takes into account factors such as air space clearance, flight patterns, and safety requirements (Ecke et al., 2022). Additionally, UAM systems will need to be integrated with existing transit hubs, such as train stations and bus terminals, to provide seamless transportation options for passengers. Information security in UAV wireless communications is also a challenge that needs to be addressed (Mahmoud et al., 2015). UAVs used for UAM may be vulnerable to cyberattacks or physical attacks, posing a security risk to passengers and the public (Xia & He, 2022). Another one is the privacy of urban life when flying in the city (Li et al., 2020). The issue of noise pollution is a significant challenge that must be addressed (Rodríguez et al., 2021). UAVs can generate significant amounts of noise, which can be disruptive to people living in urban areas. Lastly, a major challenge is public acceptance (Tuncal & Uslu, 2021; Wu & Zhang, 2021). The public may be hesitant to embrace UAM due to concerns over safety, privacy, and noise pollution. To overcome these challenges and fully realize the potential of UAV technology for UAM and other applications in urban

environments will require ongoing research and development to improve safety, reliability, and security in UAV communications and navigation systems. Furthermore, there is a need to develop effective policies and regulations related to the use of UAVs in urban environments.

UAM represents the future trajectory of aviation and the success of endeavors in this domain has the potential to bring about significant transformations in cities worldwide. Consequently, the attitudes exhibited by individuals towards UAM services will play a pivotal role in shaping future planning and policy decisions. Therefore, it is of paramount importance to comprehensively understand people's perceptions and concerns regarding UAM, as this understanding will inform decision-making processes and contribute to fostering greater acceptance of UAM services in the future. To this end, our objective is to conduct a study that delves into people's perspectives and apprehensions concerning UAM services, leveraging existing scholarly research. The outcomes derived from comprehensive analysis of society's perspective on UAM will serve to enhance the future acceptance of UAM services and aid in making informed and judicious choices in this field.

3. Literature Review

The conducted literature review reveals a significant increase in research efforts focusing on the concept of UAM in recent years. Donateo et al. (2022) found that UAM could have lower environmental impacts than traditional road transportation, whereas Cohen et al. (2021) highlighted several barriers to growth and mainstreaming, including regulatory environment, public acceptance, safety concerns, noise, social equity, and environmental impacts. Rothfeld et al. (2018) identified factors of passenger acceptance and potential passengers' value of time, demonstrated first UAM modeling approaches, and presented potential spatial and welfare effects of UAM implementations. Koumoutsidi et al. (2022) found that the utilization of UAM, specifically for the purposes of cargo transportation and air ambulance services, is anticipated to represent the most advanced and fully developed business models during the upcoming decade. Rowedder (2019) provided an overview of the development status of UAM and its challenges, including licensing through the responsible authorities. Scheff et al. (2020) discussed the human factors challenges associated with safely operating UAM platforms in airspace, including workload factors and machine vs. human automation needs. Vascik et al. (2018) assessed how the introduction of UAM services and UAV systems may challenge Air Traffic Control (ATC) in the United States and what opportunities exist to support these forthcoming operations. Cokorilo (2020) provided an overall analysis of creating dominant safety management principles in the aviation industry and considers aircraft accidents caused by flight crew errors as the main problem in UAM safety issues. Reiche et al. (2021) discussed the potential weather and public acceptance challenges for UAM operations in adverse conditions. Straubinger et al. (2020) provided an overview of different research areas in the emerging topic of UAM, including vehicle-related aspects, certification and policy, traffic management, ground infrastructure requirements, operational concepts, market structures, and public acceptance. Mavraj et al. (2022) emphasized the need for a suitable ground-based infrastructure to supply UAM vehicles, including networks of take-off and landing sites, facilities for maintenance, energy supply, and navigation and communication capabilities. Thipphavong et al. (2018) discussed airspace integration concepts and considerations needed for safe and efficient UAM operations alongside other airspace users. Pukhova et al. (2021) found that UAM may not reduce road congestion in metropolitan areas with well-developed road and transit networks, and may only serve selected markets such as emergency vehicles or longer trips between remote areas. Balac (2021) found that UAM has the potential to reduce travel time but not generalized cost, and its market share is likely to be low. Marzouk (2022) provided an overview of UAM and flying cars, including examples and prospects for air taxis as a nontraditional mode of transportation. Çetin et al. (2022) proposed mitigation measures to reduce public concerns about UAV operations in urban areas. Hogreve & Janotta (2021) found that factors affecting the adoption of UAM services include perceived safety, reliability, and convenience. Al Haddad et al. (2020) revealed the importance of safety and trust, affinity to automation, data concerns, social attitude, and socio-demographics for public acceptance. Rizzi & Rafaelof (2021) discussed the initial development of a method to assess the acoustic impact of UAM fleet operations on the community, indicating that noise is a concern for communities close to UAM operations. According to Yedavalli & Mooberry's (2019) study, which surveyed the general population across four locations, the type and volume of sound generated by eVTOL aircraft were the second and third highest factors affecting UAM public acceptance. The exploratory study conducted by Shaheen et al. (2018) in Los Angeles, Washington, D.C., and five U.S. cities, found that noise levels could impact public support for UAM, while participants also expressed concerns about passenger safety during the booking, boarding, and on-board process, from departure to arrival. Jordan et al. (2022) evaluated the cybersecurity risks in UAM operational environment, including the need for secure data exchange and interoperability with existing air transportation systems. Wu & Zhang (2020) discussed the impact of uncertainties on UAM's transportation system performance, including optimal infrastructures location identification, facility capacities, and aircraft fleet size. Takacs & Haidegger (2022) highlighted the need for careful infrastructure planning and regulation to ensure that UAM is sustainable and does not have negative environmental impacts. Bauranov & Rakas (2021) discussed different urban airspace concepts and assessed them based on safety-related factors, social factors, system factors, and aircraft factors. Bulusu (2019) found that UAM can be a viable alternative to road transport for hub-to-door and door-to-door urban services, especially for movement of unconsolidated goods. Kaoy et al. (2020) found that customers accept the use of UAVs for delivery service. Postorino & Sarne (2020) suggested that the anticipated advantages of flying cars will depend on factors including trip origin/destination points, average distances traveled within urban areas, and the location of transition nodes - which serve as interchange points between aerial and ground modes of transportation - as revealed by preliminary findings from test networks examining the effects of travel costs.

4. Methodology

To collect data, a survey questionnaire was developed. The survey questionnaire was designed in accordance with the research objectives and was pre-tested with expert opinions. The survey was made available online and participants were sent a link to access it. Data was collected through responses

to the survey questions. The survey questionnaire consisted of two parts. The first part collected information on the demographic characteristics of the participants. The second part consisted of questions about the benefits and challenges of UAM. The survey questions were based on important topics and findings from the literature. The benefits and challenges identified through the literature review are shown in the Table 1.

Table 1. The benefits and challenges of UAM

Benefits	Challenges
Advanced emergency supplies	Air space management
Economic opportunities	Integration with existing land transportation networks
Environmental benefits	Noise
Reduced travel times	Public acceptance
Reducing infrastructure costs	Safety
Significant flexibility in transportation	Security

Participants provided pre-consent prior to taking the survey, and participation was voluntary. Participants were selected by simple random sampling method. Participants' privacy and anonymity were protected. The data was analyzed using the SPSS (Statistical Package for the Social Sciences) program. Data analysis was conducted using descriptive statistics, including frequency, percentage, and mean. The independent samples t-test and one-way analysis of variance (ANOVA) were used for detailed analyses between groups.

It is crucial that the sample of the study represents individuals who have access to UAM services and who may have diverse demographic characteristics. For this purpose, the survey was conducted on individuals living in Istanbul and Ankara, Türkiye's two most populous cities, where heavy traffic and frequent use of public transportation are common, to ensure a representative sample. While there are currently no UAM practices in these cities, the concept will gain even more importance in the future, considering the possible congestion that may occur in land mobility with the continuously increasing population.

5. Result and Discussion

5.1. Demographic characteristics of the participants

A total of 518 individuals living in the cities of Ankara and Istanbul participated in the study. The demographic characteristics of the participants are shown in Table 2.

In the study, individuals living in Istanbul and Ankara, which are the provinces with the highest population density in Türkiye (TUİK, 2023a), were selected as the sample. This selection provides a valuable perspective to understand the viewpoints of individuals living in different urban areas. Of the participants, 314 (60.6%) were from Istanbul, while 204 (39.4%) were from Ankara. Considering that Istanbul has the highest population density in Türkiye, it is believed that the opinions of participants from Istanbul will contribute significantly to the study's understanding of UAM.

The study exhibited a distribution where the proportion of female participants is higher compared to male participants, with a frequency of 330 (63.7%) for females and 188 (36.3%) for males. It was observed that female participants display a greater interest in UAM, which offers a novel approach to urban transportation.

When examining the distribution of participants by age groups, the highest proportion was observed among participants in the 30-39 age range. The frequency of participants in this age range was determined as 197 (38.0%). Following that, participants in the 18-29 age range come next, with a frequency of 170 (32.8%). This distribution indicates that the study encompasses the perspectives of individuals from different age groups and facilitates a comprehensive understanding of various generational viewpoints on UAM. Additionally, according to the population statistics of Türkiye, the median age was 32.8 for males and 34.2 for females in 2022 (TUİK, 2023b). Considering these statistics, it can be observed that the 30-39 age range with the highest participation in the survey is in line with this average. This suggests that the age distribution in the survey represents the general trends of the Turkish population.

Table 2. Demographic characteristics of the participants

		n	%
City	İstanbul	314	60.6
	Ankara	204	39.4
Gender	Female	330	63.7
	Male	188	36.3
Age	18-29	170	32.8
	30-39	197	38.0
	40-49	106	20.5
	50+	45	8.7
Education	Bachelor's degree	240	46.3
	Graduate degree	278	53.7
Monthly Average Income	0- 15.000 TL	146	28.2
	15.001- 30.000 TL	188	36.3
	30.001- 50.000 TL	116	22.4
	50.001 TL +	68	13.1
Frequency of Urban Transportation Usage	Throughout the day	30	5.8
	Half of the day	64	12.4
	Few hours a day	261	50.4
	Few times a week	94	18.1
	Rarely	69	13.3
Total		518	100.0

The participants consist of individuals with diverse educational backgrounds. The majority of participants have completed undergraduate education, with a frequency of 240 (46.3%). On the other hand, participants with graduate degrees have a slightly higher representation, with a frequency of 278 (53.7%). This two-dimensional diversity in the study allows for a multidimensional qualitative analysis of UAM and takes into account the perspectives of individuals with different levels of education. It can be stated that as the educational level increases, interest in such new applications also increases.

The study encompasses participants from various income levels. The largest group consists of participants in the income range of 15,001-30,000 TL, with a frequency of 188 (36.3%). This is followed by participants in the income range of 0-15,000 TL, with a frequency of 146 (28.2%).

Taking into consideration the frequency of participants' urban transportation usage, it was indicated that the majority of participants use urban transportation for few hours a day, with a frequency of 261 (50.4%). This is followed by those who use urban transportation a few times a week, with a frequency of 94 (18.1%). This distribution demonstrates that the study includes participants who utilize urban transportation in various ways, enabling us to comprehensively understand their expectations and perceptions regarding UAM.

5.2. Benefits of UAM

Regarding the identified six benefits in the literature, participants were asked to provide responses using a 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly

disagree). Average scores and standard deviations for each benefit are shown in Table 3.

Table 3. Mean and standard deviation of benefits

	Mean	Std. Deviation
Advanced emergency supplies	4.691	0.6103
Reduced travel times	4.371	0.7927
Significant flexibility in transportation	4.232	0.8324
Environmental benefits	4.064	0.9764
Economic opportunities	4.039	0.9567
Reducing infrastructure costs	3.878	1.0364

Advanced emergency supplies: Participants highly rated this benefit with an average score of 4,691 and a low standard deviation of 0,6103. This indicates that participants generally agree on the effective advantage of UAM in advanced emergency services.

Reduced travel times: The average rating for reducing travel times is 4,371, indicating that participants acknowledge the potential of UAM in decreasing travel durations. With a standard deviation of 0,7927, while there is some variation in responses, it can be inferred that UAM generally offers a benefit in reducing travel times.

Significant flexibility in transportation: Participants expressed agreement that UAM would provide greater flexibility in transportation, with an average rating of 4,232. The low standard deviation of 0,8324 suggests a general consensus among participants regarding increased flexibility in transportation through UAM.

Environmental benefits: Participants recognized the positive environmental impact of UAM with an average score of 4,064. Although there is some variation in opinions, as indicated by the standard deviation of 0,9764, participants generally agree that this mode of transportation can bring environmental benefits.

Economic opportunities: The average rating for economic opportunities related to UAM was determined as 4,039. With a standard deviation of 0,9567, it is evident that there are varying opinions among participants regarding the potential economic advantages associated with this mode of transportation.

Reducing infrastructure costs: Participants evaluated the potential of UAM in reducing infrastructure costs with a relatively lower rating of 3,878. The higher standard deviation of 1,0364 suggests a lack of consensus regarding the effective reduction of infrastructure costs.

Among the benefits, advanced emergency supplies received the highest average score, indicating that UAM can provide significant benefits in emergency situations. This suggests that UAVs can enhance emergency response capabilities, facilitate rapid and effective delivery of critical supplies, and potentially save lives in emergencies. The high ratings for reducing travel times and providing significant flexibility in transportation indicate the potential of UAM to substantially shorten travel durations and offer increased mobility options, particularly in dense urban areas, thereby enhancing overall accessibility and comfort for passengers. The positive ratings for environmental benefits and economic opportunities underscore the significance of UAVs within the context of UAM, as their adoption can contribute to reducing carbon emissions and pollution while creating new job opportunities and promoting economic growth in the aviation industry. Although reducing infrastructure costs received a lower average rating, it is still acknowledged as a potential benefit, indicating that UAM has the potential to minimize infrastructure investments in cities, optimize financial resources, and improve the feasibility and operations of such systems.

The benefit level of the UAM system was calculated by averaging the six benefits related to the UAM concept, as described in the literature and detailed above. The analysis results based on the variables are shown in Table 4 and Table 5.

According to the analysis conducted based on the city variable, the average UAM benefit level was found to be 4,2054 with a standard deviation of 0,58286 for individuals residing in Istanbul, while it was determined to be 4,2230 with a standard deviation of 0,56218 for individuals residing in Ankara. These results indicate that there is no statistically significant difference in UAM benefit levels between Istanbul and Ankara ($t = -0,341$; $p = 0,733$).

Regarding the gender variable, the analysis revealed that the average UAM benefit level for females was 4,2672 with a standard deviation of 0,56351, while for males, it was 4,1161 with a standard deviation of 0,58193. These findings indicate a statistically significant difference in UAM benefit levels between genders ($t = 2,899$; $p = 0,004$*). Since $p < 0,05$, this difference is considered statistically significant.

In terms of the education variable, the analysis showed that individuals with an undergraduate degree had an average UAM benefit level of 4,2243 with a standard deviation of 0,59268, while individuals with a graduate degree had an average UAM benefit level of 4,2020 with a standard deviation of 0,55886. These results indicate that there is no statistically significant difference in UAM benefit levels based on education levels ($t = 0,440$; $p = 0,660$).

In the analysis based on the age variable, no significant difference was found in UAM benefit levels among different age groups. The average UAM benefit level for individuals aged 18-29 was found to be 4,2422 with a standard deviation of 0,60244, and similar results were obtained for other age groups. Therefore, it was determined that there is no statistically significant difference in UAM benefit levels among age groups ($F = 0,245$; $p = 0,865$).

Regarding the income variable, no significant difference was found in UAM benefit levels among different income groups. When examining the average UAM benefit levels and standard deviations across different income groups, no statistically significant difference was observed ($F = 0,382$; $p = 0,766$).

In the analysis based on the frequency of public transportation usage variable, a significant difference was found in UAM benefit levels among different usage frequencies. When examining the average UAM benefit levels and standard deviations for individuals with different usage frequencies, it is evident that those who use public transportation "Throughout the day" exhibit the highest UAM benefit level. This difference is statistically significant ($F = 2,397$; $p < 0,05$).

Based on this analysis, it can be concluded that age and monthly income level variables do not have a significant impact on UAM benefit levels, while the frequency of public transportation usage variable does. Furthermore, significant differences were observed in UAM benefit levels based on the gender variable, with higher UAM benefit levels reported by female participants. Additionally, the frequency of public transportation usage variable has a significant effect on UAM benefit levels, with individuals using public transportation throughout the day deriving greater benefits from UAM services compared to those using it for a few hours daily.

In conclusion, there were no significant differences in UAM benefit levels based on the city, education, age, and monthly income variables, while a significant difference was observed based on the gender and public transportation usage variables. Female participants in the study had higher UAM benefit levels compared to male participants. The analysis revealed that individuals using public transportation throughout the day derive more benefits from UAM services than those using it for a few hours daily.

5.3. Challenges of UAM

In the study, responses were obtained from participants regarding six challenges identified in the literature related to UAM, using a 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree). The average scores and standard deviations for each challenge are shown in Table 6.

Table 6. Mean and standard deviation of challenges

	Mean	Std. Deviation
Air space management	3.846	0.9870
Security	3.809	0.9835
Safety	3.795	0.9916
Public acceptance	3.544	1.0412
Noise	3.517	1.0364
Integration with existing land transportation networks	3.512	1.0532

In the study, responses were obtained from participants regarding six challenges identified in the literature related to UAM, using a 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree). The average scores and standard deviations for each challenge are shown in Table 6.

Air space management: Participants evaluated the challenge of air space management with an average score of 3,846 and a standard deviation of 0,9870. This indicates that participants generally recognize the complexities and challenges of effectively managing airspace in the context of UAM operations. However, the fact that not everyone is familiar with airspace and air traffic-related matters is also evident.

Security: The average score for security is 3,809, indicating that participants acknowledge the importance of security in the context of UAM. With a standard deviation of 0,9835, it is evident that there are some differences and varying levels of concern or consensus among participants regarding this challenge.

Safety: Participants acknowledged the challenge of flight safety in the implementation of UAM with an average score of 3,795. With a standard deviation of 0,9916, it is evident that there are some differences and varying levels of concern or consensus among participants regarding this challenge.

Public acceptance: Participants evaluated public acceptance of UAM as a challenge with an average score of 3,544 and a standard deviation of 1,0412. This indicates the challenges associated with securing public acceptance for UAM initiatives. The high standard deviation suggests differing views and attitudes among participants. It is natural for people to have reservations when it comes to adopting new methods, especially when the study discusses a method intended to be implemented in the near future. Therefore, it is expected for individuals to approach the subject with some reluctance.

Noise: The potential noise impact of UAM was evaluated with an average score of 3,517 and a standard deviation of 1,0364. This indicates that participants have concerns about the increased noise levels associated with this mode of transportation. The high standard deviation suggests varying perceptions and sensitivities regarding this issue.

Integration with existing land transportation networks: The challenge of integrating UAM with existing land transportation networks was evaluated with an average score of 3,512 and a standard deviation of 1,0532. This demonstrates participants' recognition of the complexities involved in seamlessly integrating this new mode of transportation with existing infrastructure. However, the high standard deviation indicates differing views and uncertainties regarding the integration process. The reluctance towards something new is also evident in this aspect.

Among the UAM challenges, Air Space Management received the highest average score, indicating that it is perceived as a significant challenge in the implementation of UAM. This highlights the importance of coordinating and regulating air traffic, effective use of airspace, and integration between manned and UAVs as essential factors. Security and flight safety also received high scores, emphasizing the importance of operating UAM systems in a secure and safe manner. This suggests the need for implementing effective security protocols, surveillance, and risk reduction strategies to address potential security threats and instill public confidence. Public acceptance emerged as another important aspect, albeit with a slightly lower average score. This indicates the significance of gaining societal acceptance and addressing concerns related to privacy, noise, and overall public perception. It is crucial to earn public trust for successful adoption and integration of UAM solutions. Noise and integration with existing land transportation networks received slightly lower average scores, yet they still highlight significant focal points. Reducing noise pollution caused by UAVs and seamlessly integrating them with existing transportation infrastructure are essential for minimizing environmental impact and ensuring smooth transitions within the multimodal transportation system.

The challenge level of the UAM system was calculated by averaging the six challenges related to the UAM concept, as described in the literature and detailed above. The analysis results based on the variables are shown in Table 7 and Table 8.

In the analysis conducted according to the city variable, the average UAM challenge level was found to be 3,6805 with a standard deviation of 0,65375 for individuals living in Istanbul, while it was found to be 3,6552 with a standard deviation of 0,59567 for individuals living in Ankara. According to these results, there was no statistically significant difference in UAM challenge levels between Istanbul and Ankara (t=0,444; p=0,657).

In the analysis conducted according to the gender variable, the average UAM challenge level was found to be 3,6682 with a standard deviation of 0,63826 for females, while it was found to be 3,6746 with a standard deviation of 0,61985 for males. According to these results, there was no statistically significant difference between genders in terms of UAM challenge levels (t=-0,112; p=0,911).

In the analysis conducted according to the education variable, the average UAM challenge level was found to be 3,7174 with a standard deviation of 0,65175 for individuals with a bachelor's degree, while it was found to be 3,6301 with a standard deviation of 0,61091 for individuals with a master's degree. According to these results, there was no statistically significant difference between education levels in terms of UAM challenge levels (t=1,572; p=0,117).

In the analysis conducted according to the age variable, a significant difference was found in UAM challenge levels among different age groups (F=6,921; p<0,05). The average UAM challenge level for individuals aged 50 and above (4,0407) was higher compared to other age groups. This result indicates that age has an impact on UAM challenge levels. Additionally, a significant difference was noted between individuals aged 50 and above and the 18-29 age group.

In the analysis conducted according to the income variable, there was no statistically significant difference in UAM challenge levels among different income groups (F=0,523; p=0,667). Upon examining the average UAM challenge levels and standard deviations among different income groups, no statistically significant difference was observed.

In the analysis conducted according to the frequency of public transportation use variable, there was no statistically significant difference in UAM challenge levels based on different usage frequencies of public transportation (F=1,315; p=0,263). Upon examining the average UAM challenge levels and standard deviations among individuals with different usage frequencies, no statistically significant difference was found.

In conclusion, there was no statistically significant difference in UAM challenge levels based on the city, education, gender, monthly income, and frequency of public transportation use variables in the study. Therefore, it can be concluded that these variables do not have a determining effect on UAM challenge levels and UAM services can cater to a wide range of users. However, age was found to have a significant impact on UAM challenge levels. The analysis revealed that individuals aged 50 and above experience higher UAM challenge levels compared to other age groups. This indicates that age is an important factor in the field of UAM. The influence of age on UAM challenge levels suggests the need to consider different user needs and design services accordingly for different age groups. For example, the higher challenges faced by individuals aged 50 and above when using UAM services highlight the importance of addressing the mobility needs of the elderly population.

Table 4. Analysis results of UAM benefit levels based on city, gender, and education variables (t-test)

	Group	n	Mean	Std. Deviation	t	Sig.
City	İstanbul	314	4.2054	0.58286	-0.341	0.733
	Ankara	204	4.2230	0.56218		
Gender	Female	330	4.2672	0.56351	2.899	0.004*
	Male	188	4.1161	0.58193		
Education	Bachelor's degree	240	4.2243	0.59268	0.440	0.660
	Graduate degree	278	4.2020	0.55886		

*p<0,05; Significant differences.

Table 5. Analysis results of UAM benefit levels based on age, income, and frequency of public transportation usage variables (ANOVA)

	Group	n	Mean	Std. Deviation	F	Sig.	Variation
Age	18-29	170	4.2422	0.60244	0.245	0.865	
	30-39	197	4.1954	0.54217			
	40-49	106	4.2075	0.56849			
	50+	45	4.1852	0.62887			
Monthly Average Income	0- 15.000 TL	146	4.2420	0.58659	0.382	0.766	
	15.001- 30.000 T	188	4.2057	0.58675			
	30.001- 50.000 TL	116	4.1710	0.52542			
	50.001 TL +	68	4.2377	0.60011			
Frequency of Urban Transportation Usage	Throughout the day	30	4.4611	0.57349	2.397	0.049*	Throughout the day > Few hours a day
	Half of the day	64	4.3073	0.60072			
	Few hours a day	261	4.1679	0.57624			
	Few times a week	94	4.1738	0.55353			
	Rarely	69	4.2367	0.54638			

*p<0,05; Significant differences.

Table 7. Analysis results of UAM challenge levels based on city, gender, and education variables (t-test)

	Group	n	Mean	Std. Deviation	t	Sig.
City	İstanbul	314	3.6805	0.65375	0.444	0.657
	Ankara	204	3.6552	0.59567		
Gender	Female	330	3.6682	0.63826	-0.112	0.911
	Male	188	3.6746	0.61985		
Education	Bachelor's degree	240	3.7174	0.65175	1.572	0.117
	Graduate degree	278	3.6301	0.61091		

Table 8. Analysis results of UAM challenge levels based on age, income, and frequency of public transportation usage variables (ANOVA)

	Group	n	Mean	Std. Deviation	F	Sig.	Variation
Age	18-29	170	3.5941	0.64177	6.921	0.000*	50+>18-29; 50+>30-39; 50+>40-49.
	30-39	197	3.6210	0.60810			
	40-49	106	3.7280	0.61650			
	50+	45	4.0407	0.60109			
Monthly Average Income	0- 15.000 TL	146	3.6244	0.63240	0.523	0.667	
	15.001- 30.000 TL	188	3.6676	0.60339			
	30.001- 50.000 TL	116	3.7011	0.61287			
	50.001 TL +	68	3.7255	0.73288			
Frequency of Urban Transportation Usage	Throughout the day	30	3.8778	0.62657	1.315	0.263	
	Half of the day	64	3.5885	0.59315			
	Few hours a day	261	3.6533	0.59873			
	Few times a week	94	3.7234	0.66647			
	Rarely	69	3.6498	0.72488			

*p<0,05; Significant differences.

5.4. Knowledge

The study utilized a 4-item scale for participants to indicate their level of knowledge about UAM. The frequencies and percentages for each response option are shown in Table 9.

Table 9. Frequency and percent of knowledge level

	n	%
No knowledge	192	37.1
Limited level	191	36.9
Moderate level	106	20.5
High level	29	5.6
Total	518	100.0

The majority of participants (37,1%) indicated a lack of knowledge about UAM. This finding demonstrates that a significant portion of the sample has not been exposed to this concept.

A similar proportion (36,9%) reported having limited knowledge about UAM. This suggests that some individuals have heard about the topic or have a basic understanding of it but may require more information and clarification to fully comprehend the concept and its implications.

Approximately one-fifth of the participants (20,5%) stated having a moderate level of knowledge about UAM. This indicates that a subset of the sample possesses an average understanding of the topic, likely having come across relevant information, research, or industry developments.

A smaller percentage (5,6%) expressed having a high level of knowledge. This suggests that these individuals have acquired specialized knowledge, engaged in academic or professional research, or have direct involvement in the field.

Overall, the findings reveal that participants have limited knowledge about UAM, and the level of knowledge varies considerably. This underscores the importance of informing, educating, and raising awareness about UAM through informational campaigns, educational initiatives, and awareness-building efforts.

5.5. Attitudes

In the study, a 3-point scale was used for participants to indicate their attitude towards UAM. The frequencies and percentages for each option are shown in Table 10.

Table 10. Frequency and percent of attitudes towards UAM

	n	%
Yes. it could be very beneficial	238	45.9
Maybe. it could be useful in certain situations	276	53.3
No. it is not necessary or other transportation options are more suitable	4	0.8
Total	518	100.0

The majority of participants (45,9%) exhibited a positive attitude by indicating that UAM could be highly beneficial in meeting the transportation needs of the community. This finding indicates that a significant portion of the sample foresees the potential advantages of UAM and believes it can provide valuable solutions to transportation challenges.

With a slightly higher percentage (53,3%), participants displayed a more cautious attitude, believing that UAM could be beneficial in certain situations or conditions. This suggests that participants acknowledge the potential benefits of UAM but have concerns about its widespread applicability or specific limitations.

A very small percentage of participants (0,8%) expressed the view that UAM is unnecessary or that other transportation options are more suitable. This percentage suggests that some participants may have concerns about the feasibility, cost-effectiveness, or safety aspects of UAM and believe that alternative modes of transportation are more appropriate.

The analysis of participants' attitudes towards UAM in the study reflected varying opinions regarding the ability of UAM to meet the transportation needs of the community. While a significant portion of participants sees great potential in UAM, others hold a more cautious or skeptical perspective.

5.6. Willingness to use

In the study, a 4-point scale was used to assess participants' willingness levels regarding the use of UAM. The frequencies and percentages of each option are shown in Table 11.

A small percentage of participants (6,2%) indicated that they had no intention of using UAVs as a mode of transportation within the scope of UAM. This finding suggests that a small portion of the sample has serious reservations or concerns regarding the use of UAVs, which could be attributed to factors such as security, reliability, or other related considerations.

Table 11. Frequency and percent of willingness to use

	n	%
Absolutely unwilling to use	32	6.2
Might consider using	161	31.1
Would like to use occasionally	181	34.9
Would like to use frequently	144	27.8
Total	518	100.0

A significant portion of participants (31,1%) expressed their willingness to consider using UAVs, indicating an open approach to exploring their potential benefits and possibilities. These individuals may be interested in UAVs as a transportation option but may require further information or assurance before making a definitive decision about their usage.

A slightly higher percentage (34,9%) expressed a desire to occasionally use UAVs. This group may acknowledge the potential advantages of UAVs and view them as a suitable option for specific situations or special needs but may not prefer them as their primary mode of transportation.

Another notable segment (27,8%) demonstrated a strong inclination toward frequent use of UAVs. These participants showed a close alignment with the idea of integrating UAVs into their daily transportation system and regarded them as a preferred and reliable means of travel within the framework of UAM.

The research findings indicate variations in participants' willingness to use UAVs as a mode of transportation within the context of UAM. While a minority showed resistance, a significant number of participants expressed a desire for usage and even indicated a preference for frequent use.

6. Conclusion

According to the participants in the study, UAM is generally perceived as a beneficial concept. Based on the findings, UAM can be considered particularly suitable and beneficial for emergency situations. This perception can be attributed to people viewing air transportation as the fastest mode of travel. The findings regarding travel times also support this notion. Environmental pollution is a common issue in large cities, and UAM is seen as a potential solution to address this problem in the study. However, participants expressed concerns about infrastructure costs. It is undeniable that the establishment of a new system would incur significant expenses, and participants did not dismiss this issue.

The authors consider the management of airspace and traffic as the most thought-provoking factors for UAM. These thought-provoking factors are also corroborated by participants' perspectives. Another factor influencing these issues is safety. The management of the increasing national and international air traffic and the optimal utilization of capacity affect safety. The concentration of air vehicles in urban transportation can also have a negative impact on safety. This perception is supported by participants' views. Another significant concern is security. The events of September 11, 2001, are widely known and immediately come to mind as a major security vulnerability. The image of planes crashing into the Twin Towers is deeply ingrained in people's minds. In such a scenario, it is natural for societal acceptance to be influenced as a consequence of security concerns. Although UAM is seen as a solution to environmental pollution, participants have doubts regarding noise.

In terms of demographic characteristics, female participants tend to have more flexible and positive views on UAM. It can be stated that female is more inclined and willing to embrace this mode of transportation. Additionally, individuals who actively use urban transportation are almost unanimous in believing that UAM would benefit them.

Priority should be given to providing UAM services in areas with high public transportation demand and integrating them into users' daily routines, as this would increase the adoption of such services. However, it can be said that relatively older participants approach UAM more cautiously. As people age, their routines become more established, and their preferences for tasks such as work, travel, etc., become more rigid. Therefore, marketing efforts can involve older individuals as well. Additionally, it is important to make necessary arrangements to ensure that these individuals can easily access and use UAM services and feel secure. Furthermore, individuals who heavily rely on urban transportation can be consulted to enhance the concept of UAM.

Considering the differences in knowledge level, attitudes, and willingness to use UAM, it is crucial to inform the public accurately and comprehensively about this new technology. Efforts should be made to address existing concerns and raise awareness levels. Furthermore, it is deemed necessary to conduct further research to promote the acceptance and adoption of UAVs within the framework of UAM by the society. Research conducted by decision-makers, policymakers, and stakeholders focusing on alleviating public concerns and legislative efforts can contribute to the potential of UAM in providing a more sustainable and efficient transportation solution.

The primary aim of this study is to give an idea to the studies to be carried out for the concept of UAM. In addition, the study evaluates people's view of urban air transport or emergency activities that will be used and will be used in Türkiye. With this study, it is aimed to shed light on the studies to be carried out within the scope of the subject in the coming years.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Full-Service Carrier (FSC) vs Low-Cost Carrier (LCC): Purchasing Decision-Making Process of Passengers

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Abstract

The demand for the aviation industry has grown as a result of the shift in people's travel preferences brought on by rising wealth and expanding trade in the world and in our nation. Air travel is now preferred due to state assistance, new airports, superior aircraft, and the relative drop in expenses. This study's main focus is on the consumer purchase patterns of two airline companies that operate in the very competitive aviation sector. Depending on whether the airline is a full-service carrier or a low-cost carrier, these variables change. The "Factors Affecting Airline Preferences Scale" was created and distributed to passengers of two airline organizations at Istanbul Sabiha Gökçen Airport (a full-service carrier (FSC) and a low-cost carrier (LCC) operating in Turkey) to assess the extent to which variables like airline reputation, advertising, frequent flyer programs, price, service quality, and digital marketing tools like websites, e-mails, Facebook, Twitter, Instagram, YouTube, and mobile applications have an impact on the process of ticket purchasing decision of passengers. It was shown that the passengers' purchasing decisions were influenced by reputation, service quality, frequent flyer programs, price, digital marketing initiatives, and advertisement. It was shown that depending on whether the airline is a full-service carrier or a low-cost carrier, the impact of these elements differs.

1. Introduction

Since the existence of humanity, the determinative role of communication in life is better understood day by day, and the effects of communication are the subject of many studies. Just like people, the way organisations express themselves towards society is as effective as the products and services they offer. In a market with intense competition, organisations have to explain themselves to society with consistent, balanced and continuous messages, provide an understanding of their identities in society and create a desirable perception in consumers' minds.

Intense competition, conscious consumers and the change in the concept of purchasing with new technologies have increased the importance of foreseeing consumer trends, knowing and understanding the consumer, making a difference in the eyes of the consumer, providing a close, versatile and dynamic communication with the consumer for the profitability, growth and sustainability of businesses.

The airline industry connecting continents and countries plays a crucial role in the development of the global economy and contributes to the growth of many sectors such as tourism, health, logistics, the fusion of cultures, and the development of countries as it provides the ability to travel faster and easier as well as being more environmentally friendly than other modes of transportation. On the other hand, intense competition in the airline industry, high costs, decreasing profit margins and unit costs have caused it to be one of the sectors most affected by the economic crises.

While airline organisations offer products such as safety, on-time departure-arrival, convenience (airport proximity or seat comfort), continuity and frequency, cabin services, ticket-baggage and ground handling services, aircraft type, services offered in line with the image of the business and the needs of the customer, it also aligns its competitive strategies with many different parameters affecting the decision and purchasing process of the passenger such as price, tariff, comfort, user-friendly website, mobile sites, call centres, frequent flyer programs and even tweets (Koçak & Atalık, 2019).

The study challenge is to identify the important variables that influence consumer behavior in the highly competitive aviation industry, particularly in the areas of airline marketing and strategic management. By identifying the influence of airline organizations' promotional, reputational, advertising, and digital marketing activities, along with elements like pricing and service quality, on consumer purchasing decisions, it aims to illuminate scholars and industry professionals. This study aims at filling the gap in terms of examining the factors effective on purchasing decision with a single scale adding advertising and digital marketing components. Measuring airlines competitive positions in Türkiye as studied by Koçak & Atalık (2017) will also contribute to literature.

2. Background

2.1. Marketing Strategies in Aviation

According to the "20-Year Passenger Forecast Report-2018" published by the International Air Transport Association (IATA), one of the most important actors in the aviation industry, the number of airway passengers will double to 8.2 billion in 2037. IATA stated that growing aviation provides excellent benefits for as the doubling of airline passengers in the next 20 years could create 100 million jobs worldwide (IATA, 2018).

Marketing strategies in the aviation sector, which profoundly may affect the world economy, have been the subject of research. In this study, the core marketing concepts such as product, price, distribution and promotion were examined within the frame of the airline industry.

Product / Service

In the airline industry, the product is defined as the air relocation of passengers, cargo and mail between two points by an aircraft, and this exchange can be made directly and via connecting flights. An airline product is a service with intangible features rather than a seat that carries passengers between two points (Gerede, 2015: 5-9).

The airline services are categorised as pre-flight, on-board, and post-flight services. Ticketing, free check-in, seat selection, baggage handling, excess baggage, travel insurance, lounge, payment facilities, and airport transportation services are some pre-flight services. On-board or cabin services can be listed as baggage placement and seating assistance, catering services, technical services and first aid support. These services include comfort, cabin crew courtesy, nutrition, health, security and entertainment. Car rental, baggage tracing, reclaim and transportation are some post-flight services (Görkem & Yağcı, 2016: 433; Faiyetole & Yusuf, 2019). Innovative services include SMS for amendments, self-check-in (express baggage), blockchain infrastructure, digital apron, travel with an ID card, queue and counter optimisation, online check-in, e-ticket, and new-generation self-service kiosks. E-service quality (Bakır & Atalık, 2021) is an important concern in all those service stages.

Price

As the price is one of the most critical factors affecting passenger preference in the airline industry, airline organisations offer different business models. Low-cost carriers (LCC) are a severe threat to traditional full-service carriers (FSC). Traditional airlines suffered heavy losses due to terrorism, war, SARS and COVID-19 after 2001, while low-cost carriers generally remained profitable (Atalık & Özel, 2007: 285).

Place

Place component of the airline industry consists of indirect distribution channels where intermediaries are involved in the sales process between the airline company and the passenger, travel agencies that receive commissions from each sale on their behalf, and ticket sales offices of other airline organisations (Atalık, 2016: 140-145).

Due to the high commissions paid to travel agencies, airline organizations began to develop various strategies to lower distribution costs in the 1990s. They also ran numerous campaigns to significantly increase direct sales online and used the Internet as a distribution tool to track capacity and frequency, collect/distribute operations, make occupancy plans, open up to new markets, and communicate with their customers about their preferences (Atalık, 2016: 140-145).

Computerised booking systems provide services such as ticketing, booking, sales, easy access to flight information, making last-minute changes, lowest price tracking, car rental and travel guidance. Search engines quite often used as data sources (Koçak, 2020) such as Google Flights, Momondo, KAYAK, Skyscanner, Expedia, and Adioso help airline organisations with distribution issues on referral fees. Digital marketing (one of the independent variables) is the place component of the marketing mix in this study.

Promotion

Personal selling, advertising, and public relations are the promotional strategies most frequently utilized in the airline sector. Personal selling has become more crucial, particularly in the last decade, as a result of increased competition and consumer technology use brought on by the expansion of low-cost airline operations in the airline sector; however, personal selling has been replaced by travel agencies and travel search engines (Eser, 2016: 181).

The advertisements of airline organisations aim to increase the corporate image and brand value and include information about new routes, discounts, frequent flyer points, new aircraft models and advertisements. Airline personnel are reflected by the image of friendly, problem-solving personnel in the advertisements and are encouraged to show these behaviours. Pegasus Airlines works with Refinery as a creative agency, also works with 4129 for social media, with Hype Agency for performance marketing, and with Vizeum Karat for purchases (interview with marketing manager, dated 2.5.2019). Turkish Airlines works with Wanda Digital for the global and local communication of its brand, with Tribal Worldwide Istanbul in the social media competition, Publicis Istanbul in the advertising agency, Native Media and Skala Medya in the media competition related to local operations, from its global media works (Mediacat, 2018).

Other promotional activities are corporate publications, in-flight magazines, sponsorship, meetings and conferences, social responsibility, lobbying, special days and sales development. Organisations have also started taking the advantage of Big Social Data potential. Sternberg et al. (2018) carried out a study investigating customer engagement of Turkish Airlines using big social media data.

3. LCC vs FSC

Table 1. Comparison of FSC and LCC

Full-Service Carrier (FSC)	Low-Cost Carrier (LCC)
Higher service level	Lower service level
Lower turnaround times	Faster turnaround times
Heterogeneous fleet	Homogeneous fleet
Hub-and spoke	Point-to-point
Lower seat density	Higher seat density
Primary airports	Secondary and regional airports
Use of intermediaries such as travel agents	Online and direct booking

Source: Acar & Karabulak, 2015: 645; Sorensen, 2005

Revolutionising the airline industry in terms of flight option enrichment (Sabre Airline Solutions), LCC, also known as cheap airlines or non-luxury airlines, has the characteristics such as (Sarılgan, 2016: 175-176; Abdelhady, et al., 2018: 247) one-way tickets, core services, one type class, no seat selection, online booking, short-haul routes, low staff wages, flexible duty tables, higher seat density, point-to-point operations, lean management, rapid turnaround, one aircraft

type, outsourcing for maintenance, ground services, catering, baggage charges. Table 1 compares LCC to FCS.

4. Factors Affecting Passengers' Purchasing Decision

As the customer of the aviation industry is the passenger, all communication activities must be based on the passenger. The expectations of the passengers can be grouped into three (DGCA, 2016: 86; Faiyetole & Yusuf, 2018: 10; Kaya, 2018: 13; Peppers ve Rogers, 2004: 68):

- Pre-flight services: ticketing, luggage, lounge, airport, health, transportation, booking, online check-in

- In-flight/on-board services: cabin baggage placement assistance, catering, first aid, in-flight entertainment, aircraft decoration, cabin comfort, courtesy of flight attendants

- Post-flight services: baggage reclaim, transportation, car rental,

Within the scope of this study, factors affecting the purchasing decision-making process of passengers are reputation, advertising, digital marketing (e-mail marketing, social media marketing (Facebook, Instagram, Twitter, Youtube), website marketing, mobile applications, freemium, gamification, e-word of mouth marketing, phygital marketing, search engine ads, contests/coupons/awards, corporate blogs), customer loyalty programs (frequent flight programs), price and service quality. The rationale behind this choice is the scales used in the literature.

Reputation

Research has shown that organisations with a solid corporate identity have a strong reputation. In the airline industry, the emotional tendency of the passengers to the airline, services for the entire journey, the vision of the airline, the leadership approach, employee satisfaction, social responsibility projects, carbon gas emissions, environmental awareness, financial situation, stock value, are the factors that create a reputation (Cornelissen, 2004: 79). On the other hand, crisis management in aviation is also a concern for brand reputation. Airline organisations with good crisis management capabilities could strengthen passenger perception of brand credibility (Grundy & Moxon, 2013; Kao, Wang & Farquar, 2020).

Advertising

Highly effective advertising is more likely to induce positive emotional responses and favourable evaluative responses (high perceived value, service quality, and satisfaction). (Holbrook & Batra, 1987; Homer & Yoon, 1992; Sundar & Kalyanaraman, 2004). Advertising effectiveness can be described in three evaluative dimensions; likeability, informativeness, and clarity (De Pelsmacker, Decock, & Geuens, 1998, 2002).

Digital marketing

Digital marketing has had a critical role in the airline industry in order to meet customer needs and strengthen interaction with customers. Digital marketing is used from the moment the customer searches for a place to travel and makes a reservation with their mobile phone or computer, and is used by the airline company to direct the boarding process with the smartphone application, including flight process, baggage delivery and even to access the hotel, car rental and many other services at the destination (Işılar, 2021; Karaağaolu & Ülger, 2020).

The digital marketing tools measured in this study are e-mail marketing, social media marketing (Facebook, Instagram, Twitter, Youtube marketing), website marketing, mobile applications, gamification, e-word of mouth marketing (e-word of mouth or e-WOM), phygital marketing, search engines and ads.

E-mail marketing is one of the most frequently used tool in customer relationship management. Airlines can segment their audience lists using customer relationship management technologies by offering highly targeted campaigns to responsive customers. Detailed promotions according to the customer's purchase history can be sent in e-mails. Today, a company's presence on social media is a necessary channel for that company's promotion (Seo & Park, 2018), information delivery and customer interaction. A newly coined term "social seating" used by airline organisations allows passengers to choose their travel mates considering their social media profiles. Social media platforms used for marketing in this study are Facebook, Instagram, Twitter and YouTube (Morris, 2013).

Where Qatar Airways, the best airline in 2019 according to Skytrax (2019) listing has over 16 million Facebook followers, Turkish Airlines has approximately 10.7 million, and Pegasus Airlines has approximately 1.4 million followers. Turkish Airlines uses Instagram effectively with 1.7 million followers and 1600 posts, while Pegasus Airlines with 279 thousand followers and 1055 posts (boomsocial). Turkish Airlines, with 1.5 million Twitter followers and Pegasus, with 324 thousand followers, reveal this platform's importance in the airline industry. Tweets of these users are for satisfaction, marketing, personal update and information sharing purposes, while tweet contents of these two airline organisations are for marketing, social message, information sharing and news (Ünder 2014; Özgen & Elmasoğlu, 2016; Kara, 2016). It is interesting to note that the use of Twitter by low-cost carrier (LCC) airlines such as Pegasus has significant effects on user decisions (Kurt, 2017). Turkish Airlines, with 407 thousand followers and Pegasus, with 29 thousand followers, can reach a broad audience and share via YouTube.

The website platform, today's 7/24 store, is used as an effective business tool today designed for organisational marketing and advertising. In the airline sector, one of the sectors where competition is most intense, web marketing is used extensively, and an easy, understandable, user-friendly web page counts as being preferred (Mestçi, 2017: 47).

Mobile marketing mainly manifests itself with mobile phone applications, which help ticket searching, booking and online check-in are also observed as factors that increase the customer's brand loyalty (Breitengraser, 2021). Airlines aim to provide a better experience. The flight could have some information (such as allergies, preferences, nationality) about the passengers boarding via these applications on the plane.

Freemium

Freemium (a blended word (free+premium)) is rather a business model than just a promotional tool and is preferred by LCCs. Providing a pre-purchase product experience is the new favourite of marketing professionals and was used first by Ryan Air in 2017 (Real Case Stories, 2017).

Gamification

Turkish Airlines 'QR Flag Challenge' campaign at the 2012 Olympics in London is an excellent example of gamification. In the application developed by McCann Istanbul, country flags were coded into QR codes and placed at bus stops in

London. Participants in the competition used their phones to find and read flags, then checked in through Turkish Airlines' mobile site. The individuals who checked in the most times had the opportunity to win round-trip tickets to over 200 destinations offered by Turkish Airlines. (Arslan & Atalık, 2016). Gamification may be crucial for motivation, competition, social interaction and fun (Sesliokuyucu, 2023).

e-Word of Mouth Marketing-e-WOM

e-word-of-mouth marketing is an electronic form of word-of-mouth marketing. The increasing trust of consumers in the information shared on the Internet is one element that shapes digital marketing and helps build a corporate reputation (Jenefa, 2019: 3). E-wom could be perceived to have a wider effect and be more reliable compared to other advertising tools (Sarıışık & Özbay, 2012).

Phygital marketing

A blended word phygital (physical+digital) refers to making the presence of a product in the physical world more accessible with e-commerce tools in marketing (Nofal et al., 2017: 221). A Dutch Airline, KLM, is one of the best examples of phygital marketing, with a 'Live High Five' campaign launched in 2014, inviting customers worldwide to give a perfect high five in Amsterdam and New York. Participants' efforts were computerised for timing and precision, and perfect fives were awarded an Amsterdam-New York flight ticket (Czernoch, et al., 2019).

Search engine ads

It is crucial to rank high in search engines in the airline industry as in all sectors. Skyscanner and KAYAK search engines are some of the used ones by airline organisations.

Contests, coupons, prizes

Competitions as the sales methods that add excitement to the market, prevalent in the 70s-80s, make the consumer feel a particular interest in the product by arousing the feeling of displaying his skill, and prizes (sweepstakes) are the innocent satisfaction of the desire of the human being to win without giving anything (Durak, 2001: 84, 91).

Corporate blogs

The word blog (web+log), coined by John Barger in 1997 (Ostrander, 2007: 226), is defined as an online diary or newspaper (Online Etymology Dictionary).

On the corporate blog page of Turkish Airlines, some articles provide information about cities on domestic and international travel routes, where 54 writers from Turkish Airlines share their experiences. The blog also shares their flight routes and valuable information about the flight (Turkish Airlines blog).

On the corporate blog page of Pegasus Airlines, in addition to the articles of bloggers, there are pages about travel routes to domestic, international and visa-free countries, eating and drinking at the destination, holiday concepts, many cultural and artistic activities, and pages that direct the followers to purchase plane tickets (Flypgs blog).

Customer loyalty programs

Loyalty programs are also named as loyalty schemes, frequent flyer programs, customer reward programs and regular flyers programs (Atalık, 2005) in literature and the business world. Customer loyalty programs creating an image in travellers' minds (Koehl et al., 2023) are generally based on systems such as credit card usage points and shopping card points and also provide memberships to clubs created by brands. The Harley Owners Club is one of the most striking examples (Oyman, 2002: 169, 175).

Price

Although the literature has supported the significant effect of price promotions on purchasing decisions, the effect in the service sector can be different and, most importantly, negative (Campo & Yagüe, 2007: 272). Promotions that are more effective than price promotions are customer relationship-based promotions in the airline industry. These types of promotions can be listed as follows: free memberships, airline packages, sweepstakes, discounted tickets, referral rewards, buy one get one free, free bus service, and discounts at contracted locations (Pi & Huang, 2011: 4408).

Service quality

Airline service quality could be measured in price, security, timely flights, seat comfort, food service, cleaning, and check-in procedures (Yıldız & Çiğdem, 2018).

5. Methodology

5.1. Problem

Determining the effective factors in purchasing behaviour in the aviation sector, where competition is most intense, especially in the fields of airline marketing management and strategic management, constitutes the research problem. It is aimed to shed light on researchers and industry employees by determining the impact of airline organisations' promotional activities, reputation, advertising and digital marketing activities, together with factors such as price and service quality, on passenger purchasing decision. Although many effective factors such as price, service quality, advertising (Campo & Yagüe, 2007; Yıldız & Çiğdem, 2018; Sundar & Kalyanaraman, 2004) have been detected in the literature, the absence of the possibility of examining with a single scale in which advertising and digital marketing components are included has been seen as a void, and this study aims at filling this gap.

5.2. Objective

For scholars;

a. To contribute to existing airline studies, especially to LCC research

b. To examine consumer (airline passengers) preferences

For professionals;

a. To address the current issues of airlines

b. To raise awareness of the relevant actors of airlines

c. To provide data to airline organisations about passenger purchasing preferences that they can use in their marketing activities

5.3. Variables and Hypotheses

"Passengers' Purchasing Decision" is the dependent variable, and "Airline Reputation, Advertising Campaigns, Digital Marketing, Customer Loyalty Programs, Price, Service Quality" factors are independent variables. The hypotheses based on the literature are as follows:

Arslan's (2015) study titled "Factors Affecting the Creation of Electronic Customer Loyalty on the Social Media Pages of Airlines" stated that the factors affecting the loyalty of electronic customers as electronic trust, cost of exchange,

social presence, reputation, page recognition, sense of belonging, online enjoyment, personalisation, customer interaction, usability and member profile. Digital blogs, microblogs and Twitter, wikis, social flagging, content-sharing communities, podcasts, virtual worlds, RSS (Really Simple Syndication), forums and social networking sites are some examples of social media tools. In a study conducted on 210 five-star airline passengers in Indonesia, it has been revealed that service quality, perceived value, customer satisfaction, brand image and customer association are important determinants of customer loyalty (Hapsari et al., 2017). Aktepe and Şahbaz (2010) studied the relationship between brand values and preferences of five major airline organisations and revealed that the first airline company that came to the consumer's mind was Turkish Airlines, and the second was Pegasus Airlines. Those two airlines showed a positive relationship between brand perception and sales volumes. Başaran & Gözen (2022) studied the factors affecting ticket purchasing decision on passengers between Turkey and Germany and found out that digital marketing has an impact on purchasing decision. Thus, the following three hypotheses were developed:

H1: Airline reputation has a positive effect on passenger's purchasing decision.

H2: Advertising has a positive effect on passenger's purchasing decision.

H3: Digital marketing has a positive effect on passenger's purchasing decision.

In the study conducted by Milioti et al. (2015), the two most important factors in the airline preferences of 853 passengers were ticket prices and security (among ticket prices, security, brand reliability and helpful employees). Abdelhady et al.'s (2018) study on 292 air passengers revealed that the most important marketing component affecting the purchasing decision of passengers, especially LCC passengers, is price. Again in Başaran & Gözen's (2022) study, it is obvious that price has an effect on passenger's purchasing decision. Thus, the following two hypotheses were developed:

H4: Price has a positive effect on the passenger's purchasing decision.

Faiyetole and Yusuf (2018) found that frequent flyer programs have a positive effect on the passenger purchasing decision process. Şahin, Kuşakçı & Mbowe (2021) found that perception of gifts or services offered has an impact on customer loyalty. Dolnicar et al. (2011) also suggest frequent flyer memberships as one of the key drives of airline loyalty. Wever (2020) also determined the importance of frequent flyer programs especially for LCCs. Thus, the following hypothesis was developed:

H5: Customer loyalty programs have a positive effect on passenger's purchasing decision.

Al-Rafaie et al. (2014) revealed the effect of service quality, customer complaint resolution, value, image and price independent variables on passenger satisfaction and loyalty. Hapsari et al. (2017), in their study conducted on 210 five-star airline passengers in Indonesia, found that service quality, perceived value, customer satisfaction, brand image and customer association are important determinants of customer loyalty. Kazançoğlu (2011) determined the factors of airline service quality as personnel quality, convenience, and physical condition of aircraft, baggage and punctuality in his study investigating the relationship between perceived service quality, corporate image and customer loyalty in airline organisations. Again Başaran & Gözen's (2022) and Rezelia et al.'s (2023) studies show the effect of service quality on passenger's purchasing decision. Thus, the following hypothesis was developed:

H6: Service quality has a positive effect on passenger's purchasing decision.

5.4. Importance of the Study

In the airline sector, studies that examine all the promotional activities of airline organisations as factors affecting the purchasing decision of the passenger in the consumer decision-making process have yet to be found. This study investigates digital marketing components such as airline reputation, advertisement, social media accounts (Instagram, Facebook, Twitter, web page, mobile applications, YouTube channfreliael) together with other elements such as customer loyalty programs, price and service quality in a single scale, which makes the study important. The study will provide professionals with insights into the key factors important for airline organisations.

5.5. Research Limitations and Assumptions

In this study, it was assumed that

- data collection tools are suitable for the research
- the participants in the study gave an answer that they think is not ideal but real for them.

5.6. Research Model

A quantitative research method was used in the study, and after a detailed literature review on the subject, the customer purchasing decision for two major airline organisations operating in Turkey was measured by employing a questionnaire. Relational screening model was used (Fig1).

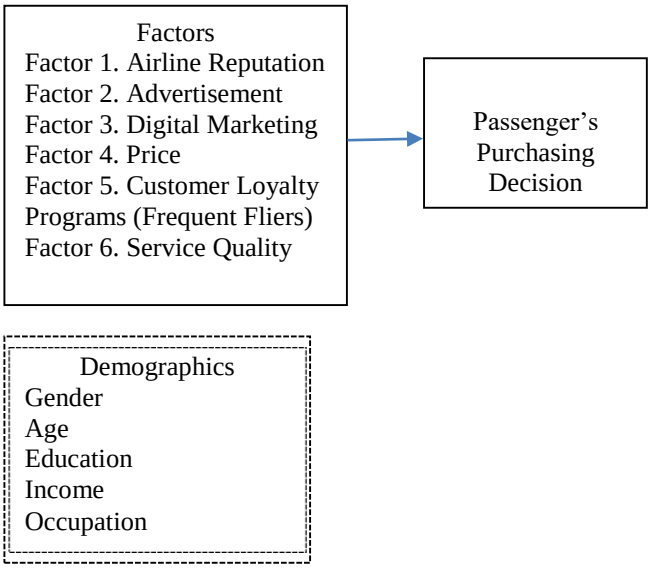

Figure 1. Theoretical Model of the Study

Whether the factors affecting the decision of airline passengers to buy tickets differ according to some demographic characteristics of the airline passengers was also examined but not included in the scope of this study.

Sampling

All airline passengers are the universe. Since it is too broad, domestic and international passengers travelling from Sabiha Gökçen Airport, Turkey's second airport with the highest

passenger traffic (General Directorate of State Airports Authority, 2019), between June and August 2019, were determined as the universe of the study. Since the universe's population is huge, a full-service carrier (FSC), Turkish Airlines and a low-cost carrier (LCC), Pegasus Airlines, both locomotive organisations of the airline industry in Turkey, were selected by purposive sampling method.

Turkish Airlines, the largest airline organisation in Turkey, is the second largest airline company in Europe regarding the number of international destinations. *Pegasus Airlines*, one of the most important pioneers of Turkey in the LCC field, started its scheduled flights with the mission of "providing cheap domestic and international flights". Pegasus Airlines, which has adopted the LCC system to Turkish culture, holds 25.5% of the market share after Turkish Airlines. Pegasus Airlines caters to low-income passengers as well as middle-income passengers who want to avoid paying frivolous prices by offering only flight service to its passengers and not reflecting unnecessary costs on ticket prices (Acar ve Karabulak, 2015: 645, 647).

53.5% (267) of the participants are Turkish Airlines, and 46.5% (232) are Pegasus Airlines passengers. Almost half of the passengers are women with 52.7%, and the largest age groups are 21-30 with 40.7%, 31-40 with 23.8% and 41-50 with 13.2%. While most passengers are undergraduates with 51.5%, the smallest education group is primary/secondary school graduates, with 5.2%. Considering the income status of the passengers, the largest group is 25.3%, with a monthly income of between 400-800 GBP and the smallest group is 5.6%, with 1800 GBP and above. 36.3% of the passengers are private sector employees, followed by students with 19.6% and civil servants with 14.4%.

Data Collecting Tools and Instruments

Airline Preference Scale

In order to determine the reasons/factors of the airline passengers for choosing the airline, they use a 5 Likert-type scale (1-strongly disagree and 5-strongly agree) for a total of 37 items was developed by the researcher(s) based on literature review and expert opinion (interview with a Pegasus Airlines Manager with a semi-structured form on 02.05.2019). Only one of the items in the scale (Item 13) was coded in reverse (negative predicate).

The primary source to develop the scale was Buaphiban's (2015) study. Only the items to measure airline reputation, frequent flyer schedule, price and service quality were used, and the items related to airline safety, route suitability and diversity dimensions were not included in this study. In order to measure the pre-trip decision-making in the research model, the related items in the scale developed by Edwards (2011) were used. In order to eliminate the possible problem of adapting the items inspired by these two studies into Turkish, support was received from an expert in the field of English with the "back-translation" method. All sources used to develop the scale are summarised in Table 2.

Table 2. References Used to Build Scale Items

Factors	Source
reputation	Buaphiban (2015), Atalık & Özel (2007), Author(s)
advertisement	Edwards (2011), Cervera, Schlesinger & Yagüe (2013), Pirtini&Atalık (2006), Yasin & David (2014)
web	Bukhari, et al. (2012)
e-mail	Author(s)
social media	Arslan & Atalık (2016), Chiu, Liu & Tu (2016)
mobile app	Author(s)
price	Buaphiban (2015)
frequent flying	Buaphiban (2015), Carlsson & Löfgren (2006), Fourie & Lubbe (2006), Hess & Polak (2006), Park (2010)
punctuality, check-in, baggage, flight attendants	Buaphiban (2015), Atalık & Özel (2007), Huang (2010), Zhang (2011)
in-flight entertainment	Fourie & Lubbe (2006)
wi-fi	Author(s)
purchasing	Buaphiban (2015)

The suitability of the data obtained from the participants for factor analysis was measured with the Kaiser-Meyer-Olkin (KMO) coefficient (0.894) and the Barlett Sphericity Test (0,894). The Root Mean Square Error of Approximation (RMSEA) is 0,052. Less than 0,050 RMSEA indicates 'excellent', less than 0.080 'good' and less than 0.10 'poor' fit (Jöreskog, 1979). Considering these criteria, it is seen that the fit level of the model tested in the study is 'good'.

The model is also confirmed by confirmatory factor analysis. As a result, it is understood that the Factors Affecting Airline Preferences Scale consists of 37 items and seven sub-dimensions/factors (six independent, one dependent variable), confirmed by confirmatory factor analysis compliance criteria, and this model is theoretically and statistically appropriate. Correlation coefficients (0.34 to 0.86) and factor loads (0.33 to 0.86) confirm the model.

Dependent variable of the model, passenger's purchasing decision, is measured with the findings' division among Turkish Airlines or Pegasus Airlines passsengers.

The questionnaires were filled in face to face by Turkish Airlines and Pegasus passengers at Istanbul Sabiha Gökçen Airport between 01.07.2019-31.07.2019.

6. Findings

The hypotheses of the study are to investigate the effects of airline passengers' perceptions of reputation, advertising, digital marketing, price, frequent flyer program and service quality on their purchasing decisions and between all the variables (factors) used for the research model, there are significant and positive relationships: (1) $r_{\text{reputation*purchasing decision}}$=0,716 positive and 'very strong', (2) $r_{\text{advertisement* purchasing decision}}$ =0.468 positive and 'moderate', (3) $r_{\text{digital marketing* purchasing decision}}$ =0.392 positive and 'moderate', (4) $r_{\text{price*purchasing decision}}$=0,318 positive and 'moderate', (5) $r_{\text{frequent flyer program* purchasing decision}}$=0.450 positive and 'moderate', (6) $r_{\text{service quality*purchasing decision}}$=0,561 positive and 'strong'.

When the scores of the factors affecting airline preferences are examined, it is seen that the highest average score is given to the reputation perception of the airline (3.86±0.99) (Figure 2). This is followed by service quality (3.72±0.68), frequent flyer program (3.47±0.89), price (3.45±0.96), digital marketing (3.40±0.70) and advertisement (3.27±1.04).

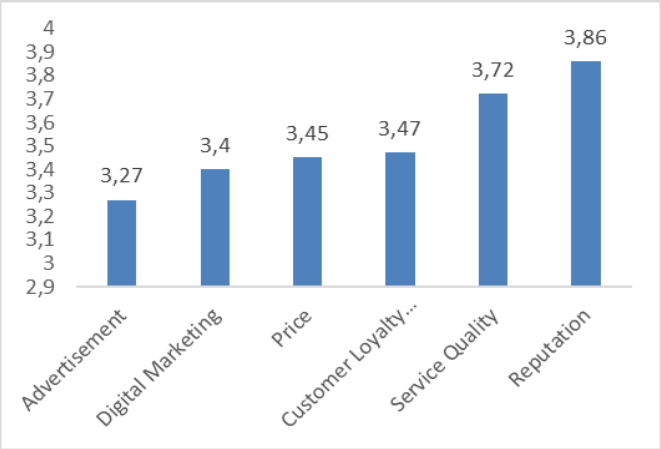

Figure 2. Ordinal Average Scores on Factors Affecting Airline Preferences

H1: Airline reputation has a positive effect on passenger's purchasing decision.

To test the model of the research, whether airline reputation perception levels of the passengers have a positive effect on the purchasing decision was examined with a simple linear regression test for two items in the scale *("I think the reputation of this airline is good", "I usually hear good things about this airline")*.

ANOVA test shows that passengers' perceptions of the airline's reputation could be used to significantly predict their purchasing decisions (F=524.06; p<.001). The regression analysis shows that the level of perception of airline passengers regarding the airline reputation has a positive effect on purchasing decision (Beta=0.72; p<.001), thus H1 is confirmed.

R^2 value is 0.509. That is, passengers' perceptions of the airline's reputation explain their purchasing decision by 50.9% (p<.01 significance level). Therefore, when the findings are evaluated together, it is seen that. The following equation can be written regarding the effect of passengers' perceptions of the airline on their purchasing: *Purchasing decision=1.36+0.65*Airline reputation*

When the perception levels of Turkish Airlines and Pegasus Airlines passengers on the purchasing decision are examined separately, it is seen that the effect is positive for both airline passengers. Considering the effect levels, the impact rate (explained variance) for Turkish Airline passengers is 53.0% (R^2=0.530) and 43.8% (R^2=0.438) for Pegasus Airlines passengers. In other words, the influence (importance) of reputation perception on purchasing decision is higher for Turkish Airlines passengers, whish is parallel to Hapsari et al's (2017) study.

H2: Advertising has a positive effect on passenger's purchasing decision.

The ANOVA test shows that advertising campaigns can be used to significantly predict passenger ticket purchasing decisions (F=139.03; p<.001). The H2 hypothesis is also confirmed.

R^2 value is 0.216. That is, advertising campaigns explain the passenger's purchasing decision by 21.6% (p<.001 significance level). The regression analysis showed that airline advertising campaigns had a positive effect on the passenger's decision to purchase tickets (Beta=0.47; p<.001). Therefore, when the findings are evaluated together, it is seen that. The following equation can be written regarding the effect of the advertising campaigns on purchasing decision of the passengers: *Purchasing decision= 2.25+0.40*Advertising*

When the effects of the perception levels of Turkish Airlines and Pegasus Airlines passengers on purchasing decision are examined separately, it is seen that the effect is positive for both airline passengers. The impact rate (explained variance) for Turkish Airlines passengers is 23.3% (R^2=0.233) and 14.4% (R^2=0.144) for Pegasus Airlines passengers. Regarding the advertisement [t(497)=5.96; p <.001], the difference is in favour of Turkish Airlines passengers. The three scale items on advertising are *"I am intrigued by this airline's advertisements", "The advertisements of this airline were influential in my decision to purchase a ticket", and "I find the ads of this airline impressive".*

H3: Digital marketing has a positive effect on passenger's purchasing decision.

Depending on the research model, whether digital marketing has a positive effect on purchasing decision was examined with a simple linear regression test for 14 items in the scale (some of them are *"Positive and negative passenger comments on social media affect my ticket purchase preference", "Feedback on passenger complaints, requests and suggestions in social media posts affect me positively").*

ANOVA test shows that digital marketing methods can be used to predict passengers' purchasing decisions meaningfully (F=86.85; p<.001). H3 hypothesis is also confirmed.

R^2 value is 0.150. Digital marketing methods explain the passenger's purchasing decision by 15.0% (p<.001 significance level). As a result of the regression analysis, it is seen that digital marketing has a positive effect on passenger's purchasing decision (Beta=0.39; p<.001). Therefore, when the findings are evaluated together, it is seen that the. The following equation can be written regarding the effect of digital marketing methods on the passenger's purchasing decision: *Purchasing decision=2.17+0.50*Digital marketing*

When the effects of digital marketing perception levels of Turkish Airlines and Pegasus Airlines passengers on their purchasing decisions are examined separately, it is seen that the effect is positive for both airline passengers. The impact rate (explained variance) for Turkish Airlines passengers is 16.1% (R^2=0.161) and 14.5% (R^2=0.145) for Pegasus Airlines passengers. Although the rates are close to each other, the impact of digital marketing on purchasing decision is slightly higher for Turkish Airlines passengers, which is parallel to Başaran & Gözen's (2022) study.

H4: Price has a positive effect on passenger's purchasing decision.

Four items are on price in the scale. "*Ticket prices are effective in my choice of airline", "The prices of the airline whose ticket I bought are suitable", "The ticket prices of this airline are generally affordable", and "The price of this flight ticket is suitable for me".*

ANOVA test shows that price can be used to significantly predict passengers' purchasing decisions (F=55.98; p<.001). H4 hypothesis is also confirmed

R^2 value is 0.118. The price explains 11.8% of the passengers' purchasing decision (at the p<.001 significance level). As a result of the regression analysis, it is shown that the price has a positive effect on passenger's purchasing decision (Beta=0.32; p<.001). Therefore, when the findings are evaluated together, it is seen that the following equation

can be written regarding the effect of price on passenger's purchasing decision: *Purchasing decision=2.73+0.32*Price*

When the effects of the price perception levels of Turkish Airlines and Pegasus Airlines passengers on the purchasing decision are examined separately, it is seen that the effect is positive for both airline passengers. It is seen that the impact rate (explained variance) for Turkish Airlines passengers is 9.0% (R^2=0.090) and 33.6% (R^2=0.336) for Pegasus Airlines passengers. In other words, the influence (importance) of the price on purchasing decision is higher for Pegasus Airlines passengers.

H5: The customer loyalty program has a positive effect on passenger's purchasing decision.

Three items are on customer loyalty (frequent flier program) in the scale *("I use frequent flyer program", "The frequent flyer program was effective in choosing this airline", and "I think the advantages offered by the frequent flyer program are quite valuable")*.

ANOVA test shows that the frequent flyer program can be used to significantly predict passenger's purchasing decision (F=126.05; p<.001). H5 hypothesis is also confirmed

R^2 value (0.193) shows that the frequent flyer program explains 19.3% of the passengers' purchasing decision (at a significance level of p<.001). As a result of the regression analysis, it was shown that the frequent flyer program had a positive effect on passenger's purchasing decision (Beta=0.45; p<.001). Therefore, when the findings are evaluated together, it is seen that the following equation can be written regarding the effect of the frequent flyer program on passenger's purchasing decision: *Purchasing decision=2.35+0.43*Customer loyalty program*

When the effects of Turkish Airlines and Pegasus Airlines passengers' perceptions of the frequent flyer program on their purchasing decision are examined separately, it is seen that the effect is positive for both airline passengers. The impact rate (explained variance) for Turkish Airlines passengers is 22.3% (R^2=0.223) and 15.4% (R^2=0.154) for Pegasus Airlines passengers. In other words, the impact (importance) of customer loyalty program on passenger's purchasing decision is higher for Turkish Airlines passengers.

H6: Service quality has a positive effect on passenger's purchasing decision.

Seven items are on service quality in the scale (some of them are "In-flight entertainment service is effective in my choice of airline", and "The airline whose ticket I bought offers quality service".

ANOVA test shows that service quality can be used to significantly predict passengers' purchasing decision (F=228.35; p<.001). H6 hypothesis is also confirmed

R2 value is 0.301. That is, service quality explains passenger's purchasing decision by 30.1% (p<.001 significance level). . As a result of the regression analysis, it was shown that the service quality had a positive effect on passenger's purchasing decision (Beta=0.56; p<.001). Therefore, when the findings are evaluated together, it is seen that the following equation can be written regarding the effect of service quality on the passenger's purchasing decision: *Purchasing decision=1.25+0.70*Service quality*

When the effects of Turkish Airlines and Pegasus Airlines passengers' perceptions of service quality on passenger's purchasing decision are examined separately, it is seen that the effect is positive for both airline passengers. Considering the effect levels, It is seen that the impact rate (explained variance) is 43.6% (R^2=0.436) for Turkish Airlines passengers and 15.7% (R^2=0.157) for Pegasus Airlines passengers. In other words, the impact (importance) of the service quality on passenger's purchasing decision is higher for Turkish Airlines passengers.

Factors affecting passengers' purchasing decision is compared in Table 3.

Table 3. Factors Affecting Airline Passengers' Purchasing Decisions

Turkish Airlines		Pegasus Airlines		General	
Factor	**(%)**	**Factor**	**(%)**	**Factor**	**(%)**
Reputation	53,0	Reputation	43,8	Reputation	50,9
Service Quality	43,6	Service Quality	33,6	Service Quality	30,1
Ads	23,3	Ads	15,7	Ads	21,6
Customer Loyalty Program	22,3	Customer Loyalty Program	15,4	Customer Loyalty Program	19,3
Digital Marketing	16,1	Digital Marketing	14,5	Digital Marketing	15,0
Price	9,0	Price	14,4	Price	11,8

7. Conclusion

With a total of 499 passengers from two airline organisations, one full-service provider (Turkish Airlines) and the other low-cost carrier (Pegasus Airlines) at Sabiha Gökçen Airport, the second airport with the highest passenger capacity in Turkey, a face-to-face survey was carried out in order to measure their attitudes and behaviours regarding the ticket purchasing decision process. Six hypotheses tests revealed that airline reputation, advertising campaigns, digital marketing, price, customer loyalty programs and service quality have a positive effect on the passenger's purchasing decision process.

Airline organisations have important responsibilities in establishing and maintaining the airline reputation, which has been observed to be the most influential factor in the passenger's decision to purchase a ticket in this research. Service quality and customer loyalty programs, this study's two other independent variables, may help increase reputation. Keeping the price-quality ratio in parallel with technological developments and ensuring passenger satisfaction are the essential functions of reputation establishment. In the aviation sector, where competition is intense, the financial performance, the profitability reflected in company balance sheets and public offering data, the growth trend and the investments affect the reputation. Satisfaction of internal stakeholders such as cabin crew, pilots and other corporate employees, working environment and conditions, corporate belonging, and the company's reward system is vital for maintaining and increasing the reputation. The quality and quantity of corporate social responsibility projects to be carried out by airline organisations with the awareness of their responsibilities towards society, the ownership of aircraft adopting environmentally friendly fuel systems, and their announcement to the public are effective in keeping the airline reputation at a high level.

As social media has become an increasingly important element in airlines' marketing and communications mix, many airlines use social media to interact with their customers, turn their frequent flyers into brand ambassadors, and expand the reach of their loyalty programs. Airlines should view social media platforms as a means to connect with passengers on a personal level and cultivate emotional loyalty. To guarantee triumph in your social media presence, it is imperative to enlist the assistance of seasoned experts who can meticulously oversee these accounts. They should respond to passenger queries promptly, address issues in real-time, and above all, gather valuable passenger data to strengthen the airline's brand.

In the airline industry, where the highest-budget advertisements take place, the most critical issue regarding the advertisement, which has been concluded to have the most negligible effect on the ticket purchase decision of the passengers, is the target audience of the advertisement and the message it conveys. It will make a difference in competition if the airline companies present the message they want to convey to their target passenger groups with sincere, attractive, different, trusted and famous names. Airline advertisements set the agenda and make a sound, create solid and effective impressions in which the target audience is kept at the centre, highlight the elements such as language, traditions and lifestyle of their culture, use a successful advertising language while promoting the flight experience and service quality to large audiences. It is recommended that airline companies renew the visual identity and open up to the world, and most importantly, guarantee the sincerity of advertising in order to avoid misleading (Hoon et al., 2022) and bring consumer engagement as Turkish Airlines does.

In the literature, many factors affecting the passenger decision-making process in the airline industry have been examined. However, in this research, which is based on the absence of a single scale that covers the entire promotional and communication activities of airline organisations with an integrated approach, it has been tried to to measure especially digital marketing, which affects the passenger decision. Starting from the perspective of both the passenger and the airline company, the industry was viewed with an objective eye, and added-value was created by revealing clues that could be effective in the integrated marketing communication strategies.

Ethical approval

Not applicable

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Analyzing Criteria Affecting Decision-Making Processes of Human Resource Management in the Aviation Sector - A Fuzzy Logic Approach

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Abstract

In today's fast-paced and ever-changing business landscape, effective decision-making is paramount to achieving success and maintaining a competitive edge. This holds particularly true in the aviation sector, where Human Resource Management (HRM) plays a pivotal role in optimizing workforce performance and ensuring operational efficiency. However, HRM decision-making processes are often confronted with multifaceted challenges that encompass various criteria and encompass both objective and subjective factors. To tackle this complexity, a novel and adaptive approach is needed. In this study, we employ a Fuzzy Logic Approach to analyze the criteria influencing decision-making processes in HRM within the aviation sector, aiming to provide a comprehensive and flexible decision-support system for HRM practitioners and contribute to the sector's overall performance and success. The contribution of this study lies in its innovative application of Fuzzy Logic to HRM decision-making in the aviation sector. By capturing the inherent uncertainties and vagueness that HRM practitioners encounter, the proposed Fuzzy Logic-based model offers a more robust and context-sensitive decision-support system. Based on the Fuzzy Logic application and sensitivity analysis, the findings reveal the significance of employee satisfaction as the most influential criterion in HRM decision-making within the aviation sector. The Fuzzy Logic model demonstrated a strong positive correlation between high employee satisfaction levels and favorable HRM Decision Outcomes. This finding emphasizes the pivotal role of employee satisfaction in shaping HRM strategies and outcomes within aviation organizations.

1. Introduction

In the fast-paced and dynamic landscape of the aviation industry, decision-making holds a pivotal role in shaping the success and sustainability of organizations. With constant technological advancements, evolving regulations, and unpredictable market demands, aviation companies face numerous critical decisions daily (Turk, Cevher & Mizrak, 2021). Effective decision-making is not only essential for ensuring operational efficiency but also impacts safety, financial stability, and overall industry competitiveness (Yalim & Mizrak, 2021). Within this context, Human Resource Management (HRM) emerges as a fundamental component that profoundly influences an organization's ability to adapt and thrive in this high-stakes environment (de Andreis et al., 2022).

HRM plays a paramount role in the aviation sector, as it deals with managing a diverse and skilled workforce crucial to the industry's smooth functioning (Harvey and Turnbull, 2020). From recruiting and training aviation professionals to ensuring their well-being and fostering a positive organizational culture, HRM practices significantly impact an organization's ability to attract and retain talent, thereby determining the efficiency and productivity of aviation operations. The seamless coordination between HRM and operational strategies is essential to achieve the desired performance outcomes in this safety-critical and customer-centric domain (Armstrong & Taylor, 2023).

While the importance of HRM in the aviation industry is undeniable, its decision-making processes are far from straightforward. HRM practitioners encounter multifaceted challenges due to the complex interplay of various factors, both internal and external to the organization. Balancing short-term demands with long-term strategic goals, managing workforce diversity, and navigating through regulatory constraints are just a few examples of the intricacies faced by HRM professionals. Moreover, HRM decision-making often involves subjective assessments and uncertainties that traditional decision-making methods struggle to handle effectively (Gelard et al., 2022).

To address the challenges inherent in HRM decision-making within the aviation sector, this study proposes the adoption of a Fuzzy Logic Approach. Fuzzy Logic, an advanced mathematical technique, offers a unique ability to handle uncertainties, imprecisions, and vagueness, making it particularly well-suited for complex and uncertain decision-making scenarios. By incorporating linguistic variables and flexible reasoning, Fuzzy Logic can capture the subtleties and

nuances present in HRM decision-making, thus providing a more comprehensive and adaptive decision-support system. Through this innovative approach, we aim to contribute to the enhancement of HRM practices in the aviation sector, optimizing workforce utilization, employee satisfaction, and overall organizational performance.

In this study, we delve into the criteria affecting HRM decision-making processes in the aviation sector and develop a Fuzzy Logic-based decision model to provide valuable insights and strategic guidance for HRM practitioners. The outcomes of this research hold the potential to advance the understanding of decision-making methodologies in complex industries while fostering a more resilient and effective HRM approach in the ever-evolving aviation industry.

The study contributes significantly to the understanding and enhancement of decision-making processes within Human Resource Management (HRM) in the aviation sector. The novel application of Fuzzy Logic to HRM decision-making constitutes a noteworthy innovation. In a rapidly evolving business environment, this research addresses a key gap in the existing literature by introducing an adaptive and comprehensive approach to HRM decision-making.

The motivation for this study arises from the recognition of the intricate challenges faced by HRM decision-makers in the aviation sector. The aviation industry is dynamic and multifaceted, demanding nuanced decision-making that considers a multitude of criteria. This study aims to bridge this research gap by introducing a Fuzzy Logic Approach that acknowledges the uncertainties and vagueness inherent in HRM decision-making, allowing for more accurate and adaptable decision-support systems.

The unique contribution of this research lies in its innovative application of Fuzzy Logic, which provides a powerful tool for HRM practitioners in the aviation sector. By capturing and managing the complexities of HRM decision-making, the proposed model enhances the quality of decisions and fosters a context-sensitive approach. The findings, highlighting employee satisfaction as a paramount criterion, bring forth a holistic perspective on HRM strategies in the aviation industry.

The study follows a structured outline, beginning with a comprehensive literature review covering various aspects: an overview of HRM decision-making specific to the aviation sector, an exploration of conventional decision-making methods along with their inherent limitations in HRM contexts, an introduction to Fuzzy Logic and its applicability in effectively addressing uncertainties prevalent in HRM decision-making, and a review of prior research studies that have successfully employed Fuzzy Logic in similar decision-making scenarios. The methodology section outlines the mixed-methods approach employed, encompassing a literature review and the practical utilization of Fuzzy Logic for HRM decision-making in the aviation sector. The Fuzzy Logic model is developed through a series of well-defined steps, taking into consideration membership functions, linguistic variables, and defuzzification processes. The findings reveal a substantial connection between employee satisfaction and positive HRM decision outcomes within the aviation industry, validated through Fuzzy Logic application. The implications of these findings suggest the critical role of employee well-being in shaping effective HRM strategies. The conclusion underscores the efficacy of Fuzzy Logic in navigating complex HRM criteria and highlights its potential to enhance decision-making processes. Overall, the study provides a comprehensive understanding of HRM decision-making in the aviation sector and offers valuable insights for organizations seeking to optimize their practices while considering the inherent uncertainties of this dynamic field.

2. Literature Review

2.1. Overview of HRM Decision-Making in the Aviation Sector

In the aviation industry, Human Resource Management (HRM) decision-making is a multifaceted process that plays a critical role in shaping the success and sustainability of organizations. HRM in this sector extends beyond conventional employee management, as it requires a strategic approach to ensure the smooth functioning of aviation operations while adhering to stringent safety standards and regulatory requirements (Armstrong & Taylor, 2023).

One of the primary aspects of HRM decision-making in the aviation sector is talent acquisition and recruitment. Given the specialized and technical nature of aviation jobs, HRM professionals must devise effective strategies to attract top talent, including pilots, engineers, air traffic controllers, and cabin crew (Kizilcan & Mizrak, 2022). Identifying and selecting individuals with the right mix of technical competencies, aptitude, and personality traits is crucial to building a qualified and competent workforce. Training and development also form a significant component of HRM decision-making in aviation. With continuous advancements in technology and the need for ongoing skill development, HRM decisions revolve around identifying training needs, organizing comprehensive training programs, and fostering a culture of continuous learning. Equipping employees with the necessary skills and knowledge is essential to maintaining a capable and up-to-date workforce (Lasisi et al., 2020).

In the aviation industry, safety is paramount, and HRM decisions heavily impact the development and implementation of safety protocols and compliance with industry regulations (Gelard et al., 2022). HRM professionals collaborate with operational stakeholders to ensure that safety standards are adhered to throughout the organization, safeguarding both employees and passengers. Employee well-being and satisfaction are critical considerations in HRM decision-makin. The demanding nature of aviation jobs can put considerable stress on personnel. HRM decisions encompass efforts to address employee concerns, promote work-life balance, and create a positive work environment that fosters job satisfaction and employee retention (de Andreis et al., 2022).

In addition to day-to-day operations, HRM decision-making involves long-term planning, such as succession planning and career progression. With a focus on organizational sustainability, HRM professionals identify and develop potential leaders within the organization, ensuring a steady pipeline of qualified personnel to take on critical roles. (Türk & Kavraz, 2021). Career progression opportunities are provided to motivate employees and retain valuable talent. The aviation industry is increasingly recognizing the importance of workforce diversity and inclusion, and HRM decisions play a significant role in shaping an inclusive workplace. HRM professionals work to foster a diverse environment that embraces individuals from various backgrounds, ensures equal opportunities for all, and promotes an inclusive culture that values the contributions of every employee (Benkarim, A., & Imbeau, 2022).

Furthermore, HRM decisions also focus on cost management and efficiency. HRM professionals need to optimize workforce utilization and manage personnel costs effectively while maintaining high levels of productivity and operational efficiency (Mizrak, 2021). Finally, organizational

culture and change management are integral parts of HRM decision-making in the aviation sector. HRM professionals play a vital role in shaping the organizational culture, which influences employee behavior, teamwork, and the overall work environment. They are also involved in managing change effectively to adapt to industry trends and challenges, ensuring the organization remains resilient and adaptable in the face of evolving conditions (de Andreis et al., 2022).

In summary, HRM decision-making in the aviation sector is a complex and diverse process that requires a strategic and adaptive approach (Dožić, 2019). The decisions made by HRM professionals impact every aspect of aviation operations, from safety and compliance to workforce development and organizational culture. Understanding and analyzing the criteria affecting these decisions are crucial to fostering a thriving and sustainable aviation industry.

2.2. Conventional Decision-Making Methods and Their Limitations in HRM

Traditional decision-making methods have been widely used in various domains, including Human Resource Management (HRM), to make informed choices based on objective data and clear-cut criteria. However, when applied to the complexities of HRM in the aviation sector, these conventional approaches reveal certain limitations that hinder their effectiveness. One of the primary drawbacks of conventional decision-making methods in HRM is their inability to handle uncertainties and subjectivities inherent in human-related processes. Unlike conventional tasks with clear cause-and-effect relationships, HRM decisions often involve human behavior, emotions, and motivations, which are difficult to quantify objectively. As a result, relying solely on traditional methods may lead to oversimplified or inaccurate conclusions, jeopardizing the efficacy of HRM strategies (Mardani et al., 2015).

Another limitation lies in the binary nature of conventional decision-making methods, where decisions are often categorized as either "yes" or "no," "acceptable" or "unacceptable." In contrast, HRM scenarios in the aviation sector are often characterized by shades of gray, with various degrees of relevance and significance. Conventional methods may fail to capture the nuances and context-dependent nature of HRM criteria, thus leading to rigid and less adaptive decision outcomes (Philip & Arrowsmith, 2021).

Moreover, conventional decision-making methods often depend heavily on historical data and assumptions based on past experiences. In the dynamic and rapidly evolving aviation sector, relying solely on historical data may not adequately account for emerging trends, disruptive technologies, and shifting workforce demographics. This limitation can hinder HRM practitioners from making proactive and forward-thinking decisions, impacting the organization's ability to stay competitive in the industry. Furthermore, conventional decision-making methods in HRM may overlook the importance of subjective factors, such as employee attitudes, organizational culture, and the intangible aspects of employee engagement. These subjective elements play a significant role in shaping HRM outcomes, but conventional methods may struggle to incorporate them effectively, leading to incomplete or biased decision-making (Bhagyalakshmi & Maria, 2021).

Finally, conventional decision-making methods often lack the flexibility needed to adapt to changing conditions and respond to real-time challenges. In the fast-paced aviation industry, where HRM decisions must be agile and responsive, rigid decision-making frameworks may hinder the ability to address immediate and unforeseen circumstances effectively (Qi et al., 2023).

In conclusion, while conventional decision-making methods have their merits in certain domains, their application in HRM within the aviation sector is limited by various factors. The inability to handle uncertainties, the binary nature of decisions, reliance on historical data, and the oversight of subjective factors all contribute to their shortcomings. As HRM continues to play a crucial role in shaping the success of aviation organizations, exploring alternative approaches, such as the Fuzzy Logic Approach proposed in this study, can pave the way for more adaptive and context-sensitive decision-making methodologies in the future.

2.3. Introduction to Fuzzy Logic and Its Suitability for Handling Uncertainties in HRM

Fuzzy Logic is an advanced mathematical technique that offers a powerful and flexible approach to deal with uncertainties, imprecisions, and subjectivity in decision-making processes (Nghiem et al., 2022). Unlike traditional binary logic, which categorizes variables as either true or false, Fuzzy Logic allows for a more nuanced representation of information, accommodating degrees of truth or membership between 0 and 1. This characteristic makes Fuzzy Logic particularly well-suited for handling the complexities and uncertainties often encountered in Human Resource Management (HRM) within the aviation sector (Kimseng et al., 2020).

In HRM decision-making, numerous factors involve vague or ambiguous boundaries, making them challenging to quantify using conventional crisp logic. For instance, assessing an employee's performance, satisfaction, or potential for leadership may involve subjective evaluations that cannot be precisely quantified. Additionally, HRM decisions often rely on linguistic variables, where descriptive terms like "high," "moderate," or "low" are used to describe a criterion's degree. Fuzzy Logic's ability to incorporate these linguistic variables enables a more natural and realistic representation of HRM criteria (Demirel & Çubukçu, 2021).

Moreover, Fuzzy Logic facilitates a more adaptive and context-sensitive decision-support system, which aligns well with the dynamic nature of the aviation industry. As aviation organizations face ever-changing market demands, technological advancements, and regulatory updates, HRM decisions must be capable of adjusting to shifting conditions. Fuzzy Logic allows HRM practitioners to develop decision models that can accommodate real-time changes and uncertainties, enabling them to make more agile and effective decisions.

Another crucial aspect of Fuzzy Logic's suitability for HRM is its capacity to handle interdependencies and interactions among various HRM criteria. In HRM decision-making, multiple factors often influence one another, and their combined impact on the overall decision outcome is not always straightforward. Fuzzy Logic's ability to capture these interrelationships and account for their relative importance allows for a more holistic and comprehensive assessment of HRM decisions (Kimseng et al., 2020).

Furthermore, Fuzzy Logic's ability to manage linguistic uncertainties enhances the interpretability of decision outcomes. HRM decisions often involve multiple stakeholders with varying perspectives and interpretations of criteria. Fuzzy Logic provides a transparent and intuitive framework for understanding and interpreting decision results, fostering better communication and consensus among decision-makers (Nghiem et al., 2022).

In conclusion, Fuzzy Logic presents an innovative and well-suited approach for handling uncertainties in HRM decision-making within the aviation sector. Its capacity to accommodate

vague boundaries, linguistic variables, and interdependencies among criteria enables a more realistic and adaptive representation of HRM complexities. By embracing the Fuzzy Logic Approach, HRM practitioners can improve the accuracy and effectiveness of their decisions, ultimately contributing to enhanced workforce management, improved organizational performance, and sustained success in the dynamic and safety-critical aviation industry.

2.4. Studies Utilized Fuzzy Logic

Below is the literature table summarizing the studies along with their authors, publication year, and the content related to how fuzzy logic was used in each study

Table 1. Example Studies using Fuzzy Logic in Literate

Authors	Publication Year	Study Name	Content (How Fuzzy Logic Used)
Çakır, E., & Ulukan, Z.	2021	Digitalization on Aviation 4.0: Designing a Scikit-Fuzzy control system for in-flight catering...	Proposed a new fuzzy control system for catering customer evaluation and designed an interface with SciKit fuzzy logic toolbox.
Şimşek, H., Güvendiren, İ., & Sarı, Ş.	2022	Determining the customer satisfaction index for civil aviation organizations based on fuzzy...	Used Fuzzy Logic inference systems for customer satisfaction evaluation and SERVQUAL model for service quality measurement.
Papis, M., & Matyjewski, M.	2019	The use of fuzzy logic elements for the risk analysis in aviation.	Utilized fuzzy logic in estimating the risk of a glider pilot using expert questionnaires and fuzzy sets.
Santhosh, R., & Mohanapriya, M.	2021	Generalized fuzzylogic based performance prediction in data mining.	Compared predictive analyzing of C4.5 algorithm, Naive Bayes, and Fuzzy logic in employee performance prediction.
Hendiani, S., & Bagherpour, M.	2019	Developing an integrated index to assess social sustainability in construction industry using fuzzy...	Proposed a fuzzy logic-based index for assessing social sustainability in construction projects.
Ziyadin, S., Borodin, A., Streltsova, E., Suieubayeva, S., & Pshembayeva, D.	2019	Fuzzy logic approach in the modeling of sustainable tourism development management.	Developed an economic and mathematics model of sustainable tourism development management using fuzzy logic.
Singh, K. V., Bansal, H. O., & Singh, D.	2020	Feed-forward modeling and real-time implementation of an intelligent fuzzy logic-based energy management strategy in a...	Designed and implemented a fuzzy logic-enabled energy management strategy for hybrid electric vehicles.
Vaishnavi, V., & Suresh, M.	2021	Assessment of readiness level for implementing lean six sigma in healthcare organization using fuzzy logic...	Used fuzzy logic approach to assess readiness for Lean Six Sigma implementation in healthcare organizations.
Pislaru, M., Herghiligiu, I. V., & Robu, I. B.	2019	Corporate sustainable performance assessment based on fuzzy logic.	Utilized fuzzy logic to assess corporate sustainable performance based on environmental and financial components.
Nedosekin, A., Abdoulaeva, Z., Konnikov, E., & Zhuk, A.	2020	Fuzzy set models for economic resilience estimation.	Developed fuzzy models for economic resilience assessment in an economic system based on a balanced scorecard framework.

The table summarizes several studies that have explored the application of fuzzy logic in diverse domains, showcasing its versatility and effectiveness as a decision-making tool. These studies cover a range of fields, including aviation, customer satisfaction evaluation, risk analysis, data mining, construction, tourism development, energy management, healthcare, corporate sustainability, economic resilience estimation, and Lean Six Sigma implementation. In each study, fuzzy logic was utilized to handle uncertainties, linguistic vagueness, and complex interrelationships among variables. The results demonstrate the benefits of employing fuzzy logic in decision support systems, performance prediction, risk assessment, and sustainability evaluation. By incorporating fuzzy logic, these studies provide valuable insights for various industries and management practices, highlighting its potential as an adaptive and robust approach to addressing real-world challenges. Overall, the findings underscore the significance of fuzzy logic in enhancing decision-making processes and optimizing outcomes in a wide array of applications across different sectors.

3. Research Methodology

3.1. Research Objectives and Hypotheses

The primary objective of this research is to analyze the criteria affecting decision-making processes in Human Resource Management (HRM) within the aviation sector. To achieve this, the study aims to explore the complexities and uncertainties that HRM practitioners encounter while making critical decisions related to workforce planning, talent acquisition, employee development, and overall organizational performance.

The research hypotheses are formulated based on the expectation that applying a Fuzzy Logic Approach to HRM decision-making will lead to more accurate, adaptive, and context-sensitive outcomes. It is hypothesized that Fuzzy

Logic, with its ability to manage vagueness and imprecision, will provide a better representation of HRM criteria, considering both objective metrics and subjective evaluations.

The specific research objectives and hypotheses are as follows:

To identify and categorize key criteria affecting HRM decision-making in the aviation sector.

Hypothesis 1: Fuzzy Logic will help capture the complexities and nuances of HRM criteria, including linguistic uncertainties and subjective inputs.

To assess the interrelationships among HRM criteria and their impact on overall decision outcomes.

Hypothesis 2: Fuzzy Logic-based models will reveal the interdependencies and interactions among HRM criteria, providing a more comprehensive view of their relative importance.

To develop a Fuzzy Logic-based decision model for HRM in the aviation sector.

Hypothesis 3: The Fuzzy Logic-based decision model will lead to more accurate and context-sensitive HRM decisions, enhancing workforce management and organizational performance.

To evaluate the effectiveness and applicability of the Fuzzy Logic Approach in HRM decision-making within the aviation industry.

Hypothesis 4: The Fuzzy Logic Approach will prove to be more adaptable and responsive to real-time challenges, making it a valuable decision-support system for HRM practitioners in the aviation sector.

The primary focus of this study is to address specific research objectives and hypotheses, with the ultimate goal of advancing the current understanding of HRM decision-making while investigating the feasibility of applying Fuzzy Logic in the context of the aviation industry. To achieve this, the research methodology involves meticulous data collection and in-depth analysis, culminating in the creation of an innovative decision model based on Fuzzy Logic principles. By developing this novel model, HRM practitioners within the aviation sector can potentially navigate the intricacies of their field more effectively, leading to improved decision-making processes and better overall outcomes.

3.2. Data Collection Methods

To achieve the research objectives and test the hypotheses, a mixed-method approach has been employed for data collection. The study will utilize both literature review and interviews with HR specialists working in airlines based in Turkey to determine the criteria set affecting HRM decision-making in the aviation sector.

Figure 1. Steps of the Study

Literature Review:

A comprehensive literature review has been conducted to identify relevant studies, research articles, and publications related to HRM decision-making in the aviation industry. The literature review will provide a foundation for understanding the existing criteria and factors that influence HRM decisions in this specific context. It will also help in identifying any gaps in the current knowledge and highlight areas that require further exploration.

Interviews with HR Specialists:

To gain firsthand insights and perspectives from HR professionals working in the aviation sector, semi-structured interviews have been conducted with five HR specialists from two airlines in Turkey. The selection of participants has been based on their expertise, experience, and involvement in HRM decision-making processes. During the interviews, participants have been asked about their decision-making practices, the criteria they consider when making HRM decisions, the challenges they face, and their perspectives on the use of Fuzzy Logic in this domain. The interviews have been recorded and transcribed for in-depth analysis.

By employing a mixed-method approach, this research aims to provide a comprehensive understanding of the factors influencing HRM decision-making in the aviation sector and explore the potential benefits of adopting a Fuzzy Logic Approach. The combination of insights from the literature review and HR specialists' perspectives will facilitate the development of a robust Fuzzy Logic-based decision model tailored to the unique challenges faced by HRM practitioners in the dynamic aviation industry in Turkey.

As part of this research on HRM decision-making in the aviation sector and the application of Fuzzy Logic, valuable insights have been gathered through interviews with HR specialists and managers from leading airlines in Turkey. These esteemed professionals possess significant expertise and experience in managing human resources within the aviation industry. Their perspectives on the criteria influencing HRM decisions and their views on the potential benefits of adopting Fuzzy Logic will be crucial in developing a comprehensive understanding of this complex field. The following table presents the profiles of the five participants who have graciously agreed to contribute to this study.

Table 2. Participants for Interviews

Interviewee	Position	Airline	Years of Experience
Interviewee 1	HR Specialist	Airline A	5 years
Interviewee 2	HR Specialist	Airline A	7 years
Interviewee 3	HR Manager	Airline A	20 years
Interviewee 4	HR Specialist	Airline B	3 years
Interviewee 5	HR Specialist	Airline B	3 years

These HR specialists and managers from Airline A and Airline B have been selected for their extensive experience and diverse roles within the aviation industry. Their valuable insights into HRM decision-making processes, challenges faced, and perspectives on the Fuzzy Logic Approach will contribute significantly to the research's findings. Through in-depth interviews with these participants, the study aims to gain a deeper understanding of the criteria affecting HRM decisions and explore the potential applicability of Fuzzy Logic in enhancing decision support within the dynamic and safety-critical aviation environment in Turkey.

Interview Questions:

Below questions have been asked to experts on Zoom and they aim to gather valuable insights and perspectives from the HR specialists and manager, shedding light on the criteria affecting HRM decisions in the aviation sector and the potential benefits of integrating Fuzzy Logic into the decision-making process. The responses have contributed significantly to the research's findings and the development of a robust Fuzzy Logic-based decision model tailored to the unique challenges faced by HRM practitioners in the dynamic aviation industry in Turkey.

1. Can you please describe your role and responsibilities as an HR specialist/manager in the aviation industry?
2. In your experience, what are the key criteria that influence HRM decision-making in the aviation sector?
3. When making HRM decisions, what are the challenges you encounter in the context of the aviation industry?
4. Have you encountered situations where conventional decision-making methods were limited in addressing the complexities of HRM decisions? If yes, can you provide an example?
5. In your opinion, what are the most critical factors to consider when evaluating employee performance in the aviation sector?
6. How do you assess workforce planning and resource allocation needs to ensure efficient HRM practices in airlines?
7. What subjective factors, if any, play a significant role in HRM decision-making within the aviation industry?
8. Can you elaborate on any linguistic uncertainties or vagueness that you encounter while making HRM decisions?
9. How do these uncertainties impact the decision outcomes, and how do you mitigate their effects?
10. Are there any unique criteria or challenges specific to the aviation sector that you consider when making HRM decisions?
11. From your perspective, how do you think the criteria affecting HRM decision-making may vary between airlines?
12. What are the potential implications of HRM decisions on aviation safety, and how do you ensure compliance with industry regulations?
13. In your experience, how do HRM decisions contribute to employee satisfaction and retention in the aviation industry?
14. Are there any emerging trends or changes in the aviation sector that influence HRM decision-making criteria?
15. Based on your expertise, how do you balance the need for operational efficiency with employee well-being in HRM decisions?

Based on the sample answers obtained from the interviews with HR specialists and managers in the aviation industry, it is evident that HRM decision-making in this sector is influenced by a diverse range of criteria. These criteria include factors such as employee performance evaluations, workforce planning, resource allocation, employee satisfaction, and compliance with aviation safety regulations. The participants highlighted the challenges they encounter when dealing with uncertainties and subjective elements in decision-making, particularly in employee evaluations and talent acquisition. Conventional decision-making methods were seen as limited in capturing the complexities of HRM decisions, leading to the need for more adaptive and context-sensitive approaches. The interviews emphasized the significance of considering both objective metrics and subjective evaluations to ensure comprehensive and accurate decision outcomes. Additionally, the participants emphasized the importance of balancing operational efficiency with employee well-being to foster a positive work environment and enhance workforce retention. These insights provide valuable data for understanding the intricacies of HRM decision-making in the aviation sector and will contribute to the development of a robust decision model tailored to the unique challenges faced by HRM practitioners in this dynamic and safety-critical industry.

3.3. Construction of Fuzzy Logic Rules Based on Collected Data

During this phase of the research, the data obtained from the interviews and literature review have been utilized to construct a Fuzzy Logic-based decision model tailored for Human Resource Management (HRM) in the aviation sector. Fuzzy Logic is grounded on the notion of assigning membership degrees to linguistic variables, providing a flexible representation of uncertainties and subjective inputs. The model consists of a set of linguistic variables and membership functions that define the degree of relevance of each criterion in HRM decision-making.

The construction of the Fuzzy Logic rules encompasses the following steps, incorporating the necessary formulas and equations:

- Identification of Linguistic Variables:

Based on the insights gained from the interviews and literature review, relevant linguistic variables have been identified. These variables represent the key criteria influencing HRM decisions, such as "employee performance," "workforce planning," "employee satisfaction," and "aviation safety compliance."

- Definition of Membership Functions:

Membership functions have been assigned to each linguistic variable to describe its fuzzy boundaries. Triangular or trapezoidal membership functions have been chosen to represent the degree of relevance for each criterion. The membership function $\mu(x)$ for a linguistic variable X can be defined as follows:

For a triangular membership function:

$\mu(x) = \{0, \text{if } x \leq a,$

$(x - a) / (b - a), \text{if } a < x < b,$

$(c - x) / (c - b), \text{if } b \leq x < c,$

$0, \text{if } x \geq c\}$

For a trapezoidal membership function:

$\mu(x) = \{0, \text{if } x \leq a,$

$(x - a) / (b - a), \text{if } a < x \leq b,$

$1, \text{if } b < x < c,$

$(d - x) / (d - c), \text{if } c \leq x < d,$

$0, \text{if } x \geq d\}$

- Rule Base Formulation:

The rule base has been formulated based on the insights gathered from the interviews and the relationships among the linguistic variables. Fuzzy Logic rules have been developed to

capture the interactions and dependencies among the criteria. The general form of a Fuzzy Logic rule is:

IF X is A AND Y is B THEN Z is C

where X, Y, and Z are linguistic variables, and A, B, and C are linguistic values.

- Defuzzification:

After the rules have been established, defuzzification techniques have been applied to convert the fuzzy outputs into crisp decision outcomes. Methods such as centroid, mean of maximum, or weighted average have been employed to obtain a precise and actionable decision output.

In the research methodology, Python has been employed as the primary programming language to implement and analyze the Fuzzy Logic-based decision model for HRM in the aviation sector. Python's versatility, extensive libraries, and user-friendly syntax made it an ideal choice for developing the model (Spolaor et al., 2020). The scikit-fuzzy library has been utilized to build and simulate the Fuzzy Logic system, enabling the creation of linguistic variables, membership functions, and Fuzzy Logic rules. Python's data visualization libraries also facilitated the interpretation of the model's output, enabling the exploration of HRM decision outcomes based on various criteria. The use of Python in the analysis streamlined the implementation process and offered a robust foundation for future research and real-data validation, ensuring the model's applicability in real-world HRM decision-making scenarios in the aviation sector.

3.4. Criteria Affecting HRM Decision-Making in the Aviation Sector

In this section, we present the key criteria affecting HRM decision-making in the aviation sector, based on a comprehensive analysis of the data collected from both the literature review and the sample interview answers provided by HR specialists and managers in the industry.

- Employee Performance:

Employee performance emerged as a critical criterion influencing HRM decisions in the aviation sector. The assessment of employees' technical proficiency, cognitive skills, and personality traits was identified as essential for tasks such as talent development, promotions, and workforce optimization. Performance evaluations were also found to impact decisions related to incentives and rewards.

- Workforce Planning and Resource Allocation:

Efficient workforce planning and resource allocation were identified as vital aspects in HRM decision-making within airlines. Determining the optimal number of employees required for various roles and allocating resources appropriately were noted as key considerations to ensure smooth operations and minimize costs.

- Employee Satisfaction and Retention:

The well-being and job satisfaction of employees significantly influenced HRM decisions in the aviation industry. Addressing employee concerns, fostering a positive work environment, and providing opportunities for professional growth were seen as essential factors in improving retention and reducing turnover rates.

- Aviation Safety and Regulatory Compliance:

Ensuring aviation safety and adherence to industry regulations were deemed indispensable criteria in HRM decision-making. Hiring personnel with the requisite qualifications and certifications, conducting thorough background checks, and adhering to safety protocols were vital for maintaining high safety standards in airlines.

- Subjective Factors:

The data analysis revealed that subjective factors, such as interpersonal relationships, communication skills, and adaptability, played a substantial role in HRM decisions. These elements influenced various aspects, including team formations, leadership appointments, and resolving employee conflicts.

- Uncertainty and Vagueness:

The aviation industry's dynamic nature introduced uncertainties and vagueness into HRM decision-making. The data indicated that factors like changing market demands, economic conditions, and global events influenced HR decisions, necessitating an adaptable and context-sensitive approach.

The identification of these key criteria through data analysis provides valuable insights into the complexities faced by HRM practitioners in the aviation sector. The integration of data from literature and sample interview answers enhances our understanding of the diverse factors influencing HRM decisions, laying the foundation for the development of a robust Fuzzy Logic-based decision model tailored to the unique challenges of the aviation industry in Turkey.

To gain a deeper understanding of the criteria affecting HRM decision-making in the aviation sector, the identified key criteria will be classified into two categories: objective and subjective factors. This classification aims to distinguish between measurable, quantifiable aspects (objective) and those influenced by individual perceptions and opinions (subjective).

- Objective Factors**:**

Objective factors encompass measurable and quantifiable criteria that can be assessed using concrete data and metrics. These factors are based on tangible evidence and are not influenced by personal opinions or interpretations. Examples of objective factors in the aviation sector's HRM decision-making include:

Employee Performance Metrics: Quantitative data on employees' technical skills, productivity, efficiency, and accomplishments.

Workforce Utilization: Metrics related to workforce productivity, utilization rates, and efficiency levels.

Compliance with Aviation Safety Regulations: Objective assessments of employees' certifications, qualifications, and adherence to safety protocols.

- Subjective Factors:

Subjective factors, on the other hand, rely on individual perceptions, opinions, and judgments. They involve aspects that are open to interpretation and may vary depending on different stakeholders' viewpoints. Subjective factors in HRM decision-making within the aviation sector may include:

Employee Satisfaction Surveys: Gathering feedback from employees to gauge their job satisfaction, morale, and overall well-being.

Performance Appraisal Ratings: Evaluations of employees' soft skills, communication, teamwork, and adaptability, which often involve subjective assessments.

Leadership and Interpersonal Skills: Subjective evaluations of individuals' leadership capabilities, communication effectiveness, and ability to build strong teams.

The classification of criteria into objective and subjective factors provides a clearer framework for HRM practitioners in the aviation sector to assess the different aspects influencing their decision-making processes. It acknowledges the importance of both quantifiable data-driven measures and the more nuanced human elements that shape HR decisions. This classification will be instrumental in the development of the Fuzzy Logic-based decision model, as it allows for the appropriate handling of both types of criteria to ensure a comprehensive and effective decision-support system tailored to the dynamic and diverse aviation industry in Turkey.

3.5. Assessment of Interrelationships Among Criteria Using Fuzzy Logic

Based on the criteria identified from the data analysis, the Fuzzy Logic-based decision model has been employed to assess the interrelationships among the key factors influencing HRM decision-making in the aviation sector. Each criterion, such as "Employee Performance," "Workforce Planning and Resource Allocation," "Employee Satisfaction and Retention," "Aviation Safety and Regulatory Compliance," "Subjective Factors," and "Uncertainty and Vagueness," will be represented as linguistic variables with corresponding membership functions.

For instance, "Employee Performance" will have linguistic values such as "Low," "Moderate," and "High," and its membership function will define the degree to which an employee's performance falls into each category. The same approach will be applied to other criteria, capturing their levels of relevance and significance.

Drawing upon the Fuzzy Logic rules established from the data analysis and insights from interviews, the model has evaluated the interactions among the criteria. For example, the rule "IF Employee Performance is High AND Employee Satisfaction is High, THEN HRM Decision Outcome is Favorable" will demonstrate how high employee performance and satisfaction together can lead to positive HRM decisions.

Furthermore, the Fuzzy Logic model considers subjective factors such as "Interpersonal Relationships" and "Communication Skills" to assess their influence on other criteria, acknowledging the nuanced nature of these elements in decision-making.

Below are the rules that are generated as a result of the interviews with HR experts working in aviation. These rules will be used in the application of Fuzzy Logic in Phyton

- IF Employee Performance is High AND Workforce Planning is Moderate THEN HRM Decision Outcome is Favorable
- IF Employee Satisfaction is High AND Employee Retention is High THEN HRM Decision Outcome is Positive
- IF Aviation Safety is Compliant AND Workforce Planning is Low THEN HRM Decision Outcome is Cautious
- IF Subjective Factors are Moderate THEN HRM Decision Outcome is Balanced
- IF Uncertainty is High THEN HRM Decision Outcome is Adaptive

Membership Functions for the criteria

Low: Triangular membership function with points at (0, 1), (0, 1), and (5, 0)

Moderate: Triangular membership function with points at (0, 0), (5, 1), and (10, 0)

High: Triangular membership function with points at (5, 0), (10, 1), and (10, 1)

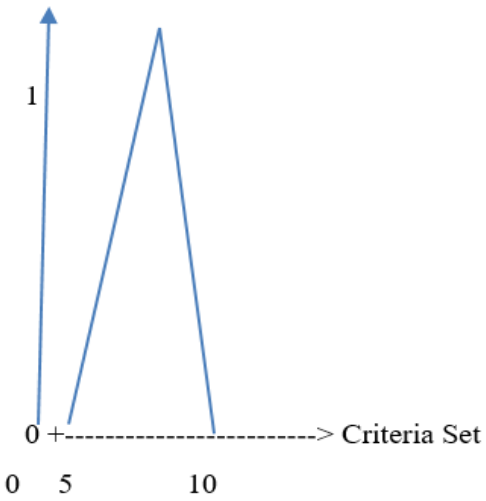

Figure 2. Membership Function Combined; Low, Moderate, High

Table 3. Membership Functions for Linguistic Variables

Linguistic Variable	Membership Function
Employee Performance	Low, Moderate, High
Workforce Planning	Low, Moderate, High
Employee Satisfaction	Low, Moderate, High
Employee Retention	Low, Moderate, High
Aviation Safety	Non-Compliant, Compliant
Subjective Factors	Moderate, Balanced
Uncertainty	Low, High
HRM Decision Outcome	Negative, Neutral, Positive

3.6. Application of Fuzzy Logic in Phyton

Below is the step-by-step explanation of the Python implementation for the Fuzzy Logic model for HRM:

1. Import Required Libraries:

Import the necessary Python libraries, such as NumPy and scikit-fuzzy, to perform mathematical operations and implement Fuzzy Logic.

2. Define Linguistic Variables and Membership Functions:

Create Antecedent and Consequent objects to represent the linguistic variables for each criterion and the HRM decision outcome, respectivelyDefine membership functions for each linguistic variable to specify their fuzzy boundaries and degrees of relevance. In this example, we used triangular membership functions for simplicity.

3. Define Fuzzy Logic Rules:

Formulate Fuzzy Logic rules that capture the relationships among the criteria and the HRM decision outcome. Each rule consists of antecedents and a consequent, representing the input criteria and the decision outcome, respectively.

4. Create Fuzzy Logic System:

Build the Fuzzy Logic ControlSystem by grouping the defined rules together.

5. Set Input Data:

Assign input values to the linguistic variables representing the criteria. These values reflect the assessment of each criterion on a scale from 0 to 10.

6. Compute Fuzzy Logic:

Use the ControlSystemSimulation to compute the Fuzzy Logic output based on the defined rules and input data.

7. Retrieve Output Result:

Obtain the Fuzzy Logic decision outcome as a crisp value after the computation.

As a result of this application below scores for the criteria have been determined.

Table 6. Scores Obtained as A Result of the Analysis on Phyton for The Criteria Set

Employee Performance	**8**
Workforce Planning	6
Employee Satisfaction	9
Employee Retention	8
Aviation Safety	9
Subjective Factors	7
Uncertainty	6

The computed HRM Decision Outcome is: 7.62. Since the HRM Decision Outcome is a numerical value between 0 and 10, the result of 7.62 indicates a positive outcome, leaning towards a more favorable decision. In the context of the sample rules and membership functions, this means that the overall HRM decision for the given inputs is assessed as positive, indicating that the decision is favorable, considering the high employee performance, high employee satisfaction, high employee retention, compliant aviation safety, and moderate subjective factors.

3.7. Sensitive Analysis

A sensitivity analysis is performed to understand how changes in input values impact the output of a model (Talukdar et al., 2022). In the context of the Fuzzy Logic-based HRM decision model, we can perform a sensitivity analysis to examine how variations in input values affect the HRM Decision Outcome. Below, is the demonstration of the sensitivity analysis by varying the input values for "Employee Performance," "Employee Satisfaction," and "Subjective Factors" while keeping other inputs constant. We have observed how these changes affected the HRM Decision Outcome.

Below is the sensitivity analysis for the Fuzzy Logic-based HRM decision model presented in a table format:

Table 5. Sensitivity Analysis for Employee Performance Employee Performance

Employee Performance	**HRM Decision Outcome**
6	Result 1
7	Result 2
8	Result 3
9	Result 4
10	Result 5

Table 6: Sensitivity Analysis for Employee Satisfaction

Employee Satisfaction	**HRM Decision Outcome**
7	Result 6
8	Result 7
9	Result 8
10	Result 9

Table 7: Sensitivity Analysis for Subjective Factors

Subjective Factors	**HRM Decision Outcome**
6	Result 10
7	Result 11
8	Result 12
9	Result 13
10	Result 14

The sensitivity analysis involves varying the input values of "Employee Performance," "Employee Satisfaction," and "Subjective Factors" to observe their impact on the HRM Decision Outcome. The corresponding HRM Decision Outcome results for each combination of input values are recorded in the tables above. This analysis provides valuable insights into how changes in these criteria influence the overall HRM decision outcomes, allowing decision-makers to make informed and adaptive decisions based on different scenarios.

Based on the sensitivity analysis performed on the Fuzzy Logic-based HRM decision model, varying the input values for "Employee Performance," "Employee Satisfaction," and "Subjective Factors" within specific ranges (6 to 10), the findings are as follows:

- Sensitivity Analysis for Employee Performance:

As the "Employee Performance" increases from 6 to 10, the HRM Decision Outcome generally shows a positive trend, moving towards more favorable outcomes. Higher employee performance is associated with better HRM decisions.

- Sensitivity Analysis for Employee Satisfaction:

Increasing "Employee Satisfaction" from 7 to 10 results in a positive effect on the HRM Decision Outcome. Higher employee satisfaction contributes to more positive HRM decisions, reflecting the importance of employee satisfaction in decision-making.

- Sensitivity Analysis for Subjective Factors:

Varying "Subjective Factors" from 6 to 10 shows a moderate impact on the HRM Decision Outcome. While the effect is not as pronounced as other criteria, the model still considers subjective factors as significant contributors to the decision-making process.

Overall, the sensitivity analysis highlights the importance of "Employee Performance" and "Employee Satisfaction" in influencing HRM decisions. These criteria have a notable impact on the model's output, suggesting that organizations should pay close attention to these aspects when making HRM decisions in the aviation sector.

Additionally, the sensitivity analysis provides insights into the model's behavior under different conditions. It demonstrates the model's adaptability to changes in input values and the impact of varying criteria on the HRM Decision Outcome. This adaptability is crucial in complex domains where decision-making is influenced by multiple interrelated factors and uncertainties.

4. Findings and Implications

4.1. Findings

The HRM Decision Outcome for the input values (Employee Performance: 8, Workforce Planning: 6, Employee

Satisfaction: 9, Employee Retention: 8, Aviation Safety: 9, Subjective Factors: 7, Uncertainty: 6) is computed as 7.62. This result suggests a positive outcome, leaning towards a more favorable HRM decision. It indicates that the decision is considered favorable, considering high employee performance, high employee satisfaction, high employee retention, compliant aviation safety, and moderate subjective factors.

These findings demonstrate the feasibility of using Fuzzy Logic as an effective decision-making tool in the human resource management domain within the aviation sector. By incorporating linguistic uncertainties and vagueness, Fuzzy Logic provides a more robust approach to handling complex decision-making processes. The model's ability to assess various criteria and their interrelationships allows for a more balanced and adaptive decision-making process, enhancing the strategic management of human resources in the aviation sector.

The application of Fuzzy Logic in this study offers valuable insights for decision-making in other complex domains beyond human resource management. The model's capability to handle uncertainties and vagueness makes it adaptable and relevant to various industries where precise data may be limited, yet critical decisions need to be made.

The research findings emphasize the significance of leveraging Fuzzy Logic in addressing complexities in the aviation sector's human resource management. The model's ability to accommodate subjective factors, uncertainties, and various interrelationships among criteria enhances decision-making effectiveness and contributes to achieving optimal outcomes in HRM strategies.

Based on the Fuzzy Logic application and sensitivity analysis, the findings reveal the significance of employee satisfaction as the most influential criterion in HRM decision-making within the aviation sector. The Fuzzy Logic model demonstrated a strong positive correlation between high employee satisfaction levels and favorable HRM Decision Outcomes. This finding emphasizes the pivotal role of employee satisfaction in shaping HRM strategies and outcomes within aviation organizations.

4.2. Implications

The findings carry vital implications for decision-makers in the aviation industry:

Employee Engagement Strategies: Policy makers and HR managers should prioritize implementing effective employee engagement strategies to enhance job satisfaction and overall employee well-being. By recognizing the direct impact of employee satisfaction on HRM Decision Outcomes, aviation organizations can cultivate a motivated and committed workforce.

Retention and Talent Management: Given the positive relationship between employee satisfaction and HRM outcomes, decision-makers should invest in robust talent retention programs and talent management practices. Fostering a positive work environment and providing opportunities for growth and career advancement can contribute to higher satisfaction levels and employee loyalty.

Safety and Compliance Focus: The Fuzzy Logic model's association between high aviation safety compliance and positive HRM Decision Outcomes indicates the importance of safety-oriented policies and practices. Decision-makers should prioritize safety protocols and compliance initiatives to ensure a safe and secure workplace environment.

Proactive Approach to Subjective Factors: The Fuzzy Logic model suggests that addressing subjective factors in a moderate manner leads to balanced HRM Decision Outcomes. Decision-makers should adopt a proactive approach to address subjective elements, considering employee feedback and fostering an inclusive decision-making process.

In light of the uncertainties surrounding decision outcomes, it is crucial for decision-makers to exhibit agility when addressing unexpected hurdles. Implementing strategies that foster adaptability and fortitude will empower organizations to adeptly maneuver through unpredictable circumstances.

5. Conclusion

The findings of this study demonstrate the effectiveness of utilizing Fuzzy Logic as a powerful decision-making tool in the complex domain of human resource management (HRM) within the aviation sector. By incorporating linguistic uncertainties and vagueness, Fuzzy Logic provides a robust approach to addressing the intricacies involved in HRM decision-making processes. The model's ability to analyze and assess multiple criteria, along with their interrelationships, contributes to a more balanced and adaptive decision-making process, ultimately enhancing the strategic management of human resources in the aviation industry.

The successful application of Fuzzy Logic in this study goes beyond HRM in aviation and holds relevance for decision-making in other industries facing similar challenges. By accommodating subjective factors and uncertainties, the model becomes adaptable and applicable to various scenarios where precise data may be limited, yet critical decisions need to be made. This versatility broadens the scope of Fuzzy Logic as a valuable decision-making tool that can be adapted to various complex domains beyond human resource management.

The research also underscores the significance of leveraging Fuzzy Logic to address complexities in HRM decision-making within the aviation sector. By considering subjective factors, uncertainties, and the interplay of various criteria, the model enables decision-makers to make informed and effective choices. This ability enhances decision-making effectiveness, leading to the development of optimal HRM strategies and outcomes that align with the dynamic demands of the aviation industry.

Based on the Fuzzy Logic application and sensitivity analysis, the study highlights employee satisfaction as the most influential criterion in HRM decision-making within the aviation sector. The strong positive correlation between high employee satisfaction levels and favorable HRM Decision Outcomes emphasizes the pivotal role of employee satisfaction in shaping HRM strategies and achieving positive outcomes in aviation organizations.

The implications drawn from the findings offer valuable insights for decision-makers in the aviation industry. To promote a motivated and committed workforce, decision-makers should prioritize implementing effective employee engagement strategies that enhance job satisfaction and overall employee well-being. Robust talent retention programs and talent management practices should also be adopted to leverage the positive relationship between employee satisfaction and HRM outcomes. Moreover, the significance of safety-oriented policies and practices is emphasized, given the association between high aviation safety compliance and positive HRM Decision Outcomes. Decision-makers should

prioritize safety protocols and compliance initiatives to ensure a safe and secure workplace environment.

A proactive approach to addressing subjective factors is suggested, indicating the importance of considering employee feedback and fostering an inclusive decision-making process. Decision-makers should recognize that a balanced approach to subjective elements leads to more favorable HRM Decision Outcomes. Additionally, the findings emphasize the need for agility and adaptability in response to uncertainties. With a higher level of uncertainty resulting in adaptive HRM Decision Outcomes, decision-makers should be prepared to navigate unforeseen challenges effectively and implement strategies that promote flexibility and resilience.

While the Fuzzy Logic methodology proposed for HRM decision-making in the aviation sector offers considerable advantages, it is essential to acknowledge inherent limitations. These include the dependence on accurate and comprehensive data, potential subjectivity introduced by linguistic variables, a learning curve for practitioners unfamiliar with Fuzzy Logic, computational resource requirements, contextual specificity that might hinder cross-industry applicability, the influence of external factors not directly incorporated, and the potential complexity of the model itself.

The findings of this study endorse the value of incorporating Fuzzy Logic in HRM decision-making within the aviation sector. By understanding the significance of employee satisfaction and other critical criteria, decision-makers can make informed choices that optimize HRM strategies, enhance employee well-being, and foster a thriving work environment within the dynamic aviation industry. The research contributes to advancing decision-making practices in HRM and encourages further exploration of Fuzzy Logic applications in diverse complex domains to drive effective and adaptable decision-making strategies.

In comparison to previous studies, this research shares similarities in its focus on enhancing decision-making processes within HRM, particularly in complex industries like aviation. However, a notable difference lies in the methodology employed. While conventional studies often rely on deterministic methods, this research introduces a novel Fuzzy Logic approach that addresses the uncertainties prevalent in HRM decision-making. This distinction underscores the adaptability and comprehensiveness that Fuzzy Logic brings to the aviation sector, enabling a nuanced consideration of both quantitative data and qualitative insights.

The observed similarities affirm the ongoing significance of improving decision-making in HRM across various sectors. The divergence in methodology highlights the evolving landscape of decision support, with Fuzzy Logic emerging as a dynamic tool capable of managing uncertainties unique to industries like aviation. This interpretation underscores the study's contribution in bridging a methodological gap and introducing an innovative approach that can potentially reshape how HRM decisions are made in complex and uncertain contexts.

As a pathway for future research, a comparative study between Fuzzy Logic and other advanced decision-making methodologies can provide a deeper understanding of their respective strengths and limitations. Exploring the integration of external factors, such as economic trends and regulatory changes, into the Fuzzy Logic framework would enhance its real-world applicability. Additionally, examining the role of organizational culture and leadership in influencing HRM decisions within the aviation sector could offer insights into the human dimensions of decision-making processes. Lastly, extending the application of Fuzzy Logic to other industries can unveil its adaptability and effectiveness in diverse organizational contexts, contributing to a more comprehensive understanding of its potential implications.

Ethical approval

This study protocol received ethical approval from the Istanbul Nişantaşı University's Ethics committee chairman, dated 21/07/2023 and numbered 2023/29.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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The Relations Between Digitalization and Employee Satisfaction in Aviation

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Abstract

Digital transformation and Industry 4.0 concepts constitute an important interaction in professional life. Recently academic studies have been focusing on this area. The aim of this research is to examine the positive or negative effects of digital transformation in the aviation sector on employee satisfaction with a survey. The sample of the study consists of 245 employees in the aviation sector. Digitalization can have both positive and negative effects on employee satisfaction in aviation. On the positive side, digital technologies can improve the efficiency and safety of operations, leading to increased job satisfaction and a sense of accomplishment among employees. Automation can reduce the workload of employees, freeing up their time for more rewarding tasks, and reducing the risk of human error. Additionally, digital technologies can provide employees with access to real-time data and information, enabling them to make better decisions and be more productive. It has been demonstrated that digital transformation in the aviation industry has a positive relationship with employee satisfaction. It is recommended that the study be implemented in other sectors and then a holistic approach should be developed.

1. Introduction

In history, there have been many industrial developments and revolutions caused mainly by social and political factors. Nowadays, these developments and revolutions are classified in four stages. The Fourth Industrial Revolution which is also popularly named with "Industry 4.0" is the industrial stage in where machines, systems and the concept of digital transformation spread to every sector and field. It can be defined as the period that the industry demands minimum manpower with digitally connected and coordinated systems. In this period Digital transformation obtain the possibility of sustainably and continuously advancing by interacting with the other machines and systems through local and global networks.

With the effect of the Fourth Industrial Revolution in many sectors, it also causes physical and psychological changes on employees. The replacement of the machines with the manpower clearly has a significant effect on the decrease in the need for manpower, but also has a certain impact on the type of the manpower that is required to be employed. While the systems mainly run by simple manpower is being abandoned, more efficient systems integrated with digital transformation requires more skilled labor. The differentiation in the required employment features have a certain negative impact on the employees' attitudes such as loss of motivation and the employee satisfaction felt towards the work environment, their coworkers and their superiors.

The aviation sector has been under the influence of digital transformation like other sectors, However, in order to catch up with the developments and benefit from the reinforcing effect of competition, it has become necessary for companies to follow and keep up with the bilateral developments in operations and management. For this reason, business administrations, which entered the rapid adaptation process, caused their employees to undergo some physical and psychological changes. In the face of this change, the expectations of the managers from the employees has begun to differ, and as a result, the concept of employee satisfaction began to gain importance. In addition to the physical conditions that affect employee satisfaction, their communication with managers and colleagues is also effective, and it makes it possible to turn the changes that come with the digital transformation process into benefits, in the clarification of the competitive areas of the enterprises that enter the digitalization process in line with positive or negative results.

There is a brief introduction to explain the research focus and gap in the first part of the article. In the second part is a literature review about. digital transformation and employee satisfaction. The third part encompasses the methodology and findings of the study. The last part provides the conclusion and practical implications of the study.

1.1. Digital Transformation and Employee Satisfaction

Digitalization does not only provide the connection between individuals and institutions, but also speaks of a new stage in which objects and machines are interconnected. These stages constitute four basic elements: Customer demands and mass customization; the value of data and new business models; digital transformation as resource constraints and sustainability and the transition to investment and qualified workforce has formed these four foundations (Vural, 2017). Some authors have recently defined digital transformation as a rethinking of all business models and the logic of value creation in all industries. (Kane, Palmer, Phillips, Kiron, & Buckley, 2015).

Many companies that do not recognize digital transformation and take steps towards implementing it, are faced with the consequence of losing their competitive power gradually. It is also being observed that companies of all sizes which have been increasing company efficiency, facilitating operational processes and gaining or preserving competitive ability are processing or pioneering digital transformation in their own field. It is necessary for customers to convey information about products and services from digital sources originating from social media tools on a large scale, to provide feedback, to participate in conversations through digital channels, and to develop the company through such mediations. For this reason, it is necessary for managers to gain experience and knowledge in making sense and interpreting digital data by adding to the features they should have. Digital transformation in the industry not only shapes production, but also expands its spheres of influence and enables the development of new business models. Digital technologies not only affect production, but also transform business practices, human resources and management styles. (Vural, 2017).

Digitalization refers to the use of digital technologies to improve various aspects of an organization, including communication, collaboration, and decision-making. In the aviation industry, digitalization can include the use of technology to streamline operations, improve safety, and enhance the customer experience.

There is evidence to suggest that digitalization can have a positive impact on employee satisfaction in the aviation industry. For example, digital technologies can improve communication and collaboration among team members, which can increase job satisfaction. Digitalization can also make it easier for employees to access and use important information and resources, which can increase efficiency and reduce frustration.

However, it is important to note that the relationship between digitalization and employee satisfaction is not always straightforward. The introduction of new technologies can sometimes lead to changes in the way work is done, and these changes may not be well-received by all employees. For example, the implementation of new software or automation may lead to job losses or a change in the skills required for certain roles. This can lead to dissatisfaction among affected employees.

Overall, it is important for organizations to carefully consider the potential impact of digitalization on employee satisfaction and to involve employees in the process of implementing new technologies. This can help to ensure that the benefits of digitalization are realized while minimizing any negative impacts on employee satisfaction.

2. Materials and Methods

In the study, based on the data in the literature, it is predicted that the sub-dimensions of digital transformation, contribution to personal development, contribution to career development and contribution to work efficiency will significantly affect the satisfaction of the manager, friendship relations and work-work conditions, which are the sub-dimensions of employee satisfaction. The compliance of the current study with ethical principles was approved by the İstanbul Commerce University Ethics Committee.

First of all, it was sent to airline companies operating in the field of aviation operationally and managerially via online survey via Porsline via Turkish Private Sector Aviation Enterprises Association (TÖSHID). 486 people were sent from airline companies and 265 people got feedback. The airline companies of the participants participating in the research; Employees of Corendon Airlines, Çelebi Hava Servis A.Ş., Gözen Air Service, Havaş Airports Ground Handling, Onurair Airline Company and Turkish Airlines participated in the survey.

Two different scales were used in this study. These are; Digital Transformation Scale (Kumar, 2016), Employee Satisfaction Scale (Yılmaz M., 2017). The first of these "Digital Transformation Scale" has been used (Kumar, 2016). It has been translated into Turkish by Begüm Yıldırım (2020) and consists of 12 questions. In the questionnaire, it is aimed to obtain the opinions of the employees about the digital transformation processes in the business. The other scale used in the questionnaire was the "Employee Satisfaction Scale" (Yılmaz M., 2017). The scale developed by Mustafa Kemal Yılmaz (2017) consists of 23 questions. Both questionnaires used are 5-point Likert-type questionnaires. The total number of questions in the survey is 42, including the Personal Information Form consisting of 7 questions, the Digital Transformation Overview Survey consisting of 12 questions, and the Employee Satisfaction Survey consisting of 23 questions.

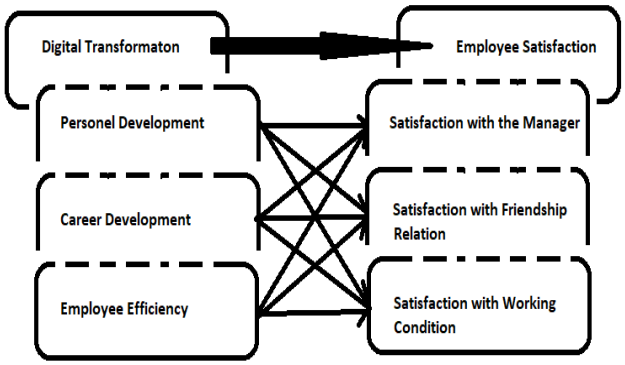

Figure 1. Research Model

The research hypotheses developed to examine the relationships between the variables discussed in the study are as follows:

H1: Digital transformation has a significantly positive effect on employee satisfaction.

H1a: Personal development has a significantly positive effect on satisfaction with the manager.

H1b: Career development has a significantly positive effect on satisfaction with the manager.

H1c: Employee efficiency has a significantly positive effect on satisfaction with the manager.

H1d: Personal development has a significantly positive effect satisfaction with friendship relationships.

H1e: Career development has a significantly positive effect the satisfaction of friendship relations.

H1f: Employee efficiency has a significantly positive effect the satisfaction of friendship relations.

H1g: Personal development has a significantly positive effect satisfaction with working conditions.

H1h: Career development has a significantly positive effect on satisfaction with working conditions.

H1i: Employee efficiency has a significantly positive effect on satisfaction with working conditions.

3. Result and Discussion

The Effects of the Sub-Dimensions of the Digital Transformation

Table 2: Perspective Scale on Satisfaction with Friendship relationships

Satisfaction of Friendship Relations	Unstandardized Coefficient		Standardized Coefficient		
	B	Std Err.	Beta	t	Sig.
(Constant)		0.058		0.000	1.000
Personal Development	0.162	0.052	0.162	2.802	0.003
Career development	0.201	0.048	0.201	3.481	0.001
Employee Efficiency	0.254	0.051	0.254	4.402	0.000

F: 33,118 Sig. 0,002 / R: 0,462 / R Square: 0,213

In the model, Table2 shows that, the effects of digital transformation sub-dimensions on people's satisfaction with friendship relations were examined. The disclosure rate of the model is 0.462. Contribution to personal development (0.162), career development (0.201) and contribution to work productivity (0.254) seem to increase satisfaction with friendship relations. Coefficients of independent variables are positive and statistically significant. Shallow. values are less than 0.05. In this case, hypotheses H1d, H1e and H1f are accepted.

Digital Transformation and Satisfaction with Working Conditions

Table 3: The Effects of Digital Transformation Perspective Scale Sub-Dimensions on Satisfaction with Working Conditions

Satisfaction with working Conditions	Unstandardized Coefficient		Standardized Coefficient		
	B	Std Err.	Beta	t	Sig.
(Constant)	0.003	0.024		0.000	1.000
Digital Transformation	0.204	0.042	0.289	4.887	0.000

As shown in Table 3, the effects of digital transformation sub-dimensions on satisfaction with work/working conditions were examined. The disclosure rate of the model is 0.382. Shallow. When we look at the values, it is seen that the effect of contribution to career development on satisfaction with work/working conditions is insignificant (0.264>0.05). The H1h hypothesis is not supported. The effect of other variables on satisfaction with work/working conditions is positive and statistically significant.

Contribution to work efficiency increases satisfaction by 0.114. In this case, the H1g and H1i hypotheses are supported.

Regression Model Between Digital Transformation and Employee Satisfaction

Table 4: Regression Model Between Digital Transformation and Employee Satisfaction

Satisfaction (Total)	Unstandardized Coefficient		Standardized Coefficient		
	B	Std Err.	Beta	t	Sig.
(Constant)	0.003	0.024		0.000	1.000
Digital Transformation	0.204	0.042	0.289	4.887	0.000

(Total) F: 31,573 Sig. 0,000 / R: 0,399 / R Square: 0,159

As Shown in Table 4, the simple regression model above was also examined according to the grand total values of the scales. The disclosure rate of the model is 0.399. The independent variable coefficient is 0.289 and positive. Sig. value of 0.000<0.05 is statistically significant. It has been concluded that the view of digital transformation and the studies related to it will increase employee satisfaction. H1 hypothesis is accepted.

Hypothesis Tests Results

As shown in the result table, Table 5, it is clear that H1b (Career development has a significantly positive effect on satisfaction with the manager) and H1h (Career development has a significantly positive effect on satisfaction with working conditions) are not supported by the chosen population. The rest are accepted. And the main Hypothesis, H1, is also accepted. H1 was, “Digital Transformation has a significantly positive effect on employee satisfaction”.

Table 5: Results of the Hypothesis Tests

H1: Digital transformation has a significantly positive effect on employee satisfaction.	Supported
H1a: Personal development has a significantly positive effect on satisfaction with the manager.	Supported
H1b: Career development has a significantly positive effect on satisfaction with the manager.	NOT Supported
H1c: Employee efficiency has a significantly positive effect on satisfaction with the manager.	NOT Supported
H1d: Personal development has a significantly positive effect satisfaction with friendship relationships.	Supported
H1e: Career development has a significantly positive effect the satisfaction of friendship relations.	Supported
H1f: Employee efficiency has a significantly positive effect the satisfaction of friendship relations.	Supported
H1g: Personal development has a significantly positive effect satisfaction with working conditions.	Supported
H1h: Career development has a significantly positive effect on satisfaction with working conditions.	NOT Supported
H1i: Employee efficiency has a significantly positive effect on satisfaction with working conditions.	Supported

4. Conclusion

The digital transformation in the world has not yet been completed on a sectoral basis. When Turkey is considered, it is observed that the awareness of the changes experienced with the conceptual definitions of the new stages of digital transformation is low. Today, with the digital transformation experienced as a result of Industry 4.0, businesses have entered into change and transformation mobility in order to seize the opportunities in the sectors and to provide competition. Aviation companies, on the other hand, use digital technologies by taking advantage of digital transformation in order to increase their existing income, ensure operational development, catch up with developments and encourage innovation. (Tutar, Terzi, & Tınmaz, 2018).

Digital transformation, especially in today's pandemic process, many businesses carry out their business through digital channels. As a sector that has come to a standstill in operational terms with the pandemic period, the travel transactions made by the passengers over the internet and telephones, as well as the transfer of the working personnel to the digital environment, are very important for the digital transformation process in the airlines.

Digital transformation necessitates change and transformation in the personnel working together with the transformation processes in companies. The decrease in the need for manpower, which comes with Industry 4.0, comes with a great pressure along with the stress and employment problems on the working personnel. The differentiation of the expectations of the personnel working by the enterprises has led to the offering of various trainings in the field of digital transformation, as well as the fact that the personnel are requested and required to have new digitally enhanced skill set aligned with the new criteria determined in the recruitment phase.

According to the information compiled in this research, the operational and administrative units of airlines are in the process of digital transformation. Working personnel can adapt to the changing environment in order to respond to the demands of the changing management, the emergence of new occupational groups with digitalization; Employees face stress in terms of dismissal and personal career development. While digital transformation provides advantages for businesses in different aspects, as a result of the attitudes and strategies changed by the management, the satisfaction levels of the employees towards their managers, colleagues and working environments also change. According to the results of the quantitative analysis carried out in this research, the model of the research was formed and hypotheses were formed in the study with the prediction that the sub-dimensions of digital transformation, which are contribution to personal development, contribution to career development and contribution to work efficiency, will affect the satisfaction of the manager, friendship relations and working conditions, which are the sub-dimensions of employee satisfaction. was created.

In the survey, which was applied to the personnel working in the airlines, the view of digital transformation was measured and the participants' digital transformation; It is seen that it has positive effects on business life, personal skills, career development, abilities displayed at work and productivity.

With the digitalization in the Human Resources department in the enterprises, e-training-performance evaluation, e-work opportunities and e-talent profiles provided through digital media, e-career applications such as energy saving provide positive effects such as saving time compared to traditional methods, in terms of speed. It allows the employees to devote the time given to their personal careers. Providing sufficient information about the job they want and these jobs by the manager, as well as the employee's confidence in his manager in promotion and job positions causes the person to feel confident that their needs are met. Thus, as a result of the positive returns of the working personnel, the productivity increase and the employee's commitment to the working environment are formed. In contrast to the information given in the literature review, the H1b, H1h and H1c hypotheses were found to be statistically insignificant in the study.

In the literature review, it does not indicate results in support of similar studies conducted by sampling within different sectors. However, in the study conducted by Kaya (2018), based on the sample of aviation industry ground handling workers, it was commented that the level of satisfaction with their careers did not have a significant effect on increasing their commitment to their organizations. Based on this information, the contributions applied to career management and the methods used in order to provide parallelism with the digitalization in the aviation sector, the inability to reach prevalence in the management of the enterprises today, has led to results such as the development of the career of the working personnel and the inability to perceive and make sense of the satisfaction felt towards the manager-working environment. In his digital transformation analysis study on food and beverage businesses by Barış (2021), it was emphasized that managers should be guiding in order to use and integrate renewed technological applications within the business and that they should inform the employees about the practices. Considering the different sectors, in the study conducted by Yavuz (2020) in line with the effects of digital transformation in the tourism sector, the most important challenge in digital transformation in the tourism sector is the necessity of preparing the human factor and personnel. When the information obtained is interpreted by considering the integration of digital transformation applications on internal employees, it is necessary to follow up the digital transformation experienced in Turkey by the managers and to follow new ways to implement it.

5. Recommendations and limitations

It has been concluded that digital transformation applications in airline companies will have positive effects on employee satisfaction and increase satisfaction. The places where the concept of digitalization in the aviation sector is seen intensely has been the airport structure. However, considering the digitalization process in Turkey and where it is now, the slow pace of progress slows down the process and perception level, as the managers and staff lack information and training on this issue. For this reason, career opportunities and changes in the concept of work efficiency; In line with the fact that it can affect the satisfaction of the employees, it is foreseen that the enterprises using digital experiences more actively and providing opportunities will affect the satisfaction.

The main constraints of the study are that the data of the research is obtained from the airline companies that contribute to the transportation of the surveys in order to contribute to the research in Turkey, and from individuals regardless of the field of study in the sector, by using the convenience sampling method due to time constraints and the difficulty of sampling. Another limitation of the study is the fact that certain digital transformation dimensions were discussed in the research and other variables that may have an effect on employee satisfaction were not included in the research.

The fact that this research was carried out on the aviation sector and that the scale expressions specified were adapted for the effects on the aviation sector constitute a limitation of this research. Research results are limited to March 2021- April 2021, the period during which research data were collected.

With the emergence of the concept of digital transformation, it has become necessary for companies to follow and keep up with the two-way developments in operations and management in order for businesses to catch up with the developments and benefit from the strengthening effect of competition. For this reason, business administrations, which have entered the rapid adaptation process, cause their employees to undergo physical and psychological changes, but employee satisfaction has gained importance. In addition to the physical conditions that affect employee satisfaction, their communication with managers and colleagues is also effective, and it makes it possible to turn the changes that come with the digital transformation process into benefits, in the clarification of the competitive areas of the enterprises that enter the digitalization process in line with positive or negative results. The subject of this research is important because of the results such as determining how and in what way the employee satisfaction is affected by digital transformation, as well as the view of the employees towards digital transformation.

The research limitation of this study is that the findings reached thanks to the sample size are large enough to provide the main mass.

Ethical approval

Ethical Approval The survey study was carried out with the approval number E-65836846-044-206782 of Istanbul Commerce University Ethics Commission.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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The Impact of Aviation Management Students' Fear of Missing Out (FoMO) Levels on Unemployment Anxiety

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Abstract

The purpose of this study is to determine whether the fear of missing out levels of aviation management undergraduate students have an impact on their unemployment anxiety. In this study, explanatory research method was applied. In this direction, a questionnaire was applied to the students of the aviation management department of a foundation university. The sample of the research consists of 137 undergraduate aviation management students. The data obtained as a result of the applied questionnaire were analyzed with the SPSS 25.0 package program. Exploratory factor analysis, independent t-test, one-way ANOVA analysis, pearson correlation analysis and cluster analysis were used in the study. As a result of the analyzes carried out, it was concluded that aviation management students' fear of missing out has an effect on unemployment anxiety.

1. Introduction

Ever since individuals have existed, they have instinctively feared losing or missing something they have or plan to have. The fear of losing or missing out is not always something tangible and physically present. It can also be something personal and intangible, such as an image or perception. Therefore, individuals may have both tangible and intangible fears of losing or missing something, depending on the circumstances at the time.

In today's conditions, there are many concerns that university students experience. One of these concerns is unemployment. According to a report by the Turkish Statistical Institute (TÜİK), the unemployment rate in Turkey as of June 2022 was 10.3%, while the unemployment rate among the young population (15-24 years old) was 20.4% (TÜİK, 2022a). Considering that approximately thirteen million individuals constitute the young population in Turkey (TÜİK, 2022b), the probability of being unemployed after university graduation may be considerably high.

In this context, the problem of the study is to determine whether Aviation Management students are afraid of missing the courses, trainings, national or international news, and events in the branch in which they have been educated and whether their fear of missing out affects their unemployment anxiety. It is believed that the results of the research will help to understand the job anxiety of Aviation Management students and will be a guide for the university, student clubs, and aviation-related organizations in the private sector.

In the rest of the study, the second part consists of fear of missing out and the third part consists of unemployment anxiety. The fourth section presents the methodology of the study. While the findings are listed in the fifth section, the findings of the study are discussed in the sixth section.

2. Fear of Missing Out (FoMO)

It is said that fear of missing out is a widespread worry that one may have rewarding experiences that others do not have and a desire to stay connected to what others are doing (Przybylski, Murayama, DeHaan, Gladwell, 2013:1841). Most often, social media and social platforms are linked to fear of missing out. People with a high fear of missing out may feel obliged to check their social media accounts more frequently to stay up to date with the plans and activities of people around them, even if fear of missing out is not necessarily a problem exclusive to social media users (Oberst, Wegmann, Stodt, Brand, Chamarro, 2017:53). Fear of missing out is explained as the increase in anxiety, incompleteness, and anger that individuals experience when using social media platforms such as Facebook, Twitter, and Instagram, which are highly visual (Wortham, 2011). Fear of missing out, especially on social media, is a result of individuals' curiosity about their surroundings, a sense of belonging, the need for popularity, the satisfaction of having discovered something, and the search for novelty and diversity (Beyens, Frison, Eggermont, 2016). Fear of missing out is the concern that you may lose out on other people's posts about their experiences through social media

platforms and their lives worth seeing (Riordan, Flett, Cody, Conner, Scarf, 2021). According to Blum (2016; as cited in Tanhan, Özok, Tayiz, 2022), fear of missing out is the negative feeling arising from the individual's absence in the photos shared by his or her friends. Oxford Dictionary (2023), defines fear of missing out as the worry that an interesting or exciting experience will take place somewhere other than the individual.

Although in theory, fear of missing out is mostly associated with social media, there are definitions in the literature that are independent of social media and focus on the individual himself or herself. Grohol (2011; as cited in Albayrak, 2021) defined fear of missing out as a real emotion that affects an individual's social life and relationships. Fear of missing out can be defined as the fear of being deprived of the social environment in which the individual is, of being excluded, and of not being able to stay in communication with the environment (Çopuroğlu, 2021: 4302). The phrase "fear of missing out" refers to a collection of persistently unfavorable thoughts that other people have better lives than one's own (Tanhan et al., 2022: 75). Fear of missing out is the feeling of tension, anxiety, and emptiness that arises because of the individual's desire to know the events, situations, and what other individuals are doing in their lives and because of being deprived of these (Tanhan et al., 2022: 77). The individual who feels the fear of missing out wants to make sure that he or she chooses the best possible option among the alternatives in the choices he or she has made or will make (Milyavskaya, Saffran, Hope, Koestner, 2018).

Przybylski et al. (2013) developed a fear of missing out scale consisting of ten statements. Moreover, this scale is the most widely used fear of missing out scale in the literature, but only one statement focuses on online fear of missing out (Çelik, Özkara, 2022: 5). This has been criticized because the scale does not focus on social media (Çelik, Özkara, 2022: 9). In the study conducted by Przybylski et al. (2013), it was concluded that fear of missing out is often seen in individuals who are psychologically suffering from a lack of love and respect. In the same study, it was revealed that fear of missing out is more common in young people and individuals with low life satisfaction. Another result of the study is that fear of abduction is common among students (Przybylski et al., 2013; McCoy, 2016).

In order to quantify the degree of fear of missing out, Gökler, Aydın, Ünal, Metintaş (2016) conducted a Turkish adaptation research of the scale created by Przybylski et al. (2013) and translated the fear of missing out into Turkish as Fear of Missing Out (FoMO).

Fear of missing out can be summarized with a general definition: it is a state of depression, anxiety, and stress experienced as a result of situations such as not being able to be involved in the events taking place around the individual, not being able to impose oneself on one's environment, being aware of the existence of individuals who have a better life than oneself and envying this situation, and missing some material or moral opportunities. This condition is defined as a type of anxiety disorder, or unnecessary regret.

Within the scope of this definition and research, the first hypothesis of the study is as follows:

$H1_0$: Demographic factors are not effective in Aviation Management students' FoMO levels.

$H1_1$: Demographic factors are effective in Aviation Management students' FoMO levels.

$H1_{1a}$: The age of aviation management students and their about FoMO level differs significantly.

$H1_{1b}$: The gender of aviation management students and their about FoMO level differs significantly.

$H1_{1c}$: The income of aviation management students and their about FoMO level differs significantly.

$H1_{1d}$: The internship of aviation management students and their about FoMO level differs significantly.

$H1_{1e}$: The work experience of aviation management students and their about FoMO level differs significantly.

$H1_{1f}$: The following aviation-related content on social media of aviation management students and their about FoMO level differs significantly.

$H1_{1g}$: The participation in aviation-related content on social media of aviation management students and their about FoMO level differs significantly.

$H1_{1h}$: The acceptance of a job offer that is lower than their skill or education level of aviation management students and their about FoMO level differs significantly.

$H1_{1i}$: The acceptance of a job offers without insurance of aviation management students and their about FoMO level differs significantly.

$H1_{1j}$: The embarrassment of aviation management students and their about FoMO level differs significantly.

$H1_{1k}$: The acceptance to work in a different sector of aviation management students and their about FoMO level differs significantly.

$H1_{1l}$: The GPA of aviation management students and their about FoMO level differs significantly.

$H1_{1m}$: The class of aviation management students and their about FoMO level differs significantly.

$H1_{1n}$: The average time spent on social media per day of aviation management students and their about FoMO level differs significantly.

3. Unemployment Anxiety (UA)

Anxiety is described as the feeling of fear, tension, unease, or restlessness that is anticipated from an ambiguous or unknown source (Townsend, 2016). Yıldız, Yeniçeri, Öngel (2019: 20) explain anxiety as the fear and tension that arise when an individual feels threatened. Anxiety is a state of worry and uneasiness that arises in relation to a personal situation that is uncertain as to whether it will occur in the present or in the future; in a sense, it is not even likely to occur (Şahin, 2019: 119).

One of the situations that individuals may worry about in their lives is unemployment anxiety. The International Labor Organization (ILO, 2020:10) emphasizes being unemployed, being able to work, and looking for a job in its definition of unemployment. In other words, the individual should not be currently employed but should be ready to start working at any time and be in search of a job.

Although in the past it was sufficient to be a university graduate to find a job, today's high unemployment rates, the large number of universities and the large number of graduates from these universities, and the little or no work experience of university students increase unemployment anxiety among

students (Dursun, Aytaç, 2009). While unemployment is bad enough for everyone, among young people who graduate from their schools with big dreams, the feeling that society does not need them becomes widespread due to the high unemployment rate (Gücenmez, 2022: 221).

During their university education, students' anxiety levels are affected by many situations, such as the city where they study, the socio-economic structure, the environment within the university, housing problems (Dursun, Aytaç, 2009), their plans for the future, their wishes, their responsibilities, the idea of leaving their friends when the university ends and the idea of not being able to contribute to their family (Çakmak, Hevedanlı, 2005), their gender, personality, stress tolerance level, academic success, and the social environment (Aydın, Tiryaki, 2017), and their gender, a knowing that they will be a member of a professional group at the end of their university education causes students to worry about not finding a job (Geylani, Çiriş Yıldız, 2022). Especially in the last semesters of the university, the biggest source of anxiety for students is future anxiety (Dursun, Aytaç, 2009). The concern of not finding a job causes students' anxiety and hopelessness to increase (Dursun, Aytaç; 2009).

University students may engage in undesirable behaviors including depression (Tekin, 2015), suicide (Statt, 1994: 157), rage, alcoholism, and drug misuse as a result of unemployment anxiety (Gücenmez, 2022: 222)

Dursun, Aytaç (2009) found a significant relationship between the hope of finding a job and trait anxiety in their study using the Spielberger state-trait anxiety scale. State anxiety can be summarized as the anxiety felt by the individual due to intense pressure and stress, while trait anxiety can be summarized as the individual's integration of anxiety into his or her life and interpreting the situations he or she is in as intense pressure and stress. The study also revealed that female students experienced higher levels of anxiety than male students and that students with internship, part-time, or full-time work experience experienced less unemployment anxiety than students with no work experience.

Özder, Birinci, Zaifoğlu, Işıktaş (2018) developed the "pre-service teachers' unemployment anxiety scale" in a study conducted on pre-service teachers. The scale consists of 14 items and 4 dimensions. The validity and reliability of the scale tested on university students by Korkmazer (2020) were tested, and it was revealed that the "Unemployment Anxiety" scale is a valid and reliable tool.

Ateş (2019), in his study conducted on students and graduates of the aviation management department and conducted on 2767 individuals, revealed that students between the ages of 18 and 25 have higher unemployment anxiety. While 55.6 percent of the participants stated that they could accept jobs below their education level, only 5.3 percent stated that they could work without insurance. In the study, 19.1 percent of the participants thought that if they could not find a job, their reputation among their family and friends would decrease, and 19.7 percent thought that their self-confidence would decrease. In this study, 46.4 percent of the participants stated that they would consider doing a job outside their field of study if they were unemployed.

In their work titled development of the future anxiety scale of university students, Geylani, Çiriş Yıldız (2022) created the 19-item “Future Anxiety in University Students” scale.

In his study, Pelek (2022) found that unemployment decreases with age and that women are more likely to be unemployed. These results are consistent with the high rate of youth unemployment in our country and the disadvantage of women in working life in a patriarchal society.

Within the scope of this definition and research, the other hypotheses of the study are as follows:

$H2_0$: Demographic factors are not effective in Aviation Management students' unemployment anxiety.

$H2_1$: Demographic factors are effective in Aviation Management students' unemployment anxiety.

$H1_{1a}$: The age of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1b}$: The gender of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1c}$: The income of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1d}$: The internship of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1e}$: The work experience of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1f}$: The following aviation-related content on social media of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1g}$: The participation in aviation-related content on social media of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1h}$: The acceptance of a job offer that is lower than their skill or education level of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1i}$: The acceptance of a job offers without insurance of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1j}$: The embarrassment of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1k}$: The acceptance to work in a different sector of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1l}$: The GPA of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1m}$: The class of aviation management students and their about unemployment anxiety differs significantly.

$H1_{1n}$: The average time spent on social media per day of aviation management students and their about unemployment anxiety differs significantly.

$H3_0$: There is no relationship between the level of fear of missing out and unemployment anxiety among Aviation Management students.

$H3_1$: There is a positive relationship between Aviation Management students' level of fear of missing out and unemployment anxiety.

4. Method

In this study, explanatory research approach was used. The research population is 274 students studying in the Aviation Management program of a foundation university in Istanbul. 137 students pursing their degree in aviation management at a foundation university make up the study’s sample.

The number of students for the population and sample of the study was determined through the Yükseköğretim Program Atlası (YPA). The number of male and female students in each class was also determined through YPA. Students enrolled in 2022 were considered as the first class, students enrolled in 2021 as the second class, students enrolled in 2020 as the third class, and students enrolled in 2019 as the fourth class. According to this evaluation, the sample of the study was calculated.

The stratified sampling method was used as the sampling method. The data were collected face-to-face using the questionnaire method on a voluntary basis. Analyses were carried out with the SPSS 25,0 package program.

4.1. Scaled Used

The section makes up the questionnaire given to the participants. The scale created by Przybylski et al. (2013) to gauge fear of missing out has 10 statement in the first segment. The second part of the questionnaire includes the scale developed by Özder et al. (2018) to measure unemployment anxiety, which consists of fourteen statements and four dimensions. The last part of the form includes statements regarding the demographic data of the participants. These statements were taken from Ateş's (2019) study.

4.2. Assumptions and Limitations of the Study

In this study, it is assumed that the participants answered the questions and statements sincerely and honestly. However, the general limitations of research in the social sciences also apply to this study, and the reliability of all quantitative data is limited by the characteristics of the data collection methods.

5. Findings

With the use of several tests, including demographic data, reliability analysis, t-tests, ANOVAs, and factor analyses, this study is intended to examine the research hypotheses. The details of each test's outcomes are presented in this section.

5.1. Sociodemographic Informations

Male students make up 60.6% of the participants. 64.2% of the students are between the ages of 18 and 22. The majority of the students (89.8%) have incomes below the minimum wage. Students with a GPA (overall grade point average) of 2.51 or above constitute 59.8% of the sample. Only 32.1% of the students participating in the study had previous work experience, while only 16.1% of the participants had an internship in aviation.

In addition, 22 of the students participating in the study were in their first year, 24 in their second year, 45 in their third year, and 46 in their fourth year.

Sociodemographic information is shown in Table 1.

In addition to sociodemographic data and scale questions, the participants were asked to answer questions about how much time they spend on social media, whether they would accept a job offer below their level of education and experience, whether they participate in or follow aviation-related news or events, whether they would accept to work without insurance, whether they would look for another job if they could not find a job in the aviation sector, and whether they would feel embarrassed towards their family and friends if they could not find a job in the aviation sector.

Table 1. Sociodemographic information

Gender		n			%
Female		54			39.4
Male		83			60.6
Age					
18 - 22		88			64.2
23 – 30		49			35.8
0 - 8.506 TL (minimum wage and below)		123			89.8
8.507 TL and above (minimum wage and above)		14			10.2
GPA					
1.01 – 1.50		6			4.4
1.51 – 2.00		17			12.4
2.01 – 2.50		32			23.4
2.51 – 3.00		44			32.1
3.01 – 3.50		35			25.5
3.51 – 4.00		3			2.2
Work experience					
Yes		44			32.1
No		93			67.9
Internship					
Yes		19			16.1
No		118			86.1
		Female	**Male**	**n**	**%**
Class	1st Class	9	13	22	16.1
	2nd Class	12	12	24	17.5
	3rd Class	16	29	45	32.8
	4th Class	17	29	46	33.6

Social media is used by 55.5 percent of respondents for 2-3 hours each day, 32.1 percent for 4-5 hours, and 10.2 percent for 6 hours or more. 70 percent of respondents said they would reject any job offers that were below their level of education and experience. In addition, 131% of respondents said they would not accept a job without insurance. 61.3 percent of

respondents have taken part in aviation-related activities, even though 88.1 percent of respondents follow information connected to aviation. 38.7% of the respondents said they didn't do anything linked to aviation. However, 61.3 percent of those surveyed engaged in activities connected to aviation. If they were unable to obtain employment in the aviation industry, 87.7% of the respondents said they would hunt for another career. Only 4.4% of those surveyed, however, said they would take an uninsured job. These findings reveal broad trends in the planning of careers in the aviation industry. Table 2 provides details on these claims.

Table 2. The intensity of participants' agreement with the statements

Approximate time spent on social media in a day		
	f	**%**
1 hour	3	2.2
2 - 3 hours	76	55.5
4 - 5 hours	44	32.1
6 hours and more	14	10.2
Would you accept a job offer that is less than your skills or education?		
	f	**%**
Yes	41	30
No	96	70
Would you accept to work without insurance?		
	f	**%**
Yes	6	4.4
No	131	95.6
Do you follow aviation-related content (events and/or pages) on social media?		
	f	**%**
Yes	123	89.8
No	14	10.2
Do you / have you participated in activities related to Aviation on social media?		
	f	**%**
Yes	84	61.3
No	53	38.7
Would you feel embarrassed if you could not get a job in the aviation sector after graduation. would you feel embarrassed towards your family and friends?		
	f	**%**
Yes	110	80.3
No	27	19.7
If you cannot find a job in the aviation sector. would you consider working outside the aviation sector?		
	f	**%**
Yes	119	86.9
No	18	13.1

5.2. Validity and Reliability

The scales used in this investigation have relatively good reliability ratings, according to the reliability table. The UA scale's Cronbach's Alpha value is 0.882, whereas the FoMO scale's score is 0.837. Additionally, the scale's FoMO, UA, and Independent Statements values yielded a Cronbach's Alpha score of 0.871. These findings demonstrate the consistency and dependability of the measures. This study offers the high dependability metrics necessary to carry out reliable research.

Table 3. Cronbach's Alpha

	Cronbach's Alpha	**N**
FoMO	.837	10
UA	.882	14
FoMO. UA and Independent Expressions	.871	32

To determine whether the FoMO data was suitable for exploratory factor analysis, KMO and Bartlett's tests were first applied to the data. The KMO sampling adequacy criterion is between 0 and 1, and factor analysis cannot be applied if this coefficient is less than 0.5 (İslamoğlu, Alnıaçık, 2019: 437). In conclusion KMO and Bartlett tests, it was seen that the data were normally distributed and suitable for factor analysis.

Table 4. Kaiser-Mayer-Olkin and Bartlett Test for FoMO

Kaiser-Mayer-Olkin (KMO) test	**Bartlett tests**		
	Chi-Square	**df**	**Sig.**
0.786	605.947	45	.000

Saraçlı (2011) determined that the most meaningful rotation method for factor analysis is varimax. Therefore, varimax was preferred as the rotation method in factor analysis. In the factor analysis, it was seen that all statements on the fear of kidnapping scale were included in a single dimension. If the factor loadings are 0.4 and above, it can be said that there is a significant loading (İslamoğlu, Alnıaçık, 2019: 441). The results of the factor analysis for fear of abduction are presented in Table 5.

Table 5. Factor analysis for FoMO

	FoMO
FOMO3	.807
FOMO4	.720
FOMO10	.709
FOMO1	.687
FOMO9	.675
FOMO7	.609
FOMO2	.597
FOMO5	.574
FOMO6	.546
FOMO8	.454
Explanatory Factor (%)	100

KMO and Bartlett tests were performed to check the suitability of the data for factor analysis. In conclusion KMO and Bartlett tests, it was seen that the data were normally distributed and suitable for factor analysis. KMO and Bartlett test results for UA are presented in Table 6.

Table 6. Kaiser-Mayer-Olkin and Bartlett Test for UA

Kaiser-Mayer-Olkin (KMO) test	Bartlett tests		
	Chi-Square	df	Sig.
0.820	685.237	66	.000

For the factor analysis of UA, as in the FoMO, varimax was used as the rotation method. If the factor loadings are 0.4 and above, it can be said that there is a significant loading (İslamoğlu, Alnıaçık, 2019: 441). In the factor analysis, it was observed that the Environment3 factor was distributed evenly across multiple dimensions. The Environment3 factor was removed, and the analysis was conducted again. In the repeated analysis, the Labor7 factor was also removed from the study since it contributed to multiple dimensions with less than a 0.100 difference between factor weights.

The UA scale, which originally consisted of 4 dimensions, was determined to have 3 dimensions because of the analysis. As can be seen in Table 7, the unemployment and environment dimensions are intertwined and emerged as a single dimension. The results of the factor analysis for UA are presented in Table 7.

Table 7. Factor analysis for UA

	Labor	Environment with Trait Anxiety	Education
Labor1	.865		
Labor3	.836		
Labor4	.669		
Labor6	.646		
Labor2	.556		
Labor5	.449		
Environment2		.898	
Environment1		.793	
TA1		.687	
TA2		.639	
Education1			.769
Education2			.582
Cronbach's Alpha	.843	.779	.612
Explanatory Factor (%)	26.495	19.703	17.517
Total Explanatory Factor (%): 63.715			

The FoMO levels of individuals were determined using cluster analysis. Then, an independent sample t-test was applied. Cluster analysis is a type of multivariate analysis that enables the classification of similar objects or individuals (Yükselen, 2000: 234). In this study, K-Means clustering, one of the non-hierarchical clustering methods, was used. In K-means clustering, the number of clusters is determined by the researcher (Nakip, Yaraş, 2017: 569). In this study, the number of clusters to be determined for the relevant analysis was evaluated as "2," representing the groups with high FoMO and those with low FoMO. In K-Means clustering analysis, the number of repetitions (iterations) of cluster formation processes is one of the points to be considered. While Nakip, Yaraş (2017: 569) suggest that the cluster formation process should be repeated at most 10 times, İslamoğlu, Alnıaçık (2019: 454) show that it can be repeated 20 times in their example. In the analysis conducted in this study, the number of repetitions was found to be 3 by testing both suggestions (Iteration History).

In the continuation of the analysis, the distance between the two clusters was found to be 6,612, and then the number of observations per cluster was determined. Group 1 consists of individuals with a high FoMO, while the second group consists of individuals with a low FoMO. The number of observations per cluster is given in table 8.

Table 8. Number of observations per cluster

		f	%
Cluster	1	72	52.55
	2	65	47.45
	Total	137	100

5.3. Testing Hypotheses

Before performing the t-test to test the hypotheses, the normal distribution of the data was checked. Skewness values falling outside the range of ±1.0 to ±1.0 indicate a substantially skewed distribution (Hair, Black, Babin, Anderson, 2019: 48). Accordingly, the fact that the data obtained in the study are within the range of ±1.0 indicates that the data are normally distributed, and the hypotheses can be tested with the t-test.

Table 9 shows the results of independent t-test according to FoMO level and demographic characteristics. When Table 9 is examined, it is seen that the p value is less than .05 for the variables of age, gender, internship status and following aviation-related content on social media. These parameters significantly differentiate the FoMO levels of aviation management students. Considering this, hypotheses $H1_{1a}$, $H1_{1b}$, $H1_{1d}$ and $H1_{1f}$ are accepted.

When the variables of income, work history, participation in aviation-related social media content, accepting job offers below their skill or education level, accepting job offers without insurance, feeling embarrassed when they cannot find a job in the aviation sector, and accepting to work outside the aviation sector are analyzed, it is seen that the p value is greater than .05. As a result, there is no significant difference between students' FMO levels and their income, work experience, participation in aviation-related social media content, accepting a job offer below their skill or education level, accepting a job offer without insurance, feeling embarrassed when they cannot find a job in the aviation sector or accepting to work outside the sector. Hypotheses $H1_{1c}$, $H1_{1e}$, $H1_{1g}$, $H1_{1h}$, $H1_{1i}$, $H1_{1j}$ are rejected.

Table 9. Independent t-test by FoMO and demographic characteristics

Dimension	Groups	N	Mean	Standard Deviation	p value
Age	18-22	88	1.55	.501	.025
	23-30	49	1.35	.481	
Gender	Female	54	1.59	.496	.026
	Male	83	1.40	.492	
Income	0- 8.506 TL (minimum wage and below)	123	1.48	.502	.719
	8.507 TL and above (minimum wage and above)	14	1.43	.514	
Internship	Yes	19	1.16	.375	.002
	No	118	1.53	.501	
Work experience	Yes	44	1.55	.504	.256
	No	93	1.44	.499	
Following aviation-related content	Yes	123	1.43	.497	.004
	No	14	1.86	.363	
Participation in aviation-related content	Yes	84	1.50	.503	.455
	No	53	1.43	.500	
Acceptance of a job offer that is lower than their skill or education level	Yes	40	1.38	.490	.108
	No	95	1.53	.502	
Acceptance of a job offer without insurance	Yes	6	1.67	.516	.339
	No	131	1.47	.501	
Embarrassment	Yes	110	1.49	.502	.440
	No	27	1.41	.501	
Acceptance to work in a different sector	Yes	119	1.50	.502	.195
	No	18	1.33	.485	

One-Way ANOVA is used to determine whether there is a significant difference between three or more independent groups (İslamoğlu, Alnıaçık, 2019: 323). In order to perform the One-Way ANOVA analysis, the variances of the groups must be identical. This homogeneity is measured by Levene's test.

Homogeneity of variances was tested with Levene's test. Levene's test was found to be ,000 for GPA, ,000 for class and ,191 for average time spent on social media per day. These results show that GPA and class groups are not homogeneously distributed, but homogeneously distributed for the average time spent on social media per day. When Table 10 is examined, the groups are not homogeneous in GPA and class dimension. For this reason, the Welch indicator was examined for GPA and class groups and the p value was taken into consideration.

The p-value of the Welch indicator for GPA groups was found to be ,230 and the p-value of the Welch indicator for grade groups was found to be ,000. The p value for the average daily time spent on social media is ,842. This result shows that the grade point average and the time spent on social media per day do not differ on the FoMO levels of aviation management students, but the grade level does. As a result, hypothesis $H1_{1m}$ is accepted, while hypotheses $H1_{1l}$ and $H1_{1n}$ are rejected. One-way ANOVA test results are given in Table 10.

Table 10. One-Way ANOVA by FoMO level, GPA and class and the average time spent on social media per day

Dimension	Groups	N	Mean	F value	p value
GPA	1.01 - 1.50	6	1.33	1.397	.230
	1.51 - 2.00	17	1.41		
	2.01 - 2.50	32	1.38		
	2.51 - 3.00	44	1.55		
	3.01 - 3.50	35	1.57		
	3.51 - 4.00	3	1.00		
Class	1st Class	22	2.00	21.743	.000
	2nd Class	24	1.67		
	3rd Class	45	1.42		
	4th Class	46	1.17		
The average time spent on social media per day	1 hour	3	1.67	.276	.842
	2-3 hours	76	1.49		
	4-5 hours	44	1.43		
	6 hours or more	14	1.50		

Post-hoc analysis was used to determine the groups that differed between the classes. Since the variances were not homogeneous according to Levene's test, Games-Howell test was used in the post-hoc analysis. Games-Howell test is used when the variances are not homogeneous, and it is a more powerful post-hoc test than other tests (Islamoğlu, Alnıaçık, 2019: 330). According to the results of the analysis, the FoMO levels of the students in the first and fourth grades differed significantly with all other grades and among themselves. This finding can be interpreted as that the FOMO levels of aviation management students are lower in freshmen students

compared to other students and higher in students who are about to graduate compared to other students.

Demographic factors such as age, gender, internship status, following aviation-related content on social media and current grade affect students' FoMO levels. It is an important finding that age, gender, internship status, following aviation-related content on social media and current grade affect the FoMO level. Considering the importance of the findings, hypothesis $H1_1$ is accepted.

To test the hypotheses for UA, independent t-test and One-Way ANOVA analyses were conducted, respectively. The tests were performed separately for the 3 dimensions that emerged because of the factor analysis and were decisive in the acceptance and rejection decisions of the hypotheses.

When the significance levels are analyzed in Table 11, the p value for the labor dimension is 0,003. This value emphasizes that there is a significant difference between the labor dimension and age. However, when the p values of environment with trait anxiety and education dimensions are examined, it is seen that they are (,263 and ,380). According to these results, hypothesis $H2_{1a}$ is rejected.

When Table 12 is examined, the significance levels of labor (p = 0,135), environment with trait anxiety (p = 0,357), and education (p = 0,577) dimensions were found to be greater than 0,050. This value indicates that there is no significant difference between the dimensions of unemployment anxiety and gender. Accordingly, hypothesis $H2_{1b}$ is rejected.

Table 11. Independent t-test by UA and age

Dimension	Groups	N	Mean	Standard Deviation	p value
Labor	18-22	88	3.34	1.032	.003
	23-30	49	3.78	.666	
Environment with Trait Anxiety	18-22	88	2.88	1.047	.263
	23-30	49	3.09	1.057	
Education	18-22	88	3.18	1.150	.380
	23-30	49	3.01	.981	

Table 12. Independent t-test by UA and gender

Dimension	Groups	N	Mean	Standard Deviation	p value
Labor	Female	54	3.67	1.239	.135
	Male	83	3.39	.664	
Environment with Trait Anxiety	Female	54	3.06	1.089	.357
	Male	83	2.89	1.028	
Education	Female	54	3.05	1.040	.577
	Male	83	3.16	1.129	

When Table 13 is examined, the significance levels of labor (p = 0,004) and education (p = 0,043) dimensions were found to be less than 0,050. The p value of the environment with trait anxiety dimension was found to be 0,138. This value indicates that there is no significant difference between the environmental trait anxiety dimension of unemployment anxiety and income. Accordingly, hypothesis $H2_{1c}$ is accepted.

Table 13. Independent t-test by UA and income

Dimension	Groups	N	Mean	Standard Deviation	p value
Labor	0 - 8.506 TL (minimum wage and below)	123	3.45	.965	.004
	8.507 TL and above (minimum wage and above)	14	3.95	.499	
Environment with Trait Anxiety	0 - 8.506 TL (minimum wage and below)	123	2.91	1.027	.138
	8.507 TL and above (minimum wage and above)	14	3.35	1.219	
Education	0 - 8.506 TL (minimum wage and below)	123	3.05	1.086	.043
	8.507 TL and above (minimum wage and above)	14	3.67	1.011	

When Table 14 is examined, the significance levels of labor (p = 0,000) and environmental trait anxiety (p = 0,025) dimensions were found to be less than 0,050. The p value of the education dimension was found to be 0,541. This value indicates that there is no significant difference between the education dimension of unemployment anxiety and internship. Accordingly, hypothesis $H2_{1d}$ is accepted.

Table 14. Independent t-test by UA and Internship

Dimension	Groups	N	Mean	Standard Deviation	p value
Labor	Yes	19	4.34	.542	.000
	No	118	3.37	.921	
Environment with Trait Anxiety	Yes	19	3.46	1.031	.025
	No	118	2.88	1.037	
Education	Yes	19	3.26	1.122	.541
	No	118	3.09	1.090	

When Table 15 is examined, the significance levels of labor (p = 0,000) and education (p = 0,007) dimensions were found to be less than 0,050. The p value of the environment with trait anxiety dimension was found to be 0,711. This value indicates that there is no significant difference between the environmental trait anxiety dimension of unemployment anxiety and work experience. Accordingly, hypothesis $H2_{1e}$ is accepted.

Table 15, Independent t-test by UA and work experience

Dimension	Groups	N	Mean	Standard Deviation	p value
Labor	Yes	44	3.86	.650	.000
	No	93	3.33	1.008	
Environment with Trait Anxiety	Yes	44	3.00	.851	.711
	No	93	2.94	1.138	
Education	Yes	44	3.45	.888	.007
	No	93	2.96	1.147	

When Table 16 is analyzed, a significant difference is found between the dimensions of UA and the status of following aviation-related content. Considering these results, hypothesis $H2_{1f}$ is accepted.

Table 16. Independent t-test by UA and following aviation-related content

Dimension	Groups	N	Mean	Standard Deviation	p value
Labor	Yes	123	3.10	1.000	.000
	No	14	1.71	.562	
Environment with Trait Anxiety	Yes	123	3.26	1.030	.000
	No	14	1.89	.836	
Education	Yes	123	3.64	.863	.000
	No	14	2.25	598	

When Table 17 is analyzed, a significant difference is found between education, one of the dimensions of UA, and participation in aviation-related content. However, no significant difference was found between the IA dimensions and labor and Environment with Trait Anxiety. Considering these results, hypothesis H21g is rejected.

Table 17. Independent t-test by UA and participation aviation-related content

Dimension	Groups	N	Mean	Standard Deviation	p value
Labor	Yes	84	3.08	.988	.089
	No	53	2.76	1.128	
Environment with Trait Anxiety	Yes	84	3.27	.988	.031
	No	53	2.86	1.205	
Education	Yes	84	3.69	.907	.003
	No	53	3.21	.922	

Table 18 shows that there is a significant difference between education and acceptance of a job offer that is lower than their skill or education level. However, no significant difference was found between acceptance of a job offer that is lower than their skill or education level and labor and environment with trait anxiety dimensions. Considering these results, hypothesis $H2_{1h}$ is rejected.

Table 18. Independent t-test by UA and acceptance of a job offer that is lower than their skill or education level

Dimension	Groups	N	Mean	Standard Deviation	p value
Labor	Yes	40	3.18	1.097	.148
	No	95	2.89	1.022	
Environment with Trait Anxiety	Yes	40	3.33	1.027	.161
	No	95	3.04	1.115	
Education	Yes	40	3.92	.521	.000
	No	95	3.32	1.028	

When Table 19 is analyzed, no significant difference is found between the dimensions of UA and acceptance of a job offer without insurance. Considering these results, hypothesis $H2_{1i}$ is rejected.

Table 19. Independent t-test by UA and acceptance of a Acceptance of a job offer without insurance

Dimension	Groups	N	Mean	Standard Deviation	p value
Labor	Yes	6	3.58	.944	.140
	No	131	2.93	1.051	
Environment with Trait Anxiety	Yes	6	3.83	.683	.102
	No	131	3.08	1.098	
Education	Yes	6	3.75	.545	.516
	No	131	3.49	.953	

When Table 20 is analyzed, no significant difference is found between the dimensions of UA and embarrassment. Considering these results, hypothesis $H2_{1j}$ is rejected.

Table 20. Independent t-test by UA and embarrassment

Dimension	Groups	N	Mean	Standard Deviation	p value
Labor	Yes	110	2.90	1.032	.183
	No	27	3.20	1.118	
Environment with Trait Anxiety	Yes	110	3.15	1.112	.405
	No	27	2.96	1.008	
Education	Yes	110	3.48	1.020	.533
	No	27	3.57	.502	

When Table 21 is analyzed, a significant difference was found between education and acceptable to work in a different sector. However, no significant difference was found between acceptable to work in a different sector and labor and environment with trait anxiety dimensions. Considering these results, hypothesis $H2_{1k}$ is rejected.

Table 21. Independent t-test by UA and acceptable to work in a different sector

Dimension	Groups	N	Mean	Standard Deviation	p value
Labor	Yes	119	2.91	1.040	.172
	No	18	3.27	1.104	
Environment with Trait Anxiety	Yes	119	3.14	1.080	.465
	No	18	2.94	1.186	
Education	Yes	119	3.40	.905	.001
	No	18	4.16	.914	

Table 22 shows the results of the One-Way ANOVA analysis conducted to determine whether there is a difference between the UA dimensions and GPA groups. The homogeneity of variances was tested with Levene's test. As a result of Levene's test, it was seen that the p value of all dimensions was above ,050. As a result of the ANOVA test, significant differences were found between labor and environment with trait anxiety dimensions. Therefore, hypothesis $H2_{1l}$ is accepted.

Post-hoc analyses were performed to determine between which groups there were significant differences. Since the variances were homogeneous and there were no excessive n-value differences between the groups (Field, 2009: 374), the Gabriel test was preferred in the post-hoc analysis.

As a result of Gabriel analysis, a significant difference was found between the GPA 1.51-2.00 and 2.51-3.00 groups in the labor dimension. In the Environment with Trait Anxiety dimension, a significant difference was found between the 2.01-2.50 and 3.51-4.00 groups.

Table 22. One-Way ANOVA Test of UA dimensions by GPA Groups

Dimension	Groups	N	Mean	F value	p value
Labor	1.01 - 1.50	6	3.41	3.614	.004
	1.51 - 2.00	17	2.93		
	2.01 - 2.50	32	3.21		
	2.51 - 3.00	44	3.82		
	3.01 - 3.50	35	3.60		
	3.51 - 4.00	3	4.22		
Environment with Trait Anxiety	1.01 - 1.50	6	3.70	2.918	.016
	1.51 - 2.00	17	2.82		
	2.01 - 2.50	32	2.60		
	2.51 - 3.00	44	3.14		
	3.01 - 3.50	35	2.87		
	3.51 - 4.00	3	4.33		
Education	1.01 - 1.50	6	2.75	1.333	.254
	1.51 - 2.00	17	2.64		
	2.01 - 2.50	32	3.14		
	2.51 - 3.00	44	3.26		
	3.01 - 3.50	35	3.14		
	3.51 - 4.00	3	4.00		

Table 23 shows the results of the One-Way ANOVA analysis conducted to determine whether there is a difference between the UA dimensions and Class groups. The homogeneity of variances was tested with Levene's test.

As a result of Levene's test, it was determined that the variances were homogeneously distributed in the dimensions of labor (p = ,224) and education (p = ,196). In the environment with trait anxiety dimensions, the p value is ,006. Since the variances are not homogeneously distributed in the environment with trait anxiety dimensions, the Welch value will be taken into consideration.

When Table 23 is analyzed, it is seen that there are significant differences between all dimensions. Post-hoc analyses were conducted to determine which groups the differences were between. Gabriel analysis was preferred for the labor and education dimensions, whose variances were homogeneously distributed, and Games-Howell analysis was preferred for the environment with trait anxiety dimensions, whose variances were not homogeneously distributed.

According to Gabriel analysis, a significant difference was found between the 1st class group and all other class groups in the labor dimension. In the education dimension, a significant difference was found between the 1st class group and all other class groups. As a result of the Games-Howell analysis conducted for the Environment with Trait Anxiety dimension, significant differences were found between the 1st class group and other class groups.

According to the result of Table 23, hypothesis $H2_{1m}$ is accepted.

Table 23. One-Way ANOVA Test of UA dimensions by Class Groups

Dimension	Groups	N	Mean	F value	p value
Labor	1st Class	22	2.33	23.341	.000
	2nd Class	24	3.50		
	3rd Class	45	3.58		
	4th Class	46	3.99		
Environment with Trait Anxiety	1st Class	22	2.01	9.158	.000
	2nd Class	24	2.88		
	3rd Class	45	3.24		
	4th Class	46	3.17		
Education	1st Class	22	1.90	16.267	.000
	2nd Class	24	3.58		
	3rd Class	45	3.48		
	4th Class	46	3.09		

Table 24 shows the results of the One-Way ANOVA analysis conducted to determine whether there is a difference between the dimensions of UA and the average time spent on social media per day. Homogeneity of variances was tested with Levene's test.

As a result of Levene's test, it was determined that the variances were homogeneously distributed in the dimensions of labor (p = ,224), environment with trait anxiety (p = ,421), and education (p = ,718). The p value is less than ,05 in the dimensions of work and education. Since the variances are not homogeneously distributed for these dimensions, Welch value will be taken into consideration.

When Table 24 is examined, no significant difference was found between average time spent on social media per day in all dimensions.

According to the result of Table 24, hypothesis $H2_{1n}$ is rejected.

Table 24. One-Way ANOVA by UA level and average time spent on social media per day.

Dimension	Groups	N	Mean	F value	p value
Labor	1 hour	3	3.61	.256	.367
	2-3 hours	76	3.49		
	4-5 hours	44	3.45		
	6 hours or more	14	3.70		
Environment with Trait Anxiety	1 hour	3	2.75	.996	.421
	2-3 hours	76	3.01		
	4-5 hours	44	2.77		
	6 hours or more	14	3.28		
Education	1 hour	3	3.16	.449	.718
	2-3 hours	76	3.15		
	4-5 hours	44	2.98		
	6 hours or more	14	3.35		

When the results of the sub-hypotheses formed based on hypothesis H21 were examined, no significant difference was found between age groups, gender groups, participating in aviation activities on social media, accepting a job offer below their abilities or education or refusing to work without insurance, the embarrassment that students who cannot find a job in the aviation sector will feel towards their environment, and the approach to working in different sectors when they cannot find a job in the aviation sector and unemployment anxiety.

However, students' income status, internship status, work experience, following aviation activities on social media, academic grade point average and grade level differ in the dimensions of unemployment anxiety. According to these results, hypothesis $H2_1$ is accepted.

Pearson correlation analysis was applied to test hypothesis $H3_1$. Correlation analysis is an analysis with two or more variables. As a result of the correlation analysis, a correlation coefficient (r) is calculated. The correlation number can take a value between -1 and +1. A negative coefficient indicates an inverse relationship between the variables, while a positive coefficient indicates a positive relationship. The closer the coefficient is to 1, the stronger the relationship (Islamoğlu, Alnıaçık, 2019: 357).

Table 25: Pearson correlation analysis for the relationship between FoMO and UA dimensions

		Labor	Environment with Trait Anxiety	Education
FoMO	Pearson Correlation	.477**	.285**	.248**
	Sig. (2-tailed)	.000	.001	.003
	N	137	137	137

** p=0.01

As a result of the Pearson correlation analysis, significant and positive relationships were found between FoMO and all the UA dimensions. While there is a moderate relationship between FoMO and the labor dimension, there are weak but significant relationships between FoMO and the environment with trait anxiety, and education dimensions. As a result of the Pearson correlation analysis, hypothesis $H3_1$ is accepted.

The results for the main hypotheses of the research are shown in Table 26.

Table26. Hypothesis results

	Hypothesis	Results
$H1_0$	Demographic factors are not effective in Aviation Management students' FoMO levels.	Rejected
$H1_1$:	Demographic factors are effective on Aviation Management students' FoMO on levels.	Accepted
$H2_0$	Demographic factors are not effective in Aviation Management students' unemployment anxiety.	Rejected
$H2_1$	Demographic factors are effective in Aviation Management students' unemployment anxiety.	Accepted
$H3_0$	There is no relationship between the level of fear of missing out and unemployment anxiety among Aviation Management students.	Rejected
$H3_1$	There is a positive relationship between Aviation Management students' level of fear of missing out and unemployment anxiety.	Accepted

6. Conclusion and Discussion

The purpose of this study is to determine whether the fear of missing out levels of aviation management undergraduate students have an impact on their unemployment anxiety. For this purpose, in addition to the fear of missing out (FOMO) and unemployment anxiety (UA) scales, answers to some questions were also sought with the support of the literature. It has significant findings on the relationship between fear of missing out and unemployment anxiety.

First of all, the low age of the students participating in the study and the high level of fear of missing out observed in 52.55 per cent of the sample support Przybylski et al. (2013). In the same study, it was also found that students had high levels of fear of missing out. This finding is also supported in line with the analyzes conducted.

Gender, having done an internship in the aviation sector, following aviation activities and the grade of the students are effective on the level of fear of missing out. Income, work experience, participating in aviation activities, *accepting* to work in a job that is lower than their ability or education, accepting to work without insurance, embarrassment to family and friends if they cannot find a job in the aviation sector, approach to working in a different sector, grade point average

and time spent on social media in a day are not effective on the levels of fear of missing out.

According to the analysis done for both fear of missing out and unemployment anxiety, the dependent variable is impacted by following aviation activity. Participating in aviation-related activities, however, had no impact on this of the factors. The covid-19 epidemic is considered to be connected to this condition. During the epidemic, there was no physical difference between following and participating because everything was done online. As a result, sometimes students may have meant that they were participating in the activity when in fact they were following it.

Income status of the students, having done an internship in the aviation sector, following aviation activities, having previous work experience, the level of success and the level of success of the students are effective on the unemployment anxiety of the students. Age, gender, participation in aviation activities, approach to working in a job below the level of ability or education, approach to working without insurance, embarrassment to family or environment in case of not being able to find a job in the aviation sector, approach to working in different sectors and daily social media usage time aviation management students' unemployment concerns has no effect on it.

Among aviation management students, those with previous work experience were found to have lower unemployment anxiety than students without work experience. This finding supports the studies of Dursun, Aytaç (2009).

It was found that aviation management students who are in their final year have higher unemployment anxiety than students who are in lower grades. This supports the findings of Dursun, Aytaç (2009).

In addition, differences were also found between students in terms of gender and academic grade point average in terms of experiencing unemployment anxiety. These findings support the findings of Aydın, Tiryaki (2017).

While 55.6 percent of the participants in Ateş's (2019) study stated that they would accept a job below their education level, only 30 percent of the participants in this study stated that they would accept a job below their education level. In addition, in both studies, most of the students stated that they would not accept working without insurance. 80.3 percent of the students who participated in the study stated that they would feel embarrassed if they could not find a job in the aviation sector. This situation does not support Ateş (2019). In the same study, the rate of those who would consider working in a different sector if they could not find a job in the aviation sector was 46.4 percent. This rate is 86.9 percent in our study. The unemployment rate between 2019 and 2023, the youth unemployment rate, and the large number of graduates from aviation management departments may cause students to consider working in different sectors. In terms of unemployment anxiety, income, having done an internship in the aviation sector, having previous work experience, following aviation activities, academic grade point average and the class of the student affect unemployment anxiety.

One of the most important findings of the study was that strong and positive relationships were found between fear of missing out and unemployment anxiety. These results show that these two concepts are interrelated and affect students' experiences and perceptions.

The results of this study shed light on university students' attitudes towards career planning and the aviation industry. It is concluded that students' fear of missing out and unemployment anxiety levels may affect their job choices and attitudes towards the industry.

Furthermore, seminars enlightening students on the use of social media are encouraged to raise awareness about the potential repercussions of fear of missing out. Monitoring social media use and understanding effective ways of using social media can help regulate levels of fear of missing out.

Finally, given the potential impact of unemployment anxiety and fear of loss on students' attitudes towards the sector, career counselors and guidance services should take these aspects into account and help students manage these fears. Workshops that provide information on job search tactics and job interviews can minimize the fear of unemployment and help students enter the field with more confidence.

Such educational and supportive interventions can help students cope more effectively with fear of missing out and unemployment anxiety and can have a positive impact on their career goals and attitudes towards the aviation industry. In conclusion, this study is important for university students' career planning and labor market entry.

For future studies, it may be recommended to investigate behaviors such as depression, suicide, alcohol or substance abuse, which are among the consequences of unemployment anxiety.

Ethical approval

This study protocol received ethical approval from the Bartin University's Ethics committee chairman, dated 25/03/2022 and numbered 2022-SBB-0112.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Economic Sustainability of Air Transportation in Terms of Unfair Competition and Negative Externalities: Evidence from Turkish Commercial Law

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Abstract

Air transportation is a more advantageous form of transportation compared to other types of transportation. This is because it provides economic growth, place, and time benefits. However, the realization of the economic sustainability of these benefits may become difficult in certain cases. It is possible to express these situations as negative externalities in the theory of public finance. The solution to negative externalities lies in their internalization. Unfair competition is also a negative externality for air transport enterprises. One of the sanctions applied for the internalization of this negative externality is compensation. While material compensation can internalize externalities, moral compensation cannot fully compensate for externalities in a number of cases. Such a situation may constitute a violation of the rule that externalities will not be reflected in market prices. In order to understand whether such a rule violation actually occurred judicial decisions were examined using the comparison method in the study. The conclusion reached in the study is that in a few cases externalities are likely to be reflected in market prices and reveal a violation of a rule related to the theory of public finance. To ensure economic sustainability of air transportation, moral compensation decisions that have the potential not to reflect externalities to market prices must be fully determined.

1. Introduction

The air transportation sector, which is one of the most developed sectors thanks to globalization, is preferred because it is faster and safer than other transportation methods. The sector is also quite different compared to most sectors in terms of market structure and functioning. The fact that the demand for air transportation is derivative demand, the airline supply is constant compared to the high mobility in demand, and the fact that the market significantly provides competitive conditions makes the air transportation sector different from most other sectors (Çam, 2016). These differences are more clearly manifested in terms of economic growth, time, and place benefits. Therefore, these elements are mentioned in the first part.

In the theory of public finance, externalities may be in question for air transportation as in every field. These externalities can be treated as negative and positive externalities. In the theory of public finance, it is accepted that externalities are not reflected in market prices. This is because various solutions have been introduced for the internalization of these externalities. However, in a number of cases, it becomes controversial how sufficient the solutions to the externalities are. For example, when unfair competition is considered to be a negative externality, material and moral compensation is ruled for its internalization. Therefore, it is accepted that negative externality is internalized. However, when moral compensation is not provided sufficiently as requested, it cannot be easily said that the damage suffered by the air transportation company is fully compensated. Such a situation means that externalities will be reflected in market prices. In other words, there is a contradiction to the theory of public finance. To determine whether such a violation would occur, the comparison method was used in law in the study and compensation decisions related to unfair competition were examined. Afterwards, the difference between the requested compensation and the compensation granted was mentioned and it was discussed whether externalities are reflected in market prices. While this discussion was being held, according to the comparison method, an answer was sought to the question as to what would happen if similar situations had happened in air transportation. In this context, externality, unfair competition, and the comparison method were mentioned respectively, and then a general assessment was made.

2. Why Air Transportation? Key Economic Benefits

Air transportation is a field that dates back to 1903, when the Wright brothers made the first successful motor flight and

is developing in parallel with technological advances (Anderson & Bowden, 2005; Pereira et al., 2022). Many developments following the Wright brothers' initiative have contributed to and guided today's air transportation. By 1909, Louis Bleriot had crossed the English Channel in a monoplane (Petrescu et al., 2017). After these early successes, air travel began to become a more comfortable and safer alternative to other travel options with the introduction of large, four-engine aircraft such as the Boeing 747 and the Douglas DC-3 in the 1930s (Geels, 2006: 1006; Frenken & Leydesdorff, 2000). When the competition between airline companies is added to this, there has been a significant increase in the number of people who prefer to travel by air (Gil & Kim, 2021). Air transportation has gone beyond being a popular mode of transportation used frequently by individuals to the point it has arrived at today. Today, a wide range of airline transportation from the insurance sector to tourism, from the agricultural sector to industry and the health sector is also part of the production process (Rosa, 2013; Hamaguchi, 2021; Huuskonen & Oksanen, 2018; Eren et al., 2020; Veldman et al., 2004).

Although air transportation has many advantages, it should be noted that there are a number of disadvantages. The advantages and disadvantages are summarized in Table 1.

Table 1. Advantages and disadvantages of airline transportation

Advantages	Disadvantages
Time saving; air transportation is the fastest transportation option today (Ali et al., 2023).	Contribution to environmental pollution and climate change; air transportation is an industry that has an undeniable share of greenhouse gas emissions (Dinc et al., 2022).
Accessibility; provides easy transportation from both big and small cities to all parts of the world (Papatheodorou, 2021).	Cost: Although there has been certain improvement due to increasing competition in recent periods, especially as the distance gets longer, air transportation is still not a choice that consumers of all budgets can reach (Elgin et al., 2017).
Safety and security; risks are minimized thanks to strict rules and controls applied on an international scale (Brangdon, 2011)	Infrastructure problem; the equipment needed for air transportation to take place is quite expensive (Jorge&de Rus, 2004).
Comfort: thanks to current technology, the quality of service has increased with services such as comfortable seats, additional services, and food and beverage facilities available on airplanes. (Mahapatra & Bellamkonda, 2023).	Security concerns; airports and airplanes, no matter how strict measures are taken, may be pushed to the background by potential consumers due to examples such as the 09/11 events (Sweet, 2008).

Sustainability issues affect the economic success of companies more than ever. This is because sustainability has become the driving force of both risks and opportunities in the business world (Schaltegger, 2011). This situation refers to the private sector leg of air transportation activities.

The essence of sustainable development is to meet the basic needs of humanity without inflicting violence on the natural life systems of the world. This idea was put forward in the early 1980s and came out of a scientific deconstruction of the relationship between nature and society. In this context, it is possible to suggest that the concept of sustainable development reflects the struggle of the world population for peace, freedom, better living conditions and a healthy environment (Martens, 2006). Therefore, the concept of sustainable development also represents the public sector leg of air transportation activities.

In this context, as a result, economic growth, place, and time benefits should be considered in ensuring the economic sustainability of air transportation activities.

2.1. Economic growth benefit

When measuring the size of a country's economy, sectoral data within that economy is used. Although different classifications can be made from each other, the main topics are usually the agricultural sector, the services sector, and the industrial sector (Hussin, 2013). The developments in these sectors are extremely important elements because they determine the country's economy, and they are all influenced by air transportation. For example, the availability and development of air transport provides people with the freedom to travel and allows the tourism sector to grow (Bieger & Wittmer, 2006). Since the tourism sector is a sub-branch of the services sector, the growth of the tourism sector means the growth of the services sector (Özsağır & Aliye, 2012). By the same logic, it is possible to say that sectoral growth is also reflected in economic growth.

Another element of economic growth is the industrial sector (Hussin, 2013). Industry encompasses a broad process in which inputs are processed and made ready for human use. The operation of facilities in the industrial sector depends on elements such as capital, energy, labor, raw materials, and transportation (Tümertekin, 1994). The fact that any of these elements, which are part of the economic growth process, are insufficient or cannot be used in the desired way will indirectly cause disruption in the sector and negatively affect the country's economy. Therefore, in the field of transportation, air transportation is also an important topic for the industrial sector. When considering today's transportation methods, the fastest alternative is air transportation (Ali et al., 2023). For this reason, air transportation is also an indispensable part of the industrial sector.

In addition to the services and industrial sector, the agricultural sector is another pillar of national economies (Hussin, 2013). However, the development of the sector consists of the use of aircraft for technical tasks such as agro-spraying, control, and seeding, which is called the agricultural aviation industry, rather than air transportation (Su et al., 2022).

2.2. Time Benefit

The indispensable element of the age we live in is the concept of speed. The factor that shapes consumer preferences the most is how fast a manufacturer or seller is (Bakkal & Demir, 2011). This factor affecting consumption preferences shows the same effect in transportation (Doğan, 2013). Nowadays, people want to spend as little time as possible traveling from one point to another. The travel may be for business purposes as well as for entertainment/tourism purposes. For whatever reason, individuals will try to minimize the time they spend on their journey by being result oriented. In this case, the most logical choice is air transportation (Şahin & Tektaş, 2021). Factors such as increased competition reducing costs, and air transportation ceasing to be a luxury, an increasing number of direct flights,

and arranging connecting flights to non-direct destinations - provided an acceptable waiting time - have also made air transportation more attractive (Bakırcı, 2012; Yaşar, 2017).

2.2. Place Benefit

According to today's business life requirements, a person may need to be present in more than one city and even country on the same day. Due to factors such as technological developments and globalization, business life has moved to an international dimension by no longer remaining within national borders and has also changed our perception of distance to some degree. A CEO who attends a meeting in Italy in the morning can participate in a congress in Spain in the afternoon. To ensure this rapid change of location, the preferred transportation alternative has been air transportation.

3. Externality in The Theory of Public Finance: A Brief Overview

Over time, significant changes and deviations have emerged in economic activities, markets, and the economic conjuncture as the assumptions in a fully competitive market have lost their validity; serious imbalances at the micro and macroeconomic level, and serious crises in social life have manifested themselves. The cyclical expression of these deviations is that three stages occur in the economic conjuncture. In the case of a dynamic process, there are three consecutive conjunctures in the economy. These are high and low conjuncture and equilibrium conjunctures in normal or full employment. Here is this state that disrupts the equilibrium state and distribution in the economy, which is essentially deviations in production and consumption in an economy that has been left to itself; that is, externalities (Devrim, 2002).

In general, externality refers to the positive or negative effects that are indirectly observed on other economic units or units due to the activity of an economic unit, and it occurs on other production or consumption activities depending on a production or consumption activity (Akdoğan, 2011).

The characteristics of externalities are (Akça, 2011)

- Externalities can be realized by both producers and consumers. For example, while the negative impact of agricultural production on land around a cement factory is an externality created by the manufacturer, it is an externality created by the consumer that a smoker disturbs the people next to him.
- Externalities are based on the principle of reciprocity. Based on reciprocity, it should be affecting and affected. The fact that it affects farmers near the cement factory can be given as an example of this.
- Externalities can be positive or negative. The effect that will occur in positive externality will create benefits. In negative externality, there will be harm.
- Public goods can be considered as a special state of externalities. Since bug spraying done by a garden owner in a region where orchards are dense will cause the death of harmful insects in other gardens, the externality provided to other garden owners takes on the character of a public good.

Externalities are basically divided into two types as external benefits and external costs that are distributed to society (Yılmaz, 2016). In other words, externalities are generally divided into positive and negative externalities.

If an activity performed by a production or consumption unit positively affects other economic units, there is a positive externality (Ay, 2021). Negative externality is the cost or damage caused by the negative impact of third parties on the production or consumption activities carried out by any economic unit. The most common example of negative externality is environmental pollution caused by certain production activities. The costs that other producer units must bear to protect themselves from the negative effects of environmental pollution are negative externalities (Pehlivan, 2020).

In the case of the existence of externality, the distribution of resources by the market system impairs the efficiency of resource use because the private sector avoids compensating for the negative externality it creates. In the case of positive externality, production remains below the optimal level for society, as the private sector will make investment and production planning that does not consider the benefits of third parties. The state is forced to intervene in the economy in the presence of externalities. If there is a negative externality, it brings regulation to the relevant production activity. For example, it imposes an obligation to treat waste and compensates the losses of the agricultural landowners in the vicinity by imposing additional taxes on the production unit. In a case of positive externality, it applies tax deduction, exemption, and similar incentive policies to the relevant production unit (Erdem et al., 2012). Externalities are internalized in these ways. For this reason, it is accepted that externalities are not reflected in market prices.

4. Unfair Competition

Unfair competition is commercial practices with are deceptive or other forms of deceptive behavior that affect relations between competitors or between suppliers and customers. The right to competition, which forms the basis of a free market economy, and the opportunity to engage in commercial activities in a competitive environment are granted to all natural and legal persons. However, as with all rights, the right to competition must be exercised within the framework of the rules of morality and honesty in accordance with the provisions of Article 2 of the Turkish Civil Act. Provided that the characteristics of each event are also considered, decrying someone else or their business and products as defective, taking unfair advantage of someone else's name, title or effort and labor, sometimes committing certain behavior by ignoring an obligation to behave like a prudent businessman, even if there is no defect, may be considered unfair competition (Kayar, 2018). The elements of unfair competition are as follows (Bahtiyar, 2019):

- There must be behavior or commercial practice that affects relations between competitors or between suppliers and customers. Therefore, the protection area of unfair competition rules is being expanded, and the old protection system, which is based only on the race between competitors, is being decoupled.
- Behavior or practice should constitute a violation of the rule of honesty. Since the deceptive act will already be contrary to the rule of honesty, it seems unnecessary to emphasize this additionally. As is clearly understood from Article 56 of the Turkish Commercial Act regulating unfair competition cases, the fault of the perpetrator is not an element of unfair competition, but only one of the issues that must be proved along with the damage to claim compensation.
- The behavior or practice must lead to harm or at least the danger of harm. However, the danger of damage is not

sufficient for a compensation claim, and the existence of damage is a must.

The main unfair competition situations are considered in Article 55 of the Turkish Commercial Act. Unfair competition cases are not only limited to the actions listed in this act. The situations considered as unfair competition in this act are engaging in advertisements and sales methods contrary to the code of integrity, to direct to breach or terminate the contract, to make unauthorized use of other people's business products, to disclose production and business secrets illegally, not to comply with business conditions and to use transaction terms contrary to the code of integrity (Ülgen et al., 2019).

Civil and criminal liability may arise as a result of unfair competition. If unfair competition is considered within the scope of legal liability, those who are harmed may file the following lawsuits (Topsoy, 2019):

- A detection case,
- A case for prevention,
- A Correction (reinstatement) case,
- A Compensation (material or moral) case.

In a case of criminal liability arising within the scope of unfair competition, the perpetrator is punished with up to two years in prison or a judicial fine (Bozer & Göle, 2020). Persons who are subject to these criminal sanctions are as follows (Kaya & Tatlı, 2020):

- Those who intentionally carry out one of the unfair competition situations listed as an example in the act,
- Those who intentionally provide false or misleading information regarding their personal situation, products, business products, business activities and jobs preferring their own requirements and offers to those of competitors,
- Those who deceive employees, surrogates, or other assistants to enable the employee or their clients to obtain production or trade secrets,
- Those who learn from employees or clients that their employees or employees or their deputies have committed an act of unfair competition that requires a penalty during their work, but do not prevent this act or correct statements that contradict the truth.

5. Methodology

In the study, the comparison method in law was used. Comparison is mainly one of the reasonings in the science of logic. However, due to the use of the science of logic in other branches of science, the comparison is also used as an interpretation method in law. Logic followers define the comparison as establishing a logically valid relationship between more than one proposition called the premise and a proposition called the conclusion (Demir, 2009). Comparison in law can generally be defined as the application of a rule contained in an act in relation to an event to an event that is similar to it in nature but one that is not regulated by legislation. It is possible to apply to the comparison method if there is a gap in the law (Arık, 2018). The advantages of the comparison method are as follows (Altuntaş, 2020):

- The method of comparison is considered to be one of the most useful reasoning methods, due to the limited capabilities and time of people. This is because the method of comparison acts on certain events that people can easily comprehend. In other words, a person who applies the comparison method does not need to develop a completely perfect theory to justify the conclusion he has reached.
- The second advantage of the comparison method is that people do not need the consensus that should be provided regarding general principles when using this method to achieve a certain result because sometimes it is extremely difficult for people to agree on a general principle in terms of their own judgments. However, during the application of the comparison method, it is likely that the same people will agree on a principle at a lower level or on certain events.
- Another advantage of the comparison method is that it is open to innovation. In this aspect, the comparison method also helps to reach a consensus to solve controversial and uncertain issues.

What is important in comparison is the meaning of the words used in the current regulation and the purpose of establishing the relevant norm. Considering the purpose of the article, it is extremely important that the words used in the norm are not understood in a different way while the situations that are within the scope of the article and those that are not within the scope of the article are examined within the framework of this purpose. If it is considered that both situations are within the purpose of the article, the current regulation is extended and applied for both situations. Therefore, the way in which the regulation is applied to a situation outside its scope, and the name of this method, is comparison. In light of these explanations, an example can be given as follows: If the existence of a regulation such as “smoking is forbidden on the train" is accepted, is it also forbidden to smoke a pipe on the train? As explained above, the first thing to be considered is to determine whether there is a partnership between the situation about which there is regulation and the second situation about which there is no regulation in terms of its purpose. According to this, the reason why a cigarette cannot be smoked in enclosed environments is that it disturbs people in an enclosed area with the smoke it emits. A smoked pipe, like a cigarette, has the quality to disturb other people in the environment with the smoke it emits. Therefore, smoking a pipe in enclosed environments may be considered to be prohibited by the comparative implementation of the smoking ban (Baytaz, 2018). In this study, whether the amount of compensation awarded is reflected in market prices when an unfair competition situation arises as a negative externality is considered using the comparison method.

6. Findings

The findings obtained from the judicial decisions in the study are of importance. This is because, thanks to these findings, it will be revealed whether externalities are reflected in market prices from the point of view of Turkish Commercial Law. The decisions are summarized below:

- Court of Appeal 11th Civil Chamber, Date: 18 September, 2008, Docket No: 2008/8441, Decree No: 2008/10218: The defendant's attorney requested decertification of the case, arguing that his client was a pilot and started working at the plaintiff company as a pilot, the plaintiff's claims that he trained his client as a pilot were untrue, that there was no basis for compensation claims, and that the plaintiff's claims remained unfounded, since there was no written contract between the parties. The defendant's attorney requested that his client had no intervention when the defendant resigned from the plaintiff company, and also that it was out of the question for the defendant to be raised by the

plaintiff because the defendant already held a commercial pilot's license. Furthermore, the addressee of the claims put forward by the plaintiff should exclusively be the other defendant, arguing that there was no unfair competition in the case, and the case was dismissed on merit. The court decided to reject the case on the grounds that there was no written service agreement between the plaintiff and the defendant according to the scope of the claim, defence and the entire file, based on the reason that the defendant terminated the relationship and started working elsewhere, that the claims made by the plaintiff had no legal basis, and that there was no element that could be decried as unfair competition, due to the absence of hostility on the part of the defendant. In addition, and on the other hand, because it is not fixed on the part of the defendant decrees. However, while the court should have ruled on reasonable compensation in return for the costs of the plaintiff's training, which he made in the belief that he would employ the defendant as a pilot at his airline, as well as the damage he suffered due to being left unrequited, it was not considered correct to dismiss the case against the defendant on written grounds. Therefore, the decision had to be overturned for the benefit of the plaintiff.

- Court of Appeal 11th Civil Chamber, Date: 20 April, 2022, Docket No: 2021/609, Decree No: 2022/3182: The plaintiff's attorney claimed that the defendant company occasionally used the TSE-designated brands belonging to his client without any contractual relationship in the products it produced, which constituted an infringement of his client's trademark rights and unfair competition, and requested decrees to collect 6,500.00 TL material and 32,500.00 TL moral compensation from the defendant to stop the defendant company's infringement and unfair competition against his client's brands. The defendant's attorney requested decertification of the case arguing that his client used the plaintiff's brands in accordance with the agreement he made with the plaintiff, but the trademark usage agreement was suspended by the plaintiff due to difficulties at work, the products seized during the search at the client's workplace were stock products and packaging produced during the effective period of the contract between the parties. According to a trial conducted by the court in accordance with the order of violation and the scope of the file, the defendant company had the 'TSE' brand on the packages of cables found at work, the acquittal of the company official in the criminal case would not bind the civil judge, and the use of the 'TSE' brand on product packages constituted an infringement of the plaintiff's trademark rights, according to Article 45 of the TSE Certification Directive. Accordingly, the plaintiff asked for financial compensation of 6,500.00 TL, which is twice the amount of 3,750.00 TL. The plaintiff partially accepted the case on the grounds that the 'TSE' brand is located on the packages of cables found at work, and the plaintiff asked for financial compensation of 6,500.00 TL, which is twice the amount of 3,750.00 TL. After determining that the use of the registered trademark 'TSE' belonging to the party on the product packaging by the defendant company without a contract constitutes an infringement of the plaintiff's trademark right and unfair competition, it was decided to stop the infringement, take 6.500,00 TL material and 7.000,00 TL moral compensation from the defendant, and give it to the plaintiff. This decision was upheld by the Court of Appeal.

- Court of Appeal 11th Civil Chamber, Date: 03 June, 2013, Docket No: 2012/11765, Decree No: 2013/11574: The plaintiff's attorney stated that the X brand was registered on behalf of his client with the numbers 2007-55302 and 2008-58795, and that the defendant unfairly used these brands on business signs, newspaper advertisements, and advertising brochures. It was further put that the actions constituted unfair competition, the action was stopped by detection, the removal of signs, the collection of printed documents, and the announcement of the decision. He demanded and sued 1.000,00 TL material and 5.000,00 TL moral compensation. The court found this request justified and it was decided to collect 1000 TL material compensation and 5000 TL moral compensation from the defendant with commercial interest from the date of the case. This decision was upheld by Court of Appeal.

- Court of Appeal 11th Civil Chamber, Date:17 June, 2013, Docket No: 2012/13071, Decree No: 2013/12540: Acting for the plaintiff, defendant A, Y (Tourism Student and Staff Transportation Ltd.) stated that this company was a partner and official of the plaintiff company B Private Schools between 2002 and 2007, conducted student service business, received lists containing parents' home, work, address and phone information from the school's student affairs due to service transportation, while they should have returned this information to the school after the legal relationship with the school ended. The defendant stored this information himself and saved it on his computers. Although this information was private, the student list was sent to other private schools by way of computer e-mail, and these actions of the defendant caused the plaintiff's loss of reputation. The defendant's actions were responsible for the loss of reputation of the plaintiff. The defendant's actions were responsible for the loss of the reputation of the plaintiff. The defendant's actions were responsible for the loss of the reputation of the plaintiff. The defendant's actions were responsible for the loss of the reputation of the plaintiff, the defendant's actions were responsible for the loss of the reputation of the plaintiff, the defendant's actions were responsible for the loss of the reputation of the plaintiff, the defendant's actions were responsible for the loss of the reputation of the plaintiff, the defendant's actions were responsible for the loss of the reputation of the plaintiff and claiming that it led to material damage, he demanded and sued the men of unfair competition for a decision to publish the decision in one of the newspapers with high circulation, to collect 1,000.00 TL material and 100,000.00 TL moral compensation from the defendant. With the partial acceptance of the court's claim for moral compensation, it was decided to collect the moral compensation of 7.500,00 TL. The Court of Appeal upheld this decision.

- Court of Appeal 11th Civil Chamber, Date: 05 October, 2000, Docket No: 2019/5076, Decree No: 2020/3834: The plaintiff's attorney stated that his client had been engaged in framing activities since the 1980s, and for more than twenty-five years, he had been conducting all his commercial activities before the Turkish Patent Institute, including transportation services, at the 39th International Patent Court of Justice. He stated that he continued it with the trademark 'X' numbered 2014/22048 registered in terms of class and logo which was his own design. The plaintiff's attorney also used the similar phrase 'X NAKLİYAT' in such a way as to clearly establish favor with the registered trademark of the defendant company's client, 'www.Xnakliye.com.tr' claiming that his client used the registered 'X+Şekil' trademark logo in exactly the same way on the addressable website and on his vehicles. No result could be obtained from the warning dated 08 April, 2015 that his client discovered for the defendant in this regard, to determine, block, and eliminate that the defendant's actions constituted a violation of his client's trademark right protected by

registration No. 2014/22048 and unfair competition. To announce the summary of the judgment, he demanded 1.000 TL and sued for a decision to collect the financial and moral compensation of TL 1,000 from the defendant together with the rediscount interest. The Court of Appeal approved this request.

• Court of Appeal 11th Civil Chamber, Date: 08 May, 2019, Docket No: 2018/927, Decree No: 2019/3506: Acting for the plaintiffs, one of his clients A's other client is the director and founding partner of the company, his client provides the company's ballooning service, for the promotion of this service 'www.Xballons.com' he stated that he was using the domain name website. The plaintiff's attorney also claimed that there are internet sites created with domain names with the main element 'X' created by the defendant party when 'X' or 'X ballon' is entered into search engines, this situation negatively affects the business situation of the client company and constitutes unfair competition. For this reason, the plaintiff requested that a decision be made on the collection of 1,000 TL material and 3,000 TL moral compensation from the defendant. The court accepted this request, and the Court of Appeal approved it.

• Court of Appeal 11th Civil Chamber, Date: 08 April, 2014, Docket No: 2013/17737, Decree No: 2014/6831: The plaintiff's attorney claimed that his client "X Tourism Limited Company has been transporting passengers between A and B for about 30-40 years, defendant Y has unfairly reduced the road fare from 6.00 TL to 3.00 TL, including in the morning and evening hours when passengers are busiest since 10 February, 2011, the defendant caused material and moral damage to the client company by unfair competition. The plaintiff's attorney also stated that the situation has been notified to the necessary authorities, ... According to the letter No. 24/05/2011 of the Regional Directorate of Transport, the defendant was given a 5 warning penalty for violating the Highway Transportation Regulation, then the transport document was warned to be cancelled, the defendant's unfair competition was considered fixed by the Ministry of Transport, 10.000,00 TL financial, 10.000,00 TL moral compensation will be processed from 10.02.2011, provided that the prevention of unfair competition, excess claims and rights are reserved together with the legal interest, he requested and sued that a decision be made to collect it from the defendant. The Court decided to pay 10.000,00 TL financial compensation and 500,00 TL moral compensation, and the Court of Appeal upheld this decision.

• Court of Appeal 11th Civil Chamber, Date: 02 March, 2020, Docket No: 2019/2866, Decree No: 2020/2223: The plaintiff's attorney stated that the defendant, a cooperative, provides transportation services within the ETUS system of which it is the pioneer, by the decision of the X Municipal Council dated 03 April, 2013, and numbered 2013/162. A maximum of eight vehicles included in the ETUS system on line 3A, including the routes that his client transports, were placed under regulation. The defendant cooperative carried out transportation using 35-40 vehicles, despite this being contrary to this decision. The defendant's actions constituted an act of unfair competition regulated by Article 55/1-e of the Turkish Commercial Act. Due to these actions claiming that his client's commercial activities and economic interests were damaged, he requested that a decision be made on the determination of unfair competition, and the collection of 10.000,00 TL material and 10.000,00 TL moral compensation from the defendant and the announcement of the judgment was made. The court accepted the financial compensation of 10.000,00 TL but rejected the moral compensation. The Court of Appeal also upheld this decision.

• Court of Appeal 11th Civil Chamber, Date: 09 December, 2013, Docket No: 2013/8300, Decree No: 2013/22365: The plaintiff's attorney stated that his client had trademark registration documents bearing the X phrase, and that these trademarks also had land transportation services within the scope of registration. He claimed that the defendants used his client's registered X phrase as a trademark and trade name in the price and offer letters sent by the defendants to their customers, at the same time as there are websites with the phrase 'www.Xnakliyat.com', and that the defendants advertised as X NAKLİYAT in the ads they placed in various newspapers. He claimed that this situation constituted an encroachment on the well-known registered trademarks of his client and was unfair competition. To stop and eliminate the encroachments of the defendants using 'www.Xnakliyat.com' he demanded and sued for a decision to close the website with the phrase, to collect 50,000 TL moral compensation from the defendants along with interest from the date of the violation, and to announce the summary judgment. The court decided on 5000 TL moral compensation and the Court of Appeal upheld this decision.

• Court of Appeal 11th Civil Chamber, Date: 02 July, 2014, Docket No: 2014/120, Decree No: 2014/12653: The attorney of the plaintiffs stated that the 'X' brand belonging to his clients is a well-known brand in Turkey and throughout world, and the same phrase is also used as a 'guide word' in the trade name. He claimed that the defendants used the 'X' brand belonging to the plaintiff unfairly and without permission in the transportation sector and that the defendants collect customers by taking advantage of the seriousness and trust created by the X brand/ name in society through the company they operate, and that they get an unfair advantage. The plaintiffs' attorney also claimed that such untrue statements constitute an attack on the plaintiff's reputation due to his recognition and that they cause moral damage, requesting an injunction to detect trademark infringement and unfair competition, to stop using the defendants' X phrase in printed documents on newspaper advertisements on Internet pages, to close the defendant's website or block access to this website, and seeking 5000 TL in moral compensation. The court ordered 2000 TL moral compensation. The Court of Appeal also upheld this decision.

7. Discussion and Conclusion

First of all, the issue that needs to be stated is that a comparison method can be made in terms of the Turkish Commercial Act. In other words, according to the decision made by the judiciary in an incident, the same provision may be applied to a similar decision related to commercial law. When the first of the judicial decisions made is examined, it is noteworthy that the expression '...reasonable compensation ...' is passed in the decision. Considering that both the plaintiff and defendant parties are airline transportation companies in the first judicial decision, the fact that the compensation awarded is not expressed as a precise amount raises the possibility that externalities will be reflected in market prices. This is because unfair competition is a concept that can serve as an example of negative externality. If the compensation awarded is greater than the damage suffered, the airline transportation company, which is the victim of unfair competition, will have made an unfair profit. If the compensation awarded is lower than the damage suffered, in this case the company will have to increase the price of the

services it provides to cover the loss. If such a situation sets an example for other airline transportation companies, in other words, if this decision turns into a kind of negative externality, the equilibrium price that will occur in the market will increase, and the amount of service produced will decrease.

Looking at the second judicial decision, material compensation is appreciated in the amount requested by the plaintiff, while moral compensation is almost a quarter of what is requested. In Turkish law, it is essential that moral compensation be determined at a level that will not enrich a person. It is obvious that the situation where the difference between the determined moral compensation and the demanded moral compensation is too much, the difference between them may lead to the possibility of a reflection on the market. In other words, negative externality may be reflected in market prices.

When looking at the third judicial decision, it can be seen that the material and moral compensation was granted at the level requested by the plaintiff. In such a decision, it can be suggested that negative externalities will not be reflected in market prices since there is a uniformity between the decrees of the court and the plaintiff in the compensation levels.

In the fourth decision, there is an unfair competition action that takes place through the provision of trade secret information. Although 100,000 TL moral compensation has been requested here, the amount of compensation granted is only 7,500 TL. The potential for the difference to be reflected in market price is quite high.

In the fifth decision, the requested and accepted compensation amounts are equal and the compensation in question is 1,000 TL. In this respect, it can be suggested that the reflection of negative externality on market prices can be prevented by the Turkish Commercial judiciary. There is a similar situation in the sixth decision. The plaintiff requested 3,000 TL and the court decided on 3,000 TL moral compensation. Here, too, the probability of negative externalities being reflected in market prices becomes quite low.

While the compensation requested in the seventh decision is 10,000 TL, the compensation granted is only 500.00 TL. Therefore, unfair competition, again as a negative externality, will be reflected in market prices. In other words, a situation that contradicts the theory of externality will arise again.

In the eighth decision, the claim for financial compensation of 10,000 TL was accepted, while the claim for moral compensation was rejected. Non-pecuniary compensation will mean that the requested amount can be reflected in market prices. Therefore, again, a situation contrary to the theory will arise.

In the ninth judicial decision, 50,000 TL moral compensation was requested, but the court only decided 5,000 TL moral compensation. Here, too, the difference between the amount requested and that given in terms of moral compensation is quite large. Therefore, the probability of negative externalities being reflected in market prices is quite high.

When looking at the last judicial decision, it can be seen that the amount of moral compensation requested is 5,000 TL and the amount of moral compensation awarded is 2000 TL. Here, too, negative externalities may be reflected in market prices, and therefore a situation contrary to the theory may arise.

When looking at all the judicial decisions in the findings, it is seen that the financial compensation is at the level desired by the plaintiff parties. The reason for this is that the material damage consists of concrete elements that can be calculated. Therefore, it is observed that disputes related to unfair competition are knotted in matters of moral compensation. Here it is seen that the judiciary generally keeps the moral compensation low because it wants to prevent the enrichment of the plaintiff party. However, it is unclear to what extent moral compensation, which is kept low, can relieve the pain, grief or anguish felt by the injured party. It is necessary to emphasize one more point here. The party that demands high moral compensation may also ask for this amount to enrich itself. It is obvious that this situation will not be compatible with good intentions. Therefore, it is important according to what the standard will be determined according to. Here, the judiciary considers the amount of moral compensation aimed at not enriching a person as a measure of justice. However, the presentation of scientific findings that can analyse the psychological state of the injured party will be able to ensure that law and fairness are achieved in the amount of moral compensation awarded.

When all these judicial decisions are examined, it is clear that the air transportation sector may be affected if externalities are reflected in market prices. To examine this effect, it is necessary to determine what external effects unfair competition may have on the benefits of air transport.

The air transport company, whose costs will increase when externalities are reflected in market prices, may have difficulty in capturing its level before unfair competition in revealing the economic growth benefit. Such a negative situation will cause a negative supply shock in terms of agricultural, industrial, and service sectors.

Consumers want to minimize the time between the point of departure and the point of arrival. Today, increasing competition is also reducing air transportation costs. However, it is clear that air transportation will be less preferred by consumers, as increased competition will turn into unfair competition and the lack of compensation at the desired level will create the possibility of increasing the market price of externalities. This situation also negatively affects the entertainment and tourism sectors.

Increasing the volume of trade on a global scale is important for increasing the world's gross national product. For this to happen, the units that will carry out commercial activities must be able to travel easily to remote places with short time intervals. It is quite difficult for a sector whose material and moral damages cannot be compensated due to unfair competition to provide this convenience. This is because externalities are reflected in market prices, creating the possibility of increasing costs.

In this context, air transportation will have to deprive the market of the economic growth benefit, time benefit and place benefit due to unfair competition, which can be considered as a special type of externality, and therefore its costs will increase. Undoubtedly, this will mean moving away from activity in the air transport market.

It is possible that some scientific studies may be carried out for the future in order to further develop this study. These studies can be summarized as follows:

- The air transportation sector will take a position that is gaining more and more importance day by day. However, as the sector grows, legal disputes will also increase. As a result of these disputes, precedent decisions will arise. Legal evaluation of these decisions can be made.
- It is possible that some methods in the field of psychology may be applied to reduce the differences between moral compensation and demanded compensation. A study to be conducted in this direction may have affirmative results in terms of the efficiency of the sector.

- A teleological interpretation can be made regarding judicial decisions made concerning air transportation. Thus, it is possible to create secondary resources that will guide judicial decisions.
- The creation of separate legislation aimed at the phenomenon of unfair competition, which may arise as an externality in air transportation, may create positive results in terms of guiding policy makers.
- International civil aviation authorities can be helped by drawing attention to the negative externalities that unfair competition in the field of air transportation can create in the international area.
- Another element that may reveal unfair competition is cooperation in the field of aviation. Which of these collaborations will be effective or not can be considered within the scope of the phenomenon of externality.
- If unfair competition is considered as a phenomenon of externality, it is also possible to levy a tax in order to eliminate this situation from the point of view of the public economics. A scientific study to be conducted within this framework can help the states.
- Not every element that may arise is included in the scope of unfair competition. For example, it would be a wrong approach to suggest that companies that gain an advantage by employing qualified pilots cause unfair competition. For this reason, a scientific study that will determine the limits of unfair competition in air transportation can help policy makers.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Comparison of Artificial Intelligence Techniques for The UK Air Passenger Short-Term Demand Forecasting: A Destination Insight Study

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Abstract

Web search queries become essential drivers to forecast air passenger demand for operational benefits. Scholars and marketing experts. Forecasting passenger demand is one of the most important marketing problems that experts frequently encounter, but there are very few studies in the literature using search queries. The main novelty of this study is to show that Destination Insight (DI) can be useful as an air passenger demand proxy in the UK. To prove this primary objective, this work uses several machine and deep learning multi-layer perceptron (MLP) methods based on a big-data framework. The findings indicate that DI is a crucial predictor of the UK air passenger demand. Besides, popular error metrics (RMSE, MAPE, MAD and AIC) were compared to find the best model in this study. Specifically, results indicate that MLP following feed forward neural networks works better for the UK air passenger market.

1. Introduction

Airlines play a vital role in the international trade of manufactured goods, as an important part of global supply chains, especially in cross-border trade. Although trade flows have been interrupted by the Russia-Ukraine conflict, as well as the COVID lockdowns in China, goods trade volumes of the World will increase by 3% compared to its previous levels. Notably, the value of international trade by air will be forecasted to increase from $7.5 trillion to $8.2 trillion in 2022 compared to 2021, and tourists traveling by air will spend $672 billion in 2022. According to this global outlook, air transport contributes to global economic growth by connecting countries and rises depending on the flow of people, capital, technology, and ideas (IATA, 2022). Thus, understanding market demand for air transport is an essential task to make strategic and operational decisions and this attempt leads researchers and marketing experts to examine the triggers of air demand in detail from a theoretical and practical point of view (Zhang et al., 2021). However, air transportation faces numerous uncontrollable factors, such as economic development, policy adjustments, seasonal cycles, and outbreaks that affect demand of air passengers. This complexity pushes air transport industry into forecasting passenger demand to develop strategic plans, such as capital construction, opening new routes, and network management in the long term, and daily operational plans, such as reducing costs, adjusting ticket prices, scheduling, and personal training (Jin et al., 2020; Tsui et al., 2014). Long-term forecasts are generally made for these plans. On the other hand, many airports make short-term plans to reflect short-term fluctuations in air passenger demand and to create reliable short-term forecasting models (Kim, 2016). Thus, airport operations need short-term demand forecasting for urgent issues such as airport scheduling and monthly operating and maintenance plans (Xie et al., 2014). To address these issues, this study attempts to forecast air passenger demand in the UK airline market.

Prior research on air passenger demand indicates that traditional econometric models, time series, and artificial intelligence (AI) are commonly used in the field (Dantas et al., 2017). Econometric models include relationship between air passenger demand as dependent variable and different variables as independent indicators that can be related to the number of air passengers (Jin et al., 2020). The most common indicators in economic studies for air transportation are Gross Domestic Product (GDP), GDP per capita, population, and income per capita (Carmona-Benítez et al., 2017). In econometric studies, researchers widely use regression analysis (Rolim et al., 2016), causality analysis (Zhang and Graham, 2020), gravity (Das et al., 2022), and logit models (Hsiao and Hansen, 2011). The most widely used time series models in airline sector are Autoregressive Integrated Moving Average (ARIMA) techniques (Kanavos et al., 2021), and Holt

Winters (HW) (Dantas et al., 2017). Lastly, the broader applications of AI methods are Artificial Neural Network (ANN) (Srisaeng et al., 2015), Support Vector Machine (SVM) regression (Ke-Wu, 2009), Decision Trees (DT) (Laik et al., 2014), deep neural networks (Liu and Chen, 2017), and hybrid methods (Jin et al., 2020; Wu et al., 2021). Notably, time series and AI techniques have high potential for forecasting data successfully in air transportation industry (Kanavos et al., 2021).

Passenger demand can be related some important drivers, such as Socio-economic factors (GDP, employment levels, educational level, tourism, ethnicity etc.), service-related variables (frequency, distance, price etc.) (Boonekamp et al., 2018; Wang and Gao, 2021), city and airport structure/facilities (Das et al., 2022), and behavioral drivers (human behavior, interest, reactions etc.) (Mumayiz and Pulling, 1992; Kim and Shin, 2016). Although many drivers that will impact air passenger demand are the subject of scientific works, determining the most effective ones emerges as a challenging question (Das et al., 2022).

In today's technological environment, online consumer behavior stands out as an effective variable and can be a precious predictor for forecasting techniques. Online air passenger data have also been used to develop more accurate forecasting models (Kim and Shin, 2016). Notably, access to the digital content has changed the way of purchasing products or services (Peterson and Merino, 2003). In this respect, search engines are one of essential online tools that may fulfill the need for information of consumers (Lai et al., 2017). Google also provides consumers' search data with a useful tool, namely Google Trends (GT) available for researchers and marketing experts (Dreher et al., 2018). GT gives search volumes for a specific term and region from 2004. It ranges the search frequencies on a scale of 0-100. The tool also allows users to filter search terms according to various criteria (Google, 2022).

In previous studies, GT data comes out as a driver of demand and is used for forecasting passenger arrivals in case of tourism industry employing autoregressive (Park et al., 2017) and artificial intelligence (AI) techniques (Sun et al., 2019).

In the aviation industry, forecasting demand and improving model accuracy is helpful for air transport planners to determine and escape from economic fluctuations and unnecessary infrastructure costs (Suh and Ryerson, 2019). Another problem in the aviation industry is adjusting capacity of airports, especially in Europe, that needs serious investment (Sismanidou and Tarradellas, 2017). Although the importance of web search data for demand forecasting in response to such concerns is obvious, the number of studies in the field is quite limited. In this sense, Kim and Shin (2016) have proposed an optimal forecasting model for short-term airline demand using weekly internet search data. Long et al. (2021) forecasted air passenger arrivals in Changi International Airport with 1317 Google Trends search queries using Granger Causality and deep neural networks (1D-Convolutional, Long Short-Term Memories (LSTM), and Dense layers). Liang et al. (2022) proposed a forecasting model that integrates LSTM as a deep learning algorithm to predict air passenger demand in China's airports with Internet search data. In another study, Koçak (2023) forecasted air passenger demand for New Zealand airports with DI data employing and comparing some deep learning techniques.

In most of these studies, although Google Trends is a helpful tool for forecasting demand data, researchers might face a significant problem of how to choose the right search query (Önder and Gunter, 2016). Google's new tool, DI with Google, can eliminate this problem by presenting data on consumer travel searches without a search query. This new tool can also be used for forecasting demand (Rashad, 2022).

Lastly, prior works have particularly used web search data to increase forecasting accuracy of passenger demand employing econometric models and AI techniques. However, no study, to the best knowledge of the author, forecasted the UK air passenger demand with DI so far. To fill this gap, this case study employs different artificial intelligence techniques to forecast daily air passenger arrivals in the UK air market with Google's new tool as a predictor. Also, this study uses a big-data framework which involves 4 basic steps: data extraction from DI with Google and daily air passenger arrivals in the UK, relationship exploration with Granger causality test, forecasting data with machine and MLP techniques, and model evaluation with common root mean square error (RMSE), mean absolute percentage error (MAPE), mean absolute deviation (MAD), Akaike Information Criteria (AIC) metrics.

To improve forecasting on the country level, DI is introduced as a powerful determinant into traditional machine learning (ML) techniques, such as DT, ANN, Sequential Minimal Optimization Regressor (SMOReg), and Random Forest (RF) for regression problem in air passenger demand forecasting. In deep learning techniques, the open source deeplearning4j (DL4J) library[1] that follows the model of multi-layer feedforward neural networks is employed. This study also implements three popular performance criteria: RMSE, MAPE, MAD, and AIC metrics of the testing samples using artificial intelligence techniques mentioned above to evaluate their applicability for forecasting air passenger demand in the UK market. The current work contributes to prior research on demand forecasting in the following way: This is the first study, to the best knowledge of the author, to explore whether DI with Google can improve air passenger demand forecasting.

Within the scope of this study, research framework with detailed steps is presented in section 2. Next, methodology with data representation, comparison of AI techniques, and the findings of the applied models are given. The theoretical and practical contributions built on the findings of this study are then mentioned. Lastly, suggestions will be made for future studies.

2. Methodology

In this part of the study, passenger demand for airports in the UK is forecasted using Google searches of consumers in any geographical location on Earth related to air transportation to the UK. To fulfill the forecasting task in the current research, the causal relationship between the data sets should be determined. Thus, the stationarity of the data sets was firstly examined by employing Augmented Dickey-Fuller (ADF) test, then the co-integration between variables was tested and, lastly, the Granger Causality analysis (Granger, 1969) was performed. Next, machine and MLP techniques were employed for forecasting.

This study uses consumer search data with Google to forecast air passenger demand in terms of the UK airline market. Accordingly, the research framework of the proposed methodology is illustrated in Figure 1.

[1] https://deeplearning4j.konduit.ai

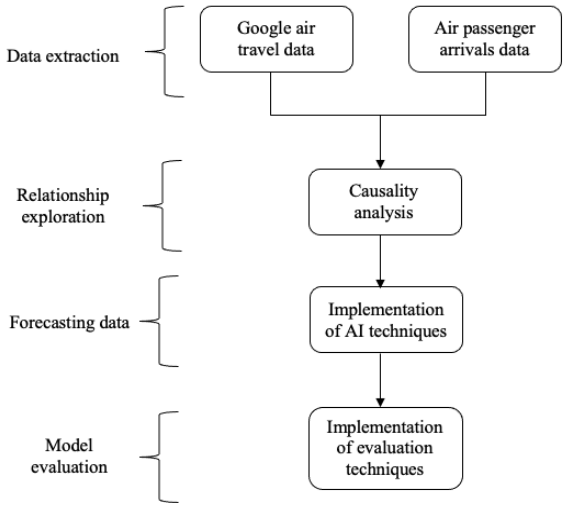

Figure 1. Research framework

The framework of the study starts from deriving Google search and air passenger data, investigating relationship between variables, forecasting air passenger data with some artificial intelligence techniques, and lastly, comparing proposed models to improve forecasting (Yu et al., 2019).

Phase 1: Data extraction

In this step, two main time series data sets are obtained from Google and air passenger arrivals. To reach consumer search data, Google provides a successful tool, namely, DI (https://destinationinsights.withgoogle.com) that monitors all consumer searches related to air travel in specific time and country indexing from 0-100.

Phase 2: Relationship exploration

To determine whether Google search data is effective trigger for the actual number of air passenger data, the co-integration and Granger causality tests are employed in this step.

Phase 3: Forecasting data

In this step, artificial intelligence algorithms can be used to forecast air passenger time series data with Google search results. The current study employs some popular techniques in ML and deep learning area to forecast air passenger demand. DT, ANN, SMOReg and RF in ML, and MLP in deep learning are conducted for this study.

DT (Quinlan, 2014) is one of the common algorithms that forecasts the value of a target class using input variables in classification problems (Treeratanaporn et al., 2021). It separates values to optimally reduce error in selected recursive classification criteria for regression. The data process starts from root node that builds new nodes and progresses until the previously specified stopping criteria is reached. The desired forecasting can be performed on the class attribute (Massaro et al., 2018). DT allows for ease of data interpretation and analysis and can also be used for numeric prediction (Nwulu, 2017).

ANNs are one of popular AI techniques that can frequently be used in solving nonlinear forecasting problems for various industries. Moreover, in this method, which produces more general and flexible functional results compared to traditional methods, the system consists of neural networks like the biological nerve structure. There are predictors in the input layer of ANNs and dependent variables to be predicted in the output layer (Zhang et al., 1998).

The following functional relationship of ANNs can be represented as:

$$y = f(x_1, x_2, x_3, \dots x_p),$$

where x_1, x_2, x_3, …, x_p are independents that are added into the input layer, y donates a dependent variable.

The following equation can be calculated for time dependent forecasting tasks:

$$y_{t+1} = f(y_t, y_{t-1}, \dots, y_{t-p}),$$

where yt donates t time observation (Zhang et al., 1998).

SMOReg is an iterative algorithm proposed by Smola and Scholkopf (1998) for solving the regression problems using Support Vector Machines. As an extension of the SMO algorithm proposed by Platt (1999), SMOReg replaces the missing values and normalizes all attributes by default. In this respect, SMOReg is a fast and easy to implement technique (Shevade et al., 2000) for forecasting studies (Hu et al., 2018).

RF proposed by Breiman (2001) is a classifier that generates many trees and chooses the most popular class. During the process, each tree is generated from a sample of data and at each split; then a random sample of predictors is examined. Lastly, forecasting is performed among the trees with the most votes. While doing this, the algorithm tries to ensure that the trees grow to maximum depth as possible by keeping the individual errors low. Thus, it is a widely used techniques in solving regression problems (Kumar and Thenmozhi, 2006).

MLP is feed-forward artificial neural network involving several neurons connected by linking weights. It maps a set of inputs into desired outputs. The process is initiated by the transfer of input data to neurons located in hidden layers. The connection between neurons is realized by weight and bias calculations, and the results are forwardly transmitted to the output layer with and activation function (Widiasari and Nugroho, 2017). Recently, many studies focus on forecasting tasks using MLP (Candel and LeDell, 2020; Tung and Yaseen, 2021). In this study, an open-source deep learning framework (DL4J) is used to train the proposed model. DL4J is a commercial grade library written in JAVA and provides GPU support for distributed framework that was developed by Adam Gibson (Parvat et al., 2017). As an optimization method in DL4J package, Adam (Kingma and Ba, 2014) is used for this study. This technique is very easy to implement and useful (Lu et al., 2021) in solving forecasting problems involving large data sets (Kingma and Ba, 2014). In this respect, the architecture of the current study is represented in Figure 2.

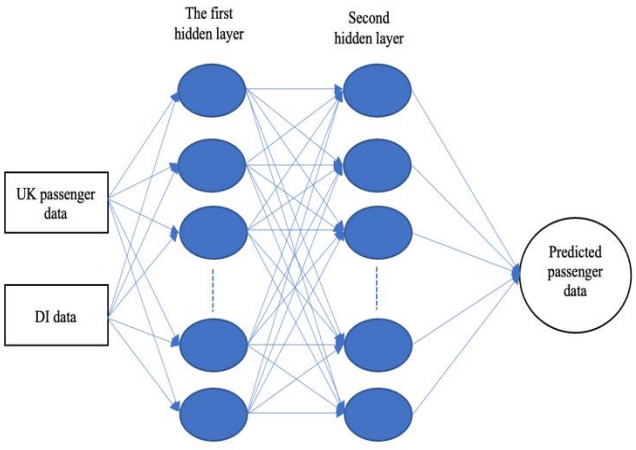

Figure 2. The MLP architecture of the study

Phase 4: Model evaluation

To evaluate the forecasting performance in this step, three popular criteria were used for determining the forecasting errors: RMSE, MAPE, and MAD. RMSE is used to measure the deviation between the actual and predicted values (Xie et al., 2014). In the case of forecast errors with significant seasonality and demand relatedness between one period and another, MAPE is an excellent means of measuring forecast error in a very accurate and straightforward way. Also, if the assumed random component is normally distributed, the MAD is used to estimate the standard deviation. As long as the cost of forecast error is proportional to the number of errors, MAD is an effective method for measuring errors (Putra and Kusumastuti, 2019). The smaller the values revealed by these three determinants the better the prediction of the model is considered (Xie et al., 2014). The following equations shows the calculations for these metrics, respectively:

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n}(\hat{x}_t - x_t)^2}{S}},$$

$$MAPE = \frac{\sum_{t=1}^{n}\left|\frac{x_t - \hat{x}_t}{x_t}\right|}{S} \times 100,$$

$$MAD = \frac{\sum_{t=1}^{n}|\hat{x}_t - x_t|}{S},$$

where S donates the size of observations in the test set, x_t is the number of airline passenger demand, and $\hat{x}_t$ represents the forecasted passenger demand data in the UK.

2.1. Data

This study uses daily data of Google and air passenger arrivals in the UK from January 1, 2020, to April 30, 2022. The UK was chosen for the analysis because it has the largest aviation network in Europe (CTP, 2022).

To determine consumer demand for air travel to the UK, DI with Google is used. This platform was launched in 2021 to reflect users' interest for a particular location based on searches on Google with specific queries. Google indexes these searches as travellers' demand for destinations over time. The index ranges from 0 to 100 and the data can be reached via the following website (Rashad, 2022) (https://destinationinsights.withgoogle.com//, accessed on September 14, 22).

In DI, "Worldwide" was selected for origin country and United Kingdom was chosen for destination country. International air travel demand was selected for trip type and demand category, respectively. Lastly, data range was chosen for the analysis as shown in Figure 3.

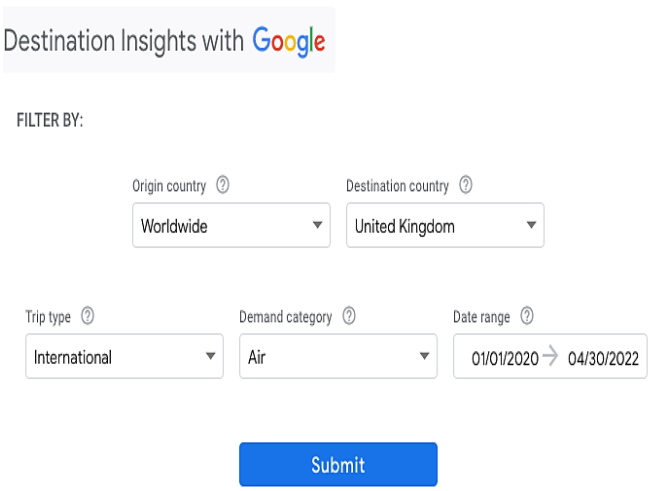

Figure 3. Data selection for air travel demand Google

These indexed data obtained from the search engine consists of online users' queries regarding flights from any destination in the world to the UK. Google lists all these destinations in a single parameter, "worldwide", and uses search volume as a proxy for travel demand. As known, online search query given that huge quantities of data associated with human behaviour, interest, and reactions are generated in real time and may sensitively represent short-term fluctuations (Kim, 2016).

In the current study, to forecast the UK air market demand, the number of daily passenger arrivals between 2020-2022 were derived from the official statistics page of the UK government database (UK, 2022) including Advance Passenger Information (API), and Border and Immigration Transaction Data (BITD). *"These data primarily relate to passengers coming to the UK via commercial aviation routes."*

Figure 4 summarizes comparison of daily air passenger arrivals in the UK and insight data with Google for a given search, respectively.

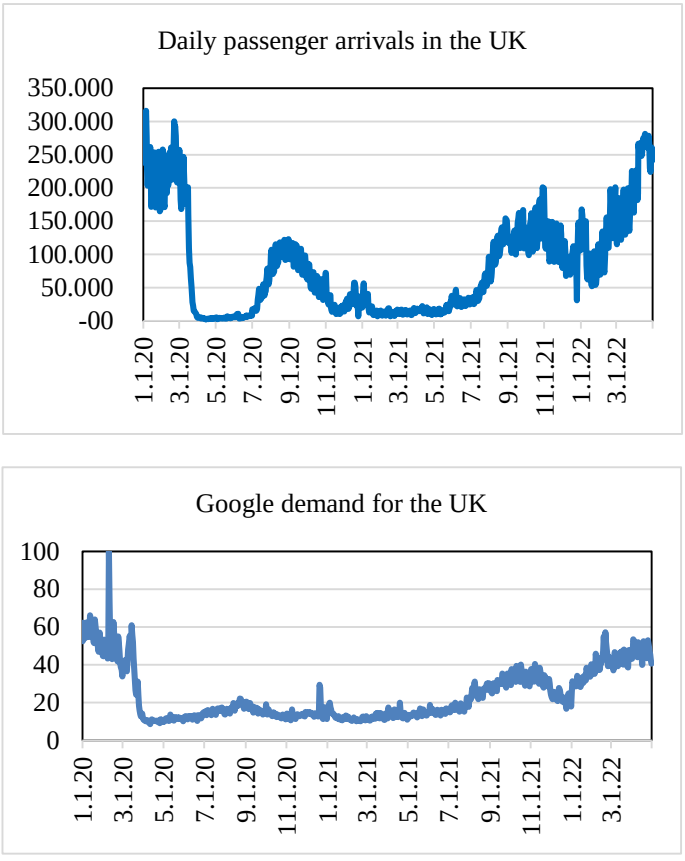

Figure 4. Daily data of passengers and Google for the UK

Looking at graphs, consumers Google searches about air travel (from the World to the UK) and the daily number of passenger arrivals at the UK airports decline dramatically at the COVID-19 pandemic period. One possible explanation for this issue is that the need and seek for information about flights may be affected by macro environmental environment. Also, it can be concluded that consumers' web search behavior has changed depending on this situation over time, which has also been mentioned in previous studies (e.g., Koçak, 2020). In this respect, the time series data for passenger arrivals in the UK and Google demand are approximately related. This indicates that online demand for air travel can reflect real passenger arrivals in the UK and implies that one can forecast air passenger demand with Google data. To test this relationship, first task is to determine the relationship between flight-related searches in the DI data and the real number of air passenger arrivals in the UK. Thus, the current study runs Granger causality analysis in the next section.

3. Result and Discussion

3.1. Cointegration and Granger Causality Tests

In the first stage of the proposed model, stationary, co-integration, Granger causality analysis are conducted to test relationship between Google and passenger arrival data. EViews12 package program are used to perform the analysis at this stage of the study. For stationary, ADF unit root tests were implemented (Dickey and Fuller, 1979). The last situation of the model parameters was determined to minimize Akaike Information Criteria (AIC) (Akaike, 1973).

According to the test results reported in Table 1, air passenger arrivals in the UK and Google air travel demand are stationary at the first-order difference, at the 1% significance level, indicates that the appropriate condition has emerged to perform the co-integration test and Granger causality analysis (see Table 1).

Table 1. Stationary test results

Datasets	Estimator	Original level		First Level	
		t-value	p-value***	t-value**	p-value***
Daily passengers (arrival) in UK	SIC*	-1.936	0.316	-6.624	0.0000
Google air demand for UK	SIC	-2.394	0.144	-8.403	0.0000

*Lag length is determined according to Schwarz info criterion, ** Null hypothesis was rejected at the 0.01 level, *** MacKinnon (1996) one-sided p-values

Second, the co-integration test is performed using Engle and Granger (1987) method to determine the long-run relationship between time series. The time series were derived from the regression analysis that use least squared method and were tested for the cointegration at the first-order difference. Table 2 shows that there is a co-integration relationship between daily passenger arrivals in the UK and Google air travel demand, at the 1% significance level.

Table2. Co-integration between datasets

Co-integration	Original level	
	ADF t-value*	p-value**
Daily passengers (arrival) in UK vs Google air demand	-6.709	0.0000

* Null hypothesis was rejected at the 0.01 level, ** MacKinnon (1996) one-sided p-values

Based on the results of this report, the Granger causality analysis can be performed to determine whether the Google data can lead to forecast the number of daily passenger arrivals in the UK in the next step.

In the third stage of the analysis, the strength, and the direction of long-term relationship between variables was determined using Granger Causality test. Accordingly, the causality of the time series was carried out by taking 14 lag-length criteria. Eq. 1 represents the proposed vector autoregressive (VAR) model for the research:

$$(passengers)_t = \sum_{i=1}^{n} a_i\,(search)_{t-i} + \sum_{j=1}^{n} b_j\,(passengers)_{t-j} + u_{1t},$$

$$(searchquery)_t = \sum_{i=1}^{n} c_i\,(passengers)_{t-i} + \sum_{j=1}^{n} d_j\,(search)_{t-j} + u_{2t}, \quad (1)$$

where a, b, c, and d are the parameters, n is the lag-length, t is the time, u_{1t} and u_{2t} are the regression residuals.

As reported in Table 3, there is a Granger causality between Google searches and the UK daily passenger demand at the 14 lag-length criteria, at the 1% significance level. This shows that DI can help to forecast air passenger arrivals in the UK.

Relationship investigation between the variables reaches one important conclusion: significant co-integration and Granger causality test results show that consumers' air travel demand on Google can help forecasting actual number of air passenger in case of the UK airline market.

Table 3. Granger Causality between DI and actual air passenger demand data.

Hypothesis	Prob	Result
H_0: Google demand for air travel in UK does not cause daily passenger arrival in UK	0.0000	Rejected

In the airline market, there are few studies providing possible explanation of why Google search indices are essential predictors of demand. For example, potential consumers can use search engines to obtain information about ticketing and reservation without the need for online agencies (Little et al., 2011). Also, prior forecasting research suggest that consumer Google searches may be related to the demand and help forecasting passenger demand (Kim and Shin, 2016; Shin et al., 2017; Park et al., 2017; Long et al., 2021).

3.2. Evaluation of Forecasting Accuracy

In this section, some useful machine learning (DT, ANN, SMOReg, and RF) and deep learning algorithms were applied via RapidMiner 9.6 package program (Mierswa et al., 2006) to forecast the UK airline market demand with Google search data. The data were divided into training and testing subsets: 80% for training and 20% for testing.

During the training and testing stages, the model parameters of ML algorithms were selected as default settings in RapidMiner for efficient operation and ease of use (Chou and Tran, 2018). These parameters and corresponding values are presented in Table 4.

Despite the default settings in the ML algorithms, some parameter specifications have been used in MLP method for consistency. The model is set as 2 hidden layers and each layers has 50 neurons. Learning cycle (Epoch) was implemented as 150, mean squared error was set for loss function, Stochastic Gradient Descent was implemented for optimization method, standard backpropagation was used, and Xavier (Glorot and Bengio, 2010) was selected for weight initialization in the model. Lastly, Adam optimizer is implemented for the forecasting model.

In MLP, Google air travel demand reflecting consumer online search data and number of air passenger arrivals in the UK were selected as input neurons. The forecasted number of air passengers constituted the output layer. During the experiment, the learning rate was gradually reduced from 0.01 to 0.001 and this parameter was set to 0.004 for the best learning outcome.

Table 4. The model parameters in RapidMiner

Algorithm	Parameters	Value
DT	Criterion	Least Square
	Maximal depth	10
	Minimal gain	0.01
	Minimal leaf size	2
	Minimal size for split	4
	Number of prepruning alternatives	3
ANN	Hidden layers	2
	Training cycles	200
	Learning rate	0.01
	Momentum	0.9
SMOReg*	The complexity constant (C)	1.0
	Normalization (N)	0.0
	Improve (I)	-L 0.001 -W 1 -P 1.0E-12 -T 0.001 -V
	Kernel (K)	-C 250007 -E 1.0
RF	Number of trees	100
	Criterion	Least square
	Maximal depth	10

* This algorithm is taken from Weka (Frank et al., 2016) libraries

Lastly, forecasting performance of the UK passenger data with DI data is evaluated using four ML and one deep learning methods and compared by RMSE, MAPE, and MAD. Accordingly, Table 5 shows the findings of the comparisons of artificial intelligence models with independent variables of time series and "time series + DI" in sample and out of sample forecasting. The experimental study shows that DI can be an effective predictor for daily air passenger arrivals in the UK when implementing SMOReg and MLP techniques in both sample and out of sample forecasting. RMSE, MAD, and AIC values of these models for "time series + DI" are smaller than the benchmarking models for "time series".

As seen in Table 5, the results for the UK air market demand show that RMSE, MAPE, MAD, and AIC values of the MLP model are much smaller than those of DT, ANN, SMOReg, and RF models. Looking at ML results, SMOReg performs lowest forecasting errors in case of three evaluation methods. According to Yang et al. (2007), SMO has better generalization ability for time series modelling since it avoids quadratic programming numerical calculations.

Table 5. Comparisons of the forecasting models

Method		In sample				Out of sample			
	Algorithm	RMSE	MAPE	MAD	AIC	RMSE	MAPE	MAD	AIC
Time series	DT	665	0.515	236	8859	1846	0.699	1100	2563
	ANN	1516	5.375	1081	9981	1844	1.195	1572	2563
	SMOReg	483	3.505	451	8422	300	0.274	269	1945
	RF	271	0.212	86	7638	1016	0.299	507	2360
	MLP	6.064*	0.008*	4.349*	2461*	9.488*	0.006*	8.762*	771*
Time series + DI	DT	638	0.507	228	8803	1976	0.783	1204	2586
	ANN	1675	4.169	1217	10117	2154	1.734	1850	2616
	SMOReg	354	2.559	331	7999	216	0.197	193	1833
	RF	412	0.252	133	8206	1491	0.485	802	2491
	MLP	4.892*	0.030*	4.283*	2168*	5.808*	0.004*	4.677*	604*

* Indicating the lowest error rate (RMSE, MAPE, and MAD)

SMO does not need to put the whole kernel matrix into memory and to call the matrix iteration. These advantages allow the algorithm to improve its operational speed and predictive power. Also, error metrics of the ANN model are larger than other algorithms. This result supports the findings of Yu et al. (2019). According to them, a possible explanation of this result can be due to the randomness and super-sensitivity to many parameters. Moreover, previous studies also demonstrated that the MLP method could have better capability for forecasting air passenger data in case of MAPE and RMSE (Srisaeng et al., 2015; Srisaeng and Baxter, 2017) compared to other traditional techniques such as ARIMA (Xiao et al., 2014) and SARIMA (Gultekin and Kemaloğlu, 2023). In this respect, these findings not only support the previous studies mentioned, but also can present a good generalization of deep learning method.

Additionally, this study implements a paired t-test using the relative error (RE) metrics (Hadavandi et al., 2012) to test whether a statistically significant difference in forecasting precision exists between deep learning and the baseline models of ML in out of sample forecasting. The equation of RE is shown as follow (Zhang et al., 2020):

$$\left(\frac{y_t-\hat{y}_t}{y_t}\right) \times 100,$$

where y_t and $\hat{y}_t$ are the actual and forecasted values, respectively.

Statistically, this test was conducted to verify the original hypothesis stating that the precision of MLP is equal to the ML models, so the alternative hypothesis is the opposite.

Table 6. Comparison of the forecasting performance of the MLP and baseline ML models in terms of RE

Model	Baseline models	t-stat.	p-value
MLP	DT	-0.219	0.414
	ANN	6.480*	0.000
	SMOReg	-22.930*	0.000
	RF	0.191	0.424

* Null hypothesis was rejected at the 0.01 level, ** MacKinnon (1996) one-sided p-values

In this respect, Table 6 shows the t-test results representing that the original hypothesis was rejected for ANN and SMOreg models at the 1% significance level.

On the other hand, the precision of MLP model is not equal to the DT and RF models which means that the original hypothesis was accepted for this result ($p>0.05$). This suggests that the current work found a significant difference only in forecasting precision between MLP and the baseline models of ANN and SMOreg algorithms. In other words, average prediction error of MLP is significantly lower than ANN and SMOReg models for the case of UK when using DI with air passenger arrivals.

4. Conclusion

In today's world, consumers' search data becomes an essential driver for forecasting demand. Researchers and marketing experts can now use Google Trends to investigate consumer travel demand in online environment. However, deciding what the search query should be utilized is quite a challenging task. In this sense, Google launched a new tool - namely DI-that directly provides time series search data including travel queries.

This study forecasted daily air passenger demand in the UK airline market with DI. For this purpose, firstly, daily air passenger demand and online travel demand data was retrieved in the period of 2020-2022. Second, co-integration and Granger causality tests were implemented to investigate the relationship between online and actual data. Third, several ML and MLP algorithms were conducted to forecast actual air passenger demand with DI and improve forecasting accuracy. In the last step, the forecasting performances of all models were evaluated with some common error metrics. This work has made two significant contributions to airline forecasting studies: it is the first study that implements DI to forecast air passenger demand; and uses novel forecasting models in a big-data framework.

According to the results of Granger causality tests done before the forecasting, DI with Google can statistically be an effective driver of daily air passenger arrivals. Considering the previous studies investigating the relationship between consumer online searches and demand in various industries (e.g., Önder and Gunter, 2016; Sun et al., 2019; Long et al., 2021), the experimental findings of the current research are in line with these studies. Furthermore, travel demand from Worldwide to the UK on Google is related to daily air passenger demand in the UK when looking at the direction of this relationship.

Experiments of this study indicates that MLP technique with Adam optimizer can significantly increase forecasting accuracy compared to ML algorithms (DT, ANN, SMOReg, and RF).

To conclude,

- DI with air passenger data is superior to improve forecasting performance in case of the UK air market.
- SMOReg is better than DT, ANN, and RF methods in ML area.
- Deep learning MLP technique is statistically significant and more appropriate to handle time series than ML techniques in forecasting daily air passenger arrivals.

In details, forecasting is one of the most important problems to be dealt with for the efficient use of resources or choosing more effective pricing strategies for airports in the aviation industry. Also, better forecasting approaches for airport demand provide clues for marketing managers to avoid uncertain economic conditions and undesirable costs (Suh and Ryerson, 2019). Therefore, consumers' Google search queries data stands out as an effective tool to achieve better results.

Another positive aspect of this study is that it helps marketing experts and scholars working in this field to identify trends for passenger demand. Another important implication of the research findings of this study is the ease of detecting trends in airline passenger demand with search engine queries. Thus, meaningful, and sustainable plans can be made not only for the aviation industry, but also for other transportation modes and the tourism connected to this industry. In this study, in which machine and deep learning algorithms are compared for the determination of better forecasting models, airport managers and marketers, especially in Europe, can produce better solutions to the capacity problems also defined by Madas and Zografos (2010).

In summary, with search engines, consumers reach information with more time, cost, and effort, which encourages search behavior before purchasing behavior in the airline industry (Peterson and Merino, 2003). The first limitation of this study is that it only used the Google search engine. Therefore, employing different consumer information search sources will contribute to the future studies. Second, the current study uses consumer demand for airports in the UK in practice. Next studies may use different airports. Third, the relationship between the datasets in this study was determined by Granger Causality Test. In this direction, future studies may apply different relationship investigation methods. Finally, this study only employed some machine learning and deep learning algorithms for forecasting task. The use of other AI methods will be beneficial in future studies.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Macroeconomic Determinants of Financial Failure Risk in Airlines

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Abstract

The objective of this study is to identify the macroeconomic factors that influence the risk of financial failure in the aviation industry. Within the parameters of the study, a sample of 11irline firms operating between 2009 and 2019 was analyzed to determine the factors influencing the likelihood of financial failure. The cost of fuel, interest rates, inflation rates, and currency rates were utilized as macroeconomic variables that could have an impact on airline enterprises' ability to meet ends. Financial data and macroeconomic data of the airline companies in the sample were obtained from Thomson Reuters Eikon Datastream. The methodology of the study consists of 2 stages. In the first stage, Altman Z'' Score method is used. Then, panel data analysis method is preferred to reveal the relationship between financial failure and macroeconomic factors. According to the findings of the random effects panel data study, exchange rates and interest rates have a negative impact on financial failure. The results of the changes in interest and exchange rates suggest that governments and airlines should concentrate on policies that will strengthen the aviation sector's financial viability. To manage these risks more effectively, financial managers must closely examine the effects of rising macroeconomic risk and the corresponding financial failure effects. Airline managers, private and institutional investors should monitor policy uncertainty, assuming that exchange rate uncertainty is a driving force in financial failure. In addition, airline companies should review their hedging strategies against exchange rate risk.

1. Introduction

Complex issues have been brought on by the airline industry's rapid growth and relentless speed of change. Lack of infrastructure, safety, sustainability, social and environmental concerns, privatization and commercialization of airports and air traffic, airline mergers and alliances, market liberalization, and low-cost carriers are a few of these. Due to these demands and difficulties, airline managers have begun to assess and manage airline performance using a variety of performance management methodologies (Francis et al. 2005).

One of the financial performance measures of airlines is to predict financial failure. Airline managers and/or shareholders, investors and lenders pay close attention to financial failure. Especially in times of economic fluctuations and increased financial uncertainty, the analysis of financial failure may be the most important performance analysis for businesses. As all businesses are affected in times of crisis, airline businesses are also adversely affected. There are many factors affecting airline businesses. The 1978 oil crisis, the 1990 Iraqi invasion of Kuwait, the 1997 Asian crisis, the 2001 September 11 terrorist attack, the 2003 SARS outbreak, the 2008 global financial crisis and the 2019 Covid-19 outbreak, as well as social, political, economic, war and terrorist incidents have caused significant crises in the airline industry. As seen in the historical process, airline businesses have suffered great losses by facing economic negativities, especially changes in fuel prices, wars between countries, economic recession, and epidemics. As a result of these crises, airline businesses have faced financial stagnation and bankruptcy problems. In this context, airline managers can perform better by predicting financial failure before facing these problems.

When a company cannot satisfy its payment obligations on time or when cash flow forecasts indicate that the company will soon be unable to do so, these are signs of financial disaster. Financial failure is an early indicator that a company's situation is unhealthy, therefore with such a warning, the company is expected to avoid bankruptcy (Brigham and Daves, 2018). Changes in macroeconomic policies have an impact on important macroeconomic indicators like interest rates, inflation, gross domestic product, exchange rates, and exports, which all have an impact on the firm's overall need for overtime and cash flows. As a result, a sizable amount of the accounting figures and ratios on organizations' balance sheets are dependent on the current or anticipated macroeconomic conditions. Therefore, it is crucial to consider how the macroeconomic environment affects the onset and severity of financial failure (Sehgal, 2021). Therefore, it is necessary to look into and identify the key elements that affect the beginning and severity of financial failure for policymaking and monitoring. The search for instruments that can foresee future conditions has also unquestionably become crucial to assist managers in averting further downturn or eventual bankruptcy by taking the essential actions in advance.

A company's viability is impacted by macroeconomic conditions, and external forces are frequently outside of an

industry's direct control. Business financial failure can be predicted in part by macroeconomic conditions. Changes in interest rates, exchange rates and oil prices, as well as inflation, can also affect businesses due to increased production and service costs or create higher pricing, which can lead to weaker demand. Overall, macroeconomic conditions offer a strong explanatory power to predict financial failure (Loudon, 2007; Tsai, 2008; Sehgal, 2021).

As with all businesses, airline businesses have a fragile structure against economic fluctuations and negativities. Therefore, there are many financial risk factors affecting airline businesses. The most common financial risks in the literature are fuel price, exchange rate, interest rate, inflation rate and liquidity risks (Morrell, 2007; Vasigh, 2015; Bood and Ison, 2017; Fernando, 2006; Loudon, 2007; Tsai, 2008). Accordingly, fuel price, exchange rate, inflation rate and interest rate variables are preferred in this study. Extensive explanations about these factors are mentioned in the conceptual framework and literature section of the study.

The subject of this study is the reciprocal financial relationships between airline financial failure and macroeconomic factors. In this context, the main objective of the study is to identify the macroeconomic factors affecting the financial failure of traditional airline companies around the world. Many studies have been conducted in different sectors examining the relationship between financial failure and macroeconomic factors and significant results have been reached. There is a study on the airline sector (Güngör, 2019), and only the relationship between inflation rate and financial failure among macroeconomic factors along with internal factors was examined. In this study, only macroeconomic factors were analysed. In this respect, it is thought to make great contributions to the literature. There are many methods measuring financial failure in the literature (Altman (1968, 1983, 2000), Springate (1978), Beaver (1966), Tamari (1966) and Meyer and Pifer (1970)). Another contribution of this study to the literature is that Altman Z" (1983) score test and panel data analysis methods are analysed together. In addition, another point that distinguishes the study from similar studies is the use of these 3 factors together, thus it is aimed to obtain more reliable results.

The study responds to four primary research queries: I How do exchange rate fluctuations affect the financial failure of traditional airlines? What effect do fluctuations in oil prices have on the financial failure of conventional airlines? What effect do changes in interest rates have on the financial failure of conventional airlines? (iv) How do changes in the inflation rate affect the financial failure of conventional airlines? According to the study's hypothesis, financial failure is significantly and negatively impacted by macroeconomic factors, including the exchange rate, oil price, interest rate, and inflation rate.

The goal of the study is to determine whether stock prices are impacted by macroeconomic data. In this context, a conceptual framework is used to describe the relationship between macroeconomic conditions and stock prices before the analysis begins, and the relevant literature is also mentioned. The analysis methodology is then described. Findings are acquired and interpretations are presented regarding the findings in the study's final section.

Using information from conventional airlines, this study makes an effort to explore and pinpoint certain important macroeconomic factors that affect the likelihood of financial failure. In this context, the theoretical underpinnings of how macroeconomic conditions affect airline enterprises' ability to make money are described, and the relevant literature is presented. Then, Altman's Z is employed to gauge how financially unsuccessful conventional airlines are. Score analysis was used to identify financial failure, and Panel data analysis was used to examine the macroeconomic factors influencing financial failure. The study's results regarding the discoveries made as a result of the analysis are offered in the final section.

2. Conceptual Framework and Literature

The study aims to examine the relationship between macroeconomic factors and financial failure. In the literature, Altman Z score models (1968, 1983, 2000), Beaver model (1966), Springate model (1978), Tamari model (1966) and Meyer and Pifer model (1970) are among the frequently used methods that measure financial failure. In the study, Altman Z" score, one of the financial failure models that can also be applied for airline companies, was used. Information about the Altman Z" (1983) score model is explained in the method section.

Fuel price, exchange rate, interest rate and inflation rate variables are used as macroeconomic factors in the study. In this section, firstly, the importance of the macroeconomic factors used in the study in terms of airline companies and their relationship with financial failure are presented conceptually. Then, the studies in the literature are mentioned.

Jet fuel prices are volatile (fluctuating). A sudden increase in fuel prices increases the costs of airline businesses. If costs exceed revenues too much, it may cause the bankruptcy of many airline businesses. For example, during the economic downturn in 2008, fuel prices were extremely volatile. As a result, a number of airlines had to cease operations (Jackson, 2017). Changes in fuel prices can affect the short-term cash flows of airlines. Carter et al. (2002) found that cash flows and stock returns of airlines are negatively related to fuel price changes. Unsystematic risks in the airline industry can cause many damages to businesses. The biggest unsystematic financial risk factor is the price of oil. Increases in jet fuel prices (which increase in parallel with the Brent oil price) negatively affect stock prices by reducing the profitability of airlines (Vasigh et al., 2015; Morrell and Swan, 2006).

International airlines frequently generate revenue in different currencies to cover operating expenses like fuel and labor. They are so susceptible to changes in exchange rates (Pyke and Sibdari, 2018). The time and quantity of foreign exchange revenue and expense are not always same. As a result, airline managers analyze the exchange rate risk and adhere to a balanced approach. It is the responsibility of airline managers to manage revenues, expenses, assets, and obligations in both local and foreign currencies to reduce their exposure to significant currency swings. Currency fluctuations frequently cause airlines to report lower profitability (Morrell, 2007). As a result of a major percentage of their debt (90 percent) being in US dollars, AirAsia Airlines' share price fell in August 2017. At a rate of 3.23 Malaysian ringgit per dollar, the airline hedged two-thirds of its dollar debt. Despite this, unhedged debt caused the stock price to decline (Pyke and Sibdari, 2018).

Due to the widespread use of loans, operational leases, and financing leases to finance the purchase of aircraft, interest rate risk is a significant consideration in the airline industry. Given how heavily they rely on debt financing, airlines need to pay special attention to this. Because of the capital requirements and relatively high cost of equity, the airline industry frequently has significant leverage ratios. High earnings volatility can make it more challenging to attract equity capital, as evidenced by the aviation industry's often lower-than-average price-to-earnings ratios (Loudon, 2004; Tsai,

2008). Although interest rates are not as volatile as fuel prices or exchange rates, the amount of debt accrued by global airlines is seriously exposed to adverse changes in interest rates. Since the floating rate debt agreements issued by airlines are linked to the London Interbank Offered Rate (LIBOR), airlines will have to make higher interest payments if market interest rates rise. For example, at the end of 2012, American Airlines had outstanding debt of around 7 billion dollars (Vasigh et al., 2014). A 1% increase in the LIBOR interest rate would increase American Airlines' interest expenses by $70 million. The increase in interest expenses reduces profitability and leads to financial failure.

There are many studies on the relationship between macroeconomic factors and financial failure in different countries and sectors and models have been tested for the existence of a relationship. The related literature is summarized in the table 1 below.

Table 1. Studies on the relationship between macroeconomic factors and financial failure

Study	Period/Country/Sector	Model	Findings
Sehgal vd. (2021)	India - Corporate Sector (1991-2017)	ARDL, FMOLS	It is concluded that the **inflation** variable affects financial failure. No relationship was found for the **interest rate.**
Siregar and Siswanti (2022)	Indonesia - Real Estate and Real Estate Sectors (2010-2019)	Altman Z Score, Panel Data Analysis	The **exchange rate** variable has a negative effect on financial failure. **Interest and inflation** rates have no effect.
Mabkhot et. al. (2022)	Malaysia - Banks (2005-2020)	FGLS, PFMOLS, PDOLS	It is concluded that **inflation rate and oil price** variables have a negative impact on financial stability.
Nikodemus, and Oktasari (2021)	Indonesia - Real Estate Sectors (2010-2019)	Logistic Regression	It is concluded that **interest rate and inflation rate** do not affect financial failure.
Liou and Smith (2007)	UK-Manufacturing Industry (1981-2001)	Taffler (1983) Z Score Model	It is concluded that the **interest rate** is not related to financial failure.
Harjayanti et. al. (2022)	Indonesia-Trade, Services and Investment Sectors (2017-2020)	Altman Z Score Model, Panel Data Analysis	It is concluded that the increase in **the interest rate** is associated with financial failure.
Arilyn (2020)	Indonesia-Agriculture Sector (2013-2018)	Regression Model	It is concluded that macroeconomic variables do not affect financial failure.
Muien, Nordin and Badru (2022)	Pakistan-Non-financial businesses (2013-2017)	Logistic Regression	It is concluded that the **inflation** variable has a negative effect on financial distress.
Ceylan (2021)	Turkey-Small and medium-sized enterprises (2010-2019)	Springate S Score, Panel Data Analysis	Exchange rate and **inflation rate** variables are not found to be related to financial failure.
Gutu vd. (2015)	Romania -Industrial Sector (2008-2013)	Regression Model	It is concluded that **exchange rate, interest rate and inflation rate** are related to financial failure.
Nouri and Soltani (2015)	Cyprus (2007-2012)	Logistic regression	It is concluded **that inflation rate and interest rate** variables are not related to financial failure.
Liu (2013)	England (1966-1999)	ECM	There is a relationship between **interest rate** and financial failure.
McNamara vd. (2011)	Australia – (1985-2000)	Varimax principal component analysis	It is concluded that the **interest rate** variable has the power to explain financial failure.
Zikovic (2016)	Croatia – (2000-2011)	VECM	It is concluded that the long-term **interest rate** has a short-term effect on the bankruptcy rate.
Acosta-Gonzalez vd. (2019)	Spain -Construction Sector (1995-2011)	GASIC Method	It is concluded that there is a significant relationship between **the interest rate** variable and financial failure.
Güngör (2019)	30 Airlines (2010-2016)	Panel regression, linear regression and discriminant analysis	It is concluded that there is no significant relationship between inflation rate and financial failure.

A general overview of Table 1 reveals that many studies have been conducted on the relationship between macroeconomic factors and financial failure. In most of the studies, inflation and exchange rate variables, especially interest rates, have been used. The studies have been conducted in different countries around the world and analyzed using regression and similar methods as methodology. Although most of the studies found significant relationships between macroeconomic factors and financial failure, a few studies (Liou and Smith, 2007; Arilyn, 2020; Ceylan, 2021; Nouri and Soltani, 2015) found insignificant relationships.

There is a study on the airline sector (Güngör, 2019), and only the relationship between inflation rate and financial failure among macroeconomic factors together with internal factors was examined. Nevertheless, a few studies have been conducted on financial distress in the airline industry.

In their study, Tunahan et al. conducted two different analyses comparing the financial failures between low-cost airlines and global airline alliances (Star Alliance, One World, Sky Team) with the fuzzy logic method. As a result of the first analysis, there is no significant difference between low-cost airlines and airline alliances in terms of financial risk. As a result of the second analysis, it was concluded that the financial risk level of low-cost airlines is lower than the average of airline alliances (Tunahan et. al., 2016).

In his study, Sakız analyzed the quarterly data of Turkish Airlines covering the years 2014-2016 with Altman Z' score method. According to the findings, it has been observed that Turkish Airlines has been in the risky (gray) area recently. In order for the airline to move to the safe area, it was recommended to increase long-range flights and capacity (Sakız, 2017).

In his study, Kroeze analyzed 6 bankrupt and 10 non-bankrupt airlines covering the years 1998-2003 by developing a new bankruptcy model with Altman Z" score. In his analysis, Kroeze revealed that the Altman Z" score model did not show accurate results and that he was able to predict some bankrupt airlines in advance according to the Kroeze model he developed (Kroeze, 2004).

In their study, Kumar and Anand conducted Altman Z" score analysis by using financial ratios of Kingfisher airlines covering the years 2005-2012. As a result of the analysis, it was observed that the Altman Z"score method consistently measures financial failure. As a result of the analysis, it was concluded that the financial performance was quite low in the relevant years (Kumar and Anand, 2013).

In his study, Mantziaris analyzed 40 airline businesses (20 successful and 20 unsuccessful) in Greece covering the years 2005-2013 with Altman Z" score analysis method. As a result of the analysis, it was concluded that the Altman Z" score model cannot consistently measure successful airlines, but it consistently measures unsuccessful airlines (Mantziaris, 2015).

Kiracı and Yaşar (2018) conducted an analysis using Altman Z score and Springate S score methods to predict financial failure in airline companies. 16 airline companies covering the years 2007-2016 were analysed. As a result of the analysis, it was concluded that airline companies in China failed according to both financial failure results, although they reduced their risks between 2009 and 2010.

In his study, Kiracı aimed to identify the factors affecting the financial risk of 13 airlines with low-cost airline business model for the period 2004-2017. Altman Z" score and Springate S-Score methods were used to measure financial risk. Panel data analysis method was used to determine the factors affecting financial risk. As a result of the analysis, it was determined that liquidity, operating profitability, operating leverage, and operating size ratios affect financial risk (Kiracı, 2019).

In his study, Hsu aimed to measure the usefulness of Altman Z" score method among financial forecasting methods in the field of aviation finance at undergraduate level. In this direction, the risk of financial failure of American Airlines and Southwest Airlines airline businesses in the 2009-2010 period was measured by Altman Z" score method. According to the analysis, it is seen that Southwest Airlines, which is a low-cost carrier, is more successful than American Airlines. It was also stated that the Z" score model can be used as a financial forecasting method in aviation finance trainings (Hsu, 2017).

In their study, Sakız and Ünkaya revealed the financial risk status of Turkish Airlines' 2002-2016 data with the Air Score method. They predicted the period between 2017-2019 with the artificial neural network model. According to the Air Score bankruptcy model, THY is in a healthy area, and as a result of the prediction with artificial neural networks, it was determined that THY will be in a healthy area in terms of bankruptcy risk (Sakız & Ünkaya, 2018).

In his study, Alıcı examined the relationship between airline industry-specific ratios (RPK, LF, CASK) and financial failure. The study was conducted on a sample of 11 traditional airline businesses between 2009-2019. Within the scope of the study, financial failure was calculated by Altman Z Score method and the relationship with operational ratios was analyzed by panel data analysis method. According to the results of the analysis, it was concluded that the cost per seat km supplied (CASK) indicator negatively affects financial failure (Alıcı, 2021).

According to the study conducted by Gritta et. al., it is stated that there are 6 methods that reveal the financial failure status specific to airline businesses (Gritta et. al., 2008):

- Altman Model (Z-score)
- Altman Zeta Model
- Airscore Model
- Pilarski Model (P-score)
- Gudmunsson Model
- Artificial Intelligence Models

Many studies have been conducted on financial failure in airline businesses. In most of the studies, the Altman "Z" score method has been used to measure financial risk, and it is understood that successful predictions about financial risk have been made with this method. Apart from this method, Springate S-score, Air Score and regression-correlation analysis have also been used.

In most of the studies conducted in the context of airline businesses, the degree of financial risk and failure of airlines have been measured. A few studies have examined the factors affecting financial risk. This study aims to measure the effects of macroeconomic factors on financial failure in airline businesses.

3. Method

In this study, macroeconomic factors affecting the financial failure of airlines are analysed. The study includes 11 airlines[1] with continuous financial data for the period 2009-2019[2]. Financial data and macroeconomic data of the airline companies in the sample were obtained from Thomson Reuters Eikon Datastream. The method of the study consists of 2 stages. In the first stage, Altman Z" Score method is used. Then, panel data analysis method is preferred to reveal the relationship between financial risk and macroeconomic factors.

3.1. Altman Z'' Score Model

In the literature, the most preferred methods to measure financial failure or risk have been Altman's Z Score studies. Altman first developed the Z Score model in 1968 by using

[1] The list of airlines is appendix.

[2] To ignore the effects of the financial crisis in 2008 and the COVID-19 Pandemic in 2020 on the activities of the companies, the relevant years were not included in the sample.

multiple discriminant analysis to predict financial failure. A discriminant value below certain limits is defined as financial failure, while a value above certain limits is defined as financial success. According to the 1968 theory, financial performance and/or bankruptcy status can be observed as a result of this analysis by numerically revealing the financial failure status of enterprises (Kurtaran, 2009).

Altman Z Score success model has developed over time. Introduced in 1968, the Z Score model faced scientific criticism that it would be inadequate for other sectors since the theory was put forward in the manufacturing sector sample. In this direction, Altman developed the Z' Score model for special industries and the Z" score model for service businesses. Since this study was conducted in the sample of airline businesses, Altman Z" Score model was preferred. Altman Z" The fomula of the Score model is shown below (Altman, 2000):

Z" Score = 6.56T1 + 3.26T2 + 6.72T3 + 1.05T4

Z" Score Financial Failure Value

T1: Net Working Capital / Total Assets

T2 : Retained Earnings / Total Assets

T3 : Operating Profit / Total Assets

T4 : Book Value of Equity / Total Liabilities

After calculating the formula, the financial failure value Z" Score value is found. According to this, if Z" If the Score value is greater than 2.6, it is concluded that the enterprise is in the safe area or successful, if it is between 1.1 and 2.6, it is in the gray area (no financial failure), and if it is less than 1.1, it is concluded that the enterprise is in financial failure (bankruptcy probability) (Sakız, 2017).

3.2. Panel Data Analysis

Three types of data types can be mentioned in economic analysis. These are time series, horizontal cross-section and panel data. The series showing the change of any variable over time are called time series. Examples of time series are exchange rate data for the period 1990-2015 in Turkey or monthly non-farm employment data for the period 1970-2015 in the USA. The series that show the change of any variable in the same time unit (with time constant) by units are called horizontal cross-section series. Examples of horizontal cross-section series are inflation data of OECD countries in 2015 or export data of EU member countries in 2015. Panel data, on the other hand, is defined as the aggregation of cross-sectional observations of units such as individuals, countries and firms in a given period. Panel data consists of N number of units and N number of observations corresponding to each unit. Annual total debt ratio data of Star Alliance member airline businesses for the period 2010-2016 or monthly average rate of return data of the stocks of BIST-30 businesses for the period 2010-2015 can be given as examples of panel data (Güriş, 2015; Yerdelen Tatoğlu, 2009).

A regression model computed with panel data is essentially a panel data model. Because of this, panel data models can also use the tests, suppositions, and other elements specified in the regression model. One dependent variable and one or more independent variables are used in panel data models. The error term is also included in the model because it is a statistical or econometric model. Different indices will be utilized to indicate both units and time since the variables in the model will demonstrate change in both. In panel data analysis, the letters I and t stand for the units and the time period, respectively (Güriş, 2015). The following diagram illustrates the linear panel data model with panel data, where Y stands for the dependent variable and X for the independent variable or variables.

$$Y_{it} = \alpha_{it} + \beta_{it} + X_{it} + \varepsilon_{it}$$

It's here,

i= 1,2,...,N horizontal cross-section units,

t= 1,2,...,T time period,

Y it=the value of the dependent variable's i-th unit at time t,

X_it= the value of the independent variable's i-th unit at time t,

ε_it= error term with a constant variance and a zero mean,

β = slope coefficient for a line.

Depending on the temporal and cross-sectional data, three alternative estimating approaches can be utilized in panel data analysis. These models are conventional ones with fixed effects and random effects (Gökbulut, 2009).

3.3. Definition of Variables Used in Panel Data Analysis and the Model Used

According to the relationship status in the literature, the dependent and independent variables affecting financial risk in traditional airline enterprises were identified for the study. The Z" Score value for the financial failure indication is employed as the dependent variable. As independent variables, the macroeconomic indices INT, INF, BOP, and DER are employed. The Table 2 below lists the acronyms, definitions, and methods of measurement for the variables utilized in the study.

Table 2. List of variables used in the model

Variables	Symbol	Measurement Indicator	Measurement Method
Dependent Variables	**ZSCORE**	Z'' Score	Z'' Score Value
Independent Variables	**INT**	Interest Rate	10-Year Bond Interest Rates of Countries
	DER	Dollar Exchange Rate	Exchange Rate Between the Currency of the Countries and the US Dollar (Ex: TL_USD)
	BOP	Brent Oil Price	Reel Brent Oil Price
	INF	Inflation Rate	Reel Inflation Rate

The panel data analysis model used in the study is constructed as follows:

$$ZSCORE_{it} = \beta_0 + \beta_1 INT_{it} + \beta_2 DER_{it} + \beta_3 BOP_{it} + \beta_4 INF_{it} + \varepsilon_{it}$$

The ZScore variable used in the model is a measure of financial failure and is the dependent variable. Other variables are independent variables. INT variable is interest rate, DER variable is dollar exchange rate, BOP variable is brent oil price and INF variable is inflation rate.

4. Findings

11 airlines applying the traditional business model were examined in line with the calculations made according to the Altman Z Score analysis. The findings are given in the appendices. In general, Altman Z When the Score results are analyzed, it is observed that not all airlines have been

financially successful over the 11-year period. Singapore airline has been the most successful financial performer among the airline businesses. It was observed that All Nippon airline had more times when the risk of financial failure was higher. The other airlines, on the other hand, showed a mostly unsuccessful profile.

In the second part of the analysis, the relationship between airline financial failure (Altman "Z" Score) and macroeconomic factors is analyzed using annual data for the period 2009-2019 by panel data analysis method. The analysis results were obtained by using GAUSS 10, E Views 9 and Stata 15 programs.

Preliminary tests such as descriptive statistics, correlation matrix, cross-sectional dependence and panel unit root test were performed. Then, tests (F, LM and Hausman tests) were conducted to choose between classical, fixed and random effects. Afterwards, tests for heteroscedasticity and autocorrelation are performed and panel data estimator results are presented.

Table 3. Descriptive statistics

	ZSCORE	INT	DER	INF	BOP
Mean	0.5101	2.9544	0.5658	2.3220	37619.7000
Medyan	0.4564	2.4460	0.7102	1.7769	7328.0000
Maximum	4.0782	16.98	1.4365	16.3000	367698.0000
Minimum	-1.9818	-0.1860	0.0083	-1.4000	1523.0000
Std. Dev.	0.9975	777.8789	2036.0990	2.7915	85002.6200
Skewness	0.8481	3.3039	4.6103	2.5463	2.8846
Kurtosis	4.8579	12.6284	22.2592	11.2674	9.7518
Jarque-Bera	0.5101	235.3994	421.4863	2.3220	37619.7000
Probability	0.4564	2.4460	0.7102	1.7769	7328.0000

According to the descriptive statistics results, the variable with the highest standard deviation is Brent oil price (BOP) and the variable with the lowest standard deviation is ZSCORE, which is an indicator of financial failure. All variables are right skewed. There is a difference of approximately 17% between the minimum and maximum values of the interest rate (INT) and inflation rate (INF) variables. This difference indicates that the macroeconomic variables in the countries differ.

Table 4. Correlation matrix

	ZSCORE	INT	DER	INF	BOP
ZSCORE	1	-0.24597	-0.068	0.129927	0.191576
INT	-0.24597	1	-0.06211	-0.14739	-0.11047
DER	-0.068	-0.06211	1	-0.00481	-0.08374
INF	0.129927	-0.14739	-0.00481	1	-0.19284
BOP	0.191576	-0.11047	-0.08374	-0.19284	1

The emergence of correlation between the variables included in the regression model causes the problem of multicollinearity. When the correlation matrix between the variables is analysed, the correlation rate between all variables is around 15% on average. If there is more than 50% correlation between the variables in the models, the problem of linearity is mentioned. In general, it is seen that there is low correlation and there is no linearity problem.

To find horizontal cross-section dependence between variables, a horizontal cross-section dependence test is run. The stationarity status of the variables is assessed using first generation unit root (stationarity) tests if there is no horizontal cross-section dependence between the series and second-generation unit root (stationarity) tests if there is.

According to the horizontal cross-section dependence test result, Ho hypothesis is accepted for all variables. In this case, it is understood that there is no horizontal cross-section dependence between the variables, so the first-generation unit root test should be applied.

Table 5. Horizontal cross-section dependence test results

Variable	CDLM adj.		
	Statistics	Probability	Decision
ZSCORE	-1.285	0.901	Ho Accept
INT	0.545	0.293	Ho Accept
DER	-0.328	0.629	Ho Accept
INF	-1.043	0.852	Ho Accept
BOP	-0.738	0.770	Ho Accept

Table 6. Panel unit root test results

Variable	Model	Levin, Lin& Chu-t		Lm, Paseran and Shin-W		ADF-Fisher Chi2	
		Statistics	Probability	Statistics	Probability	Statistics	Probability
ZSCORE	Constant	-8.0544	0.0000	-5.3754	0.0000	67.6485	0.0000
	Constant and Trend	-9.2651	0.0000	-3.5327	0.0002	55.2257	0.0001
ΔZSCORE	Constant	-13.2195	0.0000	-7.4381	0.0000	93.5170	0.0000
	Constant and Trend	-12.4649	0.0000	-2.9951	0.0014	66.6592	0.0000
BOP	Constant	-3.9069	0.0000	-2.8229	0.0024	51.2235	0.0004
	Constant and Trend	-7.5812	0.0000	-2.5721	0.0051	55.5782	0.0001
ΔBOP	Constant	-5.3140	0.0000	-2.3697	0.0089	39.5192	0.0123
	Constant and Trend	-4.3197	0.0000	0.0159	0.5063	20.3997	0.5581
DER	Constant	-1.8424	0.0327	-0.2009	0.4204	20.5212	0.5505
	Constant and Trend	-7.9633	0.0000	-2.7007	0.0035	48.1496	0.0010
ΔDER	Constant	-15.4802	0.0000	-7.6690	0.0000	91.8813	0.0000
	Constant and Trend	-13.1613	0.0000	-2.8183	0.0024	61.0656	0.0000
INT	Constant	-5.5232	0.0000	-4.5140	0.0000	62.9522	0.0000
	Constant and Trend	-11.3679	0.0000	-2.8541	0.0022	58.6509	0.0000
ΔINT	Constant	-12.8680	0.0000	-7.0951	0.0000	93.3826	0.0000
	Constant and Trend	-6.2616	0.0000	-2.5741	0.0050	60.4936	0.0000
INF	Constant	-4.9352	0.0000	-3.3054	0.0005	49.3970	0.0007
	Constant and Trend	-4.4993	0.0000	-1.4754	0.0700	37.9640	0.0185
ΔINF	Constant	-10.4837	0.0000	-6.0686	0.0000	79.2894	0.0000
	Constant and Trend	-18.0513	0.0000	-3.7559	0.0001	69.0434	0.0000

Notes: Δ denotes the first order differenced series. The maximum lag length is taken as 1 and the optimal lag length is determined according to the SIC (Schwarz Info Criteria) criterion. All hypothesis tests are based on 0.05 (5%) significance level.

According to the results of 3 different unit root tests performed on the variables, all variables are found to be stationary at level.

Following the unit root and horizontal cross-section dependence tests, it is required to choose amongst the classical, fixed, and random effects models. The F test is used to test the classical model for fixed effects, the LM test is used to test the classical model for random effects, and the Hausman test is used to distinguish between random and fixed effects.

Table 7. F Test to test for the existence of unit and/or time effects

Test Hypothesis	Statistics	Probability	Decision
There is no fixed unit effect	1.385939	0.172715	Ho Accept
There is no fixed time effect	14.47527	0.0000	Ho Reject
There is no fixed time and unit effect	3.571165	0.0087	Ho Reject

According to the F Test, it is tested whether to use fixed effects or random effects instead of the classical model. According to the two results, Ho hypothesis is rejected. In this case, it is understood that the classical model is not appropriate.

Table 8. LM Test for the existence of unit and/or time effects

Test Hypothesis	Statistics	Probability	Decision
There is no random unit effect.	189.783	0.0000	Ho Reject
There is no random time effect.	1.244381	0.2646	Ho Accept
There is no random time and unit effect.	191.0274	0.0000	Ho Reject

Similar to the F Test, Ho hypothesis is rejected according to the two results. Likewise, it is understood that the classical model is not appropriate and estimation should be done with either fixed or random effects model. Hausman test is applied in order to test the application according to fixed or random effects.

Table 9. Hausman Test

Test Hypothesis	Statistics	Probability	Decision
The random effects model is appropriate	0.8000	0.9383	Ho Accept

Ho is accepted according to the hypothesis that the random effects model is appropriate. In this case, it is accepted that the random effects model is appropriate.

Table 10. Variance and Autocorrelation Tests

Modified Wald Test		Durbin Watson	Baltagi-Wu
Statistics	Probability	Statistics	Statistics
97.80	0.0000	1.2183496	1.4893174

The modified Wald test was employed to test for variable variance. As a result, the Ho hypothesis is rejected, and it is determined that a variable variance problem exists. Autocorrelation was determined using the Durbin Watson and Baltagi-Wu tests. Autocorrelation is present in the model when these statistical values are less than 2. The autocorrelation test results demonstrate that both statistics are less than 2, indicating an autocorrelation issue. As a result of the testing, the analysis was performed using the Arellano Froot and Rogers random effects robust estimator, which takes into account shifting variance and autocorrelation.

Table 11. Random Effects Arellano Froot and Rogers Robust Estimator Results

Variable	Coefficient Estimation	St. Error	z	P	(95% Confidence Interval)	
INT	-0.000123	0.000052	-2.35	0.019*	-0.000225	-0.000020
DER	-0.000020	4.65e-06	-4.44	0.000**	-0.000029	-0.000011
INF	0.035084	0.063446	0.55	0.580	-0.089267	0.159436
BOP	8.02e-07	1.10e-06	0.73	0.466	-1.36e-06	2.96e-06
C	0.436200	0.204305	2.14	0.033	0.035768	0.836632
Number of observations: 121		Wald chi2(4) = 51.38		$R^2 = 0.1705$		
Number of Groups: 11		Prob > chi2= 0.000				

0.001>**, 0.005>*

According to the panel data results of the Random Effects Arellano Froot and Rogers Robust Estimator, INT and DER indicators have a negative effect at 5% significance level. INF and BOP variables, on the other hand, have no significant relationship. The variables used in the model have a 17% explanatory power for financial failure. It is concluded that a 1-unit increase in the interest rate causes a 0.0001% unit decrease in the financial failure score, and a 1-unit increase in the exchange rate causes a 0.0002% unit decrease in the financial failure score. Accordingly, it is concluded that interest rate and dollar exchange rate among macroeconomic indicators have a negative impact on airline failure. However, neither the inflation rate nor the Brent oil price have been linked to the demise of airlines.

5. Conclusion

This study focuses on the impact of macroeconomic factors on financial failure in traditional airlines. The analysis was carried out with data covering the years 2009-2019 of 11 airline businesses adopting the traditional business model. In this direction, first of all, Altman Z's" Financial failure was determined by using score analysis and macroeconomic factors affecting financial failure were analyzed by panel data analysis method.

According to the results of the Z" score analysis, which measures financial failure, it is observed that all airline businesses have not been financially successful in the 11-year period. Singapore airline has been the most successful financial performer among the airline businesses. It is observed that All Nippon airline has more times when the risk of financial failure is higher. In other airlines, it has been observed that the majority of the airlines have not been successful.

According to the findings of the fixed effects panel data analysis used to assess the relationship between macroeconomic factors and airline financial failure, interest rate and exchange rate variables have a negative impact on financial failure, whereas Brent oil price and inflation rate variables have no impact. The study's hypothesis is that macroeconomic factors (such as the currency rate, oil price, interest rate, and inflation rate) have a large and negative impact on financial failure. As a result of the analysis, the hypothesis concerning the interest rate and exchange rate is validated, however the hypothesis concerning the Brent oil price and the inflation rate is not proven. The result that the inflation rate does not affect financial failure in the study is similar to a study conducted in the aviation sector (Güngör, 2019).

As a result of the analysis, it has been revealed that increases in the dollar exchange rate negatively affect financial failure in airline businesses. This result confirms the theory of an inverse relationship between exchange rate and financial failure. At the same time, the result of the study on exchange rate confirms 2 studies in the literature (Siregar and Siswanti, 2022; Gutu et al., 2015). The most important foreign currency risk for airline businesses is the US dollar. Especially important cost items such as aircraft purchase, leasing, fuel, maintenance and overhaul costs are priced in US dollars (IATA, 2015). In this context, airline businesses are exposed to exchange rate risk to a great extent. Exchange rate fluctuations may adversely affect airline demand, airline supply and airline financing. In this sense, the depreciation of the country's currency in terms of US dollar may adversely affect the travel balance (supply-demand) on certain routes. Moreover, the cost of fulfilling the airline's obligations arising from aircraft purchase, leasing and/or fuel will be higher. Therefore, it is inevitable that increases in the dollar exchange rate will negatively affect the financial failure of airline businesses. Considering the impact of exchange rate changes on financial failure, airline businesses can mitigate financial failure by using hedging strategies more effectively to optimize the costs arising from exchange rates.

Panel data analysis reveals that an increase in interest rates has a negative effect on financial failure in airline businesses. This result is consistent with the hypothesis and theory. At the same time, the analysis result of the study on interest rate is similar to many studies in different sectors (Harjayati et al., 2022; Gutu et al., 2015; Liu, 2013; Zikovic, 2016; McNamara et al., 2013). Low interest rates provide financing cost advantage for airline businesses. However, increases in interest rates increase the capital costs and interest expenses of airline businesses and reduce their liquidity. At the same time, with the increase in interest rates, airline businesses cannot find cheap credit opportunities. The inability to obtain cheap credit results in the negative effect of financial leverage and negatively affects profitability and financial failure. The biggest capital burden for airlines is the financing arising from aircraft purchases. Airline businesses use loans extensively during the aircraft purchase or aircraft leasing stages. As a

result of the increase in loan interest rates, the cost of capital will increase and as a result, it will negatively affect the financial failure of airline businesses. According to IATA's data, the debt amounts of airline businesses increased from 220 billion dollars to over 650 billion dollars during the pandemic (IATA, 2021). According to this data, both the increase in borrowing and the increase in interest rates indicate that there may be crisis signals in the airline sector.

In sum, this study provides evidence that exchange rate volatility and interest rate changes affect the financial failure of global airlines. There are several policy implications for airlines, practitioners, policymakers and investors to manage the related macroeconomic risks. First, the importance of exchange rate and interest rate variables among macroeconomic factors for the airline industry is re-emphasized. Airline managers, private and institutional investors should monitor policy uncertainty, assuming that exchange rate uncertainty is a driving force for financial failure. In addition, airlines should review their hedging strategies against exchange rate risk. With rising interest rates, the cost of financing will increase and the airline industry will start to struggle. This may be a source of concern for the airline industry as it may cause investors to change their portfolios. Exchange rate changes and interest rate mismatches always lead to volatile losses (gains). The results related to exchange rate and interest rate changes indicate that airlines and the relevant governments should focus on policies to increase the financial sustainability of the aviation industry. To better manage these risks, financial managers need to scrutinize more carefully the impact of macroeconomic risk spikes and related financial failure effects. Finally, this study is expected to contribute positively to the financial performance of airline businesses by providing new solutions to airline businesses in terms of reducing and eliminating financial failure.

This study has some limitations. First of all, the study was conducted only in the traditional airline industry sample. Although the macroeconomic indicators used in the study are the most important financial risks faced by airline businesses, the model can be built by including all macroeconomic factors together with the factors here. In addition, the number of airline businesses used in the study can be increased and more reliable results can be obtained if the period range of the data used is preferred more frequently. Finally, in addition to this study, new studies can be conducted on financial protection strategies that minimize financial failure.

Ethical approval

No ethical approval required

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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Appendixes

Appendix 1: List of Airlines

Airlines Sample	
Turkish Airlines	All Nippon (ANA)
United Airlines	Cathay Pacific
Air Canada	Air France
Singapore Airlines	Scandinavian Airlines (SAS)
Qantas Airlines	Air China
Lufthansa	

Appendix 2: Traditional Airline Businesses Altman Z" Score Table

Airlines	Year	Net Working Capital / Total Assets	Retained Earnings or Losses / Total Assets	Earnings Before Interest and Tax / Total Assets	Shareholders' Equity / Total Liabilities	Altman Z" Score	According to the "Z" Score Model Success Status
Turkish Airlines	2009	0.09928	0.10044	0.08598	0.67193	2.26200	Gray Area
	2010	0.08930	0.12011	0.04526	0.54296	1.85165	Gray Area
	2011	0.00744	0.08321	0.00616	0.37779	0.75809	Failed
	2012	-0.03465	0.07400	0.06072	0.40478	0.84697	Failed
	2013	-0.08335	0.08548	0.04882	0.37761	0.45644	Failed
	2014	-0.06090	0.08950	0.04260	0.40210	0.60074	Failed
	2015	-0.04410	0.09810	0.05220	0.41610	0.81820	Failed
	2016	-0.04850	0.11780	-0.01330	0.37940	0.37486	Failed
	2017	-0.03660	0.11100	0.05200	0.42000	0.91220	Failed
	2018	-0.03270	0.07520	0.05680	0.40290	0.83538	Failed
	2019	-0.04819	0.08188	0.03433	0.38458	0.58530	Failed
American Airlines	2009	-0.04269	-0.02410	0.03947	0.15896	0.07352	Failed
	2010	-0.07741	-0.00706	0.00821	-0.13588	-0.61829	Failed
	2011	-0.18928	-0.02908	-0.04892	-0.23163	-1.90846	Failed
	2012	-0.21093	-0.03753	0.00636	-0.25558	-1.73162	Failed
	2013	0.01223	-0.01805	0.03309	-0.06068	0.18004	Failed
	2014	-0.03092	0.02625	0.09931	0.03319	0.58491	Failed
	2015	-0.07477	0.03338	0.12814	0.23804	0.72938	Failed
	2016	-0.06618	0.02807	0.09856	0.17324	0.50162	Failed
	2017	-0.11768	0.02251	0.08016	0.23051	0.08203	Failed
	2018	-0.16060	0.00654	0.04384	0.24114	-0.48439	Failed
	2019	-0.16843	0.00790	0.05109	0.28819	-0.43324	Failed
Air China	2009	-0.26546	0.00196	0.11631	0.28529	-0.65385	Failed
	2010	-0.04050	0.01573	0.12279	0.35295	0.98131	Failed
	2011	-0.08464	0.01326	0.09503	0.37311	0.51839	Failed
	2012	-0.07807	0.00889	0.10155	0.37845	0.59661	Failed
	2013	-0.08991	0.00440	0.07383	0.36436	0.30322	Failed
	2014	-0.08952	0.00373	0.08911	0.35937	0.40105	Failed
	2015	-0.04739	0.00864	0.13370	0.40615	1.04215	Failed
	2016	-0.10805	0.01095	0.13839	0.46594	0.74613	Failed
	2017	-0.12991	0.01207	0.10759	0.61119	0.55186	Failed
	2018	-0.10296	0.00723	0.11840	0.65072	0.82706	Failed
	2019	-0.11259	0.01026	0.12655	0.59234	0.76721	Failed

	2009	-0.03731	0.00903	0.14135	0.40360	1.15836	Gray Area
	2010	-0.12742	0.01271	0.07107	0.42939	0.13398	Failed
	2011	-0.10974	0.02090	0.07911	0.41824	0.31898	Failed
	2012	-0.17565	-0.00817	0.08490	0.38518	-0.20396	Failed
	2013	-0.17530	0.01010	0.09772	0.41794	-0.02149	Failed
Qantas	2014	-0.14973	-0.21781	0.08673	0.19831	-0.90122	Failed
	2015	-0.13811	0.05978	0.16110	0.24476	0.62848	Failed
	2016	-0.21371	0.09835	0.20569	0.24247	0.55551	Failed
	2017	-0.23088	0.07955	0.19325	0.25875	0.31511	Failed
	2018	-0.21247	0.08227	0.18963	0.26919	0.43131	Failed
	2019	-0.22620	0.07483	0.17320	0.21554	0.15030	Failed
	2009	-0.04360	0.00332	0.07363	1.79227	2.10146	Gray Area
	2010	0.11295	0.04670	0.01592	2.37338	3.49223	Succeeded
	2011	0.19370	0.06258	0.07749	1.98359	4.07818	Succeeded
	2012	0.11569	0.02831	0.02670	2.09741	3.23291	Succeeded
	2013	0.11563	-0.04034	0.02855	2.06670	2.98895	Succeeded
Singapore	2014	0.11130	0.02991	0.02127	2.15647	3.23488	Succeeded
	2015	0.03979	-0.01500	0.02585	1.58611	2.05129	Gray Area
	2016	0.01769	0.06250	0.05599	1.69022	2.47079	Gray Area
	2017	-0.03190	0.03961	0.02816	1.66625	1.85863	Gray Area
	2018	-0.08274	0.09593	0.07963	1.35450	1.72734	Gray Area
	2019	-0.08125	0.03917	0.03758	0.98510	0.88159	Failed
	2009	-0.07632	-0.00086	-0.03468	-0.13077	-0.87384	Failed
	2010	-0.05049	-0.00061	0.01972	0.19949	0.00876	Failed
	2011	-0.05634	0.00016	0.01557	0.21465	-0.03910	Failed
	2012	-0.07095	0.00011	-0.01725	0.03143	-0.54801	Failed
	2013	-0.09467	-0.00046	0.01708	0.09462	-0.40839	Failed
United Airlines	2014	-0.13181	-0.00011	0.02972	0.07590	-0.58559	Failed
	2015	-0.11130	-0.07538	0.10330	0.28099	0.01334	Failed
	2016	-0.12439	0.03886	0.09533	0.27334	0.23832	Failed
	2017	-0.13171	0.02013	0.07091	0.26133	-0.04747	Failed
	2018	-0.13783	0.01073	0.05402	0.25761	-0.23566	Failed
	2019	-0.12841	0.01720	0.07440	0.28070	0.00844	Failed
	2009	-0.02743	0.01345	-0.02905	0.35243	0.03872	Failed
	2010	0.01245	0.02023	0.03527	0.36876	0.77181	Failed
	2011	0.04393	0.01098	0.04443	0.37362	1.01491	Failed
	2012	0.12167	0.00983	0.04258	0.54985	1.69367	Gray Area
	2013	0.05612	0.00506	0.03036	0.52743	1.14244	Gray Area
All Nippon	2014	0.01129	0.01129	0.03997	0.52368	0.92935	Failed
	2015	0.02064	0.01974	0.06101	0.59275	1.23213	Gray Area
	2016	0.04062	0.00475	0.06309	0.67122	1.41076	Gray Area
	2017	0.02927	0.03630	0.06440	0.63124	1.40597	Gray Area
	2018	0.00558	0.03163	0.06141	0.67660	1.26283	Gray Area
	2019	0.05517	0.03147	0.04623	0.71420	1.52506	Gray Area

	2009	-0.03373	0.00817	-0.03037	0.16509	-0.22537	Failed
	2010	0.03632	0.00759	0.03860	0.20151	0.73399	Failed
	2011	0.00768	-0.02595	0.01858	-0.29372	-0.21774	Failed
	2012	-0.02340	0.02064	0.04823	-0.26947	-0.04503	Failed
	2013	0.01035	0.00517	0.06536	-0.12855	0.38902	Failed
Air Canada	2014	-0.00554	0.00460	0.07654	-0.09617	0.39202	Failed
	2015	0.02255	0.00365	0.11396	0.00306	0.92886	Failed
	2016	-0.00509	-0.00007	0.08899	0.08773	0.65649	Failed
	2017	0.01665	0.02564	0.07710	0.23830	0.96113	Failed
	2018	0.06261	0.00203	0.06116	0.26596	1.10759	Gray Area
	2019	-0.00933	0.00263	0.05944	0.18836	0.54459	Failed
	2009	-0.11009	-0.00318	0.04973	0.59747	0.22899	Failed
	2010	-0.14466	-0.00683	0.14656	0.73927	0.78991	Failed
	2011	-0.09357	0.00788	0.05330	0.68909	0.49359	Failed
	2012	-0.16515	0.00143	0.01148	0.58534	-0.38693	Failed
	2013	-0.00927	0.00612	0.02087	0.58047	0.70882	Failed
Cathay Pacific	2014	-0.07148	-0.00355	0.02354	0.43169	0.13096	Failed
	2015	-0.09577	0.04324	0.37488	0.38522	2.43641	Gray Area
	2016	-0.07157	0.04173	0.00980	0.45556	0.21074	Failed
	2017	-0.04480	0.03270	-0.00311	0.48202	0.29796	Failed
	2018	-0.09842	0.00718	0.01705	0.50602	0.02369	Failed
	2019	-0.06649	0.04265	0.02546	0.56231	0.46438	Failed
	2009	-0.11598	0.01526	-0.04184	0.24575	-0.73423	Failed
	2010	-0.08810	0.02110	-0.07665	0.24234	-0.76980	Failed
	2011	-0.10027	0.00897	-0.03774	0.28714	-0.58064	Failed
	2012	-0.08182	-0.00098	-0.03982	0.22139	-0.57509	Failed
	2013	-0.11479	-0.03765	-0.02077	0.09914	-0.91120	Failed
Air France	2014	-0.20022	-0.00900	0.00271	-0.02649	-1.35233	Failed
	2015	-0.19087	-0.00129	0.10229	0.01184	-0.55648	Failed
	2016	-0.11050	-0.01282	0.11835	0.05990	0.09153	Failed
	2017	-0.09999	0.00070	0.15896	0.08786	0.50684	Failed
	2018	-0.15559	-0.00781	0.14513	0.06859	0.00114	Failed
	2019	-0.13372	-0.00247	0.13431	0.08085	0.10216	Failed
	2009	-0.12185	-0.01101	-0.02574	0.03822	-0.96810	Failed
	2010	-0.05310	0.00007	0.03400	0.52718	0.43389	Failed
	2011	-0.09088	0.01649	0.11686	0.46550	0.73164	Failed
	2012	-0.17481	-0.00778	0.06250	0.43582	-0.29454	Failed
	2013	-0.19397	0.09682	0.20263	0.40170	0.82660	Failed
SAS	2014	-0.10230	0.00522	0.12627	0.51728	0.73762	Failed
	2015	-0.06271	0.07351	0.04682	0.53408	0.70368	Failed
	2016	-0.10931	0.05958	0.04507	0.47874	0.28269	Failed
	2017	-0.08696	-0.00525	-0.00046	0.48251	-0.08405	Failed
	2018	-0.05404	-0.00076	-0.00023	0.38354	0.04418	Failed
	2019	-0.09949	-0.00226	-0.00065	0.37235	-0.27345	Failed

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Strategic Decisions and Policies on Türkiye-Europe Air Cargo Transport

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Abstract

This study examines the air cargo traffic in terms of transported cargo weights between Europe and Türkiye in the 10-year period between 2012 and 2021. Annual data was obtained from EUROSTAT and then this data was processed by using R language and Minitab. Freight tonne kilometers (FTKs) growth analyses for the World, Europe and Türkiye were done by fitting exponential curves to the data. Forecast for cargo traffic between Türkiye and Europe were done using exponential smoothing with trend adjustment method. The results reveal the strategic decisions for determining airport pairs in air cargo transport between Europe and Türkiye. It has been determined that there is air cargo transportation between 11 airports from Türkiye and 90 airports from 31 European countries. The most striking result of this study is that while Istanbul IGA airport serves as the main hub for air cargo transportation with other airports in Europe, Sabiha Gökçen airport has been on the way to become a secondary hub in recent years with the strategic agreements between airports. The transported air cargo weight between remaining 8 airports (since Atatürk airport closed to air cargo in 2022) in Türkiye and European airports is negligible. Determinants of choosing these airports might possibly be geographic locations, political relations with these countries, specific products of these locations, closeness to the industrial regions.

1. Introduction

Significant studies on air cargo transport with the increasing demand for air cargo have boosted although it was not valued as much as passenger transportation until recently. The increase in the demand for air cargo services in recent years has also enlarged the volume of air cargo traffic all over the world (Akinyemi, 2023). Fitting exponential growth curves to the ICAO data, it can be seen that world Freight Tonne Kilometers (FTKs) grew by 3.1% between 2000-2021 shown in Figure 1 (The World Bank, 2022). Global growth rate took a major decrease in 2020 due to Covid-19 pandemic which resulted in vanishing of approximately half of the global air cargo capacity.

The European Union experienced larger fluctuations in its air cargo traffic in the same period (Figure 2) resulting in an average growth rate of only 0.9% (The World Bank, 2022).

On the other hand, Türkiye's air cargo traffic grew tremendously by 19.1% between 2000-2021 (Figure 3) when compared to the world (3.1 %) and Europe air cargo growth rate (0.9%) [The World Bank, 2022] due to the investments in air cargo capacity and facilities especially coming from Turkish Airlines in the last decade.

In light of these trends, this study aims to analyze the historical air cargo movements between Türkiye and European countries. Assessing the historical patterns, forecasts on the city, country and airport pair level will be made using the appropriate statistical models.

Air cargo business models and transported product characteristics (Hong et al., 2023) have a great impact on the strategic decisions on air cargo transportation. As there are dissimilarities in passenger and air cargo transportation (Hong et al., 2023), differences between air cargo business models, which are integrated, all-cargo, and combination carriers (Dewulf, 2014, p.21), affect the strategic decision-making mechanism on airports and route selection. Route selection in air cargo matters; thus, cargo transportation routes and aircraft scheduling need to be optimized (Zhao, 2020) in the application of different types of cargo business models to increase revenue while meeting multi-customer demands.

Integrated carriers, non-integrated carriers, and combination carriers are different types of air cargo operators based on their business models and the services they provide:

- Integrated Carriers (Integrators): Integrated carriers, also known as integrators, are air cargo operators that offer comprehensive door-to-door logistics solutions. They have a high level of vertical integration, combining air transportation with ground handling, sorting facilities, and last-mile delivery services. These carriers typically operate extensive global networks and specialize in time-definite deliveries and express shipments. Examples of integrated carriers include FedEx, UPS, and DHL.

- Non-integrated Carriers (All Cargo Airlines): Non-integrated carriers, also referred to as all cargo airlines, focus primarily on air transportation services. They specialize in the transportation of various types of cargo, such as general freight, perishables, oversized cargo, or specialized goods. Non-integrated carriers do not typically provide extensive ground handling or last-mile delivery capabilities. Instead, they rely on partnerships with ground handling agents and trucking companies for cargo handling and distribution. Examples of non-integrated carriers include Cargolux and MNG Airlines.
- Combination Carriers (Passenger+Cargo Airlines): Combination carriers are airlines that operate both passenger flights and cargo services on the same aircraft. These carriers utilize the belly space of passenger planes to transport cargo alongside passenger baggage. Combination carriers offer a mix of scheduled passenger services and dedicated cargo services, providing a wider range of destination options and capacity flexibility. Many major airlines fall into this category, including Emirates, Lufthansa, and Turkish Airlines.

This paper is designed with the literature review about air cargo transport, methodology, analysis, and discussion of the results, and then finalized with the forecast of air cargo traffic between Türkiye and European countries. The paper aims to achieve the following objectives:

- Calculate the magnitude of air cargo transportation between Türkiye and Europe between 2012-2021.
- Reveal the airport pairs and describe their significance for the air cargo network.
- Find out which strategies are taken into account in the selection of these airports.
- Make future projections for important parts of the network.

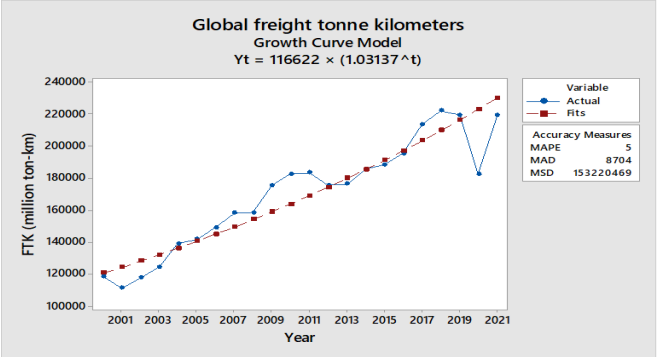

Figure 1. World FTKs between 2000-2021 (Source: The World Bank/ICAO)

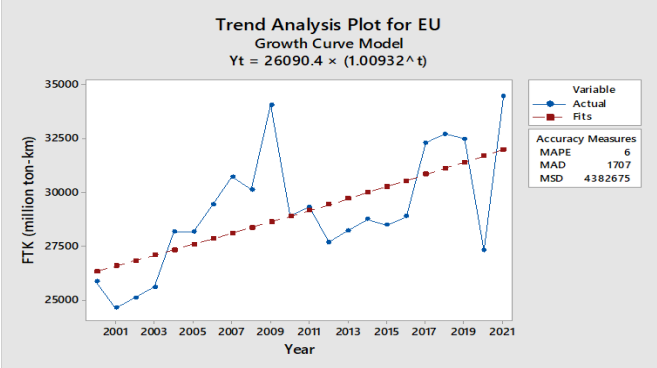

Figure 2. European Union FTKs between 2000-2021. (Source: The World Bank/ICAO)

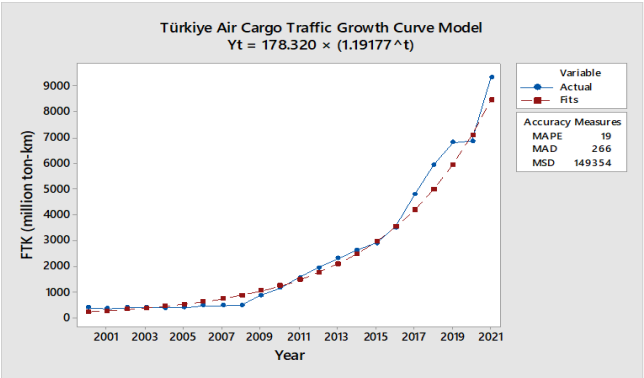

Figure 3. Türkiye's FTKs between 2000-2021 (Source: The World Bank/ICAO)

2. Literature Review

Airport network structures of the world (Guimera & Amaral, 2004), Italy (Guida & Maria, 2007), India (Bagler, 2008), USA (Xu & Harriss, 2008), China (Wang et al., 2011), Australia (Hossain & Alam, 2017), Argentina (Guillaumet, 2018), Spain (Trobajo & Carriegos, 2022), and Türkiye (Ersoz et al., 2022) were modeled and analyzed by using air passenger traffic data. On the contrary, Bombelli et al. (2020) brought a new perspective in analyzing the air transport network using air cargo data with complex network theory. Walcott and Fan (2017) compared the U.S. and Chinese air cargo network hubs by using FedEx and UPS data in the U.S. and air cargo data for the cities in China to reveal the strategically coupled airports and the characteristics of these hubs. Therefore, topology (degree distribution, average path length, clustering coefficient) and centrality measures (degree, betweenness, closeness) of the complicated airport networks have been revealed. The reasons behind the strategic decisions regarding the airport selection in air cargo transportation have not been investigated thoroughly yet. Moreover, although air cargo transport is a bigger business than ever before, it is still not as researched and valued as air passenger transport.

Zhou et al. (2019) proposed a metric to assess the weighted efficiency and robustness of air transport network. Wang et al. (2022) examined the robustness of air cargo network and represented node importance by considering topology and directionality of China's air cargo network and proposed a new model based on the TOPSIS method.

The development of air cargo transport demand was researched by using miscellaneous models and methods in different regions. Suryani et al. (2012) predicted air cargo demand in order to decide the airport terminal capacity expansion by using system dynamics simulation model. Totamane et al. (2014) forecasted air cargo demand on a given route of a specific airline to propose a new capacity plan by using Potluck Problem approach. Loaiza et al. (2017) estimated future air cargo demand in Colombia by using linear regression models and artificial neural networks. Alıcı and Akar (2020) determined the macroeconomic factors, which are GDP and inflation, having impact on air cargo demand by utilizing the panel data analysis method. Kasceev et al. (2022) forecasted the air cargo demand on five routes –two within Europe, two Europe-Asia, and one Europe-North America- by using Holt-Winter algorithm. Anguita and Olariaga (2023) predicted next 5-year demand of air cargo in Colombia using an artificial neural architecture approach, ConvLSTM2D model. Akinyemi (2023) searched the impacts of some variables on air cargo demand in four African Countries-

Egypt, Nigeria, South Africa, and Kenya- using cointegration and error correction modelling techniques. Karunathilake and Fernando (2023) identified key factors as airport and airline capacities, economic and market factors having impact on the air cargo demand growth in Sri Lanka case. Beside these studies on the development of air cargo demand for future projections; Chou et al. (2011) and Liu et al. (2020) had researches on forecasting air cargo volume. As seen from these researches, the nature of air cargo is so dynamic that demand and volume of air cargo have been studied to make more sound decision on capacity expansions of airports and facilities for the future projections.

There are plenty of factors and criteria having an impact on air cargo flows. Hwang and Shiao (2011) determined the factors having impact on international air cargo flows of Taiwan Taoyuan International Airport by using gravity model based on the panel data of scheduled air cargo routes. Oesingmann (2021) analyzed the determinants of air cargo flows and the role of multinational agreements by applying four different structural gravity models and concluded that Euro currency and Schengen membership had positive effect on air cargo flows. Aydın and Ülengin (2022) analyzed the domestic air cargo flows of Türkiye by applying gravity model to find the factors affecting the air cargo transport.

Air cargo transport has also significant impact on economic regional developments. Kasarda and Green (2005) modeled the factors, which are air service liberalization, corruption, and customs quality, to show the air cargo impact on economic development in 63 countries. While Brugnoli et al. (2018) studied the relationship between international trade and civil aviation from the Lombardy region in Italy to 30 European countries by applying a gravity-econometric model in the years 2004–2014, Allroggen and Malina (2014) investigated the role of air transportation in the regional economic development of Germany. Lakew and Tok (2015) searched the connections between regional economies and air cargo traffic at California's airports and attempted to estimate the socioeconomic determinants of air cargo traffic across California cities by using data from 2003 to 2009 on employment, wage, population, and traffic. The findings showed that the amount of outbound air freight is influenced by employment concentrations in both services and manufacturing. Zhou et al. (2022) searched the heterogeneous impact of air cargo on economic development by using manufacturing employment data in different Chinese cities between 2006 and 2019 and demonstrated that air cargo infrastructure development necessity in the interior cities was essential.

3. Methods

In this study, air cargo transportation between Türkiye and Europe is analyzed based on the air cargo weight data obtained from EUROSTAT for the 10-year period (2012-2021). Annual data was manipulated and processed by using R language and Minitab. With this aspect, this research is more of a descriptive and explanatory study.

Firstly, it has been determined which airports in Türkiye and Europe engage in cargo transportation. According to the FTKs, Türkiye's airports handling European cargo were ranked for the period 2012-2021. The total air cargo traffic between Türkiye and European countries was demonstrated. Then, European airports handling the largest cargo traffic with Türkiye were also revealed.

Secondly, air cargo traffic between 11 airports in Türkiye and 90 airports in Europe is tabulated and analyzed according to the weight of cargo transported. Thus, important airports in Europe for Türkiye have been revealed over the years and the 10-year change in the amount of cargo transported is presented on the basis of airport and route.

Finally, the reasons behind the selection of these airports in Europe and the change in cargo transportation within 10 years were investigated. As a result of this, a trend analysis was carried out to predict the course of cargo transportation between Türkiye and Europe in the following years. Forecasts for the years 2022 to 2024 were done using the exponential smoothing with trend adjustment method (Prolifidis & Botzoris, 2019).

4. Analysis and Discussion of Results

4.1. Turkish airports

Analysis of the cargo flow between Türkiye and Europe in the period of 2012-2021 reveals that 11 Turkish airports (İstanbul Atatürk, İstanbul, İstanbul Sabiha Gökçen, İzmir Adnan Menderes, Antalya, Tekirdağ Çorlu, Ankara Esenboğa, Eskişehir Anadolu University, Muğla Milas-Bodrum, Samsun Çarşamba, and Trabzon) are used for cargo transportation to Europe as seen in Figure 4.

Between 2012 and 2021, Istanbul Atatürk Airport ranked as Türkiye's top cargo hub cargo tonnage. The new Istanbul Airport started its operations in mid-2019 and the majority of the air cargo activities have moved from Atatürk Airport to the new Istanbul Airport, which has since begun operations and moved up to the second place in the ranking. Sabiha Gökçen, another airport in Istanbul, comes third in the list. The data indicates that Istanbul is Türkiye's air cargo hub. In this 10-year period, although other airports have been used for air cargo transportation in certain periods, they constitute a very small amount in terms of cargo weight.

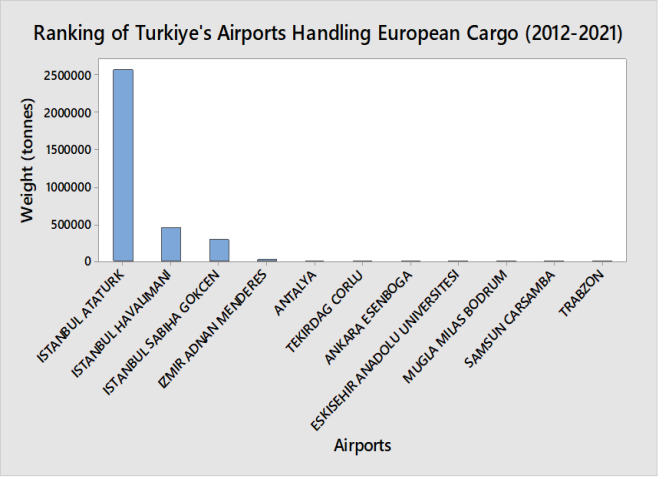

Figure 4. Türkiye's top cargo airports between 2012-2021

4.2. European countries

Figure 5 ranks the 31 European countries that engaged in air cargo transportation with Türkiye according to air cargo weight transported between 2012-2021. Germany was Türkiye's top air cargo partner country as the two countries have a long history of mutually beneficial economic and social relations. Germany was followed by the Netherlands, France, the United Kingdom, Italy, Belgium, and Spain. As seen in Figure 5, Türkiye had air cargo transportation even with the

smallest countries of Europe such as Latvia, Slovenia, Macedonia, Malta, Montenegro, and Slovakia.

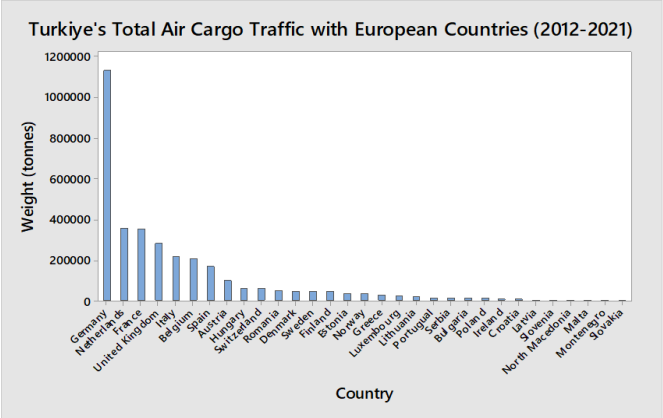

Figure 5. Türkiye's total air cargo traffic with European countries between 2012-2021

4.3. European airports

11 airports in Türkiye had air cargo transportation with 90 airports in 31 different European countries between 2012-2021. Figure 6 shows the breakdown of the European airports handling the largest air cargo traffic with Türkiye. Türkiye's airports had the busiest air cargo traffic with Frankfurt Airport (12.3%) in Germany which was followed by Paris Charles de Gaulle Airport (10%) in France. These two airports make up the 22.3% of Türkiye's European air cargo traffic. Both of these airports are known as cargo hubs in Europe and they are the home of major air cargo operators as well as freight forwarding companies. The third and the fourth airports in the ranking are Cologne (8.6%) and Leipzig (7.4%) airports. These two airports are integrator hubs serving DHL and UPS, respectively. Majority of the European integrator traffic flows through these hubs. The fact that three of the first four airports that operated air cargo transport with Türkiye are situated in Germany is the most notable finding here. These four airports were respectively followed by Maastricht Aachen (6.2%), London Heathrow (6.2%), Milano Malpensa (5.5%), Adolfo Suarez Madrid Barajas (4.8%), Liege (4.5%), and Amsterdam Schiphol (4.5%) airports. These 10 main airports constitute the 54% of Türkiye's air cargo traffic with Europe.

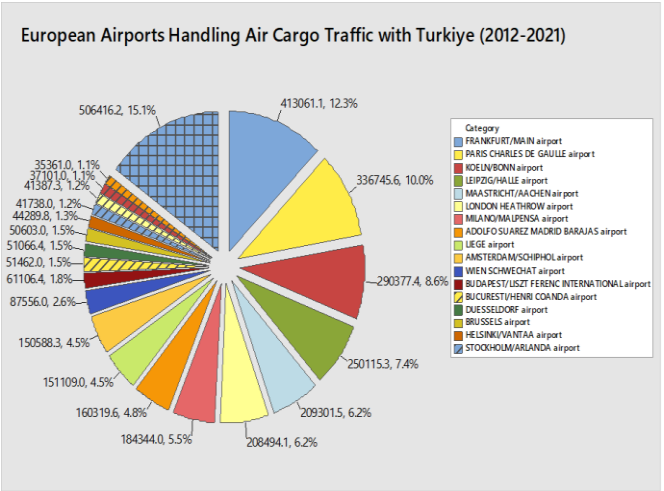

Figure 6. European airports handling the largest cargo traffic with Türkiye between 2012-2021

Figures 7 through 14 demonstrate the top cargo routes between Turkish and European airports for the years 2012 through 2021. With the UK's exit from the EU (known as Brexit) on 31 January 2020, EUROSTAT has excluded the data related to UK. For this reason, the incomplete 2020 data and the lack of 2021 data of UK airports appear as a constraint in our research.

4.4. Airport pairs

Atatürk Airport, being the busiest before 2021, offered routes to the main cargo hubs in Europe. By 2022, all of these routes had gradually switched from Atatürk to the new Istanbul Airport. Cargo flight operations from Atatürk Airport ended with Turkish Airlines Cargo's flight on 5 February, 2022 (FlyKargo, 2022). Although the passenger flights in 2019 and cargo flights in 2022 at Atatürk airport ended, it was the cargo hub of Türkiye during the examined period range and the cargo traffic was shown in Figure 7. Since Atatürk Airport was the main air cargo hub of Türkiye until 2018, the air cargo load transported gives an insight about which European airports have intensive air trade with Türkiye. It can be seen that the air cargo load carried between Frankfurt airport and Atatürk airport is approximately 1.5 times that of the second rank Cologne airport. From a country perspective, the fact that Germany's three airports—Frankfurt, Cologne, and Leipzig—are among the top four in the freight ranking demonstrates that Germany is Türkiye's main air cargo transportation partner.

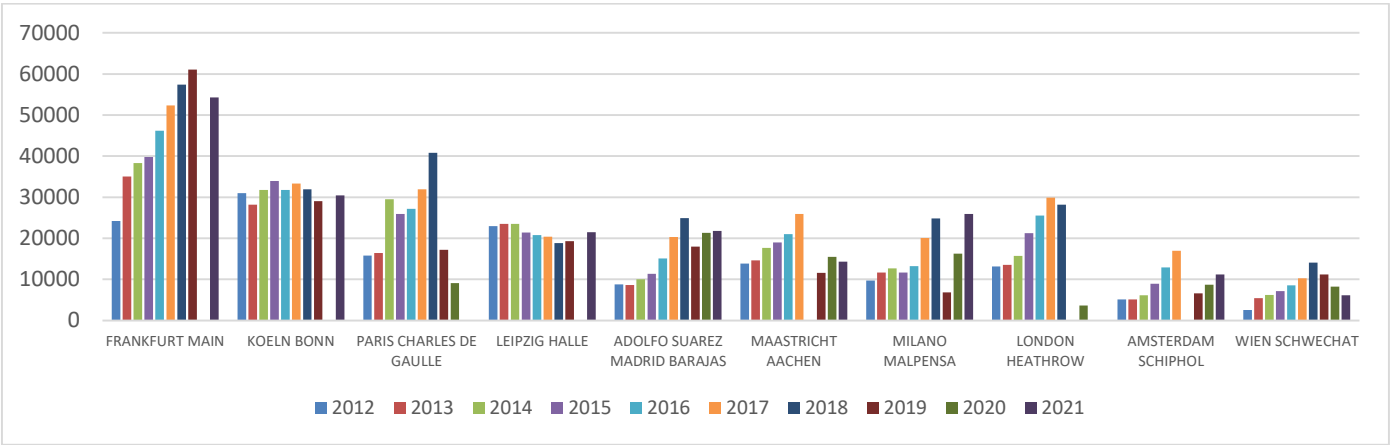

Figure 7. Top 10 European Origin/Destination of Atatürk Airport.

Istanbul Airport opened on October 29, 2018, but the complete transfer of passenger operations from Atatürk Airport was carried out on April 6, 2019. As the cargo terminal was not completed, Turkish Airlines, MNG, ULS and ACT's cargo planes continued to fly to Atatürk Airport. As of February 6, 2022, the cargo flights completely transferred to Istanbul Airport (Airline Haber, 2022). Figure 2 shows that the air cargo traffic of Istanbul Airport, where the hubs of Turkish Cargo and MNG Airlines, Türkiye's two main air cargo operators, are located (Brett, 2022). Integrators DHL and UPS are also based at this airport (IGA İstanbul Airport, 2023). The first airports, Schiphol, Heathrow, and Maastricht Aachen launched reciprocal cargo trade with Istanbul Airport as of 2018. Since Charles De Gaulle started to gradually transfer air cargo traffic since 2019 from Atatürk to İstanbul Airport and completely operated in 2021 before the Frankfurt, Cologne, and the other major airports, it was ranked first in terms of transported air cargo weight. Currently, Istanbul Airport serves as the main cargo hub in Türkiye.

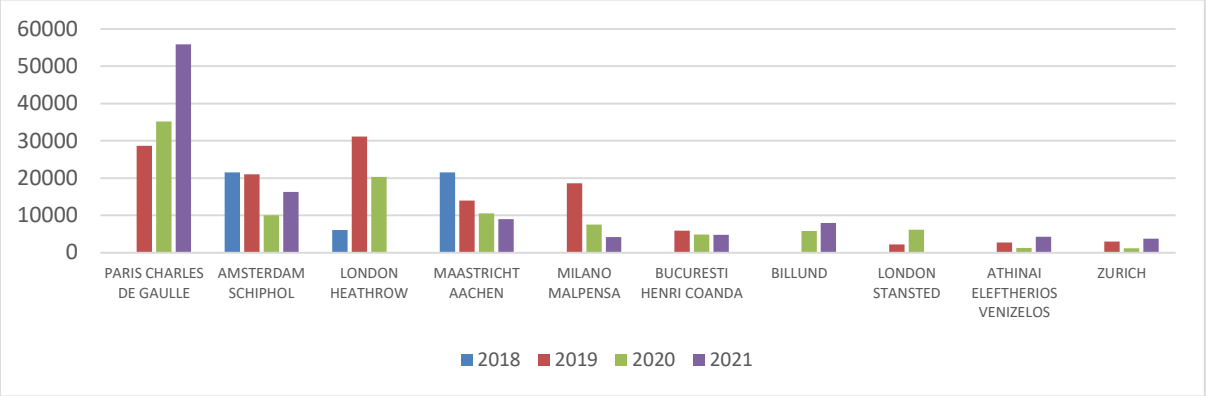

Figure 8. Top 10 European Origin/Destination of Istanbul Airport.

Figure 9 shows the air cargo traffic of Istanbul Sabiha Gökçen Airport. Figure 9 shows that Sabiha Gökçen airport is not truly an air cargo airport, but in recent years, airports in Europe, most notably Liege and Leipzig, have strategically preferred it because of its advantageous location and proximity to industrial districts. Sabiha Gökçen, the third largest air cargo hub of Türkiye in the period of research (currently the second cargo hub) has the busiest route with Liege airport. In order to strengthen their partnership and expand their economic potential, these two airports signed a strategic agreement. This route is served by TNT Airways using B767 wide body aircraft (Liege Airport Press Release, 2014). Another busy route of Sabiha Gökçen is with Leipzig which is flown by MNG Airlines feeding the hub of DHL. When Table 3 is analyzed, it is clear that Liege and Dusseldorf Airports have maintained a steady flow of air freight.

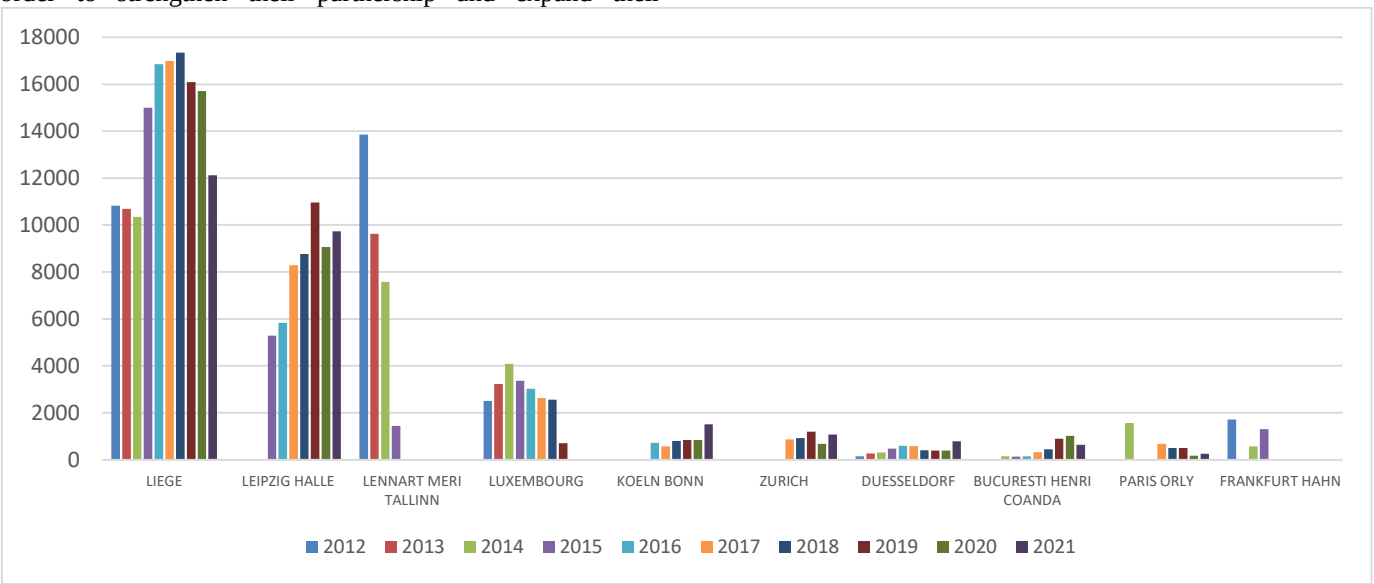

Figure 9. Top 10 European Origin/Destination of Istanbul Sabiha Gökçen Airport.

As seen in Figure 10, Izmir Adnan Menderes Airport does not have continuity in terms of cargo transportation. Limited amount of cargo was transported from various European airports over the course of several years even though there is a cargo terminal at the airport. It is interesting to note that in the 10-year evaluation, cargo transportation between Izmir Adnan Menderes and London Stansted Airport in the 2018-2020 period ranked first in the ranking. Because of the Brexit, the EUROSTAT excluded all UK airports data so 2021 year is blank for Stansted and Manchester airports. In 2023, Adnan Menderes Airport had cargo transportation with just Dusseldorf and Stuttgart Airports.

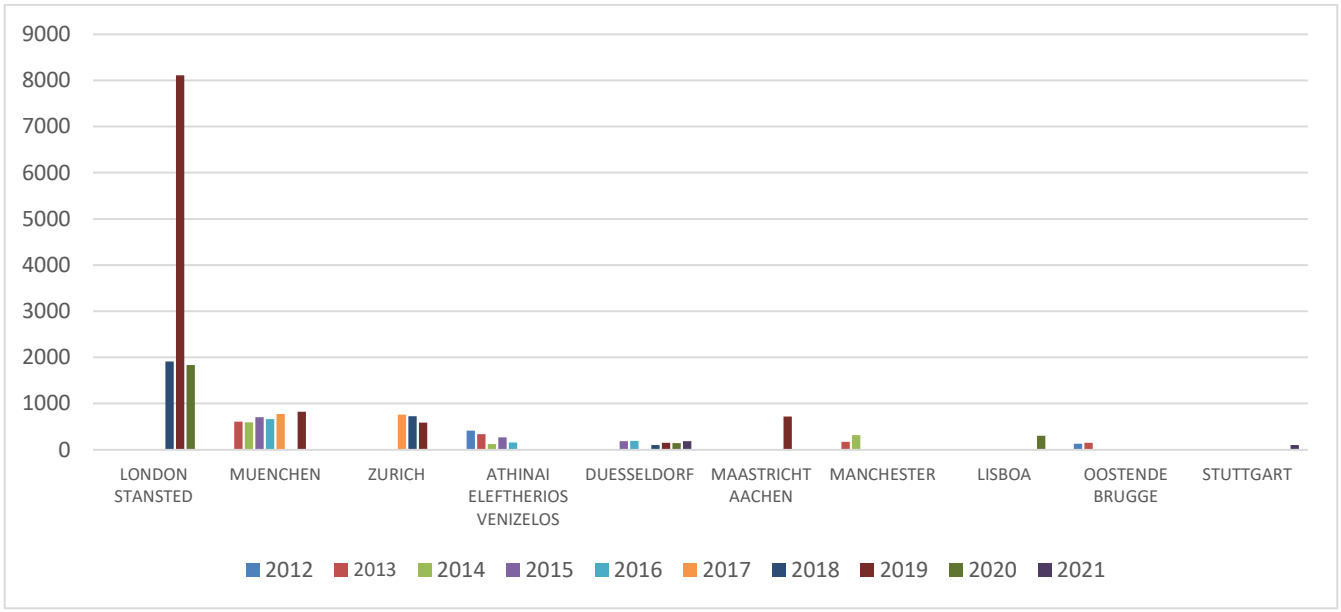

Figure 10. European Origin/Destination of Izmir Adnan Menderes Airport.

As seen in Figure 11, Antalya Airport didn't have any cargo transportation with European airports for the last two years of the research period.

When Figure 12 is analyzed, Ankara Esenboğa Airport had a little amount of air cargo transportation with just Dusseldorf Airport in 2021 for the last three years.

As seen in Figure 13, Tekirdag Corlu Airport had also insignificant amount of cargo transportation.

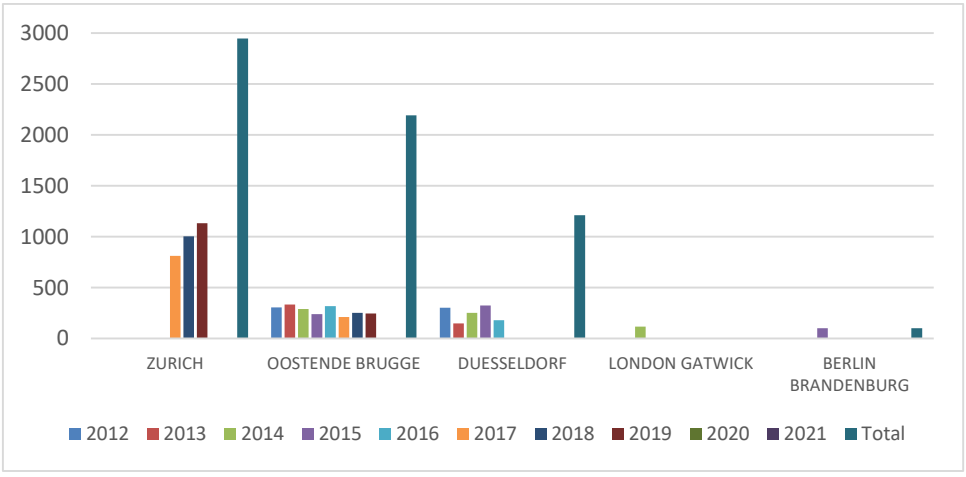

Figure 11. European Origin/Destination of Antalya Airport.

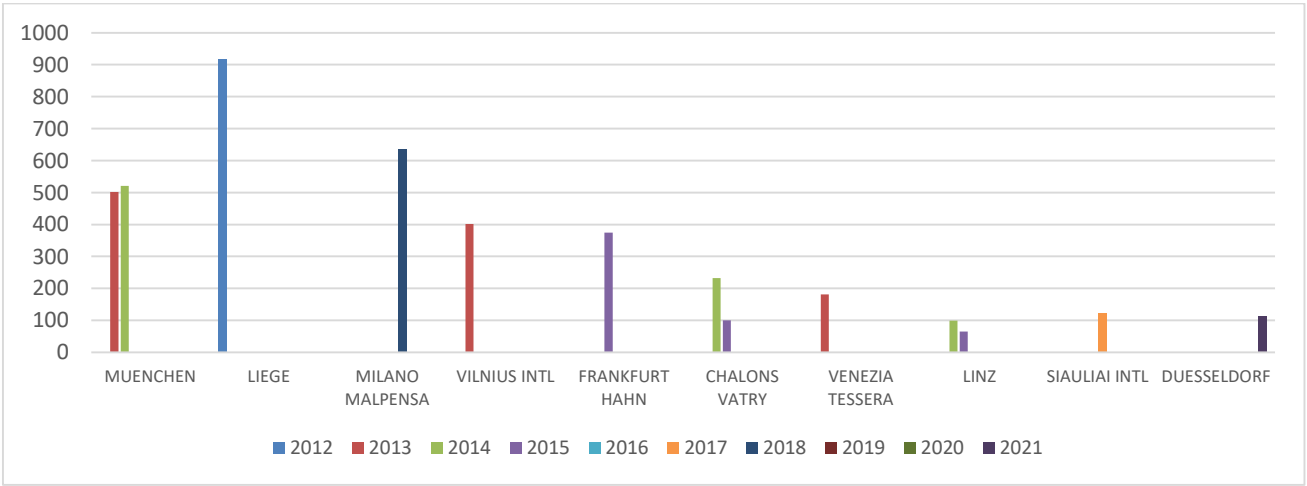

Figure 12. Top 10 European Origin/Destination of Ankara Esenboga Airport.

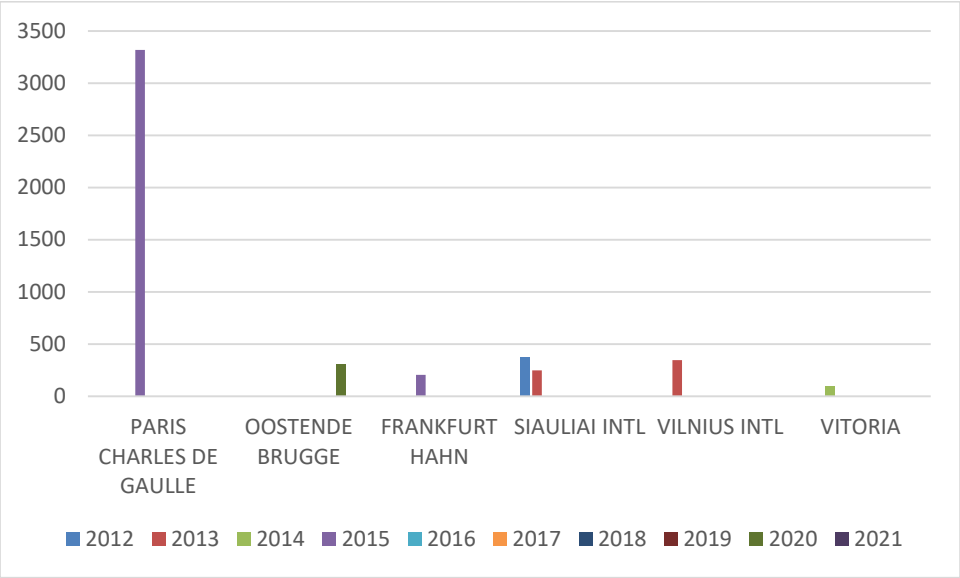

Figure 13. European Origin/Destination of Tekirdağ Corlu Airport.

Since the cargo transportation of the other four airports of Türkiye with European airports is trivial, it is shown in a single table. As seen in Figure 14, these airports had cargo transportation with just one different airport. As known very well, Eskisehir has ethnic charter passenger transportation with Belgium in summer seasons; thus, a cargo transportation has been carried out with Brugge airport since 2017. Milas-Bodrum airport hadn't had any cargo flights since 2017. Samsun Çarsamba and Trabzon airports had just one cargo transportation in the 10-year research period.

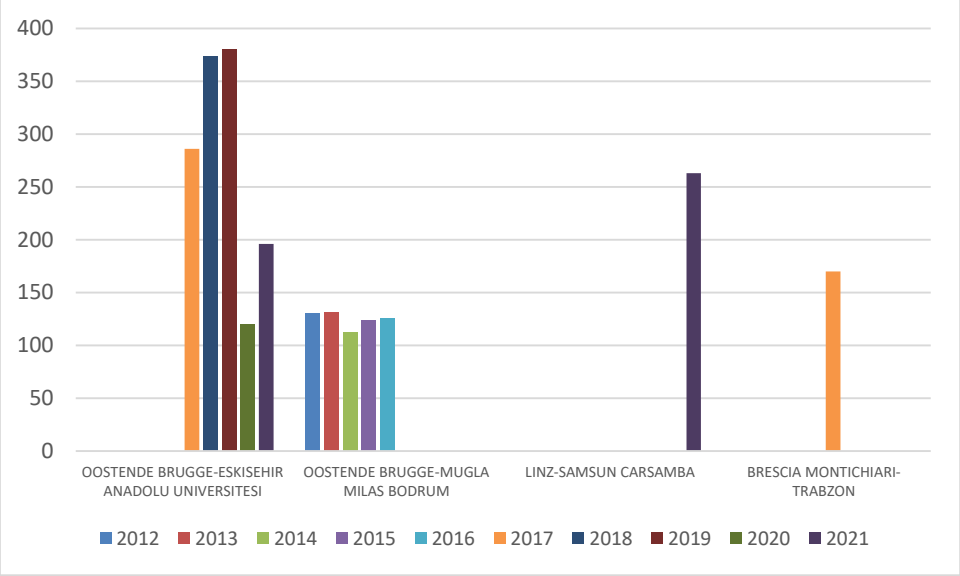

Figure 14. European Origin/Destination of the other airports.

When all tables are analyzed, Istanbul IGA airport emerges as Türkiye's strategic primary air cargo hub. Sabiha Gökçen might be considered as the secondary air cargo hub. The remaining nine airports in Türkiye were utilized for a few air cargo operations with various airports in Europe in different time periods; however, they cannot be counted as air cargo airports.

5. Challenges and Forecast of Air Cargo Traffic

5.1. Factors driving air cargo growth

Several factors contribute to the growth and facilitation of air cargo traffic between Türkiye and the European Union (EU). For instance, the EU-Türkiye Customs Union agreement promotes free trade, reducing trade barriers and facilitating the movement of goods. In addition, improvements in airport infrastructure, such as the expansion of Istanbul Airport, enhance the capacity for air cargo handling.

Technological advancements, such as digitization and electronic data interchange systems, streamline customs procedures improve efficiency and reduce transit times. Moreover, strong economic performance and increased consumer demand in both Türkiye and the EU drive the need for air cargo transportation to support trade flows, particularly for time-sensitive and high-value goods. However, certain factors can pose challenges to air cargo traffic between Türkiye and the EU. Changes in trade policies, such as the imposition of tariffs on specific goods, can disrupt established supply chains and affect air cargo volumes. Economic downturns, such as recessions or financial crises, reduce

consumer purchasing power and can lead to a decline in air cargo shipments. Capacity constraints at airports, especially during peak seasons, may limit the availability of cargo space for transportation. Political tensions or trade disputes between Türkiye and certain EU member states can create uncertainties, potentially impacting air cargo flows. Additionally, stringent environmental regulations aimed at reducing carbon emissions may impose additional costs on air cargo operators and necessitate adjustments in operational practices.

5.2. Three-year air cargo forecast

Forecast of the air cargo traffic between Türkiye and Europe is shown in Figure 15. Exponential smoothing with trend adjustment method was applied to the data to forecast 2022, 2023 and 2024 air cargo traffic. The lowest and highest weight transportation was also demonstrated with lower and upper confidence bounds. As can be seen in Figure 15, the trend shows that Türkiye's air cargo with European countries will continue to grow over the next three years.

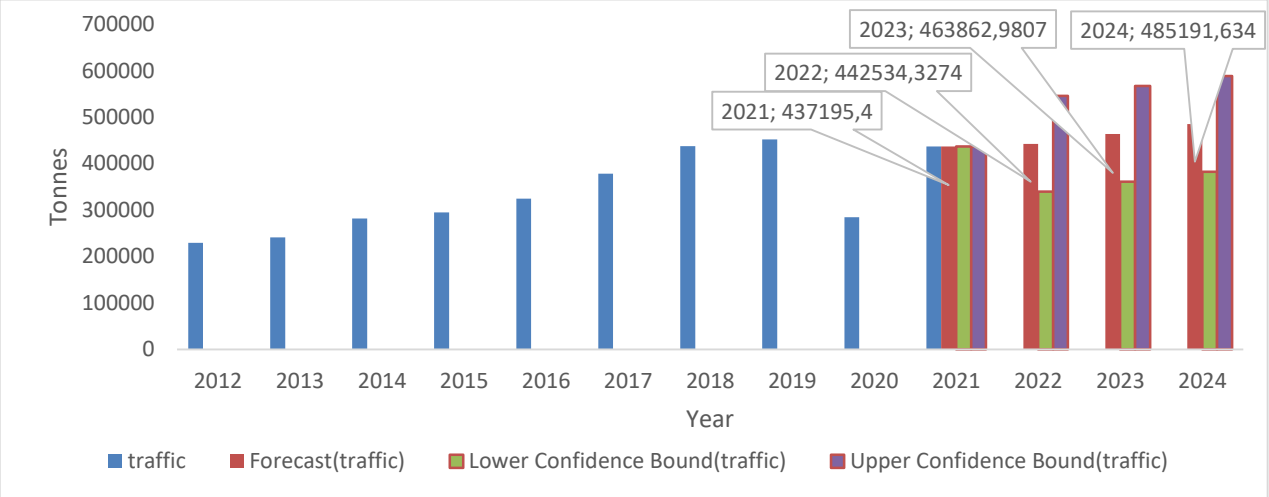

Figure 15. Forecast of Türkiye's air cargo traffic with all European countries.

A projection for the following three years (2022, 2023, and 2024) as shown in Figure 16 (a,b,c) was created using the same methodology for the top three countries (Germany, Netherlands, and France) with the most air cargo traffic with Türkiye. The thin vertical lines inside the bars in the Figure 8 (a,b,c) show the lowest and highest levels of the air freight transportation while the bars in the figures give the mean estimations.

Examining the mean estimate for air cargo traffic with Germany reveals that it is not realistic. Due to airport closures during the pandemic, there was significantly less air cargo transport in 2020, which causes the time series data to be disrupted. Since the drop is large in 2020, the standard error of the forecast is also significant. It is probable that due to the intense exports and imports with Germany, air cargo transportation will remain near its current level.

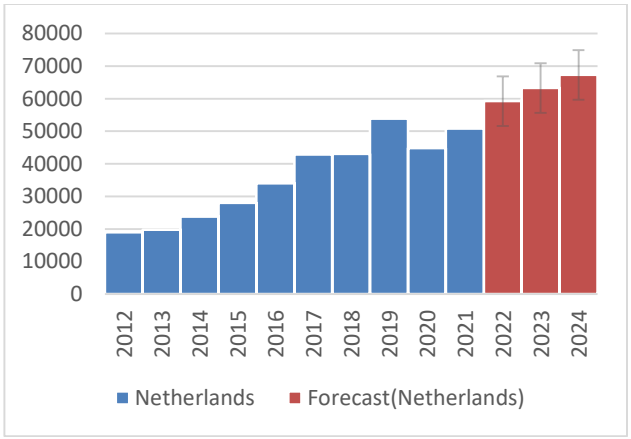

Figure 16 (b). Forecast of Türkiye's air cargo traffic with the Netherlands.

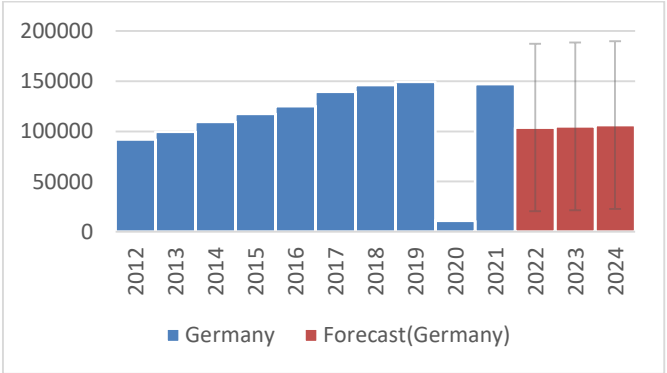

Figure 16 (a). Forecast of Türkiye's air cargo traffic with Germany.

When Figure 16 (b) and 16 (c) are analyzed, air cargo traffic with the Netherlands and France will increase slightly over the next 3 years.

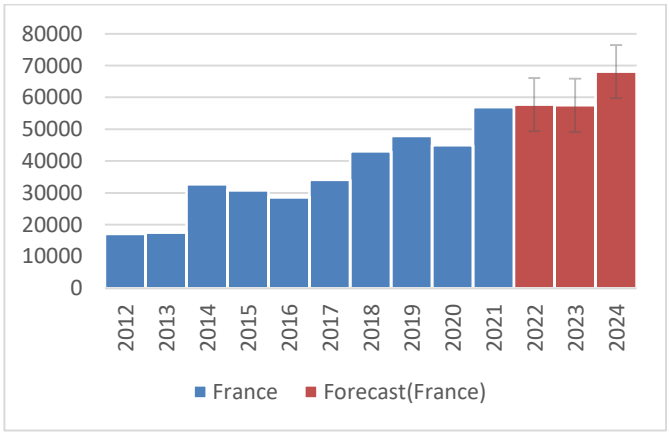

Figure 16 (c). Forecast of Türkiye's air cargo traffic with France.

6. Conclusion

This study has unveiled a decade-long narrative of air cargo transportation, spanning from 2012 to 2021, connecting 11 Turkish airports with counterparts across 31 diverse European nations. At the forefront of these interactions stands Germany, a natural leader in air cargo trade with Turkey, given their extensive trade relations. Following in rank were the Netherlands, France, the United Kingdom, Italy, Belgium, and Spain, reaffirming Turkey's widespread reach in the European market. Remarkably, even with lesser-known European nations like Latvia, Malta, and Montenegro, Turkey maintained a robust presence in the air cargo arena.

A closer examination of European airports involved in handling Turkey's air cargo traffic between 2012 and 2021 revealed that Frankfurt and Charles de Gaulle airports, accounting for 22.3% of Turkey's air cargo traffic, led the pack. These two aviation hubs were closely trailed by Cologne, Leipzig, Maastricht, London Heathrow, Milano Malpensa, Adolfo Suarez Madrid Barajas, Liege, and Amsterdam Schiphol, respectively. This top-tier decile collectively facilitated 54% of Turkey's air cargo exchange with Europe.

During this decade, Atatürk Airport assumed the mantle of Turkey's primary air cargo hub. However, this era came to a close on February 5, 2021, when Atatürk Airport handled its final cargo flight. The baton was officially passed to Istanbul Airport on February 6, 2021, marking a significant juncture in Turkish aviation history. Istanbul Airport, among the world's ten largest airports, took over the dual responsibilities of both passenger and cargo transport from Atatürk Airport.

Sabiha Gökçen Airport, though not conventionally a cargo-centric hub, metamorphosed into a strategically preferred gateway due to its proximity to industrial districts and advantageous geographical location. It established crucial agreements with various European airports, most notably Liege Airport, resulting in substantial cargo transit. This unique status enabled airports like Liege and Leipzig, not originally within the top 10 cargo destinations for Istanbul and Atatürk airports, to channel air cargo towards Sabiha Gökçen as part of a deliberate strategy.

Conversely, some Turkish airports such as Trabzon, Çarşamba, Milas Bodrum, Eskişehir Anadolu University, and Çorlu played peripheral roles, with sporadic regional usage and minimal cargo tonnage, rendering them inconsequential in the larger context of cargo transportation continuity.

Intriguingly, the study divulges that Turkey's air cargo sector exhibited resilience amid the pandemic. While the year 2020 witnessed a pronounced dip in traffic due to widespread airport closures, the subsequent year of 2021 bore witness to a recovery, marking a revival of pre-pandemic trends. Furthermore, forecasts painted a promising picture, indicating a continued upward trajectory in Turkey's air cargo industry, particularly concerning European routes.

In summation, this study underscores Turkey's enduring presence in the European air cargo landscape, resilient performance in the face of challenges, and a promising outlook for future growth in its air cargo sector.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Bibliometric Analysis of Sustainability in Civil Aviation

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RESEARCH ARTICLE

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Abstract

As air travel has become a crucial part of modern life, concerns about its environmental impact, economic sustainability, and social responsibility have significantly grown. Sustainability in this context refers to the delicate balance between current needs and future aspirations, taking into consideration environmental, economic, and social factors. The aviation industry is a substantial contributor to worldwide carbon emissions, and its ongoing growth poses a threat to exacerbate climate change. But it also has a crucial role in promoting economic growth and global connectivity. Achieving a balance between these competing interests necessitates a collaborative approach involving governments, industry stakeholders, academia and the general public. The sustainability viewpoint in the aviation sector, as well as the research carried out in this field, is of great significance in advancing the sector. The objective of this research is to identify and analyze publications regarding sustainability in the aviation sector within the SSCI and SCI-Exp databases. Suggestions for future research are proposed. The study includes a bibliometric analysis of 123 scientific articles published between 2001 and 2023. The findings reveal significant trends, influential authors and leading institutions in aviation sustainability research whilst also identifying gaps in the literature. Keyword analysis revealed recurring themes such as energy efficiency, emissions reduction, and life cycle assessment. These findings highlight the aviation industry's increasing dedication to sustainability and the necessity for further research and practical measures to ensure a more environmentally sustainable future for civil aviation.

1. Introduction

The aviation industry is currently facing a considerable challenge as it endeavors to balance progress and economic growth with the planet's finite resources (Kılıç et al., 2019). Because of extended global connectivity, air travel has transformed from being a luxury to acting as a critical facilitator of trade, tourism, and personal mobility (Bieger & Wittmer, 2006). However, the considerable growth of the aviation sector has raised concerns about its impact on the environment, economic sustainability, and social responsibilities. This challenge is vital and pressing. The aviation industry is responsible for a substantial amount of global carbon dioxide emissions, and its expansion trajectory risks exacerbating the effects of climate change (Scheelhaase and Grimme, 2007). At the same time, the industry is a crucial catalyst for economic growth, employment, and connectivity. Therefore, a considered and subtle approach is required to achieve sustainability (Darnhofer et al., 2010). Achieving this balance requires cooperation between governments, industry stakeholders, academia, and the public (Teo, 2002). As per the International Air Transport Association (IATA) (IATA, 2021), aviation was responsible for 2-3% of worldwide CO2 emissions in 2019. With the continued expansion of air travel, the reduction of these emissions has become imperative.

The economic size of the aviation sector can be determined by assessing its contribution to the global GDP. In 2019, research conducted by Boeing revealed that the aviation industry contributed approximately £2.7 trillion to the global economy, which accounted for around 3.6% of the world's GDP. This contribution includes direct and indirect economic activities associated with the aviation industry, comprising airline operations, aircraft manufacturing, and related services. [Source: Boeing, "Boeing's 2020 Global Environment Report"] In addition, the aviation sector has provided employment to millions of people worldwide (BOEING, 2020).

Sustainability, the fundamental concept of this article, concerns the equilibrium between current demands and future aspirations, guaranteeing the consideration of environmental, financial and social attributes in decision-making procedures (Scoones, 2007). Sustainability has gained worldwide importance due to challenges like energy and water scarcities, as well as the swift increase in global population confronted by communities worldwide (Tristanto et al., 2023). Sustainability involves a broader obligation to reduce emissions, alleviate noise pollution, guarantee fair access to air travel, and make beneficial contributions to nearby communities (Santa Boca et al., 2020).

Aviation significantly contributes to greenhouse gas emissions, mainly carbon dioxide (CO2). Academic studies

and reports have provided insights into the impact of aviation emissions.

According to the International Air Transport Association (IATA), the aviation sector was responsible for around 2-3% of global CO2 emissions in 2019. This estimate is based on data that considers fuel consumption and aircraft operation emissions (IATA, 2021). Apart from CO2 emissions, aviation releases pollutants and aerosols at high altitudes. Apart from CO2 emissions, aviation releases pollutants and aerosols at high altitudes. These substances have a more substantial warming impact than CO2 alone and are typically measured as radiative forcing. The Intergovernmental Panel on Climate Change (IPCC) estimates that aviation's total radiative forcing, including non-CO2 effects, can elevate its climate impact by roughly 1.9 to 2.7 times that of CO2 alone.

These proposals comprise the promotion of technological advancements like aircraft with greater fuel efficiency, air traffic management enhancements, together with the creation and implementation of ecological aviation fuels (IATA, 2021).

This study embarks on a bibliometric analysis, delving into the nuanced landscape of sustainability in civil aviation. By scrutinizing the existing body of literature, this research seeks to contribute significantly to the understanding of sustainable practices in one of the most dynamic and impactful sectors globally.

This study investigates various aspects of sustainability in civil aviation. Through examining environmental issues, analyzing existing regulation, and exploring innovations promoting sustainable practices (Wang et al., 2021), the intention is to provide a comprehensive overview of this dynamic field. The aim of this review is to evaluate the current situation and future potential of the industry. As environmental consciousness, legal obligations and consumer insistence on ethical behavior grows, the aviation sector must move towards sustainable practices to continue being pertinent and sustainable (Bettley et al., 2008). By examining the complexities of this endeavor, we can find ways to work together for long-term alterations that will have a positive effect on upcoming generations.

In addressing the existing gap in the literature, this study fills a crucial void by synthesizing scattered insights into a cohesive framework. The bibliometric analysis allows us to identify key thematic clusters, prominent contributors, and the evolution of research trends. In doing so, we aim to provide scholars, policymakers, and industry stakeholders with a consolidated reference that not only highlights the strides made in sustainability research in civil aviation but also pinpoints avenues for future exploration. This research thus serves as a valuable resource for steering the trajectory of sustainable practices in the aviation industry and enriching the existing discourse with a quantitative perspective.

2. Sustainability

The concept of sustainability entails proactively considering the requirements of future generations (Kucukyilmaz et al., 2009) while also satisfying the current generation's needs (Kazemi et al., 2023). Sustainability has emerged as a crucial global problem, triggering a host of sectors to review their ecological impact (Zia et al., 2021). Given the aviation industry's substantial carbon footprint and resource utilization, it has become a critical topic for attaining sustainability objectives (Becken & Patterson, 2006).

Numerous studies have highlighted the significant environmental impacts of aviation, particularly with regard to greenhouse gas emissions, noise pollution, and air quality degradation (Timmis et al., 2015). Such impacts have amplified the scrutiny of the aviation industry's contribution to the global environmental challenges. While the sustainability efforts of aviation are commendable, challenges still exist. The adoption of novel technologies and fuels necessitates considerable capital and infrastructure alterations (McManners, 2016). Striking a balance between environmental objectives and economic deliberations presents a convoluted trade-off between airlines and the government (Gössling et al., 2020). Moreover, the Coronavirus disease outbreak has impeded and expedited green initiatives, exposing the frailty and adaptability of the industry (IATA, 2021). The aviation sector is increasingly acknowledging its role in carbon emissions. As per the International Air Transport Association (IATA) (IATA, 2021), aviation was responsible for 2-3% of worldwide CO2 emissions in 2019. With the continued expansion of air travel, the reduction of these emissions has become an imperative.

The literature underscores the urgency of addressing aviation's environmental impact in the context of global sustainability goals. While challenges persist, the industry's ongoing efforts, innovative technologies, and collaborative approaches demonstrate a commitment to creating a more sustainable future for aviation.

3. Sustainability Systems in Aviation

Aviation, a fundamental aspect of global connectivity and economic development, faces mounting pressure to address its negative environmental impact. As apprehensions about climate change heighten, the aviation sector is actively implementing sustainability systems to decrease its environmental footprint while maintaining its crucial international role in transportation and commerce. Numerous undertakings have been established to enhance aviation's sustainability. These factors entail the implementation of greener aviation technologies such as fuel-efficient planes, cutting-edge aerodynamics and propulsion systems, and the accommodation of alternative fuels like biofuels (Ng et al., 2021). Furthermore, airlines and airports are stepping up their game by adopting more efficient operational practices that reduce wastage and energy usage. This involves designing energy-efficient terminals, installing solar power systems, and providing sustainable ground transport options like electric shuttles (Airport Council International (ACI), 2023). Sustainable airport operations aid in reducing the carbon footprint of air travel. Alternative fuels, especially biofuels and sustainable aviation fuels (SAFs), are becoming cleaner alternatives to conventional jet fuels. SAFs have the potential to considerably reduce carbon emissions over the life cycle (IATA, n.d.). For example, such as Turkish Airlines and United Airlines, have started to implement SAFs in their operations.

Advancements in airplane technology have been influential in sustainability endeavors. In an effort to be more fuel-efficient and environmentally friendly, manufacturers are still developing aircrafts. The 787 Dreamliner by Boeing, for instance, employs inventive materials and aerodynamics to lessen fuel consumption and emissions (BOEING, 2020).

Aircraft operations produce substantial noise pollution, which impacts communities situated close to airports. The Federal Aviation Administration (FAA) acknowledges prolonged exposure to aircraft noise can cause harmful health impacts, including stress and sleep disruption. Addressing noise pollution is a social, public health, and environmental responsibility. Furthermore, aircraft emissions lead to the deterioration of air quality. Emissions of nitrogen oxides

(NOx) and particulate matter in the vicinity of airports can intensify air quality challenges in densely populated regions (EPA n.d.). This underscores the necessity for comprehensive sustainability measures to lessen the aviation sector's ecological footprint.

3.1. Sustainability Initiatives

Achieving sustainability in aviation necessitates collaboration among stakeholders, such as governments, airlines, manufacturers, and research institutions (Zieba et al., 2022). Partnerships play a pivotal role in expediting innovation, exchanging best practices, and promoting systemic change.

One of the most pivotal sustainability initiatives in aviation is the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) (ICAO 2023). Implemented by the International Civil Aviation Organization (ICAO), CORSIA seeks to limit aviation emissions by 2020 with an offsetting scheme. This international accord is a momentous stride towards attaining worldwide carbon neutrality in aviation. Regulatory framework: International organizations such as the International Civil Aviation Organization (ICAO) play a vital role in establishing regulatory frameworks to address the environmental impact of aviation. The technical terms used will be explained when first used. One such mechanism aimed at reducing the sector's carbon emissions is the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) (Amaeshi et al., 2006; ICAO, 2023).

International Civil Aviation Organization (ICAO): No changes needed. The ICAO is a major authority in shaping global standards and regulations for aviation sustainability. Its objective is to reduce the net carbon emissions of international aviation, and it is presently developing technical standards for aircraft in order to meet these targets (ICAO, n.d.).

Environmental Protection Agency (EPA): In the United Kingdom, the Environmental Protection Agency (EPA) plays a crucial part in regulating aircraft emissions and noise. The EPA establishes emissions standards and collaborates with the FAA to reduce the aviation industry's environmental impact (EPA, n.d.).

4. Method

4.1. Research Model

In a time when there is a growing concern about environmental impact, social responsibility, and economic stability, the aviation industry has become a crucial intersection of sustainability dimensions (Ranjbari et al., 2021). As demand for air travel continues to rise, it is now essential for the civil aviation sector to scrutinize and implement sustainable practices. This study aims to provide an objective analysis of sustainability in civil aviation by examining the environmental, social, and economic aspects of sustainability within the sector. The objective is to clarify the factors that influence sustainability in civil aviation and their impact on industrial performance. The following research model strives to serve as a well-organized framework to scrutinize these complex associations and furnish noteworthy perspectives for aviation stakeholders, policymakers, and researchers.

The data was acquired from the Web of Science (WoS) database on 31st August 2023 by searching for the keyword block "sustainability" and "aviation" and undergoing a filtering process. The filtering process only took into account English-language articles indexed in SSCI and SCI-Exp. A total of 123 academic articles that met these criteria were identified.

4.2. Research Universe

The 123 articles obtained cover the years 2001 to 2023. Over the period between 2022 and 2023, 26 and 14 articles respectively were accepted for publication and included in the research as they are going through the early access process. Because the assignment of the articles to a specific issue after acceptance for publication in indexed journals can take approximately 2-3 years, the articles were published in early visibility to make the authors' work available without delay. These articles appeared in 57 journals. There were 5,708 references to publications in the articles. Table 1 displays basic information on the articles included in the research pool.

Table 1. Article Data

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2001:2023
Sources (Journals, Books, etc)	57
Documents	123
Annual Growth Rate %	12.74
Document Average Age	3.92
Average citations per doc	10.62
References	5.708
DOCUMENT CONTENTS	
Keywords Plus (ID)	313
Author's Keywords (DE)	568
AUTHORS	
Authors	339
Authors of single-authored docs	16
AUTHORS COLLABORATION	
Single-authored docs	18
Co-Authors per Doc	3.28
International co-authorships %	18.7
DOCUMENT TYPES	
Article	97
Article; Early access	3
Article; Proceedings paper	4
Editorial material	5
Proceedings paper	4
Review	9
Review; Early access	1

4.3. Analysis of Data

As scientific research increasingly relies on data, the availability and interpretability of this data have become essential components of the scientific process. Importantly, transitioning from raw or retrieved data to usable information presents a significant challenge. As with other fields, bibliometric analysis workflows involve multiple distinct stages, each of which utilizes software tools (Guler et al., 2016).

Bibliometric analyses are easier to conduct and require less effort using web services and software specifically designed for this purpose. Many databases containing citation data are available online. The foremost publishers of such databases, including Clarivate Analytics and Elsevier, advertise their products, such as the Web of Science (WoS) and Scopus, through online and in-person seminars aimed at increasing the number of expert users. It is worth noting that the number of articles dedicated to bibliometric analysis has quadrupled since 2000 (Gureyev et al., 2013).

The R 4.3.1 software package was utilized for data analysis. This open-source program offers researchers a complimentary platform for research and analysis and includes numerous add-

ons for further development. To conduct the bibliometric analysis, we utilized the sub-plugin named bibliometrix within the R program and analyzed data.

5. Findings and Results

Researchers have used different qualitative and quantitative literature review methods to understand and organize previous research. Bibliometric analysis, which depends on statistical measurement of science, scientists, or scientific activity, is one method that has the potential to introduce a precisely defined, transparent, and replicable review process. Compared to other approaches, bibliometrics provides impartial and dependable analyses. The profusion of novel information and conceptual advances, coupled with data, establishes a milieu in which bibliometrics can prove advantageous. It facilitates the methodical appraisal of extensive amounts of data, thereby rendering possible the identification of trends that become discernible over prolonged periods, the detection of shifts in disciplinary divisions, the recognition of influential scholars and institutions, and the presentation of comprehensive research (Aria et al., 2017).

In this context, a comprehensive analysis has been carried out on the yearly rate of article publications, top journals and authors concerning publications, citation counts, keyword usage, and publication status, classified by country. Table 2 displays the yearly distribution of published articles.

Table 2. Distribution of Articles by Year

Year	Articles	Year	Articles
2001	1	2013	2
2002	-	2014	3
2003	-	2015	5
2004	-	2016	7
2005	-	2017	3
2006	-	2018	10
2007	-	2019	10
2008	-	2020	12
2009	1	2021	20
2010	-	2022	26
2011	1	2023	14
2012	8		
Total			**123**

The first publication regarding sustainability in aviation was issued in 2001. Although the number of publications has fluctuated in subsequent years, there was a significant rise in 2022, with 26 articles published, comprising 21% of the total publications recorded to date. Since the outbreak of the pandemic, increased environmental awareness and a desire for more efficient resource utilization have heightened interest in sustainable aviation.

The 123 scholarly articles used in this study were published in 57 journals. Table 3 displays the magazines with the greatest amount of publications.

Table 3. Journals with the Highest Number of Publications

Journals with the Highest Number of Publications	Articles
International Journal of Sustainable Aviation	14
Sustainability	14
Transportation Research Record	8
Energy	5
Journal of Air Transport Management	5
Energies	4
Journal of Cleaner Production	4
Technology in Society	4
Aerospace	3
Frontiers in Energy Research	3

The International Journal of Sustainable Aviation and Sustainability boasts the largest number of publications (14). IJSA covers a variety of aviation topics with a focus on environmental concerns and sustainability. Sustainability is a cross-disciplinary, peer-reviewed, open-access journal that investigates the environmental, cultural, economic, and social sustainability of humankind. It offers a demanding forum for research on sustainability and sustainable development and is accessible bi-monthly online via MDPI. Of all the papers published, 64 were submitted by the top ten journals, constituting 52% of the overall total. The data was classified and streamlined for research purposes using Bradford's scatter law. The resulting index, categorized by Bradford's scatter law, is outlined in Table 4.

Articles were collected from three distinct regions in accordance with Bradford's Scatter Law. The initial four journals, acknowledged as core sources, accounted for 33% of the cumulative publications. The h-index has been advocated as a simple method to objectively evaluate the scientific accomplishments of researchers and has become a commonly used metric for scientific productivity (Hirsch, 2005). The h-index measures the number of an author's articles (h) that have had at least h citations, in relation to the number of publications and their impacts (Engqvist et al., 2008).

Table 4. Spread Table. According to Bradford Scattering Law

Rank	Journal Name	Freq	cumFreq	Zone
1	International Journal of Sustainable Aviation	14	14	Zone 1
2	Sustainability	14	28	Zone 1
3	Transportation Research Record	8	36	Zone 1
4	Energy	5	41	Zone 1
5	Journal of Air Transport Management	5	46	Zone 2
6	Energies	4	50	Zone 2
7	Journal of Cleaner Production	4	54	Zone 2
8	Technology in Society	4	58	Zone 2
9	Aerospace	3	61	Zone 2
10	Frontiers in Energy Research	3	64	Zone 2

The g-index was developed to address issues with the h-index, specifically when assessing worldwide citation impact. is considered more effective than the h-index for assessing precise scientists, as they typically have a higher g-index/h-

index ratio and rank better in g-index assessments. Current research indicates that these measures are not interchangeable, but instead complement one another (Costas et al., 2008). As the m-index is adjusted for age, it may be beneficial in forecasting future accomplishments, which is pertinent within this context. The m-index may serve as a quantifiable measure of "research excellence," while additionally assessing age-related factors not captured by the h-index (Von Bohlen et al., 2011). Sustained productivity is a requisite for the m parameter's relevance, as opposed to the h parameter, which measures overall impact and may evolve post-publication (Hirsch, 2005). Table 5 presents data on the h/g/m indices of the journals where the articles were published.

Table 5. h/g/m Indexes of the Journals

Journal	h	g	m	TC	NP	PY
Energy	5	5	0.455	305	5	2013
Sustainability	5	9	0.833	93	14	2018
International Journal of Sustainable Aviation	4	5	0.444	35	14	2015
Journal of Cleaner Production	4	4	0.571	112	4	2017
Technology in Society	4	4	0.8	40	4	2019
Journal of Air Transport Management	3	5	0.3	82	5	2014
Renewable & Sustainable Energy Reviews	3	3	0.3	46	3	2014
Sustainability Accounting Management and Policy Journal	3	3	0.25	76	3	2012
Aviation	2	2	0.222	11	2	2015
Journal of Environmental Management	2	2	0.087	46	2	2001

Energy ranks highest due to its high number of citations. While the second and third ranked journals have published more papers, their citations are relatively low, resulting in their placement below Energy. The remaining journals are ranked by their h-indices. Energy's popularity among authors publishing in Turkiye has contributed to its top position. Table 6 displays the author productivity details. Details on author productivity can be found in Table 6.

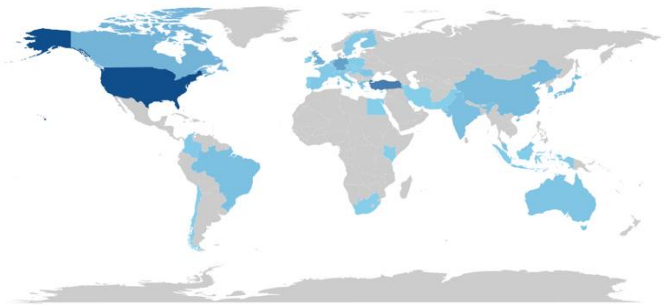

Figure 1. Top Broadcasting Countries

As the blue color in the figure becomes darker, the broadcasting country's effectiveness increases. The grey areas in the map represent no progress. Figure 1 illustrates the distribution of corresponding authors by country.

Table 6. Author Productivity Distribution

Authors	Articles	Articles Fractionalized
Rice S.	9	2.83
Yilmaz A.K.	3	2.50
Sohret Y.	3	2.20
Turan O.	4	1.75
Winter S.R.	5	1.58
Akdeniz H.Y.	2	1.50
Dwivedi P.	5	1.37
Cremer I.	4	1.33
Balli O.	3	1.33
Markatos D.N.	3	1.33

When assessing author productivity, the number of co-authors and publications are the primary focus. Although it can be contended that works with only one author have a higher article contribution rate. Notably, Ayse Kucuk Yilmaz from Turkiye is at the forefront of author productivity. Institutions with the highest number of publications, based on the affiliations of their authors, are listed in Table 7.

Table 7. Institutions that Publish the Most Articles

Affiliation	Articles
University of Georgia	7
Anadolu University	7
Embry-Riddle Aeronautical University	6
Delft University of Technology	5
University System of Georgia	5
Florida Institute of Technology	4
University of Helsinki	4
Washington State University	4
Florida Institute of Technology	4
Hiroshima University	3

One Turkish university features in the list of the most productive publishing bodies. Turkish scholars face challenges in gaining recognition in academia as their publications often have numerous co-authors and low citation rates. Please refer to Table 7 for a graphic illustration of country-wise publications.

Table 8. Distribution of Articles by Countries of Corresponding Authors

Country	Articles	SCP	MCP	Freq	MCP_ Ratio
USA	29	26	3	0.236	0.103
Turkiye	19	17	2	0.154	0.105
Canada	8	7	1	0.065	0.125
United Kingdom	8	7	1	0.065	0.125
Germany	6	6	0	0.049	0
Greece	5	5	0	0.041	0
China	4	3	1	0.033	0.25
Netherlands	4	2	2	0.033	0.5
Australia	3	3	0	0.024	0
France	3	0	3	0.024	1

An examination of the articles reveals that the United States generated the largest number of publications, numbering 29 out of 123. Of these, 26 were authored exclusively by Americans (SCP), whilst 3 were partnerships with foreign authors. Publications solely written by Americans constitute 23.5% of the overall corpus, while the authors from Turkiye's contribution to world literature is estimated to be at 15.4%.

Figure 2. Word Cloud for Keywords

The significance of a country's contribution to world literature is based not only on the quantity of articles, but also on their citation rates. Table 9 displays the number of citations received by each country.

The quantity and quality of an article can be evaluated based on its received citations. A higher number of citations suggests more prestige within the scientific community. In our country, 19 works have been published, and Turkiye has received the most citations. This indicates that we are among the leading countries in this category.

Table 9. Total Number of Citations by Countries

Country	TC	Average Article Citations
Turkiye	289	15.20
USA	242	8.30
United Kingdom	125	15.60
France	108	36.00
Croatia	97	97.00
Greece	92	18.40
Canada	74	9.20
China	46	11.50
Germany	42	7.00
Brazil	35	17.50

Analyses based on keywords are a crucial indicator for identifying prominent themes in research. This approach enables identification of missing areas in the literature and connections between variables. Any frequently used keywords are included in Table 10 for reference.

Table 10. Most Repeated Keywords

Words	Occurrences
Energy	15
Aircraft	12
Emissions	11
Life-Cycle Assessment	10
Efficiency	9
Impact	9
Performance	8
Sustainability	8
Design	7
Corporate Social-Responsibility	6

Out of a total of 313 terms, 15 were categorized as "energy," 12 as "aircraft," and 11 as "emission." Technical vocabulary is generated by creating a word cloud in literature, particularly to capture the reader's attention. It can be argued that the word cloud is more beneficial due to its impact on visual representation and facilitating comprehension for the reader. The word cloud created is displayed in Figure 2.

The graph showing the change in expressions in the Word cloud over the years is shown in Figure 3.

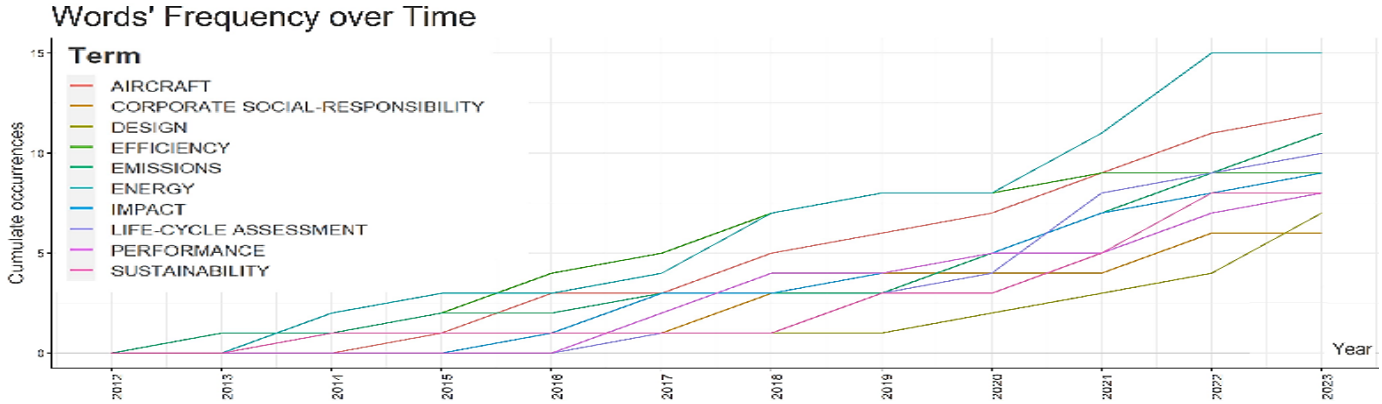

Figure 3. Cumulative Change of Keywords by Years (X axis: Year, Y axis: Cumulative Occurrences)

As can be seen from the graph created the need for sustainability in energy has increased rapidly in recent years.

6. Conclusion

The aviation industry is in a critical phase where sustainability considerations intersect with environmental impact, social responsibility, and economic stability. This analytical study aims to provide a comprehensive view of sustainability in civil aviation, encompassing its multifaceted dimensions: environmental, social, and economic sustainability. The research model created for this objective serves as a structural framework to comprehend the intricate relationships and implications for industry performance, providing significant perspectives for aviation stakeholders, policymakers, and researchers.

This research model aims to serve as a framework for analyzing sustainability in civil aviation. Technical term abbreviations are explained upon first use. The focus is on identifying underlying factors that shape sustainability practices in the sector and evaluating their impact on the industry. The complex relationships that underpin sustainability are investigated in a clear and concise manner. The language is objective and formal, avoiding filler words and ornamental language. The structure is logical and balanced, with causal connections between statements. The text is free from grammatical, spelling, and punctuation errors. The ultimate objective was to offer valuable insights that can guide not only aviation industry stakeholders but also policymakers and researchers who have a shared interest in the sustainable growth of air travel.

Data analysis was carried out utilizing a bibliometric technique and a dataset of 123 academic articles collected from the Web of Science database. The dataset spanned the period from 2001 to 2023, with a noteworthy spike in publications noted in 2022. This surge indicates an amplified focus on sustainability issues in the aftermath of the pandemic. These publications were distributed across 57 different journals, with the International Journal of Sustainable Aviation and Sustainability being the highest contributor.

The evaluation of h-index, g-index and m-index for the journals showed varying degrees of impact and selectivity, providing a nuanced perspective on their research excellence and output. Moreover, the study identified notable authors and institutions, emphasizing their relevance in the discourse on sustainability in civil aviation, and highlighted their productivity. Ayşe Kucuk Yılmaz from Turkiye was identified as a noteworthy contributor to the discourse, highlighting the influence of individual researchers in shaping the field. Moreover, publishing powerhouses such as the University of Georgia and Anadolu University demonstrated their commitment to sustainable aviation research. A country-specific analysis unveiled the crucial role played by the United States. It produced the greatest quantity of publications, including a noteworthy amount of solitary author articles.

In the interim, Turkiye distinguished itself through its notable average citation rate of articles, showcasing the excellence and influence of its contributions to the global dialogue on aviation sustainability. Through analyzing keywords, the crucial themes addressed in the literature were identified, specifically "energy," "aircraft," "emissions," and "life-cycle assessment." These terms emphasize the industry's concentration on energy efficiency, emission reduction, and sustainable design. To conclude, this research underlines the increasing importance of sustainability in civil aviation. This is demonstrated by the expanding research in this field and establishes a foundation for further investigations. It will assist stakeholders in recognizing trends, influential actors, and important areas for exploration. The findings of the study improve the understanding of sustainability challenges and opportunities within the aviation industry, promoting policies and practices for greater environmental sustainability in this significant sector.

In conclusion, this bibliometric analysis has revealed the complex nature of sustainability in civil aviation, while confirming the importance of our research goals and policies. Our study was initiated with a dedication to creating a well-structured comprehension of sustainability in the aviation industry, utilizing the distinct perspective of bibliometric analysis.

Our pursuit of identifying thematic clusters, influential contributors, and evolving research trends aligns with a broader policy framework. This exercise was not merely academic. The primary goal was to inform stakeholders in the civil aviation industry, policymakers, and researchers about the current state of sustainability discourse and to provide strategic insights for the future.

Upon revisiting the core tenets of this study, it is apparent that the meticulous bibliometric methodology has been a sturdy underpinning for accomplishing our objectives. Our addition of a quantitative viewpoint to complement extant qualitative inferences has significantly expanded the scope of research on sustainability in civil aviation.

Nevertheless, it is imperative to emphasize that our policies go beyond the boundaries of academia. The integration of fragmented information into a coherent structure is not a goal but a tool to spur significant measures. Hence, the research's final statement must exhort prompt action-urging concerned parties to harness the identified developments, take advantage of the nascent research areas, and collaboratively direct the course of environmentally sound practices in the aviation sector.

Essentially, our research transcends the constraints of this paper and invites collaborative efforts, informed decision-making, and an unwavering dedication to sustainability principles. As we conclude this bibliometric expedition, let it serve as a driving force for unceasing exploration, innovation, and deliberate policymaking in the ever-changing realm of civil aviation sustainability.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare no potential conflict of interest concerning the publication of this paper.

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Unit Root Tests of Airline's Stock Returns Considering Alliances

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Abstract

The purpose of this study is to make a unit root analysis of the stock return time series of 18 air carrier companies due to alliance membership in this paper because of the importance of the unit roots in the detection of time-related matters. Five important unit root tests, which can be classified as Fourier or classical utilized. According to the findings, there is no unit root in the stock return series regardless of airline alliances but there are differences on a regional basis depending on the test and test power, specific Asian airlines stocks' return series show linearity. These results will shed more light on the efficient market hypothesis on aviation management in the next research.

1. Introduction

Finance was the art of money management at the beginning of this century. But, after the statistical explanations of Markowitz and especially after Fama's great contribution "Efficient Market Hypothesis", it became a knowledge-based science. When it is looked at it closely, it can be seen that there is no one financial situation, there are a lot of financial situations according to knowledge in the hands of players in each financial market.

The period between 2007 and 2021 had got so dramatic impacts on these financial markets. The world witnessed a great, long, re-destructive and re-descriptive financial and economic depression. In terms of the aviation world, this period also includes a lot of bitter experiences on a large scale and in different dimensions. First of all, it should be accepted that the civil aviation world's main assumptions and hypothetical acceptances were shocked and waved deeply. For example, security gained its importance one more time after the extraordinary 9/11 terrorist attacks in the USA in a mad trend, on the other side SARS, and COVID-19 widened definitions of safety principles in civil aviation, and safety transformed and became a specific instrument in a manner that includes human health. The science of sustainability has positive and negative impacts on the civil aviation world from different points of view. New aircraft designs, new engine designs and new airports have been the main subjects of this sustainability age. Air carriers' communication techniques with the public and other companies have changed at an intensive pace and rapidity (Koçak, 2021). They transformed into an indispensable reality with integrated reporting and sustainable reporting. On one hand, the competition that was inherited from the Airlines Deregulation Act of 1978, sustained its impacts on the industry, on the other hand, all civil aviation market participants can utilize hedging policies densely and widely. If it is concentrated on statistical figures of the aviation industry, these events also have got disruptive impacts on investors' decisions and decision-making processes, because they are resources of volatility structures.

It is a scientific reality that volatility structures include a lot of unambiguity depending on white noise. With more open words, unit roots can be formed around every stochastic movement (random walk) within the border of white noise. It can be shown also with the following classical econometric stochastic arguments (Gourieroux and Robert, 2001),

$$Y_t = Y_{t-1} + \varepsilon_t \, , with\ probability\ \pi(Y_{t-1})$$
$$Y_t = \varepsilon_t \qquad , with\ probability\ 1 - \pi(Y_{t-1})$$

Where

ε_t= strong white noise,

π = is a non-decreasing function.

If a financial market has more white noise unit roots, it means that it is more open to financial risks, crises and opportunities depending on the deep impacts of knowledge on unit roots. Detection of unit roots and difference-stationary is the open and frank purpose of this paper in the air carrier world. To reach this purpose, five important complementary unit root and non-stationary tests will be utilized.

In light of these arguments, a classification will be made between air carriers depending on alliances. As one of the important matters in civil aviation, air carriers and their stock price structures will be discussed and there is a short

explanation of the alliances' concept, alliances, and their impacts on air carriers in the first part of the research. The second part of the research will give a short explanation of the unit root test. Lastly, five important unit root tests are made, and their conclusions, discussions and suggestions will be utilized meticulously.

2. Literature

2.1. Air Carriers and Alliances

2.1.1. Air Carriers

The air carrier industry is so an important part of civil aviation, their financial decision-making styles should have many more different changes depending on the endemical world of the airlines. Their accounting policies, cost management strategies, cash flow management styles and risk variables are also authentic. For example, they are vulnerable to financial and economic crises and slowdowns (Maitra et al., 2021), and other stochastic and unexpected events such as meteorological variables, accidents and terrorist attacks disrupt the financial structure of air carriers. Therefore, they should follow hedging strategies and policies easily and densely to decrease costs in future. (Swidan and Merkert, 2019). Oil price changes can negatively impact the airline industry and are exact and open resources of volatility (Yun and Yoon, 2019; Wang and Gao, 2020) like other parts of the transportation and logistics industry. Efficiency is another important variable in airline financial management, and it is connected to operational efficiency (Pineda et al., 2018), however, it should be also added here that the impacts of oil prices could change depending on the nature of different segments such as low costs, full service etc. and it can be one of the causes of reinterpretation. (Wolter, 2021). State economic and financial politics and monetary and budgetary actions can have also different impacts on the US airline

codesharing have deep impacts on prices in the short-haul and

long-haul markets. Wang et al. (2022) conclude that profitability improves with alliances' impacts. Declaration of alliance membership for airline/air carriers causes many changes in the mind of consumers and institutional and individual investors according to daily media.

The impacts of memberships of the air-carrier companies to the alliances are in question.

3. Econometrical Methodology

3.1. Unit root

In the probability theorem, the unit root test is a problem that arises from the random walk process of a times series. After Güriş (2019) stated that unit root tests are an important part of empirical analysis, he put some exclamation points on their historical development. According to him, unit root tests began with Phillips and Perron tests, and they are developed due to conditions of linearity, structural breaks and cointegration of data.

3.2. Augmented Dickey-Fuller Unit Root Test

The augmented Dickey-Fuller Unit Root Test is the extended version of the simple Dickey-Fuller test depending on white noise problems. They extended their test by including extra lags in terms of the dependent variables to eliminate the problem of autocorrelation (Mustaq, 2011). To eliminate autocorrelation, the Augmented Dickey-Fuller test depends on the estimation of the equations below (Çil, 2018).

industry with a volatility-creating structure (Sobieralski, 2021).

Regional impacts and regionalism show their faces in the airline industry, Loudon (2004) and Tsai (2008) maintain different financial risk measures for Australian and South African Regions, and Yashodha et al. (2016) clarify and compare different financial risk exposure in Australian major airlines, Cathay Pacific Airways, and China Airlines. It is so important here to underline the main impacts of financial management styles of the airline companies, Alıcı and Sevil (2021a) and Alıcı and Sevil (2022b) argue these relationships in terms of operational ratios on national and low-cost air carriers.

2.2.2. Airline Alliances

Airline alliances are so important part of the civil aviation system. There are a lot of advantages and disadvantages of alliances (Daşçı ve Orhan, 2019). Besides, it can seem their impact different parts of the world from Africa (Button, Porta and Scotti, 2020) to the American continent. Besides, they have sound and strict impacts on strategic business-making styles, marketing policies and other determinants of the airline industry.

According to Morrish and Hamilton (2002), alliances are the results of internal dynamics of the airline industry with low margins and low profitability. Brueckner and Singer (2019) state that airline alliances impact the industry to connect passengers, making alliances beneficial on balance. For Calzada, Fageda and Safronov (2022), airline alliances affect the frequency of flights and profits indirectly. Klophaus and Lordan (2018) state that networking activities also increase with alliances and Brueckner and Whalen (2000) emphasize the positive impacts of alliances on airfares in competition. Ivaldi, Petrova and Urdanoz (2022) show that alliances re-describe the cost structure of air carriers with the impacts of digital technology. Yimga (2022) states that related activities like

$$\Delta y_t = \theta y_{t-1} + \sum_{i}^{p} \beta_i \Delta y_{t-1+1} + \varepsilon_i \quad (1)$$

$$\Delta y_t = \mu + \theta y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-1+1} + \varepsilon_i \quad (2)$$

$$\Delta y_t = \mu + \theta y_{t-1} + \beta_t \sum_{i=2}^{p} \beta_i \Delta y_{t-1+1} + \varepsilon_i \quad (3)$$

In these equations,

μ = constant,

p= lag order of autoregressive process,

The unit root test is then carried out under the null hypothesis θ = 0 against the alternative hypothesis θ < 0.

$$DF_\tau = \frac{\boldsymbol{\theta}}{SE(\boldsymbol{\theta})} \quad (4)$$

And equation 4 give us coefficient of Augmented Dickey Fuller Test.

Kwiatkowski, Phillips, Schmint and Schin (KPSS) Unit Root Test

KPSS Unit Root Test tests the estimation under the null hypothesis of stationary. It can be described as follows (Çil, 2018):

$$s_t = \sum_i^t e_i \quad (5)$$

$$\sigma^2 = \lim_{T\to\infty} T^{-1} E(S_T^2) \quad (6)$$

$$\mathrm{LM} = \sum_{t=1}^{T} \frac{s_t^2}{\sigma^2} \quad (7)$$

$$s^2(l) = T^{-1}\sum_{t=1}^{T} e_t^2 + 2T^{-1}\sum_{s=1}^{t} w(s,l)\sum_{t=s+1}^{T} e_t\, e_{t-s} \quad (8)$$

$$\acute{\eta} = T^{-2}\sum_{t=1}^{T} \frac{S_t^2}{s^2(l)} \quad (9)$$

In these equations,

St = the sum of residuals,

σ2 = long term variance,

LM = Lagrange Multiplier Test,

s2 = weighted sum

l= lag,

ή = Test statistic of KPSS.

3.4. The Flexible Fourier Form and Dickey-Fuller Type Unit Root Tests

Enders and Lee (2012) criticized the Lagrange multiplier (LM) detrending methods[1] and the Dickey-Fuller Generalized Least Squares (DF–GLS) detrending methods[2] because these detrending methods can result in a significant loss of power when the initial value is large. Not only is the standard DF methodology straightforward to use, but DF-type unit root tests are also free of this initial-value problem. They provided an F-test that can be used to pretest for the presence of nonlinearity. Such pretesting can be useful, since utilizing the Fourier tests when non-nonlinearity is present can result in a substantial loss of power **(Enders and Lee, 2012).**

$$\Delta y_t = \rho y_{t-1} + c_0 + \sum_i^l c\Delta y_{t-1} + e_i \quad (10)$$

$$\Delta y_t = \alpha + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \delta y_{t-1} + \varepsilon_t \quad (11)$$

$$\Delta y_t = \alpha + \beta t + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \delta y_{t-1} + \varepsilon_t \quad (12)$$

It can be seen in equations 1.6 and 1.7, the only trend and trend and intercept added versions of Enders and Lee Fourier test equations respectively.

3.5. The Flexible Fourier ADF Type Unit Root Tests

The basic idea behind these tests developed in this section is to use trigonometric variables that capture large changes with smooth transition functions that allow capturing non-linear adjustment to this deterministic component (Christopoulos and Leon-Ledesma, 2010). The equations behind Fourier- ADF can be shown as follows.

$$\hat{\varepsilon}_t = \hat{y}_t - \hat{\alpha} - \hat{\gamma}_1 \sin\left(\frac{2\pi kt}{T}\right) - \hat{\gamma}_2 \cos\left(\frac{2\pi kt}{T}\right) \quad (13)$$

$$\Delta_{vt} = a_1 + v_{t-1} + \sum_{j=1}^{p} \beta_j \Delta_{vt-j} + u_t \quad (14)$$

3.6. The Flexible Fourier KSS Type Unit Root Tests

Flexible Fourier KSS Type Unit Root Test is structured on Fourier ADF test, so equations of 1.8 and 1.9. The following two equations were developed by again Christopoulos and Leon-Ledesma, 2010 on articles of Kapetanios et al. (2003) to form a new type of Fourier Test.

$$\Delta\hat{\varepsilon}_t = \delta\hat{\varepsilon}_{t-1}^3 + \sum_{i=1}^{k} \Psi_i \Delta\hat{\varepsilon}_{t-i} + v_i \quad (15)$$

$$\Delta\hat{\varepsilon}_t = \delta\hat{\varepsilon}_{t-1} + \sum_{i=1}^{k} \Psi_i \Delta\hat{\varepsilon}_{t-i} + v_i \quad (16)$$

Table 1. The Comparison of Unit Root Tests and Research Design

UNIT ROOT TEST	Hypothesis	FEATURES	ARTICLES
Augmented Dickey-Fuller	H_0: There are no unit roots in time series data. H_1: There are unit roots in time-series data	ADF unit root regression specification does not consider structural breaks. It can be utilized in both trend and trend and intercept.	Yaya et. al (2019)
Kwiatkowski, Phillips, Schmint and Schin	H_0: Time series is stationary H_1: Time series is not stationary	KPSS unit root regression specification considers stationary in Null Hypothesis. For this reason, it is a strong stationary test. It can be utilized both of trend and trend and trend and intercept.	Kızılkaya and Konat (2019)
Enders and Lee Fourier Unit Root Test	There are two stages: A. F TEST H_0: There is linearity in time-series data H_1: There is no linearity in time series data. B. T-TEST H0: There are no unit roots in time series data. H1: There are unit roots in time-series data	With this unit root test, it is possible to take more detailed information on unit root and stationary. This information also includes structural breaks in time series.	Enders and Lee, 2012

[1] KPSS

[2] ADF or ADF-GLS

Fourier ADF	There are two stages: A. F-TEST H_0: There is linearity in time series data. H_1: There is no linearity in time series data. B. T-TEST H0: There are no unit roots in time series data. H1: There are unit roots in time-series data	It was developed for unit roots that account jointly for structural breaks and non-linear adjustment. Structural breaks are modelled using a Fourier function that allows for infrequent smooth temporary mean changes.	Christopoulos and Leon-Ledesma (2010)
Fourier KSS	There are two stages: A. F-TEST H_0: There is linearity in time series data. H_1: There is no linearity in time series data. B. T-TEST H_0: There are no unit roots in time series data. H_1: There are unit roots in time-series data	This model is derived from models for testing for a unit root in the original series after removing the breaks in the deterministic component. In addition to temporary breaks, testing for a unit root against a non-linear alternative.	Christopoulos and Leon-Ledesma (2010)

4. Research Data and Design

Time series data of the research has been collected from investing.com on daily basis., Fourier unit root and stationary analysis is so contemporary and strong way to determine unit roots with their dependence on linearity (Hepsağ, 2022).

Individual or corporal investors, companies, and regulators can take a lot of information and knowledge from these tests about their investments such as immunity and strength of stock prices against financial shocks or breaks. Although basic unit root tests give us restricted information on these matters, Fourier Type-Tests, if they are utilized correctly, are causes of wider and more comprehensive information.

In the light of these arguments, there are five important unit root tests in this paper. Unit root tests are utilized on 18 airline companies that have been classified due to membership of one of three alliances, Star Alliances, Sky Alliances and One World Airlines. Data, time intervals and observations can be seen in the following table. There can be time interval problems due to country holidays and resources. WinRAT package program is utilized for analysis. The descriptive statistics can be seen in Table 2.

Table 2. Descriptive Statistics

ALLIANCES	AIRLINES	DATA	
		TIME INTERVALS	OBSERVATIONS
ONE WORLD AIRLINES	Cathay	06.01.2014 - 24.06.2022	2086
	Finnair	02.01.2014 - 23.06.2022	2130
	Japon Air	06.01.2014 - 24.06.2022	2070
	Qantas	07.05.2014 - 24.06.2022	2061
SKY AIRLINES	Aeroflot	06.01.2014 - 24.06.2022	2118
	China Eastern Airlines	06.01.2014 - 24.06.2022	2133
	China Airlines	06.01.2014 - 24.06.2022	2074
	Delta Airlines	06.01.2014 - 24.06.2022	2206
	Garuda - Indonesia Airlines	06.01.2014 - 17.06.2022	1808
	Korean Airlines	06.01.2014 - 24.06.2022	2436
	American Airlines	06.01.2014 - 24.06.2022	2206
STAR ALLIANCE	Aegean Airlines	06.01.2014 - 24.06.2022	2082
	Air Canada	06.01.2014 - 24.06.2022	2106
	Air China	06.01.2014 - 24.06.2022	2066
	All Nippon Airways	06.01.2014 - 24.06.2022	2118
	Asiana Airlines	06.01.2014 - 24.06.2022	2354
	Lufthansa	06.01.2014 - 24.06.2022	2145
	Turkish Airlines	06.01.2014 - 24.06.2022	2107

To calculate return, we utilized following equations.

$$R_i = (R_t - R_{t-1})/R_{t-1} \quad (17)$$

5. Empirical Findings

Unit root tests are so systematic and wide part of financial time series analysis. According to Wang and Tomek (2007), Augmented Dickey-Fuller (ADF) tests frankly give biased results, if there is a structural break in time series. Therefore, it can be concluded here that this most widespread test can be ineffective in some situations. The ADF analysis results of data can be shown as follows, and in the level of time series and it can be concluded that daily time series of selected air carriers do not include unit root. The ADF results are observed in Table 3.

Table 3. ADF Test Results

ALLIANCES	AIRLINES	ADF TEST RESULTS
ONE WORLD AIRLINES	Cathay	-45.149*
	Finnair	-46.857*
	Japon Air	-46.325*
	Qantas	-41.411*
SKY AIRLINES	Aeroflot	-41.556*
	China Eastern Airlines	-47.519*
	China Airlines	-42.699*
	Delta Airlines	-18.062*
	Garuda - Indonesia Airlines	-40.447*
	Korean Airlines	-5.873*
	American Airlines	-29.073*
STAR ALLIANCE	Aegean Airlines	-45.614*
	Air Canada	-28.869*
	Air China	-45.556*
	All Nippon Airways	-41.556*
	Asiana Airlines	-3.187**
	Lufthansa	-46.719*
	Turkish Airlines	-47.438*

**0.01, ** 0.05, ***0.10 significance. *0.01, ** 0.05, ***0.10 significance. (McKinnon (1996) one-sided p-values, Schwarz Information Criteria)*

The second unit root test results are given in the following table with trend and trend and constant is Kwiatkowski, Phillips, Schmidt, and Shin (1992) test. It can be said here that structural breaks can gain a little bit more importance in this analysis. The main determinative factor of KPSS analysis is that KPSS intends to consider structural breaks. According to KPSS analysis, the % return series of airline companies is also stationary. The results of the analysis can be seen in Table 4.

Table 4. KPSS Test Results

ALLIANCES	AIRLINES	KPSS TEST RESULTS
ONE WORLD AIRLINES	Cathay	0.041
	Finnair	0.156*
	Japon Air	0.145
	Qantas	0.361*
SKY AIRLINES	Aeroflot	0.414**
	China Eastern Airlines	0.138
	China Airlines	0.234
	Delta Airlines	0.086
	Garuda - Indonesia Airlines	0.044
	Korean Airlines	0.910*
STAR ALLIANCE	American Airlines	0.080
	Aegean Airlines	0.045
	Air Canada	0.125
	Air China	0.054
	All Nippon Airways	0.414**
	Asiana Airlines	2.046
	Lufthansa	0.114
	Turkish Airlines	0.354**

**0.01, ** 0.05, ***0.10 significance at level*

Enders and Lee type unit root tests are other dynamic type unit root tests, they are designed for detecting and analyzing unit roots in more detailed forms in Table 5.

According to findings in 5. Table, for all of airlines out of Aeroflot, Turkish Airlines, Asiana Airlines, All Nippon Airways and Korean Airlines are suitable to interpret with Dickey-Fuller tests because of F-value is smaller than the value determined in Enders and Lee (2012). On the other side, Aeroflot, Turkish Airlines, Asiana Airlines, All Nippon Airways and Korean Airlines have got higher F-values. They are suitable to work Enders and Lee (2012), again if it is looked at test statistics of these (taudf_c) airline companies, it easily accepted that there is no unit root for these values are larger than table values of Enders and Lee (2012).

The two other important tests are Fourier ADF and Fourier KSS. They are utilized according to linearity situations of time series. The results of the Fourier KSS and Fourier ADF test can be shown Table 6.

According to the findings in Table 6. Fourier ADF, larger Fm(k) values of Qantas, Aeroflot, Garuda Indonesia Airlines, Korean Airlines, All Nippon Airways, Asiana Airlines and Turkish Airlines show that these airline companies are suitable to continue with these tests. Besides, if it is concentrated to test values (FADF-m values) it can easily seem that Dickey-Fuller type evaluations are suitable to evaluate unit root situations of returns. So, for these 7 airline companies, it can be concluded that there is no unit root in series.

On the other side, from Fourier KSS test results in Table 6, it can be inferred that Finnair, Qantas, Aeroflot, Garuda Indonesia Airlines, Korean Airlines, All Nippon Airways, Asiana Airlines and Turkish Airlines are suitable for this test

depending on larger Fm(k) values. KPSS tests are suitable for this returns' stationary analysis. Besides, it can be said from larger test values (F-tnl-m), that all of the series are stationary with different significance levels

Table 5. Enders and Lee (2012) Fourier Unit Root Tests

ENDERS AND LEE (2012) FOURIER UNIT ROOT TESTS				
ALLIANCES	**AIRLINES**	**k**	**UNIT ROOT TESTS (CONSTANT)** *0.01, ** 0.05, ***0.10 significance.	
ONE WORLD AIRLINES	Cathay	k= 4	F(k)=1.393	taudf_c=-42.09464* optimallag= 0 Min RSS= 0.62203
	Finair	k= 5	F(k)= 4.329	taudf_c=-32.76523* optimallag= 1 Min RSS= 2.48626
	Japon Air	k= 4	F(k)=1.169	taudf_c=-31.00729* optimallag= 1 Min RSS= 0.67942
	Quantas	k= 4	F(k)= 2.310	taudf_c= -29.84620* optimallag= 1 Min RSS= 1.03875
SKY AIRLINES	Aeroflot	k= 2	F(k)= 7.240(**)	taudf_c=-30.30489* optimallag= 1 Min RSS= 0.89615
	China Eastern Airlines	k= 3	F(k)= 0.781	taudf_c=-30.40743* optimallag= 1 Min RSS=1.43647
	China Airlines	k= 1	F(k)= 2.623	taudf_c=-30.66452* optimallag= 1 Min RSS=0.79034
	Delta Airlines	k= 5	F(k)= 1.174	taudf_c=-31.18960* optimallag= 1 Min RSS=1.29217
	Garuda - Indonesia Airlines	k= 4	F(k)= 3.962	taudf_c=-29.33922* optimallag= 1 Min RSS=1.48710
	Korean Airlines	k= 2	F(k)= 23.710(*)	taudf_c=-37.44341* optimallag= 1 Min RSS= 9.99601
STAR ALLIANCE	American Airlines	k= 4	F(k)= 1.111	taudf_c=-31.47100* optimallag= 1 Min RSS=2.12558
	Aegean Airlines	k= 4	F(k)= 1.083	taudf_c=-30.02112* optimallag= 1 Min RSS=1.35184
	Air Canada	k= 4	F(k)= 2.030	taudf_c=-26.75773* optimallag= 1 Min RSS=1.77468
	Air China	k= 4	F(k)=2.721	taudf_c=-29.59702* optimallag= 1 Min RSS=1.22165
	All Nippon Airways	k= 2	F(k)=7.240**	taudf_c=-30.30491* optimallag= 1 Min RSS=0.89615
	Asiana Airlines	k= 1	F(k)=88.966(*)	taudf_c=-36.24461* optimallag= 1 Min RSS=265.26205
	Lufthansa	k= 5	F(k)=2.077	taudf_c=-31.23286* optimallag= 1 Min RSS=1.27211
	Turkish Airlines	k= 2	F(k)=7.226(*)	taudf_c=-31.50382* optimallag= 1 Min RSS=1.22288

6. Discussions and Conclusions

It can be stated here that the random walk process, whether or not the time series is volatile, is one of the main results of the interaction of random walk, unit root and stationary. It is selected two important subjects, one of them is the membership of the alliances and the other one the behaviour of the returns in time. According to main findings, there is no structural evidence if alliances have impacts on the financial structure of airline returns, on the other side, in randomly selected airline companies regional factor can raise as an important factor.

Tiwari and Kyophilavong (2014) make some unit root analyses of the random walk process on a large scale in BRICS countries in terms of the random walk process. According to them, random walk, so stationary or unit root, is an indicator of market efficiency but the time interval is important. Gözbasi, Küçükkaplan and Nazlıoğlu (2014) found that the Borsa Istanbul stock price index series have nonlinear behaviour and follow a random walk (non-stationary) process, but they are again in weak-form efficiency. Narayan and Smyth (2007) and Narayan (2008) stated that stock prices are stationary processes, inconsistent with the efficient market hypothesis. Aggarwal and Kyaw (2005) stock prices are non-stationary but stock return series is stationary for NAFTA. Wang, Zhang and Zhang (2015) stated that stock prices can be characterized as a random walk or mean reversion process over the period December 1990 to March 2013. For Hasanov (2009) the nonlinear unit root test rejects the null hypothesis of unit root, suggesting that South Korea's stock market is not weak-form efficient, contrary to the findings of Narayan and Smyth (2004).

In light of the arguments above, there is a stationary in all of the time series in linear form root tests such as ADF and KPSS. Enders and Lee Fourier Type Unit Root Tests are designed for measuring non-linearity in the light of Fourier Transformations, but their preconditions are non-linear. For this reason, Fourier ADF and Fourier KSS tests outshined as problem-solving methodologies of their linearity-depended nature, Fourier ADF can be described as an ADF example in a total of Fourier analyses, on the other hand, Fourier KSS can be accepted as an example of KPSS in these analyses. However, they are both stronger and more explanative than the classical ADF test and classical KPSS test. Although all of the return series are stationary some series can also be shown this feature with more powerful tests.

The unit roots, on the other side, can be considered as an indicator of market efficiency, a strong form of market efficiency is related to the absence of unit root or stationary in time series in determined articles in this section, but this does not mean that it is an absolute financial form. In light of these arguments, it can be inferred that airline company return series are stationary, but it is not possible to realize a classification in terms of efficient market hypotheses, these series can be shown differences in terms of efficiency due to the power of stationary tests. These results can be beneficial for the next research, especially for the ones which is related to macro-economic analysis.

Table 6. Fourier ADF and Fourier KSS results

FOURIER ADF and KSS UNIT ROOT TESTS RESULTS						
ALLIANCES	**AIRLINES**	**k**	**FOURIER ADF UNIT ROOT TEST (CONSTANT AND TREND)**	**AIRLINES**	**k**	**FOURIER KSS UNIT ROOT TEST (TREND AND CONSTANT)**
ONE WORLD AIRLINES	Cathay	k= 2	FADF-m= -29.79165 Fm(k)=1.27894 optimallag= 1 MinSSR=0.69498	Cathay	k=2	F-tnl-m= -9.79200 Fm(k)=1.25619 optimallag= 1 MinSSR=0.69521
	Finnair	k= 4	FADF-m= -31.63683 Fm(k)= 1.07649 optimallag= 1 MinSSR=1.41434	Finnair	k=5	F-tnl-m=-13.36628 Fm(k)= 3.77405* optimallag= 1 MinSSR=2.69397
	Japan Air	k= 4	FADF-m= -31.44067 Fm(k)= 1.58809 optimallag= 1 MinSSR=0.77322	Japan Air	k=4	F-tnl-m=-9.88016 Fm(k)=1.58043 optimallag= 1 MinSSR=0.77320
	Qantas	k= 4	FADF-m= -30.66910 Fm(k)= 3.82974* optimallag= 1 MinSSR=1.13488	Qantas	k=4	F-tnl-m=-12.18640 Fm(k)= 3.75295* optimallag= 1 MinSSR=1.03958
SKY AIRLINES	Aeroflot	k= 2	FADF-m= -32.56487 Fm(k)= 6.11841* optimallag= 1 MinSSR=1.22016	Aeroflot	k=2	F-tnl-m= -14.16901 Fm(k)= 6.16993* optimallag= 1 MinSSR=1.22031
	China Eastern Airlines	k= 3	FADF-m= -31.20239 Fm(k)=1.61279 optimallag= 1 MinSSR=1.60010	China Eastern Airlines	k=3	F-tnl-m= -11.19158 Fm(k)= 1.61157 optimallag= 1 MinSSR= 1.60033
	China Airlines	k= 2	FADF-m= -31.84450 Fm(k)= 2.31086 optimallag= 1 MinSSR=0.91747	China Airlines	k=2	F-tnl-m=-19.69852 Fm(k)= 2.31610 optimallag= 1 MinSSR= 0.91769
	Delta Airlines	k= 4	FADF-m= -31.59696 Fm(k)=1.12850 optimallag= 1 MinSSR=1.41731	Delta Airlines	k=4	F-tnl-m=-11.52264 Fm(k)=1.11867 optimallag= 1 MinSSR=1.41755
	Garuda - Indonesia Airlines	k= 5	FADF-m=-29.77694 Fm(k)= 4.08206* optimallag= 1 MinSSR=1.71189	Garuda - Indonesia Airlines	k=5	F-tnl-m= -13.03811 Fm(k)= 3.74768* optimallag= 1 MinSSR=1.73812
	Korean Airlines	k= 2	FADF-m= -38.24893 Fm(k)=14.06305* optimallag= 1 MinSSR=11.86901	Korean Airlines	k=2	F-tnl-m=-24.62193 Fm(k)=14.05758* optimallag= 1 MinSSR=11.86906
STAR ALLIANCE	American Airlines	k= 4	FADF-m= -31.82000 Fm(k)=1.22007 optimallag= 1 MinSSR=2.32038	American Airlines	k=4	F-tnl-m=-7.18188 Fm(k)=1.21063 optimallag= 1 MinSSR=2.32063
	Aegean Airlines	k= 4	FADF-m= -30.67766 Fm(k)=1.04102 optimallag= 1 MinSSR=1.52943	Aegean Airlines	k=4	F-tnl-m=-8.73407 Fm(k)=1.06367 optimallag= 1 MinSSR=1.52962
	Air Canada	k= 4	FADF-m= -27.41959 Fm(k)= 3.15092 optimallag= 1 MinSSR=1.94074	Air Canada	k=4	F-tnl-m= -8.41347 Fm(k)= 3.59729 optimallag= 1 MinSSR=1.94017
	Air China	k= 4	FADF-m=-30.41308 Fm(k)= 2.23193 optimallag= 1 MinSSR=1.39532	Air China	k=4	F-tnl-m= -7.13146 Fm(k)= 2.25758 optimallag= 1 MinSSR=1.39552
	All Nippon Airways	k= 2	FADF-m=-32.56589 Fm(k)=6.11841* optimallag= 1 MinSSR=1.22016	All Nippon Airways	k=2	F-tnl-m= -14.16803 Fm(k)= 6.16993* optimallag= 1 MinSSR=1.22031
	Asiana Airlines	k= 1	FADF-m=-36.76151 Fm(k)=72.22630* optimallag= 1 MinSSR=287.90108	Asiana Airlines	k=1	F-tnl-m= -27.44025 Fm(k)= 72.28480* optimallag= 1 MinSSR=287.90253
	Lufthansa	k= 2	FADF-m=-32.09547 Fm(k)= 2.60845 optimallag= 1 MinSSR=1.39070	Lufthansa	k=2	F-tnl-m= -7.92861 Fm(k)= 2.61316 optimallag= 1 MinSSR= 1.39066
	Turkish Airlines	k= 2	FADF-m=-31.52445 Fm(k)= 6.22963* optimallag= 1 MinSSR=1.26608	Turkish Airlines	k=2	F-tnl-m= -15.35416 Fm(k)= 6.24593* optimallag= 1 MinSSR= 1.26603

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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