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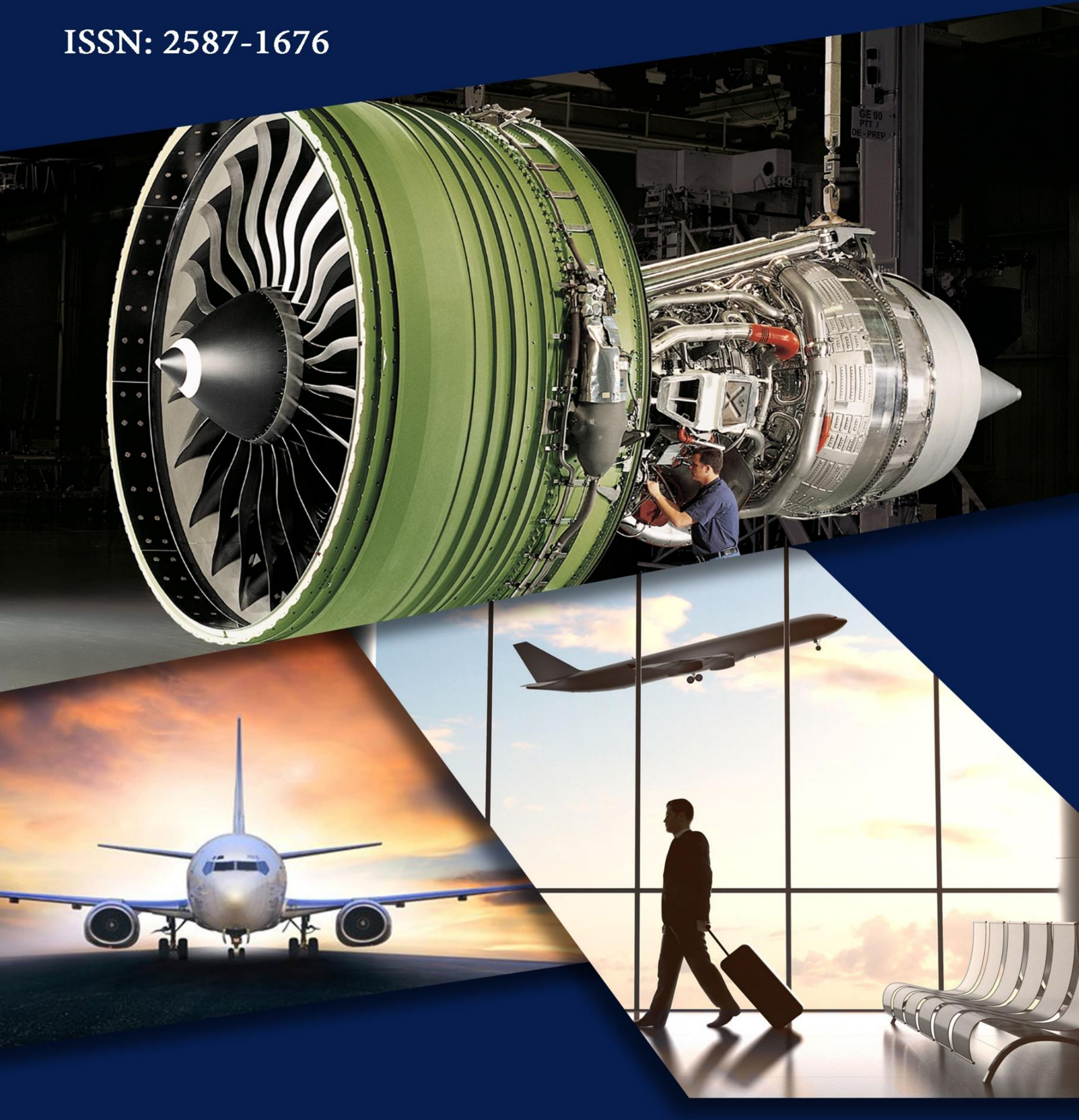

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Airfoil Optimization with Metaheuristic Artificial Bee Colony Algorithm Supported by Neural Network Trained Using Nasa-Foilsim Data

Şeyma Doğan[1*], Cemil Altın[1]

[1*]Yozgat Bozok University, Department of Mechatronic Engineering, Yozgat, Turkey. (cngsym@gmail.com).
[2]Yozgat Bozok University, Department of Mechatronic Engineering, Yozgat, Turkey. (cemil.altin@bozok.edu.tr).

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Abstract

In this study, the wing profile, which is difficult to calculate and determine, has been optimized with the help of Foilsim data and optimization algorithms. Foilsim data provided by NASA (National Aeronautics and Space Administration) and used by many researchers, especially in developing model airplanes, has been provided to use in aircraft wing shape optimization. Although Foilsim is a very useful simulation program for designers, it cannot be used effectively in optimization processes due to its web environment. Lift coefficient is needed for Lift equation in airfoil shape optimization. Lift coefficient depends on angle, camber, and thickness of airfoil Calculation of Lift coefficient is difficult and needs heavy mathematical equations or real experiments. By using Foilsim data and optimization algorithm (Artificial Neural Networks: ANN, Artificial Bee Colony: ABC), wing angle, camber and thickness values, which are difficult to determine and calculate, were estimated and comparative experiments of the values were made. (Fixed Lift, Fixed Speed, Fixed Wing Area). Experimental results have shown that it is a useful study for airfoil shape optimization. In short, in this study, by using the Foilsim data and the optimization algorithm to provide the lifting force determined by the designer, the most suitable angle, camber, thickness values of the wing, which are difficult to determine and calculate, are determined to enable the production of efficient aircraft. The user enters the desired lift value into the ABC optimization algorithm and finds the required wing properties for the desired lift value.

1. Introduction

Many research projects in aviation include metaheuristic optimization algorithms such as Genetic Algorithms, Bee Colony Algorithm, Artificial Neural Networks, or Ant Colony Algorithm on topics such as newly optimized flight trajectories, wing shapes, control technique research (Koreanschi et al., 2017). Aerodynamic shape design is the basic step of aircraft design, wing profile optimization is the most important part of aerodynamic shape design (Ma et al., 2017). The Lift-drag ratio is perhaps one of the most important considerations in the design of wings such as airplane wings (MacEachern & Yildiz,2018).

The use of optimization methods has become common for design support tool and automated design in the aerodynamic design process (Koziel & Leifsson, 2013).

CFD (Computational Fluid Dynamics) methods are used for airfoil optimization. CFD method handles aerodynamic shape optimization in 3 different ways. These are the gradient-based method, the gradient-free method, and the surrogate model.

The Gradient-Based method also uses gradients of cost functions according to design variables. The first studies of this method for aerodynamics were made by Hick and Henne (Hicks & Henne, 1978).The disadvantages of this method are that it changes each design variable and needs to recalculate the flow area, as well as the large computational cost associated with directly evaluating gradients using the finite difference method. This method was first avoided by Jameson in 1988 by indirectly evaluating the gradient through the combined method (Jameson, 1988; Jameson, 1995). The adjacent-based optimization method is very effective, the optimum can be approached within 5-100 design cycles (Jameson & Martinelli, 2000).

Gradient-free methods are of great interest, because they have global optimization capability. Adjacent-based gradient-based optimization method has a local optimization method. For example, Genetic Algorithms and Particle Swarm Algorithm. Evolutionary algorithms (EA) are the most popular global optimization method. Evolutionary algorithms have proven to be of great importance in finding the global optimum, but the high computational cost and the need for a large number of CFD simulations make this method difficult to use (Han et al., 2013).

Design problems in engineering methods require a large number of real-time experiments and computational simulations to evaluate and provide the design objectives of the problems that are subject to various constraints (Mukesh et al., 2018). A surrogate model is an engineering method used when an outcome of interest cannot be easily measured ("Surrogate model", 2022).

When the recent studies are examined, the surrogate model optimization attracts great attention (Han et al., 2015). The purpose of surrogate modeling is to correlate the input and output data through the trained neural network model (Sun & Wang, 2019). A surrogate model is an approximate model that is inexpensive to evaluate. This feature distinguishes it from target and constraint functions that are expensive to evaluate. Once a surrogate model is created, it can be used to replace a physical CFD model to estimate the cost function or state function during the optimization process. In this case, a surrogate model is used instead of a CFD solver, since a surrogate model is more efficient (Han et al., 2015). Today, surrogate- assisted metaheuristic optimization algorithms have been used to solve many computationally costly problems. The surrogate model was created based on many techniques. Such as Polynomial Regression, Radial basis Function, Support Vector Regression, and Artificial Neural Network (ANN).

Based on these models, metaheuristic optimization studies have been applied by various researchers for aerodynamic optimization aircraft wing design (Mar Aye et al., 2020).

In order to train the network we used in this study, we preferred the surrogate method using artificial neural networks, which does not require CFD analysis. ANN based surrogate model is trained with Foilsim Data with 3 Inputs (Angle, Camber, Thickness) and 1 Output (C_L: Lift Coefficient).

For training in ANN, a data set consisting of 8000 samples with angle, camber and thickness values was taken from Foilsim web page. In this dataset, 5-fold cross validation cross validation method was used to estimate the lift coefficient from Angle hump and thickness values. In K-fold cross validation, the input data is divided by the 'K' coefficient. For this reason, it is called K-folding. Since 5-fold cross validation is used in this study, we have 5 sets of data to train our model. Thus, the model was trained and tested 5 times. However, in each iteration, it will use the multiple of 1 for testing and all the remaining remainders for training.

In this article, with the help of the trained ANN model, the optimization problem is solved by using the ABC Algorithm. In this way, when a designer wants to design an airfoil, he can proceed to the design process with ideal airfoil parameters and benefit from our study and experiments, without wasting time and without difficult CFD methods.

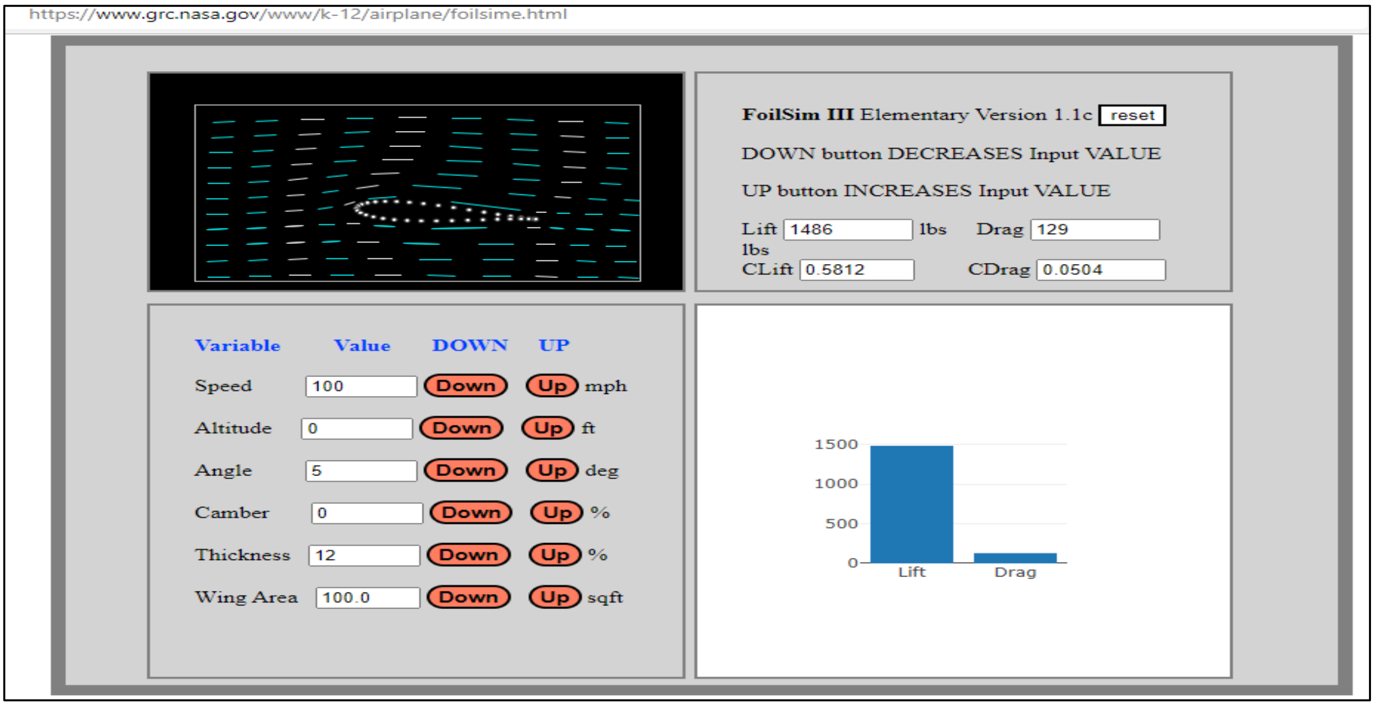

Figure 1. Foilsim Webpage and User Interface

2. Materials and Methods

2.1 Problem Definition

In this study, an optimization approach with a surrogate model is presented to predict airfoil parameters. The most commonly used method for aircraft aerodynamics is the lift-drag ratio, as it determines the aircraft's range and endurance. Foilsim is web software that works in the web environment and provides information to the designers about the amount of lift and drag according to the parameters of the aircraft wing (angle, camber, thickness, velocity, and wing area).

Although Foilsim is a very useful simulation program for designers, it cannot be used effectively in optimization cannot be solved without using algorithms, this problem has been handled in this study.

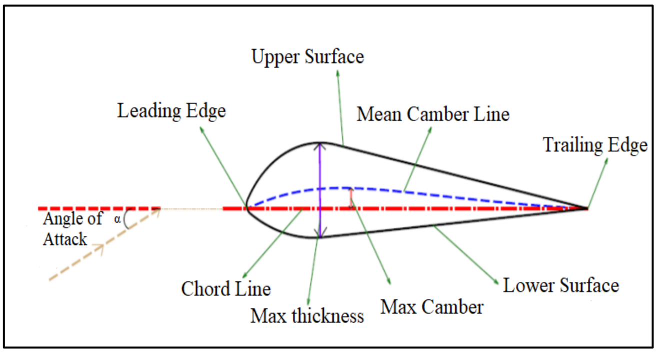

Figure 2. Airfoil Shape

The image in Figure 2 is obtained when a wing is cut parallel to the direction of flight (in the direction of the fuselage).

Angle of attack is the angle that the oncoming airflow makes with the airplane flight line and the chord line. The change in angle of attack affects the lift. Camber is the line connecting the points between the upper and lower surfaces of the wing profile along the chord line. In symmetrical profiles, this is already the chord line. The distance from any point of the camber line to the chord line is called the camber. The largest of these is called the maximum camber.

Thickness is the distance obtained by drawing perpendicular to the chord line between the upper surface and the lower surface of the profile. Chord Line is called the line connecting the leading and trailing edges. Leading Edge is the edge where the oncoming air contacts the wing. Trailing Edge is the edge where the oncoming air leaves from the wing.

The lift value of the wing is calculated by the lift equation. The lift equation is as given Equation 1.

$$L = C_L x \frac{\rho x V^2}{2} x A \qquad (1)$$

L: Lift value.
ρ: Air density.
V: Velocity over airfoil.
A: Wing area.
C_L: C_L is the coefficient at the desired angle of attack. C_L is provided by a surrogate model ANN.

The most important parameter to use when calculating the lift is the Lift Coefficient (C_L). The C_L coefficient contains complex variables and is usually obtained experimentally. The C_L coefficient is a coefficient that depends on the angle of attack, camber and thickness of the wing.

2.2 Artificial Neural Network

Artificial neural networks are information processing systems that mimic the working principle of the human brain in general. Studies on this subject first started with the modelling of the neurons that create the brain. The neural network is formed by the connections of nodes, which are elements that correspond to the brain's neurons (Kose & Oktay, 2021). Nodes are connected by connections, and each connection has a numerical weight that expresses the strength, or in other words, the importance of the input. Weights are the main purpose of long-term memory in ANNs. A neural network learns by repeatedly adjusting these weights (Negnevitsky, 2005).

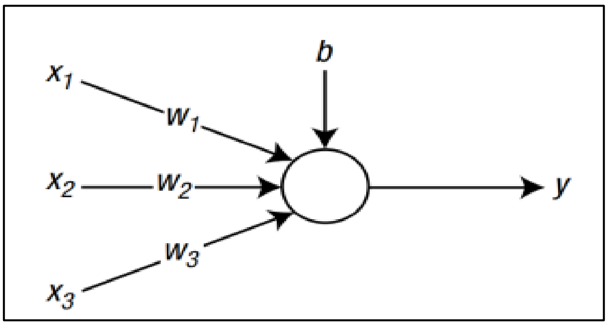

Figure 3. A neural network with 3 inputs and 1 output (Kose & Oktay, 2021)

The x_1, x_2 and x_3 values in Figure 3 are defined as the input values of the network. w_1, w_2, w_3 are also the weights of the input values. y is the output value (Kose & Oktay, 2021).

Hidden layer/layers are a set of neurons located between the input and output layers. It can be in the form of single or multiple layers (Shiruru, 2016).

Within the scope of this study, a surrogate network with 1 Output (C_L) and 1 hidden layer was obtained by training 3 Inputs (Angle, Camber, Thickness) of the wing of the aircraft with the Artificial Neural Network.

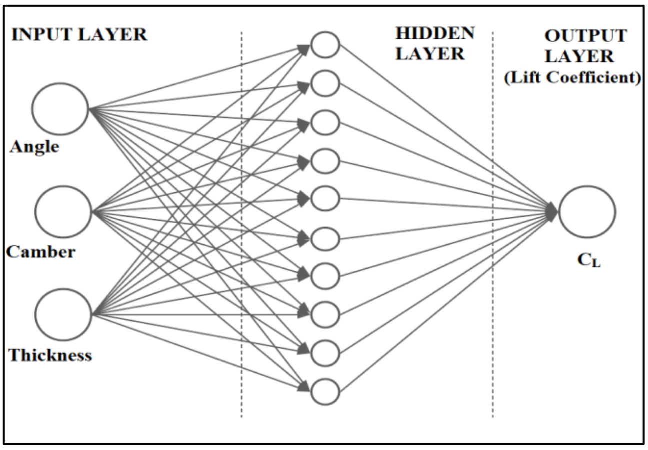

Figure 4. Neural Network Structure

For this article, the learning process in the Artificial Neural Network took place in the following order:

1. Collection of data set: It is the process of collecting data that we will give for our network to learn.
2. Determination of the network structure: The next step is to determine the structure of our network for the subject we want the network to learn. At this stage, it is determined how many inputs there will be, how many hidden layers there will be, how many neurons there will be in the hidden layers, and how many outputs there will be as a result.
3. Determination of the learning parameters of the network: After the completion of the structure of the artificial neural network that we will use for our study, the parameters such as the activation function and the learning rate, which are necessary for the continuation of the learning processes, are determined at this stage.
4. Weight and bias values: These values are given randomly at the beginning by the network itself, and then updated by the network during the learning process and ideal values are determined (Elmas,2018).
5. Giving the dataset to the network for training: After the preparations are complete, the network is ready for the learning process. Data set input and output values are given to start learning.
6. Calculations: Calculation of producing output values suitable for data input values is performed in this step.
7. Comparison of the output values of the network with the actual values: As a result of the comparison, the error of the network is calculated.
8. Change the weights and bias values of the network: In order to reduce the error of the network, the weight and bias values are calculated and updated.

Foilsim online interface developed by NASA (https://www.grc.nasa.gov/www/k-12/airplane/foilsime.htm l). Angle of attack(degree), camber(%) and thickness(%) inputs in Foilsim online interface are in the range of 0-20 for each. These values can be integer or decimal values between 0-20. The C_L dataset used in this study was collected directly by entering the angle of attack, camber and thickness values into the Foilsim online interface. The data set consists of 20x20x20=8000 C_L values by entering integer values between 0-20 (starting from 1-1-1 to 20-20-20) for each of the angle of attack, camber and thickness values. MATLAB program and Java awt Robot were used to collect 8000 pieces of data. Robot is an application that does the work that the user will do. In other words, the robot moves the mouse and presses the buttons instead of user. It also presses keys from the keyboard. This robot is used for various purposes. In this study, the Robot enters the angle of attack, camber and thickness values from 1-1-1 to 20-20-20 in the Foilsim online interface and saves the C_L value obtained for each value into an array. Angle of attack, camber and thickness values starts and increases one by one 1-1-1, 1-1-2, 1-1-3 … 1-1-20 ------ 1-2-1, 1-2-2, 1-2-3 … 1-20-20 ------ 2-1-1, 2-1-2, 2-1-3 … 20-20-20 and ends 20-20-20. An artificial neural network with 3 inputs and 1 output was trained with 8000 C_L datasets collected, and it was turned into a structure that automatically calculates the C_L value when the angle of attack, camber and thickness value is entered. For the network, 80% (6400) of the 8000 pieces of data were used for training and 20% (1600) for testing, and high success training was carried out with 5-fold cross validation.

Artificial neural networks are divided into two as forward and feedback artificial neural networks according to the way neurons are connected to each other. A feedforward neural network consists of layers and connections and communication are from input to output direction. In feedback artificial neural networks, there is a bilateral communication between the input layer and the hidden layer, and between the output and the hidden layers (Elmas, 2018).

In feed-forward neural networks, neurons are in the form of regular layers from input to output. There is only a connection from one layer to the next layers. The information sent with the data set coming to the input of the artificial neural network is transmitted to the hidden layer or layers without any change. Hidden layers transmit the information transmitted to them from the input layer to the next layer (Öztürk & Şahin, 2018).The feed forward artificial neural network is very involved in engineering studies and scientific studies, so the feed forward Artificial Neural Network was preferred in this study. (Du, He and Martins, 2021; Khurana, Winarto and Sinha, 2009; Li, Cai and Qu, 2019).

In artificial neural network algorithms, the behavior of the algorithms is controlled by hyperparameters. These hyperparameters cannot be determined by learning algorithms (Goodfellow, Bengio and Courville, 2016), they must be created by the designer who created the network.

The number of hidden layers and neurons causes the complexity of the network to increase. If the model is complex, it can be a serious waste of time, and while there is no problem in the training data, serious problems may occur in the test data. Considering these situations, the network with fewer layers and number of neurons was preferred in this study. Activation functions are used in ANN to process an input value and convert it to an output value that feeds it as input to the next layer. There are various activation functions. In this study, the Sigmoid activation function was preferred.

In this study, MATLAB R2019a numerical computing environment was used to create the ANN model. Levenberg-Marquadt Algorithm (Du, He and Martins, 2021), which is the default and frequently used for feed forward networks, is used in regression problems.

Table 1. Parameters and their values in the artificial neural network

Parameter	Value
Number of layers	1
Number of neurons	10
Learning rate	0.005
Activation function	logsig
Backpropagation Algorithm	trainlm

The information including the termination criteria of the network is decided by evaluating the criteria given in Table 2. If we want to use a certain time constraint in the training of our network, the time parameter is used. There is no time limit in this study. Another parameter is the number of iterations. The training ends when the limit iteration number that we will use in the training of our network is reached.The next parameter is the training ends when the reaches the desired minimum gradient value.Training ends when the network reaches the desired minimum performance.

Table 2. The stopping criteria used for the Neural network

Parameter	Value
Iteration	1000
Performance	1e-06
Gradient	1e-07
Time	No time constraint was used.

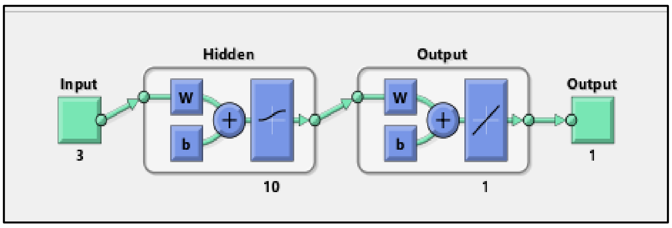

Figure 5. Artificial Neural Network structure

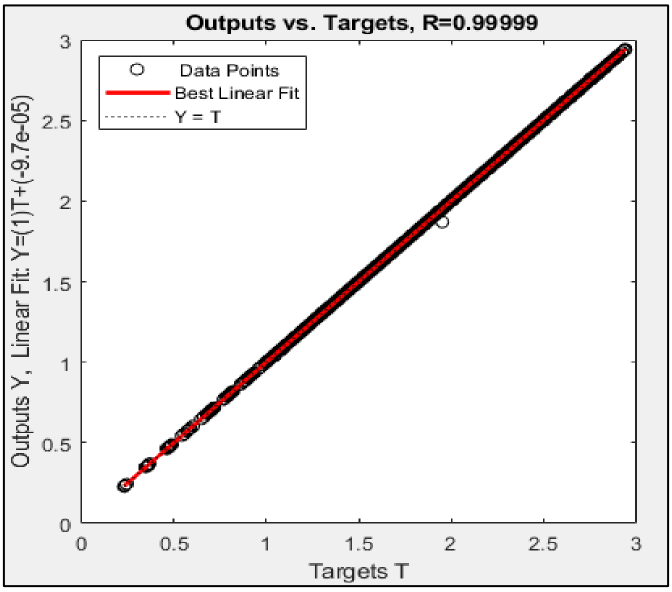

Figure 6. First fold performance

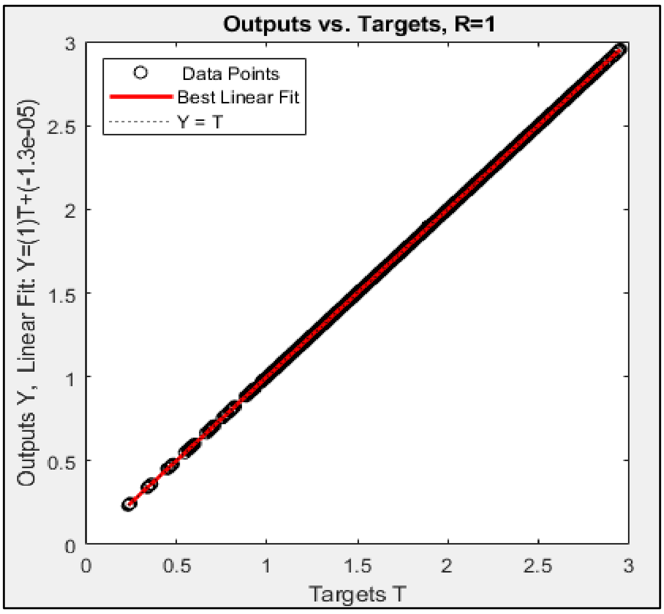

Figure 7. Second fold performance

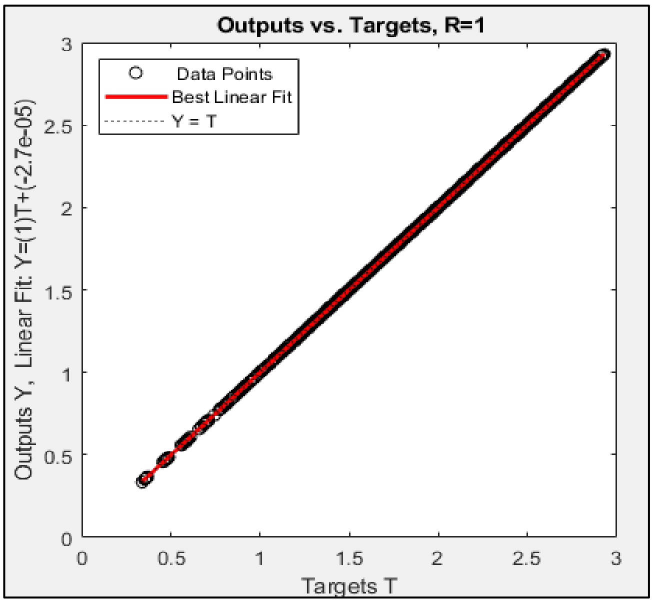

Figure 9. Fourth fold performance

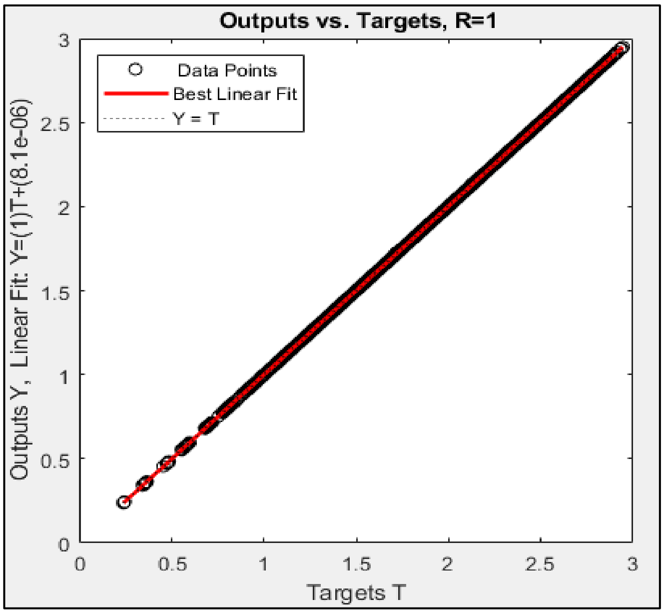

Figure 8. Third fold performance

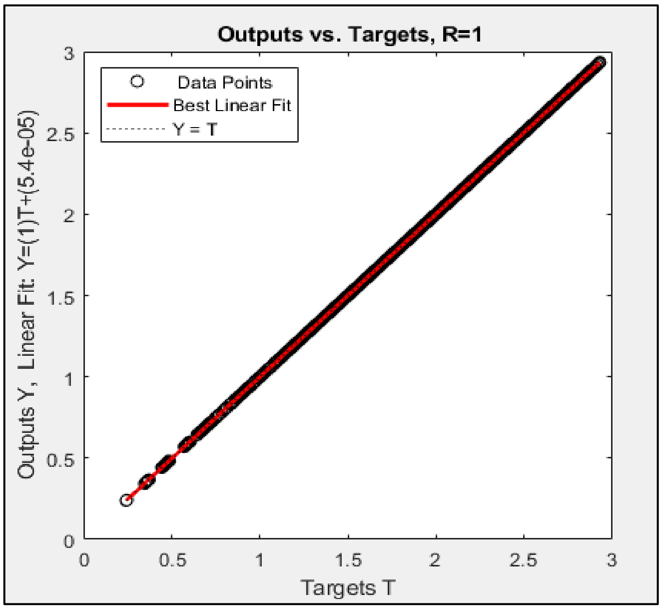

Figure 10. Fifth fold performance

2.3 Optimization

Optimization is defined as a technology that enables reaching certain goals by using the resources available in a system in the most efficient way. Optimization is used to accelerate the decision-making process and increase decision quality. It is used in the effective, accurate, and real-time solution of real-life problems (Türkay,2021).

Since most of the optimization problems in daily life are too complex to be developed when trying to solve with mathematical formulas from known methods, the solution may take a very long time and the predicted result may not be achieved. For this reason, heuristic methods have been developed as a solution to the problem and it has been tried to reach the best result that can be obtained (Gülcü & Kuzucuoğlu, 2006). Optimization is the process of finding the best solution for an identified problem or improvement.

2.4 Artificial Bee Colony Algorithm (ABC)

Artificial bee colony algorithm is an optimization algorithm inspired by the methods used by bees when searching for food by taking the unique intelligent behavior of honey bee swarms as an example. This algorithm, based on swarm intelligence, is used to solve optimization problems based on the behavior of bees moving in swarms in finding food (Küçüksille & Tokmak, 2011).

First of all, brief information about the food source search behavior of real bees is given.Foraging behavior of bees. The most important factor that ensures the continuation of the life of bee colonies is the food source. The important factors in this process are the resources accumulated in the hive, the feed sources that can be found in the environment, and the interactions of the bees. The bee leaves the hive and the food search continues randomly. If a food source is found and there is less food in this source, they start to look for a new food or they start to turn to other sources according to the information they receive from other bees (Küçüksille & Tokmak, 2011)

Akay used a grouping related to the search for food by bees in her study and explained this in her study(Akay,2009).

Food Sources: They are the sources that bees go to find food. The value of a food source has been defined, for the sake of simplicity, as its wealth. This value can be attributed to factors such as the type of source, distance from the nest, amount of nectar.

Worker bees with specific duties: This worker bee is concerned with bringing the food collected from the predetermined source to the hive.

Worker bees with uncertain duties: These bees are in charge of searching for food sources(scout bees and onlooker bees). The scout bee randomly searches for resources. The onlooker bee waits in the hive, watches the attendant bees, and directs the information from these bees to new sources.

Bees share information about the quality and location of the food source in the dance area. While one of the bees dances, the other touches it with its antenna and receives information from it. The distance between the bee and the hive, the condition of the food, the weather conditions are the factors affecting the dance (Kaya & Eke, 2020).

According to the distance from the source to the hive, there is a circular tail and quivering dance. The trembling dance provides the balance between the amount of nectar and the ability to bring food. This dance is a form of dance that is provided without giving the direction and distance to the source 50-100 meters away. It is understood that the number of repetitions in a wide area from 10 meters to 100 kilometers gives the distance information and the angle between the sun and the food source is 45 degree by making a dance similar to the number 8 (Kaya & Eke, 2020).

In the Artificial Bee Colony Algorithm, the foraging process of bee colonies is modeled and some assumptions are made.There are three different types of bees in the ABC Algorithm: scout bee, worker bee, and onlooker bee. There is one worker bee for each food source. The number of worker bees is equal to the number of onlooker bees. In case of depletion of resources, worker bees turn into scout bees and scout bees go to search for new sources. Thus, when the resources are depleted, the worker bees abandoning those resources is defined as negative feedback. The search for new resources by scout bees is defined as randomness oscillation. The number of emerging scout bees is determined by the limit parameter.

In the ABC Algorithm, the position of a food source corresponds to a solution. The nectar richness of the food source is defined through the objective function of the solution. The amount of nectar from the sources indicates the quality of the results, and the locations of the food sources represent the probability results of optimization. Worker bees search for food sources and share information about these sources with onlooker bees. Onlooker bees also tend more towards rich food sources with the information they receive from worker bees. Thus, onlooker bees show positive feedback. The ABC algorithm first starts with the production of food sources and positions suitable for these food sources (Karaboga & Akay, 2009).

Basic stages of Artificial Bee Colony Algorithm:

- Creation of food source areas,
- Repeat,
  - ✓ Sending worker bees to food sources
  - ✓ and calculating the amount of nectar
  - ✓ Calculation of probability values according to information sharing from employed bees,
  - ✓ Onlooker bees choose food source areas according to their probability values,
  - ✓ Criteria for leaving the resource: Limit and number of scout bee production,
  - ✓ Control: Maximum loop.

The stages of the ABC Algorithm are as follows.

Stage 1 : The algorithm starts by generating a random food source positions. This process starts by generating random values between the lower and upper limits of each parameter. $i= 1...N, j=1...M$, N is the number of food sources, M is the number of parameters to be optimized, x_j^{min}, lower bound of j.parameter, x_j^{max} is the upper limit of the j.parameter. In addition, at the initial stage, each resource has an $error_i$ value that expresses the number of failures to develop.

$$x_{ij} = x_j^{min} + rand(0,1)(x_j^{max} - x_j^{min}) \quad (2)$$

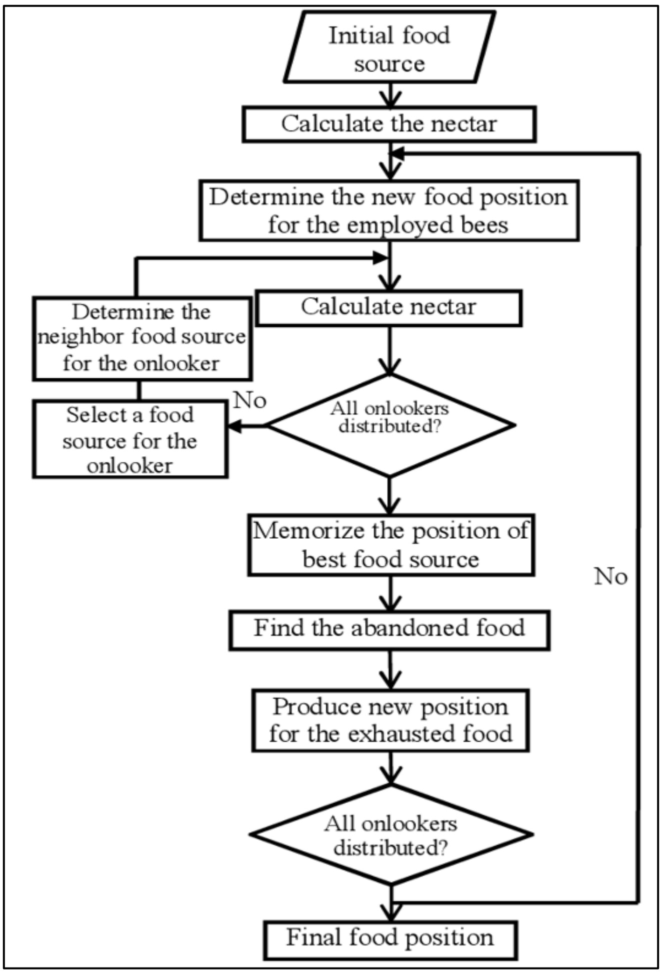

Figure 11. ABC Algorithm Flowchart (Akay, 2009)

Stage 2: The worker bee determines a new food source in the vicinity of the food source it works with and evaluates the quality of this source. If the new resource is more valuable, it memorizes the new resource. The determination of the new resource is provided by Equation 3.

$$v_{ij} = x_{ij} + \emptyset_{ij}(x_{ij} - x_{kj}) \quad (3)$$

In case the v_{ij} value produced by this process exceeds the lower-upper limits previously specified, it is shifted to the lower and upper limit values of the j.parameter using Equation 4.

$$v_{ij} = \begin{cases} x_j^{min}, & v_{ij} < x_j^{min} \\ v_{ij}, & v_j^{min} \le v_{ij} \le x_j^{max} \\ x_j^{min}, & v_{ij} > x_j^{max} \end{cases} \quad (4)$$

The parameter vector *vi* produced in the bounds range represents a new resource. By calculating the quality of this new resource, the fitness value of the new resource is calculated.. The fitness value of the solution is calculated by substituting a cost value of this resource in *f(vi)*. *fi* is the cost value of the *vi* resource (solution).

$$fitness_i = \begin{cases} 1/(1+f_i), & f_i \ge 0 \\ 1+abs(f_i), & f_i < 0 \end{cases} \quad (5)$$

A selection process is applied according to the fitness value between x_i and v_i. If the new v_i solution is better, the bee responsible for it deletes the location of the old source from its memory and assigns the location of the v_i source to the memory. If this did not happen, the bee responsible for it would continue to go to the *xi* resource, and since the solution could not be developed, the $error_i$ related to the x_i resource would increase by one, and when it was developed, the counter would be reset.

Stage 3: The onlooker bee chooses a source with probability proportional to the nectar amounts of the food sources, benefiting from the information shared through dance. This selection process using probability is done by using the fitness values corresponding to the nectar amounts in the algorithm. The selection process based on the fitness values is done by the Roulette wheel method. The angle of each slice of the wheel is proportional to its fitness value. In other words, the ratio of the fitness value of a resource to the sum of the fitness value of all resources gives the relative probability of choosing that resource relative to other resources. In the formula below, SN represents the number of employed bees.

$$p_i = \frac{fitness_i}{\sum_{i=1}^{SN} fitness_i} \quad (6)$$

Stage 4: After calculating the probability values in the algorithm, the selection is made according to the Roulette wheel and a random number is generated for each source within the range of [0,1]. Afterward, the p_i value is generated, if it is greater than this number, onlooker bees such as employed bees use Equation 3 to generate a new solution in this source region.

The new solution found is evaluated and its quality is calculated. Then, the compatibility of the new solution with the old solution is compared and it is subjected to a selection process in which the best one is selected. If the new solution found is better, this solution is taken instead of the old solution and the solution error counter error is reset, if the new solution found is not better, the solution failure counter ($error_i$) is increased by one. (Akay, 2009).

Stage 5: It is checked whether the nectar is exhausted at the source. If it is exhausted, it is replaced with a random value generated by Equation 2.

Stage 6: The best solution is kept in memory.

Stage 7: The conditions for termination are checked, and then if these conditions are not met, it must be repeated from Step 2 to Step 6 (Kaya & Eke, 2020).

In this study, after the surrogate model was trained in the artificial neural network, it was used in Equation 1 in the Artificial Bee Colony Algorithm. The most suitable angle, hump and thickness values for the lift value requested by the designer are found by the study prepared with the help of ABC algorithm.In this study, the restrictions in the Artificial Bee Colony Algorithm are given in Table 1. The algorithm was developed in MATLAB 2019a version and tested on a computer with AMD Ryzen 7 4800H Radeon Graphics 2.90 GHz processor, 16.0 GB Ram, 64 Bit Windows 10 Pro Operating system.

Table 3. Optimization constraint

Parameter	Value
Angle(degree)	1-20
Camber(%)	1-20
Thickness(%)	1-20
Air Density(slugs/ft^3)	0.00511844

The optimization constraints in Table 1 depend on Foilsim.

Table 4. Parameter of the optimization algorithm

Parameter	Value
Colony Size (employed bees+onlooker bees).	40
Limit (A food source that could not be improved through trials).	10000
maxCycle (the number of cycles of foraging is stopping criteria).	180
The number of optimised parameters.	5

3. Result and Discussion

28 experiments were carried out by using the network trained with ANN by optimizing in ABC algorithm. In the first stage of these experiments, Angle Camber and Thickness values were found in the constant velocity and fixed wing area. (Experiment 1, Experiment 8, Experiment 15, Exp 22).

Then at the same constant speed and in a different fixed wing area; Camber and Thickness values were kept constant and Angle value was observed (Experiment 2, Experiment 9, Experiment 16, Experiment 23). As a result of the observation, it was determined that there was a **decrease** in Angle values.

In Experiments 3, Experiment 10, Experiment 17, Experiment 24, Angle and Thickness values were kept constant and Camber value was observed. As a result of the observation, it was observed that there was a **decrease** in the Camber value.

In the last experiments of the first stage (Experiment 4, Experiment 11, Experiment 18, Experiment 25), Angle and Camber values were kept constant and Thickness values were observed. As a result of the observation, it was determined that there was a **decrease** in Thickness values.

In the second stage of the experiment; The wing area at the beginning of the first stage was left the same, at a different constant speed, the Camber and Thickness values were kept constant and the Angle value was observed (Experiment 5 Experiment 12 Experiment 19 Experiment 26). As a result of the observation, it was determined that there was an **increase** in Angle values.

Angle and Thickness values were kept constant and Camber values were observed in Experiment 6, Experiment 13, Experiment 20 and Experiment 27.

A **decrease** was observed in Camber values as a result of the experiment. In the last experiments of the second stage, Angle and Camber values were kept constant in Experiment 7 Experiment 14 Experiment 21 Experiment 28 and Thickness value was observed. As a result of the experiment, it was observed that there was a **decrease** in Thickness values.

This study aims to contribute to efficient aircraft design by determining the optimal wing profile by using Foilsim data in optimization.

Table 5: Observation of Angle, Camber and Thickness values. (Entered Lift=8 Ibs).

Lift(lbs) (Entered in ABC)	Experiment No	Fixed Speed(mph)	Fixed Wing Area(sqft)	Optimised Angle(°)	Optimised Camber (%)	Optimised Thickness(%)	Foilsim-Real Lift(lbs)
8	1	24	2.6	14.1459	8.35663	7.27498	8
	2	24	2.8	9.41287	8.35663	7.27498	8
	3	24	2.8	14.1459	5.66572	7.27498	8
	4	24	2.8	14.1459	8.35663	1.99969	8
	5	25.4	2.6	17.3841	8.35663	7.27498	8
	6	25.4	2.6	14.1459	6.1912	7.27498	8
	7	25.4	2.6	14.1459	8.35663	1.19178	8

Table 6: Observation of Angle, Camber and Thickness values. (Entered Lift=17 Ibs).

Lift(lbs) (Entered in ABC)	Experiment No	Fixed Speed(mph)	Fixed Wing Area(sqft)	Optimised Angle(°)	Optimised Camber (%)	Optimised Thickness(%)	Foilsim-Real Lift(lbs)
17	8	30.4	3.3	12.6009	10.2219	8.22825	17
	9	30.4	3.45	9.80014	10.2219	8.22825	17
	10	30.4	3.45	12.6009	8.41263	8.22825	17
	11	30.4	3.45	12.6009	10.2219	4.05814	17
	12	31.28	3.3	16.7070	10.2219	8.22825	17
	13	31.28	3.3	12.6009	8.73887	8.22825	17
	14	31.28	3.3	12.6009	10.2219	1.01248	17

Table 7: Observation of Angle, Camber and Thickness values. (Entered Lift= 52 Ibs).

Lift(lbs) (Entered in ABC)	Experiment No	Fixed Speed(mph)	Fixed Wing Area(sqft)	Optimised Angle(°)	Optimised Camber (%)	Optimised Thickness(%)	Foilsim-Real Lift(lbs)
52	15	41	4.2	14.6894	19.9987	13.6096	52
	16	41	4.3	9.56763	19.9987	13.6096	52
	17	41	4.3	14.6894	18.9501	13.6096	52
	18	41	4.3	14.6894	19.9987	2.7278	52
	19	41.8	4.2	16.0302	19.9987	13.6096	52
	20	41.8	4.2	14.6894	18.2971	13.6096	52
	21	41.8	4.2	14.6894	19.9987	1.1346	52

The optimal parameters (angle, camber, thickness, wing area, velocity value) obtained through the ABC Algorithm. The results checked in Foilsim web environment. It has been observed that the Foilsim data and ABC data are very close to each other, and the test results with some values are presented in Table 5, Table 6, Table 7, Table 8.

Table 8: Observation of Angle, Camber and Thickness values. (Entered Lift=157 Ibs).

Lift(lbs) (Entered in ABC)	Experiment No	Fixed Speed(mph)	Fixed Wing Area(sqft)	Optimised Angle(°)	Optimised Camber (%)	Optimised Thickness(%)	Foilsim-Real Lift(lbs)
157	22	70.7	4.5	15.0302	17.9987	12.6096	157
	23	70.7	4.65	9.29409	17.9987	12.6096	157
	24	70.7	4.65	15.0302	16.6899	12.6096	157
	25	70.7	4.65	15.0302	17.9987	1.8696	157
	26	72.1	4.5	16.2354	17.9987	12.6096	157
	27	72.1	4.5	15.0302	16.5710	12.6096	157
	28	72.1	4.5	15.0302	17.9987	1.089009	158

4. Conclusion

In our study, the C_L value was obtained by pre trained ANN, and with this C_L value, the optimum lift value (L) was obtained by ABC optimization algorithm. It is also a current research activity to perform a similar study with the drag coefficient (C_D), and drag value which is complementary to the current study and to obtain the optimum L/D ratio.

Ethical approval

Not applicable.

Nomenclature

ABC = Artificial Bee Colony Algorithm.
ANN = Artificial Neural Network.
CFD = Computational Fluid Dynamics.
D = Drag.
EA = Evolutionary algorithms.
L = Lift.

Symbols

A = Wing Area
C_L = Lift Coefficient
C_D = Drag Coefficient
$error_i$ = Number of failures.
$fitness_i$ = Calculation of the fitness value of the solution.
M = Number of parameters to optimize
N = Number of food sources
ρ = Air Density
p_i = the relative probability of choosing
$Ø_{ij}$ = random value in [-1,1]
SN = represents the number of employed bees
V = Air Speed
x_j^{min} = lower bound of j.parameter
x_j^{max} = upper bound of j.parameter

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Stability Evaluation of a Fixed-Wing Unmanned Aerial Vehicle with Morphing Wingtip

Tuğrul Oktay[1], Yüksel Eraslan[2*]

[1]Erciyes University, Faculty of Aeronautics and Astronautics, Kayseri, Türkiye. (oktay@erciyes.edu.tr).
[2*]İskenderun Technical University, İskenderun Vocational School of Higher Education, Hatay, Türkiye. (yuksel.eraslan@iste.edu.tr).

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Abstract

Aeronautical applications of morphing technologies are continued to increase their popularity and wide spread application during last years. The technology takes place in not only military, but also civil applications that aims providing superior performances to manned or unmanned aircraft than conventional configurations. However, multidisciplinary approach is required for an aerial vehicle to have ultimate outcome from such an application due to existence of interdisciplinary interactions. Therefore, this research aims to investigate effects of morphing wingtip application on longitudinal and lateral-directional stabilities of a fixed-wing unmanned aerial vehicle, which have remarkable effect on autonomous control performance considerations. In this article, morphing wingtip refers to folding the wing from a determined spanwise location with a dihedral angle. With the aim of the study, wingtips of an unmanned aerial vehicle were folded with 15, 30 and 45 degrees of dihedral angles to be compared with original non-dihedral design. Longitudinal and lateral-directional characteristics of new variations were evaluated in terms of stability derivatives by means of linearized equations of motion that were also presented in state-space representation. Aerodynamic impacts of each variation were assessed by means of computational results obtained from analyses with three-dimensional panel method. Furthermore, taking inertial changes into consideration, concluding remarks on both longitudinal and lateral-directional stability derivatives were presented for each configuration.

1. Introduction

In the last decades, increasing popularity of unmanned aerial vehicles (UAV) in both military and civil applications leaded scientists to spend further effort on performance enhancement of these vehicles (Konar et al. 2020). Both of fixed-wing and rotary-wing UAVs have their own pros and cons depending on operational purposes. For instance, while rotary-wing configurations have superior ability in hovering flight, fixed-wing configurations are capable of flying at higher altitudes and airspeeds with extended range and endurance (Konar, 2020).

One of the most recent and popular approaches are morphing applications on appropriate components of aircraft, such as wing, tail or fuselage (Sofla et al., 2010). Rather than traditional applications of control-aimed surface deflections, i.e. aileron, rudder, elevator etc., the term “morphing” refers geometrical change in any part of the aircraft to improve its aerodynamic or related disciplinary performances. The application is entitled as active or passive with respect to taking place in-flight or not, respectively (Kose et al., 2020).

Wings can be proposed as suitable for morphing applications on fixed-wing UAVs, as a major lifting surface and significant source of drag in aerodynamic manner. Lift force generation of a wing is strongly related with its sectional and planform shape, air density and airspeed, thus changing the design of the wing will be resulted in alteration of amount or spanwise distribution of lift force. On the other hand, drag force of an aircraft comprises of parasitic and induced drag components, which are also related with shape of the wing. Therefore, target performance oriented suitable adjustment of aerodynamic forces on an aircraft can be possible with changing its shape via morphing applications. For instance, induced drag relates with wing-tip vortices and generally designers make an effort to eliminate this unfavorable effect via wing-tip devices such as winglets (Yen et al., 2011). In a similar manner, additional to aerodynamics; stability, control or structural performances of an UAV can be improved via morphing wing applications (Oktay et al., 2016, Çoban, 2019, Konar, 2019). However, in order to have an effective thriving outcome for a vehicle, usually, multidisciplinary approach is required because of forecasted interdisciplinary interactions.

Autopilots are frequently used on UAVs with the purpose of guiding the vehicle without necessity for pilot assistance. This autonomous control performance is a considerable issue for UAVs and dramatically relates with shape of the main wing that is the most important component of an aircraft in terms of aerodynamics (Oktay et al., 2018, Kose et. al., 2021). Therefore, improvement of the autonomous performance can also be possible with suitable morphing applications, theoretically. Nevertheless, in order to evaluate effects of morphing technologies on autonomous control performance, it is essential to investigate stability of the aircraft which is interpreted in longitudinal, lateral and directional axes separately (Çoban, 2020). While longitudinal stability is associated with pitching motion, lateral and directional stabilities are related with roll and yaw motions, respectively. In order to investigate each motional characteristics, it is essential to evaluate aircraft equations of motion and eventually constitute longitudinal and lateral parametric state-space models. The state-space models include stability derivatives, inertial considerations and flight condition related terms (Çelik et al., 2016). Therefore, for same flight condition, as morphing application leads to different aerodynamic and inertial characteristics, they should also be investigated. Moreover, morphing related aerodynamic and geometrical alterations of an aircraft lead to change in stability derivatives and correspondingly stability of the vehicle (Kanat et al., 2019). For the purpose of investigating effects of morphing application on aerodynamic characteristics of vehicle, numerical investigation methods, such as Computational Fluid Dynamics, generally considered as proper rather than expensive experimental setups (Şumnu et al., 2021, Oktay et al. 2021).

In the recent past, there are various studies aiming investigation of aerodynamics and stability derivatives of aerial vehicles in analytical, numerical or experimental manner in the literature. A study on a transport aircraft with flared-hinge folding wingtips was shown that the folding has a little effect on longitudinal flight dynamic modes, but excessive alteration on lateral-directional dynamic modes due to generated larger drag forces (Ajaj, 2021). Implications in the article about corresponding stability and control derivatives of the aircraft were provided via aerodynamic results taken from analyses carried out with computational application of vortex lattice method. In another study, effect of in-flight folding wingtip application on aircraft roll dynamics in terms of roll damping and aileron effectiveness was assessed depending on varying wingtip size and folding angle (Dussart et al., 2019). The results were presented with respect to upward and downward deflection rates of wingtips. On the other hand, a study was investigated aerodynamic effects of morphing wingtip application in terms of both twist and dihedral angles by means of both computational and experimental approaches (Smith et al., 2014). A blended-wing-body aircraft was investigated in terms of static and dynamic stability together with taking airworthiness regulations into consideration (Lixin et al., 2022). Long range eVTOL aircraft preliminary design was assessed in terms of control and stability issues for each flight phase. With that purpose, a controller was designed with the aim of handling quality improvement. The analytical model was applied to estimate stability derivatives (Schoser et al.,2022).

In this article, stability evaluation of a fixed-wing UAV ZANKA-I was carried out in consideration of wingtip morphing application. The main wing of the vehicle folded with dihedral angles 15, 30 and 45 degrees from approximately 84.7% of its semi-span location. Taking cruise flight conditions into consideration, aerodynamic effects were investigated by means of 3D panel method. Inertial alterations were discussed and related stability derivatives were evaluated. In summary, the effect of morphing wingtip application with various dihedral angles was evaluated in stability contributions point of view.

2. Material and Method

In this article, morphing wingtip application was investigated on ZANKA-I fixed-wing UAV, given in Figure 1, in terms of effects on longitudinal and lateral stability derivatives. With respect to the objective of the paper, required reference parameters about the vehicle were taken from a previous study in the literature (Oktay et al., 2016). In order to investigate effects of morphing wingtip application on the stability derivatives, it is essential to derive aircraft equations of motion in suitable form and obtain impacts of the morphing on related terms.

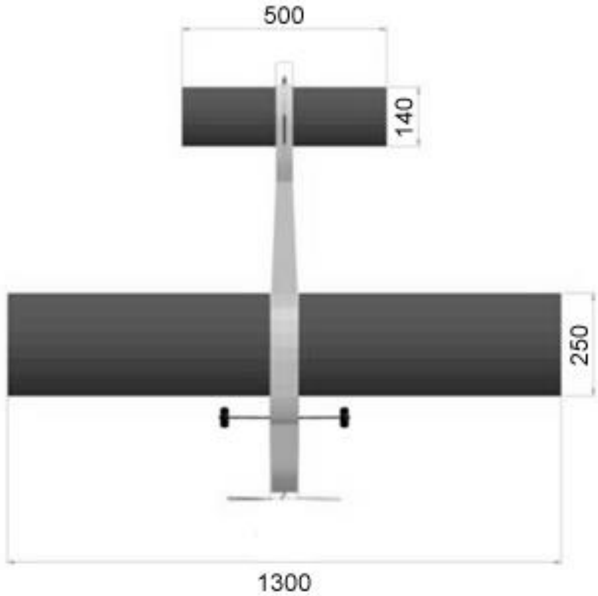


Figure 1. Top-view of ZANKA-I unmanned aerial vehicle with dimensions in mm (Oktay et al., 2016)

2.1. Equations of Motion and State-space Representation

Stability derivatives that previously mentioned are taken place in longitudinal and lateral equations of motion of vehicle. Rigid body equations of motion include force, moment and kinematic equations of the related body. As indicated, autonomous control performance of such an aircraft is dramatically depends on the related equations and so stability derivatives, naturally. The most common representation of these equations were given as parametric state-space model of the aircraft for both longitudinal and lateral approach in Equation 1 and Equation 2, respectively (Nelson, 1998). In these equations, control surface deflections (δ_e, δ_a, δ_r), linear velocities (u, v, w), angular velocities (p, q, r), forces (X, Y, Z) and moments (L, M, N) of the vehicle taken place in aircraft frame of reference, as given in Figure 2.On the other hand, there is an impact of certain inertial terms I_x, I_y, I_z and I_{xz}, which are the moments of inertia around the x, y, z axes and xz plane, respectively.

Aircraft equations of motion can be written as first-order differential equations named as state-variable representation that includes aerodynamic and inertial variables, stability derivatives and mass properties of the aircraft as given in Equation 1, where x stands for state vector and η refers to control vector, A and B are the matrices including aircraft dimensional stability derivatives (Nelson, 1998).

$$\dot{x} = Ax + B\eta \quad (1)$$

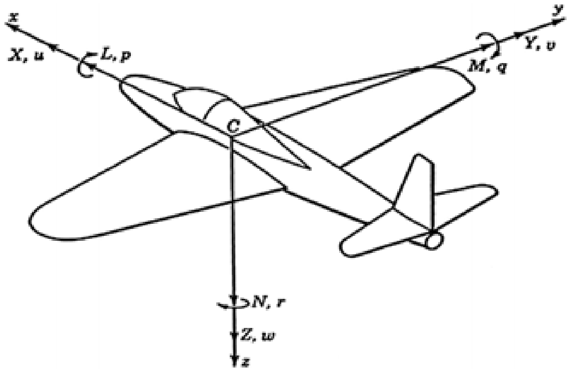


Figure 2. Aircraft body-fixed reference frame and related forces, moments, angular and linear velocities (Deepa et al., 2015)

In compliance with the equation stated above, Equation 2 and Equation 3 are the state-space representation of the aircraft equations of motion in longitudinal and lateral axes, respectively, where θ is pitching angle, ϕ is yawing angle, u is airspeed and g is the gravitational acceleration. Moreover, the subscript "0" refers to reference condition of each term.

$$\begin{bmatrix} \Delta\dot{u} \\ \Delta\dot{w} \\ \Delta\dot{q} \\ \Delta\dot{\theta} \end{bmatrix} = \begin{bmatrix} X_u & X_w & 0 & -g \\ Z_u & Z_w & u_0 & 0 \\ M_u + M_{\dot{w}}Z_u & M_w + M_{\dot{w}}Z_w & M_q + M_{\dot{w}}u_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \Delta u \\ \Delta w \\ \Delta q \\ \Delta\theta \end{bmatrix} + \begin{bmatrix} X_{\delta_T} & X_{\delta_e} \\ Z_{\delta_T} & Z_{\delta_e} \\ M_{\delta_T} + M_{\dot{w}}Z_{\delta_T} & M_{\delta_e} + M_{\dot{w}}Z_{\delta_e} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \Delta\delta_T \\ \Delta\delta_e \end{bmatrix} \quad (2)$$

$$\begin{bmatrix} \Delta\dot{v} \\ \Delta\dot{p} \\ \Delta\dot{r} \\ \Delta\dot{\phi} \end{bmatrix} = \begin{bmatrix} Y_v & Y_p & -(u_0 - Y_r) & -g\cos(\theta_0) \\ L_v^* + \frac{I_{xz}}{I_x}N_v^* & L_p^* + \frac{I_{xz}}{I_x}N_p^* & L_r^* + \frac{I_{xz}}{I_x}N_r^* & 0 \\ N_v^* + \frac{I_{xz}}{I_z}L_v^* & N_p^* + \frac{I_{xz}}{I_z}L_p^* & N_r^* + \frac{I_{xz}}{I_z}L_r^* & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \Delta v \\ \Delta p \\ \Delta r \\ \Delta\phi \end{bmatrix} + \begin{bmatrix} 0 & Y_{\delta_r} \\ L_{\delta_a}^* + \frac{I_{xz}}{I_x}N_{\delta_a}^* & L_{\delta_r}^* + \frac{I_{xz}}{I_x}N_{\delta_r}^* \\ N_{\delta_a}^* + \frac{I_{xz}}{I_z}L_{\delta_a}^* & N_{\delta_r}^* + \frac{I_{xz}}{I_z}L_{\delta_r}^* \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \Delta\delta_a \\ \Delta\delta_r \end{bmatrix} \quad (3)$$

2.2. Longitudinal Stability Derivatives

Aircraft longitudinal equations of motion comprise of longitudinal stability derivatives, which are stated as A and B matrices previously, in Equation 2. The derivatives can be divided in two groups as force and moment derivatives that can be estimated from equations that include aerodynamic coefficients, dynamic pressure Q, wing area S, mass m, reference airspeed u_0, and wing mean aerodynamic chord length $\bar{c}$ (Nelson, 1998).

Longitudinal stability derivatives of X-force and Z-force are X_u, X_w, Z_u and Z_w, which refers to variations in forces in terms of linear velocities u and w. Impact of reference drag coefficient C_{D_0} on derivative X_u can be clearly seen from Equation 4. Moreover, drag curve slope C_{D_α} and reference lift coefficient C_{L_0} have remarkable effect on X_w, as given in Equation 5. Similarly, Equation 6 and Equation 7 evidently reveals that Z-force derivatives Z_u and Z_w are directly affected from reference lift coefficient, lift curve slope C_{L_α} and reference drag coefficients of the aircraft.

$$X_u = \frac{(-C_{D_u} - 2C_{D_0})QS}{mu_0} \quad (4)$$

$$X_w = \frac{-(C_{D_\alpha} - C_{L_0})QS}{mu_0} \quad (5)$$

$$Z_u = \frac{-(C_{L_u} + 2C_{L_0})QS}{mu_0} \quad (6)$$

$$Z_w = \frac{-(C_{L_\alpha} + C_{D_0})QS}{mu_0} \quad (7)$$

Moments point of view, derivatives of M_u, M_w, $M_{\dot{w}}$ and M_q give brief idea about effects of linear velocities u and w, angular rate $\dot{w}$ and angular velocity q on pitching moment variations, respectively. Different from force derivatives, estimation of moment derivatives requires also y-axis moment of inertia I_y. Equations given below include also various pitching moment coefficient related terms C_{m_u}, C_{m_α}, $C_{m_{\dot{\alpha}}}$, and C_{m_q}, which suggest information about variation in pitching moment coefficient with linear velocity u, angle of attack α, rate of angle of attack $\dot{\alpha}$, and angular velocity q.

$$M_u = C_{m_u}\frac{(QSc)}{u_0 I_y} \quad (8)$$

$$M_w = C_{m_\alpha}\frac{(QSc)}{u_0 I_y} \quad (9)$$

$$M_{\dot{w}} = C_{m_{\dot{\alpha}}}\frac{\bar{c}}{2u_0}\frac{(QS\bar{c})}{u_0 I_y} \quad (10)$$

$$M_q = C_{m_q}\frac{c}{2u_0}\frac{QSc}{I_y} \quad (11)$$

2.3. Lateral-Directional Stability Derivatives

In order to have lateral stability of an aircraft evaluated, investigation of related stability derivatives is essential as stated previously. Together with similar variables in longitudinal equations, equations of lateral derivatives also include lateral stability coefficients, wing span, x-axis moment of inertia and z-axis moment of inertia variables.

Y-force lateral stability derivatives are Y_p, Y_r and Y_{δ_r}, which refers to variation in Y-force in terms of rudder deflection δ_r and angular velocities p and r. C_{y_p}, C_{y_r}, and $C_{y_{\delta_r}}$ are nondimensional lateral stability coefficients as stated in equations below.

$$Y_p = \frac{QSbC_{y_p}}{2mu_0} \quad (11)$$

$$Y_r = \frac{QSbC_{y_r}}{2mu_0} \quad (12)$$

$$Y_{\delta_r} = \frac{QSC_{y_{\delta_r}}}{m} \quad (13)$$

Lateral stability moment derivatives of L_p, L_r, L_{δ_α} and L_{δ_r} give brief idea about effects of angular velocities p and r, aileron deflection δ_α and rudder deflection δ_r on variation of rolling moment. Moreover, relative stability coefficients are C_{l_p}, C_{l_r}, $C_{l_{\delta_\alpha}}$, $C_{l_{\delta_r}}$ as stated in equations below.

$$L_p = \frac{QSb^2C_{l_p}}{2I_xu_0} \quad (14)$$

$$L_r = \frac{QSb^2C_{l_r}}{2I_xu_0} \quad (15)$$

$$L_{\delta_\alpha} = \frac{QSbC_{l_{\delta_\alpha}}}{I_x} \quad (16)$$

$$L_{\delta_r} = \frac{QSbC_{l_{\delta_r}}}{I_x} \quad (17)$$

Lateral-directional stability moment derivatives of N_{δ_r}, N_{δ_α} and N_r give brief idea about effects of angular velocity r, aileron deflection δ_α and rudder deflection δ_r with variation of yawing moment. Similar with previous moment derivatives, nondimensional relative stability coefficients $C_{n_{\delta_r}}$, $C_{n_{\delta_\alpha}}$ and C_{n_r} are included as stated in equations below.

$$N_{\delta_r} = \frac{QSbC_{n_{\delta_r}}}{I_z} \quad (18)$$

$$N_{\delta_\alpha} = \frac{QSbC_{n_{\delta_\alpha}}}{I_z} \quad (19)$$

$$N_r = \frac{QSb^2C_{n_r}}{2I_xu_0} \quad (20)$$

2.4. Aerodynamic Investigation

In this paper, aerodynamic investigation of the vehicle was carried out by means of general public licensed computational program, XFLR5. The program includes LLT (lifting line theory), VLM (vortex lattice method) and 3D panel method options within three-dimensional analysis environment, meanwhile capable of carrying out two-dimensional airfoil analyses with admissible accuracy for such a comparative study (Ahmad et. al., 2021).

Analysis environment constructed at sea-level density of 1.225 kg/m^3 and cruise speed of 16.67 m/s. In order to obtain realistic results in terms of parasitic drag, viscous effects were taken into consideration rather than potential flow approximation. Modeled three-dimensional wing models having dihedral angles of 0, 15, 30 and 45 degrees from 84.7% semi-span location are represented in Figure 3. It can be clearly seen that wingspan and wing area of the designs having dihedral angle were shortened and correspondingly their aspect ratios, which can be estimated from Equation 21 using wing span and wing area variables, were diminished (Gudmundsson, 2013).

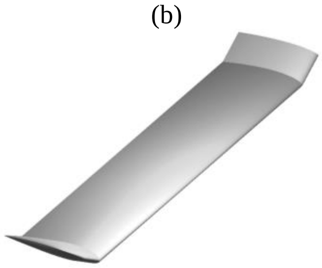
$$AR = \frac{b^2}{S} \quad (21)$$

Multi-panel wings have spanwise-varying dihedral angle, such as wingtip morphing applied wing in this article. Therefore, in this case, it is required for stability and control estimations to determine equivalent dihedral angle (EDA) of total wing. EDA of a polyhedral wing can be estimated by means of locations of different dihedral angle applied sections in terms of their semi-spanwise locations and values of dihedral angles. In case of two panel wing as our application, taking also moment fractions into consideration, EDA can be estimated from Equation 22, where Γ_1 is dihedral angle of unfolded section and Γ_2 is dihedral angle of morphing wingtip applied section (Beron-Rawdon, 1988).

$$EDA = 0.858 * (\Gamma_1) + 0.142 * (\Gamma_2) \quad (22)$$

(a)

(b)



(c)

(d)

Figure 3. Representative isometric view of ZANKA-I wing design; a) baseline (D0), b) 15-degree morphed wingtip (D15) c) 30-degree morphed wingtip (D30) d) 45-degree morphed wingtip (D45)

3. Results and Discussion

Morphing wingtip application was resulted in morphological changes as expected, and alterations in effective dihedral angle, wing span, wing area, mean aerodynamic chord length and wing aspect ratio due to folding were given in Table 1. Denominations D0, D15, D30 and D45 constructed as abbreviations with respect to wingtip dihedral angles of 0, 15, 30 and 45 degrees, respectively. EDAs for each wing configuration were estimated from Equation 22 and aspect ratios were estimated from Equation 21. The application leads to decrease in wingspan, wing area and wing aspect ratio, while mean aerodynamic chord length remains constant, as expected.

Table 1. Geometrical parameters of ZANKA-I wing design based on morphing wingtip dihedral angle

Parameter	D0	D15	D30	D45
Wingtip Dihedral Angle	0º	15º	30º	45º
Wing Effective Dihedral	0º	2.13º	4.26º	6.39º
Wing Span (m)	1.3	1.293	1.273	1.241
Aerodynamic Chord (m)	0.25	0.25	0.25	0.25
Wing Area (m^2)	0.325	0.323	0.318	0.310
Wing Aspect Ratio	5.2	5.173	5.093	4.966

In order to evaluate stability derivatives, it is required to obtain aerodynamic effects as indicated before. Therefore, computational application of 3D panel method was performed on both base model and configurations with wingtip dihedral. The results of the analyses shown that, increment in wingtip dihedral was leaded to decrease in span-efficiency, *e*, as expected due to change in direction of locally created lift force, but increase in both of the reference drag and lift coefficients. Furthermore, while D15 has reference lift coefficient of 0.66% higher than D0 configuration, D30 and D45 has 1.4% and 2.25% higher values from base model, respectively. D15, D30 and D45 was found to have 1.23%, 3.18% and 5.93% higher reference drag coefficient values than base model D0, respectively.

Table 2. Oswald efficiency factor, reference lift and drag coefficients with respect to morphing wingtip configuration

Symbol	D0	D15	D30	D45
C_{L_0}	0.6494	0.6537	0.6585	0.6640
C_{D_0}	0.01322	0.01339	0.01365	0.01401
e	1.013	1.005	0.995	0.983

Figure 4 and Figure 5 represents the change in lift coefficient and drag coefficient with respect to wingtip dihedral angle at a range of angle of attack values between -5 to 10 degrees. As dihedral angle of the wingtip was increased, lift curve slope was found to be tended to a slight increase and higher wingtip dihedral configurations were resulted in lower lift coefficients at higher angle of attacks. An opposite tendency was found at angle of attacks lower than approximately 6º. Drag coefficients point of view, minimum value of the term was found to remain approximately constant independent from wingtip dihedral angle alteration. Nevertheless, curve slope of drag coefficient was found in decreasing tendency with higher dihedral angles as seen in Figure 5. The maximum value of aerodynamic performance parameter lift-to-drag ratio was found to decrease at higher wingtip dihedral angles, where similar tendency was obtained for reference value of the term, as given in Figure 6.

As a consequence of aerodynamic investigation, alteration tendency of aerodynamic parameters due to morphing wingtip application were found in good agreement with similar studies in the literature (Smith et al., 2014).

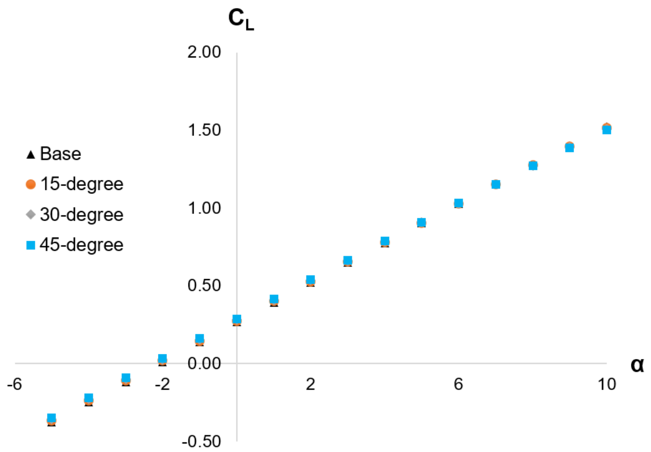


Figure 4. Lift coefficient varying with angle of attack for base model and morphing wingtip configurations of 15, 30 and 45 degrees

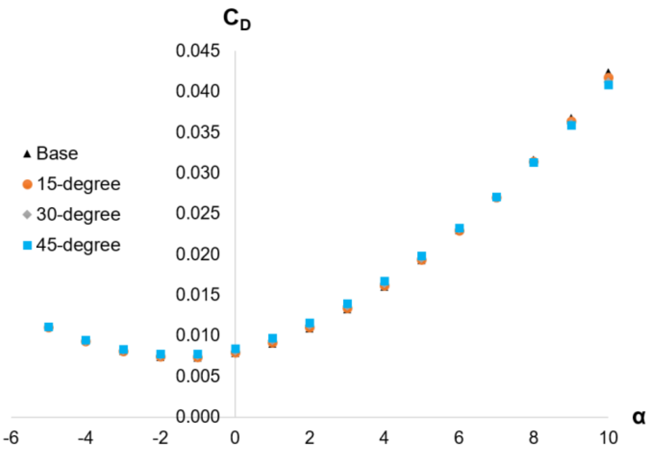


Figure 5. Drag coefficient varying with angle of attack for base model and morphing wingtip configurations of 15, 30 and 45 degrees

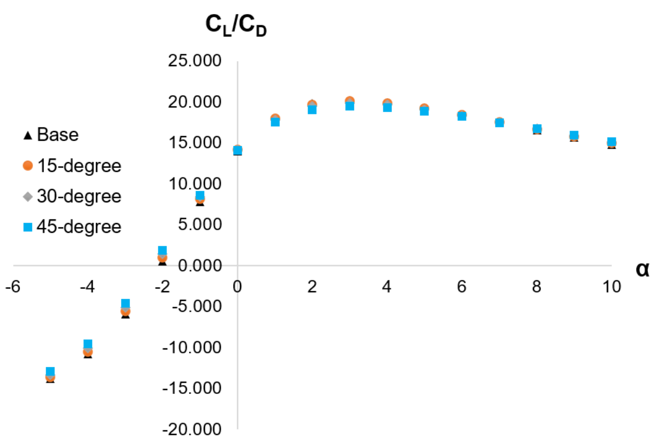


Figure 6. Lift-to-drag ratio varying with angle of attack for base model and morphing wingtip configurations of 15, 30 and 45 degrees

As stated in stability derivative equations, inertial changes have remarkable effect and required to be evaluated. Table 3 gives the resultant moment of inertia values of each configuration for x, y, z axis and also xz plane. It is clear from the table that, while x, z and xz plane moments of inertia were diminished with wingtip dihedral, y moment of inertia oppositely found to increase.

Table 3. Moments of inertia (kgm^2) with respect to morphing wingtip configuration

Symbol	D0	D15	D30	D45
I_x	0.09878	0.09843	0.09774	0.09670
I_y	0.14219	0.14330	0.14672	0.15107
I_z	0.22971	0.22892	0.22717	0.22453
I_{xz}	0.01276	0.01269	0.01250	0.01218

Table 4. Longitudinal stability derivative values with respect to morphing wingtip configuration

	D0	D15	D30	D45	Unit
X_u	-0.0602	-0.0606	-0.0608	-0.0609	s^{-1}
X_w	0.8342	0.8438	0.8416	0.8322	s^{-1}
Z_u	-1.9697	-1.9722	-1.9560	-1.9232	s^{-1}
Z_w	-7.3441	-7.3354	-7.2568	-7.1051	s^{-1}
Z_{δ_e}	-8.0212	-8.0212	-8.0212	-8.0212	ft/s^2
M_w	-1.413	-1.410	-1.381	-1.338	ft.s^{-1}
$M_{\dot{w}}$	-0.0445	-0.0443	-0.0435	-0.0424	ft^{-1}
M_{δ_e}	-61.491	-61.009	-59.590	-57.874	s^{-2}

Table 5. Lateral-directional stability derivative values with respect to morphing wingtip configuration

	D0	D15	D30	D45	Unit
Y_β	-0.07593	-0.07598	-0.07612	-0.07636	ft/s^2
N_β	0.18152	0.18111	0.17945	0.17666	s^{-2}
L_β	0.00000	-0.62075	-1.09509	-1.31102	s^{-2}
N_p	-2.304	-2.291	-2.218	-2.096	s^{-1}
L_p	-45.641	-45.263	-43.710	-41.124	s^{-1}
Y_r	0.002513	0.002513	0.002513	0.002513	ft/s
N_r	-0.035	-0.035	-0.034	-0.032	s^{-1}
L_r	4.617	4.590	4.445	4.200	s^{-1}
Y_{δ_r}	0.02675	0.02675	0.02675	0.02675	ft/s^2
N_{δ_a}	-78.932	-80.045	-81.641	-83.634	s^{-2}
N_{δ_r}	-0.159	-0.158	-0.155	-0.149	s^{-2}
L_{δ_a}	706.555	711.842	720.296	731.078	s^{-2}
L_{δ_r}	9.682	9.754	9.870	10.018	s^{-2}

Longitudinal stability derivative results in Table 4 were shown that, D45 configuration found to have 1.16% higher X_u value and 0.23% lower X_w value from baseline model, which are X-force derivatives related with linear velocities. Furthermore, while Z-force derivatives Z_u and Z_w of D45 configuration were found to decrease at the rate of 2.36% and 3.25% than baseline model, there was no any significant change found in Z_{δ_e}. In addition, moment derivative values of D45 configuration M_w, $M_{\dot{w}}$ and M_{δ_e} were both found to decrease in a rate of 5.28%, 4.66% and 5.88% from baseline model, respectively.

Dihedral effect derivative L_β and roll damping derivative L_p values at various wingtip dihedral angle configurations are given in Table 5. The derivatives were found to diminish with increasing wingtip dihedral angle, which is desired for a laterally stable vehicle. Similarly, increments in cross coupling derivative L_r, roll due to rudder derivative L_{δ_α} and lateral control power derivative L_{δ_r} with increment in wingtip dihedral angle were also desired results for improvement in lateral stability.

Static directional stability derivative N_β was found to be decreased with dihedral angle of wingtip increased, as a tendency in undesired manner. Cross coupling term N_p was found to be improved with positively tendency. Yaw damping term N_r was found to be increased, which is not proper for directional stability point of view. Adverse yaw term N_{δ_a} and rudder power term N_{δ_r} was found to be improved with wingtip dihedral angle increment.

4. Conclusion

Morphing wingtip application was carried out on a fixed-wing unmanned aerial vehicle in terms of dihedral angle with the aim of investigating aerodynamic and corresponding stability derivative impacts of the morphological transformation. In order to have aerodynamic effects of the application evaluated, three configurations with various dihedral angles (15, 30 and 45 degrees) were assessed by means of computational analyses. In addition to these results, variations in moments of inertia were taken into consideration and various longitudinal, lateral and directional stability derivatives were estimated via an analytical approach. Consequently, application of wingtip dihedral angle leaded most of the lateral stability derivatives to be improved, while static longitudinal stability was diminished. Directional stability point of view, static directional stability loss was appeared, but total directional stability could be said to be improved in terms of other directional stability derivatives. In addition, this study was shown that there is a possibility for improvement in autonomous control of UAVs as a future study.

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 Effect of Location Selection on Operational Costs and Fleet Management in the Airline Industry

Serhan Zeybel[1*]

[1*]Turkish Airlines, Flight Operations Presidency, Istanbul, Türkiye (serhanzeybel@gmail.com)

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Corresponding Author: *Serhan Zeybel*

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Abstract

The aim of this study is to reveal the effect of location selection in the airline industry on airline operational costs and fleet management. The effect of location selection on airline operational costs and fleet management in the airline industry is seen as a multi-criteria decision-making problem. For this purpose, the TOPSIS model, a multi-criteria decision-making method, was used. The data used in the research are handled in two stages as alternatives and criteria. The alternatives of the research are 5 different types of aircraft, 8 different locations and 10 different hubs. The alternatives to the multi-criteria decision-making process are operational costs. The main starting point of the study is where the airline's location should be and which aircraft should be used in order to reach 10 different main transfer centers with the lowest operational cost. The weighting has been made according to the average costs in the industry. In addition, in order to fully measure the effect of the location on operational costs, an index was developed with the average of the GDP, HDI and SDI values of the countries where the transfer centers are located, and it is ensured that it affects the decision-making process as 30%. According to the results of the research, it has been seen that the operational costs of the airlines to be established in locations such as Istanbul, London and Delhi are lower and the fleet management is more optimal. This study is important in terms of helping airline companies in the selection process of their establishment location. In addition, unlike the studies in the literature, three different indices such as GDP, HDI and SDI were included in the study, resulting in more realistic results.

1. Introduction

The globalizing world is constantly changing and developing. In this case, it is important for airline companies to adapt to the competition. For this reason, airline companies need to determine their strengths and weaknesses, opportunities and threats in their industry and make strategic analyzes accordingly in order to continue their as a global player and gain competitive advantage. In this context, the most important problems for airline companies are seen as operational costs and fleet management. To reduce operational costs by managing fleets in the best way is to be among the most important plans of airline companies. Airlines are striving to gain new benefits by using existing benefits. Among the advantages of airline companies, their geographical location stands out.

The aviation industry is seen as a service industry with its use of advanced technology, high cost, and fierce competition. Liberalization tendencies that emerged with the concept of globalization cause higher costs, low ticket prices, restrictive laws and regulations, strategic alliances, security needs, environmental awareness and competition. At this point, optimization studies of airline companies regarding airlines and flights have become more important. Airlines mostly adopt the hub and spoke model. Therefore, which centers should be preferred at this stage is important in terms of both profitability and operational costs. The costs that airlines have to bear differ according to the centers chosen (Polmar, 2006).

The geopolitical location of the airports is also effective in airline flight planning. For example, the cost of flying from Istanbul to Moscow and from Dubai to Moscow are different. Successful fleet management can eliminate all these situations. Airlines cannot compete on price without reducing their costs and general expenses. The airline industry relies on airport services, fuel supply, and workforce. However, airlines can also be viewed as legacy carriers that may be particularly dependent on costly distribution networks (O'Kelly and Bryan, 1998).

In our study, the effect of location selection in the airline industry on airline operational costs and fleet management will be revealed.

2. Conceptual Framework

In this section, the literature and method of the study are provided.

2.1. Location Selection

In addition to technological developments, developments in military and political fields enabled not only physical but also human and economic geography to be taken into account. Geopolitics is therefore regarded as an independent science. This interdisciplinary branch of science has enabled the formation of future predictions of strategic industries that directly affect country policies or are directly affected by country policies. Aviation and energy industries stand out among the industries that are directly affected by country policies or that directly affect country policies. These two industries are directly determining the wealth and development of countries and are directly seen as a working element of the geopolitical discipline (Anaz and Akman, 2017).

The aviation industry is directly affected by all the elements of geography. Aviation technology used today cannot overcome geographical obstacles. It is seen that commercial aircrafts used today actively serve within a certain flight distance. In addition, the aviation industry has been directly associated with human structures and the economic development of countries. The aviation industry directly increases the economic power of countries as the commercial network of countries develops (Debbage, 2016).

Through aviation geopolitics, it is possible to determine in which regions and areas there will be growth opportunities and how these growth opportunities will be utilized.

Geographical location is considered to be the most important factor directly affecting the aviation industry. The flight distance of civil aircraft in the aviation industry has led to this situation. Despite today's technological developments, flight range continues to be a serious physical constraint in the aviation industry (Lacoste, 2004).

While determining the design criteria, commercial passenger aircraft manufacturers aim to transport the most passengers to the longest distance with the most efficient fuel consumption. Commercial passenger aircrafts divided into three segments in terms of range they fly. These segments consist of Short-Range passenger aircraft with 50-90 passenger capacity, Narrow Body (NB) medium-range passenger aircraft with 140-300 passenger capacity and Wide Body (WB) long-range passenger aircraft with 300+ passenger capacity (Çakmak, 2016).

2.2. Operational Costs of Airlines

As in all industries, the costs incurred in order to continue the activities in the aviation industry are influential in the decisions to be taken and in the company strategy. Costs are effective in determining the price of the product or service in airline companies.

Costs are also regarded as an important indicator of the company's competitiveness. Cost classification in an airline company is made in various ways according to the purposes. Cost information is needed for three reasons due to planning and decisions to be made in airline companies. Among these reasons, airline companies want to see their total expenses in detail in different cost categories as management decisions and accounting tools. Thus, changes and trends in costs over time are determined (Doganis, 2006).

There is no single classification of expenses that can be used in strategies and decisions to be determined in every field in airline companies. Therefore, many airline companies categorize their expenditures in various ways to be used in different management stages according to different perspectives. In addition, airline companies divided expenses into operating expenses and non-operating expenses as a general practice in cost classification (Oum and Yu, 2012). In this way, the flight operations, which are the main field of activity of the company, and all the expenses made for the realization of these operations are determined. Separating operating expenses from other non-operating expenses is affected by the company's revenue management policies. It is made possible to make forward-looking decisions by determining whether each line meets its own operational expenses.

Operating expenses of airline companies are divided into direct and indirect operating expenses. Direct operating expenses include all costs incurred to maintain flight operations. Therefore, as long as the flight does not take place, there are no direct operating expenses. These expenses consist of flight crew fees, fuel and oil expenses, aircraft maintenance and depreciation expenses. Indirect operating expenses include expenses independent of flight operations. These expenses include passenger services, ticket and flight expenses, station and ground handling expenses, and general administrative expenses related to the passenger rather than the aircraft. This classification method is generally accepted by airlines. However, there are some differences in the application of the classification. For example, some expenses such as maintenance management and cabin crew expenses are considered as direct expenses by some airline companies, while some airline companies accept them as indirect expenses Şengür, 2004).

Today, the most widely used airline cost classification has been the classification made by ICAO (International Civil Aviation Organization). This classification divides the costs of airline companies into operating costs and non-operating costs. Operating costs consist of costs directly related to flight services provided by the airline operator. Non-operating costs include costs that are not directly related to flight services provided (Uslu and Cavcar, 2003).

There are extensive studies in the literature on the variables that affect airway costs. The majority of these studies focus on the impact on total airline costs or unit costs. Studies aimed at determining the factors affecting airline operating costs per aircraft movement are quite insufficient. In many studies on the effects on airline costs variables that measure an airline's output in terms of traffic are discussed. The criteria used to measure are mostly revenue passenger miles, the number of seats offered, the number of departures and the number of passengers carried (Zuidberg, 2014). In the literature analysis, the factors affecting operational costs in airline industry were determined as follows:

Table 1. Previous Studies on Factors Influencing Airline Operational Costs

Authors	Methods Used	Factors Influencing Airline Operational Costs
Uslu and Cavcar (2003)	literature review	Air traffic fares
See et al (2004)	AHP	Aircraft speed, passenger capacity
Dobruszkes (2006)	Principal Component Analysis	Airport cost, flight route cost, flight length
Berritella et al. (2009)	AHP, Monte Carlo simulation	Fuel expense, depreciation expense, engineering services, direct personnel expense
Yeh and Chang (2009)	TOPSIS, MAVT, Fuzzy set theory	Fleet
Dozic and Kalic (2014)	AHP	Passenger demand, passenger capacity, route selection, fleet selection
Durmus and Ozturk (2014)	literature review	Flight crew fees, fuel fees, maintenance fees, ground handling fees, ticketing fees
Eller and Moreira (2014)	AHP	Labor Cost, Aircraft type and features, Route, Airline marketing, Airline financial policy, Corporate strategy, management quality
Gomes et al (2014)	Fuzzy set theory	Cost of acquiring, Liquidity, cost of operation, range
Lu and Liu (2014)	AHP	Service delivery, air traffic charges, flight limits
Rezaei et al (2014)	AHP	Supplier selection
Zuidberg (2014)	Regression analysis	Depreciation cost, rental cost, maintenance cost
Bruno et al (2015)	AHP	Aircraft selection, technical performance, economic performance, environmental effects, flight quality
Deveci et al (2016)	TOPSIS	Number of passengers, route selection
Özdemir and Başlıgil (2016)	AHP	Aircraft equipment, employees, aircraft rental and purchase costs
Su et al (2018)	TOPSIS	Aircraft performance, environmental impacts
Loader and Nursery (2018)	literature review	Fuel amount, Aircraft type, employees, service, aircraft traffic fee, airport usage, cleaning expenses, financing expenses, maintenance and repair costs, insurance, depreciation
Yilmaz et al. (2018)	AHP	New route cost, economy flight, number of passengers, airport fare

In short, all expenses incurred in connection with the business subject of the airline companies were defined as operational expenses, all expenses incurred for the realization of flight operations, direct operational expenses and on-site expenses as indirect operational expenses (Doganis, 2006). As a result of literature analysis and interviews with experts, it was decided to take the operational costs of airlines as follows:

Direct Operating Expenses:

- Flight Operation Expenses:
  - Flight crew salaries and expenses
  - Fuel and oil expenses
  - Airport charges
  - Insurance cost
  - Flight equipment / crew rental
  - Repair expenses
  - Maintenance expenses:
  - Engineering personnel expenses
  - Spare parts usage expenses
  - Maintenance management expenses
- Depreciation Expenses:
  - Depreciation of flight equipment
  - Depreciation of ground facilities and equipment
  - Additional depreciation
  - Depreciation of development expenses and personnel training

Indirect Operational Expenses:

- Ground expenses
- Ground personnel expenses
- Building and equipment maintenance costs
- Transportation expenses
- Ground handling fees
- Passenger services costs
- Cabin crew fees and expenses
- Other passenger services expenses
- Passenger insurances
- Ticketing, sales and promotion expenses
- General and administrative expenses
- Other operating expenses

2.3. Fleet Managament

Fleet management includes planning how many aircraft the airline will buy and when to include them in the fleet. The purpose of the fleet management is to minimize the sum of the operating costs in the flight route and the costs caused by the revenue losses in the event that the seat capacity of the aircraft assigned on a flight leg cannot meet the demand (Żak, Redmer and Sawicki, 2011).

Policies and strategies related to range decision in fleet management are accepted as important indicators. Global airline companies aiming to operate between continents must have fleets of long-range aircraft. However, when a company wants to provide high frequency service within the country, it must have short and medium range aircraft. Companies determine their fleet structure according to their strategies. However, in order to meet the requirements of the operational units, it is necessary to adapt the fleet management. For a successful fleet management, the aircraft must be interchangeable. However, the fleet management is affected by the network type (liner or hub-and-spoke). This situation requires the use of different sizes of aircraft in each network type (Gelareh and Pisinger, 2011).

2.4. Relationships among Location Selection, Operational Cost And Fleet Management

The location selection is the leading factor that directly affects the aviation industry. The main reason for this is that civilian aircraft manufactured by the aviation industry fly at a distance. Despite the technological developments and improvements experienced today, the flight range seriously poses a physical constraint in the aviation industry. Therefore, location selection directly affects the fleet size and type (Lacoste, 2004).

The location selection has the potential to affect the company's operational costs. Due to its location, the operational costs of airlines routing to distant destinations and airlines routing to closer destinations will be different. In this context, the airline should shape its location according to the demand. Locating the airline close to the centers where the flight demand is high will reduce the operational costs of the aircraft (Uludağ and Deveci, 2013).

When the economies of scope associated with location businesses are examined, it is seen that alternative hubs are the only source of competition on low-density routes. The location of hubs becomes more important when the density of the airport increases due to the existing hubs. Even on routes served by only one carrier, the presence of a well-placed hub of the competitor creates potential competition, reducing fares and operational costs and optimizing fleet management (Butler and Huston, 1989).

2.5. Method

The main purpose of study is revealing the effect of location selection in the airline industry on airline operational costs and fleet management.

The research question is; in which location (Chicago, Los Angeles, Beijing, Shanghai, Tokyo, Frankfurt, London, Paris, Amsterdam and Dubai) should the airline's headquarters be in order to reach the 8 hubs mentioned above with the five planes listed above with the lowest operational cost and which aircraft should selected on that specific route to do so?

A fleet was created within the scope of the study and there are 5 aircrafts in this fleet. The 5 aircraft fleet has been selected according to 4 main criteria as follows:

- Most widely used
- Easy to access ground handling and maintenance service
- Providing range variety
- Reachable technical data

The five aircrafts selected in the study (Airbus A320neo, Airbus A321neo, Airbus A330-200, Airbus A350-900 and Boeing 737-900 NG) are the most frequently preferred aircraft types by airlines. Airbus A350-900 and Airbus A330-200 are wide-body aircraft, while Boeing 737-900 NG, Airbus A320neo, Airbus A321neo are narrow- body.

Ten destination candidates of hubs were selected according to total number of passenger and traffic density of last 5 years. The hubs where the flights will be made in the study are Chicago, Los Angeles, Beijing, Shanghai, Tokyo, Frankfurt, London, Paris, Amsterdam and Dubai.

Eight different geographically important locations have been identified where the airline's headquarters are planned to be established from different geographical areas of the world are London, Istanbul, Doha, Nairobi, Beijing, Delhi, Tokyo and Cape Town.

Consequently, there are 4 main analyzing step were observed in the scope of study as follows;

- Reachability
- Lowering cost
- Deciding worthful destination
- Aircraft assigning on selected route

To answer all these questions and steps, multi-criteria decision making method was preferred. Multi-criteria decision making is a process that enables the most appropriate decision to be made in the event of more than one situation affecting the decision. The most frequently used multi-criteria decision-making methods are ELECTRE, TOPSIS, VIKOR and PROMETHEE methods. In this method, alternatives are classified according to their similar characteristics and the most suitable one is selected (Velasquez and Hester, 2013).

In the TOPSIS method, it is aimed to determine the decision option at the shortest distance from the positive ideal solution and the furthest distance from the negative ideal solution. The positive ideal solution is the solution that minimizes the cost criterion and maximizes the utility criterion. The negative ideal solution is considered to be the solution that maximizes the cost criterion and minimizes the utility criterion. In this context, TOPSIS method reveals the distances to positive and negative ideal solutions (Velasquez and Hester, 2013).

There are criteria, alternatives and weights in the TOPSIS method. Alternatives refer to the list from which to choose. Alternatives in this study are routes. Thus, the conditions of reach from the locations to the hubs of the five aircraft considered in the study were examined.

In the study, the ranges of the aircrafts represent the optimum ranges that the aircraft can travel with a maximized number of passengers and cargo namely payload. In order to reach a distance greater than the optimum range value, aircraft have to reduce the number of passengers and amount of cargo. Therefore, it is not cost efficient for the aircraft to fly beyond the optimum range value. It shall be emphasized that this policy completely related with preferences of an airline company. Therefore, in this study, the optimum ranges corresponding to payload values are taken into consideration rather than the maximum ranges of the aircraft.

In this context, initially 385 flight alternatives have been created than it reduced to 140 possible flights by a reachability test by comparing optimum ranges of the aircraft and the distances between the hub and the location. The routes above the optimum range for maximum payload values of aircrafts are not considered. Each alternative includes an aircraft, a location, and a hub.

Criteria are factors to be taken into account in the decision-making process. In this study, operational costs are considered as criteria. There are many factors that affect the operational costs of aircraft. In this study, the following operational costs are considered as criteria:

Maintenance costs,

- Crew costs,
- F / R – ATC (Air Traffic Control) costs,
- Insurance costs,
- Ground handling fee,
- Depreciation,
- Fuel,
- Location index value.

The location index value was calculated by taking the average of the GDP (Gross Domestic Product), SDI (Sustainable Development Index) and HDI (Human Development Index) values of the hub location. Location index value is a value created by equal average of GDP, SDI and HDI values within the scope of the study. Location index value is created to be used in determining the geopolitical importance of the hubs that will be discussed within the scope of the study. The hub points in countries with high GDP, SDI and HDI values represent points where passenger potential is high, flight costs are relatively low, technical facilities are developed and the frequency of flights are likely to be high. Therefore, an index was created by equally averaging the

GDP, HDI and SDI values and this was named as location index value. While calculating the location index value, GDP, SDI and HDI values are primarily normalized. Then, an index was formed by taking 33% of each value.

The most important factor to consider for TOPSIS is weights. The weights reveal the importance of the above-mentioned criteria. The weights of these operation cost items were determined based on the literature review, interviews with related departments of airlines and the data have been provided from the related operation departments of anonymous airlines. For the costs of the flights, unit fuel cost for per 1000 NM, for still air conditions, for each aircraft type and ground handling costs by aircraft type for each location have been provided.

The most of cost items except ground handling cost vary depending on the flight time and distance namely the fuel amount required. Therefore, the weights of per cost items have been determined as a function of the fuel amount required by analyzing cost items of samples of real flights that provided by airlines and the rates determined by Yükçü ve Fidancı (Yükçü and Fidancı, 2018).

In the study, the weight of all operational cost elements was determined as %70 and the weight of the location index was %30. The reason why the location index was %30 is that the effect of location was determined as %30 in previous studies (Huston and Butler, 1991). Since the study aims to determine the effect of geopolitical location on location selection, a criterion called "location index value" was added to the criteria by the researcher.

After a normalization step, the weights determined for the chosen multi criteria decision making method TOPSIS are as follows:

- Maintenance costs = 0.0590
- Crew costs = 0.1271
- F / R - ATC costs = 0,0934
- Insurance costs = 0.077
- Ground handling fee = 0.092
- Depreciation = 0.0921
- Fuel = 0.2303
- Location index value = 0.30

3. Result

In this section, the results obtained from the research are presented.

3.1. Istanbul

Table 2. TOPSIS Output of Istanbul-Based Flights

Destination Hub	Aircraft	TOPSIS Value
DUBAI	Boeing 737-900 NG	0,92
AMSTERDAM	Airbus A321neo	0,92
LONDON	Airbus A320neo	0,89
FRANKFURT	Airbus A330-200	0,8
PARIS	Airbus A350-900	0,74

According to the TOPSIS method, it is possible to use all five aircraft for flights from Istanbul. Accordingly, the least costly flights are made to the hubs Dubai, Amsterdam, London, Frankfurt and Paris. Therefore, flights to Beijing, Shanghai, Chicago and Tokyo hubs do not seem appropriate from cost perspective according to TOPSIS method.

Considering that each aircraft will be used once at each hub, Boeing 737-900 NG is used in the Dubai flight, Airbus A321neo in the Amsterdam flight, Airbus A320neo in the London flight, Airbus A330-200 in the Frankfurt flight and Airbus A350-900 in the Paris flight.

3.2. London

Table 3. TOPSIS Output of London-Based Flights

Destination Hub	Aircraft	TOPSIS Value
AMSTERDAM	Boeing 737-900 NG	0,93
FRANKFURT	Airbus A321neo	0,89
FRANKFURT	Airbus A320neo	0,89
PARIS	Airbus A320neo	0,89
DUBAI	Airbus A330-200	0,46
CHICAGO	Airbus A350-900	0,3

If the flight center is London, it is possible to use all five aircraft. It is observed that the flights generally concentrate on the near regions. However, a flight to Chicago is possible with the Airbus A350-900. According to the TOPSIS method, the lowest cost flights are made to Amsterdam, Frankfurt, Paris, Dubai and Chicago.

3.3. Cape Town

Table 4. TOPSIS Output of Cape Town-Based Flights

Destination Hub	Aircraft	TOPSIS Value
DUBAI	Airbus A350-900	1

On flights based in Cape Town, only flights to Dubai can be made. Four aircraft other than the Airbus A350-900 are not in use.

3.4. Delhi

Table 5. TOPSIS Output of Delhi-Based Flights

Destination Hub	Aircraft	TOPSIS Value
DUBAI	Boeing 737-900 NG	0,94
SHANGHAI	Airbus A321neo	0,81
BEIJING	Airbus A320neo	0,77
AMSTERDAM	Airbus A330-200	0,27
LONDON	Airbus A350-900	0,19

When the Delhi-based flights are examined, it is seen all five aircrafts can be used. It is seen that Delhi-based flights are concentrated in nearby hubs Dubai, Shanghai and Beijing. Additionally, flights to Amsterdam and London are possible.

3.5. Doha

Table 6. TOPSIS Output of Doha-Based Flights

Destination Hub	Aircraft	TOPSIS Value
DUBAI	Boeing 737-900 NG	0,96
AMSTERDAM	Airbus A330-200	0,46
FRANKFURT	Airbus A350-900	0,44

When Doha-based flights are analyzed, it is seen that not all five aircraft can be used. It appears that the flights are to Dubai, Frankfurt and Amsterdam and the Airbus A320neo and Airbus A321neo are not used.

3.6. Nairobi

Table 7. TOPSIS Output of Nairobi-Based Flights

Destination Hub	Aircraft	TOPSIS Value
DUBAI	Boeing 737-900 NG	0,94
AMSTERDAM	Airbus A330-200	0,41
FRANKFURT	Airbus A350-900	0,37

When flights based in Nairobi are examined, it is seen that not all five aircrafts can be used, similar to Doha. Flights to Dubai, Amsterdam and Frankfurt are possible. However, the use of Airbus A320neo and Airbus A321neo aircraft poses a cost disadvantage.

3.7. Beijing

Table 8. TOPSIS Output of Beijing-Based Flights

Destination Hub	Aircraft	TOPSIS Value
SHANGHAI	Boeing 737-900 NG	0,87
TOKYO	Airbus A321neo	0,85
DUBAI	Airbus A330-200	0,37
AMSTERDAM	Airbus A350-900	0,22

When Beijing-based flights are examined, it is seen that usage of all five aircraft seemed to be possible in first place according to TOPSIS table. Although A320neo is eligible to fly more than one cities in terms of range, it is not the most cost efficient aircraft for both destionations. This situation turns the A320neo into perishable product in cost based. On both flights (Shanghai and Tokyo) that using other aircraft rather than A320neo could result in lower costs. It is seen that Beijing-based flights are concentrated in nearby hubs Shanghai and Tokyo. In Europe, it is possible to fly to Amsterdam at the lowest cost with the existing fleet.

3.8. Tokyo

Table 9. TOPSIS Output of Tokyo-Based Flights

Destination Hub	Aircraft	TOPSIS Value
BEIJING	Boeing 737-900 NG	0,9
SHANGHAI	Airbus A321neo	0,88
DUBAI	Airbus A350-900	0,27

Flights to Beijing, Shanghai and Dubai are possible from Tokyo. Using Airbus A320neo and Airbus A330-200 is not cost effective. Using other aircraft on Beijing and Shanghai flights where Airbus A320neo can be used will provide a cost advantage. It is seen that flights from Tokyo are concentrated in nearby areas such as Shanghai and Beijing.

When all scenarios are examined, it is seen that all aircrafts are used in Istanbul, London and Delhi, four aircrafts are used in Beijing, three aircrafts are used in Doha, Tokyo and Nairobi, and one aircraft is used in Cape Town.

When London, Istanbul and Delhi, where all aircrafts are used, are examined separately, it is seen that the flight from London to Chicago with the Airbus A350-900 does not provide enough cost advantage. Similarly, the flight from London to Dubai with the Airbus A330-200 is not cost effective. In addition, it does not seem to provide a cost advantage in flights from Delhi to European centers. However, it is seen that all five flights from Istanbul are cost-effective and their TOPSIS scores are high.

Table 10. TOPSIS Output of Possible Flights

Location	Destination Hub	Aircraft	Value
ISTANBUL	DUBAI	Boeing 737-900 NG	0,92
ISTANBUL	AMSTERDAM	Airbus A321neo	0,92
ISTANBUL	LONDON	Airbus A320neo	0,89
ISTANBUL	FRANKFURT	Airbus A330-200	0,8
ISTANBUL	PARIS	Airbus A350-900	0,74
LONDON	AMSTERDAM	Boeing 737-900 NG	0,93
LONDON	FRANKFURT	Airbus A321neo	0,89
LONDON	PARIS	Airbus A320neo	0,89
LONDON	DUBAI	Airbus A330-200	0,46
LONDON	CHICAGO	Airbus A350-900	0,3
DOHA	DUBAI	Boeing 737-900 NG	0,96
DOHA	AMSTERDAM	Airbus A330-200	0,46
DOHA	FRANKFURT	Airbus A350-900	0,44
NAIROBI	DUBAI	Boeing 737-900 NG	0,94
NAIROBI	AMSTERDAM	Airbus A330-200	0,41
NAIROBI	FRANKFURT	Airbus A350-900	0,37
BEIJING	SHANGHAI	Boeing 737-900 NG	0,87
BEIJING	TOKYO	Airbus A321neo	0,85
BEIJING	DUBAI	Airbus A330-200	0,37
BEIJING	AMSTERDAM	Airbus A350-900	0,22
DELHI	DUBAI	Boeing 737-900 NG	0,94
DELHI	SHANGHAI	Airbus A321neo	0,81
DELHI	BEIJING	Airbus A320neo	0,77
DELHI	AMSTERDAM	Airbus A330-200	0,27
DELHI	LONDON	Airbus A350-900	0,19
TOKYO	BEIJING	Boeing 737-900 NG	0,9
TOKYO	SHANGHAI	Airbus A321neo	0,88
TOKYO	DUBAI	Airbus A350-900	0,27
CAPE TOWN	DUBAI	Airbus A350-900	1

Therefore, the establishment of the airline center in Istanbul will minimize operational costs by flying to Amsterdam, Paris, Frankfurt, London and Dubai. Establishing an airline center to other regions and flying to the mentioned hubs will result in higher operational costs.

4. Conclusion

The increasing competition in air transport and the increasing costs of aircrafts force airline companies, which are very sensitive to economic conditions, to use the available resources in the most appropriate way. Companies that use available resources at the optimum level may be affected by the destructive competition in the industry and the current or probable economic fluctuations. In this context, one of the most critical decisions for airlines is the selection of the airline center. The airline center is important in terms of affecting the flight processes and operational costs of airline companies.

Choosing the airline center is also an important decision in terms of choosing the hub points.

In this context, the geopolitical location of the airports is also influential on airline flight planning. For example, the cost of flying from Istanbul to Moscow and flying from Dubai to Moscow is not the same. All of these situations can be eliminated by successful fleet management because airlines can not compete on price without reducing their costs and overheads. The airline industry relies on airport services, the provision of aviation fuel, labour, etc.

In this study, the effect of location selection in airlines on operational costs and fleet management is examined.

According to the research results, it is seen that only flights based in Istanbul, London and Delhi use the entire fleet. In other centers, Doha, Nairobi, Beijing, Tokyo and Cape Town, not all aircraft are available and an effective fleet management cannot be achieved. When London, Delhi and Istanbul are analyzed, it is seen that two flights in London and Delhi are with high operational cost, whereas flights based in Istanbul are with lower operational cost. Therefore, the establishment of the airline center in Istanbul will minimize operational costs by flying to Amsterdam, Paris, Frankfurt, London and Dubai. Establishing an airline center to other regions and flying to the mentioned hubs will result in higher operational costs.

Although there are studies on aircraft selection in the literature, there is no study revealing the effect of location selection in airline industry on operational costs and fleet management. As a result of the linear physical programming study conducted by Ilgın (2019) by evaluating 6 new generation aircraft belonging to Boeing and Airbus according to 5 criteria, it was seen that the A 321 Neo aircraft was preferred. Kiracı and Bakır (2018) determined the aircraft fleet selection by TOPSIS method in their study. In the study, it is aimed to determine the most suitable alternative among the 4 types of aircraft that are most demanded by airline companies. Wang and Chang (2007) developed an evaluation approach based on TOPSIS method in order to determine the most suitable starting trainer aircraft for the Taiwan Air Force Academy. The KT-1 aircraft has been found to be the best among the seven training aircrafts. Wei (2006) explored how airport landing charges can affect airlines' decisions about aircraft size and flight frequency through a game-theoretic model. It is found that higher landing fees will force airlines to use larger aircraft and less frequency. Givoni and Rietveld (2009) examined which factors are determinant in aircraft selection at different flight points around the world The results of the study showed that the choice of aircraft was mainly affected by the route characteristics and the characteristics of the airport were not effective in this. In this respect, the results of the study are in line with similar studies.

As a result, location selection is a long-term strategic decision that can lead an airline to success or failure, both financially and prestigious. While making this decision, an evaluation is made on many criteria, taking into account the dynamics of the day. As can be seen in this study, location selection affects the costs of the airlines and fleet management. It is relatively easy to fly from a central location like Istanbul to centers with high GDP, SDI and HDI values in Europe. Therefore, the fleet management of the flights is at the optimum level and the operational costs are at the lowest level.

It has been determined that the location selection can affect the operational costs and fleet management of airline companies. Based on the determined routes and aircraft type alternatives, the study is expected to guide airline companies in route selection. In this context, the following suggestions are possible:

- Airline companies can reduce their operational costs by flying to regions with high economic value in nearby regions.
- If airline companies can determine their headquarters according to the hubs they will fly to, they can reduce their flight costs and therefore their operational costs.
- Airline companies can reduce their costs by using all their fleets.
- Airline companies can determine their fleets depending on the location selection and thus achieve a more optimum fleet management.
- Airline companies can make the location selection process according to the flight demand, and thus, they can operate their flights with a lower operational cost.

The study is also suggested as an alternative model for airline companies to choose the location that suits their expectations, as a result of weighing the criteria determined according to their own priorities. Considering the methods applied in this study, different results can be expected by adding different criteria like different locations, different hubs or different aircraft types. Therefore, airline companies can choose the most suitable aircraft, location and hub according to their flight network and priorities by using these methods. In this respect, the study is expected to contribute to fleet management and decision making process of hub location for airline companies.

This study has some limitations. TOPSIS method was used in the study. Results may be different with a different multi-criteria decision making method. It is also planned to fly by a single aircraft to each hub. In reality, the application may be different. In addition, the economic values of the hubs were determined by GDP, SDI and HDI data. In addition, when factors such as ticket prices, frequency and passenger traffic are taken into account, different results may occur.

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Determinants of Air Cargo Demand in The European Region

Serdar Alnıpak[1*], Süleyman Kale[2]

[1*]Nişantaşı University, EASS Faculty, Department of International Trade and Logistics, Istanbul, Türkiye. (serdar.alnipak@nisantasi.edu.tr).
[2] Kırklareli University, Finance and Banking Department, Lüleburgaz, Kırklareli, Türkiye. (suleymankale@klu.edu.tr).

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Abstract

Air cargo demand estimation is crucial for every part of the air industry for determining policies, making decisions on investments, pricing, marketing, etc. This study analyses factors affecting the air cargo demand of the European Region (23 countries) where no studies were found by making use of the two-step generalized method of moments (GMM). The effects of Total Airport Investments, Consumer Price Index, GDP Per Capita, Population, Foreign Trade Volume, Industrial Production Index, and Exchange Rate on Air Cargo Demand were examined with the data set covering the years between 2009 and 2018. The findings indicated that previous air cargo demand has explanatory power on current demand, and there was an inverse relationship between the change in the consumer price index and the amount of cargo. In addition, the panel regression estimator indicates a positive relationship between Foreign Trade and Industrial Production Index. The results show that price stability is of great importance not only from a macroeconomic perspective but micro economically also.

It is the revised and edited version of the paper presented in Turkish at the IERFM2021 Congress and published only as an abstract in the proceedings book.

1. Introduction

Air cargo transportation is an integral part of trade, high-tech industries, and general economic development (Lo et al., 2015). Air cargo transportation, which is frequently used for the transportation of high-value (computers, microchips, mobile phones, etc.) and perishable goods (flowers, vegetables, etc.) stands out with its features such as reliability, efficiency, security, and flexibility, particularly in long-distance operations (Lo et al., 2015; Suryani et al., 2012). In recent years, the increase in global trade volume, the development of transportation networks, and the change in modern logistics principles have enhanced the importance of air cargo transportation (Shiao & Hwang, 2013). Besides, as the market grew, the competition between countries, companies, and airports accelerated. Sectoral research shows that the air cargo industry will continue to grow. In this context, determining the factors that may affect air cargo demand is of strategic importance for all parties in the industry. Studies on this subject provide benefits in planning infrastructure and superstructure investments, managing daily operations, reducing costs, increasing competitiveness, determining business strategy development policies, increasing efficiency, and fleet optimization for the shareholders of the industry (Li et al., 2020; Totamane et al., 2014). In addition, the demand for aviation services is an important parameter in terms of energy consumption and greenhouse gas emissions originating from the air cargo sector.

Many methods have been used in studies on this subject, including statistical, econometric, artificial intelligence-based, and hybrid. While there are many studies on air passenger demand forecasting in the literature, there are very few studies on air cargo demand estimation and forecasting. In this context, studies in which air cargo and passenger demand are analyzed together are even fewer (Wadud, 2013). It is seen that the geo-economic characteristics of airports and/or hinterlands of countries are used as explanatory variables in a significant part of the literature discussed in detail in the next section (Hwang & Shiao, 2011; Wang et al., 1981).

Air cargo demand, trade, and Gross Domestic Product (GDP) are directly interrelated factors. As the trade volume and economic activity increase, the demand for cargo increases. In this context, GDP, economic growth, population, unemployment and freight rate are among the most frequently used explanatory variables (Hsu et al., 2009; Magaña et al., 2017). In addition, in many studies, Foreign Direct Investment (FDI) is seen as a competitive factor for the industry of countries and it is stated that there is a positive relationship between air cargo traffic (Kupfer et al., 2017; Suryani et al., 2012). Many criteria and components affect air cargo statistics. According to Boeing (2021) World and regional GDP growth, new commodities, export promotions, new trade relationships, national development programs, open skies and new air services agreements, deregulations, express markets, 'just in time' concepts, the proliferation of points served, shipper utilization, airline market and shipper education, airline market research, and widebody freighters and lower holds positively contributes to air cargo growth. On the other hand, trade quotes and restrictions, currency revaluations, environmental regulations, lack of airport access, air and surface labor stoppages, oil and fuel prices and availability, terrorism and armed conflict, airport curfews, surface competition directional imbalances, and industry imbalances are the constraints.

The pandemic has deeply affected the entire airline industry and has led to a decrease of 26.2% in the air cargo market, which has been on the rise in recent years, although not as dramatic as the number of passengers (IATA, 2020, 2021). Despite this, the sector, which entered 2021 with an increase, has reached the data of the pre-pandemic period. Although there is a pandemic process, forecasts for 2039 show that air cargo traffic will grow by 4% every year, as can be seen in Figure 1 (Boeing, 2021; KPMG, 2021).

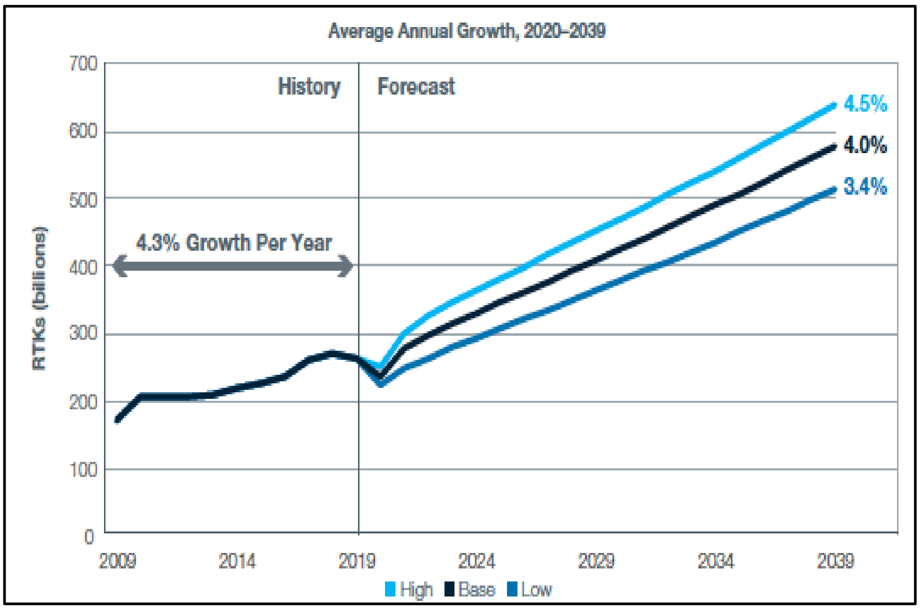

Figure 1. World Air Cargo Traffic Forecast in the Next 20 Years (Source: Boeing, 2021)

When the European region is examined, it is predicted that the air cargo market had a value of 24.68 billion USD in 2018 and this amount will reach 36.15 billion USD in 2027. The European region produced 23.6% of the world's air cargo sector in 2019 and 22.3% in 2020. In this context, the relevant region is very valuable for the sector (ReportLinker, 2019).

It is important to measure the interaction between air cargo demand and macroeconomic variables and to determine the aspects of the relationships. Considering the importance of sector and region, the factors that may play a role in air cargo transportation are discussed with dynamic panel data analysis based on the 2009-2017 period of 23 countries in the European Region. The variables used separately in previous studies were considered together as explanatory variables in the model of this study. Also, to the best knowledge of the authors, no study focused only on air cargo demand in the European region. This study differs from previous studies in applying a comparatively new method, the two-step system GMM, also. In this context, it is thought that the study may provide a modest contribution to the literature. In the next part of the study, it has been attempted to provide a summary of the literature relating to air cargo demand, then the methodology and findings are mentioned in the following section, also the conclusions and recommendations are summarized in the last section.

2. Literature Review

The literature on air cargo demand, which the number of studies is much less than the number of studies related to air passenger demand reveals that many variables affecting passenger demand are also used in air cargo demand analysis. Explanatory factors used in related studies are divided into two groups. The first group consists of external factors that are not under the direct control of the shareholders of the industry, such as the geological, geographical, or economic environment in which the airport is located. These factors include the economic activities and geographical features of the hinterlands surrounding airports and routes. Exogenous factors such as GDP per capita, population, employment rate, and FDI can be given as examples. The second group of factors is the internal factors that include the characteristics of the air transport system under the control of the shareholders. Income and population variables of locations (which are close to airports) are widely used as measures of activity-related factors. These factors are related to service quality and expenses. In particular, the frequency of service, equipment availability, reputation, and transportation costs are such factors (Hwang & Shiao, 2011). Hsu et al. (2009) stated that shippers focus on rates and flight frequency.

The main methods used in the current literature on forecasting the air cargo demand are econometric modeling, exponential smoothing, trend analysis, seasonality indices, time series analysis, etc. (Magaña et al., 2017). Although there are very few studies in which both air cargo and passenger demand are analyzed together for estimating (Chen et al., 2012; Wadud, 2013), more studies are focusing on the price and income elasticities of air cargo demand (Chi & Baek, 2012; Lo et al., 2015; Wadud, 2013). Hwang and Shiao (2011) aimed to determine the variables affecting the cargo demand with the Gravity Model using the data set for Taiwan Taoyuan airport between 2004-2007. Variables analyzed in this study are flight frequency, cost of transportation, GDP per capita, population, Open Skies agreement (dummy variable-dummy), trade block agreement (TradBloc) (dummy) and colonial links (dummy). The results showed that all dummy variables, population and cost of transportation were the determining variables. Wu and Morrell (2007) used the log-log econometric approach to forecast the air cargo demand in China and used GDP, FDI inflow and trade volume as the variables. Chi and Baek (2012) examined the long-run demand elasticities of US domestic air freight volume using a completely modified ordinary least squares model using the data set from 1996 to 2010. The air cargo demand function consists of GDP, 9/11 terrorist attacks (dummy), air cargo fee, and other modes of transportation. Wadud (2013) analyzed air cargo and passenger demands together using Seemingly Unrelated Regression (SUR) for HSI airport. The author used crude oil prices, national price level and GDP as variables and analyzed the price and income elasticities of those. According to this study, air cargo demand at HSI airport has more price and income elasticity than air passenger demand. Morrell (2012) stated variables such as GDP, foreign trade volume, foreign exchange trade, current rates, interest rates, air freight rates, service quality and competition with other transportation modes as factors affecting air cargo demand. Lo et al. (2015) analyzed the price and revenue elasticities of air cargo demand at Hong Kong airport using the data between 2001-2013. Author used price, jet fuel prices, exchange rate, monthly real GDP, transportation sector price index, hinterland income and internet traffic as variables. The results obtained with OLS, 2SLS and 3SLS methods were compared. The results showed that the increase in internet usage increased the demand for air cargo transportation and price is an important determinant of air cargo demand. Also, it has been revealed that air cargo demand has become more sensitive to changes in both price and revenue after the 2008 global financial crisis. Yao and Yang (2012) analyzed China's air cargo demand by applying the general error correction method based on data from 31 cities for the period 1995-2006. Employment, regional GDP, population, land transportation and trade volume were used as explanatory variables and it was found that these variables were not statistically significant in the short run, but were significant in the long run. Chen et al. (2012) used the Back-Propagation Neural Networks algorithm to adjust the forecast accuracy of air passenger and cargo demand from Japan to Taiwan. Population (of Taiwan), employed population (of Taiwan), a number of listed companies (of Tokyo), GNP (of Taiwan), import price index (of Taiwan), gross import volume (from Japan to Taiwan), economic growth rate (of Taiwan), industrial production volume (of Japanese), per capita income (of Taiwan) and GDP (of Taiwan) were used as variables and it was found that the economic growth rate in Taiwan was the most important factor for air cargo demand forecasting. Hakim & Merkert (2016) analyzed the relationship between air transportation and economic growth through Pedroni/Johansen cointegration, Granger long-run and Wald short-run causality tests by using the data for the past 42 years (1973-2014) in the context of the 8 countries in South Asia. The authors used the following variables in the model: the number of passengers carried and the amount of cargo, GDP per capita, travel per capita and the number of travel per capita weighted by the population of countries. Unlike the past studies, the results of the analysis showed that there was a one-way causality, rather than a two-way one, from the economic growth towards the air operation in the context of South Asia. In addition, the findings confirmed the long-term one-way Granger causality between the GDP and the airline passenger and cargo volumes. Kupfer et al. (2017) determined the amount of air cargo as the dependent variable and the share of the manufacturing sector in the global goods export volume, the air cargo return index, the amount of world cargo export and the oil price index per barrel in US dollars as independent variables. The authors analyzed the relationships between these variables through the error correction model and performed a prospective prediction using the relationship function they obtained. The findings revealed that the exports strongly affected the air cargo demand. Kiraci & Battal (2018) examined the relationships between airline transportation and macroeconomic parameters specifically in Turkey through the VAR analysis by using the data for the years between 1983-2015. The authors included in the model the indicators for the number of passengers (domestic and international lines) and the quantity of cargo (international line) carried through airline transportation. The model was analyzed in three stages. Macroeconomic indicators that are used in the first model investigating the domestic passenger demand are the GDP per capita, CPI and interest rates, whereas the indicators used in the second model as regards the international passenger demand are the GDP, CPI and interest rates. On the other hand, macroeconomic indicators used in the third model that is created for cargo quantity (international line) demand are the GDP, industrial production index, foreign direct investment amount and foreign trade volume. The findings suggest that domestic passenger demand is affected by income per capita and CPI while international passenger demand is affected by the GDP and CPI indicators. The analysis of the third model indicates that international cargo demand is affected by the industrial production index and GDP. Kiraci & Akan (2020) used the Panel causality analysis and bootstrap panel Granger causality analysis methods to investigate the causality relationship between the trade volume and the sea and air transportation for EU-G20 (for 15 countries) and US-G20 (for 16 countries). The study employed the volumes of the sea and air transportation, which were used in total trade and commercial operations destined to G20 countries from the EU between 2002-2016 as well as the volumes of total trade and transportation modes from the USA to G20 countries between 1999-2016. The findings point out the presence of a causality relationship between the relevant parameters. Moreover, it is found that the trade wars between the countries will affect sea and air transportation volumes adversely. On the other hand, Alici & Akar (2020) investigated the relationships between macroeconomic indicators and air cargo demand through the instrument of the p data analysis. This study used the data from the 13 countries with the highest air cargo capacity (e.g. USA, Qatar, Japan, France, Singapore, England, China, South Korea, Canada, India, Turkey, the Netherlands and Germany) for the years between 1980-2018. The GDP ($), export amount ($), import amount ($) and inflation were used as the independent variables in the model while the amount of air cargo transported (tons) was selected as the dependent variable. The findings revealed that air cargo demand had a positive relationship with GDP and a negative relationship with inflation. Furthermore, it is discovered that import and export quantities have no relation to air demand.

The studies mentioned in this section are summarized in Table 1.

Table 1. Studies on Air Cargo Demand Estimation and Forecasting

Study	Location	Method	Variables
(Hwang & Shiao, 2011)	Taiwan Taoyuan	Gravity Model	Flight Frequency, air freight rates, GDP Per Capita, Population, Open Skies Agreement (dummy), Trade Block (dummy) and Colony Links (dummy)
(Wu & Morrell, 2007)	China	Log-Log Model	GDP, foreign direct investment (FDI) inflows and trade volume
(Chi & Baek, 2012)	USA	Completely Modified OLS	GDP, 9/11 terrorist attacks (puppet), air freight rates and other modes of transportation
(Wadud, 2013)	HSI	SUR	Crude oil prices, national price level, GDP and number of airline passengers
(Morrell, 2012)	-	-	GDP, foreign trade volume, foreign exchange trade, current rates, interest rates, air freight rates, service quality and competition with other transportation modes
(Lo et al., 2015)	Hong Kong	OLS 2SLS 3SLS	Price, Jet fuel prices, exchange rate, monthly real GDP, transport sector price index, the revenue of hinterland and internet traffic
(Hakim &Merkert, 2016)	South Asia	Pedroni/Johansen cointegration, Granger long-run and Wald short-run causality tests	GDP per capita, Trips per capita, Trips per capita weighted by country population
(Kupfer et al., 2017)	Worldwide	Error correction model	Airfreight yield, Merchandise exports, % of manufactures in merchandise trade in volume, Crude oil prices
(Kiracı & Battal, 2018)	Turkey	VAR Analysis	GDP, Foreign Trade Volume, Industrial Production Index, Direct Foreign Investment
Kiracı & Akan, 2020)	EU–G20 and USA–G20	Panel causality analysis & Bootstrap panel Granger causality analysis	Trade volume between countries, sea and air transportation volume between countries
Alıcı & Akar, 2020)	13 countries	Panel data analysis	GDP, Import volume, Export volume, Inflation
(Yao & Yang, 2012)	China	General ECM	Employment, regional GDP, population, land transportation and trade volume
(Chen et al., 2012)	Taiwan	BPN	Population (of Taiwan), employed population (of Taiwan), number of listed companies (of Tokyo), GNP (of Taiwan), import price index (of Taiwan), gross import volume (from Japan to Taiwan), economic growth rate (of Taiwan), industrial production volume (of Japanese), per capita income (of Taiwan) and GDP (of Taiwan)

3. Methodology, Data and Variables

3.1. Data and Variables

This study aims to determine the internal and external factors affecting air cargo demand. "Air Cargo Volume" is taken as an indicator of air cargo transportation. "Airport Investments" (as the internal factor) and "Consumer Price Index, Foreign Trade Volume, Industrial Production Index, GDP per Capita, Population, Exchange Rate" are considered external factors. 23 countries in the European region (Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Lithuania, Latvia, Luxembourg, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, and Romania) were analyzed by the data between 2009-2018. Since the value differences between the data are big, their natural logarithms are used. The explanations, units, and data sources of the variables used in the study are presented in Table 2.

Table 2. Variables Used in the Study

Notations	Definitions	Units	Data Source
lfreight	Air Cargo Volume	Ton	Eurostat
lairportinvest	Airport Investments	EUR	OECD
lcpiall	Consumer Price Index		Eurostat
lgdppc	GDP per Capita	USD	World Bank
ltotalpop	Population		OECD
lfortrade	Foreign Trade Volume	USD	World Bank
lindpi	Industrial Prod. Index		OECD, IMF
lfx	Exchange Rate		OECD

The number of air cargo planes, the number of airports, household consumption expenditures, inflation in the transportation sector and foreign direct investments are also considered to be used as variables. However, variables with high correlation and/or variables that make results inconsistent are discarded from the model. The correlation between inflation in the transportation sector and the consumer price index is 83%; the correlation between household consumption expenditures and airport investments is 81%, and the correlation between household consumption expenditures and foreign trade volume is 91%.

3.2. Methodology

To investigate the effect of independent variables on air cargo demand a dynamic panel data model is employed. We believe that the dynamic panel data model is more realistic than the static panel data model in reflecting the real situation as the dynamic model assumes that the previous value of the dependent variable is effective in explaining the air cargo demand of the following period. Additionally, when historical data is comparatively limited, dynamic panel models become more advantageous. The initial dynamic model is formulated as follows:

$$Iy_{it} = \alpha + \beta y_{it-1} + \delta x_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

y_{it}	The dependent variable of i at time t.
y_{it-1}	Lagged dependent variable
β	Short-term parameter
δ	Coefficient of independent variables.
x_{it}	Independent variables.
μ_i	Time invariant unit effect
ε_{it}	Error term of i at time t.

The model represented by Equation (1) is estimated with a two-step system Generalized Methods of Moments estimator which is developed by Arellano and Bover (1995) and Blundell and Bond (1998), and implemented by Roodman (2009). The two-step system Generalized Methods of Moments estimator is based on the first differencing and transforming the Equation (1) to the following Equation 2 form. Then, systems of differenced equations and initial equations are solved with a two-step system GMM estimator.

GMM estimator can be used when unit dimension (N) is greater than time dimension (T) in panel data. It controls for endogeneity, omitted variables bias, unobserved panel heterogeneity, and measurement errors. System GMM estimator is consistent and unbiased when instruments are valid, a number of instruments are less than the number of units, Hansen test specifies the overall validity of the instruments used and it should not be below 0.1 and too greater than 0.25 to indicate consistency and overall validity. Differenced error terms should not be second-order serially correlated, AR(2), implying that moment conditions are correctly specified. Two-step system GMM is more efficient and robust to heteroscedasticity and autocorrelation than one-step system GMM (Roodman, 2009).

For illustration, the fixed effect (FE) estimator of panel data regression is applied to the same data. When units in the sample constitute the almost entire population FE model is more appropriate, and when the units in the sample are randomly selected from the population, the RE model is more reasonable (Brooks, 2019). Housman, Chow (F) and/or Breusch-Pagan LM (1980) Tests can also be used to decide the estimator. Since our sample constitutes almost the entire population, and it always gives consistent estimates, the FE estimator is used for illustration purposes in addition to the two-step system GMM. It is applied to the same model represented in equation (1). Our data suffers from consisting comparatively very short time period. Nonstationary is not a concern, in particular when the dynamic model is estimated in small T situations. Also according to Baltagi, cross-sectional dependence is not a problem in micro panels and one does not deal with nonstationarity (Baltagi, 2021).

4. Results and Discussion

Descriptive statistics of internal and external factors were presented in Table 3. According to the statistics it is seen that the highest fluctuation occurred in airport investments and the lowest fluctuation occurred in the consumer price index. This shows that price fluctuations in European countries are low. According to 2017 data, Germany is the country with the highest amount of transportation with 4.8 million tons of cargo. Germany is followed by Turkey with 3.9 million tons and France with 2.4 million tons. Looking at the change in the period between 2009 and 2018, Turkey's increase was 123%, while Germany's increase was 45% and France's was 66%. The highest increase was realized by Norway with 240%, while there was a small decrease in Norway and Greece.

Table 3. Descriptive Statistics

Variable	Average	Std. Dev.	Min	Maks
lfreight	11.98	1.73	8.63	15.39
lairportinvest	17.99	2.05	11.25	21.73
lcpiall	4.58	0.07	4.14	4.94
lgdppc	10.30	0.70	9.01	11.69
ltotalpop	9.13	1.45	5.76	11.33
lfortrade	26.33	1.21	23.18	28.88
lindpi	4.67	0.13	4.47	5.10
lfx	0.84	1.64	-0.34	5.64

Although there is no theoretical assumption or an empirical consensus, we expect airport investment, GDP growth, total population, foreign trade, industrial production and foreign exchange rate to positively affect air-cargo freight. The effect of consumer price may be negative since it represents both price change and macroeconomic instability.

The analyzes of the internal and external variables used in the study are presented in Table 4. Concerning this analysis, the F statistic shows that the model as a whole is significant. The number of instrument variables is lower than the number of units. AR(1) indicates the presence of first-order autocorrelation, while AR(2) shows no second-order autocorrelation. Hansen's statistics of 0.112 show the overall validity of instruments used. For illustration, the model presented in Equation (2) was estimated with Panel Data regression and fixed effect (FE) estimator, and the results are presented in Table 4 in addition to the GMM result. Since the number of airline passengers in the previous period is included in the model, the model calculated with the fixed effect estimator is also dynamic and offers the opportunity to compare with the model calculated with the system GMM estimator. The results obtained with both estimators are statistically significant and confirm each other.

According to the results of the two-step system GMM model, the air cargo volume in the past period has the power to explain the air cargo volume in the following period at a 1% confidence level. A 1% change in air cargo volume in the past period is associated with an increase of 0.753% in the following period. Considering that the changes in the economy did not happen all at once, the result seems reasonable. A relationship was found between consumer inflation and the amount of cargo at a 10% confidence interval. As expected, an inverse relationship was found between the change in the consumer price index and the change in cargo; a 1% increase in inflation causes a decrease of 1.091% in the amount of cargo at almost the same rate. No statistically significant relationship was found between other variables and the amount of cargo. The results show that price stability is of great importance not only in terms of macroeconomic indicators such as economic growth but also in terms of sectors such as airway transportation. In general, the results are in line with the results of Yao and Yang (2012)'s study, which did not find a statistical relationship between "air cargo demand'' and "employment, regional GDP, population, land transport and trade volume''. The panel regression fixed effect estimator also shows that the amount of cargo in the previous period is an important factor in explaining the amount of cargo in the next period, as in the GMM estimator. However, the past period effect is not as much as the effect on the number of passengers; it is also calculated lower according to the GMM estimator. The 1% increase in the amount of cargo in the previous period is reflected as 0.555% in the next period. According to the FE model, at the 5% confidence interval, a 1% increase in GDP per capita causes a 0.690% decrease in freight transport. Although this situation is statistically significant, it does not seem economically reasonable. In the studies given in Table 1, no statistically significant relationship was found between air cargo demand and GDP per capita. Both Foreign Trade and Industrial Production Index at a 10% confidence level positively affect the cargo amount. The 1% increase in the Foreign Trade or Industrial Production Index affects the freight amount positively by 0.895% and 0343%, respectively. These results seem to be in line with the findings of Yao and Yang (2012) in terms of Trade Volume.

Table 4. Factors Affecting Air Cargo Demand (Dependent variable: Air Freight Amount, lfreight)

	Two-step system GMM		Panel Regression, FE	
	lfreight	p	lfreight	p
L1. lfreight	**0.753**	**0.000**	**0.555**	**0.000**
lairportinvest	0.079	0.422		
lcpiall	**-1.091**	**0.052**	-0.005	0.723
lgdppc	0.322	0.335	**-0.690**	**0.045**
ltotalpop	0.108	0.639	0.056	0.807
lfortrade	0.049	0.722	**0.895**	**0.069**
lindpi	0.925	0.170	**0.343**	**0.082**
lfx	0.001	0.968	0.255	0.282
Cons	-3.333	0.284	0.489	0.041
The number of obs.		207		207
Number of countries		23		23
Number of Inst. Var.		12		
F statistics p		0.000		0.000
R-sq				0.655
AR(1) p		0.041		
AR(2) p		0.296		
Hansen p		0.112		

5. Conclusion

Globalization, trade, digitalization, intense competition, and the increasing importance of effective supply chain management have increased the shipment of high technology products by air. In addition, the fast delivery and quality service advantages it offers, economic growth, open-skies policies, and inventory policies of companies due to 'Just In Time' show that the air cargo transportation market will grow. In this context, estimation and prediction studies to be carried out on the relevant subject have strategic importance and competitive power-enhancing features for all components of the sector. This study aims to analyze the factors affecting air cargo demand. For this purpose, many variables were tested, and the Consumer Price Index, which did not invalidate the model and/or did not have a high correlation with other variables, GDP per Capita, Population, Foreign Trade Volume and Exchange Rate were used as independent variables. In the present study, in which the annual data of 23 countries in the European Region for the period 2009-2018 were used, the system GMM method showed that a 1% change observed in the amount of cargo in the past period is associated with an increase of 0.753% in the next period. Besides, in line with the expectations, an inverse relationship was found between the change in the consumer price index and the amount of air cargo. The results show that price stability is of great importance not only from the macroeconomic point of view, but also from the microeconomic point of view. In addition, the panel regression estimator indicates a positive relationship between Foreign Trade Volume and Industrial Production Index. No previous studies dealing with the 23 countries of the European Region have been found in the literature. Also, the variables used separately in previous studies were considered together as explanatory variables in the model of this study. Also, to the best knowledge of the authors, no study performed the analysis methods used in the present study. In this respect, it is thought that the research will make an original contribution to the literature. However, it would be useful to confirm the results obtained with data covering longer periods. Addressing the effects of the pandemic crisis that has been going on since 2019 stands as a new research area.

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 Effect of Price Perception on Customer Loyalty in Airline Cargo Transportation

Erkut Artık[1], **Adnan Duygun**[2*]

[1] Istanbul Gelisim University, Graduated from Master of Aviation Management, Istanbul, Türkiye. (erkutartik@gmail.com).
[2*] Istanbul Gelisim University, Faculty of Economics, Administrative and Social Sciences, Business Administration (English) Department, Istanbul, Türkiye. (aduygun@gelisim.edu.tr).

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Abstract

Airline cargo transportation is the preferred transportation system as the fastest transportation way today. However high costs also lead to high prices. Therefore, pricing is one of the issues that businesses should pay the most attention to when planning. Although competition over price is a competitive factor that businesses do not want to enter, this situation has become inevitable due to the intensity of the competition. To cope with this situation, it is beneficial for businesses to constantly measure and evaluate the price perception of customers.

In addition, it is of great importance for every customer for airline cargo companies that want to stay afloat in a dynamic market. Providing unconditional customer satisfaction and turning these customers into loyal customers is the key to sustainable success for companies engaged in airline cargo transportation.

Based on what has been described so far, it is possible to express the main purpose of this study in the form of investigating the effect of price perception on customer loyalty. The businesses using airline cargo transportation were included in the research and in this direction, research was carried out with 33 businesses operating in the Marmara Region and using airports in Istanbul.

In the study, it was concluded that airline cargo service price perception does not have a statistically significant effect on airline cargo service customer loyalty. Finally, suggestions have been made to those interested in the subject.

This study was derived from the master thesis of Erkut Artık and conducted under the supervision of Assoc. Prof. Dr. Adnan Duygun

1. Introduction

Nowadays, commerce has begun to take place in a virtual world by the widespread use of computers and mobile phones in the 21st century. Thanks to the virtual world, people have started to buy the product they want from anywhere in the world. Those who want to quickly obtain the products they buy have started to prefer the airline. This has caused airline cargo to gain importance.

The ability of people to transport from one place to another as soon as possible has increased the volume of trade of countries to high levels and ensured the unofficial disappearance of borders. Since it is difficult to establish an airline business primarily due to high costs and the politic of the countries, the airline cargo sector is controlled by very few businesses. Air transport has been the most expensive mode of transport for many reasons, such as a small number of businesses and high costs.

This research, it is aimed to determine the effect of price perception on customer loyalty of businesses using airline cargo transportation.

2. Price and Price Perception

The concept of price is generally defined as the amount of money that a seller demands from the customer to give up a product or service that he has (Ertuğrul, 2008). According to the Turkish Language Society, the concept of price means "the value for money of something in buying or selling, worth, pricey" (Sözlük, 2021).

Monroe (1990) specified the concept of price as the value arising from the monetary amount received by the seller or the products/services divided by the amount of products/services received by the buyer.

As for the concept of perception, it is defined as the whole process of defining, arranging, and interpreting anything that a person feels with his sense organs to create a phenomenon in his mind (Schacter et al., 2010). In its simplest form, price perception can be defined as a customer's view of the price they will pay for a product or service they want to buy (Bei and Chiao, 2001).

The most important factor that gives customers a clue about a product or service they want to buy is the price, and the price is perceived as a feature of the product or service. 40% of customers make comparisons as a result of their research before making a purchase (Helgeson and Beatty, 1985). To ensure customer satisfaction and become loyal customers, businesses should evaluate how their customers perceive prices along with their attitudes and behaviors and make the right pricing. How the price of a product or service offered by the business to its customers will be perceived by the customer determines the profitability of the business and its existence in the long term. The customer's perception of price has a very important place in deciding which business to choose for shopping (Ene and Özkaya, 2013).

Price represents the amount of economic expenditure that must be sacrificed for customers, based on the fact that it is present in all purchasing situations, while the perceived price represents the amount of money that must be given up. Therefore, although high prices negatively affect the purchasing possibilities, they can be perceived as a signal for product quality for many customers (Lichtenstein et al., 1993). Price perception is one of the factors affecting the positive or negative image formed in the customer's mind about a product or service they want to buy (Küçükergin and Dedeoğlu, 2014). The fact that the price is expensive or cheap can be perceived differently by different customers. While some customers may perceive the high price they will pay for the product or service they will buy as a waste of their money, some customers may think that they have a high price because of its quality and buy it (Yaraş, 2008).

3. Customer and Customer Loyalty

The concept of the customer, according to the Turkish Language Society, is “Service, goods, etc. It is defined as the person who receives and pays a fee in return” (Sözlük, 2021). A customer is a person and organization inside and outside the business that requests a product or service that the business produces as the final output. These individuals and organizations are the final consumers who buy and consume the product (Huge and Anderson, 1988).

The buyer or end-user of a service or product output is the customer. The result that the modern marketing approach wants to achieve is that customers make regular purchases from a business or are loyal to a brand and prefer it. According to Statt (1997), to be a customer, there must be an ongoing relationship between a particular business, brand, or store.

Customer loyalty is defined as the fact that customers constantly buy the product or service they buy from a certain business or brand, and do not look for another brand or business when they think about purchasing again (Aktepe et al., 2009). According to Koç (2002), the concept of loyalty means 'sincere and solid friendship, sincere loyalty, solidity in feelings and emotions, not betraying, conformity to the truth'.

The fact that customers continue to exchange with the business, spend time on it or intend to say positive things about the business is a sign of loyalty. Shankar et al. (2003) defined loyalty as the commitment a customer makes to a particular brand, website, or online service provider when alternative options are available. Customer loyalty is a psychological relationship that customers establish with the business, not just buying products or services again. When the customer is loyal, it integrates with the business and completely belongs to the business (Smith, 1996).

In the early 1980s, the importance of customer loyalty began to be understood thanks to regular flight schedules. Until these years, businesses have prepared customer loyalty creation forms for customers, tested them, and applied them to customers. The purpose of this whole process is based on keeping customers connected to the business for a longer period, and as a result, increasing sales and profits (Duffy, 2005).

Nowadays, customers are more knowledgeable, more investigative, and more protective of their rights. The fact that customers began to display a more selective or more willing image when choosing a product or service allowed them to become price-conscious. In such an environment, the trust and loyalty of the customer to the brand are extremely important. In an increasingly competitive environment, businesses have to be customer-oriented (Gronstedt, 2002).

For a business to have a long life and to make a profit, it must have a loyal customer portfolio (Dekimpe et al., 1997). The fact that the customer regularly makes frequent purchases from the same business is stated as the first stage of customer loyalty. Customers who have real loyalty to the business, on the other hand, do not give up making their purchases from the business to which they are connected, even if their conditions are not favorable or if competing businesses have better offers (Altıntaş, 2000).

According to Rundle-Thiele and Mackay (2001), loyal customers show more intense interest in businesses and, as a result, they become attached to the business. Loyal customers of the business do not accept the offers of other businesses, even if they are more suitable, and they are willing to pay more fees to their businesses.

In markets where competition is very intense, businesses want almost all of their customers to be fan customers as much as possible. The main reason for this is that there are businesses that can substitute the same product or service in the market. The dynamic nature of market conditions has encouraged businesses to take care of their customers rather than to gain customers. Lifelong customer relationships and valuing their customers have become mandatory for businesses. They have to spend 5 times more energy, time, and money than normal to regain a lost customer. Despite all these costs, businesses cannot regain 68% of their lost customers (Uyar, 2018). It seems to be possible for businesses to increase their revenues by 85% by increasing their existing customer loyalty by 5%. It is an 85% probability that the customers who are not satisfied and about to give up on the business can be regained at the right time and with the right intervention (Taşpınar, 2005).

When businesses try to acquire new customers instead of focusing on the current customer, they have to incur more costs. Realizing this, businesses have begun to value their existing customers more and develop new strategies to make them loyal customers. Desiring the best for the customer and satisfying them is the basis of creating loyal customers. Loyal customers will not accept the attractive offers of competitor companies, they will defend their business under all circumstances and will contribute the economic value for the business (Hackl and Westlund, 2000).

3.1. Customer Loyalty Approaches

Customer loyalty approaches; examined in three categories as behavioral, attitudinal, and combined. Firstly, behavioral loyalty; can be explained with sub-headings such as the customer's intention to repeat the purchase from the same business for shopping, then to express his satisfaction to other people and to pay more to the business for shopping (Ha and Jang, 2010). Behavioral loyalty; is related to the consistency of the customer and includes the behavior of repurchasing a product or service from the same business, how often he buys it, and the repetition of his behavior (Giray and Girişken, 2015).

This loyalty approach is not limited to business transactions only and beyond that, it covers customer behavior revealed by motivational factors (Doorn et al., 2010). The missing aspect of this dimension is the misconception that every purchase will provide loyalty to the brand. A customer whose expectations are not met may tend to shift to another business at the point where the business finds an alternative to its products (Batmaz, 2008).

In the behavioral loyalty approach, loyalty is determined by behavioral movements. Therefore, what is important in this approach is that the customer repeats the purchase and maintains his intention to purchase in the future (Altıntaş, 2000).

Secondly, attitudinal loyalty approach reveals the true feelings of customers and focuses on exactly how they see the business rather than why they buy a product or service (Gounaris and Stathapoulos, 2004) This approach can be defined as the customer's psychological commitment to the business. The reason for this is that he is willing to recommend the business to someone else even if he does not make any purchases (Bowen and Chen, 2001). Businesses with more customers with attitudinal loyalty can sell at higher prices and gain larger market shares (Ayas, 2012).

In contrast to the behavioral loyalty approach, the attitudinal loyalty approach goes further than the behavioral loyalty approach and expresses the strength of the customer's emotional closeness to the business (Mechinda et al., 2009). While behavioral loyalty is determined in part by situational factors (such as the availability of a brand), attitudinal loyalty is more persistent (Cáceres and Paparoidamis, 2007).

Finally, the unified loyalty approach emerges by combining the behavioral and attitudinal loyalty approaches; is explained depending on the frequency and rate of shopping according to the customer's product, service, or brand preference (Bowen and Chen, 2001).

The combined loyalty approach is also referred to as the mixed loyalty approach in many sources. The most important point in the unified loyalty approach; is to eliminate this confusion by determining whether the repetition of the purchasing behavior specified in the behavioral approach is due to loyalty or any obstacle or habit-based behavior (Baykal and Ayyıldız, 2020).

According to, the mixed definition put forward by Jacoby and Kyner (1973) through combining attitudinal and behavioral approaches, loyalty "is a behavioral result developed by a decision-making unit against one or more brands among the existing brands, as a function of psychological processes and revealed consciously, without relying on chance, for a certain period".

4. Methodology

In this section; the aim of the research, the importance of the research, the data collection method, the variables of the research, the model of the research, the hypotheses of the research, the universe, and the sample of the research were emphasized. SPSS program was used for the analysis of the data collected in the research and it was studied with a 90% confidence level.

4.1. Purpose of the Research

The main purpose of this thesis is to measure the effect of the price perception of the companies using airline cargo transportation on customer loyalty. In addition, determining the airline cargo usage habits and operating characteristics of the businesses included in the research and benefiting from airline cargo transportation were determined as sub-objectives.

4.2. Importance of the Research

The airline cargo transportation industry takes into account the wishes of the customers to respond well to customer demands and needs, however, due to its high costs such as operating costs, it offers high transportation fees to its customers, causing the customer to sell their products at higher prices. Due to the price policy of airline cargo companies, businesses can choose slower but more profitable transportation routes in order not to lose their customers and gain profits. From this point of view, the research is important in terms of increasing the loyalty levels of customers using airline cargo and shaping price perceptions depending on loyalty. It is thought that the results of the research will help and guide researchers, academics, and experts interested in the subject in determining marketing strategies, and also contribute to the literature, especially in terms of the industrial market, given that there are not enough studies.

4.3. Data Collection Method and Research Variables

In this study, a questionnaire was used as data collection management. When the questionnaire form is sent to the businesses by e-mail, the question "Have you used airline cargo transportation at least once a year?" a filter question was asked and the survey was continued with businesses that answered yes to this question.

The questionnaire used consists of four parts. In the first part; airline cargo usage habits, in the second part; business information, in the third section; airline cargo service price perception, and finally, in the fourth section, questions about airline cargo service customer loyalty are included.

Table 1. Research Variables

	Number of Variables	References
Airline Cargo Usage Habit	3 Variables	
Business Information	4 Variables	
Airline Cargo Service Price Perception	25 Variables	Lichtenstein, Ridgway and Netemeyer (1993)
Airline Cargo Service Customer Loyalty	9 Variables	Madak and Salepçioğlu (2020), Kazançoğlu (2011), Mermertaş (2018), Narunart and Panjakajornsak (2019), Pi and Huang (2011)

Table 1 includes the variables used in the research and the sources used to determine the variables. Variables other than airline cargo usage habits and business information were asked in the questionnaire form with the help of a 5-point Likert scale.

The habit of using airline cargo is listed as “How many times have you worked with an airline cargo business in the last year”, “Which airline cargo business is your most preferred” and “The main reason for using airline cargo”.

Business information is in the form of “Business type”, “Establishment year of the business”, “Activity field of the business”, and “Annual revenue of the business”.

The airline cargo service price perception scale consists of 25 variables. The scale developed by Lichtenstein, Ridgway and Netemeyer in 1993 was used for the scale (Lichtenstein et al., 1993).

The variables of airline cargo service price perception used in the research are listed as follows:

- APP1- If the price of the cargo service is low, I am also concerned about the quality of the service provided.
- APP2- I also compare the prices of other airline cargo businesses to make sure I get my money's worth.
- APP3- When purchasing airline cargo service, I always try to maximize the quality I get for the money I spend.
- APP4- When I purchase airline cargo service, I like to make sure I get my money's worth.
- APP5- Although I usually get airline cargo service at lower prices, I give importance to certain service quality.
- APP6- When I purchase airline cargo service, I usually compare unit prices.
- APP7- I check the list price to make sure I'm getting the best airline cargo service for the money I spend.
- APP8- I wouldn't want to spend extra effort to find a lower-priced airline cargo service.
- APP9- Although I usually get airline cargo service at lower prices, I give importance to certain service quality.
- APP10- The time and effort it took to find a lower-priced air freight service are not worth the money I save.
- APP11- I would never work with more than one airline cargo company to find a lower-priced airline cargo service.
- APP12- Often the time it takes to find a lower-priced airfreight service isn't worth the effort.
- APP13- In general, high-quality airline cargo service implies a high price.
- APP14- In general, you get what you pay for in airline cargo service.
- APP15- The price of airline cargo service is a good indicator of the quality of the service.
- APP16- I always pay a little more for the best air freight service.
- APP17- Others notice when you buy the most expensive airfreight service.
- APP18- Receiving a high-priced airline cargo service makes us feel better as a business.
- APP19- Buying the most expensive airfreight service makes the business feel great.
- APP20- When the business purchases a high-priced airline cargo service, it enjoys its prestige.
- APP21- When you buy the higher-priced airline cargo service, you are implying something to others.
- APP22- If you consistently buy the lowest-priced version of an air freight service, others will think you're stingy.
- APP23- I buy the most expensive of an air freight service because I know others will notice.
- APP24- I think that others have judged the business based on the airline cargo service I purchased.
- APP25- I find it impressive to buy an expensive airfreight service even for a relatively inexpensive item.

APP8 (I wouldn't want to spend extra effort to find a lower-priced airline cargo service), APP10 (The time and effort it took to find a lower-priced air freight service are not worth the money I save), APP11 (I would never work with more than one airline cargo company to find a lower-priced airline cargo service) and APP12 (Often the time it takes to find a lower-priced airfreight service isn't worth the effort) were asked as negative judgments in the questionnaire. After the survey was completed, the necessary transformations were made about these variables, they were made positive and then included in the analysis.

The variables of airline cargo service customer loyalty used in the research are listed as follows:

- ACL1- I like to work with the airline cargo company I work with.
- ACL2- I believe that the airline cargo company I work with is a good airline cargo company.
- ACL3- I will continue to receive service from the airline cargo company I work with.
- ACL4- I will continue to recommend the airline cargo company I work with.
- ACL5- I would like to work with this airline cargo company in the coming years.
- ACL6- I would like to work more often with the airline cargo company I work with.
- ACL7- When I want to work with an airline cargo business, my first choice would be this airline cargo business.
- ACL8- I am happy to work with this airline cargo business.
- ACL9- Even if this airline cargo business increases its prices, I still prefer the same business.

4.4. Basic Hypothesis of the Research

According to the survey study conducted in this research, it is possible to express the main hypothesis to be tested in the research as follows:

H_0: Price perceptions of the businesses using airline cargo do not have a statistically significant effect on customer loyalty.

H_1: Price perceptions of businesses using airline cargo have a statistically significant effect on customer loyalty.

4.5. The Universe and Sample of the Research

The universe of the research; consists of businesses operating in the Marmara Region and benefiting from airline cargo transportation through airports in Istanbul. Since it is not possible to reach all businesses in terms of time and cost, the snowball sampling method, which is one of the non-random sampling methods, was used. A survey was conducted with 33 businesses using airline cargo transportation between 15 July 2021 and 30 August 2021.

5. Findings

In this section; the reliability analysis of the scales used in the research, the normality analysis of the scale scores, the frequency distributions of the airline cargo usage habits, the frequency distributions of the business information, and finally the effect of the airline cargo service price perception on the airline cargo service customer loyalty are included.

5.1. Reliability Analysis of the Scales

Likert-type scales are generally used to measure Cronbach's alpha coefficient consistency between variables. It is a method used to test the reliability of the variables in the research. It is possible to interpret the Cronbach alpha values as follows (Yıldız and Uzunsakal, 2018).

- If 0.00 <α <0.40, the scale is unreliable.
- If 0.40 <α <0.60, the scale has low reliability.
- If 0.60 <α <0.80, the scale is quite reliable.
- If 0.80 <α <1.00, the scale is highly reliable.

5.1.1. Reliability Analysis of the Airline Cargo Service Price Perception Scale

Variables that significantly impair reliability in the airline cargo price perception scale were identified and removed from the scale. Reliability analysis was then performed again. The reliability analysis was repeated until there were no variables that impair reliability. Accordingly, APP1 (If the price of the cargo service is low, I am also concerned about the quality of the service provided), APP15 (The price of airline cargo service is a good indicator of the quality of the service), APP20 (When the business purchases high-priced airline cargo service, it enjoys its prestige), APP21 (When you buy the higher-priced airline cargo service, you are implying something to others), APP22 (If you consistently buy the lowest-priced version of an air freight service, others will think you're stingy) are excluded from the scale. The final result is outlined in Table 2.

Table 2. Airline Cargo Service Price Perception Scale Reliability Statistics

Cronbach's Alpha	N of Items
0.689	20

As can be seen in Table 2, there are 20 variables in the airline cargo price perception scale. The Cronbach's Alpha value for the scale was determined as 0.689. This shows that the scale is quite reliable.

5.1.2. Reliability Analysis of Airline Cargo Service Customer Loyalty Scale

Similar to the airline cargo price perception scale, a variable that significantly impairs reliability in the airline cargo customer loyalty scale was excluded from the scale. ACL9 (Even if this airline cargo business increases its prices, I still prefer the same business), a reliability analysis was performed again. The final result is shown in Table 3.

Table 3. Airline Cargo Service Customer Loyalty Scale Reliability Statistics

Cronbach's Alpha	N of Items
0.964	8

As seen in Table 3, there are 8 variables in the airline cargo customer loyalty scale. The Cronbach's Alpha value for the scale was determined as 0.964. In this case, it is possible to state that the scale has high reliability.

5.2. Normality Analysis of Scale Scores

The Kolmogorov-Smirnov test was used to determine whether the scale scores were normally distributed. Table 4 and Table 5 show the results. According to the results, it was concluded that the distribution of scale scores was not normal (sig.<0.10).

Table 4. Airline Cargo Service Price Perception Scale Score Normality Analysis

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Airline Cargo Service Price Perception	0.160	33	0.032

a. Lilliefors Significance Correction

Table 5. Airline Cargo Service Customer Loyalty Scale Score Normality Analysis

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Airline Cargo Service Customer Loyalty	0.210	33	0.001

a. Lilliefors Significance Correction

5.3. Frequency Distributions of Businesses

In this section, the frequency distributions of the airline cargo usage habits of the businesses and the business information are included. Variables related to airline cargo usage habits; The number of times working with the airline cargo business in the last year is listed as the most preferred airline cargo business and the main reason for using airline cargo. Business information is business type, establishment year of the business, activity field of the business, and annual revenue of the business.

Table 6. Using Airline Cargo Business in the Last Year

	Frequency	%	Valid %	Cumulative %
4 times and less	8	24.2	24.2	24.2
5-8	6	18.2	18.2	42.4
9-12	6	18.2	18.2	60.6
13 times or more	13	39.4	39.4	100.0
Total	33	100.0	100.0	

According to the results obtained in Table 6, from 33 businesses participating in the survey; 8 of them 4 times or less (24.2%), 6 of them 5-8 times (18.2%), 6 of them 9-12 times (18.2%) and 13 of them 13 times or more (39.4%) has used airline cargo transportation in the last year.

Table 7. Most Preferred Airline Cargo Business

	Frequency	%	Valid %	Cumulative %
Turkish Cargo	20	60.6	60.6	60.6
Pegasus Cargo	3	9.1	9.1	69.7
MNG Cargo	7	21.2	21.2	90.9
ULS Cargo	3	9.1	9.1	100.0
Total	33	100.0	100.0	

Depending on Table 7, 33 businesses participated in the survey; 20 of them preferred Turkish Cargo (60.6%), 3 of them Pegasus Cargo (9.1%), 7 of them MNG Cargo (21.2%), and 3 of them ULS Cargo (9.1%).

Table 8. The Main Reason for Using Airline Cargo

	Frequency	%	Valid %	Cumulative %
Imports	6	18.2	18.2	18.2
Export	23	69.7	69.7	87.9
Domestic sales	3	9.1	9.1	97.0
Domestic Purchase	1	3.0	3.0	100.0
Total	33	100.0	100.0	

The results are shown in Table 8, 33 businesses participating in the survey; 6 of them preferred airline cargo transportation due to import (18.2%), 23 for export (69.7%), 3 for domestic sales (9.1%), and 1 for domestic purchase (3%).

Table 9. Business Type

	Frequency	%	Valid %	Cumulative %
Private Business	27	81.8	81.8	81.8
Foreign Capital Business	6	18.2	18.2	100.0
Total	33	100.0	100.0	

As can be seen in Table 9, the 33 businesses participating in the survey; 27 of them were registered as private businesses (81.8%) and 6 of them as foreign capital businesses (18.2%).

Table 10. Establishment Year of the Business

	Frequency	%	Valid %	Cumulative %
1950 and before	3	9.1	9.1	9.1
1951 –1970	5	15.2	15.2	24.2
1971- 1990	9	27.3	27.3	51.5
1991- 2005	7	21.2	21.2	72.7
2006 -2015	7	21.2	21.2	93.9
2016 and after	2	6.1	6.1	100.0
Total	33	100.0	100.0	

According to the results shown in Table 10, from 33 businesses participating in the survey; 3 of the 1950 and before (9.1%), 5 of them 1951-1970 (15.2), 9 of them 1971-1990 (27.3%), 7 of them 1991-2005 (21.2%), 7 of them 2006 -2015 (21.2%) and the last 2 were established in 2016 and later (6.1%).

Table 11. Activity Field of the Business

	Frequency	%	Valid %	Cumulative %
Manufacturing Business	14	42.4	42.4	42.4
Trade Business	19	57.6	57.6	100.0
Total	33	100.0	100.0	

As can be seen in Table 11, 33 businesses participated in the survey; 14 of them (42.4%) continue their activities as manufacturing businesses, and 19 of them (57.6%) as trade operations.

Table 12. Annual Revenue of the Business

	Frequency	%	Valid %	Cumulative %
250.001 – 500.000 TL	3	9.1	9.1	9.1
500.001 – 1.000.000 TL	3	9.1	9.1	18.2
1.000.001 – 2.000.000 TL	8	24.2	24.2	42.4
2.000.001 – 4.000.000 TL	5	15.2	15.2	57.6
4.000.001 TL or more	14	42.4	42.4	100.0
Total	33	100.0	100.0	

Table 12 shows the annual revenue of 33 businesses participating in the survey for 2020. Accordingly, businesses; 3 of them are 250.0001-500.000 TL (9.1%), 3 of them are 500.001-1.000.000 TL (9.1%), 8 of them are 1.000.001-2.000.000 TL (24.2%), 5 of them are 2.000.001 – 4.000.000 TL (15.2%) and lastly, 14 of them have 4.000.001 TL and above (42.2%) annual revenue.

5.4. The Effect of Airline Cargo Service Price Perception on Airline Cargo Service Customer Loyalty

In this section, the effect of airline cargo service price perception on airline cargo service customer loyalty is examined. For this reason, the regression analysis presented in Table 13. Since the data did not show a normal distribution, first of all, the data were adapted to the normal distribution. Then, regression analysis was performed.

Table 13. The Effect of Airline Cargo Service Price Perception (ACSPP) on Airline Cargo Service Customer Loyalty (ACSCL)

	Unstandardized Coefficients		Standardized Coefficients
	B	Std. Error	Beta
Static	4.715	15.576	
ACSPP	23.003	30.210	0.135
	t	Sig.	R^2
Static	0.303	0.764	
ACSPP	0.761	0.452	0.018

Table 13 shows that airline cargo service price perception (ACSPP) does not have a statistically significant effect on airline cargo service customer loyalty (ACSCL). Therefore, the H_0 hypothesis is accepted.

6. Conclusion

Businesses to get ahead of their competitors in the global market and to make their existence sustainable by keeping their market share high have started to actively use the fastest means of transportation, thus airline cargo.

Airline cargo transportation; is a transportation system that has very important advantages such as high speed, establishing a wide transportation network under certain conditions, and security. It is considered an effective system for the long-distance transportation of especially urgent cargo. However, in geographically large countries, dispersed in terms of the settlement, and not conducive to transportation networks due to natural conditions, actively used airline cargo transportation causes very high costs. Airline cargo transportation requires huge investments especially in infrastructure, fuel and operation costs, etc. compared to passenger transportation in addition to high overhead fixed costs such as; it has had suitable aircraft for cargo flights, state-of-the-art cargo handling operation equipment, areas where logistics operations are required for intermodal transportation can be carried out, warehouses and warehouses suitable for all kinds of cargo, and bear these costs.

It is possible to state that the price perceptions and customer loyalty of customers using airline cargo services are among the issues that businesses that provide airline cargo transportation services should focus on when evaluating their customers. Therefore, this study; it is aimed to examine the effect of the price perceptions of the businesses that receive airline cargo transportation services on their loyalty to the airline cargo businesses.

Research was carried out by using a questionnaire as a data collection method with 33 businesses operating in the Marmara Region and using the airports in the province of Istanbul. Of the 33 businesses participating in the research, in the last year, 8 of them have used airline cargo transportation 4 times or less (24.2%), 6 of them 5-8 times (18.2%), 6 of them 9-12 times (18.2%) and 13 of them used it 13 times or more

(39.4%). During this period, 20 businesses were operated by Turkish Cargo (60.6%), 3 businesses by Pegasus Cargo (9.1%), 7 businesses by MNG Cargo (21.2%), and 3 businesses by ULS Cargo (9.1%) preferred. 6 businesses prefer these airline businesses for import (18.2%), 23 businesses for export (69.7%), 3 businesses for domestic sales (9.1%), and 1 business for domestic purchase reasons (3%) benefited from cargo transportation. 27 businesses receiving airline cargo service were registered as private businesses (81.8), and 6 businesses were registered as businesses with foreign capital (18.2%). 3 of these businesses were between 1950 and before (9.1%), 5 of them between 1951-1970 (15.2%), 9 of them between 1971-1990 (27.3%), 7 of them between 1991-2005 (21.2%), 7 of them were established between 2006-2015 (21.2%) and 2 of them were established in 2016 and after (6.1%). While 14 businesses participating in the survey are manufacturing businesses (42.4%), 19 businesses operate as commercial operations (57.6%). Businesses according to their revenue in 2020; 3 businesses 250,0001-500,000 TL (9.1%), 3 businesses 500,001-1,000,000 TL (9.1%), 8 businesses 1,000,001–2,000,000 TL (24.2%), 5 businesses 2,000,001 – 4.000.000 TL (15.2%) and lastly 14 businesses are listed as 4.000.001 TL and above (42.2%).

The main hypothesis tested in the study is expressed as follows:

H_0: Price perceptions of the businesses using airline cargo do not have a statistically significant effect on customer loyalty.

H_1: Price perceptions of businesses using airline cargo have a statistically significant effect on customer loyalty.

In the research has been concluded that airline cargo service price perception does not have a statistically significant effect on airline cargo service customer loyalty. In this case, the H_0 hypothesis was accepted.

It would be useful to make comparisons with other studies conducted to better evaluate the result obtained in the research. One of the hypotheses included in the article titled "The Analysis of Customer Loyalty and Its Antecedents in Turkish Internet Service Provider Sector with Structural Equation Modelling" published by Karakaş Geyik and Gökçen in 2014 is "Price perception has a positive effect on customer loyalty" (Karakaş Geyik and Gökçen, 2014). As a result of structural equation modeling, it was revealed that the hypothesis in question was not confirmed (Karakaş Geyik and Gökçen, 2014). For this result obtained; they stated that loyal customers are customers with low price sensitivity, and customers with high loyalty act independently of price (Karakaş Geyik and Gökçen, 2014). This result is similar to the result obtained in the study.

Narunart and Panjakajornsak (2019) supported the result obtained in the research with their statements in the article they published. They expressed price insensitivity as the customer's commitment not to switch to other products, whether there is an increase in the price of the product or not. Therefore, it has been stated that loyal customers act independently of price.

The research conducted by Anuwichanont (2011) with passengers; examined the effect of price perception on customer loyalty in the context of airlines, and discussed the moderating effect of consumers' price perception in explaining service loyalty. The moderating effect of price perception is significantly evident, only due to the relationship between brand effect and loyalty structures. According to this result, price perception does not directly affect brand loyalty and is similar to the result of the research.

O'Cass and Frost (2002) listed the factors that affect the customer's purchase of a product or service in the form of brand and quantity. It has been understood that customers with brand loyalty are less affected by price increases than customers with lower loyalty levels, but price sensitivity gains more importance when it comes to quantity. Apart from the effect of the quantitative variable, it is possible to state that the result of this research partially overlaps with the result obtained in the research.

Johnson et al. (2001) examined the evolution and future of national customer satisfaction index models based on five different industries, including airlines. They revealed the low positive effect of price on loyalty for airlines.

The results obtained in more recent studies are similar to the results obtained in the research. It is possible to interpret that customers' understanding of loyalty changes over time. As customers' loyalty levels increase, they act independently of price perceptions.

Considering both the results obtained in the research and the results of similar studies in the literature, it is seen that the effect of price perception on customer loyalty is either not or is very limited. Whether this situation is similar or different for the industrial market (B2B - Business to Business) has been revealed by research. It has been concluded that the result is similar and supportive of the literature.

In addition to what has been said so far; it is also possible to make suggestions to researchers and academicians who want to work on this subject. The research was carried out with a small number of samples It will be useful to study it with a larger number of samples and compare the results obtained.

It is important not only for airline cargo but also for repeating the research in different fields or sectors, comparing the results, and determining the differences or similarities in the field or sector.

It may be recommended to repeat the study in different regions or countries. Thus, it will be possible to detect differences or similarities in terms of regions or countries.

Considering that this research was carried out during the Covid-19 pandemic period, there is a possibility that the pandemic may affect the results. To understand and demonstrate whether this effect exists, it would be useful to repeat the research and compare the results obtained after the pandemic period.

Finally, repeating the research with different variable or variables that may be related to the price perceptions and customer loyalty of airline cargo customers, or even with variable or variables that are thought to have a regulatory effect on the price perceptions and customer loyalty of airline cargo customers can be suggested.

Ethical approval

Istanbul Gelisim University, Ethics Committee Chairman, Meeting Date: 03 June 2021, Decision No: 2021-20-19.

Conflicts of Interest

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

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Evaluation of the Airline Business Strategic Marketing Performance: The Asia-Pacific Region Case

Niyazi Cem Gürsoy[1*], Furkan Karaman[2] and Mert Akinet[3]

[1*]University of Turkish Aeronautical Association, Department of Flight Training, 06797, Etimesgut, Ankara, Türkiye. (ncemgursoy@gmail.com).
[2] University of Turkish Aeronautical Association, Department of Management, 06797, Etimesgut, Ankara, Türkiye. (furkaankaraman@gmail.com).
[3] University of Turkish Aeronautical Association, Department of Aviation Management, 06797, Etimesgut, Ankara, Türkiye. (mertakinet@gmail.com).

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Abstract

Businesses provide various marketing strategies in order to gain a competitive advantage and achieve sustainable profitability in today's globally competitive environment. While some of these strategies are realized through traditional marketing methods, some of them are implemented through digital marketing applications. The continuous and rapid change in information and communication technologies has made it obligatory for businesses to reconsider their marketing strategies and activities. In the literature, there are various studies conducted with multi-criteria decision-making methods in order to measure the marketing performance of businesses. However, there is no study conducted with these criteria specific to airline companies' marketing performance. The criteria determined as a result of the literature review were analyzed using the fuzzy-AHP and Fuzzy-BWM methods for weight determination, and the TOPSIS method for alternative selection which are among the multi-criteria decision-making techniques. As a result of the study, net profitability, load rate, and total passenger number criteria came to the fore among other criteria, evaluations were made for the 6 airline companies examined, and the best and the worst alternative airline companies were determined, and evaluations were made in terms of marketing strategies. As a result, an exemplary application was introduced to airline companies in order to improve their marketing strategies and performances, and inferences that could contribute to future studies were made in the literature.

1. Introduction

Marketing, which is one of the most important functions of businesses in today's globally competitive environment, has a very important place in gaining a competitive advantage in the market and ensuring the sustainability of businesses (Thomas and Gupta, 2005). Since it is an important function, the evaluation of the performances of enterprises and their interpretation by digitizing play an important role in terms of competition (Brookes, et al., 2004).

It ensures that the marketing activities planned to be measured, controlled, evaluated, and reviewed on the marketing performance reach the desired results. Continuous monitoring of marketing performance is important for businesses to achieve their goals. Today, measuring marketing performance attracts the attention of both the industry and researchers. There are several studies in the literature on determining and measuring criteria that can be used in marketing performance and performance measurement and related studies mostly focused on conceptual content and analysis (Ambler, 2000; Ambler, Kokkinaki, and Puntoni, 2004; Patterson, 2007; Bruni, Cassia, and Magno, 2017; Liang and Gao, 2020).

The airline industry is one of the sectors where fierce competition is experienced. This is true for both mature and emerging markets. Airline operators who want to gain a competitive advantage by differentiating the same service should closely follow the strategies of their competitors and can improve these strategies by comparing them or offering a superior service. Using multi-criteria decision-making (MCDM) techniques to analyze the competitors of airline operators serving in the same market can be useful in developing response strategies.

In this study, in order to evaluate the strategic marketing performance of airline companies, weight determination with fuzzy AHP (Analytic Hierarchy Process) method and evaluation of the best airline among the alternatives with TOPSIS method, which is one of the multi-criteria decision-making techniques, was applied on 6 airline companies operating in the Asia-Pacific region. The airlines considered are full-service providers and offer similar services. First, the conceptual framework was created by examining the strategic marketing literature, and then literature on multi-criteria decision making (MCDM) methods applied to airline companies were reviewed. After that, the criteria to be examined in the study were determined, and a proposed multi-criteria decision-making hybrid model was created. The reflection of the priorities of the criteria evaluated in the model to the application was provided with the help of fuzzy logic, therefore the sensitivity of the decisions made was increased and the effect of the uncertainty of human evaluations was thus tried to be reduced. With the FAHP and fuzzy BWM method, the weights of the criteria that are effective in evaluating the marketing performance of the airline business were calculated as fuzzy and then defuzzified. After that, comparisons and detailed analyzes were made with the data of 6 airline companies operating in the Asia-Pacific market using TOPSIS method. The consistency ratios of both weighting methods were compared. Finally, the outputs of the application were made in the literature, and suggestions for future studies were made.

2. Conceptual Framework

In the literature, the starting point of performance measurement in marketing is based on control theory. Control theory assumes that management has a strategy and a series of intermediate stages (plans) against which actual performance can be compared (Ambler, Kokkinaki, and Puntoni, 2004). The marketing unit should set the right strategic goals, measure, and control them continuously. In the airline industry, where competition is increasing day by day, managers constantly observe the performance of their business, especially in finance, marketing, and operational areas (Lu, Wang, Hung, and Lu, 2012).

The criteria used in marketing performance research; financial measures such as market share, profitability, cash flow, and non-financial criteria such as quality, customer satisfaction, and innovation (Ambler, 2000; Patterson, 2007). The studies of Schefczyk (1993) and Liedtka (2002) also show that non-financial performance data of airline companies are related to financial performance. In addition, airline companies mainly use financial and operational performance indicators in performance measurement (Schefczyk, 1993; Francis et al., 2005).

Francis et al. (2005) mentioned that the most widely used operational performance indicator for airlines is "cost per empty seat". This is also seen by airline managers as the most important indicator reflecting full operational performance.

Several studies show that success in non-financial performance affects financial performance in the airline industry. Khim et al. (2010) stated that performance indicators regarding customer satisfaction in airline operations are a leading indicator of the company's future performance. The results of the same study show that the efforts of airlines to correct mistakes (e.g. reducing the number of damaged baggage pieces) positively affect both short and long-term financial performance.

In a competitive market situation, an airline's activities can be viewed as a sequential and cyclical process, and operators decide on the most appropriate factor input for the current period (e.g. labor, assets, capital, etc.) based on customer consumption in the previous period (Feng and Wang, 2000).

At the same time, under a certain factor input, more product output at the production stage (e.g. seat-km, total debt, interest expense, etc.) and likewise, given product price and factor cost, more consumer consumption can be studied at the marketing stage (e.g. passenger-km, operating income, net income, etc.) (Feng and Wang, 2000).

Clark (1999) demonstrated that traditional accounting measures (profit, sales, cash flow) have expanded to include non-accounting measures (market share, quality, customer satisfaction, loyalty, brand equity), as well as marketing control, enforcement orientation, and wider issues.

Riley et al. (2003) stated that the load factor of airline companies and the current ton-kilometer amount are directly proportional to the equity share values, and the performance indicators regarding their market shares and the ton-kilometers offered are related to their financial performance.

3. MCDM Methods Applied to Airline Businesses Literature Review

Tsaur et al. (2002) proposed a fuzzy MCDM model to evaluate airline service quality. First, they used AHP to find the weight of the criteria, and then they defuzzied the weights. They used the TOPSIS method for the final evaluation. They collected the data by conducting a survey. As a result of the study, it was determined that airline customers are affected by the physical and empathy of the service and that the airline company, which is in the first place in the evaluation, also has the highest share in the market.

Chuang et al. (2007) argued that the corporate image and reputation of airline companies are very important in seeing their position in the market and in developing marketing strategies, and they tried to measure these two phenomena with the hybrid multi-criteria decision making (MCDM) methods they developed. They determined the safety and service criteria of Taiwan Airlines and made a comparison using fuzzy AHP, one of the fuzzy MCDM methods, to measure corporate image and reputation. Similar to that study in 2007, Liou and Chuang (2008) created a hierarchy network to measure the corporate image of airline operators and separated them into factors that determine the corporate image of the enterprise and its components. Based on the factors of the corporate image such as communication, incentives, customer relations, service and planning and communication, safety records, publications, management style, and other factors, firstly fuzzy integral, then based on the factors AHP finally Simple Additive Weight (SAW) methods used and evaluated the corporate image and reputation of airlines.

Kuo (2011) tried to evaluate the service quality of airline companies for a market where China and Taiwan Airlines are competing, using the hybrid fuzzy MCDM methods they developed, and obtained the data by surveying the passengers. In the model he developed, range values are fuzzified and that is based on gray relational analysis (GRA) and VIKOR. It is stated that with the presented model, he emphasizes the strengths and weaknesses of the airline by identifying the points they lack in service quality.

Pineda et al. (2018) developed a hybrid MCDM model to evaluate airline financial and operational efficiency. In the study, first, the DRSA method to determine the most effective criteria among the criteria determined from the database, then the DEMANTEL method to determine the relationship between the airline operational performance criteria, the DANP method to determine the relational weights after determining the relationship between the criteria, and finally they used the VIKOR method to analyze difference with the desired ideal level. As a result of the study, airlines will be able to see their strengths and weaknesses, so that they will prioritize their benchmarking reference and improvement aspects for improvement.

Bakır et al. (2019) used MCDM methods to evaluate the service quality performance of main airlines that adopt the LCC business model in Europe. They analyzed airline passenger criticism based on seven evaluation criteria and used the entropy method to determine the weights of the criteria and the WASPAS method to rank them.

Dožić (2019) reviewed the studies written using MCDM methods in the field of aviation between 2000-2018. According to the results of his study, a) MCDM methods were mostly used in airline studies. b) The main theme in most of the studies has been measurement. c) fuzziness is included in 50% of the articles. d) Analytical Hierarchy Process-AHP (including Fuzzy AHP) was applied in 40% of the reviewed articles. e) Taiwan ranked first in the list of academicians who wrote articles and case studies in which countries were presented. The theme of the articles on airlines, in which the MCDV method was applied, was given as service quality, partnership, fleet, competition, financial performance, safety, and others, respectively.

4. Marketing Performance Indicator Set

Common mistakes in determining criteria to measure marketing performance; the tendency to use easily measured and known criteria, to use criteria that do not reflect real marketing results, to prefer only quantitative data, to focus on activities and activities rather than results, and lastly, the overuse of indicators for efficiency rather than efficiency (Torlak Altunışık, 2018).

The list of criteria selected in the study and the literature review is given in Table-1 respectively;

Table 1. Literature Review of Criteria

	Criteria	Literature Review
C1	Net Profitability	(Francis et al., 2005)
C2	Net Profit/Revenue Passenger Kilometers (Profit/RPK)	(Francis et al., 2005; Feng and Weng, 2000)
C3	Total Number of Passengers	(Erdoğan and Kaya, 2014)
C4	Load Factor	(Schefczyk, 1993; Francis et a 2005; Erdoğan and Kaya, 2014)
C5	Market Share	(Leong, 2008; Surovitskikh and Berendien, 2008; Khim, 2010)
C6	The ratio of operational expense to operation kilometer (Expense/RPK)	(Erdoğan and Kaya, 2014; Sarangaand Nagpal, 2016)
C7	Marketing Expenditures	(Keh, vd. 2006; Doganis, R. 2009)

Grønholdt and Martensen (2006) reviewed the marketing performance criteria examined in the literature and combined them into four groups. These groups are; mental consumer indicators (brand awareness, customer interest, perceived differentiation, perceived quality, etc.), behavioral customer indicators (customer loyalty, churn rate, number of customer complaints, number of transactions per customer, share of wallet), market-related indicators (sales, new customer sales, sales trends, market share, number of customers, number of new customers, penetration, customer conversion rate, etc.) and financial indicators (profitability, gross margin, customer profitability, customer gross margin, cash flow, return on investment, customer lifetime value).

Airlines use some criteria in strategic marketing performance measurement. As a result of the literature review criteria like net profitability, the ratio of net profitability to paid passenger kilometers (Profit/RPK), the total number of passengers, load factor, market share, ratio of operational expense to operation kilometer (Expense/RPK), and marketing expenditures were mentioned in the results and definitions of studies.

Airline companies mainly use financial and operational performance indicators in performance measurement (Schefczyk, 1993; Francis et al., 2005). From the airline companies' internal business perspective, the first efficiency performance indicator is the load factor. In some airlines, load factor measurement is made for each flight, while others are made for each flight line (Erdoğan and Kaya, 2014). Load factor is an indicator used by most companies.

On the other hand, while indicators such as the number of customers, customer complaint rates, and market share are similar to performance indicators in other sectors, additional indicators based on different characteristics of the airline sector are used by airline companies. Some of these additional indicators are check-in service efficiency, the quality of cabin services, the quality of in-flight catering, and the effectiveness of customer loyalty programs (Leong, 2008; Surovitskikh and Berendien, 2008).

From the point of view of the customer, the mentioned indicators are accepted as supportive. In addition, studies show that customer satisfaction increases market share and profitability. Moreover, indicators related to customer complaints are considered as leading indicators for long-term financial profitability projections (Khim, 2010).

Another criteria profitability is financial indicator followed by all airlines and is closely related to the total number of passengers and the load factor. There are revenue management departments that determine different seat prices in order to increase profitability on the basis of flight lines and to ensure maximum profitability for airline companies. Since some airlines operate by chartering aircraft, these airlines monitor profitability by excluding aircraft rental costs.

With a strong emphasis on marketing spending, Kotler (2015) lists four types of marketing controls: annual plan, profitability, efficiency, and strategy. These factors enable the company to distinguish whether it has chosen the right goals (strategy), whether the goals have been achieved (efficiency or annual plan), whether the company has earned or lost money (profitability), and the return (efficiency) of each marketing expenditure. Therefore, marketing expenditures must be in line with the annual plan, profitable, efficient, and strategy.

The number and variety of measures offered to firms have increased significantly in recent years (Meyer 1998). Francis et al., (2005), the most frequently used financial performance indicators in airline performance measurement are operational cost, cash flow rate, operational income, profitability, return on capital invested, debt/equity ratio, income/expense ratio, price/earnings, ratio. They mentioned that it could consist of share price and earnings per share ratio.

While most financial performance indicators used by airlines are similar to those in other industries, there are a number of financial performance indicators specific to the airline industry. These indicators are RPK (revenue passenger kilometer), ASK (available seat kilometers), and WLU (income per workload unit).

In a competitive market, an airline's activities can be viewed as a sequential and cyclical process, and operators decide on the most appropriate factor input (eg labor, assets, capital, etc.) for the current period. At the same time, according to the customer consumption in the previous period, more product output under a certain factor input (eg seat-km, total debt, interest expense, etc.) can be planned as input for the next period (Feng and Weng, 2000).

Given the product price and factor cost, more consumption in the marketing phase (for example, passenger-km, operating income, net income, etc.) as a result of sales in this period, at the implementation stage, it can be used to calculate the price of factor input for this period and decide on the amount of factor (Feng and Weng, 2000).

Another criterion used in airlines is the ratio of operational expense to revenue passenger kilometers (expense/RPK). Airlines increase their operating kilometer by expanding and diversifying the network structure they offer to the market and try to reduce their per-operation costs by distributing them on top of the expanded network structure (Erdogan and Kaya, 2014; Saranga and Nagpal, 2016).

The ratio of operational expenses to the number of seats shows how much operational expenses they spend per seat for airlines. It aims to reduce operational expenses by applying different strategies given the cost structure of airlines (Erdoğan and Kaya, 2014; Saranga and Nagpal, 2016).

The marketing expense / operational income ratio shows the distribution of marketing expenses on operational income. Airlines aim to reduce marketing expenses and increase their operational revenues. But this ratio should follow a balanced distribution (Keh, et al. 2006; Doganis, 2009).

5. Proposed Hybrid Multi-Criteria Decision-Making Model

In a decision-making process, it is possible to determine the best alternative within the framework of the determining criteria by considering the interaction of many elements with each other in logical order. In this study, the first weights of determined airline marketing performance criteria were appointed using the Fuzzy AHP method. The criteria comparisons of the decision-makers were made according to linguistic evaluations and fuzzified. The fuzzified values were weighted using the F-AHP and F-BWM methods. Therefore, consistent results were obtained by removing the uncertainty factor in the discourses of decision-makers. After determining the weights of the criteria with fuzzy AHP and fuzzy BWM, the marketing performances of the airlines determined using the TOPSIS method will be evaluated, and the best will be selected within the framework of the criteria determined. Depending on the results obtained, weight determination methods were compared.

Figure-1 shows the procedure for selecting an airline based on marketing performance. In the literature, it has been seen that the combined use of fuzzy AHP and TOPSIS has been applied to different areas. Mahmoodzadeh et al. (2007) were used in project selection Balli et al. (2009) in selecting the appropriate operating system for computers, Gumus (2009) in evaluating hazardous waste transport companies, Mandic et al. (2014) evaluation of Serbian banks, Ertugrul and Karakasoglu (2009) evaluating the performance of Turkish cement firms and Kumar and Singh (2012) Supply Chain Management third party logistics service provider assessments. It has been observed that the use of the fuzzy BWM method and TOPSIS together has increased in recent years. Omrani et al. (2018) to determine the optimum mix among power plant facilities, Norouzu and Namin (2019) to evaluate the risk analysis of the railway construction project, Tian et al. (2018) in the selection of green suppliers in the agri-food industry, again Yücesan et al. (2019) in green supplier selection, Sagnak et al. (2021), Samanlıoğlu et al. (2020) used the fuzzy BWM and TOPSIS method together to evaluate the potential website and digital solution providers and Gupta (2018) to evaluate the green human resources performance of enterprises. Neither the fuzzy AHP nor the fuzzy BWM method has been used together in the literature in evaluating the performance of aviation or airline companies.

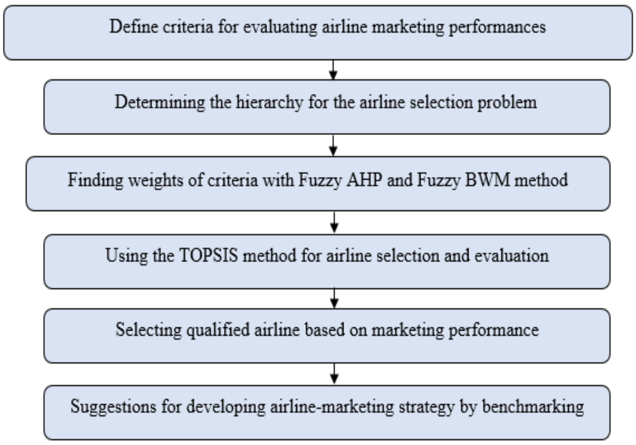

Figure 1. Airline Selection Procedure Based on Marketing Performance

6. Fuzzy Set Theory in Multi-Criteria Decision Making

There is always uncertainty in the decisions people make when describing or evaluating situations, events, substances or their environment while maintaining their lives. Since people's assessments include subjectivity, imprecision, and uncertainty. It is impossible to predict with precise numbers based on human evaluations when real-life problems are modeled to solve them (Mehrjerdi, 2012). Zadeh (1965,1976), based on this view, revealed fuzzy sets, and argued that traditional quantification is insufficient to explain complex situations, and therefore it is necessary to use linguistic variables whose values can be expressed in words or sentences. He noted that there are potential advantages to being able to work with linguistic variables, such as low computational cost and ease of understanding. Fuzzy set algebra developed by Zadeh (1965) is a theoretical whole that allows the handling of imprecise predictions in uncertain environments (Emrouznejad and Ho, 2017).

The application of fuzzy set theory to MCDM techniques started with the applications of Belman and Zadeh (1970) and Zimmermann (1978). Thus, they paved the way for a new family of methods that could not be solved with standard techniques.

Fuzzy sets, unlike standard sets, do not have crisp members and allow partial membership. The mathematical definition of the fuzzy set is given below.

If X is generally obtained by the collection of objects x, and fuzzy set a is a set of ordered pairs in X, and thus the fuzzy set is obtained as Equation 5.1.

$$\tilde{A} = \{ (X, \ \mu_{\tilde{A}}(x)) | x \in X \} \tag{5.1}$$

$\mu_{\tilde{A}}(x)$ is a membership function and shows the degree to which elements in any range of values belong to a fuzzy set (Zimmermen,1996, p.12). The most common membership functions are triangle, trapezoid, bell curve, exponential, Gaussian, pi (π) shaped and S shaped (Ali et al., 2015).

All of the fuzzy AHP methods developed used triangle membership functions (Pehlivan et al., 2017). It has been preferred in the fuzzy AHP method since triangle membership functions are easy to use and easy to calculate by decision makers (Kannan et al. 2013). Let $\tilde{A}$; (a, b, c) be a triangle consisting of fuzzy numbers and given as $a \leq b \leq c$. parameters a, b, and c represent the smallest possible value, the most promising value, and the largest possible value, respectively. Let X be a set representing the universe and containing a set of elements, and let its elements be denoted by x.

Let $\tilde{A}$, which is a fuzzy set in X, be represented by $\mu_{\tilde{A}}(x)$, which is a membership function, and let every element of x in $\tilde{A}$ give a real number between 0 and 1. The fuzzy set triangle membership function is defined as in Equation 5.2 (Zadeh, 1965, 1976) and given in Figure-2.

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < a, x > c \\ \dfrac{x-a}{b-a}, & a \leq x \leq b \\ \dfrac{c-x}{c-b}, & b \leq x \leq c \end{cases} \quad (5.2)$$

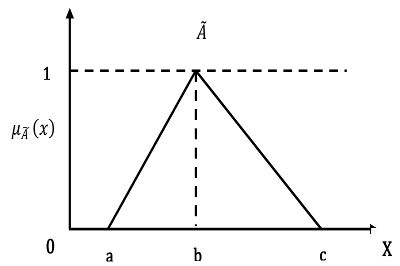

Figure 2. The triangular membership function of the fuzzy set A

7. The Methodology of Fuzzy AHP Used to Determine the Weights of Criteria

The analytical hierarchy process (AHP) was developed by Saaty (1980) and has become one of the most frequently used MCDM techniques in the literature. The AHP method is a technique used to select one of the finite multiple preferences, and three basic principles are proposed for the solution process. These are, respectively, the development of hierarchical structure, the binary comparison of alternatives and criteria, and finally synthesis (Saaty, 1986). If we obtain a matrix by comparing the decision-making criteria in binary and give an example of the most extreme points in the evaluation scale; it will give the equivalent of equally important criteria "1" and "9" when there are criteria that are very strongly important than the other, thus quantifying their views between "1-9". The decision maker may feel uncertain in his assessments of the criteria. For this reason, the criteria of the decision maker were studied as fuzzy to comparison values, and various fuzzy AHP methods were developed at different times. Pehlivan et al. (2017) considered the basic fuzzy AHP methods developed as methods proposed by Van Laarhoven and Pedrycz (1983), Buckley (1985), Chang (1996), and Mikhailov (2002, 2003).

In this study, the F-AHP method developed by Buckley (1985) with the geometric mean calculation will be used to determine the weights of the criteria that will be evaluated as criteria. The use of the F-AHP method developed by Buckley has advantages that it is easy to put it into a fuzzy state compared to other methods, ease of calculation, and guarantee a single solution (Pehlivan et al., 2017).

The degrees of binary comparison of linguistic variables can be expressed using fuzzy numbers, as shown in Table 2.

Table 2. Fuzzy Values Scale (Kannan vd., 2013)

Linguistic Variables	Fuzzy Triangle Scale	Fuzzy Triangle Opposite Scale
Equally Importance (EI)	(1,1,1)	(1,1,1)
Moderately Importance (MI)	(2,3,4)	(1/4,1/3,1/2)
Strong Importance (SI)	(4,5,6)	(1/6,1/5,1/4)
Very Strong Importance (VS)	(6,7,8)	(1/8,1/7,1/6)
Extremely Strong Importance (ES)	(9,9,9)	(1/9,1/9,1/9)
Intermediate Values	(1,2,3)	(1/3,1/2,1)
	(3,4,5)	(1/5,1/4,1/3)
	(5,6,7)	(1/7,1/6,1/5)
	(7,8,9)	(1/9,1/8,1/7)

The degrees of binary comparison of linguistic variables can be expressed using fuzzy numbers, as shown in Figure 3 (Tzeng and Huang, 2011:20).

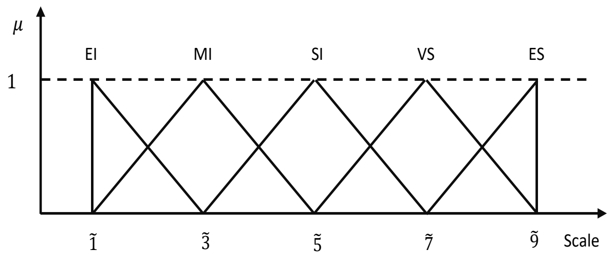

Figure 3. The Degrees of Binary Comparison of Linguistic Variables

The steps of Buckley's (1985) geometric mean method are shown below;

Step 1: Fuzzy binary comparison matrix $\tilde{D} = [\tilde{a}_{ij}]$ is created as in Equation 5.3;

$$\tilde{D} = \begin{bmatrix} (1,1,1) & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & (1,1,1) & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & (1,1,1) \end{bmatrix} \quad (5.3)$$

Here $\tilde{a}_{ij} \times \tilde{a}_{ji} \approx 1$ and $\tilde{a}_{ij} \cong w_i / w_j$, $i, j = 1, 2, \dots, n$.

Step 2: The Fuzzy geometric mean value $\tilde{r}_i$ is calculated as in Equation 5.4 for each i criterion.

$$\tilde{r}_i = (\tilde{a}_{i1} \times \tilde{a}_{i2} \times \dots \times \tilde{a}_{in})^{1/n} \quad (5.4)$$

Step 3: The calculated fuzzy weight value for each i criterion is shown in $\widetilde{w}_i$ Equation 5.5.

$$\widetilde{w}_i = \tilde{r}_i \times (\tilde{r}_1 + \tilde{r}_2 + \cdots + \tilde{r}_3)^{-1} \tag{5.5}$$

Here $\tilde{r}_k = (l_k, m_k, u_k)$ and $(\tilde{r}_k)^{-1} = \left(1/u_k, 1/m_k, 1/l_k\right)$.

Step 4: Fuzzy weight $\widetilde{w}_i = (l_i, m_i, u_i)$ can be defuzzified using any defuzzification method. Center of Area (CoA) method (Equation 5.6) was used here.

$$\widetilde{w}_i = \frac{l_i + m_i + u_i}{3} \tag{5.6}$$

8. The Methodology of Fuzzy BWM Used to Determine the Weights of Criteria

The BWM method was developed by Rezaei (2015) based on the creation of decision vectors by comparing the best and worst among criteria or alternatives by reducing the number of comparisons in the AHP method. Guo and Zhao (2017) developed the BWM method with fuzzy logic.

The steps of this method that will be used in determining the weights of the criteria in this study are given below.

Step 1: Determination of n decision criteria $\{c_1, c_2, \ldots, c_n\}$ that will affect the decision to be made.

Step 2: Determining the best (most important) c_B criterion and the worst (least unimportant) criterion c_W.

Step 3: By comparing the best criterion with the other criteria, how well it is from each of them is determined and the vector in Equation 5.7 is obtained. The fuzzy numbers obtained as a result of the comparison are obtained by using Table 3.

$$\tilde{A}_B = (\tilde{a}_{B1}, \tilde{a}_{B2}, \ldots \tilde{a}_{Bn}) \tag{5.7}$$

By comparing the best criterion with itself, $\tilde{a}_{BB} = (1, 1, 1)$ is obtained.

Step 4: The worst criterion is compared with other criteria. How much better the other criteria are than the worst criterion is determined with the help of Table 2 and the vector in Equation 5.8 is obtained.

$$\tilde{A}_W = (\tilde{a}_{1W}, \tilde{a}_{2W}, \ldots \tilde{a}_{nW}) \tag{5.8}$$

As a result of comparing the worst criterion with itself, $\tilde{a}_{WW} = (1, 1, 1)$is obtained.

Step 5: Determination of optimum fuzzy weights,

To reach optimum weights absolute difference $\left|\frac{\widetilde{w}_B}{\widetilde{w}_j} - \tilde{a}_{Bj}\right|$ must be greatest and $\left|\frac{\widetilde{w}_j}{\widetilde{w}_W} - \tilde{a}_{jW}\right|$ must be the smallest. After solving the nonlinear optimization problem given in Equation 5.9, the optimum weights of the criteria are obtained.

$$\min \max_j \left\{\left|\frac{\widetilde{w}_B}{\widetilde{w}_j} - \tilde{a}_{Bj}\right|, \left|\frac{\widetilde{w}_j}{\widetilde{w}_W} - \tilde{a}_{jW}\right|\right\}$$
$$s.t. \begin{cases} \sum_{j=1}^{n} R(\widetilde{w}_j) = 1 \\ l_j^w \le m_j^w \le u_j^w \\ l_j^w \ge 0 \\ j = 1,2,\ldots,n \end{cases} \tag{5.9}$$

Where $\widetilde{w}_B = (l_B^w, m_B^w, u_B^w)$, $\widetilde{w}_j = (l_j^w, m_j^w, u_j^w)$, $\widetilde{w}_W = (l_W^w, m_W^w, u_W^w)$, $\tilde{a}_{Bj} = (l_{Bj}, m_{Bj}, u_{Bj})$, $\tilde{a}_{jW} = (l_{jW}, m_{jW}, u_{jW})$.

The nonlinear constrained optimization problem in Equation 5.10 can be transformed as follows.

$$\min \xi \tag{5.10}$$
$$s.t. \begin{cases} \left|\frac{\widetilde{w}_B}{\widetilde{w}_j} - \tilde{a}_{Bj}\right| \le \xi \\ \left|\frac{\widetilde{w}_j}{\widetilde{w}_W} - \tilde{a}_{jW}\right| \le \xi \\ \sum_{j=1}^{n} R(\widetilde{w}_j) = 1 \\ l_j^w \le m_j^w \le u_j^w \\ l_j^w \ge 0 \\ j = 1,2,\ldots,n \end{cases}$$

The weights found as a result of the solution of the problem are fuzzy values. Equation 5.11 was used to defuzzificate the fuzzy values.

$$R(\tilde{a}_i) = \frac{l_i + 4m_i + u_i}{6} \tag{5.11}$$

For the fuzzy BWM method, the consistency index has been proposed to control the comparison data. In Table 4, consistency indexes were calculated as shown by Guo and Zhao (2017).

Table 3. Consistency Index (CI) for Linguistic Assessments

Linguistic Variables	Fuzzy Triangular Scale	CI
Equally Importance (EI)	(1,1,1)	3
Intermediate Value	(1,2,3)	6
Moderately Importance (MI)	(2,3,4)	7,37
Intermediate Value	(3,4,5)	8,7
Strong Importance (SI)	(4,5,6)	10
Intermediate Value	(5,6,7)	11,275
Very Strong Importance (VS)	(6,7,8)	12,53
Intermediate Value	(7,8,9)	13,77
Extremely Strong Importance (ES)	(9,9,9)	13,77

9. TOPSIS Method for Sorting Airlines

The TOPSIS (Technique for Order preference by Similarity to Ideal Solution) method is one of the methods used in Multi-Criteria Decision-Making problems developed by Hwang and Yoon (1981). In the TOPSIS method, it tries to determine the most appropriate alternative among the alternatives, the shortest distance to the positive ideal solution and the furthest distance from the negative ideal solution. The TOPSIS method is a technique that is easy to implement, the steps are clear, the best alternatives for each criterion are searched with its simple mathematical structure, priority values are included in the comparison processes, and it allows working with different verbal evaluations or experimental data (Gomez et al., 2009). In the TOPSIS method, the weights of the criteria are given by decision makers based on their personal opinions. The opinions of decision makers can be as fuzzy as they are important. For this reason, the weights of the criteria were determined using the fuzzy AHP and fuzzy BWM methods.

Below are the implementation steps of the TOPSIS method.

Step 1: Creating the Decision Matrix

The rows of the decision matrix are created as Equation 5.12 in size mXn, so that the rows are an alternative to m and the columns are an evaluation factor of n.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \begin{matrix} i = 1,2,\ldots,m \\ j = 1,2,\ldots,n \end{matrix} \quad (5.12)$$

Step 2: Creating the Normalized Decision Matrix

To facilitate cross-criteria comparison, the TOPSIS method normalizes the values in the decision matrix, resulting in a normalized decision matrix. Vector normalization (dividing each row vector by the norm of that Vector) is used to normalize Matrix values. Notation is given in Equation 5.13 and 5.14.

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_i{}^2}} \quad i = 1,2,\ldots,m;\ j = 1,2,\ldots,n \quad (5.13)$$

Thus, the generated normalized decision matrix is obtained as follows.

$$R_{ij} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}_{m\times n} \quad (5.14)$$

Step 3: Creating the Weighted Normalized Decision Matrix

The weighting process is the only subjective part of the TOPSIS method. Each value in the normalized matrix is weighted, depending on the degree of importance determined ($w_j = w_1, w_2, \ldots w_n$) by the decision makers. But it should be noted that the sum of the w_j value must be equal to 1 ($\sum_{j=1}^{n} w_j = 1$). Thus, the weighted normalized matrix Equation is found as in 5.15.

$$V_{ij} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & \cdots & w_n r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ w_1 r_{m1} & w_2 r_{m2} & \cdots & w_n r_{mn} \end{bmatrix}_{m\times n} \quad (5.15)$$

Step 4: Determination of Ideal and Negative Ideal Solutions

After obtaining a weighted normalized matrix, the goal may be maximization or minimization, depending on the nature of the evaluation element. If the goal in each column is maximization, the largest value is the ideal solution, and the smallest value is the negative ideal solution value. On the contrary, if the goal is minimization, the smallest value in the column can be the ideal solution, and the largest value can be the negative ideal solution value.

The Ideal solution value (when the evaluation factor is maximization) is calculated as in Equation 5.16.

$$A^+ = \left\{ \underset{i}{mak}\ v_{ij} \middle| i = 1,\ldots,m\ ; j = 1,\ldots,n \right\} \quad (5.16)$$

$A^+ = \{v_1^+, v_2^+, \ldots v_j^+, \ldots v_n^+\}$ consists of evaluations of alternatives that get the best value in each criterion.

Negative ideal solution values;

$$A^- = \left\{ \underset{i}{min}\ v_{ij} \middle| i = 1,\ldots,m\ ; j = 1,\ldots,n \right\} \quad (5.17)$$

$A^- = \{v_1^-, v_2^-, \ldots v_j^-, \ldots v_n^-\}$ consists of evaluations of alternatives that get the best value in each criterion.

Step 5: Obtaining Distance Values to Ideal and Negative Ideal Points

In this step, the evaluation of each decision point is calculated from the Euclidean distance approximation of the distances to the ideal and negative ideal solution. The resulting distance values (deviation values) are called distance to the positive solution (S_i^+) and distance to the negative solution (S_i^-) In calculating these offsets, Equation 5.18 and Equation 5.19 are used, respectively;

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2}, i = 1,2,\ldots,m \quad (5.18)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2}, i = 1,2,\ldots,m \quad (5.19)$$

Step 6: Calculation of Relative Proximity to The Ideal Solution

When calculating the relative proximity values of each point to the ideal solution, the distance values to the ideal and negative ideal points are used. The relative proximity to the ideal solution is represented by C_i^* and takes value in the range $0 \le C_i^* \le 1$. $C_i^* = 1$ indicates the absolute proximity of the relevant decision point to the ideal solution, and $C_i^* = 0$ indicates the absolute proximity of the relevant decision point to the negative ideal solution. In Equation 5.20, the calculation of relative proximity to the ideal solution is given.

$$C_i^* = \frac{S_i^-}{S_i^- - S_i^+} \quad (5.20)$$

10. Application

The aim of the study is to evaluate the marketing performance of airlines and to find the best one. For this reason, marketing performance criteria which determines marketing performance have been determined by scanning the literature and developed in order to make more precise evaluation. Two different methods have been proposed to evaluate the marketing performance of airlines. The first one is two-step Fuzzy AHP and TOPSIS and the other one is using Fuzzy BWM as the weighting method and then sorting with TOPSIS. MS Excel was used to implement the study. Firstly, the decision matrix was filled to determine the weights of the criteria with Fuzzy AHP and Fuzzy BWM, referencing the literature and the opinions of the decision makers. Three decision makers were consulted during the determination of the weights of the criteria. Two of the aforementioned decision makers are researchers studying in the field of aviation marketing and strategy, and the other one is an expert with seven years of airline industry experience. The weights of the obtained criteria were used as input in the TOPSIS method, and a systematic sorting of the airlines was carried out. The marketing strategies of the best airline companies based on the results were examined.

Figure-4 shows the model used in the study of the hierarchical structure of airline selection based on marketing performance;

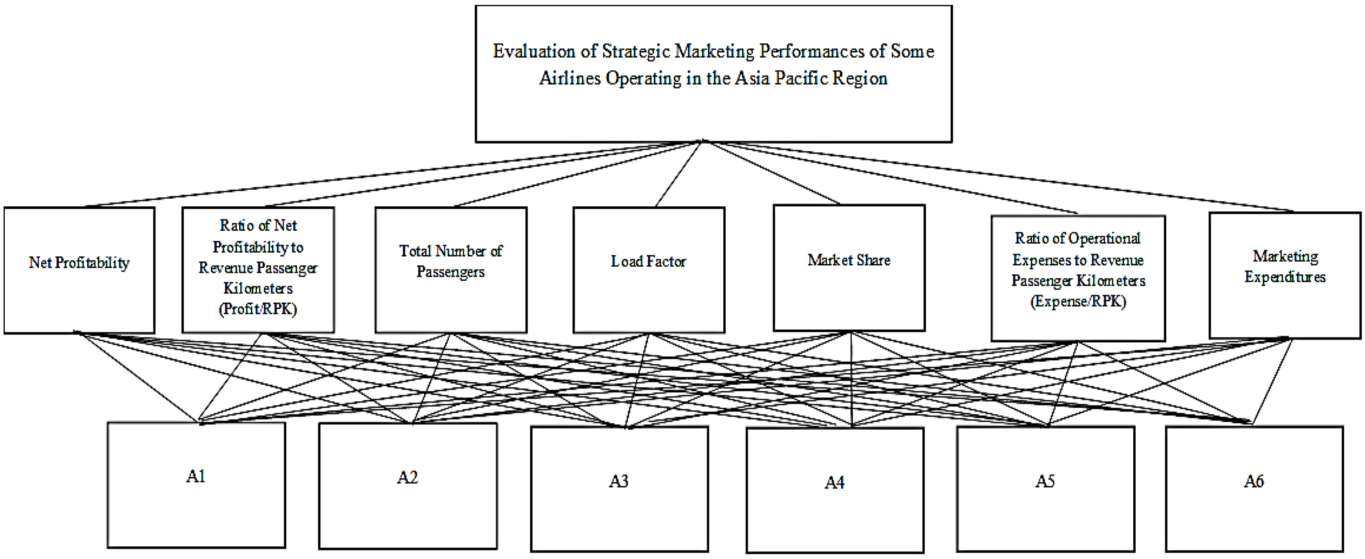

Figure 4. Hierarchical Structure of Airline Selection Based on Marketing Performance

In this study by examining the marketing performance of airlines operating in the Asia - Pacific market with multi-criteria decision-making methods, the data were obtained the 2019 annual reports of airlines, the articles studied in the relevant literature, the websites of airlines, and the examination of theses. As a result of the Covid-19 pandemic that emerged towards the end of 2019, the total seat capacity of airlines operating in Asia Pacific decreased by approximately 35% at the end of 2020 compared to 2019 (ICAO, 2021). The reason for using the data of 2019 in the study is that airline marketing activities are intended to be freed from the effects of the Covid-19 pandemic process. Thus, it is aimed to save the study from the effects of artificial results that will arise due to the pandemic. Data from a total of 6 airlines operating in the Asia - Pacific market was available. The reason for choosing full-service carriers operating in the Asia-Pacific region in the study is that the mentioned airlines are competitive in the region and their marketing strategies can be determined more accurately in terms of the market they focus on.

First, the weights of 7 criteria determined by applying the fuzzy AHP method. For the determination of weights, the criteria were compared in binary terms from 1-9, taking into account the linguistic values in Table 2. Then, using this Equation 5.15, the decision maker's level of inconsistency in the binary comparison was determined. If the discrepancy rate is below 10%, the decision maker is asked to review the binary comparison judgments if it exceeds this rate while being accepted (Saaty, 1996). CI used in equation; Consistency Index, RI; it represents the Random Consistency Index and the CR; consistency ratio.

$$CR = \mathrm{CI/RI} \tag{5.21}$$

For matrices of different sizes, the random consistency index value is obtained by using Table-4.

The CI contained in Equation 5.21 is calculated as in Equation 5.22.

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{5.22}$$

the λ_{max} is calculated as in Equation 5.23.

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n} \frac{\sum_{j=1}^{n} a_{ij} w_j}{w_j} \tag{5.23}$$

The consistency ratio of the binary comparison matrix of the determined criteria was found to be 0.092, and from here it seems that the comparison of the criteria is consistent.

Table 4. Random Consistency Index

Size (n)	*RI*
1	0
2	0
3	0,58
4	0,90
5	1,12
6	1,25
7	1,32
8	1,41
9	1,45
10	1,49

The resulting matrix was created using the fuzzy values scale given in Table 2. Table-5 contains a fuzzified comparison criteria matrix.

Table 5. Fuzzy Criteria Comparison Matrix with F-AHP

	C1	C2	C3	C4	C5	C6	C7
C1	(1,1,1)	(2,3,4)	(3,4,5)	(2,3,4)	(1,2,3)	(1,2,3)	(5,6,7)
C2	(1/5, 1/4, 1/3)	(1,1,1)	(2,3,4)	(1,2,3)	(2,3,4)	(1,1,1)	(2,3,4)
C3	(1/5, 1/4, 1/3)	(1/4, 1/3, 1/2)	(1,1,1)	(1/4, 1/3, 1/2)	(1/6, 1/5, 1/4)	(1/3, 1/2, 1)	(1,2,3)
C4	(1/4, 1/3, 1/2)	(1/3, 1/2, 1)	(2,3,4)	(1,1,1)	(4,5,6)	(1,2,3)	(3,4,5)
C5	(1/3, 1/2, 1)	(1/4, 1/3, 1/2)	(4,5,6)	(1/6, 1/5, 1/4)	(1,1,1)	(1,2,3)	(3,4,5)
C6	(1/4, 1/3, 1/2)	(1,1,1)	(1,2,3)	(1/3, 1/2, 1)	(1/3, 1/2, 1)	(1,1,1)	(2,3,4)
C7	(1/7, 1/6, 1/5)	(1/4, 1/3, 1/2)	(1/3, 1/2, 1)	(1/5, 1/4, 1/3)	(1/5, 1/4, 1/3)	(1/4, 1/3, 1/2)	(1,1,1)

The geometric mean method proposed by Berkeley (1985) was used to calculate the weight of criteria. The fuzzy geometric mean value for each i criteria was calculated as shown in Equation 5.4, and the fuzzy weights of the criteria were calculated as follows by applying Equation 5.5.

$$\begin{aligned} \tilde{w}_1 &= (0.187, 0.337, 0.596) \\ \tilde{w}_2 &= (0.100, 0.176, 0.299) \\ \tilde{w}_3 &= (0.028, 0.048\ 0.089) \\ \tilde{w}_4 &= (0.104, 0.184, 0.336) \\ \tilde{w}_5 &= (0.069, 0.120, 0.219) \\ \tilde{w}_6 &= (0.057, 0.101, 0.195) \\ \tilde{w}_7 &= (0.021, 0.034, 0.061) \end{aligned} \tag{5.24}$$

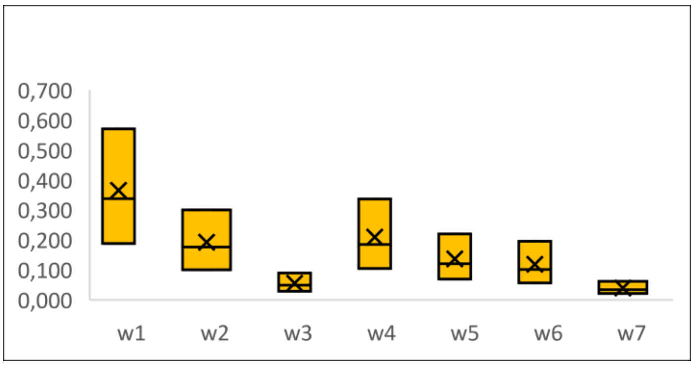

Figure 5. Weights Obtained by Fuzzy AHP

The weights of the criteria determined in Figure 5 are shown in the graph. It is seen that the difference between the lower and upper limits of the criteria with high weights is larger.

The weight of each criterion in problem solving was determined by using the center of area method in Equation 5.6. The weights of the criteria are indicated in the vector given in Equation 5.25.

$$W = (0.327, 0.173, 0.045, 0.187, 0.122, 0.106, 0.035) \tag{5.25}$$

Table 6. Best Criteria Comparison with Others

Criteria	C1	C2	C3	C4	C5	C6	C7
Best Criteria = C1	(1,1,1)	(2,3,4)	(5,6,7)	(2,3,4)	(1,2,3)	(2,3,4)	(6,7,8)

Table 7- Worst Criteria Comparison with Others

Criteria	Worst Criteria= C7
C1	(6,7,8)
C2	(3,4,5)
C3	(1,2,3)
C4	(4,5,6)
C5	(4,5,6)
C6	(2,3,4)
C7	(1,1,1)

The method suggested by Guo and Zhao (2017) was applied to determine the weights with the fuzzy BWM method. It has been determined that "Net Profitability" (C1) criterion is more important than others by decision makers in order to evaluate the marketing performance of airlines, and "Marketing Expenditures" (C7) is the least important criterion compared to the others. Table 6 shows the comparison of the best criterion with the others, and Table 7 shows the comparison of the least important criterion with the others based on linguistic values.

As a result of the obtained comparisons, the following nonlinear programming model was obtained and solved with MS Excel solver.

$$\min\ k^*$$

$$s.t. \begin{cases} \left|\frac{(l_1^w, m_1^w, u_1^w)}{(l_1^w, m_1^w, u_1^w)} - (l_{11}, m_{11}, u_{11})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_1^w, m_1^w, u_1^w)}{(l_2^w, m_2^w, u_2^w)} - (l_{12}, m_{12}, u_{12})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_1^w, m_1^w, u_1^w)}{(l_3^w, m_3^w, u_3^w)} - (l_{13}, m_{13}, u_{13})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_1^w, m_1^w, u_1^w)}{(l_4^w, m_4^w, u_4^w)} - (l_{14}, m_{14}, u_{14})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_1^w, m_1^w, u_1^w)}{(l_5^w, m_5^w, u_5^w)} - (l_{15}, m_{15}, u_{15})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_1^w, m_1^w, u_1^w)}{(l_6^w, m_6^w, u_6^w)} - (l_{16}, m_{16}, u_{16})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_1^w, m_1^w, u_1^w)}{(l_7^w, m_7^w, u_7^w)} - (l_{17}, m_{17}, u_{17})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_2^w, m_2^w, u_2^w)}{(l_7^w, m_7^w, u_7^w)} - (l_{27}, m_{27}, u_{27})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_3^w, m_3^w, u_3^w)}{(l_7^w, m_7^w, u_7^w)} - (l_{37}, m_{37}, u_{37})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_4^w, m_4^w, u_4^w)}{(l_7^w, m_7^w, u_7^w)} - (l_{47}, m_{47}, u_{47})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_5^w, m_5^w, u_5^w)}{(l_7^w, m_7^w, u_7^w)} - (l_{57}, m_{57}, u_{57})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_6^w, m_6^w, u_6^w)}{(l_7^w, m_7^w, u_7^w)} - (l_{67}, m_{67}, u_{67})\right| \le (k^*, k^*, k^*) \\ \left|\frac{(l_7^w, m_7^w, u_7^w)}{(l_7^w, m_7^w, u_7^w)} - (l_{77}, m_{77}, u_{77})\right| \le (k^*, k^*, k^*) \\ \sum_{j=1}^{7} R(\tilde{w}_j) = 1 \\ l_j^w \le m_j^w \le u_j^w \\ l_j^w \ge 0 \\ j = 1,2,3,4,5,6,7 \end{cases} \tag{5.26}$$

The optimum solution of the problem has been reached. The optimum fuzzy weights of the criteria are given in Equation 5.27. The graphic representation of the weights is given in Figure 6.

$$\begin{aligned} \tilde{w}_1 &= (0.243, 0.278, 0.293) \\ \tilde{w}_2 &= (0.100, 0.144, 0.196) \\ \tilde{w}_3 &= (0.050, 0.056\ 0.062) \\ \tilde{w}_4 &= (0.100, 0.144, 0.228) \\ \tilde{w}_5 &= (0.152, 0.208, 0.228) \\ \tilde{w}_6 &= (0.100, 0.139, 0.164) \\ \tilde{w}_7 &= (0.032, 0.034, 0.034) \end{aligned} \tag{5.27}$$

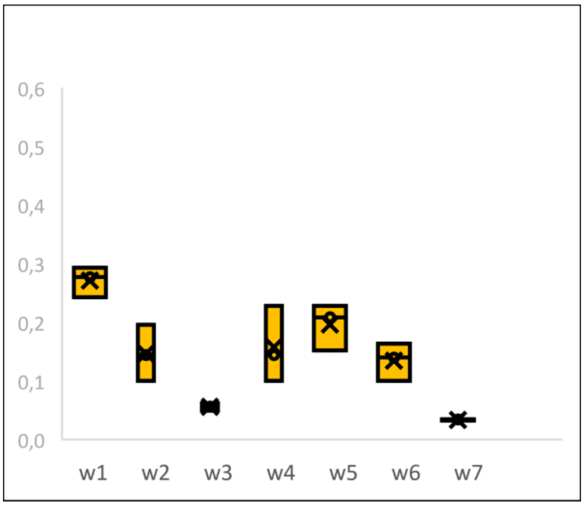

Figure 6. Weights Obtained by Fuzzy BWM

Since $C_{BW} = C_{17} = (6,7,8)$, using the consistency index in Table 3, the consistency ratio is found by dividing it by $k^* = 1{,}079$. The consistency ratio is found to be 1.079/12.53=0.086. The consistency ratio is an acceptable value.

The fuzzy weights were defuzzificate using Equation 5.11 and the weights in Equation 5.28 is obtained.

$$W = (0.274, 0.145, 0.056, 0.151, 0.202, 0.137, 0.034) \quad (5.28)$$

Marketing performance evaluation of airline companies was performed using the TOPSIS method of data related to criteria determined by weights. First, The Decision Matrix given in Table-8 was obtained. TOPSIS allows each criteria to serve its purpose. This aspect is also taken into account when calculating.

Table 8. Airline Selection Decision Matrix

	C1	C2	C3	C4	C5	C6	C7
A1	508.067.350	0,036	32.400.000	71%	3,60%	0,045	102.000.000
A2	477.000.000	0,046	20.906.000	81,90%	3,10%	0,055	48.000.000
A3	205.777.687	0,018	27.408.300	82,30%	2,60%	0,041	31.000.000
A4	456.000.000	0,024	56.000.000	78,80%	5,40%	0,033	69.900.878
A5	671.000.000	0,047	40.480.000	84,20%	3,20%	0,047	57.560.000
A6	266.186.784	0,021	29.800.000	78,70%	2,70%	0,029	25.500.000
Weights	32,77%	17,25%	4,96%	18,73%	12,24%	10,58%	3,48%
Goal	max	max	max	max	max	min	min

After the creation of the decision matrix, which is the first step in TOPSIS, the normalized decision matrix was calculated and then each element in the matrix was multiplied by the weight of the relevant criterion and then weighted normalized. Table 9 was obtained by following the relevant steps.

Table 9. Ideal (S^+) ve Negative Ideal (S^-) Distances to the Solution and Relative Closeness to the Ideal Solution (M^*) with F-AHP

	A1	A2	A3	A4	A5	A6
S^+	0,094	0,085	0,159	0,107	0,038	0,148
S^-	0,080	0,088	0,026	0,074	0,156	0,039
M^*	0,540	0,493	0,862	0,591	0,196	0,792

When the weights determined by F-AHP and the relative closeness values of the airlines to the ideal solution are taken into account, the ranking of the airline companies is $A_3 > A_6 > A_4 > A_2 > A_1 > A_5$

On the other hand, when the weights obtained by fuzzy BWM were applied to TOPSIS, the final Table 10 was obtained.

Table 10. Ideal (S^+) ve Negative Ideal (S^-)Distances to the Solution and Relative Closeness to the Ideal Solution (M^*) with F-BWM

	A1	A2	A3	A4	A5	A6
S^+	0,066	0,073	0,155	0,080	0,037	0,136
S^-	0,098	0,100	0,024	0,090	0,150	0,038
M^*	0,401	0,424	0,864	0,471	0,199	0,783

When the weights determined by F-BWM and the relative closeness values of the airlines to the ideal solution are taken into account, the ranking of the airline companies is $A_3 > A_6 > A_2 > A_1 > A_4 > A_5$

11.Conclusion

In the study, 6 airlines operating in the Asia-Pacific region were applied with multi-criteria decision-making techniques such as fuzzy logic, weight determination with F-AHP and F-BWM and choice between alternatives with TOPSIS in order to evaluate strategic marketing performances.

Firstly, the conceptual framework was created by examining the strategic marketing literature in the study. Secondly, Multi-Criteria Decision-Making (MCDM) methods applied to airlines were scanned in literature. Then, the criteria to be examined in the study were determined and the proposed multi-criteria decision-making hybrid model was created. In addition, comparisons and detailed analyses were made with the data of 6 airlines operating in the Asia-Pacific market.

The weights of the criteria were determined by fuzzy-AHP and fuzzy-BWM methods. Considering the consistency ratios, it was seen that the consistency ratio of fuzzy-BWM was higher. In the F-AHP method, it was observed that the gap widened as the weight increased. TOPSIS application was made with both weights and rankings were obtained depending on the marketing performance of alternative airlines. With the use of different weight determination methods, the third, fourth and fifth rankings differed, but the place of the others did not change.

As a result of the analysis, A3 airline took the first place when evaluated in terms of selected marketing performance evaluation criteria. It has been determined that the A3 airline performs above the average in terms of load rate, market share and total number of passengers, although it spends less on marketing compared to other airlines.

On the other hand, the airline with the lowest marketing performance according to the selected criteria is the A5 airline. Among the reasons for this situation, marketing expenses of the relevant airline are almost twice as much as those of the A3 airline, although there are no major differences in load factor and are close to each other in terms of the ratio of operational expenses to operational mileage.

In addition, when the marketing strategies of the A3 airline were examined, the fact that it uses digital marketing activities more actively than traditional marketing activities was reflected in marketing expenditures and came to the fore as an important factor affecting the ranking.

The contribution of the study to the literature is that multi-criteria decision-making techniques were used for the first time in the aviation sector in determining the marketing performance in the literature. The relevant study was carried out on 6 airline companies operating in the Asia-Pacific market, using annual reports and criteria selected as a result of literature review.

The fact that measuring the efficiency of marketing activities is quite complex and varies depending on many different variables is the biggest obstacle for marketing strategists to determine the appropriate strategy. In this study, it has been tried to evaluate the efficiency of marketing activities through the indicators such as “Profitability in airline marketing”, “Net Profit/RPK”, “Load Factor”, “Market Share”, “Expense/RPK”. It has been observed that the leading airline companies support their marketing strategies with activities that are closely related to digitalization and technology, such as technology investment, search engine marketing, e-mail marketing, social media marketing. At the end of the study, it is important to make the necessary investments for the airlines that aim to compete with the airline companies that are the subject of the study, to gain a competitive advantage and to make this competitive advantage sustainable. At the same time, it is vital to align the marketing indicators related to these investments.

In future studies, studies that cover the whole market can be carried out and the study can be updated by changing the criteria according to the decision 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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Analysis of Turkish Civil Aviation Accidents Between 2003 and 2017

Erdinç Ercan[1*], Ahmet Uğur Avcı[1]

[1*]University of Health Sciences, Department of Aerospace Medicine, Ankara, Türkiye. (drerdincercan@gmail.com).
[1]University of Health Sciences, Department of Aerospace Medicine, Ankara, Türkiye. (ahmetuguravci@gmail.com).

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Corresponding Author: *Erdinç Ercan*

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Abstract

Aviation accidents are caused by a chain of errors in many steps. Detection and classification of human factors in accidents are critical for taking effective precautions. This study aims to investigate the factors affecting civil aviation accidents in Turkey and increase aviation safety by raising awareness against the contributing factors in the accidents. Final accident reports of Turkish Civil Aviation Accidents, including fatalities or injuries between 2003 and 2017, were analysed retrospectively using the Human Factors Analysis and Classification System (HFACS). 59 aviation accidents were included in this study. Crew Resource Management (CRM) (41.4%), Loss of Situational Awareness (LSA) (39.0%), and meteorology (29.2%) were found to be the most contributing factors in 41 Plane, Helicopter, Glider (PHG) accidents, while meteorology (77.7%) and CRM (61.1%) were found to be the most contributing factors in 18 Balloon accidents. The rate of HFACS levels in the PHG/Balloon accidents were found to be 90.2%/66.6% in Level-1 (Unsafe Acts), 95.1%/100% in Level-2 (Preconditions for Unsafe Acts), 78.0%/94.4% in Level-3 (Unsafe Supervision), and 58.5/83.3% in Level-4 (Organizational Influences). These findings show that human factors are still major contributing factors in aviation accidents. Academic training like CRM, Aviation Meteorology and LSA should be given more frequently to the aviators to prevent accidents. Including Spatial Disorientation, hypoxia, and night vision practical training into the civilian pilot training and integrating HFACS into the "Aviation Safety Management System" might help to reduce aviation accident rates.

1. Introduction

Aircraft are preferred more and more every new year for transportation and are critically important for economic and socio-cultural interaction. Aviation activities in Turkey are improving progressively. While there were 29 general aviation and 12 balloon establishments in 2009, this number increased to 83 for general aviation and 34 for balloon establishments in 2019 (DGCA, 2019). Approximately 34 million passengers and 964 thousand tons of cargo were transported in 2003, 211 million passengers and 3.85 million tons of cargo were transported in 2019 (DHMI, 2020). Safe, fast, and low-cost trips are some of the reasons why air travel is so preferred. A disruption in flight safety will adversely affect air transport despite all its other advantages.

It is accepted that aviation accidents are not caused by a single factor but by a chain of errors in many steps. The most frequently encountered factor in the chain is human-derived errors. Shappell et al.'s (2007) study showed at least one human error in 60-80% of aviation accidents. To reduce human errors in accidents, it is necessary to focus on the causes of the error instead of focusing on those who made it (Dekker, 2001). Many factors such as stress, fatigue, and insufficient training can facilitate human errors during flight (Murray, 1997). The main challenge is the difficulty of tracking the factors that lead to human errors. Reason (1990a, 1990b) named these factors as active and latent factors; he stated that they only occur in the presence of a trigger, and he defined the model, also known as the Swiss Cheese Model, in which he explained that accidents could only occur as a result of the combination of more than one fault that will occur in various layers. Shappell and Wiegmann (2001) developed the Human Factors Analysis and Classification System (HFACS) based on the Swiss cheese model. HFACS gathers human factors at four levels (Figure 1). HFACS has been used in many different fields besides aviation since its development and has been a valuable tool for detecting human factors in accidents (Cohen et al., 2015; Celik & Cebi, 2009). Detection and classification of human factors in aviation accidents have critical importance for taking effective precautions.

This study aims to reveal the contributing factors in the Turkish Civil Aviation Accidents between 2003 and 2017, classify and compare them with other studies in this field, and increase aviation safety in our country by enabling suitable countermeasures against the contributing factors in aviation accidents.

2. Materials and Methods

2.1. Subjects

Civil aviation accidents, including fatalities or injuries in Turkish airspace or Turkey registered civil aircraft get involved in an accident in foreign airspaces between 2003 and 2017, were included in this study.

2.2. Procedures

The researchers analyzed final accident reports in the Transportation Safety Investigation Centre of Turkey. Turkey and other countries where the accidents took place, are members of ICAO, and it has been observed that accident investigations are carried out according to Annex 13 recommendations. Findings included in the final accident report were evaluated using the HFACS scheme. Findings were used as stated in the original investigation reports without any changes. General-commercial aviation flights were classified as specified in ICAO Annex 6, and accident and injury definitions were used as specified in ICAO Annex 13. Occurrence categories were used as specified in ICAO Accident/Incident Data Reporting.

Although it is a non-motorized aircraft, glider accidents were evaluated under general aviation accidents among plane and helicopter accidents due to its ability to move in 3 axis and the low number of accidents. Balloon accidents were considered as a separate category.

2.3. HFACS model

Data were analyzed using the HFACS model described by Wiegmann and Shappel (2003). Findings in the final reports were evaluated according to the HFACS model presented in Figure 1 and Table 3, considering a total of 140 factors under four main levels, 12 headings and in the first and second level there are12 subheadings. A contributing factor (finding) in an accident was attributed to only one factor listed within the same HFACS Level.

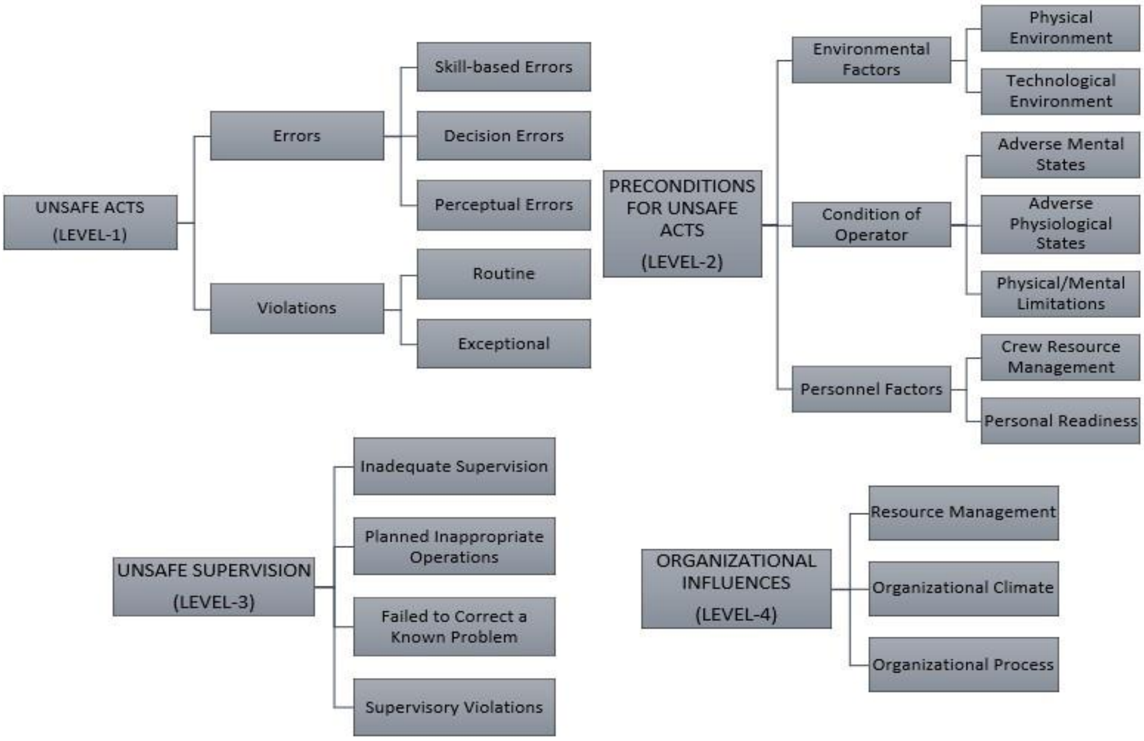

Figure 1. Human Factors Analysis and Classification System (HFACS) scheme

2.4. Researchers

The first researcher completed the Residency in Aerospace Medicine. He completed the 8th Human Factors in Aircraft Accident Investigation certification program held at the US DOT Transportation Safety Institute. He holds a private pilot license (PPL) and an ultralight aircraft pilot license (UPL) and has a bachelor’s degree in civil aviation management. The second researcher is a flight surgeon and continues to Residency in Aerospace Medicine and the aviation management undergraduate program.

2.5. Statistical Analysis

The accident data was obtained from records of original final reports. The study data was edited in Microsoft Excel, and statistical analyses were executed in the IBM SPSS program. $P<0.05$ was considered statistically significant. Descriptive statistics for accidents were presented as frequency and percentage. "Chi-Square Test" and “Fischer’s Exact test” were used for testing relationships between categorical variables.

3. Result and Discussion

59 Turkish Civil Aviation Accidents between 2003 and 2017, including fatalities or injuries, were analyzed in this study. All accidents were investigated using scientific methods, and suggested countermeasures based on the findings in the final reports were taken immediately after the accidents.

A total of 62 aircraft were involved in the accident (32 planes, seven helicopters, three gliders, 20 balloons). Two gliders in one accident and four balloons in two separate accidents occurred as mid-air collisions, and the aircrafts and balloons involved in the same accidents were analyzed in the relevant final report. Among 59 accidents, there were 32 (54.2%) plane, 7 (11.9%) helicopters, 2 (3.4%) glider, 18 (30.5%) balloon accidents. The number of deaths and injuries in 59 accidents was 309 and 298, respectively.

3.1. The Plane, Helicopter, Glider (PHG) Accidents

Of the 41 PHG accidents, distribution of accident occurrence categories, flight class and phases, fatalities, and

Table 1. Overall Accidents outcomes of Plane, Helicopter, Glider.

NO	CLASS	D	I	Occurrence Category	Flight Phase	NO	CLASS	D	I	Occurrence Category	Phase
A01[*,†,‡]	C	75	.	CFIT, NAV	Descent	**A22**[¶]	C	9	120	SCF-NP, LOC-I	Descent
A02	Gen(t)	2	.	LOC-I	Cruise	**A23**	Gen(t)	.	2	SCF-PP	Landing
A03	Gen	1	.	SCF-PP, LALT	Cruise	**A24**	Gen(t)	.	1	CTOL, RE	Landing
A04[*]	Gen	1	.	AMAN, LOC-I LALT	Cruise	**A25**	Gen	.	2	ARC	Landing
A05	Gen	1	.	LOC-I	Take-off	**A26**[¶]	Gen(t)	.	2	LOC-I	Cruise
A06	Gen	1	.	LALT	Cruise	**A27**[†,¶]	C	.	3	RE	Landing
A07	Gen	2	.	SCF-PP, LOC-I	Cruise	**A28**[*]	Gen(t)	.	1	CFIT, UIMC	Cruise
A08[¶]	C	1	1	FUEL	Descent	**A29**[*,¶]	Gen(t)	.	2	CFIT	Cruise
A09	Gen(t)	1	1	CFIT	Cruise	**A30**	Gen(t)	.	1	RE	Take-off
A10[*]	Gen	2	.	WSTRW, UIMC, LOC-I	Cruise	**A31**[¶]	Gen	.	2	RI	Taxi
A11	Gen	1	.	LOC-I	Take-off	**A32**[*,†,‡,¶]	C	37	36	USOS	Landing
A12[§]	Gen	2	.	AMAN, SCF-NP	Cruise	**H-1**[*,¶]	C	1	2	CFIT, UIMC	Cruise
A13[§,¶]	Gen(t)	2	.	SCF-PP, LOC-I	Descent	**H-2**[¶]	C	1	2	CTOL	Take-off
A14	Gen	1	.	SCF-NP, LOC-I	Take-off	**H-3**[*]	C	2	.	ICE	Cruise
A15[¶]	Gen(t)	1	1	CFIT	Cruise	**H-4**[§]	Gen	5	.	SCF-PP	Cruise
A16	Gen(t)	2	.	SCF-PP, FUEL	Take-off	**H-5**[¶]	Gen	2	.	SCF-PP	Take-off
A17[†,¶]	C	57	.	CFIT, NAV	Cruise	**H-6**[*]	C	.	1	LOC-I, TURB	Landing
A18[*,†,¶]	C	75	5	USOS	Landing	**H-7**[*,¶]	C	6	.	CFIT, UIMC	Cruise
A19	Gen	1	1	LOC-I, LALT	Landing	**G-1**[¶]	Gen(t)	2	.	MAC	Cruise
A20	Gen(t)	2	.	LOC-I	Take-off	**G-2**[§,¶]	Gen(t)	2	.	LOC-I	Landing
A21[*]	Gen	2	.	CFIT, UIMC	Cruise						

D: Deaths, I: Injuries
H: Helicopter, G: Glider, C: Commercial Aviation, Gen: General Aviation, Gen(t): General Aviation – Training Flight
CFIT: Controlled Flight Into or Toward Terrain, NAV: Navigation Errors, LOC-I: Loss of Control-Inflight, SCF-PP: System/Component Failure Or Malfunction (Powerplant), LALT: Low Altitude Operations, SCF-NP: System/Component Failure Or Malfunction (Non-Powerplant), USOS: Undershoot / Overshoot, AMAN: Abrupt Maneuver, FUEL: Fuel Related, WSTRW: Wind Shear or Thunderstorm, UIMC: Unintended Flight in IMC, CTOL: Collision with Obstacle(s) During Take-off and Landing, RE: Runway Excursion, RI: Runway Incursion, ARC: Abnormal Runway Contact, ICE: Icing, TURB: Turbulence Encounter, MAC: Midair Collisions
** Meteorology is a contributing factor, † Occurred During Dark Hours, ‡ Dysrhythmia or Fatigue, § Intoxication, ¶ CRM.*

injuries, were presented in Table 1. Twenty-nine of PHG accidents (70.7%) were general aviation accidents and 12 (29.3%) of PHG accidents were commercial aviation accidents and 12 (37.5%) of 32 plane accidents and 2 (100%) of 2 glider crashes were in training flights. There were no training flights among helicopter accidents (Table 1).

3.2. Balloon Accidents

Table 2 presented the causes of balloon accidents, death and injury statistics, and flight phases of the accidents. All balloon flights were commercial flights, and there were no training flights among balloon accidents.

3.3. HFACS classification

The frequency and percentages of HFACS in all subcategories of the accidents are summarized in Table 3. When the accidents were grouped according to aircraft categories and compared between aircraft groups, the rate of HFACS Level-1 findings detected in PG accidents (n=32, 94.1%), were higher than helicopter accidents (n=5, 71.4%) and balloon accidents (n=12, 66.7%) and the difference was statistically significant (Chi-Square Test; p=0.029). The rates of HFACS Level-2 findings were similar in both aircraft (PG, n=32, 94.1%; helicopters, n=7, 100% and balloons, n=18, 100%), and the differences between aircraft categories were not statistically significant (Chi-Square Test; p=0.467). Rate of HFACS Level-3 findings detected in helicopters (n=7, 100%) and balloons (n=17, 94.4%), were higher than PG (n=25, 73.5%) but the difference was not statistically significant (Chi-Square Test; p =0.071). HFACS Level-4 findings detected in PG (n=21, 61.8%) and balloons (n=15, 83.3%), were higher than helicopters (n=3, 42.9%) but the difference was not statistically significant (Chi-Square Test; p =0.113).

3.4. Meteorological Events

Meteorology contributed to 29.2% of the PHG accidents (Table 1). It was determined that the accident occurred due to Unintended Flight into the IMC (Instrument Meteorological Conditions) in 12.1% (n=5) of the PHG accidents. In 14 (77.7%) balloon accidents, meteorology was one of the contributing factors (Table 2). When the accidents were grouped according to aircraft categories, the effects of meteorological factors were found to be higher in balloons (n=14, 77.7%) and helicopters (n=4, 57.1%) compared to PG (n=8, 23.5%), and the difference was statistically significant (Chi-Square Test; p=0.001).

3.5. Night Flight

5 (12.1%) of PHG accidents occurred between sunset and sunrise (Table 1). In the night flight accidents, 244 people died, and 44 were injured. Statistical analysis of the effects of

darkness was compared between helicopter and plane crashes, as balloon and glider flights were performed only between sunrise and sunset. The effects of darkness were found to be higher on planes (n=5, 15.6%) compared to helicopters (n=0, 0%), but the difference was not statistically significant (Fischer's Exact Test; p=0.56)

3.6. Biorhythm Disruptions (Dysrhythmia) or Fatigue

In 2 (4.8%) PHG accidents, dysrhythmia or fatigue affected the accidents (Table 1). Fatigue or dysrhythmia was not found in helicopter and balloon accidents. The effects of dysrhythmia and fatigue were found to be higher in PG (n=2, 5.9%), compared to balloons (n=0, 0%) and helicopters (n=0, 0%), but the difference was not statistically significant (Chi-Square Test; p=0.47).

3.7. Aircrew Intoxication

Intoxication was a factor in 4 (9.7%) of 41 PHG accidents. Alcohol (46 mg/dl, 15mg/dl) use was detected in 2 (4.8%) plane accidents, and psychoactive substance use was detected in 1 (2.4%) glider accident as a contributing factor. In 1 (2.4%) helicopter firefighting flight, carbon monoxide (CO) intoxication is considered to have contributed to the accident (Table 1). No intoxication was found among balloon accidents. The effects of intoxication were found to be higher in helicopters (n=1, 14.3%) and PG (n=3, 8.8%) compared to balloons (n=0, 0%), but the difference was not statistically significant (Chi-Square Test; p=0.34).

3.8. Crew Resource Management (CRM)

CRM was found as one of the causal factors in 41.4% (n=17) of 41 PHG accidents (Table 1). CRM was found as one of the causal factors in 61.1% (n=11) of the balloon accidents (Table 2). CRM effects were found to be higher in balloons (n=11, 61.1%) and helicopters (n=4, 57.1%) than PG (n=13, 38.2%), but the difference was not statistically significant (Chi-Square Test; p= 0.25).

Table 2. Overall Causal Factors and Flight Phases of Balloon Accidents.

No	D	I	Cause of Accident	Phase of Flight
*1**,†	1	10	Air collision	Cruise
*2**,†	.	1	Contact with a power line	Landing
*3**,†	.	1	Hard landing	Landing
4†	.	2	Hard landing	Landing
*5**	.	7	Hard landing	Landing
*6**,†	.	3	Contact with a base station	Descent
7†	.	12	Hard landing	Landing
*8**,†	.	18	Fire after hard landing	Landing
*9**,†	.	3	Hard landing	Landing
*10**,†	.	3	Contact with a power line	Cruise
*11**,†	1	7	Hard landing	Landing
*12**,†	1	1	Hard landing	Landing
*13**	3	22	Air collision	Cruise
*14**	1	7	Contact with a power line	Cruise
*15**	1	.	Hard landing	Landing
16	1	.	Falling from the basket (Ground personnel)	Landing
*17**	.	9	Hard landing	Landing
18	.	6	Hard landing	Landing

D: Deaths, I: Injuries
***** *Meteorology is a contributing factor, † CRM is a contributing factor.*

3.9. Loss of Situational Awareness (LSA)

LSA was a contributing factor in 16 (39.0%) of 41 PHG accidents (Table 4). 14 (87.5%) were plane accidents and 2 (12.5%) were helicopter accidents (Fischer's Exact Test; p=0.685). 9 (56.25%) of the LSA accidents were commercial, and 7 (43.75%) were general aviation accidents (Fischer's Exact Test; p=0.004). 4 (25.0%) of LSA accidents were training flight accidents (Fisher's Exact Test; p=0.501). 5 (31.3%) of the accidents, including LSA, occurred in night-time (Fischer's Exact Test; p=0.006).

3.10. Spatial Disorientation (SD)

Spatial Disorientation (SD) was found as one of the causal factors affecting the accident in 4 (9.7%) of 41 accidents (Table 4). There were three plane and one helicopter accidents (Fischer's Exact Test; p=0.563). 2 (50%) of them were training flight accidents (Fisher's Exact Test; p=0.573). 1 (25%) was commercial, and 3 (75%) were general aviation accidents (Fischer's Exact Test; p=1.0). Meteorology was the causal factor in 4 (100%) SD accidents (Fischer's Exact Test; p=0.033). All the SD accidents (100%) occurred during daylight hours (Fischer’s Exact Test; p=1.0).

3.11. Engine Malfunctions and Non-Engine System Malfunctions

In 10 (39.0%) of the 39 PH accidents, engine malfunctions and/or non-motor system malfunctions were determined as one of the causal factors (Table-1). Engine malfunctions and/or non-engine system malfunctions were detected in 25% (n=8) of planes and 28.6% (n=2) in helicopters, but the difference was not statistically significant (Fischer's Exact Test; p=1.0).

In our study, it was seen that the first two levels of HFACS were more dominant in the PHG accidents. Li et al. (2008) reported similar HFACS distribution (85.4% Level-1, 82.9% Level-2, 75.6% Level 3, 68.3% Level-4) in 41 civil aircraft accidents and this might be since the findings at first two levels can be obtained more easily in accident investigations. In the Kilic’s (2020) study, Level-1 (51.1%), Level-2 (44.61%), Level-3 (1.94%), Level-4 (%) 2.30) were reported in balloon accidents. It was seen that our results were higher than Kilic’s study, especially in level 3 and level 4 rates. The differences might occur since our study included balloon accidents in Turkey with all contributing factors, while Kilic’s study was conducted on US balloon accidents with only probable cause. It was also considered that especially with a detailed assessment of the 3rd and 4th level findings in the final accident reports to prevent balloon accidents, might lead to these high rates of level -3 and level -4 findings in our study.

Most fatal civil aviation accidents (94%) were general aviation accidents (Boyd and Hinkelbein 2017). Similarly, in our study, the plane, helicopter, and glider (PHG) accidents mainly occurred in general aviation (70.7%).

According to the literature, environmental factors, especially meteorology, seem effective in aviation accidents. Capobianco and Lee (2001) reported that meteorology was a factor in 27% of fatal general aviation accidents. Hasham et al. (2004) stated that adverse weather conditions were detected in a significant part of the balloon accidents. In the study of Goh and Wiegmann (2001), approximately 19% fatality rate was found in other types of general aviation accidents, while this rate was reported to be approximately 80% in VFR flight into IMC accidents. In our study, five accidents were VFR flights into IMC, and 4 (80%) of these accidents were fatal. In our study, following the literature, meteorology contributed 29.2% of PHG accidents, while 77.7% of the balloon accidents.

Although only 11% of aviation accidents occurred during dark times, these accidents were mainly fatal (Capobianco and Lee, 2001). The rate of fatigue has been reported to be at least 4-8% in aviation accidents (Caldwell, 2005). Kilic and Gumus's study (2020) showed that 63,33% of the nighttime accidents and incidents are associated with physical environment (such as severe turbulence, clear air turbulence, and wake turbulence). Our study determined that 12.1% of PHG accidents occurred during dark hours, and circadian dysrhythmia or fatigue affected the accident in 4.8% of the accidents. Pilots need to learn about bad weather, darkness, and physiological vision restrictions in reducing accidents.

Table 3. Frequency and Percentages of HFACS Categories for All Accidents.

	Plane, Helicopter, Glider Accidents						**Balloon Accidents**	
HFACS Category	All PHG Accidents (**N=41**)		General Aviation (**N=29**)		Commercial Aviation (**N=12**)		Balloon (**N=18**)	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Level-1 Unsafe Acts	**37**	**90.2**	**25**	**86.2**	**12**	**100**	**12**	**66.7**
Skill-Based Error	23	56.0	15	51.7	8	66.6	8	44.4
Perceptual Error	11	26.8	6	20.6	5	41.6	-	-
Decision Error	18	43.9	11	37.9	7	58.3	4	22.2
Routine Violations	31	75.6	20	68.9	11	91.6	7	38.8
Exceptional Violations	21	51.2	13	44.8	8	66.6	7	38.8
Level-2 Preconditions for Unsafe Acts	**39**	**95.1**	**27**	**93.1**	**12**	**100**	**18**	**100**
Physical Environment	24	58.5	13	44.8	11	91.6	15	83.3
Technological Environment	3	7.3	-	-	3	25.0	1	5.5
Adverse Mental States	21	51.2	12	41.3	9	75.0	2	11.1
Adverse Physiological States	6	14.6	4	13.7	2	16.6	-	-
Physical/Mental Limitations	17	41.4	11	37.9	6	50.0	-	-
Crew Resource Management	17	41.4	8	27.5	9	75.0	11	61.1
Personal Readiness	14	34.1	8	27.5	6	50.0	7	38.8
Level-3 Unsafe Supervision	**32**	**78.0**	**21**	**72.4**	**11**	**91.6**	**17**	**94.4**
Inadequate Supervision	22	53.6	12	41.3	10	83.3	16	88.8
Planned inappropriate operations	5	12.1	1	3.4	4	33.3	2	11.1
Failed to correct a known problem	6	14.6	5	17.2	1	8.3	-	-
Supervisory violation	9	21.9	8	27.5	1	8.3	2	11.1
Level-4 Organizational Influences	**24**	**58.5**	**14**	**48.2**	**10**	**83.3**	**15**	**83.3**
Resource management	7	17.0	2	6.8	5	41.6	10	55.5
Organizational climate	4	9.7	1	3.4	3	25.0	-	-
Organizational process	22	53.6	13	44.8	9	75.0	12	66.6

Since more than one causal factor was found to be associated in each accident, the sum of the rates within the same main group is not equal to 100%.

A comprehensive study in the USA found a history of driving-while-intoxicated (DWI) in 3.4% of the pilots, and a history of DWI was associated with a 43% increase in accident risk (Li et al., 2005). Another study conducted in the USA between 2000 and 2008 found that 10.6% of pilots involved in a fatal accident and had a previous history of alcohol or substance use had consumed alcohol before the accident (Botch and Johnson, 2009). Canfield et al. (2012) reported that alcohol above the limits was detected in 7% of the samples taken from pilots who lost their lives in civil aviation accidents between 2004 and 2008. In Mitchell and Lilywhite's (2013) study, 31 medical-related accidents were detected, and the majority (n=24, 77%) were psychiatric causes, including illicit/psychoactive substance or alcohol use. In our study, intoxication was a factor in 9.7% of 41 PHG accidents. Alcohol consumption was detected in 2 (4.8%) plane accidents, and psychoactive substance use was detected in 1 (2.4%) glider accidents. In aviation, carbon monoxide (CO) exposure can be in the form of a fire in the cockpit, mixing the exhaust into the cabin ventilation system, and causes intoxication (Dehart and Davis, 2002). Busch (2015) stated that CO exposure can cause clinical symptoms in rescue helicopter pilots. In our study, CO intoxication contributed to 1 (2.4%) firefighter helicopter accidents.

Crew Resource Management (CRM) is one of the prominent factors in PHG accidents. Li et al. (2008) found the effect of CRM to be 68.3% in their study. The CRM rate in accidents in Australia was found as 5.3% by Lenne et al. (2008) and it has been reported that it is mainly associated with violations, and its relationship with the upper levels in the HFACS could not be established. CRM was a factor in 41.4% of all accidents in our study.

Loss of Situational Awareness (LSA) and Spatial Disorientation (SD) have been significant problems for aviation safety. In Kirkham et al. (1978) study, it was reported that SD was detected in 2.5% of general aviation accidents, these accidents resulted in 90% fatalities. It is reported that 90-100% of pilots experience SD once in their career, and 6-32% result in an accident (Newman, 2007). Newman and Rupert (2020) reported the rate of SD as a primary cause or contributing factor in 549 Loss of Control accidents as 17.1% and stated that the annual number of SD accidents is increasing, and current pilot training may not be sufficient to prevent SD. SD-specific simulators in SD training help pilots better understand SD and perform escape maneuvers more effective (Gibb et al., 2011). In our study, it has been determined that LSA and SD were factors in 39% and 9.7% of PHG accidents, respectively, and these accidents have quite devastating results (268 deaths, 173 injuries in 16 LSA accidents and 8 deaths, 3 injuries in 4 SD accidents). Flight experience and adequate training are needed to prevent SD and LSA accidents. SD practical training is given periodically to military pilots as an effective countermeasure. For these reasons, we strongly recommend that incorporating SD practical training in the flight training of civilian pilots would be very beneficial as a countermeasure against SD accidents.

Engine malfunctions and/or aircraft system malfunctions other than engine faults were rare in aviation accidents. The rate of malfunction-related accidents in the NTSB data was reported as 14.3% in aircraft manufactured between 1970-1984, and the rate decreased to 12.2% in aircraft manufactured between 2000 and 2014 (Boyd and Hinkelbein, 2017). Głowacki and Balicki (2017) found that engine and/or non-engine system malfunctions were 40.6% for airplanes with a maximum take-off weight (MTOW) lower than 5700 kg, while 30.6% for airplanes with MTOW higher than 5700kg. In our study, following the literature, engine and/or non-engine system malfunctions were determined as contributing factors in 39% of the PH accidents.

Table 4. Overall Causes and Factors of SD and LSA Accidents

No	Class	D	I	Occurrence Category	Phase
A01†,‡	C	75	.	CFIT, NAV	Descent
A08	C	1	1	FUEL	Descent
A09	Gen(t)	1	1	CFIT	Cruise
A10*,†	Gen	2	.	WSTRW, UIMC, LOC-I	Cruise
A15	Gen(t)	1	1	CFIT	Cruise
A17‡	C	57	.	CFIT, NAV	Cruise
A18†,‡	C	75	5	USOS	Landing
A19	Gen	1	1	LOC-I, LALT	Landing
A21†	Gen	2	.	CFIT, UIMC	Cruise
A22	C	9	120	SCF-NP, LOC-I	Descent
A27‡	C	.	3	RE	Landing
A28*,†	Gen(t)	.	1	CFIT, UIMC	Cruise
A29*,†	Gen(t)	.	2	CFIT	Cruise
A32†,‡	C	37	36	USOS	Landing
H1†	C	1	2	CFIT, UIMC	Cruise
H7*,†	C	6	.	CFIT, UIMC	Cruise

D: Deaths, I: Injuries
H: Helicopter, C: Commercial Aviation, Gen: General Aviation, Gen(t): General Aviation – Training Flight
*CFIT: Controlled Flight into or Toward Terrain, NAV: Navigation Errors, LOC-I: Loss of Control-Inflight, LALT: Low Altitude Operations, SCF-NP: System/Component Failure or Malfunction (Non-Powerplant), USOS: Undershoot / Overshoot, FUEL: Fuel Related, WSTRW: Windshear or Thunderstorm, UIMC: Unintended Flight in IMC, RE: Runway Excursion, *Accidents Involving Spatial Disorientation, † Meteorology is a contributing factor, ‡Occurred During Dark Hours.*

4. Conclusion

This is the first study using official final accident reports analyzing "Turkish Civil Aviation Accidents" with the authors' best knowledge. This study showed that human factors still have a significant rate in civil aviation accidents. We think that academic training like CRM, LSA, SD, fatigue in aviation, aviation meteorology, etc., should be given more frequently to the aviators to prevent aviation accidents. In addition, it is considered that integrating Spatial Disorientation, Hypoxia, and Night Vision practical training, which are given periodically to military aircrews in many countries, into the civilian flight training and integrating HFACS factors into the "Aviation Safety Management System" might help to reduce aviation accidents' rates.

Ethical approval

Permission was obtained from the Republic of Turkey Ministry of Transport and Infrastructure to analyze the accident investigation reports. Each stage of the research was carried out based on the Declaration of Helsinki, and the University of Health Sciences Turkey, Gulhane Ethics Board approved the study (2019: 19/360).

Conflicts of Interest

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

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The Evolution of the Low-Cost Carriers in Australia's International Air Freight Market

Glenn Baxter[1*]

[1*] School of Tourism and Hospitality Management, Suan Dusit University, Huahin Prachaup Khiri Khan, Thailand, 77110. (g_glennbax@dusit.ac.th).

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Abstract

This study examines the development of the low-cost carriers (LCCs) in Australia's export and import air freight markets. The study period is from 2004 to 2020. The study used a qualitative instrumental case study research approach. The data gathered for the study was examined by document analysis. The study found that the development of the low-cost carriers (LCCs) share of Australia's annual export and import air freight markets occurred in three distinct phases. In the initial phase, 2004-2005, the market was served by just one low-cost carrier (LCC) Pacific Blue Airlines, who did not transport any export or import air freight in 2004. In 2005, the airline made a strategic policy decision to transport air freight. Phase 2 saw the inception of international services by Jetstar Airways in 2006. Jetstar Airways immediately gained import and export air freight traffic. The third phase took place from 2007 to 2020, when the major Asia-based low-cost carriers entered the market, starting with AirAsia-X in 2007. The low-cost carriers (LCCs) annual air freight market growth rates oscillated substantially over the study period, particularly for export air freight traffic. Despite the strong growth, the low-cost carriers (LCCs) annual market export and import air freight shares are considerably lower than those of the dedicated all-cargo carriers and full-service networks carriers (FSNCs).

1. Introduction

One of the most ubiquitous trends in the world airline industry over the past three decades or so has been the rapid growth of the low-cost carriers (LCCs). The low-cost carriers are defined as carriers which, via a variety of operational processes, achieve cost advantages over full-service network carriers (FSNCs) and pass these cost advantages to consumers through lower air fares (Schlumberger & Weisskopf, 2014). The low-cost carriers (LCCs) are often viewed as one of the most successful business concepts that have happened within contemporary travel. The astute business model of these airlines by offering significantly lower prices through the elimination all the in-flight extras together with their strict focus on cost-control has enabled them to capture significant market share (Voigt, Buliga &Michl, 2017).

The low-cost carriers (LCC) business model has evolved in more recent times with several low-cost carriers (LCCs) now operating long-haul, scheduled, no frill services (Albers et al., 2020; De Poret, O'Connell &Warnock-Smith, 2015; Martín Rodríguez & O'Connell, 2018; Soyk, Ringbeck, & Spinler, 2017; Whyte & Lohmann, 2015). The low-cost carriers (LCC's) have also introduced regional services in recent times as well (Schofield, 2015). This has led to the development of Indonesia-based Indonesia Air Asia-X, Malaysia-based AirAsia-X, Philippines-based Cebu Pacific Air, Thailand-based Thai AirAsia-X, Singapore-based Scoot Tigerair, and the long-haul unit of Jetstar Airways, which is based in Melbourne, Australia. These three airlines all operate wide-body aircraft in contrast to the traditional low-cost carriers (LCC) carriers' reliance on narrow-body aircraft (Cowie, 2010).

Typically, the low-cost carriers (LCCs) did not tend to transport air freight (Bubalo, 2014). This was because a key element of the low-cost carriers (LCCs) business model is on tight flight schedules and rapid aircraft turnaround times (Air Cargo News, 2012). However, like the full-service network carriers (FSNCs), the low-cost carriers (LCCs) are now viewing the carriage of air freight as an important revenue stream and, as such, have introduced air freight services on their long-haul flights. Air Asia-X, Cebu Pacific Airlines, and Jetstar Airways, for example, all offer air freight products on their long-haul services. Air freight is defined as "anything carried in an aircraft except for mail or luggage carried under a passenger ticket and baggage check but including baggage shipped under an airway bill or shipment record" (Hui, Hui & Zhang, 2004).

The objective of this study is to examine the development of the low-cost carriers (LCCs) in Australia's export and import air freight markets. A secondary objective is to identify the low-cost carriers (LCCs) annual export and import air freight traffic growth rates vis-à-vis their competitors, the full-service network airlines (FSNCs), and the dedicated all-cargo carriers. A further objective is to identify the most prominent low-cost carriers (LCCs) competing in Australia's export and import air freight markets as measured by market-share. A final objective is to examine the annual export and import air freight market share of the low-cost carriers (LCCs) vis-à-vis their competitors, the full-service network airlines (FSNCs), and the dedicated all-cargo carriers. The study period is from 2004 to 2020. The first low-cost carrier (LCC) to transport air freight in Australia's international air freight market was Pacific Blue Airlines, who entered Australia's air freight market in 2004.

The paper is organized as follows: the literature review is presented in Section 2. This is followed by an overview of the research methodology that underpinned in the study in Section 3. The case study is presented in Section 4. The findings and conclusions of the study are presented in Section 5.

2. Background

2.1. Air freight as a strategic option for the low-cost carriers

Historically, the low-cost carriers (LCCs) were not normally associated with the carriage of air freight (Air Cargo News, 2012), as their primary focus was on passenger transportation. Indeed, air freight is often an afterthought for low-cost carriers (LCCs). Whilst air freight is regarded as an important revenue source for most full-service network airlines (FSNCs) it has generally not been viewed as a core component of the low-cost carriers (LCC) business model. Some low-cost carriers (LCCs) have a policy of not carrying air freight at all, as they are concerned that it would increase aircraft turnaround times and costs, thus, outweighing any revenue gains (Centre for Aviation, 2018a). In recent times, however, some low-cost air carriers (LCCs) have increasingly focused on the carriage of air freight to take advantage of available capacity in their passenger aircraft (Air Cargo World. 2013a).

The air freight product is offered by combination carriers, both full-service network airlines (FSNCs) and low-cost carriers (LCCs), to produce additional revenue on flights that are already scheduled passenger services (McKnight, 2010). Combination airlines principally offer point-to-point (airport-to-airport) services on a wholesale basis, relying on international freight forwarders for pick-up and delivery, sales to shippers, and customer service (Doganis, 2019). In contrast, the integrated carriers, DHL Express, FedEx, and United Parcel Service (UPS) are shipping carriers that control the complete air and road delivery networks and these firms offer an extensive range of package delivery services (Malighetti et al., 2019).

2.2. Passenger aircraft belly-hold air freight capacity

In the global air cargo industry, air freight is transported by combination airlines, dedicated all-cargo carriers, and the integrators, DHL Express, FedEx and United Parcel Service (UPS) (Baxter & Wild, 2021; Dresner & Zou, 2017; Merkert & Alexander, 2018). Air freight capacity in a combination airline service is an economy of scope by-product arising from the supply of passenger services. This is because for most passenger airlines, both passenger and air freight services are combined, and thus, are jointly produced (Doganis, 2019; Wensveen, 2016). This arrangement, in which passengers are carried on the aircraft's main passenger deck, and air freight is carried below in the lower lobe "belly hold" compartments, is referred to as a combination aircraft (Dempsey & Gesell, 1997). It is important to note that the design of passenger aircraft is dictated by passenger requirements. As a result, the space for air freight is what is left over in the otherwise unusable space below the main passenger deck of the aircraft that is not required for the stowage of passengers' luggage. This space exists simply due to the aerodynamic requirements for a tubular shape for the aircraft fuselage (Tretheway & Andriulaitis, 2016).

Combination airlines air cargo capacity may come in the form of narrow bodied, single-aisle aircraft, such as, the Airbus A320 aircraft, or wide-bodied, twin aisle aircraft, such as the Airbus A350-900 aircraft (Baxter, 2015a). Other wide-bodied aircraft include the Boeing B787-9/-10, 777-300ER and 747-8 aircraft as well as the Airbus A330, A350 and A380 aircraft (Morrell & Klein, 2019).

The lower deck belly hold air freight capacity on a passenger aircraft is determined by the available payload and volume of space available once passengers and their luggage have been taken into consideration (Aircraft Commerce, 2015; Billings, Diener & Yuen, 2003; Morrell & Klein, 2019). In a typical combination airline's operation, the aircraft's operating costs are normally covered by passenger revenue. Air freight revenue is only required to cover incremental costs, including fuel, cargo handling, marketing, and warehousing. The carriage of air freight provides an opportunity for an airline to earn revenue by filling lower deck belly hold space that would otherwise fly empty (Aircraft Commerce, 2015).

2.3 Combination airline passenger and freighter airline aircraft route networks

Line-haul operators transport air freight traffic on an airport-to-airport basis and as previously noted, are typically dependent upon international air freight forwarders, who deal directly with shippers. Line haul operators offer both scheduled and unscheduled all-freight services. All-cargo airlines offer high reliability and have the capability to transport large volumes of air freight traffic over long distances. For the combination passenger airlines, air freight operations are often comprised of long-haul services, with large volumes of air freight being transferred onto shorter haul feeder services. (Reynolds-Feighan, 2001). Some combination airlines also operate freighter aircraft in addition to their passenger services (Cook & Billig, 2017; Dresner & Zou, 2017).

As shippers' expectations regarding the speed of moving their products within their supply chains, reliability and timeliness of air transport has increased significantly, so too has the attraction for the operations of dedicated freighter aircraft. The larger capacities of dedicated freighter aircraft are also an increasingly important advantage as major firms often need to ship large consignments, which in many cases is at short notice. As freighter fleets have expanded, the ability of airlines to schedule higher frequencies services has further strengthened the attraction for freighter operations. Higher freighter frequencies are critical as they permit manufacturers to more tightly time larger consignments to fit in neatly meshed production networks (Bowen, 2004).

Inter-continental freighter routes are designed to link up the major centres of world trade. Such networks consist of long-haul flights to and from the airline's major hub airport, where long-haul shipments are often broken down and uplifted on subsequent flights to their final destinations. The major types of freighter aircraft operated on long-haul inter-continental routes are the Boeing B777-200LRF, B747-400F B747-8F and MD11 aircraft (Baxter, 2015b). The Airbus A330 and Boeing B767-300F freighter aircraft are also extensively used in the air cargo industry (Aircraft Commerce, 2016, 2017). Regional freighter routes are designed to link up the airline's major hub airport with important centres of regional trade. Air cargo is sourced from these markets and transported back to the airline's hub airport for subsequent loading onto to the airline's long-haul inter-continental services (Baxter, 2015b).

2.4. Low-Cost carrier competition for air freight market share

The global air freight market is highly competitive and is characterized by the presence of a large number of international and regional players (Saunders, 2020). Air freight provides a competitive alternative to surface-based transport modes (road, rail and ocean) in satisfying shippers requirements in terms of speed, service quality (lower damage to packaging), and cost (Abeyratne, 2018; Doganis, 2019; Shaw, 2016). Thus, in the air freight market, the combination airlines, dedicated all-cargo carriers, and the integrators compete for market share based on price, service offering, speed to destination, and the provision of suitable air freight capacity to satisfy shippers supply chain and logistics requirements.

3. Research Methodology

3.1. Research method

With the aim of examining the development of the long-haul, low-cost carriers (LCCs) in Australia's international air freight market, a qualitative research approach was used. The study of the development of long-haul, low-cost carriers' (LCCs) transportation of air freight is an emergent area of study. Thus, the most appropriate research method for such an emerging area is a qualitative method (Edmondson & McManus, 2007). A case study approach was therefore used in this study as this research approach allows for the exploration of complex phenomena (Cua & Garrett, 2009; Remenyi et al., 2010; Yin, 2018) and permits researchers to build theory and connect with practice (Ridder, 2016; Simons, 2009).

A qualitative instrumental case study research approach was used in the present study. An instrumental case study is the study of a case, for example, a firm or firms, that provides insights into a specific issue, redraws generalizations, or builds theory (Stake, 1995, 2005). The instrumental case study research approach provides an understanding of a specific phenomenon and is designed around established theory (Grandy, 2010). The present study was designed around the established long-haul, low-cost carriers' (LCCs) business model (Albers et al., 2020; Francis et al., 2007; Renehan & Efthymioun, 2019; Wensveen & Leick, 2009) and air freight management and operations (Doganis, 2009; Dresner & Zou, 2017; Morrell & Klein, 2019; Sales, 2013, 2016, 2017).

3.2. Data collection

The data gathered for analysis in the study was obtained from the Bureau of Infrastructure, Transport and Regional Economics (BITRE) annual "International Airline Activity" reports. In addition, data was sourced from the long-haul, low-cost carriers' serving Australia's international air freight market materials that were available on the internet. These documents provided the sources of the study's case evidence. An extensive source of the leading air transport and air freight-related journals and magazines was also conducted. The study also included a search of the SCOPUS and Google Scholar databases.

Secondary data was therefore used in the study. The three principles of data collection as recommended by Yin (2018) were followed: the use of multiple sources of case evidence, creation of a database on the subject and the establishment of a chain of evidence.

3.3. Data analysis

Document analysis was used to examine the documents gathered for the case study. Document analysis is a research approach that is commonly used in in case studies. The primary focus of document analysis is analyzing the information and data from formal documents and company records that are collected for a study (Oates, 2006; Ramon Gil-Garcia, 2012). The documents collected for the present study were examined according to four criteria: authenticity, credibility, representativeness and meaning (Fulcher & Scott, 2011; Scott, 2014; Scott & Marshall, 2009).

The study's document analysis was conducted in six discrete phases. The first phase involved planning the types and required documentation and their availability for the study. In the second phase, the data collection involved sourcing the documents and developing and implementing a scheme for managing the gathered documents. The gathered documents were examined to assess their authenticity, credibility and to identify any potential bias in the third phase of the document analysis process. In the fourth phase, the content of the collected documents was carefully examined, and the key themes and issues were identified and recorded. The fifth phase involved the deliberation and refinement to identify any difficulties associated with the documents, reviewing sources, as well as exploring the documents content. In the sixth and final phase, the analysis of the data was completed (O'Leary, 2004).

In this study, all the collected documents were downloaded and stored in a case study database (Yin, 2018). All the documents used in the study were all written in English. Each document was carefully perused, and key themes were coded and recorded (Baxter, 2021; Baxter & Srisaeng, 2020).

4. Findings

4.1. Australia's international air freight market: A brief overview

Throughout its history, Australia has been a trading nation, and thus, the country's material wealth and prosperity is dependent on its ability to export and import its trade (Adams, Brown & Wickes, 2013; Capling, 2001). However, Australia is a relatively remote continent (Kerns, 2004), and consequently, Australian exporters and importers are reliant on the air and ocean transport modes to ship their goods in their supply chains. Air freight and ocean transport are the only two transport modes available for any trade being shipped to or from Australia (Baxter & Srisaeng, 2018; Srisaeng, Baxter & Wild, 2018). The types of commodities exported from Australia by the air freight mode typically comprise low bulk and high value, and/or time-sensitive (including perishable cargoes). The types of products imported by air freight consist primarily of high-value, high-technology manufactured goods, for example, computers and other electronic goods (Productivity Commission, 1998).

Australia's export and import air freight is principally transported in the lower deck belly holds of combination airlines passenger aircraft (both the full-service network carriers and low-cost carriers with the remaining share carried on dedicated freight services. Thus, Australian exporters and importers have access to main deck freighter capacity for their oversize consignments, with freighter services being provided by the integrators, for example FedEx and United Parcel Service (UPS) as well as by dedicated freighter operators and by some full-service network airlines (FSNCs), for example, Cathay Pacific Airways, Qantas Freight, and Singapore Airlines.

Like other air freight markets, Australia's international air freight market largely started after the conclusion of World War II. In 1949-50, there was only a small volume and proportion of Australia's annual international trade transported by air freight mode. During this market infancy period, four aviation firms, British Commonwealth Airlines, Qantas Empire Airways Ltd, British Overseas Airways Corporation, and Tasman Empire Airways transported Australia's international air freight. The primary destinations for these air freight consignments were the South Pacific Islands, Hong Kong, London, Tokyo, and Vancouver (Australian Bureau of Statistics, 2001 p. 1038). From these modest beginnings, Australia's international air freight mode has become an integral part of Australia's economy.

Figure 1 presents the annual volumes of Australia's export and import air freight traffic for the period 2004 to 2020. As can be observed in Figure 1, Australia's export and import air freight increased from 293,070.4 and 383,422.8 tonnes in 2004 to 433,508 and 461,208 tonnes in 2020, respectively. Figure 1 also shows that historically there were greater volumes of import air freight, however, in later years export air freight volumes have grown strongly and are almost equivalent to import air freight volumes.

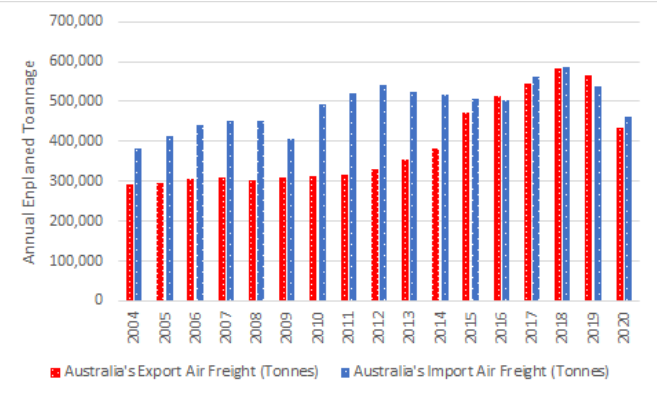

Figure 1. Australia's annual enplaned export and import air freight tonnage: 2004-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2008-2021), Bureau of Transport and Regional Economics (2005-2007).

4.2. Development of the low-cost carriers in Australia's international air freight market

The low-cost carriers (LCCs) entered Australia's international air freight market in 2004. The initial air freight services were pioneered by Pacific Blue Airlines. Figure 2 shows the development in the annual volumes of Australia's export air freight traffic from 2004 to 2020. As can be observed in Figure 2, the low-cost carriers (LCCs) export air freight market development occurred in three distinct phases. Phase 1 (2004-2006) was the initial entry of Pacific Blue Airlines. Phase 2 saw the introduction of international services by Australia-based Jetstar Airways in 2006. The third phase (2007-2020) followed the introduction of services by the major Asia-based LCCs, commencing with Air Asia-X in 2007, and since followed by the introduction of services by Cebu Pacific Air, Jetstar Asia, Indonesia Air Asia, and Scoot Tigerair. Another important development occurred in 2010, when Pacific Blue was rebranded as Virgin Australia, and Pacific Blue Airlines airline's business model evolved from a low-cost carrier (LCC) to a full-service network model (FSNC) (Srisaeng, Baxter & Wild, 2014 Whyte, Prideaux & Sakata, 2012).

Figure 2 shows that despite the entry to the market in 2004, Pacific Blue did not transport any air freight in its first year of operation. Also, as can be observed in Figure 2, there were two pronounced spikes in the low-cost carriers (LCC's) export air freight carriage in 2006 (+626.24%) and 2007 (+404.17%), respectively. These large spikes can be attributed to the success that Jetstar Airways enjoyed in capturing market share in 2006 and 2007, as well as the entry into the market by AirAsia-X in 2007. Figure 2 shows that the low-cost carriers (LCC's) largest annual share of Australia's export air freight occurred in 2017, when the LCCs carried 20,404.7 tonnes of export air freight traffic from Australia. Over the study period, the low-cost carriers (LCCs) annual export air freight tonnages have predominantly displayed an upward trend. This is demonstrated by the year-on-year percentage change line graph, which is more positive than negative, that is, more values are above the line than below. Figure 2 also shows that was the only three years during the study period when the low-cost carriers (LCCs) annual export air freight tonnage declined on a year-on-year basis. In 2013, the LCCs annual enplaned export air freight tonnage decreased by 18.15% on the 2012 levels (Figure 2). Australia's annual export air freight market grew in 2013, with the full-service network airlines (FSNCs) and the dedicated all cargo carriers increasing their enplaned tonnage in that year. In 2017, the low-cost carriers (LCCs) annual enplaned export air freight tonnage decreased by 0.65% on the 2016 levels. Australia's annual export air freight market grew in 2017, with both the full-service network airlines (FSNCs) and the dedicated all cargo carriers increasing their enplaned tonnage in that year. In 2020, the low-cost carriers (LCCs) annual enplaned export air freight tonnage decreased by 55.85% on the 2019 levels (Figure 2). The Australian international air travel market was impacted by the corona virus pandemic in 2020 (Bureau of Infrastructure, Transport and Regional Economics, 2021). The year 2020 was unprecedented within the aviation industry. In 2020, the airline industry—at a global level—experienced a very sharp and sustained decline in air passenger demand, which had a very adverse impact on the world's airlines (Garrow, Lurkin & Marla, 2022; Xuan et al., 2021). Australia's response to the COVID-19 pandemic was rapid with the closure of international borders by the Australian Government (D'Souza & Dunshea, 2021). In Australia, travel bans, border closures, and the stay-at-home orders severely disrupted various industries including the country's aviation industry (Gao & Ren, 2020).

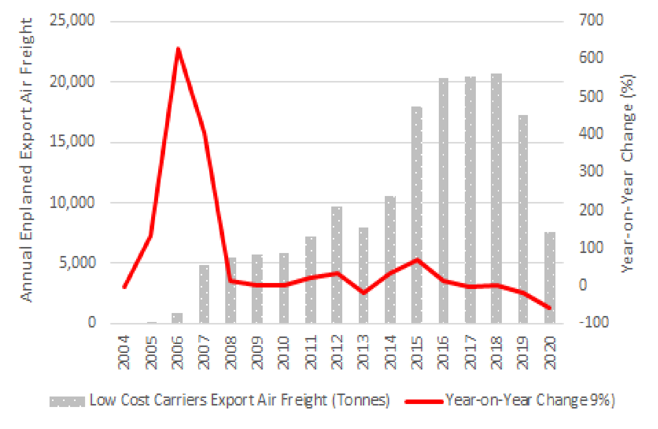

Figure 2. Low-cost carriers annual enplaned export air freight traffic and year-on-year change (%): 2004-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2008-2021), Bureau of Transport and Regional Economics (2005-2007).

The development of Australia's low-cost carriers (LCCs) import air freight enplaned tonnage for the period 2004 to 2020 is presented in Figure 3. The low-cost carriers (LCCs) annual import air freight tonnages also follow the same market development phases as that for the low-cost carriers (LCCs) annual export air freight tonnage. Figure 3 shows that there were two very pronounced spikes in the low-cost carriers (LCCs) annual import air freight tonnage recorded in 2006 (+900.0%) and 2007 (+833.5%), respectively. These spikes can be attributed to the significant volumes of import air freight carried by Jetstar Airways in 2006 and 2007. Over the study period, the low-cost carriers (LCCs) annual import air freight tonnages have predominantly displayed an upward trend. This is demonstrated by the year-on-year percentage change line graph, which is more positive than negative, that is, more values are above the line than below. The only exception to this positive growth trend occurred in 2013, 2019, and 2020, when the low-cost carriers (LCCs) annual import air freight tonnages decreased by 13.48%, 28.85% and 62.81% on the previous year's levels, respectively (Figure 3). In 2013, 2019, and 2020, Australia's annual import air freight tonnages decreased due to a lower demand for imported airborne trade.

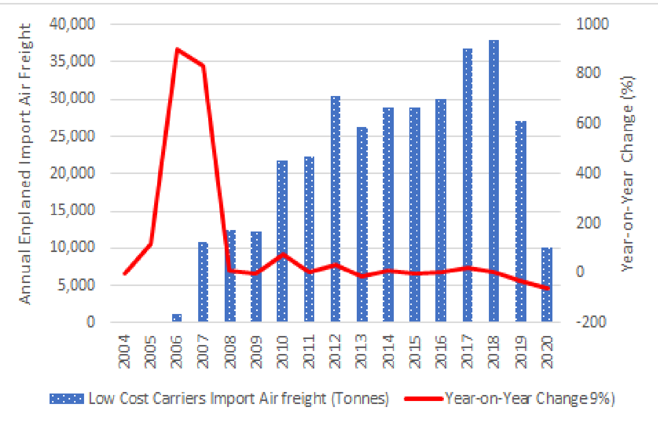

Figure 3. Low-cost carriers annual enplaned import air freight traffic and year-on-year change (%): 2004-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2008-2021), Bureau of Transport and Regional Economics (2005-2007).

4.3. The long-haul, low-cost carriers serving Australia's international air freight market

4.3.1. Air Asia-X

In 2007, Malaysia-based AirAsia established AirAsia-X as its long-haul carrier (Grant, 2013; Lee & Carter, 2012; Ribeiro de Almeida, Costa & Abrantes, 2020). Today, the airline provides services to a range of destinations located throughout the Asia-Pacific and Middle East regions, operating services on routes with sector lengths of four hours or greater. The airline also delivers 'feeder traffic' to the AirAsia Groups' various regional low-cost carriers (LCCs). AirAsia X operates a fleet of Airbus A330 widebody aircraft (Centre for Aviation, 2022). At the time of the present study, AirAsia-X had a fleet of eight Airbus A330-300 aircraft of which six were in active service (Curran, 2022). The Airbus A330-300 offers an air freight payload of around 17 tonnes (Morrell, 2011).

AirAsia-X commenced services to Australia in November 2007, when it launched services from Kuala Lumpur to the Gold Coast in Queensland. The airline expanded its Australian services in 2008 with the addition of new services to Melbourne and Perth. The airline commenced services to Sydney in April-2012 (Centre for Aviation, 2013).

AirAsia-X annual enplaned export air freight tonnage and the year-on-year change (%) from 2007 to 2020 is presented in Figure 4. Figure 4 shows that the AirAsia-X annual enplaned air freight tonnage increased from a low of 6.4 tonnes in 2007, when the airline first entered the Australian market, to 10,013.8 tonnes in 2019. It can be observed in Figure 4 that there have been two discrete phases in AirAsia-X carriage of Australian airborne export trade, with the first phase occurring between 2007 and 2009 when there were high growth rates recorded as the airline developed its export air freight product in the market. The pronounced spike in the airline's annual growth rate in 2008 (+2,648.4%) can be attributed to the airline's first full year of operations, as it only provided services for two months upon its entry to the market in 2007. There was quite rapid growth in the airline's enplaned export air freight tonnages in 2009 (+137.52%) and 2010 (+141.52%) as the airline captured greater market share following the introduction of services to Melbourne and Perth in in November 2008. The second phase in AirAsia-X carriage of Australian airborne export trade has occurred from 2010 to 2018, when the airline experienced year-on-year growth in its enplaned air freight traffic. The growth in enplaned export air freight traffic was also assisted by the addition of services to Sydney. Sydney is Australia's largest export air freight market. Thus, over the study period, AirAsia-X annual export air freight tonnages have largely displayed an upward trend. This is demonstrated by the year-on-year percentage change line graph, which is principally more positive than negative more values are above the line than below. Figure 4 shows that there were just two years in the study period where AirAsia-X annual enplaned export air freight tonnage decreased on a year-on-year basis. These decreases occurred in 2019 (-35.1%) and 2020 (-74.39%) (Figure 4). In late 2018, Air Asia-X announced that it would suspend its daily services from the Gold Coast to Auckland in early 2019 (Centre for Aviation, 2018b). These Trans-Tasman services ceased on the 9th of February 2019 (Liu, 2018). Australia's annual export air freight market also decreased by 14.16% in 2020 due to the lower demand for Australia's export airborne trade.

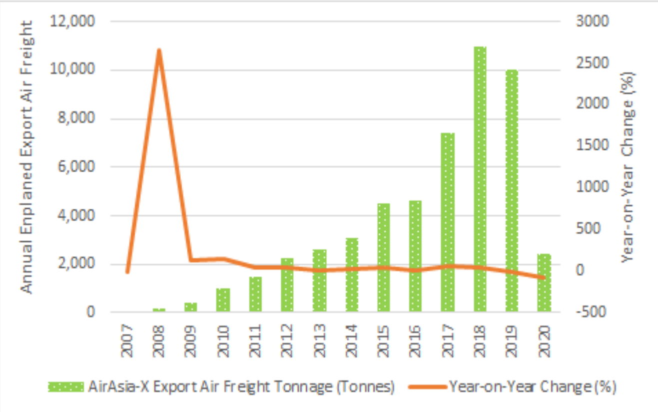

Figure 4. AirAsia-X annual enplaned export air freight traffic and year-on-year change (%): 2007-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2008-2021).

AirAsia-X annual enplaned import air freight and the year-on-year change (%) for the period 2007 to 2020 is presented in Figure 5. Figure 5 shows that AirAsia-X annual enplaned import air freight tonnages have oscillated throughout this period. There was quite rapid growth experienced in the early years of the airline's operations to Australia as the airline established itself in the marketplace. In 2005, there was a 423.15% increase in the airline's enplaned import air freight tonnage, and this was followed by quite significant increases in 2009 (+142.19%) and 2010 (+279.33%) as the airline expanded its Australian services to include both Melbourne and Perth. From 2011 to 2020, the most significant annual increase in enplaned air freight tonnage was recorded in 2016, when the airline's annual enplaned import air freight increased by 58.86% on the 2015 levels. Figure 5 also reveals that there were four years during the study period where the airline's annual enplaned import air freight declined. These occurred in 2014 (-24.13%), 2015 (-24.14%), 2019 (-35.1%), and 2020 (-74.39%), respectively (Figure 5). Australia's total annual enplaned import air freight tonnage declined on a year-on-year basis in 2014, 2015, and 2019. As previously noted, AirAsia-X withdrew from the Coolangatta to Auckland aviation market in February 2019 and this had an impact on the airline's enplaned import air freight traffic. Australia's annual import air freight market decreased by 16.03% in 2020.

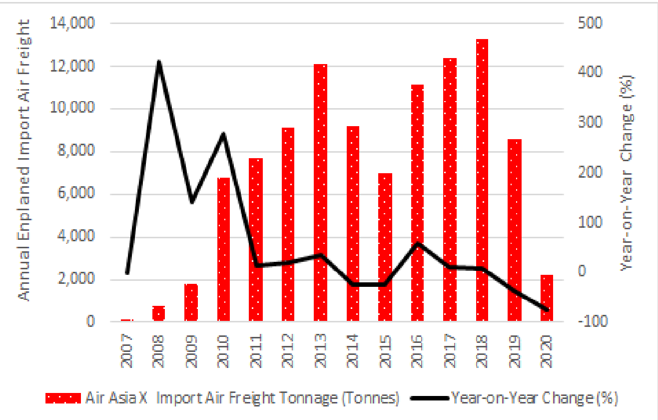

Figure 5. AirAsia-X annual enplaned import air freight traffic and year-on-year change (%): 2007-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2008-2021).

AirAsia-X annual share of Australia's export air freight market from 2007 to 2020 is depicted in Figure 6. As can be observed in Figure 6, AirAsia-X annual share of Australia's export air freight market has shown a steady upward trend increasing from a low of zero percent in 2007 to a high of 1.88% in 2018. Also, as can be seen in Figure 6, there has only been two years throughout the study period when Air Asia-X annual export market share decreased on a year-on-year basis. These decreases occurred in 2019, when the airline's annual export market share decreased from 1.88% in 2018 to 1.77% in 2019, and in 2020, when the airline's annual export air freight market share decreased from 1.77% in 2019 to 0.56% in 2020 (Figure 6).

Figure 6. AirAsia-X annual export air freight market share and year-on-year change (%): 2007-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2008-2021).

Figure 7 shows that AirAsia-X annual share of Australia's import air freight increased from a low of 0.03% in 2007 to a high of 2.31% in 2013. As can be observed in Figure 7, AirAsia-X annual import air freight market share decreased in 2014 (-22.51%) and 2015 (-22.9%). There was a pronounced spike in this metric in 2016, when it increased by 60.86% on the 2015 levels. Towards the latter years of the study period, that is, 2019 and 2020, AirAsia-X annual import air freight market share decreased on a year-on-year basis. In 2019, the airline's annual import market share decreased by 29.2%. The cessation of Trans-Tasman services was a contributory factor in this decrease. Figure 7 shows that there was a pronounced decrease in this metric in 2020, when Air Asia-X annual import air freight market share decreased by 70.0% from 1.60% in 2019 to 0.48% in 2020.

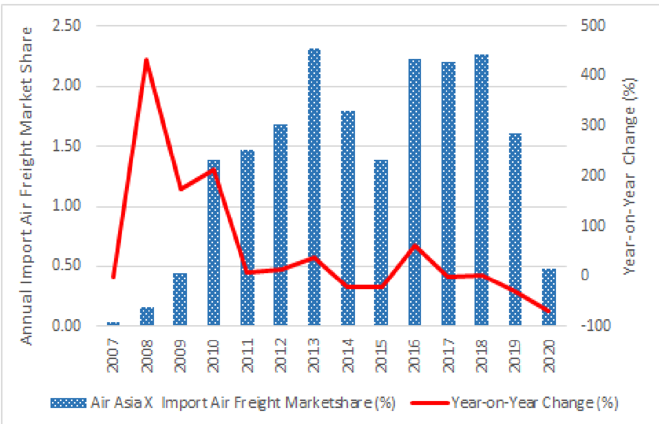

Figure 7. AirAsia-X annual import air freight market share and year-on-year change (%): 2007-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2008-2021).

4.3.2. Cebu Pacific Air

In 1991, Cebu Pacific Air received its formal permission from the Philippines Government to operate both domestic and international services. The airline commenced passenger services in 1996, with an in-augural flight between Cebu and Manila. The airline began international operations in November 2001. Cebu Pacific Air formally adopted the low-cow carrier (LCC) business model in 2005 (Mills, 2016). At the time of the present study, Cebu Pacific Air operated a fleet of Airbus A330-300 aircraft on its long-haul, low-cost services as well as on high-density domestic services. The airline received its first Airbus A330neo (New Engine Option) aircraft on November 28, 2021 (Cebu Pacific Air, 2021).

Cebu Pacific Air commenced services to Australia in September 2014, when it began a daily Airbus A330-300 service from Manila to Sydney (Australian Aviation, 2014). Cebu Pacific Air added a second Australian destination in August 2018, with the start of nonstop flights between Manila and Melbourne's Tullamarine Airport. These services are also operated with an Airbus A330-300 aircraft (Australian Aviation, 2018; International Airport Review, 2018).

Cebu Pacific Air annual enplaned export air freight tonnage and the year-on-year change (%) for the period 2014 to 2020 is presented in Figure 8. As can be observed in Figure 8, Cebu Pacific Air annual enplaned export air freight tonnage increased from 65.3 tonnes in 2014 to 3,108.8 tonnes in 2019. There was a rapid growth in the airline's enplaned export freight tonnage in 2015, when the annual volumes increased by 1239.3%. This large increase was due to the first full year of operations, so the large increase came from a low base in 2014. Another significant development occurred in 2017, when the airline's annual export air freight traffic increased by 99.29% on the 2016 levels, reflecting a greater market share by the carrier in 2017. The introduction of Melbourne services in 2018 contributed to the growth in the airline's traffic in both 2018 (+20.83%) and 2019 (+0.54%) (Figure 8). As can be observed in Figure 8, there was very pronounced decrease in the airline's enplaned export air freight traffic in 2020, when it decreased by 71.84% on the 2019 levels. As previously noted, Australia's aviation industry was adversely impacted by the Corona virus pandemic and the subsequent border closures in 2020.

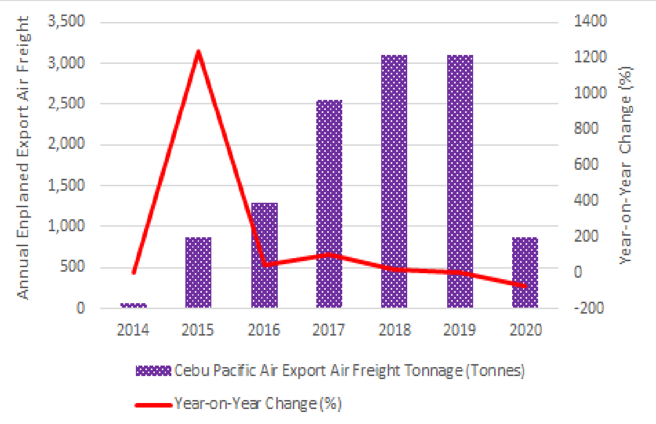

Figure 8. Cebu Pacific Air annual enplaned export air freight traffic and year-on-year change (%): 2014-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2015-2021).

Cebu Pacific Air annual enplaned import air freight tonnage and the year-on-year change (%) from 2014 to 2020 is presented in Figure 9. Figure 9 shows that since its inception of operations to Australia in 2014, Cebu Pacific Air annual enplaned import air freight has exhibited an upward growth trend, with the highest annual growth being recorded in 2015 (+529.3%). The addition of Melbourne services in 2018 contributed to a 71.42% annual growth rate in 2018 (Figure 9). Figure 9 shows that the airline's annual enplaned import air freight traffic was adversely impacted in 2020 when it decreased by 82.42% on the 2019 levels. This decrease could be attributed to the downturn in demand for aviation services as well as Australia's border closures.

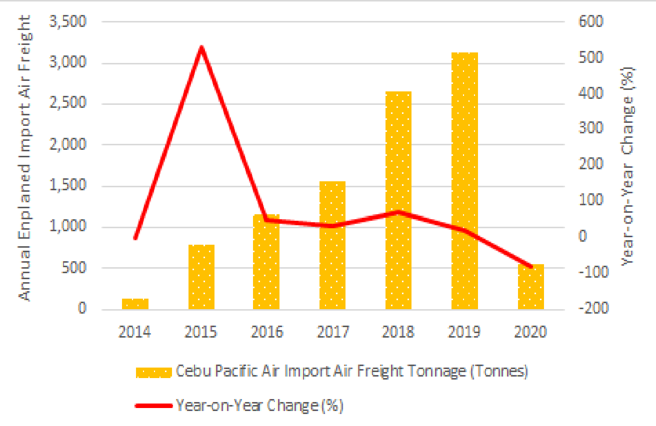

Figure 9. Cebu Pacific Air annual enplaned import air freight traffic and year-on-year change (%): 2014-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2015-2021).

Figure 10 presents Cebu Pacific Air's annual Australian export air freight market share from 2014 to 2020. As can be observed in Figure 10, the airline has steadily increased its share of Australia's export air freight market. Cebu Pacific Air's annual export market share increased from 0.03% in 2014 to a high of 0.55% in 2019 (Figure 10). Figure 10 shows that the airline's annual export air freight market share decreased by 63.63% in 2020 from 0.55% in 2019 to 0.20% in 2020.

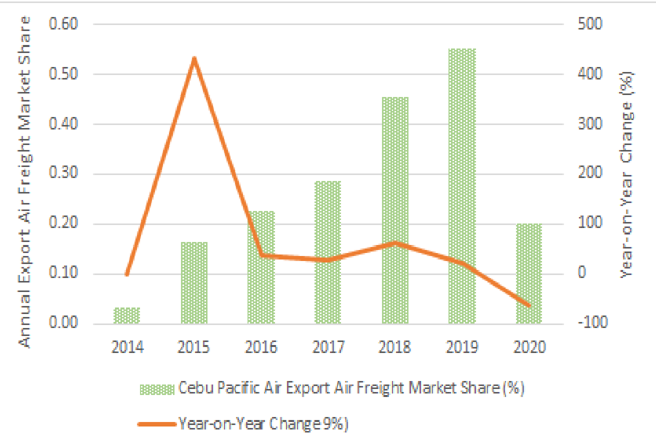

Figure 10. Cebu Pacific Air annual export air freight market share and year-on-year change (%): 2014-2020. Data derived from Bureau of Infrastructure, Transport and Regional Economics (2015-2021).

Figure 11 presents Cebu Pacific Air's annual Australian import air freight market share from 2014 to 2020. As can be observed in Figure 11, the airline steadily increased its share of Australia's import air freight market as it expanded its services to Australia. Cebu Pacific Air's annual export market share has increased from 0.01% in 2014 to a high of 0.58% in 2019 (Figure 11). Figure 11 shows that the airline's annual import air freight market share decreased by 79.31% in 2020 from 0.58% in 2019 to 0.12% in 2020.

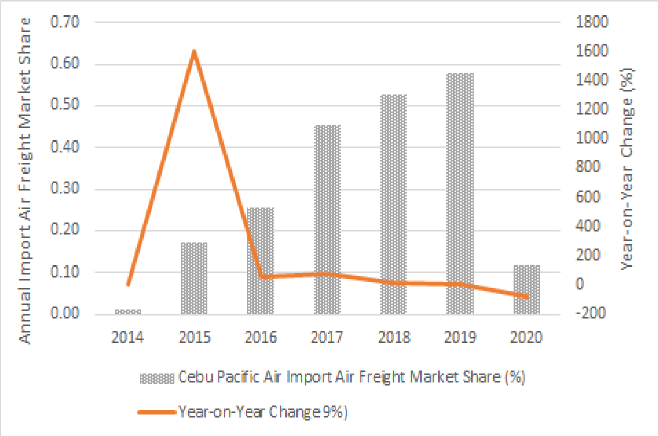

Figure 11. Cebu Pacific Air annual import air freight market share and year-on-year change (%): 2014-2020. Data derived from Bureau of Infrastructure, Transport and Regional Economics (2015-2021).

4.3.3. Indonesia AirAsia-X

Indonesia AirAsia-X was formed in December 2004, as a 49:51% joint venture with AirAsia, when AirAsia acquired a private airline called AW Air International. The airline was subsequently renamed Indonesia AirAsia-X and began commercial operations in 2005 (Bowen, 2019). Indonesia AirAsia-X entered the Australian market in 2010 (Bureau of Infrastructure, Transport and Regional Economics, 2011). In October 2015, Indonesia AirAsia-X commenced Airbus A330-300 services from Denpasar Airport, Bali to Sydney. The route was operated five times per week (Anna Aero, 2015).

Figure 12 presents Indonesia AirAsia-X annual export air freight tonnage and the year-on-year growth (%) from 2010 to 2020. As can be observed in Figure 12, for the first five years of its operations to Australia the airline did not carry any export air freight traffic on its services from Australia. This situation changed in 2015, when the airline uplifted 1.4 tonnes of air freight from Australia. Once again in 2016, Indonesia AirAsia-X did not uplift any export air freight traffic from Australia. From 2017 to 2020, the airline resumed carrying small volumes of export air freight on its services from Australia (Figure 12). Indonesia AirAsia-X highest annual enplaned export air freight tonnage was recorded in 2019, when the airline uplifted 11.9 tonnes on its services from Australia. Like other airlines, the airline's annual export air freight tonnage declined significantly in 2020 (-89.81%) from a high of 11.9 tonnes in 2019 to 1.2 tonnes in 2020 (Figure 12).

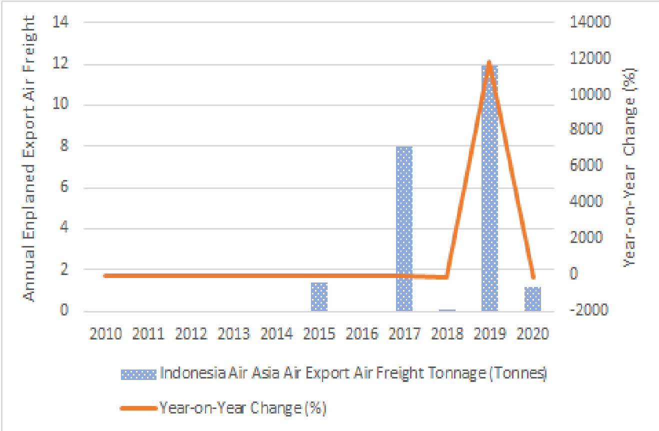

Figure 12. Indonesia AirAsia-X annual enplaned export air freight traffic and year-on-year change (%): 2010-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2011-2021).

Indonesia AirAsia-X annual enplaned import air freight tonnage and the year-on-year change (%) for the period 2010 to 2020 is presented in Figure 13. A similar trend to the airline's export air freight carriage can be observed, that is, no import air freight traffic was carried between 2010 and 2014 and again in 2016. The most significant annual uplift of import air freight was recorded in 2015, when Indonesia AirAsia transported 444.4 tonnes of import air freight on its services to Australia. Figure 13 shows that the airline's annual volumes of enplaned import air freight traffic decreased on a year-on-year basis from 2017 to 2020, with the most significant decrease occurring in 2020, when the airline's annual import air freight tonnage decreased by 84.12% on 2019 volumes. This followed a decrease of 66.97% in the airline's annual enplaned import air freight traffic in 2019 (Figure 13). The decreased import air freight tonnage could be attributed to the airline's decision to withdraw from the Denpasar to Melbourne and Sydney markets in September 2016 (Australian Aviation, 2016). Sydney and Melbourne are Australia's largest import air freight markets. Also, the Corona virus pandemic and the associated border closures impacted the airline's 2020 import air freight traffic volumes.

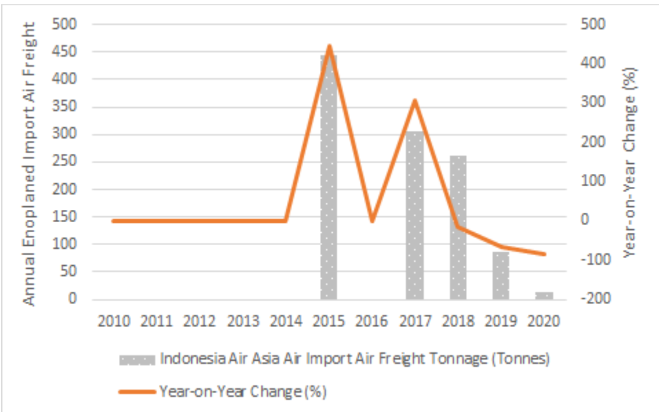

Figure 13. Indonesia AirAsia-X annual enplaned import air freight traffic and year-on-year change (%): 2010-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2011-2021).

Indonesia AirAsia-X annual Australian export air freight markets share from 2010 to 2020 is depicted in Figure 14. As previously noted, the airline carried no export air freight from Australia from 2010 to 2014. The airline carried 1.4 tonnes of export air freight in 2015, which equated to a market share of 0.0003% The airline did not carry any export air freight traffic in 2016 and only uplifted very small quantities of air freight from Australia from 2017 to 2020. As can be seen in Figure 14, the airline's export market share was 0.0015% in 2017, 0.00002% in 2018 and 0.0100% in 2019 and 2020, respectively.

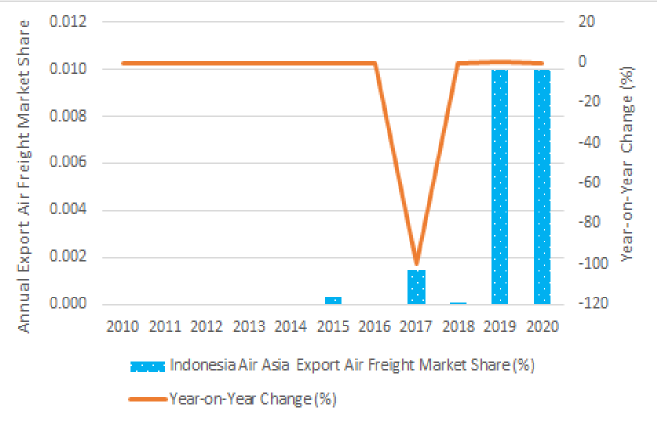

Figure 14. Indonesia AirAsia-X annual export air freight market share and year-on-year change (%): 2010-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2011-2021).

Indonesia AirAsia-X annual Australian import air freight markets share from 2010 to 2020 is depicted in Figure 15. Indonesia Air Asia-X did not carry any import air freight traffic during the period 2010 to 2014 and again in 2016. Figure 15 shows that Indonesia AirAsia-X highest annual import market share was recorded in 2015 (0.09%). From 2016 to 2020, the airline's annual import air freight market share decreased on a year basis due to the lower volumes of import air freight traffic carried by the airline (Figure 15). Figure 15 shows that in 2020, Indonesia AirAsia-X annual Australian import air freight market share was 0.003%.

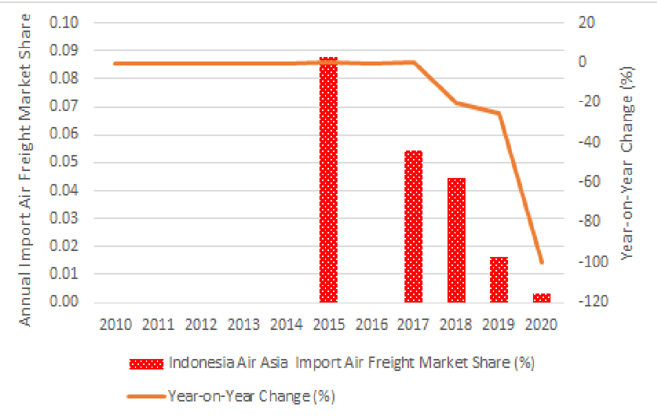

Figure 15. Indonesia AirAsia-X annual import air freight market share and year-on-year change (%): 2010-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2011-2021).

4.3.4. Jetstar Airways

Qantas established Jetstar Airways in 2003 (Bowen, 2010; Homsombat, Lei & Fu, 2014; Peng, 2022). Jetstar is a fully owned subsidiary of the Qantas Group (Schofield, 2013). The airline commenced low fare operations in Australia in May 2004 (Knibb, 2004). In December 2005, Jetstar commenced services from Brisbane, Gold Coast, Melbourne and Sydney to Christchurch, New Zealand (Thomas, 2007). In 2006, Qantas announced plans to launch a new low-cost international division, Jetstar International. The new airline's focus was targeted at the market between single-class low cost and the traditional two-or-three class international carrier services. Jetstar's international services involved initial stage lengths of between 6 to 10 hours to key Asian and Pacific leisure destinations (Knibb, 2006). Jetstar International commenced long-haul international services in November 2006 with wide-body Airbus A330 services to Bangkok and Phuket in Thailand. These services were followed by services to Ho Chi Minh City in Vietnam and Denpasar, Bali (Ionides, 2007). Services to Honolulu and Osaka in Japan commenced in 2007 (Srisaeng, Baxter & Wild, 2014). In 2010, Jetstar Airways began Airbus A330-200 services from Melbourne to Singapore (Centre for Aviation, 2010; Elliot, 2010). Jetstar extended its market presence into Asia by setting up joint venture franchises in Japan, Singapore, and Vietnam (Flottau, 2008; Schofield, 2014). At the time of the present study, Jetstar Airways had a fleet of 11 Boeing B787-9, 53 Airbus A320 and 8 A321 aircraft (Jetstar Airways, 2021b). Qantas Freight, the air freight division of Qantas Airways, markets the lower-deck belly hold space capacity of all domestic and international Jetstar Airways flights (Air Cargo World, 2013b). Based on a full passenger load and prevailing weather conditions, the Jetstar Airbus A320 has an air freight payload of 1,000kgs. The Jetstar Airbus A321 aircraft have an air freight payload of 3,000kgs, whilst the airline's Boeing B787-9 aircraft can accommodate up to 17,900ks (Qantas Freight, 2022).

Jetstar Airways annual export air freight tonnage and the year-on-year change (%) from 2006 to 2020 is presented in Figure 16. As can be observed in Figure 16, Jetstar's annual export air freight tonnage oscillated over this period. Figure 16 shows that Jetstar's annual export air freight tonnages have developed in four distinct phases. The first phase covered the period 2006 to 2008. During this phase, Jetstar established its presence in the market and in 2007 and 2008 increased its annual enplaned tonnages by 1,399.2% and 13.86%, respectively (Figure 16). Following this initial growth phase, the airline's annual export air freight tonnage subsequently decreased in the second phase by 6.62% and 14.89% in 2009 and 2010 (Figure 16). During the third phase from 2011 to 2015, Jetstar's annual enplaned air freight tonnage increased each year with the exception being in 2013, when it declined by 23.61% on the 2012 levels. Figure 16 shows that in the fourth phase of Jetstar Airways annual export air freight market development, the airline's annual enplaned export air freight tonnage decreased in 2016 (-23.56%), 2017 (-38.33%), 2018 (-28.37%), 2019 (-16.98%), and 2020 (-72.72%), respectively (Figure 16). In 2016, the airline's export air freight traffic from Australia to Fiji, Indonesia, Japan, New Zealand, Singapore, Thailand and the United States of America were all down on the 2015 volumes (Bureau of Infrastructure, Transport and Regional Economics, 2017). In 2017, Jetstar Airways uplifted smaller volumes of export air freight traffic from Australia to Fiji, Indonesia, Japan, New Zealand, and Thailand (Bureau of Infrastructure, Transport and Regional Economics, 2018). In 2018, Jetstar Airways significantly reduced its services in the Australia to Singapore market (Corporate Travel Community, 2018). Singapore is one of Australia's largest air freight markets. In 2019, the airline's air freight traffic from Australia to New Zealand decreased quite significantly which impacted its overall air freight traffic volumes in 2019. Similar to the other airlines operating in Australia's aviation market, Jetstar Airways was adversely impacted by the Corona virus pandemic and border closures and travel restrictions in 2020.

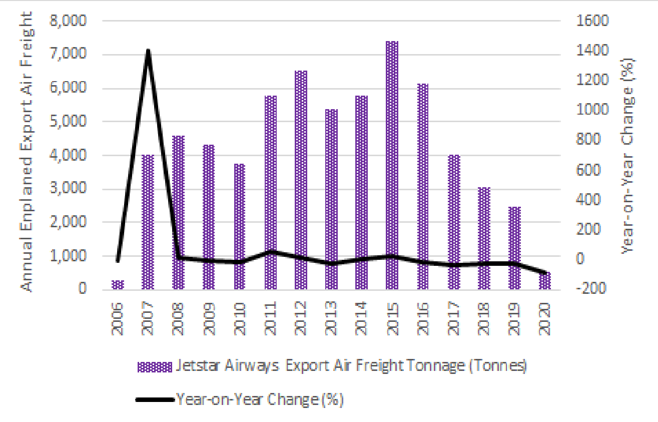

Figure 16. Jetstar Airways annual enplaned export air freight traffic and year-on-year change (%): 2006-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2007-2021).

Jetstar Airways annual import air freight tonnage and the year-on-year change over the period 2006 to 2020 is presented in Figure 17. Figure 17 shows that Jetstar's annual import air freight tonnages fluctuated quite markedly throughout study period. There was a pronounced spike of 1708.33% recorded in 2007 as the airlines import air freight traffic increased from 547.2 tonnes in 2006 to 9,804.5 tonnes in 2007, this was because 2007 was the first full year of operations by Jetstar Airways. The airline's import air freight traffic increased steadily from 2009 to 2012, when it reached a high of 17,418.2 tonnes in 2012. From 2013 to 2020, the airline's annual import air freight tonnages decreased on a year-on-year basis in 2013 (-16.14%), 2015 (-3.47%), 2016 (-21.58%), 2019 (-20.72%), and 2020 (-79.07 (Figure 17), respectively. Figure 17 shows that Jetstar Airways increased its import air freight traffic in 2017 and 2018 by 8.25% and 16.52%, respectively (Figure 17). These two annual increases reflect stronger levels of import air freight traffic being recorded in 2017 and 2018 by the airline. During the latter years of the study, that is, 2019 and 2020, Jetstar Airways enplaned import air freight traffic decreased by 13.09% in 2019 and by 79.07% in 2020 (Figure 17). The pronounced decrease in 2020 may be attributed to Australia's border closures and the impact that this had on airlines services.

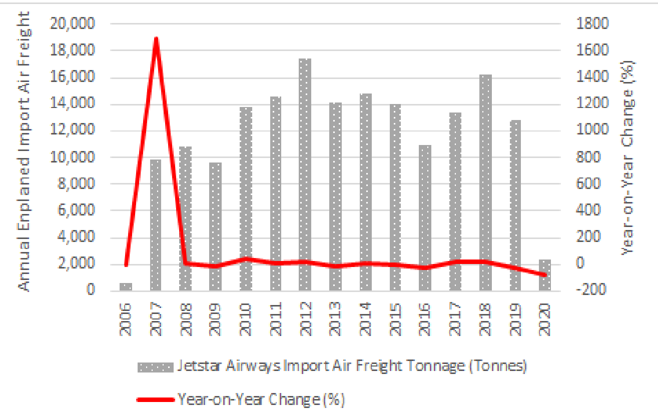

Figure 17. Jetstar Airways annual enplaned import air freight traffic and year-on-year change (%): 2006-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2007-2021).

Jetstar Airways annual Australian export air freight market share from 2006 to 2020 is depicted in Figure 18. As can be observed in Figure 18, Jetstar Airways annual export air freight market share has oscillated throughout the study period rising from a low of 0.09% in 2006 to a high of 1.99% in 2012. Figure 18 shows that from 2015 to 2020, the airline's annual export air freight market share declined on a year-on-year basis reflecting the lower volumes of export air freight traffic carried by the airline. In 2020, Jetstar Airways annual export air freight market share was 0.12% (Figure 18). As can be observed in Figure 18, there were two quite pronounced spikes in Jetstar Airways export air freight market share. These increases occurred in 2007, when the airline's market share increased by 1355.55% on the 2006 levels (Figure 18). In 2006, Jetstar Airways launched services from Australia to Indonesia, Singapore, Thailand, Vietnam, and the United States. The second significant spike in the airline's market share was recorded in 2011, when this metric increased by 52.5% on the 2010 level (Figure 18). In 2011, Jetstar Airways commenced services from Australia to Malaysia and Japan, both of which are important air freight markets.

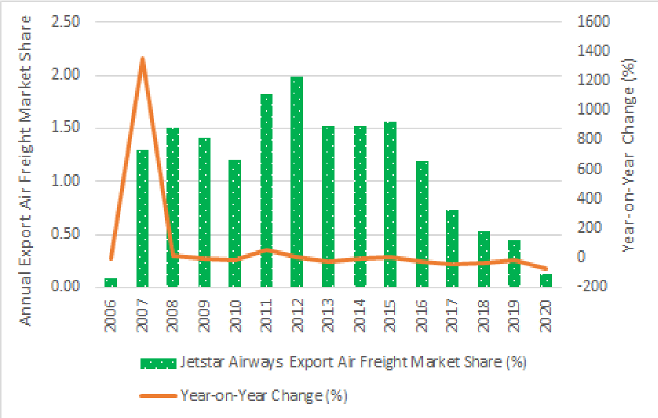

Figure 18. Jetstar Airways annual export air freight market share and year-on-year change (%): 2006-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2007-2021).

Jetstar Airways annual Australian import air freight market share for the period 2006 to 2020 are depicted in Figure 19. Jetstar Airways annual import air freight market share has also oscillated throughout the study period rising from a low of 0.12% in 2006 to a high of 3.22% in 2012. In 2020, Jetstar Airways annual import air freight market share was 0.50% (Figure 19). Figure 19 shows that there was a very pronounced spike in the airline's annual import air freight market share, when it increased by 1708.33% on the 2006 levels. As noted earlier, Jetstar Airways began services to two important markets (Japan and Malaysia) in 2011. The largest year-on-year decrease in the airline's market share was recorded in 2020, when it declined by 79.07% on the 2019 level (Figure 19). The downturn in flight activity associated with the Covid 19 pandemic and Australia's border closures could have attributed to this decrease. Furthermore, there was a very pronounced decrease in Australia's annual import air freight traffic in 2020.

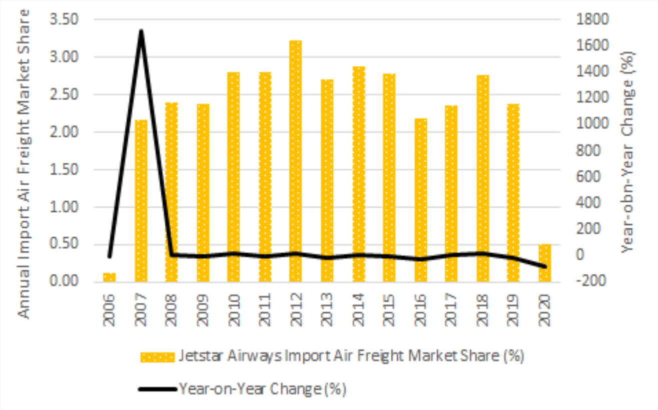

Figure 19. Jetstar Airways annual import air freight market share and year-on-year change (%): 2006-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2007-2021).

4.3.5. Jetstar Asia

In December 2004, Qantas established Jetstar Asia, a low-cost carrier (LCC), based in Singapore. At its inception of commercial operations, Qantas held 49% of the new airline's shares, Temaseck held 19%, and two local investors held the remaining shares (Mathews, 2004; Mills, 2016). Jetstar Asia commenced services from Singapore to a range of destinations including Hong Kong, Manila, and Taipei (Mills, 2016). At the time of the present study, Jetstar Asia served 22 destinations in North and Southeast Asia with a fleet of 18 Airbus A320 aircraft (Jetstar Airways, 2021a).

On 12 September 2019, Jetstar Asia announced a new partnership agreement with Sydney-based Qantas Freight, the air freight division of Qantas Airways. Under the terms of the partnership agreement, Qantas Freight will manage Jetstar Asia's freight capacity across 23 destinations in 13 markets. The new agreement was effective November 20, 2019. The new partnership agreement is intended to provide increased connectivity and access for Jetstar Asia's customers to Qantas Group's wider network as well as to Qantas Freight's 130 partners (Gill, 2019; Ngai, 2019; Toczauer, 2019). Jetstar Asia entered the Australian market in 2010.

Figure 20 presents Jetstar Asia's annual export air freight tonnage and the year-on-year change (%) from 2010 to 2020 As can be observed in Figure 20, the airline did not transport any export air freight from Australia during its first four years of operations. Figure 20 shows that the largest volumes of export air freight carried by the airline occurred in 2015 (19.2 tonnes). The lowest annual export air freight tonnage was recorded in 2020, when Jetstar Asia uplifted 1.8 tonnes, a decrease of 81.25 % on the 2019 levels (Figure 20). As can be observed in Figure 20, there were several quite pronounced annual decreases in the volumes of export air freight uplifted from Australia. These pronounced decreases were recorded in 2016 (-11.97%), 2017 (-21.89%), and 2019 (-46.06%) and reflected lower levels of demand for the airline's air freight services (Figure 20). Jetstar Asia discontinued its daily Airbus A320 Singapore-Perth service on the 25th of March 2018 (Chaser, 2017). The largest single annual decrease in the airline's export air freight traffic was recorded in 2020, when it decreased by 80% on the 2019 levels (Figure 20).

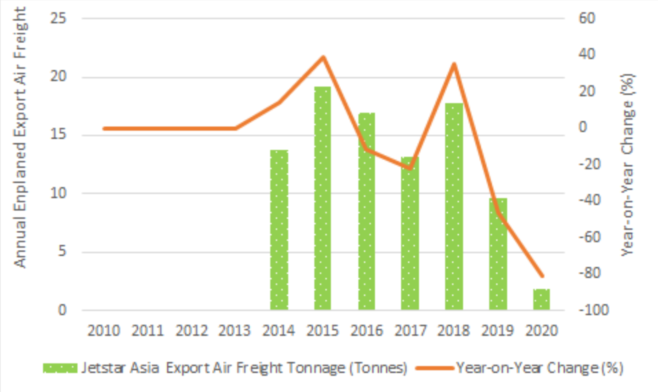

Figure 20. Jetstar Asia annual enplaned export air freight traffic and year-on-year change (%): 2010-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2011-2021).

Jetstar Asia's annual import air freight tonnage and the year-on-year change (%) for the period 2010 to 2020 is presented in Figure 21. Figure 21 shows that the airline did not transport any import air freight traffic during its first four years of operations from Singapore to Australia. Figure 21 shows that there are two discernible trends in Jetstar Asia's annual import air freight tonnages. In the first phase, from 2013 to 2016, Jetstar Asia recorded year-on-year increases in its import air freight traffic, reaching a high of 136.3 tonnes in 2016. Figure 21 shows that in the second phase during the latter years of the study (2017-2020), Jetstar Asia's annual import air freight tonnage declined on a year basis, with the lowest annual uplift of import air freight traffic occurring in 2020 (4.5 tonnes) (Figure 21). There was a pronounced spike in the airline's import air freight tonnage in 2014, when it increased by 100.3% on the 2013 level. This was due to 2014 being the first year when Jetstar Air Asia carried import traffic on its services from Singapore to Australia. The airline's annual import traffic grew by 28.41% in 2015 reflecting a higher demand for its services. The largest single annual decrease in the airline's annual import air freight traffic was recorded in 2020, when it decreased by 87.67% on the 2019 levels (Figure 21). As previously noted, Australia's border closures and the decrease in the volumes of airborne import trade impacted the airlines serving Australia's international air freight market in 2020.

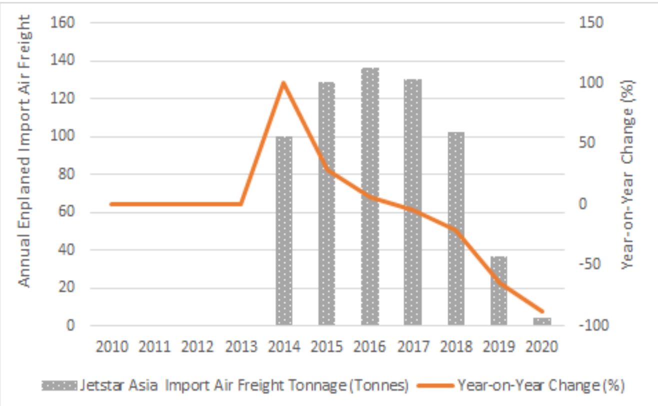

Figure 21. Jetstar Asia annual enplaned import air freight traffic and year-on-year change (%): 2010-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2011-2021).

Jetstar Asia annual Australian export air freight market share from 2010 to 2020 is presented in Figure 22. As noted earlier, during the first four years of Jetstar Asia operations to Australia, the airline did not carry any export or import air freight traffic. Figure 24 shows that Jetstar Asia annual export air freight market share has largely exhibited a downward trend, decreasing from a high of 0.004% in 2015 and 2016 to a low of 0.0004% in 2020. This decrease in export air freight market share is demonstrated by the year-on-year percentage change line graph, which is more negative than positive, that is, more values are below the line than above. Figure 24 shows that there was only one increase in the airline's annual export market share which occurred in 2018, when the airline's total the export market share increased by 50% on the previous year levels. The single largest annual decrease in Jetstar Asia's annual import air freight market share was recorded in 2020, when it declined by 80% to 0.0004%. Figure 22 also shows that there were two further significant annual decreases in the airline's export air freight market share in 2017 (-33.33%) and in 2019 (-33.33%). The decline in market share can be attributed to the lower volumes of export air freight traffic carried in 2015, 2019 and 2020 by the airline.

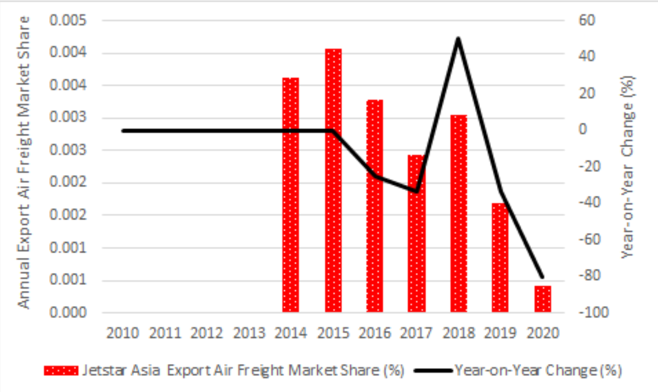

Figure 22. Jetstar Asia annual export air freight market share and year-on-year change (%): 2010-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2011-2021).

Jetstar Asia annual Australian import air freight market share from 2010 to 2020 is presented in Figure 23. As can be observed in Figure 23, the airline's annual import air freight market share fluctuated over the study period. Figure 23 shows that Jetstar Asia import air freight market share increased from 0.02% in 2014 to 0.03% in 2015 and 2016, respectively. From 2016 to 2020, Jetstar Asia annual import air freight market share declined on a year-on-year basis, with three significant annual decreases being recorded in 2017 (-50%), 2019 (-50%), and 2020 (-100%), reflecting lower levels of demand for the airline's air freight services in these latter years of the study period. In 2020, the airline held a 0.001% share of Australia's import air freight market.

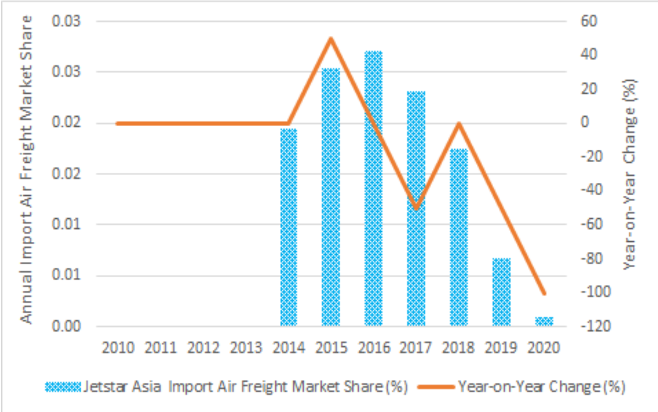

Figure 23. Jetstar Asia annual import air freight market share and year-on-year change (%): 2010-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2011-2021).

4.3.6. Jin Air Co. Ltd

Jin Air entered South Korea's domestic air travel market in 2006 (Zhang et al., 2008). Jin Air is associated with Korean Air (Kim, 2011; Kim, Kim & Lee, 2011). South Korea based low-cost carrier Jin Air operated 16 return seasonal services on the Seoul-Cairns route with a Boeing 777-200ER aircraft between December 2016 and February 2017. The carrier operated 12 seasonal services on the Seoul-Cairns route during December 2017 and January 2018, using a Boeing B777-200ER aircraft (Australian Aviation, 2017). In the year ended December 2017, Jin Air carried 5.2 tonnes of import air freight and 67.5 tonnes of export air freight. Jin Air carried 5.5 tonnes of export air freight but no import air freight in the year ended December 2018. In 2017, Jin Air export air freight market share was 0.012%. Jin Air's import air freight market share was 0.0009% in 2017. In 2018, Jin Air's export air freight market share was 0.001%.

4.3.7. Pacific Blue Airlines

Virgin Blue Airlines commenced operations in Australia in August 2000 with two Boeing B737 aircraft (Thomas, 2006). Virgin Blue Airlines was granted authority by the Australian Government to commence New Zealand flights in 2003. In accordance with the "Open Skies" air services agreement ratified between Australia and New Zealand; Virgin Blue acquired unlimited capacity to New Zealand (Knibb, 2003).

Virgin Blue Airlines launched its Christchurch, New Zealand leisure-based airline, Pacific Blue Airlines in January 2004 (Knibb, 2005a, 2005b). Pacific Blue commenced daily services from Christchurch to Brisbane on the 29th of January 2004 (Virgin Australia, 2004a). Christchurch to Melbourne services were introduced on March 4th, 2004 (Virgin Australia, 2004b). Pacific Blue continued its expansion of Trans-Tasman services in 2004 commencing daily services from Sydney to Christchurch and Wellington on the 10th of May 2004 (Virgin Australia, 2004c). Pacific Blue Airlines commenced direct services from Brisbane to Nadi, Fiji, and from Melbourne to Nadi on September 9 and September 10, 2004, respectively (Virgin Australia, 2004d). Pacific Blue Airlines introduced new services from Melbourne to Port Vila, Vanuatu on 20 September 2004 (Virgin Australia, 2004e). On the 2nd of November 2004, Pacific Blue commenced services between Christchurch and Coolangatta (Gold Coast) and Wellington and Brisbane (Virgin Australia, 2004f).

On the anniversary of their first year of operations in 2005, Pacific Blue Airlines announced that the airline would offer an international air freight service between New Zealand, Australia, Fiji and Vanuatu using the lower lobe belly hold capacity in their fleet of Boeing B737-800 aircraft (Virgin Australia, 2005a). These aircraft offer an air freight payload of 2,000kgs (Virgin Australia, 2022).

Pacific Blue Airlines continued to expand its Trans-Tasman services in 2005. The airline introduced Brisbane to Auckland and Coolangatta (Gold Coast) to Auckland on the 12th and 14th May, respectively (Virgin Australia, 2005b). Pacific Blue gained entry to Auckland Airport, New Zealand's principal gateway airport, in 2005 (Airline Business, 2005). Pacific Blue expansion continued in 2005 with the launch of direct flights to Tonga from both Australia and New Zealand (Virgin Australia, 2005c).

On the 22nd of September 2008, Pacific Blue launched flights from Melbourne to Auckland and, in so doing, became the first low-cost carrier (LCC) to provide services on this important air route (Virgin Australia, 2008a). Pacific Blue Airlines added Port Moresby on 3 November 2008, when the airline launched direct services from Brisbane to Port Moresby (Virgin Australia, 2008b).

Air New Zealand and Virgin Australia announced a new joint network strategy on the 16th of May 2011, whereby Air New Zealand would operate services equal to 70 per cent of the total capacity and Pacific Blue Airlines would provide the remaining 30 per cent. These were like the market shares held by the two airlines prior to the agreement. Also, both airline's flights were aligned under the agreement to ensure more convenient schedules for passengers (Centre for Aviation, 2011; Elliot, 2011).

On the 7th of December 2011, the Virgin Australia group of airlines officially launched its international airlines V-Australia and Pacific Blue under the new brand, "Virgin Australia" (Creedy, 2011; Curran, 2021). At this time, Virgin Blue changed its business model from a low-cost carrier (LCC) model to the full-service network (FSNC) airline business model (Hubbard, Riced & Galvin, 2015; Whyte, Prideaux & Sakata, 2012). As previously noted, during the company's history, Pacific Blue's services were operated by the airline's Next Generation Boeing B737-800 aircraft.

Pacific Blue Airlines annual export air freight tonnage and the year-on-year change (%) for the period 2004 to 2010 is presented in Figure 24. The airline transported no export air freight in its first year of operations in 2004. However, over the study period, Pacific Blue Airlines annual export air freight tonnages principally displayed an upward trend. This is demonstrated by the year-on-year percentage change line graph, which is more positive than negative, that is, more values are above the line than below. Figure 24 shows that there was a very pronounced annual growth rate recorded in 2006 (423.45%) following strong growth in the airline's Fiji and New Zealand air freight markets in 2006. During the company's operations, the largest annual enplaned export air freight tonnage was in 2010, when the airline uplifted 1,082.8 tonnes of export air freight traffic. Figure 24 also shows that there was only one annual decrease in the airline's annual export air freight tonnage and this decrease occurred in 2008, when the annual tonnage decreased by 7.14% on the 2007 levels.

Figure 24. Pacific Blue Airlines annual enplaned export air freight traffic and year-on-year change (%): 2004-2010.
Data derived from Bureau of Transport and Regional Economics (2005-2007), Bureau of Infrastructure, Transport and Regional Economics (2008-2011).

Figure 25 presents Pacific Blue Airlines annual import air freight tonnages and the year-on-year change (%) from 2004 to 2010. As can be observed in Figure 25, Pacific Blue Airlines annual import air freight tonnage fluctuated over the study period. The airline transported no import air freight in its first year of operations in 2004. Like the airline's annual export air freight traffic, there was a very significant increase in the volumes of import air freight carried in 2006 (+432.79%), which was attributed to strong growth in the airline's Fiji and New Zealand markets. The largest volume of import air freight traffic carried by the airline was in 2010, when Pacific Blue Airlines transported a total of 1,117.3 tonnes on its services. Figure 25 also shows that in 2008, the airline's annual import air freight tonnage declined by 23.38% on the 2007 volumes. This was the only year in which there was a decrease in the transportation of inbound air freight to Australia.

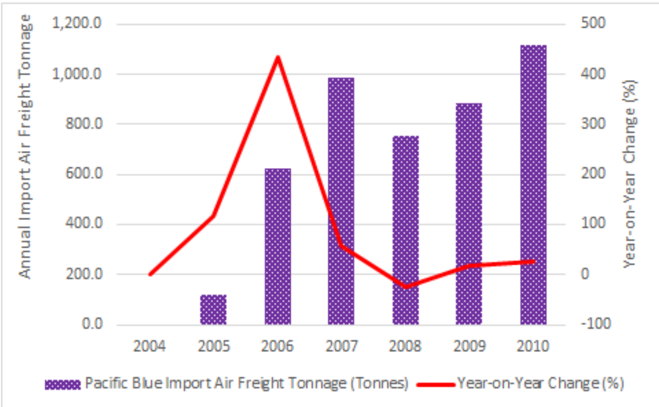

Figure 25. Pacific Blue Airlines annual enplaned import air freight traffic and year-on-year change (%): 2004-2010.
Data derived from Bureau of Transport and Regional Economics (2005-2007), Bureau of Infrastructure, Transport and Regional Economics (2008-2011).

Pacific Blue Airlines annual Australian export air freight market share from 2004 to 2010 is presented in Figure 26. Figure 26 shows that the airline was able to steadily increase its share of Australia's export air freight market throughout its history of operations as a low-cost carrier (LCC). The airline's annual export air freight market share rose from 0.05% in 2005 to a high of 0.34% in 2010. Throughout its history of operations, the airline only recorded one annual decrease in its export air freight market share. This occurred in 2008, when the airlines annual market share decreased slightly from 0.26% in 2007 to 0.25% in 2008 (Figure 26). Figure 26 shows that there was a pronounced spike in the airline's export air freight market share in 2006, when it increased by 360% on the 2005 level. As noted earlier, the airline's export air freight traffic from Australia to Fiji and New Zealand grew very strongly in 2006.

Figure 26. Pacific Blue Airlines annual export air freight market share and year-on-year change (%): 2004-2010.
Data derived from Bureau of Transport and Regional Economics (2005-2007), Bureau of Infrastructure, Transport and Regional Economics (2008-2011).

Pacific Blue Airlines annual Australian import air freight market share from 2004 to 2010 is presented in Figure 27. A similar trend can be observed in the airline's annual import air freight market share, which increased from 0.03% in 2005 to a high of 0.23% in 2010. Pacific Blue Airlines annual import air freight market share decreased only once throughout its history of operations. This decrease occurred in 2008, when the airline's annual import air freight market share decreased from 0.22% in 2007 to 0.17% in 2008 (Figure 27). Figure 27 shows that there was a pronounced spike in the airline's import air freight market share in 2006, when it increased by 366.6% on the 2005 level. As noted earlier, the airline's import air freight traffic from Fiji and New Zealand displayed high growth rates in 2006.

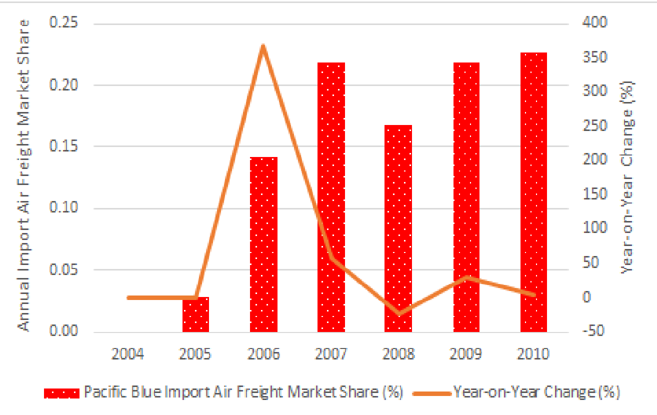

Figure 27. Pacific Blue Airlines annual import air freight market share and year-on-year change (%): 2004-2010.
Data derived from Bureau of Transport and Regional Economics (2005-2007), Bureau of Infrastructure, Transport and Regional Economics (2008-2011).

4.3.8. Scoot Tigerair

In recent times, Singapore Airlines has launched new airlines, such as, Scoot and Silk Air, that are targeted at various niche markets (Dempsey, 2019). Scoot Tigerair is the low-cost airline subsidiary of the Singapore Airlines Group (Lohmann & Spasojevic, 2018; Schofield, 2016; Taneja, 2018). Singapore Airlines launched its low-cost carrier subsidiary Scoot Pte Ltd in June 2012. Scoot initially started operations with a fleet of Boeing B777-200 aircraft that were outfitted in a two-class configuration. These aircraft were deployed to enable Scoot to compete in the long-haul low-cost carrier market segment against Air Asia-X and Jetstar Airways (Taneja, 2016). Scoot has subsequently expanded its route network and serves key markets in the Asia-Pacific region plus India (Chia & Singh, 2016). Scoot took delivery of its first Boeing 787 aircraft on the 1st of February 2015 (Chow, 2015). Scoot planned to retire all six of its Boeing 777-200s aircraft, which were formerly from Singapore Airlines, around the middle of 2015 and shift to an all-Boeing 787 fleet (Centre for Aviation, 2015).

Singapore Airlines announced on 5th of February 2016 that it had acquired more than 90% stake in Tigerair and that the airline would delist its short haul Tigerair subsidiary. Tigerair had been listed on the Singapore Exchange since early 2010, at which point Singapore Airlines held a minority share (Centre for Aviation, 2016). On May 14, 2016, Singapore Airlines (SIA) established a holding company to own and manage its budget airlines Scoot and Tiger Airways, following the delisting of Tiger Airways (which operates as Tigerair) from Singapore Exchange (SGX-ST) (Singapore Airlines, 2016). On July 25, 2017, Singapore Airlines merged both its low-cost airlines, Scoot and Tigerair (Centre for Aviation, 2017; Chuanren, 2017; Kapoor, 2017), and renamed the airline Scoot Tigerair.

On 4 June 2012, Scoot commenced services from Singapore to Sydney, which were operated with a Boeing B777-200ER aircraft. Shortly thereafter on 12 June 2012, Scoot began operations from Singapore to Coolangatta (Gold Coast). These services were also operated by Boeing B777-200ER aircraft (Anna Aero, 2012). The Boeing B777-200 aircraft offers an air freight payload of 20 tonnes (Morrell, 2011). In November 2015, Scoot commenced direct services from Singapore to Melbourne with a Boeing 787 Dreamliner aircraft (Platt, 2015). Scoot launched services from Singapore to Perth using Boeing B787 aircraft in February 2015 (Centre for Aviation, 2015).

Figure 28 depicts Scoot Tigerair annual enplaned export air freight tonnage and the year-on-year change (%) from 2012 to 2020. As can be noted in Figure 28, Scoot Tigerair annual enplaned export air freight tonnage has oscillated over this period, rising from a low of 955.2 tonnes in 2012 to a high of 8,426.1 tonnes in 2016. Figure 28 also shows that the airline carried no export air freight traffic from Australia in 2013. There was a pronounced spike recorded in 2014 when the airline once again began uplifting export air freight traffic from Australia. In the latter years of the study, that is, 2017 to 2020, the airline recorded an annual decrease in the volumes of export air freight carried, with the most significant decrease occurring in 2019, when the annual export air freight tonnage decreased by 61.01% on the 2018 levels (Figure 28). Australia's annual export air freight tonnage grew in 2017 and 2018 but declined in 2019. Figure 28 shows that Scoot Tigerair's annual export air freight tonnage increased by 196.37% in 2020 from 1,552 tonnes in 2019 to 4,599 tonnes in 2020.

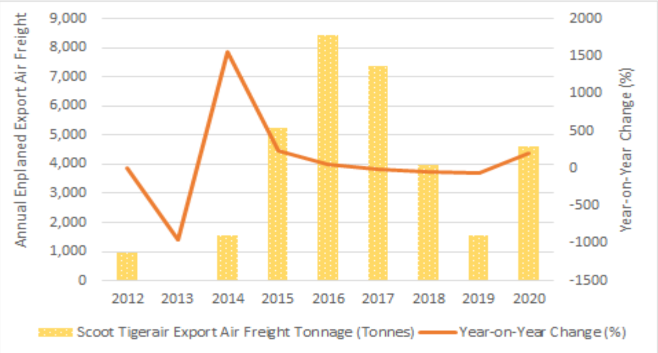

Figure 28. Scoot Tigerair annual enplaned export air freight traffic and year-on-year change (%): 2012-2010.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2013-2021).

Scoot Tigerair annual enplaned import air freight traffic and the year-on-year change (%) from 2012 to 2020 is presented in Figure 29. Like the airline's annual export air cargo traffic, the annual uplift of import air cargo has oscillated throughout the time that the airline has served the Australian import air freight market. As can be observed in Figure 29, Scoot Tigerair enplaned import air freight traffic increased on a year-on-year basis from 2012 to the 2017, with the only exception being in 2013, when the airline did not transport any import air freight traffic. The pronounced spike in 2014 was due to the uplift of import air freight traffic re-commencing in 2014. Scoot did not transport any import air freight from Singapore to Australia in 2013. In 2018 and 2019, the airline's annual import tonnage declined by 37.68% and 53.76%, respectively (Figure 29). Australia's annual import air freight market increased in 2018 but decreased in 2019 due to lower levels of demand for imported air freight products by Australian importers and consumers. Figure 29 shows that Scoot Tigerair's import air freight traffic increased by 110.05% in 2020, from 2,339.1 tonnes in 2019 to 4,913.5 tonnes in 2020.

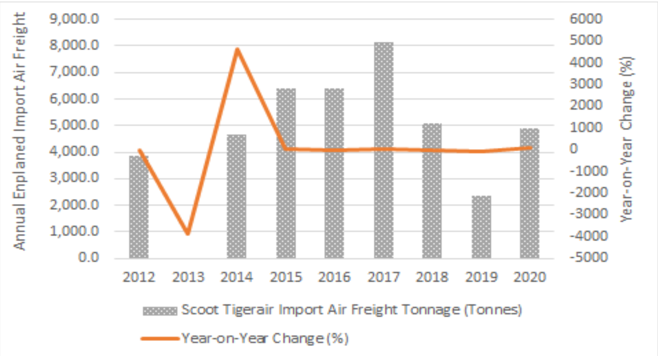

Figure 29. Scoot Tigerair annual enplaned import air freight traffic and year-on-year change (%): 2012-2010.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2013-2021).

Figure 30 presents Scoot Tigerair annual Australian export air freight market share for the period 2012 to 2020. As previously noted, the airline did not transport any export or export air freight traffic on its Australian services in 2013. Figure 30 shows that the airline's annual export air freight market share increased from 0.41% in 2014 to a high of 1.64% in 2016. From 2017 to 2019, the airline's annual export market share decreased on a year-on-year basis, declining from 1.35% in 2017 to 0.27% in 2019 (Figure 30). In 2020, the airline's annual export air freight market share increased by 292.59% from 0.27% in 2019 to 1.06% in 2020. Figure 30 shows that there were two quite significant annual decreases in the airline's market share during the study period. These decreases occurred in 2018 (-49.62%) and 2019 (-60.29%) and reflected the lower levels of export air freight traffic carried on its services from Australia to Singapore. The largest single annual increase in the airline's export air freight market share was recorded in 2020, when it increased by 292.59% on the 2019 level.

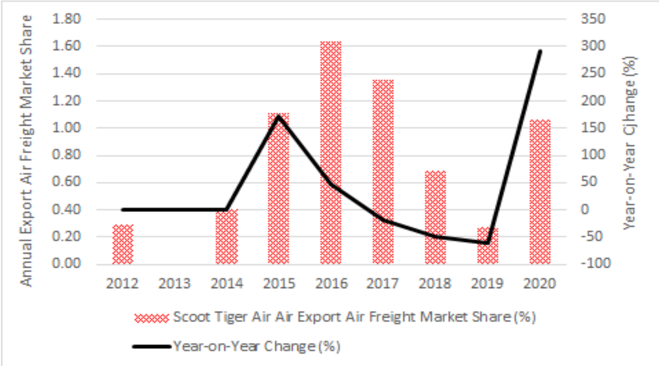

Figure 30. Scoot Tigerair annual export air freight market share and year-on-year change (%): 2012-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2013-2021).

Figure 31 presents Scoot Tigerair annual Australian import air freight market share for the period 2012 to 2020. Scoot Tigerair import air freight traffic increased from 0.90% in 2014 to a high of 1.44% in 2017(Figure 24). As can be observed in Figure 31, Scoot did not transport and inbound cargo to Australia in 2013. In 2018 and 2019, the airline's import air freight market share declined from 1.44% in 2017 to 0.86% in 2018, and to 0.44% in 2019 (Figure 24), and these decreases reflected a lower level of demand for the airline's services. In 2020, Scoot Tigerair's annual import air freight market share increased by 143.18% from 0.44% in 2019 to 1.07% in 2020 (Figure 31)). This increase was attributed to the greater volumes of import air freight traffic transported between Singapore and Australia in 2020 by the airline. During the study period, there were two quite pronounced decreases in Scoot Tigerair's annual import air freight market share, with these decreases being recorded in 2018 (-40.27%) and 2019 (-48.83%), respectively (Figure 31). These decreases could be attributed to the airline's lower import air freight traffic levels in 2018 and 2019.

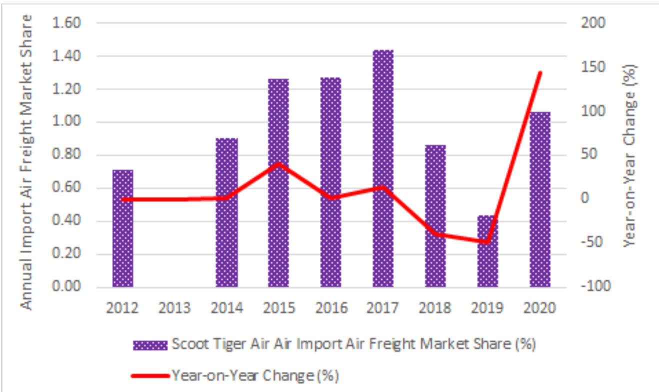

Figure 31. Scoot Tigerair annual import air freight market share and year-on-year change (%): 2012-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2013-2021).

4.3.9. Thai AirAsia X

In November 2003, AirAsia announced its plans to form Thailand-based Thai AirAsia as a joint venture with the Shin Corporation. Shin corporation had a 51% shareholding whilst Air Asia held the remaining 49% of the company's shares (Bowen, 2019; Mutum & Ghazali, 2014; Singh, Pangarkar & Heracleous, 2014). Thai AirAsia commenced commercial services in February 2004, linking Bangkok with other major cities in Thailand (Air Asia, 2019). Thai AirAsia X commenced services from Bangkok's Don Mueang Airport to Brisbane on 25 June 2019. The services are operated with an Airbus A330-300 aircraft (Australian Aviation, 2019). Thai AirAsia X planned to serve Brisbane four times per week from its Bangkok Don Muang hub airport (Curran, 2019). At the time of the present study, Thai AirAsia-X had a fleet of nine Airbus A330-300 aircraft of which five were in active service (Curran, 2022).

In 2019, Thai AirAsia-X uplifted 48.7 tonnes of export air freight on its services from Brisbane to Bangkok's Don Mueang Airport. This represented an annual Australian export air freight market share of 0.008%. Thai AirAsia-X transported 159.4 tonnes of air freight on its services to Brisbane in 2019. This enabled the airline to capture 0.029% of Australia's annual import air freight traffic in 2019. In 2020, Thai AirAsia-X export traffic declined by 74.94% from a high of 48.7 tonnes in 2019 to a low of 12.2 tonnes in 2020. In 2020, the airline's annual Australian export market share decreased by 75% to 0.002%. Similarly, the airline's annual import air freight traffic volumes declined in 2020 by 71.32% from 159.4 tonnes in 2019 to 45.7 tonnes in 2019. As a result, Thai Air Asia-X annual import air freight market share declined by 68.96% in 2020 at which time the airline had captured 0.009% of Australia's annual import air freight traffic.

4.4 Comparison of the low-cost carriers, full-service network airlines and dedicated all-cargo carriers annual traffic growth rates and market shares

Like many other air freight markets around the world, Australia's international air freight market is served by both full service and low-cost carriers (LCCs) as well as several dedicated all-cargo carriers. The major full-service network carriers are Air New Zealand, Qantas Airways, Emirates Airline, and Virgin Australia. It is important to note that a number of full-service network airlines (FSNCs) also operate freighter services to and from Australia in addition to their scheduled passenger flights. For example, Qantas operates an extensive freighter network linking Australia with key markets in Asia, China, New Zealand, and the United States (Baxter, Srisaeng & Wild, 2019). Cathay Pacific Airways and Singapore Airlines are also full-service network airlines that operate scheduled freighter services to Australia. These freighter services are in addition to their passenger flights. In 2020, all-cargo services were provided by FedEx, Kalitta Air, Pacific Air Express, Polar Air Cargo, Tasman Cargo Airlines, and United Parcel Service (UPS) (Bureau of Infrastructure, Transport and Regional Economics, 2021).

Figure 32 presents the low-cost carriers (LCCs), full-service network airlines (FSNCs), and dedicated all-cargo carriers annual export air freight market growth rates from 2004 to 2019. Figure 32 shows that there was a very pronounced increase in the low-cost carriers' (LCCs) export air freight growth in 2005 (+132.6%), 2006 (+626.24%) and 2007 (+404.17%). These increases were a result of the decision of Pacific Blue Airlines to carry air freight effective in 2005, the launch of services by Jetstar Airways in 2006, and the introduction of services to Australia by AirAsia-X in 2007. From 2008 to 2020, the low-cost carriers (LCC's) annual export air freight growth rate fluctuated quite markedly. Throughout this period, the highest annual growth rate was recorded in 2015 (+70.01%), whilst there were just three decreases in the low-cost carriers (LCCs) annual export traffic. These decreases were recorded in 2013 (-18.15%), 2019 (-16.74%), and 2020 (-52.28), respectively (Figure 32). Despite the growth in Australia's export air freight traffic in 2013, the low-cost carriers annual enplaned export air freight traffic declined in 2013, whilst the full-service network carriers (FSNCs) and dedicated all-cargo airlines were able to take advantage of the traffic growth. In 2019, Australia's annual export traffic declined on a year-on-year basis and this downturn in traffic impacted the low-cost carriers as well as the full-service network carriers (FSNCs) and dedicated all-cargo airlines. As previously noted, in response to the COVID-19 pandemic in 2020 the Australian Government closed the country's borders (D'Souza & Dunshea, 2021). In Australia, travel bans, border closures, and the stay-at-home orders severely disrupted various industries including the country's aviation industry (Gao & Ren, 2020).

Figure 32 shows that the full-service network airlines (FSNCs) annual export air freight market growth rates were predominantly positive. The highest annual growth rate was recorded in 2015, when the full service-network airlines annual (FSNCs) export air freight growth rate increased by 19.56% on the 2014 levels. Figure 32 also shows that over the study period, the full-service network carriers (FSNCs) annual export air freight growth rate decreased in 2007 (-0.39%), 2008 (-1.75%), 2019 (-3.92%), and in 2020 (-30.34 %), respectively (Figure 32). In 2007, the low-cost carriers (LCCs) were able to grow their export air freight market share, which resulted in a higher market share for the low-cost carriers in 2007. In 2008, the full-service network carriers (FSNCs) annual enplaned export air freight traffic decreased on a year-on-year basis whilst the low-cost carriers (LCCs) annual export air freight traffic increased, thus enabling the low-cost carriers (LCCs) to secure a higher market share.

Figure 32 shows that the annual export air freight market growth rate of the dedicated all-cargo carriers fluctuated throughout the period 2004 to 2020. Figure 32 shows that from 2004 to 2010, the dedicated air cargo carriers annual export air freight growth rate decreased on a year-on-year basis with the only exception being in 2007, when it increased by 0.7% on the previous year level. During these early years of the study, the integrated carriers (FedEx and UPS) had quite low levels of export air freight traffic. As can be observed in Figure 32, the dedicated air cargo carriers recorded positive annual increases in their export freight growth from 2011 to 2019, with the only exception being in 2014, when the annual export market growth decreased by 7.44% on the 2018 level. The low-cost carriers (LCCs) and the full-service network carriers (FSNCs) were able to increase their export air freight market share in 2014. The highest single annual increase in the export air freight traffic carried by the dedicated all-cargo carriers occurred in 2015, when the annual air freight traffic volumes increased by 148.04 % on the 2014 levels. Australia's annual export air freight traffic grew strongly in 2015, and the dedicated all-cargo airlines were able to capture higher levels of air cargo traffic which enabled them to increase their annual market share. Figure 32 also shows that there was a pronounced spike in the export air freight traffic carried by the dedicated all-cargo carriers in 2020. In 2020, the export air freight traffic levels uplifted by the dedicated all-cargo airlines increased by 78.19% on the 2019 levels and this strong growth reflected a higher demand for the dedicated all-cargo carriers' services (Figure 32).

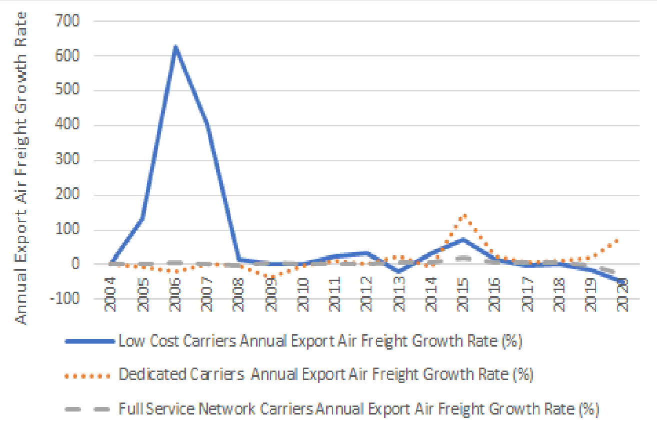

Figure 32. Low-cost carriers, all-cargo airlines, and full-service network carrier's annual enplaned export air freight traffic growth rates and year-on-year change (%): 2004-2020. Data derived from Bureau of Infrastructure, Transport and Regional Economics (2008-2021), Bureau of Transport and Regional Economics (2005-2007).

Figure 33 presents the low-cost carriers (LCCs), full-service network airlines (FSNCs), and dedicated all-cargo carriers annual import air freight market growth rates from 2004 to 2020. As can be observed in Figure 33, the low-cost carriers (LCCs) annual import air freight growth rates fluctuated quite extensively over the study period. The pronounced spike for 2005 to 2007 was due to the launch of air freight services by Pacific Blue as well as the inception of services by Jetstar Airways in 2006. In 2007, AirAsia-X entered the Australian import air freight market and successfully captured import air freight traffic. Figure 33 also shows that the low-cost carriers (LCCs) annual import air freight growth rates increased quite strongly in 2010 (+75.77%) and again in 2017 (+22.95%). Air Asia-X and Jetstar Airways recorded very significant growth in their annual enplaned import air cargo traffic in 2010, and this enabled these airlines to increase their annual import air freight market share. Cebu Pacific, Jetstar Airways and Scoot Tigerair recorded strong growth in their import air cargo traffic in 2017, and once again this contributed to the low-cost carriers' higher annual market share in 2017. Figure 33 also indicates that there were several years when the low-cost carriers (LCCs) annual import air freight growth rate declined on a year-on-year basis. These decreases were recorded in 2009 (-0.03%), 2013 (-13.48%), 2019 (-28.46%), and in 2020 (-62.06%), respectively (Figure 33). This loss in market share by the low-cost carriers (LCCs) could be attributed to the decrease in the annual import air freight tonnage in 2009, 2013, 2019, and 2020, respectively. As can be noted in Figure 33, the full-service network airlines (FSNCs) annual import air freight growth rates also fluctuated over the study period. The full-service network airlines (FSNCs) highest annual import air freight growth rate occurred in 2010, when these carriers annual import freight market share increased by 19.67% on the previous year levels. Like the low-cost carriers (LCCs), the full-service network airlines annual import air freight market growth decreased in 2009 (-9.79%), 2013 (-2.89%), 2014 (-2.3%), 2015 (-1.65%), 2019 (-8.67%), and 2020 (-23.48%) (Figure 33). In each of these year's, Australia's total annual import air freight traffic decreased on a year-on-year basis.

The dedicated all-cargo carriers annual import air freight market growth rate also fluctuated from 2004 to 2020 (Figure 33). The dedicated all-cargo carriers highest annual import air freight growth rate occurred in 2020, when these carriers annual import freight market share increased by 66.26 % on the 2019 levels (Figure 33). Figure 33 also shows that the dedicated all-cargo carriers import air freight traffic volumes increased quite significantly in 2010 (+11.18%), 2017 (+10.72%), and 2018 (17.31%), reflecting the greater demand for dedicated all-cargo services in these years. The largest single annual increase in the dedicated all-cargo airlines import air freight market share was recorded in 2020, when it increased by 66.26% on the 2019 levels.

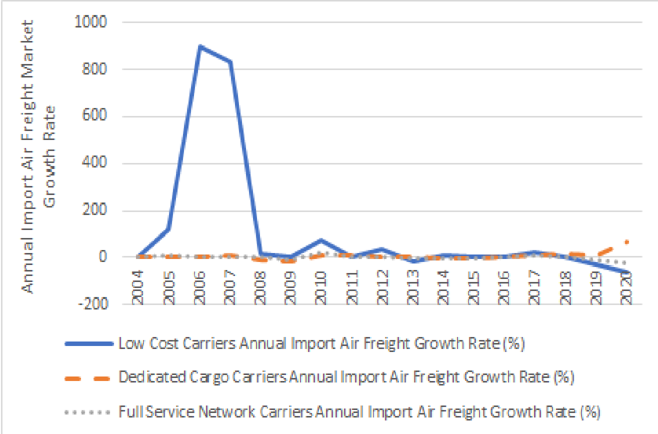

Figure 33. Low-cost carriers, all-cargo airlines and full-service network carrier's annual enplaned import air freight traffic growth rates and year-on-year change (%): 2004-2020. Data derived from Bureau of Infrastructure, Transport and Regional Economics (2008-2021), Bureau of Transport and Regional Economics (2005-2007).

The low-cost carriers (LCCs), full-service network airlines (FSNCs), and dedicated all-cargo carriers annual export air freight market shares from 2004 to 2020 are presented in Figure 34. Figure 34 shows that the low-cost carriers (LCCs) export air freight market share displayed an upward trajectory from 2005 to 2016 before declining in the period 2017 to 2020. The low-cost carriers (LCCs) highest annual export air freight market share was recorded in 2016, when the low-cost carriers (LCCs) transported 3.96% of Australia's annual export air freight traffic. Figure 34 also shows that during the infancy of the low-cost carriers (LCCs) participation in Australia's export air freight market their market share was very low. In 2005, the low-cost carriers (LCC's) accounted for just 0.05% of Australia's annual export air freight market share. Figure 34 shows that in the latter years of the study (2017 to 2020), the low-cost carriers (LCCs) annual export air freight market share decreased on a year-on-year basis and declined from 3.96% in 2016 to 1.90% in 2020.

As can be seen in Figure 34, the full-service network airlines (FSNCs) have historically held the greatest share of Australia's annual export air freight market. The full-service network carriers (FSNCs) highest annual export air freight market share was recorded in 2010, when these carriers accounted for 95.82% of Australia's annual export air freight tonnage. As can be observed in Figure 34, the full-service network carriers (FSNCs) annual export air freight market share has declined in the latter years of the study period (2015-2020). The lowest annual export air freight market for these airlines occurred in 2019, when they accounted for 89.89% of Australia's annual air freight market (Figure 34).

The dedicated all cargo carriers annual share of Australia's export air freight market has oscillated over the period 2004 to 2020 (Figure 34). From 2005 to 2010, the dedicated all cargo carriers annual market share decreased on a year basis from a high of 5.80% in 2004 to a low of 2.31% in 2010. From 2011 to 2014, the dedicated all cargo carriers market share remained quite consistent at around 2.62% (Figure 34). From 2015 to 2020, the dedicated all-cargo carriers market share has increased on a year-on-year basis and reached a high of 16.44% in 2020 (Figure 34). The integrated carriers FedEx and UPS have achieved strong market growth in recent years, which has underpinned the increase in the dedicated all-cargo carriers overall Australian export air freight market share.

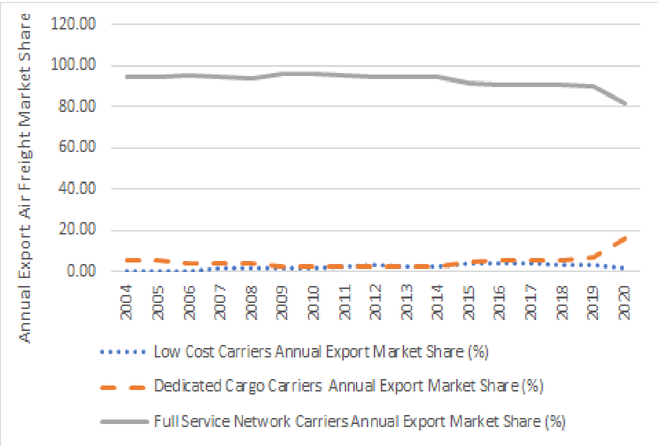

Figure 34. Low-cost carriers, all-cargo airlines, and full-service network carrier's annual export air freight market shares: 2004-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2008-2021), Bureau of Transport and Regional Economics (2005-2007).

Figure 35 presents the low-cost carriers (LCCs), full-service network carriers (FSNCs), and the dedicated all-cargo carriers annual share of Australia's import air freight market from 2004 to 2020. Like Australia's export air freight market, the full-service network carriers (FSNCs) have historically captured the largest share of Australia's import air freight market. However, Figure 35 shows that these airlines annual market share has displayed a downward trend from a high 91.57% in 2005 to a low of 75.65% in 2020. The low-cost carriers (LCCs) annual import air freight market share has predominantly shown an upward trend increasing from a low of 0% in 2004 to a high of 6.54% in 2017. In the latter years of the study, the low-cost carriers (LCCs) decreased on a year-on-year basis, declining from 6.54% in 2017 to 2.23% in 2020 (Figure 35). As can be observed in Figure 35, the dedicated all-cargo carriers annual share of Australia's import air freight market has been relatively consistent and has averaged around 7.96% over the study period. The dedicated all-cargo carriers highest annual share of Australia's import air freight market was recorded in 2020, when the dedicated all-cargo carriers held a 22.11% market-share. As can be observed in Figure 35, the dedicated all-cargo carriers lowest annual share of Australia's import air freight market was in 2010, when the dedicated all-cargo carriers accounted for 7.09% of Australia's annual import air freight market.

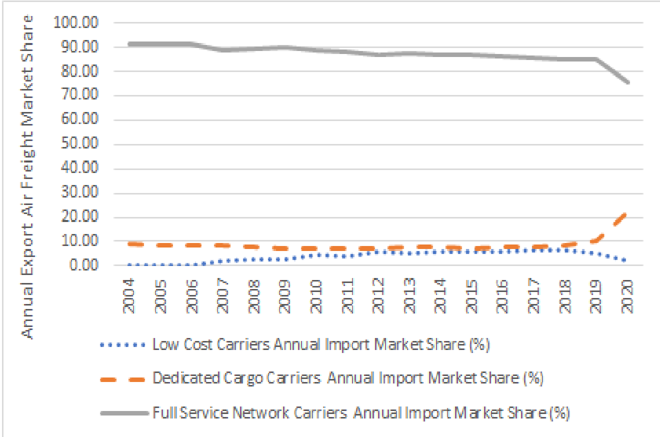

Figure 35. Low-cost carriers, all-cargo airlines, and full-service network carrier's annual import air freight market shares: 2004-2020.
: 2004-2020.
Data derived from Bureau of Infrastructure, Transport and Regional Economics (2008-2021), Bureau of Transport and Regional Economics (2005-2007).

Amongst the low-cost carriers serving Australia's export air freight market, Pacific Blue held the largest Australian export air freight market share in both 2005 and 2006. Of the low-cost carriers serving Australia's export air freight market, Jetstar Airways held the largest Australian export air freight market share from 2006 to 2012. In 2013, AirAsia-X surpassed Jetstar Airways annual Australian export share, and thus, became the largest low-cost carrier in this air freight market segment. Air Asia-X captured the highest share of the low-cost carriers competing in Australia's export air freight market in 2014. The situation changed in 2015 when Jetstar Airways once again captured the highest share of the low-cost carriers competing in Australia's export air freight market. During the period 2017 to 2019, Air Asia-X held the highest share of the low-cost carriers competing in Australia's export air freight market. In 2020, Scoot Tigerair captured the highest share of the low-cost carriers competing in Australia's export air freight market.

Amongst the low-cost carriers serving Australia's import air freight market, Pacific Blue held the largest share of Australia's import air freight traffic in both 2005 and 2006. Of the low-cost carriers serving Australia's import air freight market, Jetstar Airways held the largest Australian import air freight market share from 2006 to 2015. In 2016, AirAsia-X surpassed Jetstar Airways annual Australian import share, and thus, became the largest low-cost carrier competing in this air freight market segment. The situation changed again in 2017 when Jetstar Airways once again captured the highest share of the low-cost carriers competing in Australia's import air freight market. During the period 2017 to 2019, Jetstar Airways held the highest share of the low-cost carriers competing in Australia's import air freight market. In 2020, Scoot Tigerair captured the highest share of the low-cost carriers competing in Australia's import air freight market.

5. Conclusion

Using an instrumental qualitative case study research design, this study has examined the development of the low-cost carriers (LCCs) in Australia's export and import air freight markets. The period of the study was from 2004 to 2019. The qualitative data was analyzed using document analysis. The study was underpinned by a case study protocol and research framework that followed the guidance of Yin (2018).

The case study revealed that the development of the low-cost carriers (LCCs) share of Australia's annual export air freight market occurred in three distinct phases. In the initial phase, 2004-2005, the market was served by just one low-cost carrier (LCC) Pacific Blue Airlines who did not transport any export air freight in 2004. In 2005, the airline made a strategic policy decision to transport air freight in the lower deck belly holds of its Boeing B737-800 aircraft. Thus, in 2005, Pacific Blue Airlines became the first low-cost carrier (LCC) to uplift export air freight from Australia. Phase 2 saw the inception of international services by Jetstar Airways in 2006. Jetstar Airways immediately gained export air freight traffic, and hence, became the second low-cost carrier (LCC) to serve Australia's export air freight market. The third phase took place from 2007 to 2020, when the major Asia-based low-cost carriers entered the market, starting with AirAsia-X in 2007. The low-cost carriers (LCCs) share of Australia's export air freight traffic increased from 132.6 tonnes in 2005 to a high of 20,713 tonnes in 2018. The low-cost carriers (LCCs) share of Australia's annual import air freight market followed a similar trend as that for the low-cost carriers (LCCs) export air freight tonnage. In the early years of the market (2005-2007), there was very rapid growth in the annual enplaned import air freight traffic of the low-cost carriers (LCCs). This was particularly so for Jetstar Airways who transported significant tonnages during this period. Once again, following the introduction of services by the Asia-based low-cost carriers, the low-cost carriers (LCCs) annual import air freight traffic continued to increase from 2007 to 2019, with the only exceptions occurring in 2013, 2019, and 2020, when the annual volumes of import air freight traffic carried by the low-cost carriers (LCCs) declined. The low-cost carriers (LCCs) increased their uplift of Australia's annual import air freight traffic from a low of 117.1 tonnes in 2005 to a high of 37,949.40 tonnes in 2018.

As previously noted in the case study, the low-cost carriers (LCCs) serving Australia's export and import air freight market's annual growth rates oscillated quite markedly over the study period. During the infancy period of the low-cost carriers' (LCCs) participation in Australia's export air freight market (2004 to 2006), the low-cost carriers (LCCs) annual export air freight market growth rates were exceptionally high as they gained a foothold in Australia's export air freight market. The highest annual growth rates were recorded in 2005 (+132.6%), 2006 (+626.24%), and 2007 (+404.17%), respectively. From 2007 to 2020, the low-cost carrier's annual export air freight growth rates were higher than the full-service network carriers and the dedicated all-cargo carriers in 2007, 2008, 2010-2012, and in 2014, respectively. In 2009, the full-service network carriers had the highest annual export air freight market growth rate (+4.48%). The dedicated all-cargo carriers recorded the highest annual export air freight market growth rates in 2013 and then again from 2015 to 2020. Towards the latter years of the study (2017 to 2020), the low-cost carrier's (LCCs) annual export air freight market growth rates were appreciably lower than those of their full-service network airlines (FSNCs) and dedicated all-cargo carrier counterparts. Like the situation with Australia's export air freight market, the low-cost carriers (LCCs) experienced very high annual import air freight market growth rates from 2005 to 2007, as they gained entry to this market. The inception of operations by Jetstar Airways in 2006 was particularly notable, as the airline immediately had success in capturing import air freight traffic. The low-cost carriers highest annual import air freight market growth rates were recorded in 2006 (+900.08%) and 2007 (+833.5%), respectively. From 2007 to 2020, the low-cost carriers had the highest annual import air freight market traffic growth rates from 2008 to 2010, again in 2012, and once again from 2014 to 2017. In 2011, the dedicated all cargo carriers recorded the highest annual import air freight traffic growth rate (+11.2%). In 2018 and 2020, the dedicated all cargo carriers once again had the highest annual import air freight traffic growth rates continuing their strong position in the market. Over the study period, the full-service network airlines (FSNCs) annual import air freight traffic growth rates only exceeded the low-cost carrier's (LCCs) annual growth rate in two years. These were in 2011, when the low-cost carriers (LCCs) import air freight traffic growth rate was 2.62% and the full-service network carriers was 5.73%, and in 2018, the full-service network carriers (FSNCs) annual import air freight traffic growth rate was 3.53% versus the low-cost carrier (LCCs) annual import air freight traffic growth rate of 3.03%.

Throughout the history of serving Australia's export air freight market, the low-cost carriers (LCCs) have steadily increased their annual share of the market. In 2005, the low-cost carriers (LCCs) carried 0.05% of Australia's annual export air freight traffic, this was the lowest market share over the study period. In 2019, the low-cost carriers (LCCs) carried 1.90% of Australia's annual export air freight traffic. The low-cost carriers (LCCs) highest annual export air freight market share was in 2016, when they carried 3.96% of Australia's export air freight traffic. The dedicated air cargo carriers annual export market share fluctuated over the study period, from a low of 2.31% in 2010 to a high of 16.44% in 2020. The full-service network carriers (FSNCs) held the major export air freight market share over the study period. The full-service network carriers (FSNCs) highest annual export market share was recorded in 2010, when they carried 95.82% of Australia's annual export air freight traffic. The full-service network carrier's (FSNCs) lowest annual share of Australia's export air freight market occurred in 2020, when these airlines uplifted 81.66% of Australia's annual export air freight traffic. The low-cost carriers (LCCs) have also successfully increased their share of Australia's annual import air freight market. In 2005, the low-cost carriers (LCCs) import air freight market share was 0.03%, whilst in 2020 the low-cost carriers (LCCs) carried 2.23% of Australia's annual import air freight traffic. The low-cost carriers (LCCs) highest annual import air freight market share was recorded in 2017, when they uplifted 6.54% of Australia's annual import air freight traffic. The dedicated all-cargo carrier's annual import air freight market share remained relatively constant over the study period. The lowest annual import market share was recorded in 2009 (7.15%), and the highest annual import air freight market share was in 2020 (22.11%). The full-service network carriers (FSNCs) carry the largest share of Australia's annual import air freight traffic. Over the study period, their highest annual import air freight market share was 91.57% in 2005. In the latter years of the study (2016-2020), the full-service network carriers (FSNCs) annual import share had decreased on a year-on-year basis and stood at 75.65% in 2020; this was the lowest annual import market share recorded by the full-service network carriers (FSNCs) during the study period.

Since launching services to Australia in 2007, AirAsia-X has consistently increased its export air freight market share from a low of zero in 2007 to a high of 1.77% in 2019. Cebu Pacific Airlines has followed a similar trend and increased its export air freight market share from 0.03% in 2014 to 0.55%

in 2019. Jetstar Airways export air freight market share oscillated throughout the study period, from a low of 0.09% in 2006 to a high of 1.99% in 2012. In 2020, Jetstar export air freight market share was 0.12%. Australia's aviation industry was badly impacted by the Corona virus pandemic and the subsequent border closures in 2020. Throughout its history of international services, Jetstar Airways has been the leading low-cost carrier in Australia's import air freight market. Jetstar Airways increased its import air freight market share from 0.12% in 2006 to a high of 3.22% in 2012. Air Asia-X has also successfully increased its share of Australia's annual import air freight market. The airline has increased its market share from 0.03% in 2007 to 1.60% in 2019. AirAsia-X highest annual import air freight market share was recorded in 2013, when it accounted for 2.31% of Australia's annual import air freight market. Cebu Pacific Air has steadily built its import air freight market share from 0.01% in 2014 to 0.58% in 2019. Scoot Tigerair export air freight market share increased from a low of 0.29% in 2012 to a high of 1.64% in 2016. The airline did not carry any export air freight traffic from Australia in 2013. In 2020, Scoot Tigerair export air freight market share was 1.06%. Scoot Tigerair lowest annual import air freight market share was recorded in 2019 (0.44%), whilst the airline's highest annual import air freight market share was recorded in 2017 (1.44%). Jetstar Asia, Indonesia Air Asia and Thai Air Asia-X also provide import and export air freight services to and from Australia, however, due to the smaller volumes of air freight traffic carried these airlines market shares are quite small to those of AirAsia-X, Cebu Pacific, Jetstar Airways, and Scoot Tigerair.

A limitation of the present study was that it was restricted to a single market, that is, Australia's export and import air freight markets. A possible future study could conduct a cross-sectional analysis of the low-cost carriers' (LCCs) air freight traffic volumes and market shares in other air freight markets. A further limitation of the study was that was based on enplaned air freight tonnages. An import metric used in the air freight industry is the freight tonne kilometres flown (FTKs). Freight tonne kilometres (FTKs) are generated by airlines when they transport one tonne of cargo one kilometre. Should this data become available in the future then it could be used to empirically examine the low-cost carriers (LCCs) air freight FTKs vis-à-vis their competitors, the full-service network airlines (FSNCs), and the dedicated all-cargo carriers.

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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Presenteeism Among Ab-initio Pilots in Turkey

Bilal Kılıç[1*], Melis Tabak[2]

[1*]Nisantasi University, School of Aviation, Pilot Training Department, Istanbul, Türkiye. (capt.bilalkilic@gmail.com).
[2] Ozyegin University, Faculty of Aviation and Aeronautical Sciences, Istanbul, Türkiye. (melis.tabak@ozu.edu.tr).

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Abstract

In this study, we set out to estimate the prevalence of presenteeism and to define its possible association with organizational factors, committing errors and stress among ab-initio pilots. Presenteeism is a major safety-related issue and has been extensively studied in a variety of occupation groups. As a cross-sectional study, a self-administered questionnaire was used to collect the data from ab-initio pilots. The participants assessed themselves on the Stanford Presenteeism Scale (SPS-6). Correlation analysis was performed to explore the association between organizational factors and presenteeism. Based on the findings, the prevalence of presenteeism was 29.1 percent among the ab-initio pilots (N=175). Furthermore, there was a strong association between training-related stress ($p< 0.01$) and presenteeism. The student pilots with presenteeism were found to make mistakes during flight. Better and effective supervision for ab-initio pilots was associated with lower levels of presenteeism, highlighting the need for a supportive and comfortable atmosphere in the flight deck in which ab-initio pilots may feel comfortable. The findings presented here may facilitate improvements in the field of aviation safety.

1. Introduction

In recent decades, there has been an increasing interest in research examining presenteeism (Lack, 2011; Lohaus & Habermann, 2019). This term refers to attending work despite complaints and illness (Gosselin et al., 2013). The effect of presenteeism on employees' performance has not received considerable attention (Lohaus & Habermann, 2019). Nevertheless, it may cause unwanted organizational and individual outcomes (e.g., performance deterioration, productivity losses, increased costs, near-miss, incident and accident) (Fapohunda, 2016). A large and growing body of literature has investigated presenteeism in the workplace (Jung et al., 2020; Lack, 2011; Salas-Nicás et al., 2021) Furthermore, this particular phenomenon among students has received considerable attention over the past decade (Akin et al., 2013; Matsushita et al., 2011; Mikami et al., 2013).

Presenteeism may be one of the reasons for employees to underperform their duties and experience organizational consequences in various workplace groups. It may also have severe effects on workers' performance (e.g., reduced situational awareness, mental and physical fatigue of aircrew and air traffic controller) and organizational expenditures (e.g., medical expenses, aircrew scheduling and delayed flight operation) in the context of aviation. Furthermore, reduced performance and motivation of aircrew may be detrimental to flight safety and result in near-misses, aviation accidents and incidents (Kilic, 2021a). There are quite a few studies on presenteeism in aviation (Johansson & Melin, 2018a; Üzüm & Şenol, 2019). However, no research that examined presenteeism among ab-initio pilots has been found.

Recently, the literature has produced numerous results on individual factors and work-related factors causing presenteeism. It has been reported that stress and organizational factors may be attributed to presenteeism (Karimi et al., 2015). The particularity of this study is to elicit this important phenomenon among student pilots. The aims of this study are twofold: first, our study examines the prevalence of the propensity to perform a flight duty while sick. Second, organizational factors associated with presenteeism are explored. Furthermore, the relationship between stress and presenteeism is studied.

1.1. Presenteeism

The simplest definition of presenteeism is attending work while ill (Aronsson et al., 2000). To put it another way, it is defined as presenting to work when one is sick with the result of lack of efficiency (Arslaner & Boylu, 2015)

Various sicknesses may give rise to presenteeism such as headache, muscle pain, allergy, depression, stress, high blood pressure, asthma, diabetes, sleep deprivation and cholera (Dalkılıç & Harmancı Seren, 2018), but they are not the primary reasons for presenteeism. Employees feel anxious about being absent at work due to its possible consequences. The reasons for this anxiety may be listed as work-related demands (replaceability, job insecurity, management style, control over the pace of work and time pressure) and organizational policies (absence policies, disciplinary proceedings to come into work, return to work policies, absenteeism cost, productivity loss)(Gül & Gül, 2016).

Presenteeism has significant outcomes affecting the managerial side of the workplace as well as the individual. In an organizational perspective, presenteeism's adverse effects on the individual create costs for the organization (Cullen & McLaughlin, 2006). Presenteeism losses, usually associated with reduced work output, errors on the job and failure to meet company standards, have been shown to incur 5.1 times more costs than those incurred for being absent at work (Brown et al., 2014). Furthermore, presenteeism may be the origin of the existing illness to become more serious, aggression, fatigue, weak concentration, lack of motivation, and most importantly, accidents and errors due to dysfunction (Ulu et al., 2016). In this perspective, presenteeism may cause catastrophic results with loss of concentration if we consider that ab-initio pilots are inexperienced students (Kilic, 2019). It may be pointed out that presenteeism has worse effects than being absent at work on both the individual and the workplace. There is a considerable number of studies on presenteeism in various sectors such as tourism (Cullen & McLaughlin, 2006), education (Pérez-Nebra et al., 2020), textile (Yılmaz & Günay, 2020), health (Lui et al., 2018) and organizational sectors (Fapohunda, 2016). However, there is only a small number of studies related to presenteeism and aviation (Johansson & Melin, 2018a; Üzüm & Şenol, 2019). Therefore, we set out to study presenteeism in aviation.

1.2. Presenteeism and Aviation

Presenteeism is a contemporary concept which is common among employees in occupations with extensive interpersonal interaction (Lui et al., 2018). In the field of aviation, presenteeism among pilots is considered a safety-related problem because of the fundamental corollaries of this phenomenon (e.g., productivity loss, distraction, stress increase and adverse mental and physical states) (Καυγάς, 2015). There are several factors that lead pilots to go to work despite being sick, such as anxiety about job security, negative peer censure or judgment or strong pressure from management for employees (Καυγάς, 2015) (Kilic, 2021b).

Pilots are prone to making errors when they are ill (Johansson & Melin, 2018a) (Kilic, 2020a). There is an association between errors and adverse psychological and mental states of aircrew (e.g., sickness, stress, fatigue, loss of situational awareness and lack of vigilance) (Kilic & Gumus, 2020) (Kilic & Soran, 2019)(Kilic, 2022)

Adverse physiological and mental states of the aircrew were attributed to 29% of training flight accidents (Kilic, 2019), 7% of air cargo accidents (Kilic & Gündogdu, 2020) and 16% of hot-air balloon accidents (Kilic, 2020b).

Interestingly, deteriorated situational awareness and fatigue of flight crew were reported as the most important factors causing gross navigation errors during transatlantic flights (Havle & Kılıç, 2019). The prevalence of presenteeism among airline pilots has been widely investigated. It has been demonstrated that 63% of pilots performed a flight duty when they were sick. Pilots with reported presenteeism mentioned that they made more errors (Johansson & Melin, 2018a). Therefore, pilots' awareness of health issues plays an important role in ensuring flight safety (Kilic & Soran, 2020).

Student pilots may be more prone to failures due to lack of experience and presence of stressors (Kilic, 2021a; Kilic & Ucler, 2019) (Kilic, 2021c). It is highly likely that student pilots may feel stressed and anxious about instructors' criticism, classmates' censure and judgment and competitiveness among them (Saipanish, 2003). These factors may give rise to presenteeism among ab-initio pilots. When a student pilot performs a training flight with health issues (e.g., headache, stomachache, inner ear infection, flu, vestibular neuritis and motion sickness), there may be deterioration in concentration and an increase in stress level that may impede flight safety (Orford & Silberman, 2008). It has been already reported that impaired concentration poses a greater safety risk for student pilots, their colleagues and for their flight schools (Kilic, 2019). Furthermore, sick students may endanger their peers due to spread of disease and decline in performance (Kilic & Tabak, 2022).

2. Methods

2.1. Participants and Procedure

The questionnaire was delivered to 520 student pilots across five flight training organizations in Turkey. In the population of the study, 175 students completed the questionnaires. The response rate was %33,65. Participation was voluntary and anonymous. The study was approved by Özyeğin University's Human Research Ethics Board (2020/16/02).

2.2. Measures

The data were collected from 175 ab-initio pilots on general demographics including gender, age (17-23 years, 24-30 years or 31 years), type of pilot license (student pilot license, private pilot license or commercial pilot license), flying hours (0-50 hours, 51-100 hours, 101-200 hours or 201 hours). Regarding variables related to organizational factors, the attitudes of flight instructors, the relationship between student pilots and instructors and support of instructors were taken into account. Workplace stress was included as a confounding factor in our study. The prevalence of presenteeism was measured through the question "During the last 12 months, have you begun a flight even though your health status made it reasonable to take sick leave?" If the participants answered yes to this question, they were requested to answer the following six questions developed in the SPS-6 scale (Koopman et al., 2002).

2.3. Statistical Analysis

In data analysis, as descriptive statistics, frequency, percentage, mean and standard deviation values were calculated. Reliability analysis and factor analysis were applied in examining the presenteeism scale and presenteeism-related organizational factors scale. Examination of these two scales based on the characteristics of the participants, their stress status and error-making status involved t-test, analysis of variance, and in examining the group causing the differences, Sidak test. To investigate the levels of relationship between the dimensions, correlation analysis was carried out. In the study, $p<0.05$ was accepted as statistically significant. The analyses were conducted by using the SPSS (Statistical Package for the Social Sciences) 25.0 package software.

3. Result and Discussion

3.1. Results

Among the participants, 80.6% were male, and 19.4% were female. The ages of the participants were 17-23 by 62.3%, 24-30 by 16.6% and 31 or older by 21.1% The licenses that the participants had were Commercial Pilot License (CPL) by 8%, Private Pilot License (PPL) by 64 % and Student Pilot License (SPL) by 28%. The flight experience of the participants was as 0-50 flying hours by 32.6%, 51-100 flying hours by 42.9%, 101-200 flying hours by 17.1% and 201 flying hours or longer by 7.4%.

Table 1 shows that the reliability level of the presenteeism scale (sp1-sp6) was 0.77, which showed a generally reliable level. As a result of the factor analysis, it was determined that the Presenteeism Scale had one dimension as the Presenteeism dimension. The KMO sample adequacy coefficient calculated in the study was 0.72. The explanation rate of the total variance was observed as 44%. The aforementioned coefficient showed that 51 questionnaire forms were adequate for factor analysis. Additionally, according to the result of the Bartlett's test on the significance of the factor structure ($p=0.01$, $p<0.05$), the obtained construct was significant.

Among the participants, 29.1% took part in flights despite being sick in the last 12 months. The participants stated that they never (10.9%), occasionally (71.4%), sometimes (8.6%), frequently (7.4%) or highly frequently (1.7%) took part in flights despite being sick and made mistakes. The participants also reported that they never (1.1%), occasionally (12%), sometimes (25.1%), frequently (42.9%) or highly frequently (18.9%) found flight training stressful.

Table 2 shows that there was a significant, weak and negative relationship between the participants' Presenteeism and Organizational Factors scores ($r=-0.36$, $p=0.01$). The education provided within the flight training to the students, the students' practices and the practices of the trainers were found to significantly reduce the students' presenteeism levels. There was a statistically significant relationship between strong support from the supervisor and low presenteeism.

Table 3 shows that the presenteeism levels of the participants differed based on their genders. The presenteeism levels of the men were significantly higher than those of the women ($p=0.04$).

It was observed that the presenteeism levels of the participants differed based on their ages. In the study, it was seen that the presenteeism levels of the students at the ages of 24-30 were significantly higher than those at the ages of under 23 or over 31 ($p=0.01$).

It was found that the presenteeism levels of the participants differed based on the types of their pilot licenses. The presenteeism levels of the students with a CPL license were significantly higher than those with an SPL license ($p=0.01$). It was determined that the presenteeism levels of the participants differed based on their flight experience. It was seen that the presenteeism levels of those with an experience of 201 flight hours or longer were significantly higher than all others with an experience of 200 flight hours or shorter ($p=0.01$). It was identified that there was a difference in the presenteeism levels of the participants based on their statuses of taking part in flights despite not being suitable for flight and making mistakes. It was observed that those who reported presenteeism made higher levels of errors ($p=0.01$). The presenteeism levels of the participants differed based on their statuses of finding the flight training stressful. In the study, those who never or occasionally found the flight training stressful had lower presenteeism levels ($p=0.01$).

3.2. Discussion

This study set out with the aim of examining the prevalence of presenteeism and examine possible associations with organizational factors, stress and committing errors among ab-initio pilots. The results of this study showed that presenteeism was prevalent among ab-initio pilots, and there was an association between organizational factors (e.g., supervisory support) and presenteeism. It is interesting to note that low support from the supervisor gave rise to presenteeism. This was consistent with previous results (Leineweber et al., 2011). Another important finding was that the ab-initio pilots who considered pilot training as stressful reported presenteeism.
The most interesting finding was that the ab-initio pilots with reported presenteeism made more errors, suggesting presenteeism to be a significant threat to flight safety. This was well in-line with previous findings (Johansson & Melin, 2018b). These findings suggested that supervisory support (e.g., encouragement by flight instructor) is of great importance for preventing presenteeism among student pilots. The ab-initio pilots with longer hours of flying experience exhibited higher presenteeism compared to the less experienced ab-initio pilots over the past year. It may be therefore assumed that higher level of flying experience may give rise to overconfidence among trainee pilots and tendency to go flying when they are sick.

4. Conclusion

Presenteeism may give rise to unwanted occurrences in aviation. Ab-initio pilots are especially prone to committing errors in the cockpit even under normal circumstances due to their limited flight experience (flight hours). Henceforth, we set out to examine presenteeism among ab-initio pilots.

This study has shown that the prevalence of presenteeism was 29% among the ab-initio pilots. Presenteeism among student pilots may cause various negative effects, such as reduced attention, deteriorated situational awareness and making errors. One of the more significant findings to emerge from this study was that the ab-initio pilots with presenteeism made more errors. Therefore, pilots with acts of presenteeism are a potential risk to flight safety. Organizations (e.g., aviation authorities, universities and flight training organizations) need to prepare ab-initio pilots to cope with presenteeism.

It was also shown that stress and supervisory support were strongly associated with presenteeism. Therefore, it is essential that supervisors (e.g., flight instructors, academic advisors and faculty members) should listen to ab-initio pilots' stress and difficulties and share their personal experience to improve training and reduce stress. Emotional and technical support should be provided by supervisors. Based on the rules and regulations implemented by civil aviation authorities, pilots shall be refrained from the duty when they are not fit (e.g., adverse mental or physical state), which may jeopardize flight safety.

The findings in this study are subject to at least two limitations. First of all, the ab-initio pilots might have hesitated to participate in the questionnaire. Secondly, the participants might have not objectively answered the questions. Further research regarding the role of mental health would be worthwhile.

This is the first study examining presenteeism among ab-initio pilots. The results of this study make a major contribution to the field of aviation safety.

Table 1. Reliability and Validity Tests for dimensions

Dimension	Statement	Factor Loads	Explained Variance	Reliability	KMO
Presenteeism (n=51)	sp1	0.51	44%	0.77	0.72
	sp2	0.52			
	sp3	0.54			
	sp4	0.50			
	sp5	0.52			
	sp6	0.56			
Organizational factors (n=175)	OF1	0.62	52%	0.85	0.83
	OF2	0.63			
	OF3	0.65			
	OF4	0.66			

Table 2. Examination of the relationship between Presenteeism and Organizational Factors

Dimensions		Organizational Factors
Those reporting presenteeism	R	-0.36
	P	0.01*
	n	51

Table 3. Presenteeism and Participant Characteristics

Student Characteristics and Views		Presenteeism (Yes n=51) X±SD	p
Gender	Male	3.23±0.55	0.04*
	Female	3.10±0.65	
Age	17-23	3.26±0.53	0.01*
	24-30	3.56±0.31	
	31 or older	2.96±0.64	
License Type	CPL	3.50±0.44	0.01*
	PPL	3.24±0.61	
	SPL	3.01±0.47	
Flight Experience	0-50 hours	3.19±0.42	0.01*
	51-100 hours	3.11±0.58	
	101-200 hours	3.36±0.90	
	201 hours or longer	3.72±0.09	
I have made an error during flight as I took part in flight despite being unsuitable for flight in the last 12 months	Never	2.58±0.73	0.01*
	Occasionally	3.23±0.37	
	Sometimes	3.43±0.19	
	Frequently-Highly Frequently	3.50±0.54	
I find the flight training stressful	Never-Occasionally	2.64±0.66	0.01*
	Sometimes	3.08±0.39	
	Frequently	3.22±0.54	
	Highly Frequently	3.77±0.18	

Appendix

1. Gender
   a. Female
   b. Male
   c. Prefer not to say

2. Age
   a. 17-23
   b. 24-30
   c. 31 and older

3. Holding type of license
   a. SPL
   b. PPL
   c. CPL

4. How many flying hours experience do you have?
   a. 0-50
   b. 51-100
   c. 101-200
   d. 201 and more

5. I consider my work (flight training) stressful
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly agree

6. During the last 12 months, have you begun a flight even though your health status made it reasonable to take sick leave? If yes, please answer the following questions. If no, please do not answer the following questions.
   a. Yes
   b. No

7. Because of my (health problem), * the stresses of my job were much harder to handle.
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly agree

8. Despite having my (health problem), * I was able to finish hard tasks in my work (flight duty).
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly agree

9. My (health problem) * distracted me from taking pleasure in my work (flight duty).
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly Agree

10. I felt hopeless about finishing certain work tasks, due to my (health problem).
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly Agree

11. At work (flight duty), I was able to focus on achieving my goals despite my (health problem).
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly agree

12. Despite having my (health problem), * I felt energetic enough to complete all my work (flight duty).
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly agree

13. I have made errors in the cockpit due to flying in unfit states (Presenteeism) during the last 12 months?
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly Agree

14. My immediate supervisor (flight instructor) gives me the encouragement I need
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly Agree

15. When the workload is heavy, my immediate supervisor (flight instructor) makes sure that my burden is lessened
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly agree

16. I am confident enough to express critical opinions without fear of reprisals from my immediate supervisor.
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly Agree

17. My immediate supervisor (flight instructor) makes sure that I do not begin a flight while feeling tired, fatigued, or unfit for other reasons
   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly Agree

Ethical approval

The study was approved by Özyeğin University's Human Research Ethics Board (2020/16/02).

Conflicts of Interest

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

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Investigation of Organizational Power Distance Levels of Pilots Working on Airlines in Turkey: Flight Safety and Professional Courtesy Dilemma

Özlem Çapan Özeren[1*], Şener Odabaşoğlu[2] and Güray Tezer[3]

[1*]Maltepe University, Civil Air Transport Management Program, Istanbul, Türkiye. (ozlemozeren@maltepe.edu.tr).
[2] Maltepe University, The Head of Department Aircraft Technologies, Istanbul, Türkiye. (senerodabasoglu@maltepe.edu.tr).
[3] Beykoz University, Istanbul, Türkiye. (guraytezer@gmail.com).

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Abstract

This study aims to obtain new data that will mediate the development of safety culture by investigating the power distance, which is one of the cultural dimensions of communication, and causes accidents in aviation, through the assertiveness levels of the pilots and their social approval needs. The method of this research is quantitative, data were collected through online questionnaires. The population and the sample of the research are consisted of the civilian pilots in Turkey. The questionnaires were applied to 75 pilots. In male pilots participating in the study; The levels of "Instrumental Use of Power" and "Legitimation of Power", which are sub-dimensions of organizational power distance, are significantly higher than female pilots. In addition, it has been revealed that female pilots pay less attention to the judgments of others than male pilots. These results suggest that male pilots need more organizational power than female pilots. One of the results of the research is the strong positive relationship between the assertiveness level of the participants and "Consent to Power", which is one of the sub-dimensions of power distance; it is thought that this relationship stems from the social adaptation capacity of assertive individuals. The study also showed that the main factor determining the behavior of the employees is the organizational culture. Within this scope, sharing the accident reports of Turkish registered aircraft prepared by Transport Safety Investigation Center with researchers and institutions will contribute significantly to the need for resources.

1. Introduction

National culture consists of common beliefs, values , and attitudes that shed light on the perception, thought, reasoning, decision-making, and relationship styles of people living together (İlhan, 2019). These common values are shared, through the relations established among the members of the society, and are transformed into actions and reproduced over time. In this way, the culture that societies have developed by transferring it from generation to generation has an integrating role. Individuals carry the effects of the culture they were born and raised in for a lifetime (İlhan & Alimanoğlu Yemişci, 2020).

Culture is a fabric of meaning that guides and develops the attitudes, beliefs and actions, institutions and rules (Acar, 2018), and forms of communication of a certain group of people regarding their lives in society (Hofstede, 2001). According to Blumer (1969, p. 2), individuals establish relationships with each other and with objects through the common values mediated by this fabric of meaning. Individuals are born into a unique national culture in which their daily life practices and interpersonal relationships are regulated, and they remain under the influence of the culture of the society they belong to until the end of their lives (İlhan & Alimanoğlu Yemişci, 2020). The culture acquired through these influences is internalized through time and becomes the characteristic of the individual (Kottak, 2012). Bourdieu associated the social with the individual and developed the concept of habitus. Habitus, which means the person's social capital, includes all kinds of social bonds and interpersonal relationships (Bourdieu, 1990), and determines the attitudes and behaviours of people. While making their choices, individuals rely on their own habitus (Çağırkan, 2017).

If the concept of culture is defined as the sum of the values, beliefs, rules, and institutions of the society, organizational culture is the sum of all these values and the emphasis is placed on its use to provide competitive advantage (Acar, 2018). In other words, organizational culture is described as a set of common values, beliefs, traditions, assumptions, norms that guide the behavior of employees and keep them together to achieve a goal (Deal ve Kennedy, 1982; Kast ve Rosenzweig, 1985; Nahavandi ve Malekzadeh, 1999). The internal functioning of the employees, their practices regarding human resources, and interpersonal relations constitute the culture of that organization (Alper ve Erdem, 2021). Organizational culture also affects the emotions, thoughts, and behaviour patterns of its members (Cameron, 2013; Wasti, 1995). The culture of organizations is not independent of the culture of the nation. Because the members of the organization create the organization's own culture by integrating the national culture into their intra-organizational ways of doing business, interpersonal relations, attitudes, and behaviours. Therefore, national culture shapes both organizational culture and working life. In addition to this, according to Hofstede and Peterson (2000), national culture has a bigger role in the social relations individuals establish than the culture of the institution they work in (Hofstede and Peterson, 2000).

On the other hand, the structure of national culture would be better understood by looking at the relationship between the individual and power (İlhan & Alimanoğlu Yemişci, 2020). Studies on organizational culture have focused on the concept of power and its effect. According to these studies, while power is explained as the ability to influence another and to lead them to a certain behavior, individuals who exhibit the ability to attract different people in the direction they want are called "strong" (Koçel, 2018). Culture permanently affects the behavior of society and individuals and the power distance in relationships. The Middle East where Turkey is also located, the Far East, South Asian and North African societies have high power distances (Çetingüç, 2021; 781). Power distance is one of the concepts used to explain power relations in society (Yorulmaz et al., 2018). This concept has been defined as “the degree of inequality between less powerful individuals in the same social system and those who are stronger than them” (Hofstede, 2001, 83). Hofstede's "power distance", which means the unfair distribution of power, is also a major determinant of interpersonal relations at the organizational level. As the difference or distance between the powers grows, the dominance of the stronger individual over the less powerful increases (Solmaz & Serinkan, 2020). Thus, people in social life are positioned to be privileged or at a lower level according to their financial status, political preference, status, rank, seniority, race, religion, and gender (Çetingüç, 2021; 781). On the other hand, power distance shows the extent to which the unequal distribution of power is accepted by the less powerful members of the organization. People working in organizations with high hierarchy and high power distance associated with this high hierarchy have an attitude suggesting that “because they believe their rulers are above and stronger than them; the commands that are given by the organization should be followed without question; the power of the management must be respected, the stronger should always have more privileges, and the less powerful should be subordinate to the powerful” (Bolat ve Duranay, 2018).

Individuals in communitarian and high power distance cultures, such as Turkey, give importance to social harmony and obedience to their hierarchical superiors. Studies, that were conducted in parallel to this, have shown that the individualistic culture is superior to the communitarian culture in promoting aviation safety (Soeters & Boer, 2000; Li et al., 2009). The role of organizational factors in air transportation, which gains momentum with the developing technology and comes to a safe level day by day, is gaining more importance day by day (Ustaömer and Şengür, 2020). Because the accidents experienced due to technical reasons in the early days of aviation are generally the result of human and organizational factors today. Researches have shown that people who cause accidents have common behavioral tendencies, human factors such as stress, fatigue or insomnia as well as personality traits are determinative, and external causes such as equipment, culture, rules and procedures, and organization also prepare an environment conducive to the accident. By the concept of human factor is meant the mutually sustained relationship between man, machine and environment. On the other hand, when we consider every accident, incident and near miss, a chain of errors is encountered. For this reason, causal factors for each event should be categorized separately and in detail with modern analysis methods.The Human Factors Analysis and Classification System (HFACS) was developed to understand the underlying causes that could lead to an accident in aviation. HFACS considers human factors at four levels: unsafe actions, preconditions for unsafe actions, unsafe supervision, and organizational effects (Wiegmann and Shappell, 2003). At the fourth level, Organizational Climate refers to the working atmosphere within the organization (eg structure, policies, culture). In the aviation industry, the organizational culture should be in a form that is independent of power distance and is integrating safety elements into all ways of doing business. This is because one of the reasons for the lack of communication that leads to accidents in aviation is cultural and originates from power distance (Ustaömer, 2020). According to Gladwell (2009), a significant portion of aircraft accidents is due to a lack of communication (Gladwell, 2009). Research has revealed that, in the aviation industry, nations with high power distance have more aircraft accidents. Accordingly, in the root cause analyses carried out in the aircraft crashes in fourteen NATO countries; it has been found that the share of organizational elements in accidents involving pilots from high power distance countries such as India and Taiwan is higher compared to their US counterparts (Martinussen and Hunter, 2010). Regional differences in accident rates suggest that there may be something else behind simple human error in these accidents (Jing, Lu & Peng, 2001). Tear et al., (2018) revealed that national culture interacts with intra-organizational safety culture and power relations in organizations. Accordingly, before evaluating the organizational safety culture or before a change attempt regarding this culture, it is extremely crucial to consider the impact of upper and lower dynamics on the culture (Tear et al., 2018).

In organizational cultures where power distance is high, it is seen that the co-pilot uses a "softened language" or "Extreme professional courtesy" during communication to show respect for authority. In middle and far eastern societies where the power distance is high, excessive professional courtesy is more common than western societies. In a simulation study conducted by United Airlines to investigate excessive professional courtesy, the captain of the aircraft was asked to undetectedly stop flying the aircraft during the approach and act as if there was no problem. In the simulation, it was observed that 25 percent of those sitting in the second pilot's seat did not pay attention to what the captain did, or did not take the controls from the captain even if they noticed, and turned a blind eye to the accident (Çetingüç, 2021 :785).

In high-risk industries such as aviation, speaking (giving feedback) is like a matter of life and death and has a very crucial role in reducing errors (Bienefeld and Grote, 2014). On the other hand, in a cockpit with a high power distance, even if they see the wrong commands of the captain pilot, the second pilots prefer not to make a sound instead of intervening, and they watch both their own deaths and the deaths of hundreds of people (Çetingüç, 2021;781). Due to the hierarchical discipline in the cockpit, second pilots are reluctant to express their opinions to the captain and give feedback on a situation that went wrong. This is because pilots who dare to give feedback to the captain are exposed to an environment where they are reprimanded, accused of cowardice, ridiculed, and humiliated, which is governed by a toxic communication incompatible with professionalism. Therefore, when an emergency occurs in a cockpit with the authoritarian captain pilot, it is seen that the second pilot has a fear of retaliation such as “If I interfere with the captain, he will get angry with me and he will make me pay for it” (Reader & O'Connor, 2014; Detert & Edmondson, 2011). In other words, in a cockpit environment where the power distance is high and hierarchical superiors are seen as untouchable, the fact that the captain pilot calls the second pilot nicknames such as "son, kiddo, newbie" and gives commands with imperative forms, and the second pilot does not object to such treatment, and responses with "My Commander, my teacher, my big brother" is far from meeting the requirements of a healthy, safe and equidistant working environment (Çetingüç, 2021;782). As such status differences create feelings of inferiority and superiority in employees, low-status individuals underestimate the value of their own contributions and prefer to wait for higher-status employees to make decisions by applying self-censorship (Driskell & Salas, 1991).

On March 11, 2018, one of the airspeeds on the TCTRB registered aircraft belonging to MC Aviation malfunctioned and gave an Overspeed warning condition, therefore stall protection system (SPS) was activated and the aircraft started to push the nose down. The captain's reaction was to pull up on the control wheel repetitively and finally ended in dual engine flameout and pass to stall condition accordingly. The cockpit crew who took the training on what to do with an emergency situation, could not respond to the malfunction in a fully coordinated and effective manner as written in the emergency procedures. The captain's behavior interrupted the co-pilot's attempts to read the emergency checklist three times. Despite all the efforts of the co-pilot, the emergency checklist could not be read, the captain pilot held the nose of the airplane and forced the engines, resulting in the loss of both engines. Despite all warnings from the co-pilot the captain continued to hold onto the plane's nose and the pilot did not take the necessary action, which led to the crash of the plane. Despite all these errors of the captain, the fact that the co-pilot does not take the control from the captain is considered a problem within the power distance (Parallel to this situation, the Guam crash experienced by Korean Air on 06 August 1997 can be given as an example. In the crash, the captain pilot who became sleepy started to descend, thinking that a light they saw twenty miles from Guam was an airport. Although the second pilot realized that the meteorological conditions were not suitable for landing at the airport, he could not express the situation to the captain out of fear because the aircrew knew that the captain did not welcome the warnings from their subordinates. In the end, a warning was given by the flight engineer to the captain for them to go around, who tried to land despite heavy fog and rain at midnight, but the warning was not taken into consideration by the captain. After the engineer insistently told them to pass for the second time, the captain pilot did but because they reacted late to the warning, the accident took place and that caused the plane to crash into the ground and killing 228 people (NTSB, 2000). In the year of the accident, the accident/loss rate of United Airlines, one of the American airlines, was 0.27 per four million departures, while the loss rate of Korean Airlines for the same period was 4.79. This means that Korean Air had 17 times more loss per million departures than United Airlines. After this accident, Delta and Air France terminated their cooperation with Korean Air (Freivalds, 2009).

In cultures with high power distance, feedback and reporting for errors are low due to fear of punishment. Members of the organization with relatively lower power do not speak up to their hierarchical superiors, even if they are wrong or mistaken, or do not fulfill their responsibilities to prevent mistakes by being overly courteous. The decision to speak up often involves some uncertainty as to whether a concern is justified, whether an idea is worthwhile, or whether a question is reasonable (Tear et al., 2018). Another factor that determines the interaction between teams is the psychological security levels of team members. Edmondson (1999a) used the term psychological security to describe team members' beliefs that they can take interpersonal risks without fear of punishment, rejection, or embarrassment. Accordingly, it is thought that the level of psychological security is a subjective situation that mediates the decision not to remain silent (Bienefeld & Grote, 2014). On the other hand, excessive professional courtesy or softened language can be experienced even in crises with the risk of death at the end. One of the accidents that best reflects this situation occurred on March 10, 1989 in Canada. According to the extremely detailed accident report, it is seen that the root cause of the accident is power distance. From the analyzes in the report, the themes related to power distance were examined and it was tried to draw attention to their role in the accident. According to this report, the Air Ontario type F28 airplane with flight number 1363 took off from Dryden airport without having the ice and snow on its wings cleaned off and crashed into the land 126 meters ahead of the runway end 49 seconds after takeoff. (Moshansky, 1992:1068-1079).

An accident investigation commission, including clinical and social psychologists, was established to investigate why people who saw the snow pile on the wings and were aware of the danger did not talk to the captain. According to the data obtained at the end of the examinations by this commission; it was tried to find out why the pilots, who were flying as passengers at the time of the crash and survived the accident, had not warned the flight crew, although they were aware of the danger. Firstly, Captain Haines, who flew as a passenger on the plane, was asked by the accident commission why he did not take action to warn the flight crew. Captain Haines conveyed that “he assumed that there was a de-icing system on the wings of the aircraft and therefore did not interfere with it when taking off without de-icing". Captain Haines said, "Had I known there was no de-icing system on the plane, I would have blocked its take-off, I would have done everything, including breaking the cockpit door,” (Moshansky, 1992: 1071-1084). When pilot Berezuk, who was sitting in the passenger position, was asked why he did not warn the flight crew about the snow pile on the wing, he stated that until the last point or the last second before take-off, he trusted the pilot to perform the de-icing and was not aware that he had no intention of not doing it. He also emphasized the professional courtesy and respect he felt towards the pilots and defined his not interfering in the cockpit as "a courtesy peculiar to the piloting profession". To the question of “So is it fair to say that the courtesy and respect attributed or acknowledged by the crew on March 10, 1989 outweigh your concerns about the amount of snow on the wings?” asked by the commission, he answered “Yes”. As the reason for his non-intervention, he said that he "trusted the captain and was reluctant as a pilot to give advice to another pilot flying the plane". The people on the plane to prevent this accident did not take any action and kept their silence in the face of this fatal problem (Moshansky, 1992).

Organizational silence is not expressing opinions about the problems encountered, just like in this accident (Macit & Erdem, 2020). This MUM effect is explained by the general reluctance of employees to convey negative information despite possible unrest, and therefore preferring to remain silent. It has been suggested that the MUM effect arises from the feeling of uneasiness experienced during the transmission of bad news, the worry of discord between the reporter and the receiver of the news (Morran et al., 1991), and the feeling of guilt about not being able to share the misfortune of the receiver of the news (Tesser and Rosen, 1972) (Rosen and Tesser, 1970: 254). As the power distance increases, employees experience uneasiness when reporting their concerns about injustice or a problem to their superiors, and they keep their opinions to themselves and keep their silence or distort the truth in order to avoid a negative outcome. Studies have revealed that this situation is experienced bilaterally and that superiors avoid receiving feedback or deliberately delay it (Benedict et al., 1988, Brinsfield et al., 2009).

However, when faced with a crisis in the cockpit, the pilot is expected to establish strong and direct communication with the co-pilot and air traffic unit. Regardless of their job descriptions, the fact that all employees in the enterprise take active responsibility in order to prevent all kinds of mistakes and violations that may lead to accidents determines the level of safety culture in the organization (Güneş et al., 2020). Considered also in terms of Crew Resource Management (CRM), power distance is one of the most critical issues in aviation. Softened language and showing respect only to those who are above oneself hierarchically is one of the most typical indicators of high power distance. In the Avianca-52 accident, which was experienced due to the high power distance and language problems in communication, the plane that made the Bogota-New York flight on January 25, 1990, crashed because it ran out of fuel and 73 passengers on the plane died. The reason for this accident was that the captain pilot of the plane, which was toured for one hour and seventeen minutes during its landing at New York Airport, did not speak English, and therefore, the second pilot, who made contact with the air traffic unit, could not communicate with the tower that the fuel was out and the situation was critical and did not insist on the priority of landing, instead, a softened language was used and eventually the plane ran out of fuel and crashed (NTSB, 1990). In organizations with a high power distance, interpersonal communication is disrupted, and it is seen that accurate and sufficient information cannot be transmitted in a timely manner in emergencies. Employees of organizations with a high power distance may act with hesitance about safety rules, prefer not to interfere with their stakeholders, especially their hierarchical superiors, who misbehave until the last moment, and even if they intervene at the last moment, they cannot prevent the accident from happening because they are late. The accidents experienced as a result of power distance have revealed the importance of equal authorization of the pilots involved in the flying of the aircraft. Within this scope, a four-step progression to survival that has been developed: "Probing, Alerting, Challenging, Emergency (PACE)" to be implemented by the second pilot in case their warnings to a captain pilot who makes wrong decisions are not taken into consideration (Fogarty, 2018) Process of PACE is shown in Fig.1.

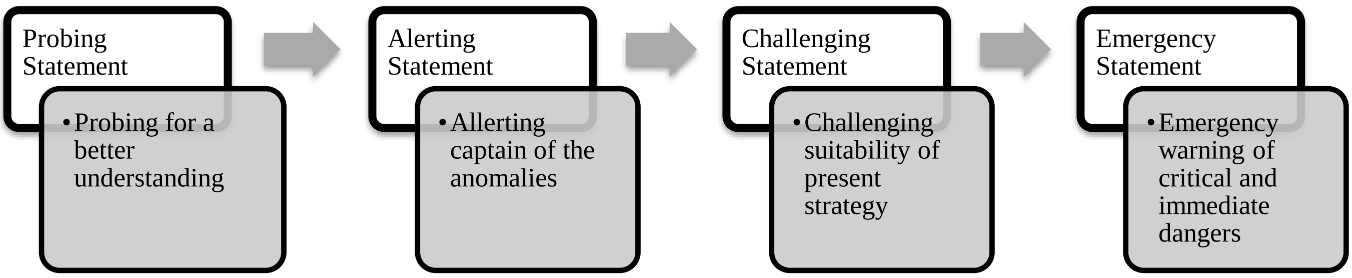

Figure 1. Process of PACE

Approval/attention seeking, which is one of the components of CRM, which has an important place in interpersonal communication and establishing social bonds, is seen at a high rate in individuals who are "Extremely concerned with the opinions of others", "Perfectionists", "Praise-seeking", "Unable to say no", "Helpful" and "Obedisive". However, this need causes the individual to lead a life in line with the wishes and expectations of others rather than his own wishes and needs in countries like Turkey where the communitarian culture is dominant. As the level of need for social approval in individuals increases, the severity of behaviors aimed at seeking the approval of another and avoiding disapproval also increases at the same rate (Karaşar, 2016). In other words, individuals with a high need for approval may be extremely uncomfortable with exhibiting behaviour that they think will not be approved, and may have an obedient attitude that accepts and overlooks mistakes in order to gain admiration.

"Assertiveness", which is one of the interpersonal communication skills, has been translated into Turkish language as "being able to take initiative", "self-confidence", and "ambitious". Its conceptual equivalent is the ability to calmly defend one's own or someone else's rights without attacking anyone or displaying a passive attitude that admits wrongdoing. According to Jakubowski and Spector (1973), assertiveness is explained as "It does not mean to belittle someone else, it also means not to belittle yourself. One can easily make demands from someone else or reject requests from them, when one is rejected, they find it reasonable, their self-confidence is unshaken" (Jakubowski and Spector, 1973 as cited in Voltan, 1980). Assertiveness is thought of as a kind of decision point between aggression and passivity. In summary, assertiveness is the ability to defend oneself and one's rights in an honest, direct, and respectful manner in all communication/interactions with relatives, customers, colleagues, or managers, at work or at home. It has been determined that there is a positive and moderate relationship between self-esteem and assertive personality trait (Sucan et al., 2015). In addition, assertive individuals have higher social adaptation abilities (Simarmata & Rahayu, 2018). According to Yusuf (2006), social adaptation is defined as the ability to respond appropriately to social reality, situations and relationships. Studies show that the higher the assertiveness, the higher the social cohesion will be (Simarmata & Rahayu, 2018).

Human behavior emerges as a result of sociological, psychological, and physical influences as well as personality traits of the individual. Power distance is the cultural dimension of communication and is subject to a sociological framework that determines it. In the studies, the accidents that occur as a result of not responding to the emergency situation adequately due to a softened language or excessive professional courtesy in organizations with high power distance and the relationship of these accidents with power distance are discussed.

However, there is no detailed study that analyzes the sociological aspect of accidents caused by power distance. However, in cultures where collectivism is dominant, like Turkey; there are thought to be individuals who care too much about what other people would say and that those individuals prefer to remain silent and obey instead of expressing themselves in the face of organizational power distance, they especially abstain or display a harmonious attitude towards their hierarchical superiors because they do not consider themselves equal and/or they are afraid of being disapproved (Macit and Erdem, 2020). As a result, it is thought that there is a relationship between organizational power distance and the employee's need for social approval and assertiveness skills. There is a need for a holistic research that investigates the relationship between organizational power distance and the behaviors that lead to aviation accidents and deals with the results from a psychosocial perspective.

1.1. Purpose of the study

This study aims to obtain new data that will mediate the development of safety culture by investigating power distance, which is one of the cultural dimensions of communication, which causes accidents in aviation, through the assertiveness levels of pilots and their social approval needs. With these data, it will be possible to develop communication skills that will contribute to a positive safety culture in aviation. Moreover, this study will provide outcomes that will shed light on the trainings to be given in order to reveal the cultural and communicative barriers that prevent all employees from taking an active role in preventing mistakes and violations, which is one of the most important requirements of safety culture, to provide a suitable environment that will encourage employees to give or report feedback and to improve employees' skills regarding feedback, reporting, and assertiveness.

The hypothesis of this research is based on the assumption that these behaviors of people who cannot defend the truth knowingly because of organizational power distance or who show softened or excessive professional courtesy may be related to their assertiveness skills and the level of their need for social approval. Aviation history has witnessed many aircraft accidents caused by power distance.

It is possible to prevent an aircraft accident caused by power distance, by establishing a safety culture that has been eliminated from all hierarchies of the employees of the organization, for this, there is a need for an organizational culture that encourages its employees to prevent mistakes / violations under any circumstances. In order to prevent accidents in aviation, it is necessary to establish and maintain a management system that will determine the risks of accidents before they occur and control them at acceptable levels by minimizing their damage after they occur. In aviation, this is called the Safety Management System. The establishment of a safety culture depends on how the safety management system in the organization works. One of the components of the Safety Management System, which is defined as the safety management activities performed by the organization in order to ensure acceptable safety, is the promotion of safety within the organization (SMS, 2015).

On the other hand, it is thought that individuals who are overly sensitive to the judgments of others, who care so much to gain the management's attention and leave a positive impression as to compromise safety, are more affected by cultures with a high organizational power distance. It is assumed that as individuals' assertiveness skills increase, they will be less affected by organizational power distance or they will have more courage to cope with safety risks arising from power distance.

In this study, the relationship between the organizational power distance of pilots and their need for social approval and assertiveness levels will be investigated. In this study, the independent variable is organizational power distance, while the dependent variables are assertiveness skills and the need for social approval.

In line with the purpose of the study, answers to the following questions are sought:

- Is there a relationship between the organizational power distance of the pilots and their assertiveness levels and their need for social approval?
- In which direction and what kind of changes are observed in the assertiveness skills of individuals as the organizational power distance increases?
- In which direction and what kind of changes are observed in organizational power distance as the need for social approval increases?
- Is there a relationship between assertiveness skill and need for social approval?

2. Methodology

The design of the research is quantitative and scanning method was used. The population and the sample of the research consists of civilian pilots in Turkey. According to SHGM's 2021 annual report, the number of airline and helicopter pilots in Turkey are 10.734 as of 2021 (SHGM, 2021). The convenience sampling method was chosen as the sample selection method in the research and it was aimed to reach as many different pilots as possible, both from civilian and military backgrounds. Convenience sampling aims to obtain a sample of appropriate elements.

2.1.Research method and data collection

Participants in the study were chosen on a voluntary basis. Between the 30th of September and the 25th of December 2021, it was tried to reach the maximum number of samples, including civilian pilots and pilots of military origin, through an electronic survey. Since most of the participants would be on flights, convenient sampling was preferred. Pilots were invited to participate in the online survey via e-mail. Participants were informed by e-mail that their participation was on a voluntary basis, that their answers would be kept anonymous, and it was emphasized that the data gathered from them would only be used for research purposes. Despite sending questionnaires to more than 500 pilots, giving a three-month response time, and all dissemination efforts, only 75 participants were able to respond. This limited the data of the study

After the application of the questionnaire, construct validity was tested with Confirmatory Factor Analysis, validity with criterion validity, and reliability by calculating the internal consistency coefficient.

Questionnaire; Consent form, and demographic questions, including the adapted one, were formed from three different scales whose validity/reliability studies were completed.

These scales are, Yorulmaz et al. (2018) Organizational Power Distance Scale (ODMS); Rathus Assertiveness Inventory by Voltan (1980), Öğmüş et al. (2016) as the Need for Social Approval Scale (SOIO).

The Organizational Power Distance Scale and the Need for Social Approval Scale and the Rathus Assertiveness Inventory were prepared in a 5-point likert type. The scales and sub-dimensions used for the research are shown in Figure 2.

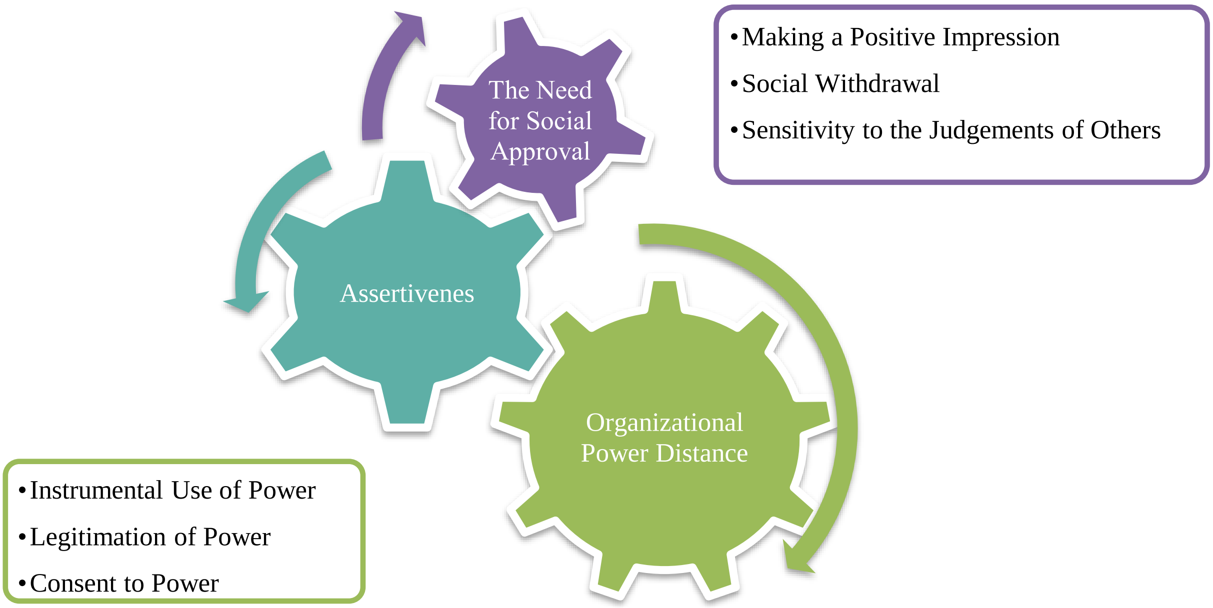

Figure 2. Scales Used in the Study

2.2.Validity and reliability analysis of scales

Confirmatory factor analysis was performed to test the factor structures of organizational power distance, assertiveness, and the need for social approval scales. The level of agreement of the scales with a certain factor structure was examined by confirmatory factor analysis. In the study, the highest likelihood estimation (maximum likelihood) technique was used. According to the obtained fit indices, it was seen that the factor structure of the scales showed a good fit. Inter-scale fit indices are shown in Table 1.

Table 1. Indices of Concordance Between Scales

Acceptable Fit Indices	Calculated Fit Indices		
	Organizational Power Distance	**Assertiveness**	**The Need for Social Approval**
$\chi 2/sd$ <5	1,999	2,026	2,493
GFI >0,90	0,852	0,784	0,902
AGFI >0,90	0,910	0,909	0,901
CFI >0,90	0,912	0,905	0,910
TLI>0,90	0,901	0,906	0,899
RMSEA <0,08	0,077	0,079	0,077
RMR <0,08	0,072	0,075	0,079

Reliability analysis was performed to determine the reliability level of the scale used in the study and the Cronbach alpha coefficient was obtained.

Evaluation criteria used in the evaluation of Cronbach's Alpha Coefficient;

If $0.00 \leq \alpha < 0.40$, the scale is unreliable.
If $0.40 \leq \alpha < 0.60$, the scale has low reliability.
If $0.60 \leq \alpha < 0.80$, the scale is quite reliable.
If $0.80 \leq \alpha < 1.00$, the scale is highly reliable.

The Cronbach alpha coefficients obtained and the reliability analysis of the scales are shown in Table 2.

In line with these criteria, the scales are highly reliable.

Table 2. Reliability Analysis of Scales

	Cronbach Alpha
Organizational Power Distance Scale	0,814
Acceptance of Power	0,825
Instrumental Use of Power	0,836
Legitimation of Power	0,799
Consent to Power	0,726
Assertiveness	0,824
Need for Social Approval	0,874
Sensitivity to the Judgements of Others	0,789
Social Withdrawal	0,774
Making a Positive Impression	0,804

3. Findings

3.1. Demographic findings

The questionnaires were filled out by 75 pilots. When the distribution of the participants by age groups is examined, the percentage of people in the 20-30 age group is 2.7 percent; The percentage of people in the 31-40 age group is 6.7 percent; The percentage of people aged 41-50 is 32 percent, and the percentage of people aged 50+ is 58.7 percent.

The rate of those with a military background in their professional career is 70.7 percent. 76 percent of the participants are working, 6.7 percent are not working, and 17.3 percent are retired. When the distribution of total professional experience is examined; the rate of employees working for 1-5 years is 6.7 percent; the rate of employees working for 6-10 years is 5.3 percent; the rate of employees working for 11-20 years is 6.7 percent; the rate of employees working for 21-30 years is 41.3 percent, the rate of employees working for 31-40 years is 30.7 percent, and the rate of employees working for more than 40 years is 9.3 percent.

When the distribution by monthly income is analyzed, the rate of those with an income of less than 5000 TL is 6.7 percent; the rate of those with 5001-10000 TL is 10.7 percent; 8 percent of those with 10001-15000 TL; the rate of those with 15001-20000 TL is 10.7 percent, and the rate of those whose income is more than 20000 TL is 64 percent.

When the change of organizational power distance scale according to gender When the change of organizational power distance scale by gender was given in table 3. It was seen that the sub-dimensions of instrumental use of power and legitimation of power differed significantly according to gender ($p<0.05$). Men's levels of instrumental use of power and legitimation of power are significantly higher than women's

Table 3. The Change of Organizational Power Distance Scale by Gender

		N	Average	Standard deviation	t	p
Acceptance of Power	Men	68	17,6	3,3	2,175	0,145
	Women	7	15,7	1,3		
	Total	75	17,4	3,3		
Instrumental Use of Power	Men	68	12,8	4,3	3,492	0,046*
	Women	7	9,7	2,7		
	Total	75	12,5	4,2		
Legitimation of Power	Men	68	5,9	2,0	8,089	0,006*
	Women	7	3,7	0,8		
	Total	75	5,7	2,0		
Consent to Power	Men	68	23,7	4,2	1,470	0,229
	Women	7	25,7	2,8		
	Total	75	23,9	4,1		

When the change of organizational power distance scale according to working time is examined; while it was observed that the sub-dimension of acceptance of power differed significantly according to the working time ($p<0.05$), it was seen that the other sub-dimensions did not show a significant difference. According to the results of the TUKEY test, which was conducted to determine which group the difference originated from for the acceptance of power sub-dimension, which showed a significant difference; it has been observed that the level of acceptance of power of the employees who have been working for 6-10 and 11-20 years is significantly higher than the other working time groups. The Change of Organizational Power Distance Scale by Working Time Groups are shown in Table 4.

Table 4. The Change of Organizational Power Distance Scale by Working Time Groups

		N	Average	Std. Deviation	F	p
Acceptance of Power	1-5 year	5	17,2	3,96	4,45	0,001*
	6-10 year	4	20,25	1,71		
	11-20 year	5	20,6	3,65		
	21-30 year	31	17,58	2,14		
	31-40 year	23	16,52	3,75		
	40+	7	19,29	1,8		
	Total	75	17,43	3,25		
Instrumental Use of Power	1-5 year	5	11,8	4,32	1,54	0,19
	6-10 year	4	13,75	2,75		
	11-20 year	5	16	5,24		
	21-30 year	31	11,94	4,04		
	31-40 year	23	11,74	3,92		
	40+	7	14,86	5,01		
	Total	75	12,51	4,22		
Legitimation of Power	1-5 year	5	6,2	3,11	0,57	0,723
	6-10 year	4	6,25	1,5		
	11-20 year	5	6,8	1,92		
	21-30 year	31	5,52	1,9		
	31-40 year	23	5,43	1,95		
	40+	7	5,43	2,15		
	Total	75	5,65	1,98		
Consent to Power	1-5 year	5	23,6	2,7	1,31	0,271
	6-10 year	4	21,75	3,86		
	11-20 year	5	21,8	3,42		
	21-30 year	31	23,81	4,34		
	31-40 year	23	24,04	4,22		
	40+	7	27	3,51		
	Total	75	23,92	4,13		

When the change of organizational power distance scale according to income is examined; while the change of legitimation of power sub-dimension according to income is significant, the change of other sub-dimensions according to income is not significant. According to the results of the TUKEY test, which was conducted to determine which group the difference originated from for the legitimation of power sub-dimension, which showed a significant difference; the legitimation of power level of those with an income of 5001-10000 TL is significantly higher than those whose income is less than 5000 TL and whose income is 20000+ TL. The change of organizational power distance scale according to income are shown in Table 5.

Table 5. The Change Of Organizational Power Distance Scale By Income

	Monthly Income (TL)	N	Average	Std. Deviation	F	p
Acceptance of Power	<5000	5	16,6	2,1	0,736	0,57
	5001-10000	8	19,1	3,2		
	10001-15000	6	17,8	1,9		
	15001-20000	8	17,6	5,6		
	20000+	48	17,1	3		
	Total	75	17,4	3,3		
Instrumental Use of Power	<5000	5	10,8	3,3	0,684	0,606
	5001-10000	8	12,9	4		
	10001-15000	6	14,8	5,8		
	15001-20000	8	12,5	3		
	20000+	48	12,3	4,3		
	Total	75	12,5	4,2		
Legitimation of Power	<5000	5	5	2	2,571	0,045*
	5001-10000	8	7,3	2,5		
	10001-15000	6	6,3	2,3		
	15001-20000	8	6,4	2,2		
	20000+	48	5,3	1,7		
	Total	75	5,7	2		
Consent to Power	<5000	5	23,4	4	0,702	0,593
	5001-10000	8	22,8	3,2		
	10001-15000	6	23,8	5,9		
	15001-20000	8	22,3	4,9		
	20000+	48	24,5	4		
	Total	75	23,9	4,1		

When the change of the need for social approval scale according to gender was examined, it was seen that the sub-dimension of sensitivity to the judgments of others showed a significant difference according to gender (p<0.05), while the sub-dimensions of social withdrawal and making a positive impression did not differ significantly according to gender. The sensitivity level of men to the judgments of others is significantly greater than that of women. The change of the need for social approval scale according to gender are shown in Table 6.

Table 6. The Change of The Need For Social Approval Scale by Gender

		N	Average	Std. Deviation	F	p
Sensitivity to the Judgements of Others	Men	68	28,7	5,9	3,983	0,049*
	Women	7	24	6,2		
	Total	75	28,3	6,1		
Social Withdrawal	Men	68	18,2	6	1,1	0,298
	Women	7	15,7	3,8		
	Total	75	17,9	5,9		
Making a Positive Impression	Men	68	19,3	6	0,057	0,812
	Women	7	18,7	5,5		
	Total	75	19,2	5,9		

When the change of need for social approval scale according to income is examined; social withdrawal sub-dimension showed a significant difference according to income (p<0.05), while other sub-dimensions did not differ significantly. According to the results of the TUKEY test, which was conducted to determine which group caused the difference for the social withdrawal sub-dimension, which showed a significant difference; the average of social withdrawal of those with an income of 15001-20000 TL and an income of 5001-10000 TL is significantly higher than the average of those with an income of <5000 TL and 20000 TL. It has been observed that the level of acceptance of the power of the employees who have been working for 6-10 and 11-20 years is significantly higher than the other working time groups. Participants whose income is both below 5000 TL and above 20 thousand TL exhibit less social withdrawal behavior compared to other income groups.

The Change Of Need For Social Approval Scale by income are shown in Table 7.

Table 7. The Change of Need For Social Approval Scale by Income

	Monthly Income (TL)	N	Average	Std. Deviation	F	p
Sensitivity to the Judgements of Others	<5000	5	24,8	5,6	1,681	0,164
	5001-10000	8	30	4,1		
	10001-15000	6	32,8	4,5		
	15001-20000	8	29,3	11,2		
	20000+	48	27,6	5,2		
	Total	75	28,3	6,1		
Social Withdrawal	<5000	5	14,8	5,6	3,249	0,017*
	5001-10000	8	21,5	3,9		
	10001-15000	6	18,5	7,1		
	15001-20000	8	22,8	10,1		
	20000+	48	16,8	4,5		
	Total	75	17,9	5,9		
Making a Positive Impression	<5000	5	17	6	1,483	0,217
	5001-10000	8	21	3,1		
	10001-15000	6	23,3	9		
	15001-20000	8	20,8	7		
	20000+	48	18,4	5,5		
	Total	75	19,2	5,9		

When the change of the need for social approval scale according to the working time groups is examined; While it was observed that the sub-dimension of sensitivity to the judgments of others showed a significant difference according to the working time (p<0.05), it was observed that the other sub-dimensions did not show a significant difference. According to the results of the TUKEY test, which was conducted to determine which group the difference originated from for the "sensitivity to the judgments of others" sub-dimension, which showed a significant difference; the average of those who have been working for more than 40 years is significantly higher than those who have been working for 1-5 years, 6-10 years, 21-30 years and 31-40 years. In addition, the average of those who have been working for 11-20 years is significantly higher than those who have been working for 6-10 years and 31-40 years. the change of the need for social approval scale according to the working time groups are shown in Table 8.

Table 8. The Change Of The Need For Social Approval Scale by The Working Time Groups

		N	Average	Std. Deviation	F	p
Sensitivity to the Judgements of Others	1-5 year	5	26,2	3,56	2,827	0,022*
	6-10 year	4	23,5	3,7		
	11-20 year	5	33	7,45		
	21-30 year	31	28,39	5,73		
	31-40 year	23	26,78	6,27		
	40+	7	33,43	3,91		
	Total	75	28,27	6,06		
Social Withdrawal	1-5 year	5	17,8	7,09	1,765	0,132
	6-10 year	4	15	3,92		
	11-20 year	5	23,6	9,29		
	21-30 year	31	17,77	4,59		
	31-40 year	23	16,61	5,54		
	40+	7	20,71	7,87		
	Total	75	17,93	5,88		
Making a Positive Impression	1-5 year	5	19,2	6,06	0,876	0,502
	6-10 year	4	17,25	2,22		
	11-20 year	5	20,8	8,17		
	21-30 year	31	20,23	5,57		
	31-40 year	23	17,39	5,92		
	40+	7	20,86	7,2		
	Total	75	19,23	5,92		

3.2. Correlations Between Scales

Correlation analysis was performed to determine the relationships between the scales and the Pearson correlation coefficient was obtained and given in the table 9.

Table 9. Correlations Between Scales

		Acceptance of Power	Instrumental Use of Power	Legitimation of Power	Consent to Power	Assertiveness	Sensitivity to the Judgement of Others	Social Withdrawal	Making a Positive Impression
Acceptance of Power	r	1	,506**	,489**	-,084	-,043	,514**	,454**	,260*
	p		,000	,000	,473	,711	,000	,000	,024
Instrumental Use of Power	r	,506**	1	,380**	-,230*	-,123	,364**	,454**	,479**
	p	,000		,001	,047	,292	,001	,000	,000
Legitimation of Power	r	,489**	,380**	1	-,228*	-,156	,260*	,368**	,269*
	p	,000	,001		,049	,182	,024	,001	,020
Consent to Power	r	-,084	-,230*	-,228*	1	,808**	,094	-,354**	-,375**
	p	,473	,047	,049		,000	,421	,002	,001
Assertiveness	r	-,043	-,123	-,156	,808**	1	,108	-,277*	-,302**
	p	,711	,292	,182	,000		,355	,016	,008
Sensitivity to the Judgements of Others	r	,514**	,364**	,260*	,094	,108	1	,548**	,453**
	p	,000	,001	,024	,421	,355		,000	,000
Social Withdrawal	r	,454**	,454**	,368**	-,354**	-,277*	,548**	1	,738**
	p	,000	,000	,001	,002	,016	,000		,000
Making a Positive Impression	r	,260*	,479**	,269*	-,375**	-,302**	,453**	,738**	1
	p	,024	,000	,020	,001	,008	,000	,000	

The assertiveness scale has a positive and significant relationship at the level of 80.8 percent with consent to power which is a subdimension of the organizational power distance scale. The assertiveness scale has a negative and significant relationship at the level of 27.7 percent with social withdrawal, and at the level of 30.2 percent with making a positive impression which are subdimensions of the need for social approval scale.

Acceptance of power, which is a subdimension of the organizational power distance scale, has a positive and significant relationship at the level of 51.4 percent with sensitivity to the judgments of others, at the level of 45.4 percent with social withdrawal, and at the level of 26 percent with making a positive impression which are subdimensions of the need for social approval scale.

Instrumental Use of Power, which is a subdimension of the organizational power distance scale, has a positive and significant relationship at the level of 36.4 percent with sensitivity to the judgments of others, at the level of 45.4 percent with social withdrawal, at the level of 47.9 percent with making a positive impression which are subdimensions of the need for social approval scale.

Legitimation of Power, which is a subdimension of the organizational power distance scale, has a positive and significant relationship at the level of 26 percent with sensitivity to the judgments of others, at the level of 36.8 percent with social withdrawal, and at the level of 26.9 with making a positive impression which are subdimensions of the need for social approval scale.

Consent to Power, which is a subdimension of the organizational power distance scale, has a negative and significant relationship at the level of 35.4 percent with social withdrawal, and at the level of 37.5 percent with making a positive impression which are subdimensions of the need for social approval scale.

4. Conclusion and Discussion

In the male pilots who participated in the study; the levels of "Instrumental Use of Power" and "Legitimation of Power", which are sub-dimensions of organizational power distance, are significantly higher than in female pilots. According to this, it is understood that the men in the study stand closer to the management, compared to the women, in order to gain benefits. In addition, it is understood that male employees use some legal rules and regulations to justify the unbalanced power distribution more than women. In addition, female pilots pay less attention to the judgments of others than male pilots. These results suggest that male pilots need more organizational power than female pilots.

The most important outcome of the study is the strong positive relationship between the assertiveness level of the participants and the "Consent to Power" dimension, which is one of the sub-dimensions of power distance. According to this, as the assertiveness levels of the pilots increase, the dimension of "Consent to Power" also increases. According to Gramschi, individuals have a tendency to accept the social manipulations of the dominant majority in society (Gramschi, 1971). The tendency to consent works similarly in organizations. Especially if the culture of fear is dominant in the organization or the risk perception of the employees is high, the dimension of "Consent to Power" similarly increases.

According to the findings of the study; The dimension of "Consent to Power" does not mean accepting power without questioning, on the contrary, the individual who consents to power does not adopt the practices of the power holders and does not choose to be close to those who have power or to take part in regulations that support the unequal distribution of power. However, although they do not approve of it, they do not object to it as well. The reason for the lack of objection is not the fear of making a negative impression or of being disapproved by others. The "Consent to Power" dimension is related to the fact that the employees in the organization with a high power distance think that they do not have the capacity to make a change in the practices in the organization. For example, cabin crew Hartwick, who served in the Air Ontario accident, seems to have an unwavering conviction that the situation will not change, even though they report the snow puddle on the wing to the captain. According to the study, if the organizational culture does not impose the consequences of non-compliance with all stakeholders and holds only one person responsible, if the person objecting to the practice does not achieve any change with this objection and faces various difficulties due to this behavior in the following periods, it will not be surprising that they choose not to speak up against the wrong practices in other similar situations. When the MUM effect, which means a general reluctance to convey negative information, is added to this, the negative effect of the organization's power distance in terms of causing accidents will increase even more.

The dimension of “Consent to Power” can be expressed with the proverb “If you can’t beat them, join them”, and it can be considered as a kind of confession of the helplessness experienced in this state. This confession includes a judgment that excludes all options other than accepting the situation. This judgment is the result of a cognitive effort. According to this, one was convinced that complying with the management's decisions was the most correct option and that any other action was a waste of money; so they consented to power. Assertive individuals are those who can defend their rights and adapt to new situations they encounter. In other words, the social adaptation skills of assertive individuals are also improved. Therefore, it is thought that the positive relationship between the assertiveness levels of the employees and the dimension of "Consent to Power" stems from the social adaptation capacity of the assertive individuals. In this state, if the assertive individual has nothing else to do to change the outcome in an organization with high power distance, it is a behavior expected from them to accept the situation and consent. In the accident that caused the crash of the registration of TC-THG plane belonging to MC Aviation in Iran, the fact that the co-pilot did not take control despite all these mistakes made by the captain is considered a problem due to the power distance.The courteous initiative of Korean Air's flight engineer was not enough to stop the captain who was determined to go around. The voice of the flight engineer in the Tenerife crash was not heard, warning the captain to make sure there was no other aircraft on the runway. The extremely softened language used by the second pilot of Avianca 55 in their communication with the tower did not succeed in conveying the urgency of landing priority to the air traffic controller, as the plane was about to crash because it ran out of fuel. The reasons for the occurrence of these accidents, in which High Power distance is effective, show similarities. Almost all of these accidents happened due to erroneous decisions made by the captain pilots/air traffic contollers or the hierarchically empowered people that threaten flight safety, and their insistance on the decisions they made despite all warnings. Other members of the crew either did not object to this wrong decision or objected weakly. In CRM practices carried out to prevent power distance related accidents, it is aimed that all members of the team do not remain silent in the face of each other's wrong decisions, that they have communication skills to stop each other's mistakes when necessary, and that all members of the team have the competence to listen to each other and take into account their warnings. Airline Operators have also updated their standard application procedures in order to prevent accidents that may arise from power distance in CRM applications.

This study revealed that assertive individuals working in organizations with high power distance do not oppose some wrong practices in the organization, but, on the contrary, they adapt to the situation. For this reason, it is against the ordinary flow of life to put the personal characteristics of individuals in a place independent of the organizational culture and to expect employees to exhibit behaviors that are not encouraged by the organizational culture. This study also showed that the main factor determining the behavior of the employees is the organizational culture. It is suggested that further research on this subject should be handled on a macro scale and structured in a way that includes the effects of national culture. Within this scope, it is of vital importance that detailed reports of accidents in our country are brought into the literature and educational content in order to take lessons from their results, include them in practices, and thus establish a safety culture.

There is no doubt that comprehensive accident reports (Moshansky, 1992) published by the Canadian Accident Commission as a case study, which includes interviews with crew and passengers who survived aircraft accidents, accompanied by clinical and social psychologists (Moshansky, 1992), will shed light on academic research on this subject. In this context, sharing Turkish registered aircraft accident reports with researchers and institutions will contribute significantly to the need for resources.

Appendices

When the path coefficients of the items of the need for social approval scale are examined; the lowest coefficient was found to be 0.298, and the highest coefficient was 0.806. therefore, there is no item excluded from the scale. The path coefficients of the items of the need for social approval scale are shown in Figure 3.

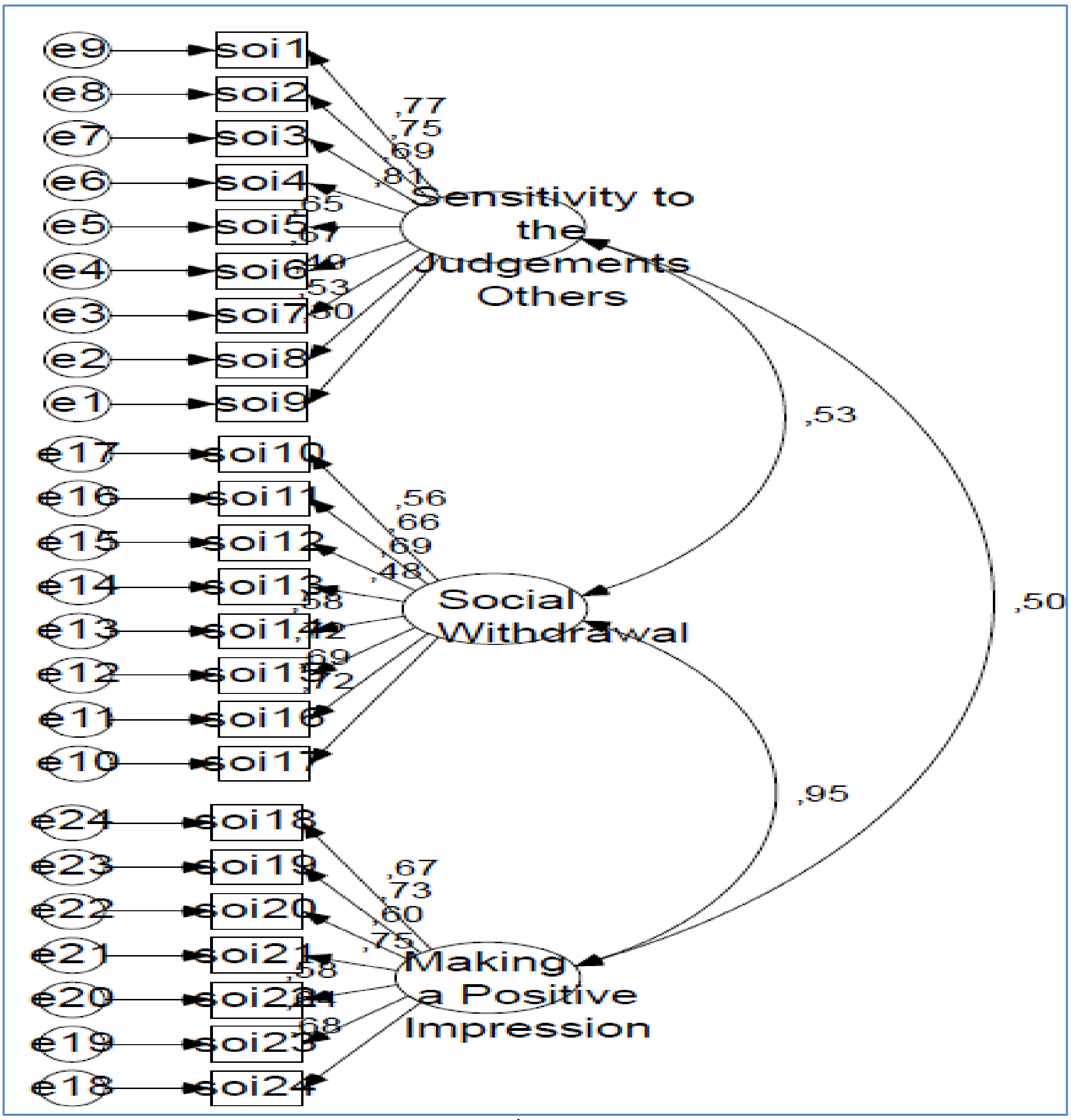

Figure 3. The Path Coefficients Of The İtems Of The Need For Social Approval Scale

When the path coefficients of the organizational power distance scale items were examined, although the coefficient of the 13th item was low, it was not excluded from the study.

The Path Coefficients Of The Organizational Power Distance Scale İtems are shown in Figure 4.

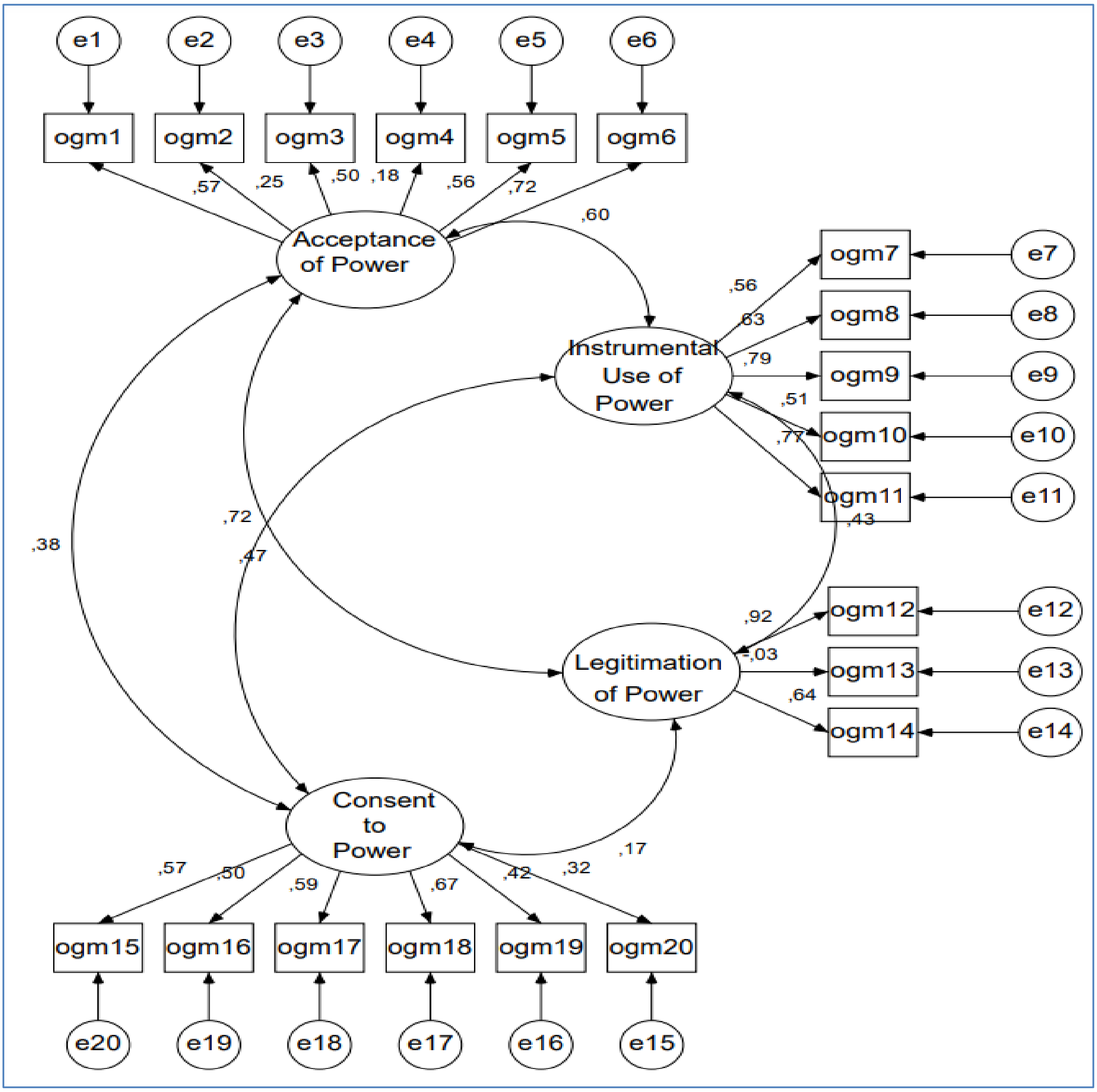

Figure 4. The Path Coefficients Of The Organizational Power Distance Scale Items

Path coefficients of the assertiveness scale range from 0.222 to 0.671, and there is no item left out of the scale.

Path coefficients of the assertiveness scale are shown in Figure 5.

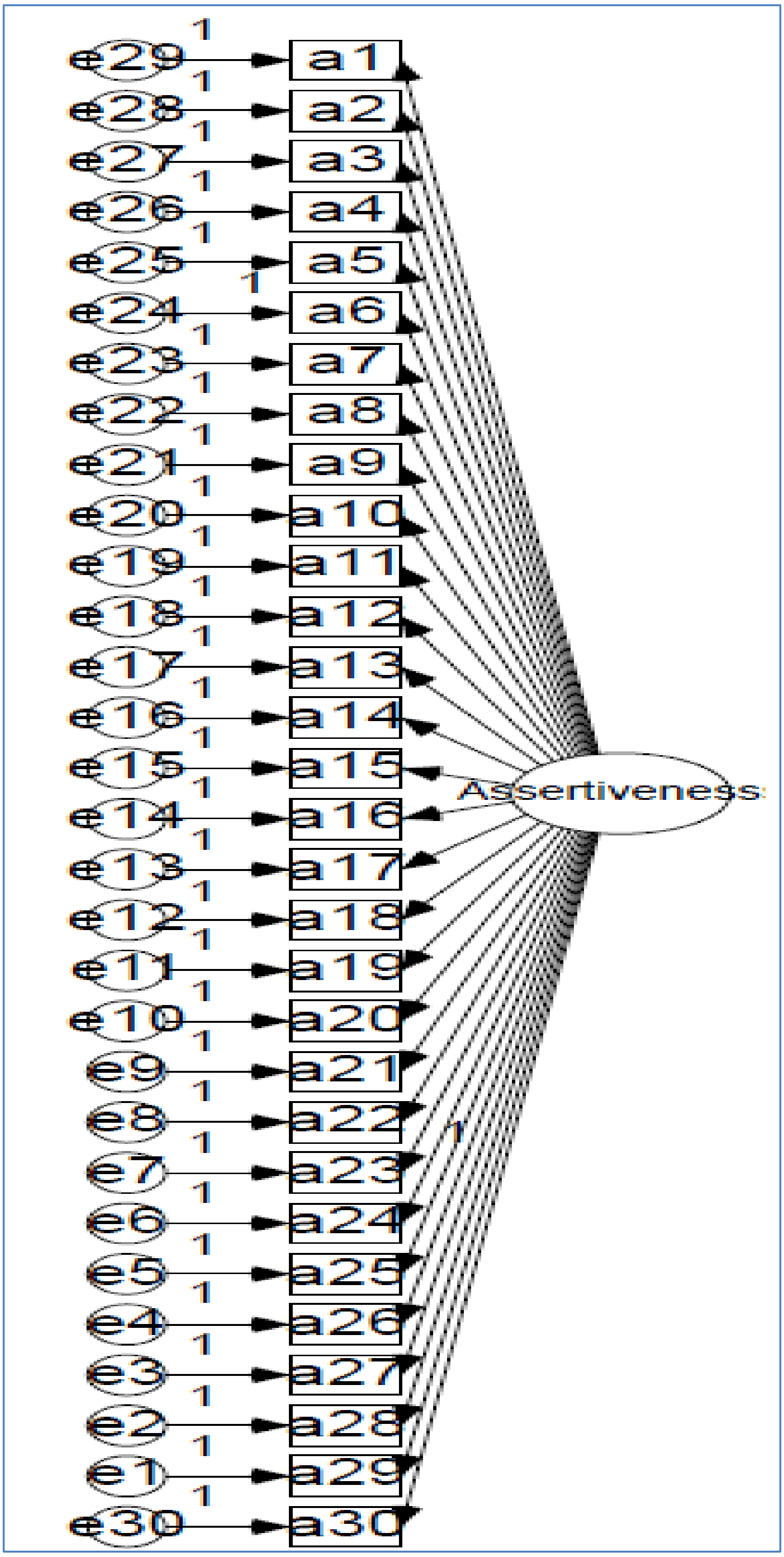

Figure 5. The Path Coefficients Of The Assertiveness

The Need for social approval standard regression coefficients is shown in Table 10.

Table 10. The Need for Social Approval Standard Regression Coefficients

			Estimate
soi9	<---	Sensitivity to the Judgments of Others	,298
soi8	<---	Sensitivity to the Judgments of Others	,530
soi7	<---	Sensitivity to the Judgments of Others	,493
soi6	<---	Sensitivity to the Judgments of Others	,667
soi5	<---	Sensitivity to the Judgments of Others	,653
soi4	<---	Sensitivity to the Judgments of Others	,806
soi3	<---	Sensitivity to the Judgments of Others	,692
soi2	<---	Sensitivity to the Judgments of Others	,755
soi1	<---	Sensitivity to the Judgments of Others	,775
soi17	<---	Social Withdrawal	,715
soi16	<---	Social Withdrawal	,687
soi15	<---	Social Withdrawal	,720
soi14	<---	Social Withdrawal	,584
soi13	<---	Social Withdrawal	,484
soi12	<---	Social Withdrawal	,685
soi11	<---	Social Withdrawal	,660
soi10	<---	Social Withdrawal	,556
soi24	<---	Making a Positive Impression	,679
soi23	<---	Making a Positive Impression	,639
soi22	<---	Making a Positive Impression	,577
soi21	<---	Making a Positive Impression	,746
soi20	<---	Making a Positive Impression	,603
soi19	<---	Making a Positive Impression	,725
soi18	<---	Making a Positive Impression	,674

Assertiveness Scale Standard Regression Coefficients are shown in Table 11.

Table 11. The Assertiveness Scale Standard Regression Coefficients

			Estimate
Rae29	<---	Assertiveness	,003
Rae28	<---	Assertiveness	,481
Rae27	<---	Assertiveness	,483
Rae26	<---	Assertiveness	-,258
Rae25	<---	Assertiveness	,340
Rae24	<---	Assertiveness	,453
Rae23	<---	Assertiveness	,478
Rae22	<---	Assertiveness	,424
Rae21	<---	Assertiveness	,530
Rae20	<---	Assertiveness	,306
Rae19	<---	Assertiveness	,331
Rae18	<---	Assertiveness	,235
Rae17	<---	Assertiveness	,635
Rae16	<---	Assertiveness	,671
Rae15	<---	Assertiveness	,511
Rae14	<---	Assertiveness	,500
Rae13	<---	Assertiveness	,463
Rae12	<---	Assertiveness	,534
Rae11	<---	Assertiveness	-,501
Rae10	<---	Assertiveness	,575
Rae9	<---	Assertiveness	,402
Rae8	<---	Assertiveness	,325
Rae7	<---	Assertiveness	,436
Rae6	<---	Assertiveness	,230
Rae5	<---	Assertiveness	,442
Rae4	<---	Assertiveness	-,222
Rae3	<---	Assertiveness	,266
Rae2	<---	Assertiveness	-,485
Rae1	<---	Assertiveness	-,368
Rae30	<---	Assertiveness	,277

Organizational power distance scale standard regression Coefficients are shown in Table 12.

Table 12. The Organizational Power Distance Scale Standard Regression Coefficients

			Estimate
ogm1	<---	Acceptance_of_Power	,573
ogm2	<---	Acceptance_of_Power	,253
ogm3	<---	Acceptance_of_Power	,504
ogm4	<---	Acceptance_of_Power	,179
ogm5	<---	Acceptance_of_Power	,563
ogm6	<---	Acceptance_of_Power	,724
ogm7	<---	Instrumental_Use_of_Power	,565
ogm8	<---	Instrumental_Use_of_Power	,628
ogm9	<---	Instrumental_Use_of_Power	,785
ogm10	<---	Instrumental_Use_of_Power	,515
ogm11	<---	Instrumental_Use_of_Power	,768
ogm12	<---	Legitimation_of_Power	,916
ogm13	<---	Legitimation_of_Power	-,026
ogm14	<---	Legitimation_of_Power	,643
ogm20	<---	Consent_to_Power	,318
ogm19	<---	Consent_to_Power	,415
ogm18	<---	Consent_to_Power	,667
ogm17	<---	Consent_to_Power	,594
ogm16	<---	Consent_to_Power	,496
ogm15	<---	Consent_to_Power	,574

Ethical approval

Yes. Maltepe University Ethics Committee approved the Research with a letter 2021/25-01 dated 24.09.2021

Conflicts of Interest

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

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Evaluation of the Effects of Air Cargo Transportation on Global Competitiveness

Hüseyin Tamer Hava[1*]

[1*] Turkish National Defence University, Air Force NCO Higher Vocational School, Administrative Sciences Department, 35410, Gaziemir, İzmir, Türkiye. (thava@msu.edu.tr)

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Corresponding Author: *Hüseyin Tamer Hava*

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Abstract

Global competitiveness has become just as crucial in the rapidly growing world economy. For this reason, the problem of delivering the products to the consumer at the right place and time has become indispensable to survive in the global market and has brought the logistics factor to the fore. One of these logistics activities, the transportation sector, ensures that human needs are met at the desired place and on time. It has become essential to deliver products to target markets faster and safer than their competitors, and airplanes have been used in cargo and passenger transportation. The rapid technological change has also led to aircraft development used in cargo transportation. Thus, air cargo transportation, which is less risky and faster than other transportation modes, has come to the fore in time-bound and valuable goods. The main purpose of this study, which is carried out with the qualitative research method, is to determine and evaluate the effects of air cargo transportation on global competitiveness. In the study, firstly, the concept of air cargo transportation tried to be explained. Then, the literature review created the background of the study. In this context, the development process of air cargo transportation was discussed in terms of its historical, corporate, and economic development. Then, the types of aircraft used, airports, and cargo companies operating on a global scale, which are the elements of air cargo transportation, were examined. In addition to the high capacity and fuel efficiency produced by the current technology of the aircraft, the issue of further reduction of costs due to capacity increase by optimizing the loading problem has been mentioned. Finally, by analyzing the findings, the effects of air cargo transportation on global competitiveness were discussed and evaluated, and suggestions were made to increase this power. This article, which is a direct study on the effects of air cargo transportation on global competitiveness, is crucial as it will contribute to the literature.

1. Introduction

The world is in constant change in terms of economy and many aspects. The main goal of economic change is the creation of a single and integrated world economy. Many factors, such as cultural changes, and technological innovations created by urbanization in this process, differentiate the needs of individuals day by day. This situation has also affected world trade, which led to the disappearance of trade borders between countries and to significant increase in global competition. In this competitive environment, the efforts of countries to exist in the worldwide market have brought along new searches. At the beginning of these are the logistics activities that meet the goods and services people need at the desired place and time under appropriate conditions. Therefore, success in logistics activities will also bring success in international trade. In this context, the importance of logistics activities and the logistics industry is increasing day by day and is becoming an essential driving force of global trade. Today, products designed in any geographical region of the world are produced in different geographical areas and are demanded from other parts of the world. For this reason, the "speed" factor, which is vital in the functioning of logistics, has become one of the prerequisites for competitiveness in global trade.

Each mode of transport used to transport products subject to global trade has advantages and disadvantages. However, according to the severity and urgency of the requested product, air cargo transportation comes to the forefront due to certain benefits such as time, space, and security. With air cargo transportation, which is far from many limitations that influence other transportation modes, perishable, high-value products can be transported to the most extended distances quickly and safely. Due to its importance in the global supply chain, the demand for air cargo transportation increases despite its high cost compared to other transportation modes.

Humankind, who has been trying to fly like birds since the past times, has started to use the airline first in wars and then in trade after succeeding in this. Air transport, which is the most modern form of logistics offered by the developing technology, has started to be used as passenger transport in commercial activities. Its use in cargo transport activities has been somewhat delayed. Cargoes were initially carried with passengers. The development of the aircraft manufacturing industry in parallel with technological developments, enabled the manufacturing of passenger aircraft with cargo sections and of aircraft with cargo only. Thus, the demands for air cargo transportation tried to be met.

Businesses that can offer their products quickly in today's logistics environment have a competitive advantage in the global market. In this sense, air cargo transportation serves these purposes of businesses in world trade, where the importance of fast and safe service provision increases daily. Thus, the share of air cargo transportation in products transported in international trade increases. Success in this field will enable countries to achieve success in foreign trade.

The study is vital in laying the groundwork for future studies by examining the development process of air cargo transportation, which has the potential to affect world trade but is still thought to be not where it should be. In this context, aircraft, airports, and airline cargo companies, which are in close relationship with each other in the service delivery of air cargo transportation, which is a service production, have been examined in the historical process, and a perspective has tried to be put forward. In line with these examinations, the effects of air cargo transportation on global competitiveness in the rapidly globalizing world were determined and evaluated.

2. The Concept of Air Cargo Transportation

Before discussing the concept of air cargo transportation, it would be appropriate to define the concepts of transportation and cargo as a basis. As with the definition of many concepts, there are also differences in the definition of transportation. The first of the generally accepted definitions of transportation was expressed by Black (2003:3) as the movement of people and goods from one place to another. However, Hensher (2004:309) emphasized that this definition would be incomplete if the information were not added because it would not be possible to manage, support, and expand the movement of goods and people. With truly accurate information, it will be possible to save time, manage inventory and choose between supply chains. On the other hand, Kasilingam (1998:157), who examines transportation in terms of the production-consumption relationship, stated that the connection between production, storage, and consumption could only be achieved through transportation. Therefore, it is seen that the benefits of time and place come to the fore in the main transportation definitions mentioned (Çancı & Erdal, 2013:5).

The concept of cargo was defined in The Dictionary of Transport and Logistics prepared by Lowe (2002:33), with a general expression, primarily as a word used instead of freight in the shipping and air freight sectors. However, today, this concept is interpreted as a separate cargo from the goods carried under postal freight or international postal agreements and the baggage carried by the passenger. In summary, baggage that is not accompanied and is transported by issuing a bill of lading is defined as cargo (Öktem, 1992:9).

After the various definitions are given above, when the concept of transportation is reduced to the airline specifically, air transportation is defined as the displacement of people, goods, or mail with an aircraft, regardless of the purpose of transportation (Gerede, 2002:9). Air cargo can be defined as transporting goods from one place to another by aircraft (Allaz, 1998:8). In a broad sense, the term air cargo includes air freight, postal and other packages sent for any purpose. In a narrow sense, everything other than departing passenger baggage in a passenger aircraft's cargo compartment is considered air cargo. In other words, since passenger baggage is regarded as a part of the passenger, it is not included in this scope (O'Connor, 2000:271). Based on the definitions so far, depending on the ICAO (International Civil Aviation Organization) and IATA (International Air Transport Association) rules, and taking into account the country and carrier restrictions, air cargo transportation can be defined as the packaging of goods (excluding mail and baggage), labeling, proper preparation of documents, and dispatch by an aircraft (Turşucu, 1995:38). ICAO and IATA are two international organizations working to standardize aviation rules apart from international agreements and national legal regulations.

Air cargo transportation, a sub-market of air transportation, ensures that goods with low volume and weight but high value are delivered to their destination more quickly and safely than other modes of transportation. This is an essential feature in terms of competition. In addition, Taneja (2003:139-140) states that air transportation, which was preferred at first because it provides speed, reliability, and advantages in the transportation of fragile/perishable products, is preferred due to more logistics support as a result of rapidly changing consumer expectations today. He also states that this minimizes transportation costs and reduces distribution costs. In this context, the tendency for air cargo transportation, which is newer than other modes of transportation, to be preferred by the actors in the global trade market is increasing, and its development is accelerating. The rapid increase in demand for the sector has enabled the production of aircraft used in air cargo transportation with technology development. It has started to play an essential role in international trade.

Cargoes subject to air cargo transportation are classified because they have their characteristics. In this framework, the loads carried are generally classified in two ways. First, the classification made according to "the wishes and needs of the sender regarding the transportation service" is classified under three sub-headings "urgent cargo," "routine perishable cargo," and "routine non-perishable cargo." The second type of classification is according to the "characteristics of the cargo to be transported," which are classified as "general cargo," "special cargo," and "hazardous goods" (Kaya et al., 2012:93).

3. Literature Review

The rapid development of technology has emerged as an element that affects commercial life. The introduction of the internet into our daily lives in the 1990s has also changed our shopping habits. This change has occurred in both consumers and manufacturers, and the number of those who shop online has gradually increased. Thus, traditional transportation has introduced logistics as a new business line. In parallel with technological developments, air cargo transportation, one of the sub-branches of logistics, has also developed rapidly. As a result, research on logistics, which has become an area of interest since the end of the 20th century, has also increased. Although various studies were found in the literature review on air cargo transportation within the framework of the research subject, no direct research was found on the effects of air cargo transportation on global competitiveness. In this respect, the study is crucial as it will contribute to the literature. The literature review contributed to the formation of the study's theoretical background. Noteworthy studies in the reviewed literature are given in the table below:

Table 1. Literature Review

Author(s)	Period	Country/ Countries	Method	Findings
Akoğlu, B. & Fidan, Y. (2020)	-	Turkey	Qualitative Research Method	In the study, the world air cargo transportation sector was examined, and the place of Turkey's increasing capacity in the industry tried to be determined.
Aunurrofik, A. (2018)	-	Indonesia	Multiple Regression Analysis	The study examined the importance of air transport on regional development. It was concluded that the number of passengers and cargo carried by air had a positive and significant effect on regional per capita income. Moreover, this effect is more substantial in air cargo transportation.
Chang, Y-H. & Chang, Y-W. (2009)	1974-2006	Taiwan	Granger Causality Test	The causal relationship between air cargo expansion and economic growth was examined in the study. As a result, it was concluded that there is a long-term balance and bidirectional relationship between air cargo expansion and economic development.
Debbage, K. & Debbage, N. (2021)	-	-	Qualitative Research Method	The study aimed to understand better the changing role of air transport logistics in the modern global economy. For this, the historical evolution of global air transport, large cargo airports, airport logistics-centered growth theory focusing on the concept of aerotropolis, and the future challenges faced by the industry due to the complex and heterogeneous structure of the air transport logistics market were analyzed.
Demirbilek, A., Öz, S. & Fidan, Y. (2018)	2007-2016	Turkey	Qualitative Research Method	The study evaluated the relationship between the air cargo transportation system and the Logistics Performance Index in Turkey. As a result, it has been found that the adequate power of air cargo transportation in globalization is also reflected in the logistics performance index.
Emirkadı, Ö. & Balcı, H. (2018)	-	Turkey	Qualitative Research Method	The reflections of the rapidly developing logistics sector on Turkish foreign trade were evaluated in the study.
Gün, D. (2014)	-	Turkey	Qualitative Research Method	The study drew attention to the importance of logistics in air transportation in terms of time constraints and the quality of the materials used. In addition, it has been stated that airline companies will create value in the competitive market with the correct implementation of logistics strategies.
Nedeva, K. & Genchev, E. (2018)	2000-2016	Bulgaria	Data Processing Method with Gretl Program	The study examined the relationship between the development of air transport, the economic development of Bulgarian regions, and the improvement of competitiveness. It has been concluded that the development in air transport positively affects the region's competitiveness and stable socio-economic growth.
Sesliokuyucu, S.O., Sayar, G. & Polat, İ. (2019)	2017	28 European Countries	K-Means Cluster Analysis Method	The study examined European countries' regional and international relations in terms of international trade and aviation infrastructure variables. The findings showed that the nations gathered in two clusters, and all variables affected the formation of sets from different aspects.
Vega, H. (2008)	2000-2006	South America	Case Study	The results obtained in the study are consistent with the concerns of manufacturers that the competitive advantage gained due to low labor costs in the export of time-sensitive, perishable and exotic products will be lost due to the high air cargo costs.
Yuan, Low & Tang (2010)	1990-2006	Singapore, Hong Kong	ACSCOR Model	It has been shown in the study that the cargo traffic at an airport is significantly affected by the operating characteristics, the performances of the sub-air cargo and supporting logistics industry, and the economic environment in which it operates.
Zhang, A. & Zhang, Y. (2002)	-	USA, Asia	Qualitative Research Method	The study deals with a general discussion of various issues related to the liberalization of air cargo services in international aviation.

When considering the literature review in Table 1, it was observed that the studies were conducted for different countries and periods. It was also noted that the common focus of these studies, which were carried out using other methods for different subjects, is the increasing importance of air cargo transportation.

4. Method

The main purpose of this study, which was carried out with the qualitative research method, is to determine and evaluate the effects of air cargo transportation on global competitiveness. In the study, first, air cargo transportation tried to be explained. Then, the literature review created the background of the study. In this context, the development process of air cargo transportation was discussed in terms of its historical, corporate, and economic development. In addition, the types of aircraft used, airports, and air cargo companies, which are the elements of air cargo transportation, were examined. Finally, in line with the findings obtained from the reviewed literature, the effects of air cargo transportation on global competitiveness were determined and evaluated.

5. Development Process of Air Cargo Transportation

We can group aviation activities under two main categories, "civil aviation" and "military aviation," with a general distinction. It is possible to divide civil aviation into "air transportation" and "general aviation." Again, we can examine air transportation activities in "passenger transportation" and "cargo transportation." General aviation activities include non-scheduled private, commercial, sportive, balloon flights, and parachute flights. On the other hand, military aviation covers activities for combat, transport, reconnaissance and surveillance, unmanned aerial vehicles, and missiles (Ministry of Transport, Maritime Affairs and Communications, 2013:120). In this part of the study, the development process of air cargo transportation, the newest type of transportation that has proliferated in recent years, will be examined. Firstly, information will be given about air cargo transportation's historical, corporate, aircraft use, and economic development. Then, airports, which are one of the elements of air transport, will be examined.

5.1. Historical Development

The desire of humans to fly, which is as old as the history of humanity, is proved by the pictures that have survived from ancient civilizations to the present day (Ahipaşaoğlu & Arıkan, 2003:117). However, scientific studies on the desire to fly began in the Middle Ages. The first scholar working on this subject is known as Leonardo da Vinci. The flight principles of gliders and helicopters can be found in Vinci's drawings that have survived from 1505 (as cited in Arıkan, 1998:47). The Montgolfier Brothers carried out the first successful balloon flight in world aviation history over Paris in 1783 (Arıkan, 1998:47). Humankind's efforts to fly continued constantly. By 1903, the Wright brothers made the first flight with the first motorized and controllable aircraft they had invented, albeit for 12 seconds (as cited in Uğraç et al., 2020:1315). In 1909, the Frenchman Louis Bleriot became the first pilot to cross the English Channel by plane (Başol, 2012:9), and this went down in the history of world aviation as the first international flight (Long, 2012:167). The success achieved in the process that started with the dream of humankind to fly continued with the use of airlines on battlefields and trade.

Air transport, which was used only for passenger transportation initially, started to be used for cargo transportation later. The transportation of cargo by air began in 1910. The Americans took the first step in this process. Glenn Curtiss transported mail bags 240 km away in 2.5 hours. Fabric materials were transferred to 105 km on the passenger seat by another American company, Wright Company (as cited in Akoğlu & Fidan, 2020:33). Another successful trial in the United States that same year was the transport of 10 bales of silk from the Huffman Prairie Flying airport in Dayton to Columbus, Ohio. Following these innovations, the first air cargo transportation in Europe was in 1911 when the Berliner Morgenpost newspaper was moved from Berlin-Johannisthal to Frankfurt. Then, in 1918, regular air cargo transportation services were started between Washington DC and New York. Air cargo transportation, which began to become widespread in the 1920s, expanded with the establishment of larger airline companies and the production of large-capacity aircraft. For example, Ford Motor Company started to send its cargo through Henry Ford's Express airline company in 1925 (as cited in Ergin, 2020:5). Air postal service pioneered the establishment and development of today's air cargo transportation industry, primarily in the United States (USA).

There has also been an increase in air cargo trade, with large-capacity aircraft incorporated by larger airline companies established in the 1930s. After World War II, cargo operations increased faster with the manufacturing of larger and more efficient aircraft (as cited in Ergin, 2020:5). The production of Jumbo jet aircraft in 1970 increased the attention to air cargo transportation and has led to the growth of the global market in this sector (Akoğlu & Fidan, 2020:33). The use of air cargo transportation, which is relatively new compared to other transportation types in terms of its historical development process, has shown an increasing trend in general. However, it has decreased in some periods, as in the Covid-19 pandemic, and it is estimated that this trend will continue to develop in the future as well.

It can be said that global economic growth is roughly dependent on economic reforms, free trade agreements, and monetary unions. In this context, countries trying to ensure their national interests by joining large commercial blocs have dramatically changed the nature of international trade since the 1990s (Çelik, 2015:3). As a result, the variety of products subject to global trade has increased; parallel to this, competition has intensified, and business processes have been accelerated. To meet the needs above, air cargo transportation, which primarily carries goods with relatively low volume and weight, but with high economic value, has started to be preferred more as a dynamic sector due to its advantages (Çancı & Erdal, 2003:2). As it can be easily understood, companies or countries that compete or aim to compete globally will have to prefer air cargo transportation to meet their customers' fast and reliable delivery expectations.

5.2. Corporate Development

Aviation law historians state that the human beings who succeeded in flying started the regulations regarding the flight after the first balloon flight of the French Montgolfier brothers, which took off from Paris. After the Wright brothers first flew an engined aircraft, these regulation efforts came to the fore. Finally, the air navigation agreement signed between Germany and France on August 15, 1913, marked the beginning. Then, England in 1920, Germany in 1922, and France in 1924 promulgated air navigation laws. After these first regulations for aviation, air transportation spread and developed rapidly. Thus, the need to establish international regulations and rules for civil aviation has emerged (Battal et al., 2016:5).

In parallel with the developments in aircraft, problems began to arise about the air space dominance of the states. States have tended to make international regulations on air transport by arguing within the framework of two opposing views. The first agreement made in this context was the Paris Agreement, signed by 27 states on October 13, 1919. Since all states did not accept this agreement, the Madrid Agreement was signed in 1926. Later, the 20 states that formed the Pan-American Union signed the Havana Agreement in 1928. The diversity of this agreement, which includes the basic principles of the Paris Agreement rules, gives more freedom to aircraft used for commercial purposes. The Warsaw Agreement, which determined the international rights and responsibilities of those engaged in civil air transport activities, was signed in 1929. Still, some of its articles were changed with the Hague Protocol in 1955. The purpose of the Chicago Convention, which genuinely guides aviation, is stated in the first declaration as "to prepare the necessary ground for establishing a safe and regular international civil aviation that targets equal opportunity and economic efficiency for the states parties." In this context, the countries participating in the conference signed the International Civil Aviation Agreement on December 7, 1944, to solve the existing and future problems in civil aviation. Under this agreement, the International Civil Aviation Organization (ICAO) was established and started. In addition to these, the 1933 Rome Agreement, the 1963 Tokyo Agreement, the 1970 Hague Agreement, and the 1971 Montreal Agreement were also signed. (Battal et al., 2016:5-7). With these listed agreements, international aviation rules have tried to be placed on a particular ground.

Aviation rules have been further developed by establishing international organizations other than the above-mentioned international agreements. FAR (Federal Aviation Regulations), which regulate the civil aviation rules of the United States of America, were created in 1970. JAR (Joint Aviation Requirements), which are the civil aviation rules of Europe, started to be designed by JAA (Joint Aviation Authorities) in 1990. Later in 2010, JAA was replaced by EASA (European Aviation Safety Agency), the civil aviation authority of the European Union. Founded by the countries participating in the Chicago Convention, ICAO was accepted as the Legal Aviation Body of the United Nations in October 1947. Established in Havana in 1945, IATA (International Air Transportation Association) aims to solve the commercial and political problems that member airline companies cannot solve (Battal et al., 2016:9-11). Issues that may occur or may arise in rapidly developing air transport operations can be prevented or resolved through these institutions.

Although air cargo transportation is a more costly mode of transportation than other transportation modes, the change in e-commerce and logistics strategies due to globalization has changed the perspective of enterprises on air cargo transportation. They have started to increase their cargo capacities (Popescu, 2006:1-2). The aforementioned strategic changes have increased the customers' expectations for faster and reliable delivery, especially for products with a short shelf life, and increased competition in air cargo transportation that meets these expectations. In this context, globalization and the development of international trade have brought air cargo transportation to the fore.

The emergence of air cargo transportation has given businesses the ability to hold less inventory. From the 1920s onwards, the volume of cargo carried by air increased. Thus, although there are initiatives such as Ford Company's express company, American Railway Express, National Air Transport, General Air Express, United Airlines, and Air Cargo Inc., which four major airline companies founded, airline companies operating only in this field started their activities after World War II. These companies, established under Slick, Flying Tiger, U.S. Airlines, and Airnews, could not achieve the success they wanted in their activities and were vanquished. Later, in 1964, major passenger airlines such as United Airlines started to offer intercontinental cargo services (U.S. Centennial of Flight Commission). Globalization, which has increased the volume and depth of trade and business relations since the last quarter of the 20th century, has also reshaped business organizations related to transportation. New business organizations aiming to meet global consumer demand cheaply, efficiently, and effectively highlight transportation approaches within the value-added chain (TOBB, 2012:66-67). Airline companies, which started their air transportation activities by carrying mail, have canalized to cargo transport, which has turned into an important market and passenger transport due to the sector's rapid technological and structural changes.

Boeing classifies air transport into four categories "All Cargo," "Combination Carrier," "Express Carrier," and "Passenger Belly Only" (Boeing World Air Cargo Forecast Team, 2020:18). The air cargo transportation sector has its characteristics, and ways of carrying cargo in the market can be considered four types of business: combined transportation, only cargo, door-to-door transportation, and intermediary air cargo businesses (Doganis, 2002:304-307). In addition, it can be divided into four different markets air mail, air express, courier, and air freight, depending on the services provided by the companies operating in this sector and the type of goods transported. Although these are general classifications, they are not entirely decisive. Courier is an extension of air express. Due to the removal of weight limits by air express and the ability to make scheduled flights, today, the differences between air freight are gradually decreasing (Long, 2012:175). Air cargo transportation companies serving in both mentioned divisions can organize their activities for only one type of service, considering customer expectations.

Within the corporate development process, there are two types of companies in air cargo transportation: those that do cargo as a side business and those that deal only with this business. These are also divided into integrated airline carriers, scheduled airline carriers, and non-scheduled carriers, in which charter planes are used as specialized cargo carriers (Murphy and Knemeyer, 2016:269). The status of air transportation changed in the 1980s when a young entrepreneur named Fred Smith believed that combining airline passenger and air cargo traffic was inefficient. Smith founded the company Federal Express in 1973, which provides a next-day delivery guarantee and only air cargo transportation. During its ten years of operation, it has achieved an incredibly significant revenue of one billion dollars. Federal Express bought Flying Tigers owner Tiger International Inc. in 1989 and merged the two airlines. Thus, Federal Express, the world's largest company that only transports air cargo, officially changed its name to FedEx in 1994. UPS, one of the important companies operating in air transport, has its origins in 1907, but it started to provide continuous air transport service since 1953 (U.S. Centennial of Flight Commission). On the other hand, Dalsey, Hillblom, and Lynn founded DHL, one of the world's largest air cargo transportation companies, as a door-to-door express delivery service in 1969 (Prezi). Besides, "Thomas Nationwide Transport (TNT)," a trucking and transport company in Australia, was founded in 1946 by Ken Thomas with a single truck. Wanting to expand towards Europe and the United

States, TNT moved its headquarters first to New Zealand and then to Brazil. The company changed its name to TNT Express Services U.K. & Ireland in 1978. In 1982, it got into the courier business by purchasing IPEC Holdings Co. Ltd., which operates in the USA and 26 countries (Hallsworth and Taylor, 1999:165). FedEx, UPS, TNT, and DHL, whose establishments are given above, are the world's four largest integrative companies operating in express air cargo transportation (Popescu, Keskinocak, and Mutawaly, 2010:216). On the other hand, when we consider the air cargo transportation as a whole, although many companies are operating in this field, according to the statistical report of IATA (2019), the companies that carry the most cargo are respectively FedEx, Emirates, Qatar Airways, UPS, Cathay Pacific Airways, Korean Air, Lufthansa, Cargolux, Air China, and China Southern Airlines. Today, the air cargo market has become a global market that concerns the whole world. All companies engaged in air cargo transportation, especially those mentioned above, are to expand their flight networks to increase their market shares and flight frequencies and reduce their costs by entering global markets.

5.3. The Development of Aircraft Used

Undoubtedly, the most critical vehicle used in air transportation is the aircraft. Aircraft produced in the historical development period affect the air transportation market differently. O'Connor (2000:65) divides the aircraft operating in the air cargo transportation market into three "dedicated aircraft," "convertible aircraft," and "combi aircraft." Dedicated aircraft are produced at a height where cargo can be quickly loaded, with large and wide doors. Convertible aircraft initially served as airliners one day and as cargo aircraft the other day with their seats removed. Aircraft used as an airliner was later converted to cargo aircraft due to their difficulties. On the other hand, Combi aircraft allow cargo to be carried both under the aircraft and in a section of the main fuselage reserved for passengers.

Aircraft used in air cargo transportation are also classified according to their body size and payload. Those with a capacity of fewer than 45 tons are categorized as "standard body," those with a capacity between 40 and 80 tons as "medium widebody," and those with a capacity of more than 80 tons as "large body." In this context, two major aircraft manufacturing companies, the American Boeing and the European Airbus draw attention. They produce the majority of airliners and cargo aircraft worldwide. However, some air cargo carriers also prefer Antonov, Ilyushin-type cargo aircraft. Standard Body aircraft consists of the Boeing 727, 737, 757, MD-80, DC-9, and Airbus A320 series. Medium Widebody aircraft are Boeing 767, DC-10, Airbus A300/A310, A330, and Ilyushin II-76TD. Large Body aircraft consist of Boeing 767, 777, MD-11, Antonov An-124, and Ilyushin II-96T aircraft (Boeing World Air Cargo Forecast Team, 2020:90). With the development of the aviation industry day by day, the production of wider-bodied aircraft and the expansion of the fleets of airline companies with these aircraft provide essential cargo capacities for international transportation.

5.4. Economic Development

Air cargo transportation, which is more expensive than other transportation systems, has emerged as an important market with the rapid changes in aircraft technology, large-capacity production, fuel-efficient, low-noise, emission-level aircraft, and the increase in global trade. To understand the economic development of air cargo transportation, it will be helpful to examine the amount of cargo carried, the fleets created to transport them, and the distribution of revenues.

In the 1930s and 1940s, it was thought that air transport, which initially started as postal transportation, would gradually become the most crucial source of income for airlines (Wensveen, 2007:325). However, air transport continued to develop with the increase in international trade. Companies directed their activities from postal transportation to passenger transportation and cargo transportation, escalating. O'Connor (2000:58) stated that from 1961 to 1971, the Freight Tonne Kilometers (FTK), carried only by American scheduled airlines, increased by five times, while the increase in passenger traffic was only three times.

With the liberalization of U.S. air cargo transportation in 1977, the sector rapidly changed. After that, Treaty on Open Skies between the USA and the Netherlands (1992), Canada-US (2006), EUUS (2007, amended in 2010), and ASEAN-China (2010) facilitated global airline alliances (International Transport Forum, 2019:16). In the civil aviation sector, together with the liberalization regulations in the USA, the European Single Aviation Market (1997) was implemented among the member states of the European Community, and the privatization of airline companies was supported. Instead, the increase in per capita income and the development of interregional trade in the Asia-Pacific region until the end of the 1990s expanded the air cargo market. By 1997, the U.S. Federal Aviation Administration (FAA) also removed all domestic cargo carriers' routes, pricing, and aircraft type restrictions. Thus, air cargo carriers could freely determine the prices, the markets they would serve, and their aircraft. In parallel with this, the development of air cargo transportation in the USA and the world increased with the introduction the just-in-time production (JIT) approach. On the other hand, while enabling the liberalization sector to turn into a more commercial structure, it also greatly affected the service quality, efficiency, and scope.

Today, the air cargo transportation market has become a global market that includes all regional markets and concerns worldwide. The development of world air cargo transportation traffic between 1989 and 2019 is seen in Figure 1. When examined, it is seen that the sector achieved significant annual growth of 5.8% in the period between1989-1999. However, during this period, the development experienced in this area slowed down, including in 1998, with the effect of the 1997 Asian Crisis. Between 1999 and 2009, the sector's growth rate slowed down. In this period, although there was some regression between the years 2000-2001, it is seen that the actual collapse was due to the effect of the 2008-2009 Global Financial Crisis. The average growth of 4.3% in the last ten-year period covering the years 2009-2019 shows that the effects of the crisis did not last long. Still, despite the adverse developments in the previous 30 years, it is seen that the air cargo traffic is in a stable development with an annual average growth of 4.1%.

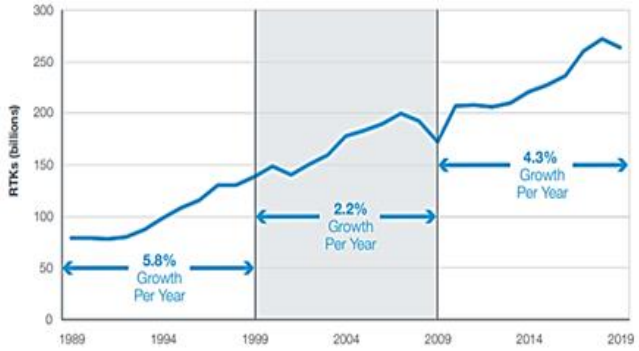

Figure 1. World Air Cargo Traffic (1989-2019)
Source: Boeing, 2020:21

There is a strong relationship between air cargo traffic, economic activity measured by GDP, and industrial production. It is one of the most critical determinants in developing the air cargo market. When Figure 2, where these relations are given together, is examined, the growth in global trade for the last 15 years until 2021 has significantly surpassed the growth in GDP, and the growth in the air cargo market has been more than the growth in global trade. This growth is due to the acceleration of globalization in the same period with liberalization, the development of service options, the awareness of the air cargo market by customers, economic advancements, and express transportation development.

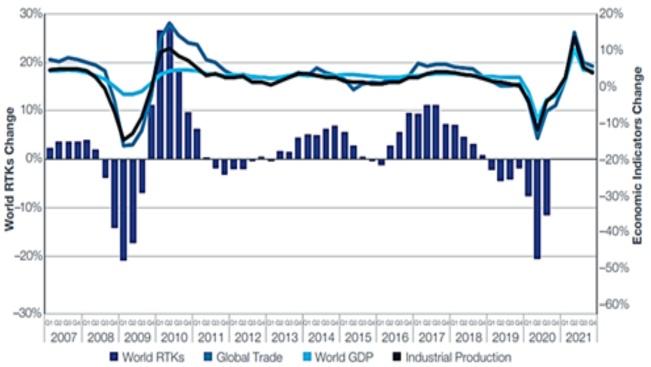

Figure 2. Relationship between World Economy, Global Trade, and Air Cargo Traffic
Source: Boeing, 2020:5

In this context, when the growth of air cargo traffic is analyzed with the help of Figure 3, it is seen that the annual average has grown by 4.3% between 2009 and 2019. For the reasons mentioned above, it is clear that it is a global and highly dynamic market that shows a growth trend, despite the decrease in traffic volume from time to time. Despite the short-term disruption caused by the pandemic at the end of the period, it is estimated that air cargo traffic, measured by Revenue Tonne-Kilometer (RTK), will grow by an average of 4.0% annually until 2039. Parallel to this, when air cargo transportation is taken into account directly in global trade, it is estimated that global trade will grow by an average of 4.7% annually from 2020 to 2025, according to the data of Boeing (2020:7,13,15,22). In this context, it is expected that the global air cargo transportation volume, which was 257 billion RTK in 2019, is more than double and will reach 568 billion RTK in 2039. The strong investor and customer confidence in the air cargo market strengthen these forecasts.

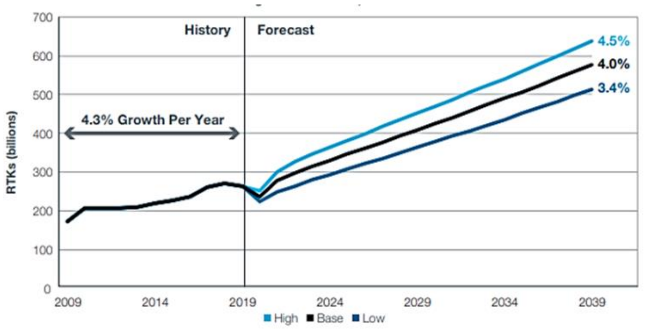

Figure 3. World Airline Cargo Traffic Growth Display (2009-2039)
Source: Boeing, 2020:8

If the prophecies come true, cargo aircraft that have carried more than 50% of the world's air cargo traffic since 2009 will continue to maintain this capacity by 2039. Excluding postal products from these cargoes, general cargo transportation, including all goods sent by air, constitutes the majority of the total world air cargo. It accounts for 81% of worldwide RTK and has an essential role in the global supply chain.

In parallel with the volume of air cargo traffic developments, the fleets have grown due to the airline companies' more investments in cargo, and new businesses have emerged in the sector market. As shown in Figure 4, while the number of freighter fleets carrying various sizes was 2,010 in 2019, it is estimated to grow by more than 60% to 3,260 in 2039.

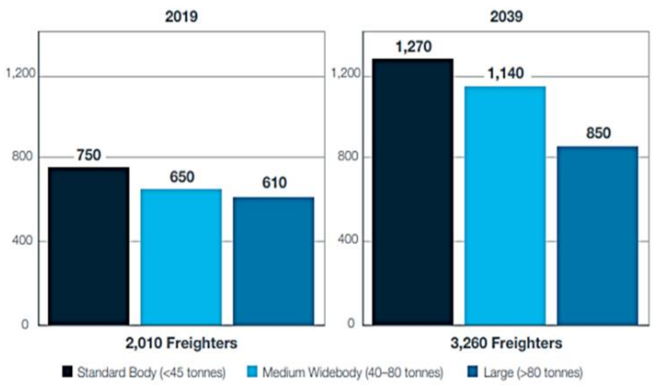

Figure 4. Freighter Fleet Totals
Source: Boeing, 2020:10

To compete in the air cargo transportation market, freighters, which are critically important, have been subjected to four distinctions by Boeing (2020:15) according to their mode of transportation. These are Express Carrier, Combination Carrier, All Cargo, and Passenger Belly Only. The distribution of the total revenues of the air cargo sector, which was 106 billion dollars for 2019, according to the modes of transportation, is shown in Figure 5. 42% of this revenue was obtained from Express Carrier, 36% from Combination Carrier, 11% from transportation with All Cargo aircraft and 11% from transportation as Passenger Belly Only. However, it is seen that airline companies that have Airlines Operating Freighters in their fleets have approximately 90% of the total revenue in the sector.

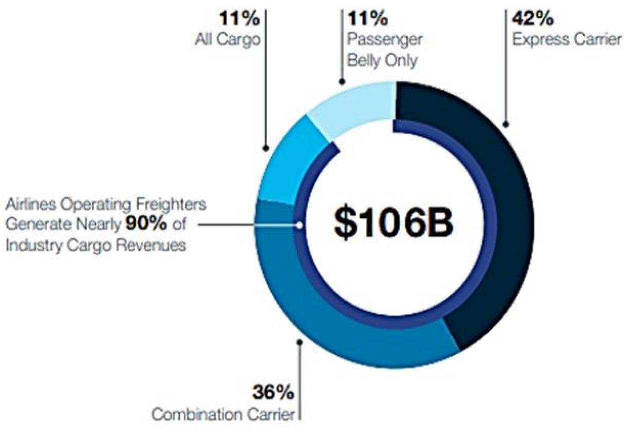

Figure 5. Air Cargo Freight Revenues (2019)
Source: Boeing, 2020:19

All in all, air cargo transportation has an important place in global trade. Air cargo meets approximately 1% of world trade only with the cargo volume but 35% of the world trade with its 6 trillion USD cargo value (IATA). This shows the necessity of preferring air cargo transportation for fast and safe transportation of valuable cargo. Indeed, competitiveness in the global economy depends on speed, trust, and the ability to offer high-quality products worldwide at affordable prices. In addition, air cargo transportation is a sector that facilitates trade, creates employment, and contributes to global economic development.

6. Airports

One of the critical factors for the realization of air cargo transportation is airports as well as aircraft. According to the data published by Airports Council International (ACI), 20 airports with the heaviest cargo handling capacity globally are shown in Table 2. Accordingly, Asia and America mainly have the most enormous cargo volumes. According to 2019 data, 4.8 million tons of cargo were handled at Hong Kong Airport, ranking first. Cargo airports, which provide significant advantages to compete in global trade, have strategic significance. Three different strategies are applied in the design of cargo airports in the world, depending on their characteristics and the city-region they are located in (Köprülü, 2019:26):

The first is the organization of airports in mega aviation cities as global cargo transfer parks. International airports such as Schiphol, Frankfurt, Charles de Gaulle, and Incheon, which are trying to become the leading logistics centers in the global economy, are examples of this trend. Of these, Incheon and Frankfurt are among the 20 airports with the heaviest cargo handling capacity in the world. They have cargo handling volumes of approximately 2.8 million tons and 2.1 million tons, respectively.

The second strategy implemented is to become a global logistics center through a strong logistics company. An example is the relationship between FedEx's logistics company and Memphis Airport. Memphis Airport has become a worldwide hub with the launch of FedEx and the creation of new cargo facilities. Almost all (95%) of the total cargo transported from Memphis Airport, which has been at the top of the world's air cargo transportation rankings for many years, is handled by FedEx. For 2019, Memphis Airport ranks second with a handling capacity of 4.3 million tons.

Another strategy is the regional planning approach in cities and airports where global centers cannot be established. Cargo business volumes are also low due to the lack of or limited "re-export" activities. With this practice, cargo operations at regional airports are expanded, services are diversified, and different product segments tried to be created. Munich, Vienna, Brussels, East Midland, Lyon Saint Exupery, Nice, Helsinki, and Liege airports can be given as examples of such regional cargo airports. However, they are not among the 20 airports with the highest cargo handling volume in the world.

Table 2. Top 20 Airports in The World According to Cargo Traffic Ranking (2019)

Place	Airport	Total Cargo (metric tons)*
1	Hong Kong, HK (HKG)	4 809 485
2	Memphis TN, US (MEM)	4 322 740
3	Shanghai, CN (PVG)	3 634 230
4	Louisville KY, US (SDF)	2 790 109
5	Incheon, KR (ICN)	2 764 369
6	Anchorage AK, US (ANC)**	2 745 348
7	Dubai, AE (DXB)	2 514 918
8	Doha, QA (DOH)	2 215 804
9	Taipei, TW (TPE)	2 182 342
10	Tokyo, JP (NRT)	2 104 063
11	Paris, FR (CGD)	2 102 268
12	Miami FL, US (MIA)	2 092 472
13	Los Angeles CA, US (LAX)	2 091 622
14	Frankfurt, DE (FRA)	2 091 174
15	Singapore, SG (SIN)	2 056 700
16	Beijing, CN (PEK)	1 957 779
17	Guangzhou, CN (CAN)	1 922 132
18	Chicago IL, US (ORD)	1 758 119
19	London, GB (LHR)	1 672 874
20	Amsterdam, NL (AMS)	1 592 221

*Cargo: Loaded and unloaded freight and mail in metric tons
** Includes transit freight
Source: Airports Council International, 2020

7. Effects of Air Cargo Transportation on Global Competitiveness

Rapid developments in globalization and technology have increased urbanization rates in the recent past. Hence, as the value judgments and cultures began to change, the societies' similarities began to emerge. In this context, significant changes have occurred in the demands of individuals. As a result, it has become a question that products designed in any geographical region of the world and produced in a different geographical region are demanded from another geographical region. In this context, product diversity has increased, shelf life has shortened, and the value of manufactured goods has increased. This has affected the logistics sector, and the reputation of supply chain management has grown. In line with these developments, the importance of competition between countries has increased even more.

In recent years, increasing trade trends in the global economy, which are becoming increasingly dependent on each other day by day, and rapid technological developments have increased the importance of logistics activities. Today, it is impossible to compete in the global arena only by producing. For this, the product's price in the market with the same quality and characteristics must be lower than its competitors. This will be possible by reducing the cost of logistics activities. However, the dispersed location of logistics activities increases the costs significantly. The supply chain needs to be set up correctly to reduce transportation costs. In this context, clustering practices of logistics activities in specific areas called logistics hubs are becoming increasingly common. Integrating various transport modes in these logistics centers directly contributes to global competitiveness.

Air cargo transportation, which has become one of the fastest-growing sectors in the logistics sector, has become one of the most crucial elements for expanding the national economy and facilitating trade and global competition. Moreover, air cargo transportation, which is integrated with logistics centers, contributes to the international competition of countries because it has the highest cargo volume among transportation modes. Indeed, as stated in the previous section, while air cargo transport carries an exceedingly small amount of world trade in terms of volume, it has more than one-third of its value.

As can be easily understood from the above statements, mostly goods with relatively low volume and weight but high value are transported in air cargo transportation. The increasing preference for air cargo transportation is based on reasons such as the increase in the variety of products subject to world trade, the acceleration of business processes, and the intensification of competition (Kotler, 1997). Time-sensitive products and luxury goods are frequently transported in air cargo transportation in this context. Furthermore, with the increase in total welfare, individuals have shifted their demands from more products to higher quality products and services. For this reason, the demand for air cargo transportation has increased in the transportation of exotic foods, cut flowers, and medicine (Wells, 1999:364). Goods transported by air cargo are different from those transported by other modes of transport. There are two main reasons for this. The first is that it is possible to deliver the goods on time by shipping the goods faster than other types of transport. The other is that goods are transported more safely than road and maritime transportation, and cargo losses are much less (Air Cargo Week, 2021). Fast and reliable deliveries are essential to increase competitiveness in global trade and prevent customer loss (Teng, 2020:1) because globalization has brought fast delivery of goods to the forefront for producers and consumers. In addition to speed, safe, secure, and frequent transportation services are essential for the manufacturer. In this context, air cargo transportation has safe handling methods to prevent personnel or third parties from interfering with the cargo, which allows this to be realized.

Air cargo transportation is the only alternative in the trade conducted with transoceanic distances and requires speed. In general, the market share of air cargo transportation, which is faster and more reliable than other types of transportation, in the logistics sector is increasing. For this reason, the demand for the sector is rising, and investments are growing in parallel. Thus, the sector's global competitiveness increases with the decrease in waiting times and the decrease in transportation costs due to the reduction in storage costs. Furthermore, with the spread of logistics hubs, the "door to door" delivery model implemented by integrated transportation companies such as FedEx, UPS, and DHL by providing multimodal connections has been another factor that directly contributes to global competition by reducing the number of handling.

Another prominent issue in the global competition regarding air cargo transportation is aircraft technologies. The significant increase in international commercial activities with globalization necessitates that the aircraft used in transportation must be efficient and economical, especially in terms of fuel, for competitiveness. However, transportation costs are increasing due to the increasing oil prices and environmental awareness. In addition, the conversion of expired airliners into cargo aircraft, which is mentioned in the development of aircraft section, creates a disadvantage due to low capacity and fuel efficiency and maintenance costs due to malfunctions that occur due to the age of the aircraft. Therefore, aircraft fleets should be modernized by purchasing new technology aircraft to eliminate these negativities and increase global competitiveness.

In addition, one of the crucial factors for reducing costs in air cargo transportation is the optimization of the payload. The optimization problem, which tries to maximize profitability by using different loading options and aiming to use the current payload at the highest rate, is called "Loading Problem in Air Cargo Transportation (LPACT)" (Küçük and Hava, 2022:185). To achieve this, the shape and dimensions of Unit Load Devices (ULD), standards determined by IATA, should be used following the cross-section of the aircraft fuselage. In addition, damage to ULDs is another crucial factor that increases costs. To keep these to a minimum, innovation studies are currently being carried out to produce ULDs that are lighter, more robust, and reduce transportation risks. With ULDs, the amount and duration of handling are kept at a minimum level, thus reducing both packaging costs and wastage and losses.

Restrictions in the world economy for various reasons, such as the latest Covid-19 pandemic, 9/11 attacks, or the Asian Economic Crisis experienced in previous years, have devastating effects on global trade. The restrictions brought by the legal regulations to overcome this situation cause tighten the security measures, especially in air cargo transportation. As a result, the speed factor, which is the most vital advantage of air cargo transportation, cannot be used effectively, and delays occur in transportation processes, thus affecting global competition negatively.

Airports are undoubtedly one of the factors that play a significant role in the competitiveness of air cargo transportation in the global arena. To carry out these activities, the infrastructure of the airports is as vital as the economic, industrial, and commercial structure of the region. However, these alone are not enough, and airports should be considered as logistics hubs for other transportation modes. This situation was revealed in Sit's (2004:150) research on air transport logistics centers, and it was stated that the hubs to be created should be logistics and production centers that are time-sensitive, meeting the needs of e-commerce and new information systems, rather than just a terminal for the air transportation. Furthermore, he stated that these air cargo-based logistics hubs would potentially become a center that can accelerate development by bringing together new technological developments such as trade, emergency transportation services, JIT philosophy, and products produced in many global regions.

Air cargo transportation, a logistics sub-sector and one of the strategically valuable sectors that directly contributes to global competitiveness, tend to develop rapidly. However, it is thought that although its potential has increased with the effect of technological developments, it is not used enough. For this, investing in air cargo transportation is essential for countries that want to improve their global competitiveness. Investments in this context should be made at airports that allow multimodal transportation, and these should be logistics hubs. Thus, with the advantages of air cargo transportation, it is predicted that it will become a vital sector in global competition by making more remarkable breakthroughs in the upcoming years.

8. Results

Air cargo transportation began to attract humankind's attention after managing to fly in its current form only in 1970 with the introduction of Jumbo jets into our lives. In these years, rapid changes in aviation technology have allowed the development of large-capacity, fuel-efficient, more eco-sensitive aircraft. On the other hand, the companies that emerged with the liberalization of aviation activities enabled the sector to become more commercial. National and international institutions have established the legal framework for functioning increasingly institutionalized air transport. The legal regulations regarding the sector should be constantly updated following the global commercial dynamics.

Although air cargo transportation is newer than other transportation modes in terms of its historical development process, it has become a mode of transportation that has been increasingly preferred in recent years. Air cargo transportation, which is a dynamic sector in which goods with relatively low volume and weight but high value are transported, is increasingly preferred due to its speed and safety advantages, especially with the intensification of global competition in parallel with the increase in the diversity of products in world trade. Although air cargo transportation is the type of transportation with the highest unit transportation costs, the necessity of speed brought by global competition and the difficulties encountered in transportation routes due to geographical locations can be counted among the most important reasons for developing this mode of transportation.

On the other hand, due to the globalization of the world economy, the increase in international trade volume and fast delivery expectations cause products with a short shelf life to prefer air cargo transportation over long distances. Thus, time and place benefit is provided in meeting the customers' needs. Air cargo transportation, which plays a crucial role in international trade, is developing rapidly due to increased interaction between countries. For this reason, it should be ensured that the tendency towards air cargo transportation should be increased by ensuring the continuity of the measures to meet the consumer needs at the right place and time.

One of the ways to increase global competitiveness in air cargo transportation is to modernize the aircraft fleet with fuel-efficient state-of-the-art aircraft. Thus, it will be possible to reduce fuel and maintenance costs, and the costs per unit load will also be reduced by using a more expansive capacity. In this context, optimization of the payload is also an essential factor. For this reason, packaging costs, number, and duration of handling should be reduced by using ULDs suitable for the cross-section of the aircraft fuselage.

Air cargo transportation, which has become one of the fastest-growing sectors in the logistics sector, contributes significantly to the global competition of countries due to having the highest cargo volume among transportation modes. However, the increasing potential of the air cargo transportation sector, which has a strategic importance that directly contributes to global competitiveness, is not used sufficiently with the effect of technological developments. Therefore, investment should be made in air cargo transportation. Furthermore, in hubs where logistics activities are clustered, investments should be made, and integration with other transportation modes should be ensured. In addition, transforming airports into logistics hubs equipped with the latest technological developments for different transportation modes should also be considered within this scope. Thus, with the advantages of air cargo transportation, it is predicted that it will become a vital sector in global competition by making more remarkable breakthroughs in the upcoming 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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Pilot Selection in Airline Organizations with the Analytical Hierarchy Process

Halil Şimşek[1*], İ. Hakan Özaslan[2], and İnan Eryılmaz[3]

[1*]Süleyman Demirel University, School of Civil Aviation, Keçiborlu, Türkiye. (halilsimsek@sdu.edu.tr).
[2] Maltepe University, Logistics and Supply Chain Management Department, İstanbul, Türkiye. (ilkerhakanozaslan@gmail.com).
[3] Süleyman Demirel University, School of Civil Aviation, Keçiborlu, Türkiye. (inaneryilmaz@sdu.edu.tr).

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Abstract

In the aviation sector, where intense rules and competition prevail, safe flight operations are possible with the employment of qualified human resources who can adapt to technology. The aim of this research is to investigate how the most suitable candidate can be recruited by evaluating many criteria together in the pilot recruitment processes, which are of critical importance for aviation enterprises. In this context, the opinions of senior pilots working in the world's top 10 airline organizations were consulted in the study carried out with the Analytical Hierarchy Process (AHP), which is one of the multi-criteria decision support methods. As a result of the literature research, the recruitment criteria for pilot candidates, which are actively used in the sector, have been listed in the context of the suggestions of experienced captains who also take part in various management positions in the aviation sector. A total of 17 criteria, 3 of which are upper and 14 are sub-criteria determined were weighted with the AHP method. As a result of the analysis, "technical", "non-technical" and "occupational criteria" were listed as the upper criteria according to the degree of importance in terms of local weights.

1. Introduction

The fact that competition has become much more fierce than in the past has created new challenges in business life. The aviation industry, which has a global economic potential of 2.7 trillion dollars (Allianz, 2019), needs qualified human resources, which is the only permanent weapon of competition (Česynienė, 2008). Because the aviation sector, which has grown under the control of strong organizations in terms of technology, business development and diplomacy, leads the technological transformation, which is reflected in other industrial areas, especially in the economic systems of developed countries, with its role as a locomotive, thus supporting the creation of qualified added value (Ministry of Development, 2018). Therefore, it is possible to adapt to innovation quickly and effectively with technological adaptation, by investing in human resources, which is the main pillar of success. Managers who are aware of this use a number of carefully prepared criteria to determine the most suitable candidate for the relevant position in the selection of human resources that reflect the identity of the business. Because the main purpose of personnel selection, which is one of the human resources functions, is not only optimizing personnel expenses, which is one of the items that will keep costs at low levels. The main goal is to carry out all activities with minimum cost and maximum benefit, and thus to keep the business afloat in challenging competitive conditions in constant change.

A person who steps into aviation with the dream of becoming a pilot goes through a number of difficult processes, including theoretical, practical and flight stages (Carretta and Ree, 2000; Bates, Colwell, 1997; Howse and Damos, 2011). Successfully overcoming these processes requires above-average competencies from analytical thinking to verbal and applied sciences. Compared to other occupational groups, it is known that even the slightest mistake in the piloting profession can cause irreparable results in terms of both financial and human life. This puts heavy responsibilities on businesses in the selection of pilots (Olaganathan and Amihan, 2021) who ensure that operations are carried out safely and successfully.

While evaluating the competencies of the pilots they employ, aviation organizations take into account non-technical characteristics as well as technical competence. There are many studies on what these criteria are. The common points that these studies focus on are; pilots' flight ability and experience, as well as individual abilities such as decision making, communication, stress management and teamwork, and psychomotor skills such as spatial, visual and auditory memory ability (Carretta and Ree, 1994; Yazgan et al., 2017; Bates et al., 1997; Howse and Damos, 2011). Making the most accurate assessments will benefit businesses both in terms of reputation and finances in the long run and will permanently support growth.

Multi-criteria decision making (MCDM) methods, which have been used in many sectors from past to present, allow the selection of the most suitable personnel among the candidates. However, as a result of the literature review, it is seen that MCDM methods are not used much in the aviation sector. Yazgan and Üstün (2011) who are researchers working on this subject used the MCDM method in weighting the criteria they determined. In this context, the determination of the recruitment criteria applied in the selection of personnel for pilots from human resources management functions and their importance levels were emphasized in the research. The determined criteria were first ranked according to their importance with the survey method, within the framework of the opinions of experienced captains who have worked in airlines for many years, both in pilot and manager positions. These criteria were then weighted with the help of the Analytical Hierarchy Process (AHP), one of the MCDM's, and it was determined which criteria would correspond to how many points. Thanks to the weighting process made with the AHP method, the evaluation criteria used in recruitment are scored without subjective tendencies.

2. Conceptual Framework

As of the end of 2019, a total of 295 thousand 547 people, 11 thousand 840 of whom are pilots, are employed in the Turkish civil aviation sector (SHGM, 2020). In this respect, it is possible to say that aviation is a very large and developing sector. The fact that today's aircraft consists of highly developed safe systems brings the human factor to the fore in accidents (Gopal, 2000). Studies show that 70 to 80% of all aviation accidents are related to human factors (Shappell and Wiegmann, 2003). Similarly, Li et al. (2001) revealed in their study that 80% of aviation accidents and 50% of aviation incidents are related to pilot errors. The fact that human errors are so high has increased the importance of pilot selection, which is a function of human resources management.

Errors that develop independently of environmental factors are called pilot error (Plant and Stanton, 2012; Shappell and Wiegmann, 2001; Shappell et al., 2007). In addition, factors such as excessive fatigue, workload and poor communication are also known to be effective in increasing pilot errors (Helmreich, 1997; Helmreich, 2000). Factors underlying errors also develop depending on decision-making, skill-based and perceptual factors (Shappell and Wiegmann, 2000; Shappel et al., 2017). Decision-making errors are stated as errors that occur because of the wrong choices of the pilot who is in the decision-making situation. Errors that develop due to factors such as carelessness and forgetting are skill-based errors. Perceptual errors can also prevent the healthy fulfillment of professional requirements. The common point of all these errors is that they affect flight safety negatively.

Goeterset et al. (1993) explained the professional success of pilots with their abilities in reasoning, situational awareness, perceptual speed, memorization, psychomotor coordination, reaction orientation, time-sharing, selective attention, spatial orientation, divided attention, control sensitivity, and visualization. Similarly, Hilton and Dolgin (1991) pointed out three important factors in pilot selection: intelligence, psychomotor skills and personality. Griffin and Koonce (1996), on the other hand, stated that psychomotor, perceptual-cognitive, paper-pencil and computer tests were performed during the selection process of military pilot candidates who will serve in the United States, which is the leader in aviation (Martinussen and Torjussen, 1998; Bailey and Woodhead, 1996; Burke et al. 1997).

Yazgan and Üstün (2011) conducted their studies for pilot candidates using the ANP method with 3 upper and 15 sub-criteria. The upper criteria are listed as technical, non-technical and occupational criteria. Sub-criteria are university exam score, basic mathematics, physics, aviation knowledge, english proficieny, personality traits, communication ability, teamwork skills, decision making and problem solving, intelligence, spatial orientation, visual memory, auditory memory, psychomotor skills and determined as an interview. Yazgan and Erol (2016) used binary logistic regression and multiple linear regression analyzes to determine the selection criteria for civilian pilot candidates. As the selection criteria, the scores obtained from the tests measuring the psychomotor, cognitive, and numerical abilities of the candidate, the numerical score of the university exam, the school achievement and the score obtained from the oral exam were used. Oktal and Onrat (2020) used the AHP method in the selection of airline pilot candidates in their study. Grade point average, English, mathematics and physics proficiency, individual characteristics, operational abilities, and basic and integrated mental abilities were used as criteria.

As can be seen, although it varies according to the sector, enterprises can benefit from many criteria in the personnel selection processes. The common goal of all these criteria determined for the sector and the task is to select the most suitable candidate in terms of efficiency. MCDA is used for different sectors and positions as well as aviation. In this context, Bedir and Eren (2015) used a total of 5 criteria to select personnel in their study in the retail sector with the integration of AHP-Promethee ranking methods. Liang and Wang (1994) carried out the personnel selection with the multi-criteria decision-making method in their study. Bali et al. (2013) used delphi technique and heuristic fuzzy sets methods in staff selection. Özgörmüş et al. (2005) conducted a supply planning engineer personnel selection study with fuzzy AHP. Güdük and Önder (2017) used the AHP method in the selection of data entry personnel in health services. In their study, Temiz and Cingöz (2015) used the AHP technique in the recruitment process of a fast-food business manager candidate. Doğan and Önder (2014) used AHP and TOPSIS methods for sales representative personnel selection in their study. Koyuncu and Özcan (2014) carried out their studies by using AHP and TOPSIS methods in the selection of production supervisors. Turan and Turan (2016) carried out their studies with the AHP method in the selection of nurses in the health sector. Türeli and Davraz (2016) carried out their studies by using AHP and VIKOR methods in the selection of personnel in the health sector. Weingarten et al. (1997) used the AHP for the selection of surgical assistants. Wang et al. (2017) performed physiological and psychological selection for a high-performance fighter pilot based on the AHP.

3. Methodology

3.1. Criteria Selection

In the research methodology, first, the criteria required for the weighting process with AHP were determined. The criteria determined as a result of the literature review were collected in a common pool and each criterion was handled separately in the context of air transport. Considering the difficulties experienced in personnel selection processes (Sackett et al. 2008), operating a fair and effective process in terms of results will positively affect the justice perceptions of the candidates and minimize possible objections (Ryan and Ployhart, 2000; Truxillo et al. 2009).

During the evaluation and prioritization of the criteria, the opinions of experts who worked in different units, especially in teacher piloting and human resources management, were consulted. The demographic characteristics of these people in decision-making positions were determined based on the demographic variables included in the study on flight crew resource management conducted by Aktaş and Tekarslan (2013). Information about the experts is presented in the table below.

Table 1. Demographic Characteristics of Experts

	Education	Age	Status	Flight Year	Flight Hours
Participant 1	Bachelor's Degree	43	Exeminer Pilot	18	14860
Participant 2	Bachelor's Degree	48	Exeminer Pilot	19	15600
Participant 3	Master's Degree	46	Exeminer Pilot	18	15320
Participant 4	PhD	51	Exeminer Pilot	24	16800
Participant 5	Master's Degree	48	Exeminer Pilot	20	15900
Participant 6	PhD	52	Exeminer Pilot	27	17190
Participant 7	Bachelor's Degree	39	Exeminer Pilot	16	13940
Participant 8	Bachelor's Degree	40	Exeminer Pilot	15	13370
Participant 9	PhD	50	Exeminer Pilot	25	16480
Participant 10	Bachelor's Degree	38	Exeminer Pilot	15	13090

When the demographic characteristics and professional experiences of the experts, all of whom have higher education levels, are examined it is seen that the average age is 45.5, the average flight year is 19.7, and the average flight time is 15200 hours. In addition to their administrative and technical duties, it is evaluated that the experts, all of whom are teacher pilots, have a high level of competence in terms of pilot employment. In this context, 3 basic and 14 sub-criteria based on Yazgan and Üstün (2011)'s work with the contribution of its experts are presented in the table below (Hilton and Dolgin, 1991; Griffin and Koonce, 1996; Yazgan and Erol, 2016; Oktal and Onrat, 2020).

Table 2. Criteria and Explanations

Code	Criteria	Description
C_1	***Technical Criteria***	***Express their professional skills and experience.***
C_{1a}	Flight Year Experience	Time spent actively in the piloting profession.
C_{1b}	Total Flight Hours (Todd and Thomas, 2012; Carretta and Ree, 2000)	Total flight time with the aircraft as a pilot.
C_{1c}	Type Rating	The type of aircraft authorized to fly.
C_{1d}	English Language Proficiency (Yazgan and Üstün, 2011)	English language proficiency, which is the international aviation language.
C_{1e}	Simulator Test Results (Bolstad et al. 2002; Carretta and Ree, 2000)	Virtual reality system data that can simulate flight conditions for the pilot.
C_2	***Non-Technical Criteria***	***Criteria not directly related to the aircraft and the work performed***
C_{2a}	Decision Making and Problem Solving (Yazgan and Üstün, 2011)	Usually, the ability to deal with abnormal situations or solve a problem.
C_{2b}	Stress Management (CAA, 2014)	Ability to act correctly and make right choices when under stress
C_{2c}	Communication Skills (CAA, 2014; Yazgan and Üstün, 2011)	Ability to use language
C_{2d}	Teamwork Skill (CAA, 2014; Yazgan ve Üstün, 2011)	Ability to work as a member of a group.
C_{2a}	Personal Characteristics (Carretta and Malcolm, 1996; Yazgan and Üstün, 2011)	Personality traits that characterize an individual
C_3	***Occupational Criteria***	***Express the criteria related to the piloting profession.***
C_{3a}	Interview (Yazgan and Üstün, 2011; Carretta and Ree, 2000)	Interview for candidates for evaluation
C_{3b}	Spatial Orientation (Endsley, 1999; CAA, 2014; Yazgan and Üstün, 2011)	The ability to orient the body and postural position according to the physical environment in a static position or movement.
C_{3c}	Visual Memory (Endsley, 1999; CAA, 2014; Yazgan and Üstün, 2011)	The ability to accurately remember an object and then associate its properties with others.
C_{3d}	Auditory Memory Ability (Endsley, 1999; CAA, 2014; Yazgan and Üstün, 2011)	Ability to store and remember auditory information.

3.2. Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP), developed by Saaty in 1977, is one of the most frequently used (Zietsman and Verschuren, 2014) multi-criteria decision-making methods. A predefined comparison scale is used in AHP, where the systems approach is adopted. For this, with the help of expert opinions, the importance levels of the criteria affecting decision making are determined and one-to-one comparisons are made. In the hierarchical structure setup, there is the purpose at the top, the sub-criteria at the middle level, and the alternatives at the bottom. In this system, which is different from the traditional decision tree, each level represents a different segment. AHP, which should theoretically include homogeneity, reciprocity, meeting expectations and independence (Saaty, 1980, 1990, 2004, 2008), helps to make the best decision and make the right choice with clear justifications by synthesizing the results of criterion comparisons. The steps to be followed while applying AHP are given below:

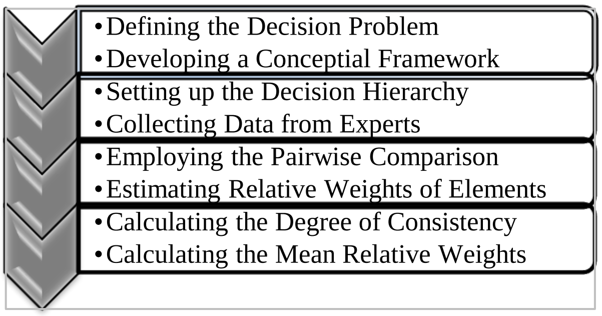

Figure 1. AHP Process
Source: Saaty, R.W. (1987).

First of all, as a result of defining the problem, the purpose, criteria and alternatives are determined, and a hierarchical structure is created. During this step, surveys and face-to-face interviews can be conducted with experts. There should be no significant differences between the experience and knowledge levels of the experts whose opinions are sought. The importance degrees to be used for weighting the criteria selected or determined during the multi-criteria scoring process are given in Table 3.

Table 3. The AHP Pairwise Comparison Scale

Intensity of importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favor one factor over another
5	Essential or strong importance	Experience and judgment strongly favor one fctor over another
7	Very strong importance	A factor is strongly favored and is dominance demonstrated in practice
9	Extreme importance	The evidence favoring one factor over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed

Source: Saaty, R.W. (1987).

In the First step, the pairwise comparison matrix is created as shown in formula (1).

$$A = \begin{vmatrix} 1 & a_{12} & a_{1n} \\ 1/a_{12} & 1 & a_{2n} \\ 1/a_{1m} & 1/a_{2m} & 1 \end{vmatrix} \quad (1)$$

In the next step, the normalization of the pairwise comparison matrix is performed by normalizing the values of the matrix. The normalized matrix is obtained by using the formula (2) as a result of dividing the value in each column in the matrix by the column sum.

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{a} a_{ij}} \quad (2)$$

Then, the average of the sum of each row of the normalized matrix is taken and the criteria weights are found using formula (3).

$$W_i = \frac{\sum_{j=1}^{a} b_{ji}}{n} \quad (3)$$

The next step is to check whether the criteria weights are consistent or not. In the meantime, formula (4) is used to find the consistency ratio (CR). As a result of the process, the consistency ratio (CR) is expected to be lower than 0.10. If it is otherwise high, it is defined as inconsistency and requires reconsideration of expert opinions.

$$\text{CR} = \frac{CI}{RI} \quad (4)$$

Formula (5) is used to calculate the required consistency index value (CI).

$$\text{CI} = \frac{(\lambda max - n)}{(n-1)} \quad (5)$$

The random index (RI) table is used for the random index value. In this context, the value that is suitable for the number of criteria used is selected.

Table 4. Random Consistency Index (RI) Values by Matrix Dimensions

n	1	2	3	4	5	6	7	8	9
R.I.	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45

Source: Saaty, R.W. (1987).

Finally, the consistency of the matrix is tested by comparing the selected value with the consistency index value (Saaty, 1987).

3.3. Implementation

In this study, the importance degrees of the criteria used in the pilot recruitment processes in the aviation sector are emphasized. In order to determine and weight the criteria, the opinions of the expert participants were used, and the weight of each criterion was found. Within the framework of literature review and expert opinions, 3 upper and 14 sub-criteria were determined in a hierarchical structure, and experts were asked to make pairwise comparisons for the criteria. The research model created is shown in the figure below.

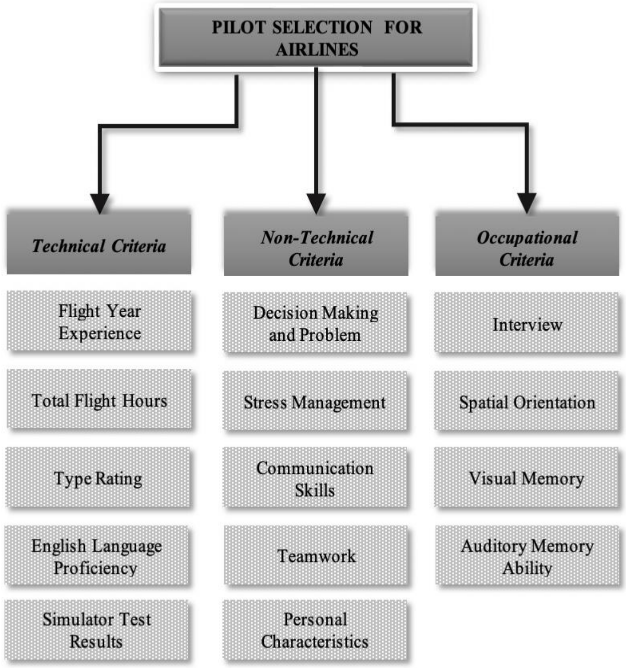

Figure 2. Research Model

The weighting processes made based on upper and sub-criteria with AHP were carried out with the following steps. With the help of the created matrix, the local and global weights of each criterion were calculated. For this, first, pairwise comparison matrix was formed based on upper and then sub-criteria and normalized. Afterwards, the relative importance values of the criteria were determined, and their consistency was checked.

The pairwise comparison matrix for the upper criteria determined within the framework of the literature review and expert opinions is presented in Table 5.

Table 5. Pairwise Comparison Matrix for the Upper Criteria

	C_1	C_2	C_3
C_1	1,00	5,00	9,00
C_2	0,20	1,00	5,00
C_3	0,11	0,20	1,00
Total	1,31	6,20	15,00

In the second step, criteria weights are calculated by normalizing each value in the pairwise comparison matrix. For this process, the value in each column is divided by the column total and the arithmetic average is taken. The matrix formed as a result of the process is presented in Table 6.

Table 6. Normalized Matrix and Criterion Weights for the Upper Criteria

	C_1	C_2	C_3	Weights
C_1	0,76	0,81	0,60	0,72327
C_2	0,15	0,16	0,33	0,215765
C_3	0,08	0,03	0,07	0,060965

After obtaining the normalized matrix, it is necessary to find the relative importance values (weights of the criteria) that enable the criteria to be placed in order of importance within themselves. The procedure here is to calculate the arithmetic mean for each row of the normalized comparison matrix. Thus, the most important decision criterion is determined with criterion weights (wi).

Table 7. Relative Importance Values for the Upper Criteria

	C_1	C_2	C_3	Total	Total / C
C_1	0,72	1,08	0,55	2,35	3,250208
C_2	0,14	0,22	0,30	0,67	3,083180
C_3	0,08	0,04	0,06	0,18	3,012848

In the next step, the consistency of the criterion weights was checked. Consistency ratio (CR) should be less than 0,10 [56]. In this context, the consistency index (CI) was calculated, and the consistency of the matrix was tested, and the results are presented in Table 8. Since the value found with 0,09 is less than 0,10, the consistency tests were successful. 0,58 was used for the RI value of 3.

Table 8. Consistency Test Results for the Upper Criteria

Total	Weights	Total / C	Landa Max	Consis tency Index	Random CI	CI/RI
2,350778	0,72327	3,250208	3,115412	0,0577 06	0,09 949 3	<0,10
0,665243	0,215765	3,08318				
0,183677	0,060965	3,012848				

After the processes related to technical, non-technical and professional upper criteria, pairwise comparison matrix was formed for each of them based on sub-criteria, and then the consistency of the sub-criteria, whose relative importance values were determined, was checked. Sub- of technical criteria; flight years' experience, total flight hours, type ratings, English language proficiency and simulator test results are divided into 5 groups. The pairwise comparison matrix created is shown in Table 9.

Table 9. Pairwise Comparison Matrix for the Sub-Criteria of Technical Criteria

	$C1_a$	$C1_b$	$C1_c$	$C1_d$	$C1_e$
$C1_a$	1,00	1,00	5,00	7,00	9,00
$C1_b$	1,00	1,00	5,00	3,00	5,00
$C1_c$	0,20	0,20	1,00	1,00	1,00
$C1_d$	0,14	0,33	1,00	1,00	1,00
$C1_e$	0,11	0,20	1,00	1,00	1,00
Total	2,45	2,73	13,00	13,00	17,00

The normalized matrix and criterion weights created for the sub-criteria of the technical criteria following the pairwise comparison matrix is shown in Table 10.

Table 10. Normalization of the Pairwise Comparison Matrix Created for the Sub-Criteria of the Technical Criteria

	$C1_a$	$C1_b$	$C1_c$	$C1_d$	$C1_e$	Weights
$C1_a$	0,4082	0,3663	0,3846	0,5385	0,5294	0,445390
$C1_b$	0,4082	0,3663	0,3846	0,2308	0,2941	0,336793
$C1_c$	0,0816	0,0733	0,0769	0,0769	0,0588	0,073512
$C1_d$	0,0571	0,1209	0,0769	0,0769	0,0588	0,078138
$C1_e$	0,0449	0,0733	0,0769	0,0769	0,0588	0,066166

The relative importance values calculated for the sub-criteria of the technical criteria following the normalization process are shown in Table 11.

Table 11. Relative Importance Values for the Sub-Criteria of the Technical Criteria

	$C1_a$	$C1_b$	$C1_c$	$C1_d$	$C1_e$	Total	Total / C
$C1_a$	0,4454	0,3368	0,3676	0,5470	0,5955	2,2922	5,146505
$C1_b$	0,4454	0,3368	0,3676	0,2344	0,3308	1,7150	5,092113
$C1_c$	0,0891	0,0674	0,0735	0,0781	0,0662	0,3743	5,091014
$C1_d$	0,0624	0,1111	0,0735	0,0781	0,0662	0,3913	5,007949
$C1_e$	0,0490	0,0674	0,0735	0,0781	0,0662	0,3342	5,050483

After calculating the relative importance values, the consistency of the criteria weights was checked. In this context, the consistency index (CI) was calculated, and the consistency of the matrix was tested, and the results are presented in Table 12. Since the value found with 0,01740 is less than 0,10, the consistency tests were successful. 1,12 was used for the RI value of 5 (Table 4).

Table 12. Relative Importance Values Determined for the Sub-Criteria of the Technical Criteria

Total	Weights	Total / C	Landa Max	Consistency Index	Random CI CI/RI	
2,292204	0,44539	5,146505	5,077613	0,019403	0,017 40	<0,10
1,714989	0,336793	5,092113				
0,374253	0,073512	5,091014				
0,391313	0,078138	5,007949				
0,334168	0,066166	5,050483				

Sub-criteria of non-technical criteria; decision making and problem solving, stress management, communication ability, teamwork ability and personal characteristics. The pairwise comparison matrix created is shown in Table 13.

Table 13. Pairwise Comparison Matrix for the Sub-Criteria of the Non-Technical Criteria

	$C2_a$	$C2_b$	$C2_c$	$C2_d$	$C2_e$
$C2_a$	1,00	1,00	5,00	7,00	9,00
$C2_b$	1,00	1,00	5,00	3,00	3,00
$C2_c$	0,20	0,20	1,00	3,00	1,00
$C2_d$	0,14	0,33	0,33	1,00	1,00
C2e	0,11	0,33	1,00	1,00	1,00
Total	2,45	2,86	12,33	15,00	15,00

The normalized matrix and criterion weights created for the sub-criteria of the technical criteria following the pairwise comparison matrix is shown in Table 14.

Table 14. Normalization of the Pairwise Comparison Matrix Created for the Sub-Criteria of the Non-Technical Criteria

	$C2_a$	$C2_b$	$C2_c$	$C2_d$	$C2_e$	Weights
$C2_a$	0,4082	0,3497	0,4055	0,4667	0,6000	0,445999
$C2_b$	0,4082	0,3497	0,4055	0,2000	0,2000	0,312666
$C2_c$	0,0816	0,0699	0,0811	0,2000	0,0667	0,099866
$C2_d$	0,0571	0,1154	0,0268	0,0667	0,0667	0,066525
C2e	0,0449	0,1154	0,0811	0,0667	0,0667	0,074944

The relative importance values calculated for the sub-criteria of the non-technical criteria following the normalization process are shown in Table 15.

Table 15. Relative Importance Values Created for the Sub-Criteria of the Non-Technical Criteria

	$C2_a$	$C2_b$	$C2_c$	$C2_d$	$C2_e$	Total	Total / C
$C2_a$	0,446 0	0,312 7	0,499 3	0,465 7	0,674 5	2,398 2	5,37706 5
$C2_b$	0,446 0	0,312 7	0,499 3	0,199 6	0,224 8	1,682 4	5,38083 7
$C2_c$	0,089 2	0,062 5	0,099 9	0,199 6	0,074 9	0,526 1	5,26821 5
$C2_d$	0,062 4	0,103 2	0,033 0	0,066 5	0,074 9	0,340 0	5,11152 9
C2e	0,049 1	0,103 2	0,099 9	0,066 5	0,074 9	0,393 6	5,25160 1

After calculating the relative importance values, the consistency of the criteria weights was checked. In this context, the consistency index (CI) was calculated, and the consistency of the matrix was tested, and the results are presented in Table 16. Since the value found with 0,06229 is less than 0,10, the consistency tests were successful. 1,12 was used for the RI value of 5 (Table 4).

Table 16. Relative Importance Values Determined for the Sub-Criteria of the Non-Technical Criteria

Total	Weights	Total / C	Landa Max	Consistency Index	Random CI CI/RI	
2,398166	0,445999	5,377065	5,2778 49	0,06946 2	0,06 229	<0,10
1,682403	0,312666	5,380837				
0,526118	0,099866	5,268215				
0,340044	0,066525	5,111529				
0,393575	0,074944	5,251601				

The sub-criteria of the criteria related to the profession are divided into 4 groups. These are interview, spatial ability, visual memory ability and auditory memory ability. The pairwise comparison matrix created is shown in Table 17.

Table 17. Pairwise Comparison Matrix for the Sub-Criteria of the Occupation-Related Criteria

	$C3_a$	$C3_b$	$C3_c$	$C3_d$
$C3_a$	1,00	3,00	5,00	7,00
$C3_b$	0,33	1,00	1,00	1,00
$C3_c$	0,20	1,00	1,00	1,00
$C3_d$	0,14	1,00	1,00	1,00
Total	1,67	6,00	8,00	10,00

The normalized matrix and criterion weights created for the sub-criteria of the criteria related to the occupation following the pairwise comparison matrix is shown in Table 18.

Table 18. Normalization of the Pairwise Comparison Matrix Created for the Sub-Criteria of the Occupational Criteria

	$C3_a$	$C3_b$	$C3_c$	$C3_d$	Weights
$C3_a$	0,60	0,50	0,63	0,70	0,605951
$C3_b$	0,20	0,17	0,13	0,10	0,147318
$C3_c$	0,12	0,17	0,13	0,10	0,127857
$C3_d$	0,08	0,17	0,13	0,10	0,118875

The relative importance values calculated for the sub-criteria of the occupational criteria following the normalization process are shown in Table 19.

Table 19. Relative Importance Values Created for the Sub-Criteria of the Occupational Criteria

	$C2_a$	$C2_b$	$C2_c$	$C2_d$	Total	Total / C
$C2_a$	0,61	0,44	0,64	0,83	2,52	4,157618
$C2_b$	0,20	0,15	0,13	0,12	0,59	4,032186
$C2_c$	0,12	0,15	0,13	0,12	0,52	4,029818
$C2_d$	0,08	0,15	0,13	0,12	0,48	4,028463

After calculating the relative importance values, the consistency of the criteria weights was checked. In this context, the consistency index (CI) was calculated, and the consistency of the matrix was tested, and the results are presented in Table 20. Since the value found with 0,02344 is less than 0,10, the consistency tests were successful. 0,89 was used for the RI value of 4 (Table 4).

Table 20. Relative Importance Values Determined for the Sub-Criteria of the Occupational Criteria

Total	Weights	Total / C	Landa Max	Consistency Index	Random CI CI/RI	
2,519311	0,605951	4,157618	4,062 021	0,020674	0,02 344	<0,10
0,594013	0,147318	4,032186				
0,515240	0,127857	4,029818				
0,478882	0,118875	4,028463				

As a result of the calculations made with AHP, the local and global weights of the criteria to be used for pilot recruitment were determined. Local weights were calculated for the upper criteria, and both local and global weights were calculated for the lower criteria.

Table 21. Local and Global Weights of all Criteria

Upper Criteria	Local Weights	Lower Criteria	Local Weights	Global Weights
Technical Criteria	0,723270131	Flight Year Experience	0,445390464	0,321
		Total Flight Hours	0,336793179	0,243
		Type Rating	0,073512482	0,053
		English Language Proficiency	0,078138332	0,056
		Simulator Test Results	0,066165543	0,047
Non-Technical Criteria	0,215765137	Decision Making and Problem Solving	0,445999057	0,096
		Stress Management	0,312665724	0,067
		Communication Skills	0,099866478	0,021
		Teamwork Ability	0,066524959	0,014
		Personal Characteristics	0,074943782	0,016
Occupational Criteria	0,060964732	Interview	0,605950599	0,036
		Spatial Orientation	0,147317864	0,008
		Visual Memory	0,127856786	0,007
		Auditory Memory Ability	0,11887475	0,007

According to the calculations the global weights of technical criteria are 0,723270131, non-technical criteria are 0,215765137, and occupational criteria are 0,060964732.

Among the technical criteria, the local weight of the flight year experience is 0,445390464, and the global weight is 0,321; the local weight of the total flight hours is 0,336793179, and the global weight is 0,243; the local weight of the type trainings received was 0,073512482, and the global weight was 0,053; English language proficiency has a local weight of 0,078138332 and a global weight of 0,056; the local weight of the simulator test results was found to be 0,066165543 and the global weight to be 0,047. As a result of these calculations, it is possible to say that the criterion with the highest local and global weight under the technical criteria is the experience of the flight year.

Among non-technical criteria, decision making and problem solving has a local weight of 0,445999057 and a global weight of 0,096; stress management has a local weight of 0,312665724 and a global weight of 0,67; the local weight of the communication ability is 0,099866478, and the global weight is 0,021; The local weight of teamwork ability is 0.066524959, its global weight is 0,014, the local weight of personal characteristics is 0,074943782, and its global weight is 0,016. As a result of these calculations, it is possible to say that the criteria with the highest local and global weights under non-technical criteria are decision making and problem solving.

Among the criteria related to the profession, the local weight of the interview is 0,605950599 and its global weight is 0,036; the local weight of spatial ability is 0,147317864, and the global weight is 0,008; visual memory ability has a local weight of 0,127856786 and a global weight of 0,007; The local weight of the auditory memory ability was found to be 0,1887475, and the global weight was 0,007. As a result of these calculations, it is possible to say that the criterion with the highest local and global weight under the criteria related to the profession is the interview.

Finally, all the sub-factors were ranked according to their global weights obtained by AHP. The most important criteria are flight years' experience (0,321), total flight hours (0,243) and decision making and problem solving (0,096), while the least important criteria are visual memory ability (0,007) and auditory memory ability (0,007).

Table 22. The Order of Importance of the Sub-Factor

Sub-Criteria	**Global Weights**	**Sub-Criteria**	**Global Weights**
Flight Year Experience	**0,321**	Interview	**0,036**
Total Flight Hours	**0,243**	Communication Skills	**0,021**
Decision Making and Problem Solving	**0,096**	Personal Characteristics	**0,016**
Stress Management	**0,067**	Teamwork Ability	**0,014**
English Language Proficiency	**0,056**	Spatial Orientation	**0,008**
Type Rating	**0,053**	Visual Memory	**0,007**
Simulator Test Results	**0,047**	Auditory Memory Ability	**0,007**

4. Results and Discussions

Personnel selection process, which is one of the human resources management functions, is of vital importance for businesses. Each business determines various criteria to select the most suitable candidate for the working conditions. These criteria vary according to the sector. Determining recruitment criteria is very important for the long-term success of businesses. Because a correct procurement procedure also means efficient work outputs and lower labor turnover. When it comes to aviation, recruitment processes become much more critical. Because the aviation industry is one of the most risky and competitive industries. The fact that even the slightest mistake can cause irreparable results is another factor that distinguishes the aviation industry from others. This makes it necessary to carry out all activities with a preventive approach. Within the aviation sector, the area where commercial and reputational pressure is at the forefront is air transportation. In this context, the study focuses on the pilot selection criteria in the air transport sector.

The criteria determined as a result of the literature review were expanded with expert opinions. A total of 17 criteria, including 3 upper and 14 lower criteria, were determined. These criteria were put in order of importance within the framework of the opinions of 10 participants, who were determined among the most experienced captain pilots of the airline transport sector. All criteria were weighted at local and global level by using pairwise comparison matrix with the AHP method. According to the results of the research, it was seen that the most important recruitment criterion was flight experience with a global weight index of 0,321. Flight year experience is followed by total flight hours (0,243) and decision making and problem solving (0,096) criteria. It was seen that the criteria with the least importance are visual memory and auditory memory ability (0,007). In general, the criteria used in the air transport sector are similar to those in this research. However, it is the superior side of the research that these criteria have been expanded within the framework of expert opinions. However, it is seen that the determination of pilot selection criteria has been done in military aviation. It is known that the dynamics of civil aviation differ from military aviation by being partially similar. In this context, the fact that the research was conducted on civil air transportation sector can be considered as another advantage. In this respect, the study is not only a useful resource for the literature, but also for the sector. Finally, it is possible to mention some limitations of the research. The first of these is the study of the Turkish sample, even though the industry is dependent on international dynamics. The second is that it has been studied specifically for air transport. Finally, experts are limited to 10 people. As a result, although these limitations negatively affect the generalizability of the research results, this study is a resource for other researchers on the subject.

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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Investigation of the Effects of Ukraine - Russia Tension on Turkish Airspace and Istanbul Airport

Gül Çıkmaz[1*], Metehan Atay[2] and Hüseyin Keskin[3]

[1]Hasan Kalyoncu University, Vocational School, Department of Transportation Services, Civil Aviation Cabin Services, Gaziantep, Türkiye. (gul.cikmaz@hku.edu.tr).
[2] Hasan Kalyoncu University, Vocational School, Department of Electronics and Automation, Unmanned Aerial Vehicles Technology and Operation, Gaziantep, Türkiye. (metehan.atay@hku.edu.tr).
[3]General Directorate of State Airports Authority, Türkiye. (huseyin.keskin@dhmi.gov.tr).

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Corresponding Author: *Gül Çıkmaz*

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Abstract

It is known that the airline industry, which is known to be more dynamic and complex among all sectors in the world, has been affected by many changes and events. Especially the political tensions between the states and the fact that the airline industry creates a large amount of capital make this situation even more complex and unpredictable. In this study, the reflections of the political tension between Ukraine and Russia in Turkey, which has intense commercial relations with both countries, were examined in the context of the airline industry. As a result of the analyzes carried out, it was seen that the tension between Ukraine and Russia is in a positive correlation with the traffic in Turkish airspace and Istanbul Airport, and it was concluded that Istanbul airport effectively increased the aircraft traffic with the airspace occupation. The study is expected to be the basis for future comprehensive studies.

1. Introduction

Since the existence of humanity, transportation activity has presented us many problems and fields of study from the past to the present. As in every business area, it is an important factor to monitor and control the dynamic environment in the airline industry, which is the main way of transferring goods and passengers today. For this reason, optimization studies in the changing and developing environmental conditions in the airline industry have gained an undeniable place in the field of optimization. Under these circumstances, the International Air Transport Association (IATA) guides all these efforts, supporting global standards for aviation, including aviation safety, flight safety, flight efficiency and sustainability, and providing manual data retention to keep dynamic environmental factors in check and provides resources for new studies.

Conditions that vary from country to country have created new and different problems. These problems encouraged creative and innovative ideas and paved the way for platforms to present different ideas in the field of work. With the developments in recent years, Turkey, which is among the top ten countries in the field of air transport, is expected to make even more significant contributions to world air transport in the coming years, both in domestic and international transfer centers. Since the airline industry is made up of a dynamic environment, it is very sensitive to many changes. This high degree of precision makes managing and operating this industry day-to-day difficult. Especially financial crises or other environmental and political events that may lead to financial crises easily affect the aviation industry. COVID-19, one of the pandemics in history, has caused an unprecedented crisis for the world's airlines (Albers and Rundshagen, 2020). All states in the world have taken measures to cope with this pandemic situation in the aviation sector, as in many other sectors. As a result of these measures, the travel and hospitality industry in general and the airlines in particular have been hit hard and more than 60 percent of the world's commercial aircraft have been grounded (Hollinger, 2020). In addition, many governments have also announced support packages and aid, as the aviation industry is seen as an important source of income for many countries (Rushe, 2020). From this point of view, finding cost sources and taking precautions in the airline industry play a key role in ensuring continuity in the crisis period. However, profitability factors in the airline industry have changed and differentiated in the world over time (Scotti and Volta, 2017). Similar to the differentiation in the sector, it is possible to encounter various business models and cost structures from cost structure to service range. Considering all these situations, the structure of the airline industry, which is intertwined with other sectors and politics, has caused it to be sufficiently affected not only by financial crises but also by political crises.

On the other hand, it is known that political events lead to investments and new business models in the sector (Atay et al., 2021a). Under these conditions, it is inevitable that a sector that is so affected by current events will have environmental and climatic consequences as well as major economic sanctions and consequences (Atay et al., 2021b). Beyond the environmental and climate effects, when the financial effects and human effects are compared, the resulting grievances and financial losses appear to be an issue that needs to be examined, since they are largely conspicuous. Despite the global crisis experienced in the world in 2003, Turkish Civil Aviation continues its growth that it started in 2002. This growth is expected to continue in the coming years and to reach the 2023 targets in civil aviation.

Having one of the largest airports in the world, especially with its Istanbul Airport infrastructure, Turkey has experienced a significant change in 16 years and has managed to achieve this growth in the sector after liberalization. As people start to prefer air transportation, the number of businesses that will serve in the sector is increasing rapidly, and therefore countries are trying to reach the best standards in transportation. So much so that in many studies carried out during the construction phase, the predicted number of passengers easily reached the estimates and performed above the expected (Atay et al., 2019). However, due to the COVID-19 pandemic that emerged in 2020, its efficiency has decreased due to the closures and reductions in flights, and the aviation industry has suffered a great injury, as is the case all over the world. Since Turkey is a major tourism country and serves as a bridge between Europe and Asia, the disruptions in air transportation caused great damage and pioneered radical changes in the sector. According to the data published by the Ministry of Culture and Tourism, tourism activity increased 4.5 times after COVID-19 compared to the previous year, 2021, and the country with the largest share in this mobility was Russia with a 10% share (KTB, 2022). In terms of total foreign tourist mobility, the ranking by transportation type is shown in Figure 1.

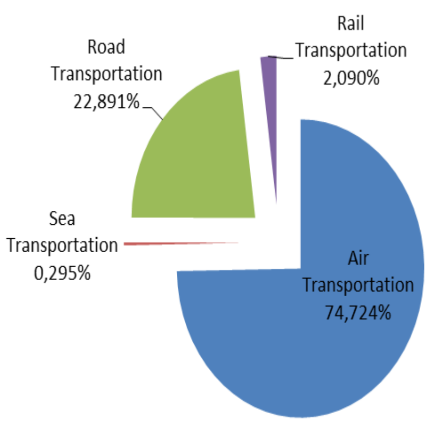

Figure 1: Rates of foreign tourists entering Turkey by transportation type (KTB, 2022)

As can be seen from Figure 1, the majority of tourism mobility uses the airline. This situation is thought to be due to the fact that Turkey is a tourism country and that it offers advantageous holiday opportunities in the current economic conditions. Although the situation seems to be good, it is possible to deduce that Turkey, which is a country that hosts tourists from many nationalities and shares airlines with almost all countries, will be affected in any political or economic crisis, regardless of its size because Turkey has a role of bridge that links Europe and Asia in terms of aviation. In the light of this information, the aim of this study is listed below as;

- Observe the efficiency changes in Turkish aviation and especially the Istanbul airport, based on the Ukrainian-Russian political tension,
- Reveal the adaptations of aviation operations because of this tension.
- Detect the rapid effects of political crisis on Turkish aviation activity.

The data of the statistics carried out in the study were compiled from official and open sources, and the Turkish Statistical Institute (TUIK), the General Directorate of Civil Aviation (SHGM), the State Airports Authority (DHMI) and the Ministry of Culture and Tourism were used as the main data sources.

2. Literature Review And Conceptual Framework

While the development of transportation activities on a local, regional and global scale plays one of the most important roles in the overall life planning, any disruption in transportation creates extremely comprehensive problems. When we examine some global events affecting air transport, it is seen that there is a mutual interaction between transportation and tensions between countries. This situation shows its effect more significantly in air transportation.

When we look at the effect of the Gulf Crisis (1990 – 1991) on air transport; Towards the 1990s, the development of world trade and tourism, the catch of a certain balance in fuel prices, again caught a profitable trend in the civil aviation sector. However, while a sector in the civil aviation sector was expected to revive in this period, the Gulf Crisis that occurred in 1990 brought the airline companies into a new crisis period (75.Year THY 2009:175-176). This crisis had a negative impact on most sectors in the world. However, the biggest impact of this crisis was seen in the World Civil Aviation Sector. IATA airlines, which made a total profit of 2.3 billion dollars in 1989, suffered a loss of almost 2 billion dollars in 1990 due to the effect of the crisis. In this process, while many airline companies in the world and especially in the United States declared bankruptcy, there were airlines that stopped their operations and were on the verge of bankruptcy (75.Year THY 2009:197), (Esin and Denge, 2021: 252). Likewise, when we examine the effects of Terrorist Attacks (9/11) on air transport; It is known that terrorism has a great impact on the international trade and aviation sector. In air transport, company revenues have decreased as terrorist attacks have reduced passenger demand; operating costs have also increased for contributions and incentives (Bükeç and Erdoğan, 2010: 5). While the world aviation industry has progressed positively since 1997, it suffered a loss of 12.6 billion dollars in 2001 as a result of the terrorist attacks in the USA on September 11, 2001. This loss affected all airline companies at approximately the same rate. Compared to the 1991 Gulf Crisis, the September 11 attacks seem to have had far more negative economic consequences; The loss of the Gulf Crisis is approximately 8 billion dollars (Torum, 2002:

9). Terrorist attacks and the psychological effects of these attacks on people have led to a significant decrease in the use of airlines in transportation. Similarly, the air transport sector experienced a sudden decline with the September 11 attacks. In the first four days after the attack, 74% of flight reservations in the USA and 19% of flight reservations outside the USA were canceled (Peter and Fariba: 2002). Some holiday travelers have chosen to cancel their holidays due to fears caused by the September 1 attacks. Some passengers traveling for business, on the other hand, preferred to hold business meetings via teleconference and postponed or canceled their flights (Bükeç and Erdoğan, 2010: 6).

The pandemic has had very sharp effects on air transport. Travel restrictions caused by the pandemic have brought about the cancellation of essential travel, which has led to a significant decline in air transport demand. The Covid-19 Pandemic has caused many airline companies to suffer serious financial losses. Similar to the changes caused by the Covid-19 pandemic around the world, it has also occurred in Turkey. In this process, extraordinary situations related to transportation emerged and some measures were started to be taken gradually since the first detection of the pandemic. The measures taken caused significant decreases in the number of passengers and the amount of cargo compared to previous periods (Bakırcı: 2020: 46). In general, during the Covid-19 Pandemic process, for the first time in a global sense, air transport had almost reached its point. According to the report presented by Global Outlook for Air Transportation, the COVID-19 pandemic is unprecedented, particularly due to the policy response that has included the cessation of many economic activities, including air traffic. The pandemic is the biggest challenge the aviation industry has ever faced. Makes previous shocks such as the 1979 oil price crisis, the Gulf War, and the Global Financial Crisis seem like minor events in comparison (Global Outlook for Air Transportation, Special Edition)

When we try to brought everything together, sustainability of air transport is closely related to operational, economic, social and environmental dimensions (Janic 2004). Similarly, the economic dimension relates to operating revenues, and the social dimension relates to an airline's contributions to the regional and national community as well as contributions to the globalization and internalization of business and leisure activities such as trade, investment and tourism. Likewise, the environmental dimension relates to the physical effects on human health, such as air pollution, airport noise, airplane crashes, and waste generation from airlines. Janic (2004) also reveals that some studies only consider economic, social and environmental dimensions. However, all dimensions are affected by political and legal issues and thus affect an airline's operations and this has a direct impact on an airline's economic and operational performance. Aviation is a highly regulated industry, both nationally and internationally. Therefore, the legal and regulatory environment is an important and complex factor influencing the performance of an airline and airports, as airline operations require strict adherence to relevant civil aviation regulations. Some other legal procedures implemented in a country, although not directly applicable to airlines, greatly affect their operational or economic performance. The airline industry is very susceptible to political situations such as tax and fines, government interference, and trade wars between countries, as there are various laws that indirectly affect airlines and airports. In this study, the effects of the political tension between Ukraine and Russia on Turkish airspace and Istanbul airport will be tried to be explained with data and statistics from official sources.

3. Crisis and Uncertainty in Aviation

The aviation industry has faced many challenges since deregulation in 1978. Over the past few decades, the aviation industry has faced numerous challenges stemming from oil and energy crises, global market challenges, and unending political tensions. These economic challenges have traditionally focused on key issues where industry has focused its efforts and experts are working relentlessly to find the right strategies. However, our main focus, on which we hope to work, continues to change from day to day. The aviation industry continues to face wider economic challenges that now require its own strategies, experts and solutions. The economic environment that exists today is constantly changing, nationally and globally. This change encompasses not only unexpected events, but also other challenges that add to these deep-rooted economic difficulties. For example, the COVID-19 pandemic, social unrest, global politics and pilot shortage are just some of the new challenges the aviation industry needs to find a solution to right now. The aviation industry and airlines have weathered many storms, from past deregulations to the 9/11 tragedy, but the conditions we are in present complex problems that are very different from what airlines have experienced in the past and need new solutions. This difference is not primarily due to the size of these problems, but to the sheer number of problems that need to be addressed simultaneously. The airline industry faces more challenges today than it did in the past. Discussing and explaining these challenges and how they affect the aviation industry as a whole has the potential to be a resource that can shed light on future uncertain problems.

Considering the global pandemic, for example, it is clear that in early 2020 the global airline industry is about to face a world of challenges that it has never faced before. It was also unclear how exactly airlines would be affected, what these impacts would mean for the industry going forward, or how long that would last. A pandemic of this magnitude had not been seen since 1918, just years before the first aircraft took off. The airline industry has not only had to deal with fundamentally pandemic challenges, but the problem has had to address problems that have had to resolve the constraints placed on it by the states that have intervened. Many governments have intervened and changed the industry with new applications for the entire industry, from personnel to daily operations, with the new requirements of operations and measures taken under the uncertainty of the pandemic. While this intervention caused many airlines to lose money, the industry had to employ different personnel due to government regulations. In addition to these problems, many problems arose for those working outside the sector. Although airlines receiving government funding were not allowed to lay off their employees, this was not a wholly restrictive measure as airlines could still retire early and lay off relevant employees from various positions. Combined with the fact that airlines had to park up to 90% of their planes and cut their operations by the same proportion, there was a significant reduction in revenues.

On the other hand, even before the war in Ukraine, airlines faced serious geopolitical tensions resulting from the various ways in which the world's largest countries competed. In this case, it is clear that the airline's industry is heavily impacted when countries compete in what are sometimes called trade or currency wars. The airline industry plays a huge role in the escalating world tensions since 2018. Political events like this pose fundamental challenges to the economy. For example, as a result of the tension between Ukraine and Russia, the change in the basic fiscal and monetary policies in the countries where the airlines of the two countries operate has led to the making of parallel arrangements in their neighboring countries. Airlines operating in countries that implement expansionary fiscal and monetary policies are likely to see inflation prices leave their customers out of the market. With the collapse of the global economy as a result of the effects of political events, it becomes more difficult for some customers to risk using airlines and creates a bottleneck. However, it is also possible to observe the positive effects of some political events on the sectors. As can be seen in Figure 2, the tension, which gave its first signals on January 25, had a great impact on airport statistics.

Figure 2: Monthly passenger change at IGA Istanbul airport (EUROCONTROL, 2022)

As can be seen, the effects of a political tension have had an impact on airport statistics. On the other hand, on the days when the tension escalated, Istanbul airport turned into a much more crowded transfer center than usual due to both evacuation flights and the closure of the airspace. In addition, according to the report presented by EUROCONTROL, the effects of the current crisis are obvious, since the most daily flights from Russia and Ukraine, excluding domestic flights, are to Turkey (EUROCONTROL, 2022b). As of March, the closure of the European airspace to Russia, the lack of maintenance and spare parts services for European origin aircraft, etc. Such sanctions also aggravated the effects of the current crisis

4. Purpose and Method

The main purpose of this study is to analyze the effects of the Ukraine - Russia Tension on air transport in Turkey by explaining the effects of the Ukraine - Russia Tension on air transport in a conceptual framework. The study was created within the framework of the evaluation of the data. Correlation analysis was performed in the study. Correlation analysis is an analysis technique that shows the strength and direction of the relationship between dependent and independent variables.

$$Correlation(X,Y) = r_{XY} = \frac{Cov_{XY}}{S_X S_Y} = \frac{\frac{\sum(X-\bar{X})(Y-\bar{Y})}{(N-1)}}{S_X S_Y} = \frac{\sum(X-\bar{X})(Y-\bar{Y})}{S_X S_Y} \times \frac{1}{N-1} = \frac{\sum Z_X Z_Y}{N-1}$$

Cov_{XY} is called covariance, equal to;

$$\frac{\sum(X-\bar{X})(Y-\bar{Y})}{(N-1)}.$$

Its format is very similar to variance:

$$\frac{\sum(X-\bar{X})(X-\bar{X})}{(N-1)}.$$

It measures how two variables go together, or co-vary. The strength of the relationship between the variables takes values between +1 and -1. A positive value indicates that the relationship between the variables is in the same direction, and a negative value indicates that the relationship is in the opposite direction (İslamoğlu A., 2019: 249).

5. Conclusion

The data used, especially the total flight traffic of IGA Istanbul Airport, and the sanctions against Russia were also used as input data. The main reason for investigating the effects of the sanctions on air traffic is that the closure of the Russian and Ukrainian airspaces as a result of the sanctions will provide information about the effects on the Turkish airspace.

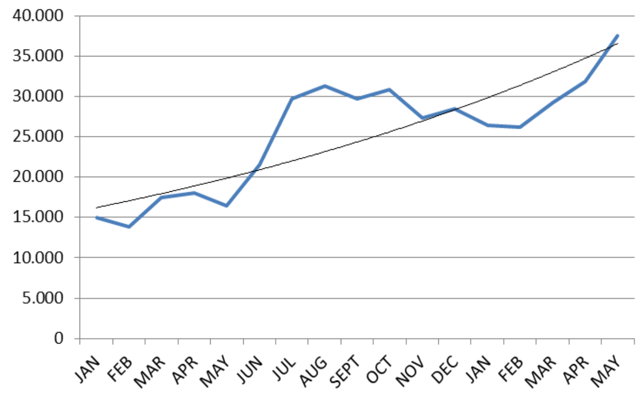

Figure 3: IGA Istanbul Airport Aircraft Traffic between 2021-2022 (DHMI, 2022)

In the graphic above, the previous period aircraft traffic of IGA Istanbul Airport is shown. When the graph is examined, it can be said that while the traffic density of the airport tends to increase from month to month, there is a seasonal increase in demand. However, the relevant graph cannot be considered sufficient to explain any relationship. Therefore, documenting the relevant traffic data simultaneously with the time series of sanctions imposed on Russia by other states as a result of the Russia-Ukraine tension helps to better explain the situation.

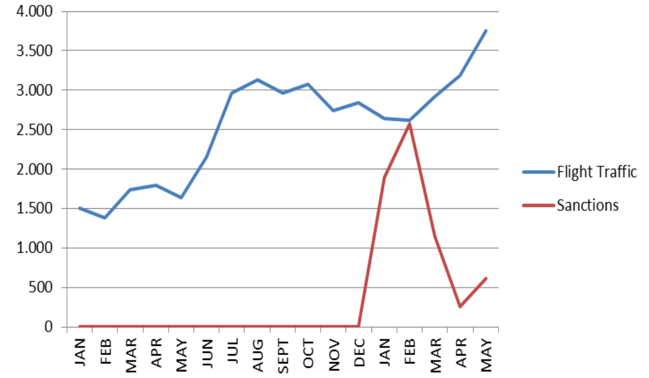

Figure 4: Comparison of Istanbul Airport Traffic with the Amount of Sanctions

As can be seen in Figure 4, when the number of sanctions and traffic data are visualized, the increase in the number of sanctions can also be seen as a trigger for the increase in air traffic. However, it is not possible to say for certain information. For this reason, correlation analysis, which is our most basic analysis used to explain the relationship, has been applied in order to be able to say a certain information. Because correlation is a coefficient that indicates the direction and strength of the relationship between two variables and can offer ideas. Although the data on the amount of sanction from the data of the relevant analysis were tried to be obtained from various sources, the most definitive data was published by statista (Statista, 2022). The data shown in the relevant analysis are presented in the figure below.

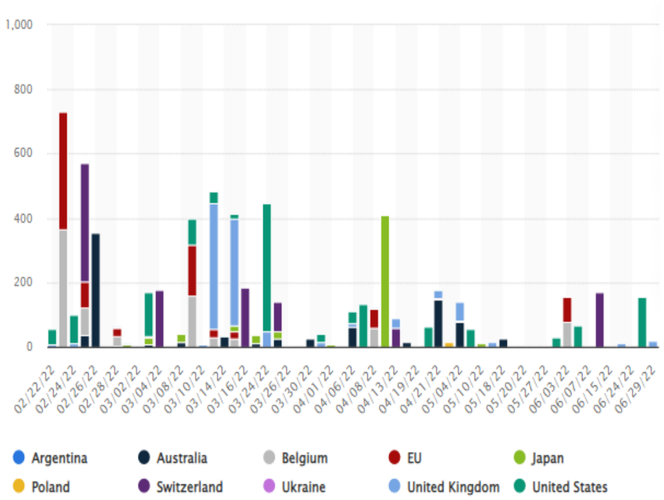

Figure 5: Daily breakdown of sanctions against Russia (Statista, 2022)

Based on the available data, İGA flight traffic data was obtained by the State Airports Authority and was subjected to correlation analysis with the amount of sanctions, which is the other data item obtained. According to the results of the correlation analysis, the correlation coefficient was found to be positive 0.209 at the 95% confidence interval, and thus, it was seen that the effect of the increase in sanctions on air traffic was in the same direction. The relevant correlation graph and confidence interval are shown in the figure below.

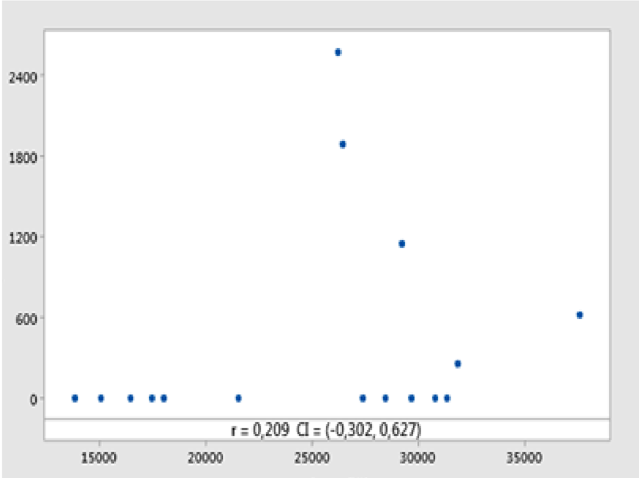

Figure 6: Correlation analysis graph and coefficient

Although the positive determination of the correlation coefficient showed that a political action could have an effect on the Turkish airspace, it is not possible to say that it has fully proven it. Because this effect is very dynamic and it is not healthy to prove with a small amount of data. On the other hand, it can be said that the expectation of a positive effect on its effects is correct.

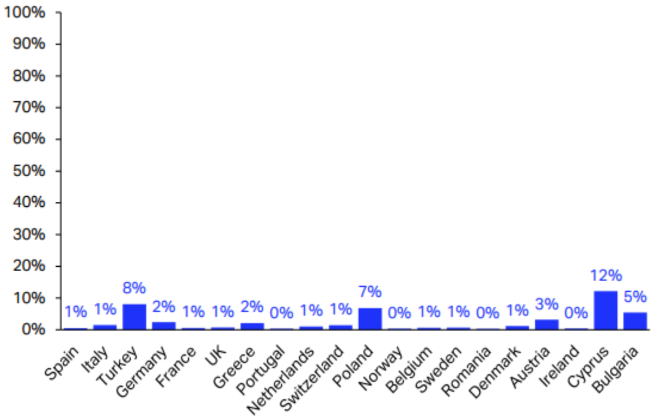

Figure 7: Exposure of European markets to Russia and Ukraine in 2021 (IATA, 2022)

By looking Figure 7, Cyprus, Turkey, Poland and Bulgaria had the highest share of total passenger numbers coming from those two countries in 2021 (5% to 12%). Since Turkey remains open to Russia, it might in fact benefit from its popularity for Russian holidaymakers, as options to travel to other warm countries will be limited. Thus, it can be said that Turkey, which has the highest number of daily flights, is automatically affected by the current situation, valid for both countries that are subject to tension, considering both tourism-oriented and other commercial activities.

6. Discussion and Suggestions

The ongoing socio-economic and political crisis for each nation will surely affect the air transport industry, including both security and operational aspects. The air transport industry and relevant stakeholders must prepare themselves and what measures to take in the face of financial, social and political instability and uncertainty. But unexpected events and political bottlenecks require unprogrammed solutions to this type of problem. From this point of view, several dangers can be found for airline companies and the entire industry in a crisis environment. These;

- Failure of cooperating states to perform their safety oversight functions in the midst of sudden crisis profits.
- Overloading of the capacity and security infrastructure at airports and within the airspace than planned.
- Economic challenges following the increase in both the human and financial resources required to run safety oversight functions.
- Many risks that increase business complexity, particularly those arising from value-creating activities such as growth and profits.

Apart from the limited measures that can be taken against these risks and dangers, the fact that the location, time or probability of the dangers is not known is another issue that makes it difficult to examine this issue. In addition, the fact that the current political tension has not yet come to an end constitutes an obstacle to making a definitive judgment. From the point of view of analysis, the scarcity of data and information required to measure the environment created by the tension that has just occurred in a qualified and concrete way has made the accuracy of the study questionable. In this case, there is a need to improve the current study and to improve the method and methods used. However, reaching more data on the current tension before the development phase of the study will enable the study to sit on a more solid foundation. This study provides an insight into the impact of the current situation. It is expected that it will provide the basis for future studies at the initial stage and shed light on the future.

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 Conceptual Study on the Crises Affecting the Aviation Industry

Emre Nalçacıgil[1*], **Betül Kaçar**[2]

[1*] Kapadokya University, Aviation Management Department, 50420, Mustafapaşa, Nevşehir, Türkiye. (emre.nalcacigil@kapadokya.edu.tr).
[2] Kapadokya University, Aviation Management Department, 50420, Mustafapaşa, Türkiye. (betul.kacar@kapadokya.edu.tr).

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Abstract

The aviation industry is one of the fastest and most affected industries by the developments in the world. In the study, the historical events that shape the development of civil aviation in the world and in Turkey and the events that cause the sectoral characteristics of the industry to change and develop were examined. It has been concluded that the contribution of the aviation industry to the global economy is 4.3 times higher than other business lines worldwide. For this reason, the resistances and activities of various airports from around the world to the crises were researched and suggestions were presented. The motivation of this study has been to investigate the factors affecting the aviation industry, which has such a global importance, and the managerial decisions that have allowed the industry to survive until now.

1. Introduction

The most basic activity of a business is the activities carried out to meet the needs between the buyer and the seller. To better understand businesses, it is necessary to understand the concept of systems. A system can be defined as a whole set of subsystems that are combined to serve a common goal. Systems are divided into two as open and closed systems. While open systems are systems that are affected by economic, social, and similar factors in their environment, closed systems are not affected by the factors inside themselves and are not affected from the outside. With this definition, it is possible to say that the aviation industry is a completely open system. Many factors such as an economic crisis in the world, a political decision, the actions of a group of people, terrorist activities and epidemics can affect this industry. The input and output of each system that has the scope of aviation, when we look at the aviation system of the input of manpower, money, materials, energy substances, such as that of the output of the aviation system in a safe manner to move passengers and cargo from one place to another we see. According to this definition, the most basic activity carried out by airport operators is to provide safe and efficient air transportation (Sengur, 2018).

In addition to being an industry that is open to such an impact, aviation is also an industry with a very large area of influence. According to data from Air Transport Action Group (ATAG), the contribution of the aviation industry to the economy on a global basis is approximately 4.3 times that of other business lines in the world ("Facts and Figures", 2022). The aviation sector is of great importance in terms of the development of the economy, tourism, cultural activities and trade of the countries. One of the industries that relies most heavily on aviation is tourism. By facilitating tourism, air transport helps generate economic growth and alleviate poverty. Currently, approximately 1.4 billion tourists are crossing borders every year, over half of whom travelled to their destinations by air ("Economic impacts", 2022). With the increase in airline companies and the increase in the number of flights in our country, the sector has developed further. Today, there are airports in many cities, and the aviation sector has started to be used more widely when early ticket purchases, promotions and prices are close to the prices of road transportation.

In this study, historical events that led to the definition of the aviation industry as it is today and various crises that caused the industry to be affected were examined. In the next parts of the study, the developments that shape the sector, the historical development of aviation, economic crises, crises that threaten security, epidemics, and the methods of various airports to cope with these crises are discussed. Examined crisis examples and airports' coping/inability to cope with them were also discussed and suggestions were made. The study has been prepared in the form of a compilation article for small or large airport operators and decision makers to get information about the size of the sector's sphere of influence.

2. Historical cases that shaped the aviation industry

In the aviation industry, which is quite open to environmental effects, political, economic, safety and health-related problems have led to great changes. Under this title, these events were examined and the factors affecting them, and the results of the events were examined.

2.1 Wars events

Air power has undoubtedly succeeded in becoming the focus of nations and armies as an important element of war towards the end of World War I. As a result of the experience gained in this war, the use of aviation, especially in the military sense, has become one of the most important issues for armies and nations. However, the use of aviation for military reconnaissance was first carried out by the Italians on October 23, 1911, on the Turkish defense lines, in the Battle of Tripoli. Reconnaissance flights, which were normally made with balloons, were replaced by an airplane for the first time in this history. In this reconnaissance activity, which was carried out for the first time from the air, reconnaissance was carried out with the cameras placed under the pilot's seat (Tekin, 2020). In the Tripoli War, which had many firsts in the field of aviation, events such as the distribution of the first leaflets for propaganda from the air and the first night flight took place. In the First World War, airplanes accompanied the balloons, which were used for reconnaissance purposes in wars. The war between 1914-1918 witnessed the full use of the aviation industry as a war advantage. The production of aircraft, which has become an increasingly important competitive advantage for the nations in wars, also parallels the dates of the mentioned wars. 1350 aircraft were manufactured in 1911, 1425 in 1912, and 1296 aircraft in 1913 (Yalcin, 2016). While the countries were following the current developments, the first military aircraft was included in the American army and other countries tried to adapt to it in line with their possibilities. Following the United States, France and England also started to develop in military aviation. As a result, in the First World War, countries could not show a great development in the aviation industry due to high costs and technical inadequacies (Yalcin, 2009).

Whereas in 1919, the year in which international civil aviation was born, only 1,025,000 miles was flown by civil aircraft throughout the world (except for China and Russia) and 3,500 revenue passengers were carried, some thirty years later, in 1950, the corresponding figures for scheduled services were 890,000,000 miles and 31,200,000 passengers (Wassenbergh, 1962). As with Aviation in World War I, military investment during World War II drove aviation forward in leaps and bounds ("World War II", 2022). World War II, which is another war that will affect the fate of countries, took place between 1939-1945 and aviation once again played a key role. The aviation industry, which gained significant advantages in important wars such as the First World War and Tripoli, showed great progress especially after the World War II and made great contributions to its current development. After these wars, the most important technological developments that carried the aviation industry to another dimension and proved its power to the whole world were the Spitfire, which was designed for the World War II with its small, light and maneuverable features, jet engines that made the aircraft fly faster, and the widespread use of radar systems. In the period following the end of the Second World War, the world found itself in a new environment of competition and tension between the Eastern and Western Dec headed by the Soviet Union and the United States. In the early stages of this struggle, known as the Cold War, heavy bombers played a critical role in the balance of nuclear horrors as the only type of platform that could deliver nuclear weapons to the target (Egeli, 2021). One of the most striking results of the wars that took place in the post-Cold War period is the Gulf War. In the Gulf War, which was carried out to drive Iraq out of Kuwait in 1991, the experiences gained from the previous wars were abundantly used. Some of the consequences of the Ukraine-Russia war, which is one of the current wars, are the inability to make flights due to the insecurity of Ukraine's airports and the heavy sanctions imposed on Russia in the field of aviation. Due to this situation, the citizens of both countries were seriously affected by air transportation and their travels were prevented (Karabuga et al., 2022).

2.2 Economic events

The concept of economic crisis is expressed in the form of unexpected problems in the economy that have a negative impact on the economy on a global and national scale (Aktan & Sen, 2001: 1226). The most common reason for the economic crises that occur due to various reasons affecting each other is the wrong economic policies. In addition to this reason, excessive borrowing, international capital movements, inflation, exchange rate policies, fiscal policies based on public expenditures are among the important causes of economic crises (Taner, 2012). In the history of the world economy, the years 1929-1933 are accepted as the period of great depression (recession). During this period, unemployment increased, and great misery was experienced (İmren, 1994). One of the biggest factors in the 1929 economic crisis was the First World War. As a result of the 1929 world economic crisis, millions of people lost their jobs, the national income of the countries decreased, the economies shrank, and mutual trade was interrupted to a great extent. As a result, international trade rapidly contracted, employment and living standards began to decline (Egilmez, 2009). As a result, international trade shrank rapidly, employment and living standards began to decline, production decreased, unemployment reached its peak, and many establishments were closed. Although the world economy had its best period after the Second World War until the early 1970s, the crisis that emerged as an oil shock at a time when the economic recession was thought to be history, has been the second biggest shock the world economy has faced since 1929 (Erim, 2012). After these two crises overcame, in the 1990s, global economic crises started to emerge again. With the phenomenon of globalization, capital movements have accelerated between countries. Intensive capital inflows into countries with a high return potential have led to the spread of the economic crisis experienced by any country and to the formation of widespread economic crises. After the global economic crises that occurred in the 19th century, these crises continued in the 20th century. Especially the forerunner of the last 2008 global crisis was the mortgage crisis that emerged in the USA. Mortgage crisis emerged in the USA when 10 million people gave back the houses they bought with loans to banks (Erim, 2012). This has led to the fact that many global airlines are no longer able to provide services in the flight sector as profitably as they used to; this is felt more deeply in the United States and Europe (Capital Magazine, "The World Aviation Sector is Shrinking", 19-9, 2011, s. 19). One of the most important points that the crisis affected the aviation industry is the costs arising from the exchange rate difference on a global scale. Especially in the aviation industry, where fuel costs are high, economic crises have widened the exchange rate difference on a global scale. One of the issues that the crisis significantly affected was the decrease in the number of airports of the countries, their closure or the decrease in the number of people working at these airports. Especially, many airports in Europe became unusable due to the damage, the decrease in the number of waiting and transferring aircraft, and the decrease in the number of preferred landings. This has led to a decrease in investments made or to be made in airports.

2.3 Health related events

From past to present, epidemic diseases (Ebola, SARS, COVID-19, etc.) have continued to have a global impact for a long time, and many lives and property have been lost with the spread of the epidemic all over the world (Yilmaz, 2021). Between the months of March-June, when the epidemic was most effective and there was not much information about the disease yet, there was a decrease of up to 90% in air traffic around the world compared to previous periods, and flights around the world came to a standstill (Hopanci, 2021). Ebola virus first caused two simultaneous outbreaks in 1976 in Nzara, Sudan, and Yambuku, Democratic Republic of Congo. During the Ebola Virus Disease outbreak, existing requirements concerning the transport of biological specimens and affected individuals were reinforced and States were requested to reduce landing, take off and overflight restrictions ("Icao", 2022). In order to cope with this epidemic, In the response phase of two recent major public health events, ICAO has coordinated a transport working group that has made of a number of UN agencies and representatives of the transport sector, to quickly develop and issue public statements on risk, with a view to encouraging aircraft operators to continue services to affected regions and passengers and crew to continue flying. Another epidemic that affected the aviation industry for the first time in late February 2003; It is an outbreak of the SARS virus that has been reported to originate in Asia, North America, and Europe. History shows that SARS has been the most serious epidemic impacting traffic volumes in the recent period. Overall, in 2003, the loss of confidence and fears of global spread impacted both business and leisure travel to, from and within the region, resulting in Asia-Pacific airlines losing 8% of annual RPKs (Revenue Passenger Kilometers) and $6 billion of revenues ("IATA", 2022).

In the past, the airline industry has shown some resilience to many crises, including pandemics. Even after the SARS epidemic, monthly international passenger traffic returned to pre-crisis levels within 9 months. Finally, the name of the disease that causes the greatest effects globally and causes one of the biggest crises in the name of Aviation is COVID19, and COVID19 is a respiratory disease with a high infectiousness. First detected in December 2019, COVID19 disease has spread from the Wuhan province of China to the whole world and was declared a pandemic by the WHO on March 11, 2020. As a result, while the total number of flights (passenger + cargo) organized worldwide in 2019 was 42.1 million, it decreased to 27.6 million in 2020. The decrease in the number of flights is 34.4%. In Europe, which became the epicenter of the epidemic in March-April, the rate is 52.4% (Hopanci et al., 2021). In order to reduce and minimize the effects of the Coronavirus on the sector, some measures have been taken by airlines from time to time, and many of them are still being implemented. As a result of making too many changes in the procedure in line with the measures, such as increasing the number of call center employees, minimizing contact by making catering arrangements, creating a seating arrangement according to the number of guests, performing mask control and other necessary procedures, and increasing the amount of cleaning to be done on the plane. Many long-term but temporary effects in the sector remain quite simple besides the economic effects (Helvacioglu, 2021). Considering its economic effects, the last updated report published by ICAO in 2022 will be one of the most reliable sources to examine. According to this report, when the first two months of 2022 and the whole of 2019, the period when the coronavirus had not yet appeared, there was a decrease between 26% and 30% in the total number of passengers flying in the world. When the same comparison is made for 2021 and 2019, this rate is 49%; When it is done for 2020 and 2019, it is concluded that it is 60%. In addition, when 2019 and 2021 are compared in terms of financial returns, it is stated that there is a revenue decrease of approximately 324 billion dollars (ICAO, 2022).

In times of epidemics, the extremely limited circulatory action is an important obstacle primarily for people. However, the restriction of circulation hits the transportation sector the most, being one of the large-scale and dangerous barriers to trade. In the last period of the Covid-19 pandemic, the effects of this problem have been greatly felt. The civil aviation sector has also been one of the sectors at the center of this problem. The problems experienced by the sector have made it compulsory for all actors in the sector to enter into a process of change and transformation based on a strategic management approach model. Airline carriers have taken measures regarding the Covid-19 pandemic within the scope of flight crews, aircraft, and in-flight products. The flight crews were notified about the Covid-19 disease, its symptoms, and the rules to be followed in the aircraft. Healthcare workers returning from abroad were subjected to a health check, and they were directed to use personal protective equipment and hand disinfectants. (Mert, 2020)

3. Conclusion

Transportation, which is defined as the transportation of people, cargo and mail by some vehicles, is in a very broad framework in terms of not only the means of transportation, but also from where to where it is transported (Sengur, 2004). Air transportation is defined as the transportation of passengers, cargo, and mail by air vehicles for a commercial purpose. Civil aviation activities generally refer to all types of transportation by air, excluding military aviation activities. The limits of these activities are determined by the regulations made by the International Civil Aviation Organization-ICAO. Countries become members of ICAO and documents called Annex are published by ICAO to ensure the order of flight traffic between these countries. Civil aviation activities are as follows: commercial air transportation services, airport services, air navigation services, general aviation, training services, civil aviation manufacturing services and maintenance and repair services ("Introduction to General Aviation", 2016). The range of airline companies is quite wide. In the aviation industry, some companies' fleets consist of hundreds of aircrafts, while others only have one aircraft. There are businesses that make hundreds of trips a day in the sector, and there are also those that make trips periodically. Thanks to the aviation sector, it is possible to reach cities, countries and even continents (Mishkin, 1996: 25). In addition to passenger and freight transportation services, the airline industry also contributes significantly to economic growth and development. The aviation industry is a very important industry, and it affects the social lives of individuals and their relations with other countries both economically and politically (Taylor, 2009: 16). Although the aviation industry has an important place in terms of economy and politics, as well as environmental factors, it is seriously affected by epidemics and political and economic crises occurring throughout the world. The fact that Turkey is in a geographically central location and connects two continents plays an important role in the development of the transportation sector (Bakirci, 2012: 343).

Air transportation is one of the most used sectors among the transportation sectors. Especially nowadays, it is preferred much more than other means of transportation. The aviation sector has been in constant change from the past to the present and has developed more and more day by day. This development and change of the aviation industry has been very closely related to the economies of both our country and rival countries. Activities in the field of civil aviation in Turkey started in 1912. Although the sector has developed over the years, the real developments started after the Second World War. With the development and modernization of THY in the civil aviation sector, increasing the number of passengers by providing quality service, Turkey has had a significant share in the international market. This study deals with the historical development of the civil aviation sector and how the economic crises affect the aviation sector. Especially in recent years, with the increase in technological developments, the removal of international borders and the development of the economy, developments have also been seen in the aviation sector. The aviation industry makes significant contributions to the development of the world economy, the increase of trade, the development of tourism and cultural developments. The aviation sector was not affected much by the crises in the first place, and later, the sector was partially affected by the decline in tourism and economic reasons. After the crises in the aviation sector, bankruptcies were experienced and the credit ratings of the airlines were lowered. The decline in the credit rating has left the airlines in a difficult situation, and since it is a sector with high capital, some negative tables have been faced. There has been a decrease in profit rates.

Parallel to the world economy, the air transport industry experienced one of the biggest contractions in 2009 after the Second World War, following the 2008 global economic crisis. In addition to the global shrinkage in the industry, significant company bankruptcies and job losses have occurred. In the air transport industry, it was observed that the passenger load factor decreased due to the increase in the demand realized in 2008 below the expectations and the inability to adjust the capacity, operational loss and high net loss with the increase in fuel prices. In 2009, demand and supply contracted compared to the previous year, and although total revenues decreased, the air transport industry achieved a limited operational profit due to the decrease in fuel prices and operational costs, and thus expenses, but the year-end was closed with a net loss.

The air transport sector has made a significant progress in Turkey with liberalization policies since 2003. Although passenger, freight and aircraft traffic in Turkey continued to increase in parallel with the Middle East region during the global crisis, the rate of increase in these traffic indicators decreased. In passenger traffic, international routes were more affected, and in cargo traffic, domestic routes shrank in 2008 and 2009. It is understood that the operating profit of the airline companies in Turkey decreased in 2008 compared to the previous year due to the increase in fuel and operational expenses. Despite the increase in passenger-freight demand and revenue in 2010 and 2011, with the rise in fuel prices, it was understood that the profitability figures followed an unstable course and the operating profit margin in Turkey remained below the global industry operating profit margin. It has been concluded that more effective management of fuel costs in the air transport sector in Turkey can contribute to increasing profitability (Karaer, 2015:119).

The fact that the COVID19 virus began to be effective around the world, and then the World Health Organization declared the COVID19 disease a pandemic, greatly affected the aviation industry. We have been faced with a crisis even bigger than the crisis experienced in the September 11 attacks, where the aviation industry was the focal point. The failure to contain the rapidly spreading epidemic brought the aviation industry to a standstill. Airlines lost 1.7 billion passengers and 6.1 million flights; however, not only airline companies but also airports and air navigation service providers were affected by this crisis. European aviation announced a net loss of 56.2 billion Euros in this period. The economic hardship caused 191,000 direct job losses. With the relative control of the pandemic with the summer months, countries have lifted their travel restrictions. As a result, an increase in flight traffic was observed and the rate of flight loss was reduced from 90% to 50% compared to 2019. After the summer season, there was a normal decrease in flights until the end of 2020, but stability could not be achieved. The magnitude of the impact of the epidemic on the aviation industry can also be understood from the planes remaining on the ground. By the end of 2020, 51% of the aircraft of European airline companies remained on the ground (ICAO, 2021).

The aviation industry has started to implement new strategies after the crises. Airlines have developed strategies to reduce their costs and increase their revenues in order to be less affected by the financial crisis periods. At the same time, they have always started to make a second plan in order to put it into action in possible crisis situations. They also aimed to benefit greatly from the development of technology. Apart from all these, they aimed to make new plans for aircraft purchase and flight networks for short and long terms. It is important to realize these goals in order to keep up with the globalizing world, to reach an important position in the sector and to be strong against its competitors. Despite all the negativities experienced after all the crises, the sector developed itself and continued to grow rapidly. The number of airports in domestic routes increased in a short time, and most importantly, the opening of Europe's largest airport in Istanbul in 2019 has made Turkey take very important steps towards becoming one of the world's most important countries in the aviation sector and will contribute significantly to the growth of the aviation sector in Turkey. foreseen. The air transport sector is a sector with high fixed costs, requiring large investments, and therefore, it is not flexible enough to respond to demand changes. The problem of capacity adjustment in the aviation sector affects income items more than expenditures due to the decrease in occupancy rates, and the decrease in demand shakes the income-expenditure balance of the enterprises, causing bankruptcies and job losses. If the data of aviation sector indicators such as passenger, freight, and aircraft traffic fall below certain reference values during economic crisis periods that lead to recession and decrease in demand, government incentives to the air transport sector or tax and social security premium deferral and structuring until the normal situation is restored. It is considered that putting it on the agenda will reduce the negative effects of economic crises on the balance sheets of airline companies. For this reason, it is important for decision makers to implement new policies by considering the evaluations obtained from the analysis of the study while deciding on the strategies to be applied in times of crisis.

There are some indicators that will help predict economic crises earlier. These indicators are determined by reviewing the data on the financial sector and the real sector. The data obtained from these sectors helps to identify the weaknesses, so that solutions can be produced before reaching the crisis. These data are very important to see the weaknesses and they need to be evaluated. These data have a great contribution in making crisis predictions (Mauldin, 2011). What the crisis has made most clear as a policy for airlines is that the work on the way products is presented is becoming more obvious and the products are being presented in this way. The most important point in this regard is the “distinction” and “reduction to private” policies (Rigas Doganis, The Airline Business, 1st Edition, London, England: Routledge, 2005, s.45). On the other hand, for those who choose certain periods when purchasing tickets or who have a clear preference for ticket purchases, airline companies offer their tickets for sale in times of crisis, in a way and at prices that will meet their wishes. By this means, airline companies try to keep their customers within their structure even in times of crisis by creating a special process (Stephen, Shaw, Airline Marketing and Management, Hampshire, England: Ashgate Publishing Limited, 2007, p. 137). It is seen that the level of damage suffered by civil aviation, which is very important in terms of employment and economic growth for countries, due to the global pandemic, is higher than ever before when the effects of previous crises are examined. To reduce the effects of sectoral losses reaching up to 90%, governments in many countries have supported aviation enterprises in order to get out of this process that the sector has entered (Kaygin, 2021).

In future studies, focusing on the wrong policies and wrong investments implemented by airline companies in times of crisis, and examining the data sources of the sectors in detail may be important research areas on this subject.

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Can A Green Business Strategy be an Alternative to the Success of the Airport Environmental Management System?

Gülaçtı Şen[1*]

[1*]Istanbul Esenyurt University, Aviation Management Department, 34469, Esenyurt, Isanbul, Türkiye. (gulactisen@esenyurt.edu.tr).

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Corresponding Author: *Gülaçtı Şen*

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Abstract

Environmental problems, which continue to exist as a global threat in the world, have recently been frequently discussed both in the media and in academic. It is obvious that enterprises in different sectors in the business world cannot ignore environmental problems. One of the most important of these sectors is the aviation sector. In the sector, there are harmful effects on air, water, soil pollution, natural life and wildlife, especially noise pollution. With the establishment of airports and the start of aviation activities in the sector, it is suggested that construction works, increase in waste, development of industrialization around the airport, rapid consumption of energy resources, growth of residential areas, increase in population should be brought under control with 'Environmental Management System' practices. A green business strategy is being researched in order to successfully manage the environmental management practices applied at airports around the world and to spread environmental awareness throughout the enterprise. Green business strategy refers to the tendency of all business units to integrate environmental issues into business strategy. In this work you can stop the environmental degradation and even the environment etc. As a result of these factors, environmental pollution also increases. Today, the green business strategy is being researched as a phenomenon that can contribute to the successful management of environmental management systems in order to control the environmental pollution effect resulting from the activities at the airports. From this point of view, whether the green business strategy will be an alternative to the success of the airport environmental management system is discussed with the conceptual-theoretical application method.

1. Introduction

Aviation activities have negative effects on the environment. Although there are technological and systemic developments to reduce the environmental impact, the environmental problems are more than the positive effects of the increase in air traffic (Netjasov, 2012: 1077). Air traffic has been increasing rapidly from past to present, and as the number of aircraft in the sector and the number of airports in the regions increase, environmental problems also increase. One of the best examples of this is the Covid-19 pandemic, which emerged in 2019 and caused the world to be declared a pandemic (Mhalla, 2020: 96). In the rapidly growing sector, passenger transportation has come to a standstill due to the pandemic, and this has proven that the skies are cleared with the closure of airlines and the planes landing on the ground. The National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA) have noted a drastic reduction in the levels of Carbon Dioxide (CO2) and other greenhouse gases (GHGs) with the decreasing level of transportation. Again, according to NASA and ESA, air pollution in some epicenters of Covid-19, such as Wuhan, Italy, Spain and the USA, has decreased by up to 30% (Barua and Nath, 2021: 2). Of course, it is not desirable for passenger transport to come to a standstill. However, it is important to eliminate or minimize the negative situation caused by the aviation industry to the environment. In the return to the new normal after the pandemic, the total passenger traffic in the world has increased. The actual and estimated values of the total passenger traffic in the world for the year 2020-2021-2022 are shown in Table 1 compared to 2019. It is obvious that the increase in environmental problems continues due to the increase in traffic and that measures should be taken by the relevant authorities, businesses and governments in this regard. Recently, the climate crisis and its proposals as a global problem have become an issue that countries cannot ignore. The continuous increase in air traffic in the aviation sector and the increase in the number of airports in the world have brought the environmental problems arising from the sector to be dealt with together with the climate crisis and urgent solutions to be found. According to the report published by EUROCONTROL, it has been stated that activities to reduce the effects of climate change in the aviation sector can be effective now and in the future. However, studies on this subject have never been done by aviation actors (CAPA, 2019 Gürçam (2022) revealed that the practice called green washing and adopted by the aviation industry was unfortunately not successful. The aviation industry ignored the environmental impacts and covered up the climate crisis. With the development of technology and the aviation industry, electric airplanes, hydrogen-powered airplanes, biofuel studies, high efficiency, etc. Despite such innovative projects, it has been revealed that it is quite dysfunctional in environmental problems and the climate crisis continues to increase (Gürçam, 2022: 178).

Table 1. World Total Passenger Traffic.

The Covid-19 impact on world scheduled passenger traffic for year 2020 (actual results), compared to 2019 levels:	The Covid-19 impact on world scheduled passenger traffic for year 2021 (preliminary estimates), compared to 2019 levels:	The Covid-19 impact on world scheduled passenger traffic for year 2022 (estimated results), compared to 2019 levels:
Overall reduction of 50% of seats offered by airlines – Overall reduction of 2.7 billion passengers (-60%)	Overall reduction in 40% of seats offered by airlines – 49% reduction in 2.2 billion passengers	19% to 22% reduction in total seats offered by airlines
Overall reduction in 50% of seats offered by airlines – 60% reduction in 2.7 billion passengers	Overall reduction in 40% of seats offered by airlines – 49% reduction in 2.2 billion passengers	– Overall decrease from 1,123 to 1,292 million passengers (from -26% to -30%)
Approximately US$ 372 billion loss in gross passenger operating revenues of airlines	Approximately US$ 324 billion loss in gross passenger operating revenues of airlines	– Airlines lost between $169 and $191 billion in gross passenger revenues

Reference: (Rahma, 2022).

With the rapid development of the aviation industry, there has been a significant increase in the number of airports around the world. There are over 41,700 airports all over the world according to the Central Intelligence Agency. The United States alone has over 13,000 airports listed with the Central intelligence Agency (Welsch, 2021). The increase in the number of airports around the world may cause environmental problems to increase if necessary precautions are not taken. This includes local noise disturbance from airplanes around airports, soil pollution from fuel kerosene leaks and material spilled from airplane tires, waste from traffic at airport ground operations, etc. The problems are cause for concern. Particulate matter, other atmospheric emissions, can harm the environment in wider geographical areas. The transport of greenhouse gases such as CO to the upper atmosphere at the global level has potentially serious global warming effects (Button, 2003: 167). Airports face greater environmental challenges as they develop and/or expand. In other words, an increase in airport-related activities means an increase in environmental impacts (Asinjo, 2011: 2). An airport environmental management system is recommended for the environmental problems of airports. Airport Environmental Management System prevents or minimizes the environmental impacts arising from the operational activities of airports. The purpose of the environmental management system applied at airports in the world is to identify, monitor, evaluate, reduce and manage the process of negative environmental effects resulting from the activities of the enterprise (ICAO, 2021: 5).

This article considers from a conceptual-theoretical point of view whether the green business strategy can be an alternative for the success of the airport environmental management system. More specifically, the following questions are addressed;

- What are the environmental problems that may arise in airport operations and what are the suggestions for solving these problems?
- What is the purpose of the airport environmental management system?
- What is the importance of the green business strategy?
- Can a green business strategy be an alternative to the success of the airport environmental management system?

A green business strategy is a strategy that complements business, operations and asset strategies, public or private, government or commercial, that are already well understood and often well-articulated by the organization. A green strategy can basically be expressed as an organization taking decisions as a positive impact on the environment (Olson, 2008: 22). The implementation of the 'green business' strategy, which has recently attracted attention in the literature, can be effective in eliminating the environmental problems caused by the operation carried out at the airport. The green business strategy, which is expressed as the environment-friendly activities of enterprises rather than causing environmental problems, may be important in terms of minimizing the negative impact, although it does not completely eliminate the environmental problems arising from airports. In this direction, the applicability of the green business strategy in the success of the airport environmental management system is investigated in this study of.

2. Methods

In this article, the case study method, which is one of the qualitative research methods, was used. First, the purpose of the airport environmental management system and how it can be implemented as a strategy are discussed in depth. Air, water, soil, noise pollution etc. created by airports in the geography. environmental problems and what these problems are are revealed. The concept of green business has gained importance in the literature, as the depletion of natural resources and business activities in different sectors cause environmental problems. Green business refers to environmentally friendly products and services that do not harm the environment. In this study, it is emphasized that the green business strategy in business activities and the execution of activities without harming the environment. It is not easy to implement the green business strategy in the activities carried out at airports and increasing day by day. It is not possible to completely eliminate environmental problems at airports. Successful implementation of airport environmental management strategies is effective for reducing potential environmental problems; however, good management of this process is very important. In this article, the green business strategy in the success of the airport environmental management system strategy is discussed and solutions are proposed to improve the process.

3. Airport Environmental Management System

Environmental management system can be expressed as part of the overall management system that includes the organizational structure, planning activities, responsibilities, practices, procedures, processes and resources to develop, implement, achieve, review and maintain environmental policy. The purpose of the environmental management system is to put the environmental policies of the relevant organization into practice (Lozano and Valles, 2007: 495).

ISO 14001:2015 is recommended as the environmental management system that a business can use to improve its environmental performance. ISO 14001:2015, which can be used partially or wholly to systematically improve environmental management, is designed to be used by an organization that aims to manage its environmental responsibilities in a systematic way that contributes to the environmental pillar of sustainability (ISO, 2022). ISO 14001:2015 summarizes how the environmental management system can provide added value for businesses to achieve long-term success and contribute to sustainable development (ISO 14001, 2015);

- To prevent environmental problems and protect the environment;
- To reduce the possible negative effects of environmental conditions on the organization;
- Assisting the organization in meeting its compliance obligations;
- Increasing the efficiency of environmental performance;
- To provide continuous control of the product life cycle of the enterprise;
- Achieve financial benefits and operational efficiency;
- Communication of all environmental information.

One of the studies to identify the environmental aspects at airports and which of them can have a significant impact on the environment is to follow the steps described in ISO 14001:2015. First, as an environmental dimension, it is an element of the airport's activities, products and services that can interact with the environment in a beneficial or negative way (eg material consumption, discharges, spills, etc.). Second, as an environmental impact, it is a beneficial or negative environmental change resulting from activities, products or services. An example of this environmental review was made by the Athens International Airport Environmental Management System, which mentioned the effects on noise, water, energy, air pollution, bird control, biological monitoring, public awareness, environmental management, protection of global heritage (Boulevard, 2022: 12-13).

Airports are very important because of their functional role and economic impact. The increasing intensity of civil air transport and the increase in the number of airports cause different environmental problems. A wide variety of research activities have been applied to analyze and reduce the environmental impacts of airports. Among the civil aviation environmental problems covered by the research studies are noise pollution, electromagnetic effect, aircraft and land transport emissions, waste water management and thermal pollution (Radomska, 2020: 76).

In the literature, there are studies on the negative environmental effects of airports. Previous research on airport environmental protection has mainly focused on two factors: noise pollution (Brechet and Picard, 2012; Girvin, 2009; Lijesen et al., 2010; Prats et al., 2011) and air pollution (Girardet and Spinler, 2013; Kurniawan et al. Khardi, 2011). Regarding airports around the world, there is no evidence of a reduction in overall environmental impact or adherence to overall consumption or waste limits (Chao, Lirn, & Lin, 2017: 62). Korul (2004) developed the Airport Environmental Management System in order to reduce and control the noise, air and water pollution and the effects of airports on natural life, Oto (2010) environmentally friendly approaches and green airport project at airports, Akın (2013) energy efficiency and energy efficiency at the airport. Dursun and Aksoy (2017) discussed the implementation of the installation in all its dimensions under eight headings; noise, air pollution, water pollution, impact on wildlife, wastes, public health, construction works, and land use, which are environmental effects originating from airports. Pitt, Brown, and Smith (2002) report waste management at airports, Blacka et al. (2007) discussed the noise management regulations and policies at commercial airports and discussed the negative effects of noise on public health. and investigated the differences and common applications in systems. In the studies put forward, it is suggested that the environmental management system applications should be integrated into the aviation industry and the airport environmental management system. As seen in Figure 1, the issues addressed as airport environmental management strategies; management of noise control, environmental impacts on public health, management of water and air pollution, impact from construction works, land use impacts, etc. is in the form (Graham ve Guyer, 1999: 175).

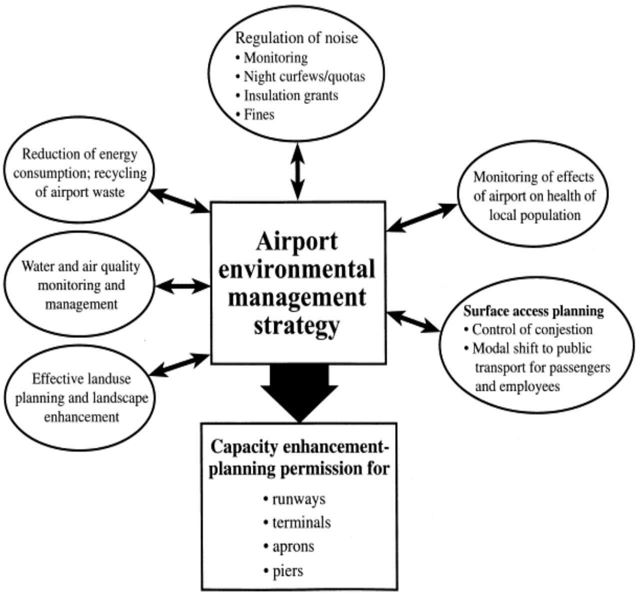

Figure 1. Airport Environmental Management Strategy

Airport Environmental Management System (EMS) is an organizational structure that enables an organization to proactively and systematically manage its operations with potential environmental impacts in order to fulfill its regulatory compliance obligations (Chao, Lirn, & Lin, 2017: 62). The airport environmental management system has a direct impact on the development of the aviation industry. If explained in order; The growth of aviation directly affects airlines and related businesses, civil aviation manufacturers selling aircraft and their components. On the other hand, indirect impacts include the employment and activities of suppliers to the air transport industry, such as aviation fuel suppliers, construction companies building airport facilities, suppliers of aircraft subcomponents, manufacturers of goods sold at airport retail outlets, and a wide range of activities in the business services sector (call centers, information technology, accounting, environmental management, etc.) (Mehta, 2015: 180). Among these activities, the environmental effects of airports' activities negatively affect the geography they are located in. Environmental impacts such as air pollution, noise, water and soil pollution, waste, loss of biodiversity can result from the operation and development of airports. For this reason, it is important to manage and implement the Airport Environmental Management System correctly.

Airport Environmental Issues

According to EUROCONTROL (2008), when the environmental impacts of airports' activities exceed the limits determined during the planning stages, they adversely affect the society in their geography. In particular, noise or emissions, lack of energy and water resources have the potential to limit the operational capacity or growth potential of airports. As a result, the challenges for airport operators will be to balance the social and economic benefits an airport provides to a region or city with the inconvenience on the environment and human health (Dimitriou, Voskaki and Sartzetaki, 2014: 2). In the congress organized by the EU (European Union) in 2007, the main effects of airport operations, maintenance and expansion are listed as follows (Comendador, Valdes and Lisker, 2019: 6);

- Noise issues
- Water quality issues from fuel storage as well as the effects of de-icing and anti-icing activities
- Air quality issues
- Emission of toxic air pollutants

According to the European Aviation Environment Report, the main environmental impacts of aviation are defined as noise, air quality and climate change. The environmental survey conducted by ACI in 2018 specifically addressed the state of environmental impacts at European airports. The environmental problems created by the airports in the geography where they are located are explained in detail below.

Air Quality Management

The main causes of air pollution in airports are; are the polluted gases emitted from aircraft engines and ground handling vehicles engines. Technological developments over the next 5 to 10 years predict significant improvements in emissions globally and air quality impacts locally; however, these advances do not completely eliminate the negative effects on the quality of life and the additional environmental effects caused by environmental pollution (Cohen et al., 2008: 119). Therefore, efforts to prevent air pollution should be sustainable. It is important to eliminate or minimize the problems that will cause air pollution by country governments, international aviation authorities, aviation enterprises and stakeholders. International Civil Aviation Organization (ICAO), a memorandum of understanding named CORSIA (Carbon Offsetting and Reduction sheme for International Aviation) has been achieved in emission reduction focused on the aviation sector. The aim of CORSIA is to reduce toxic gas emissions. Thus, it is aimed to support clean technology, use less fuels that give less to the environment, and increase forest areas in the world (Doğan, 2018: 147).

Noise Reduction

One of the biggest problems facing modern airports is the noise from air traffic and the effect this noise has on those living near the airport. Aircraft noise affects quality of life (health effects such as sleep disturbance, hearing, etc.). The lack of noise control also prevents the expansion of the airport (Sardjono et al., 2021: 3). At the global level, the noise problem around airports needs to be given great attention at the legal, professional and scientific level. In this direction, Netjasov (2012: 1078-79) discusses 18 measures to reduce noise at airports. These are not listed below;

1. Determination of noise reduction procedures
2. Restriction of starting the engine
3. Choosing suitable runways
4. Determination of airport bans
5. Studies on noise charges
6. Restricting Air Power Unit operation
7. Determination of noise level limits
8. ICAO Annex 16 Chapter 3/Chapter 2 Studies on Restrictions
9. Setting quotas for businesses
10. Determination of noise budget constraints
11. Supporting sound insulation (Residential and Public Buildings)
12. Assurance of purchase of houses in the airport noise-affected area
13. Overflight Easements
14. Enactment of zoning laws
15. Airport Noise Contour Overlay Maps

In order to control the noise, noise measurements should be made. Noise mapping describes the acoustic situation in large areas using long-term indicators. These measurements are an important tool for reducing noise emissions and defining different strategies (Gasco, Asensio and Arcas, 2017: 839).

Waste Management

As a result of the activities carried out at the airports, a large amount of waste is produced every day and this causes a major environmental problem. Waste management directly affects the airports environment, and this can be effectively mitigated by dumping waste at sources, that is, separating it and recycling it into renewable materials (Li et al., 2018: 1). The environmental management system can also be effective in this process. Wastes at the airport vary. In general, airport solid wastes can be listed as follows (Parameshwar, 2012: 152); (1) Municipal Solid Waste (2) Industrial Waste (3) Hazardous Waste (4) Hospital Waste (5) Construction and Demolition Waste (6) Waste from electrical and electronic equipment (7) Agricultural Waste.

Liquid waste at the airport comes from various sources. Domestic sewage wastes (from terminals, offices, personnel facilities, canteens and restaurants, kitchens and catering companies), industrial wastes from aircraft maintenance and washing, and wastes containing de-icing liquids as a result of aircraft de-icing operations. Waste management is one of the critical environmental issues facing airports. Although it has social and economic effects, it is mainly an environmental problem. For waste management at airports, it is necessary to develop a waste management system that includes waste separation and recycling at the source (Santos et al., 2020: 1). Waste reduction, reuse and recycling are important policies that should be promoted within airport companies as well as tenant concessionaires and airlines. Leveraging recycled materials is also important to improve recycling markets. Airport companies need to provide their staff, tenants and airlines with information and training on ecologically sound behavior. More research is needed to identify best practice approaches to mitigate issues and achieve continuous improvements. This should be accompanied by stronger policies led by the central government. (Pitt, Brown and Smith, 2002: 206).

Energy Monitoring

Airports of all sizes offer minimal services that require energy use to keep flights safe and efficient. The most common energy uses at an airport are (1) the airport terminal and (2) the airport airside. Lighting, heating and cooling (air conditioning) and appliances (luggage handling systems, terminal bridges) in the terminal use energy. Airside facilities such as runway lighting, auxiliary power units (APUs) and aircraft ground energy systems (AGES), ground vehicles (from airport operators, ground handling companies and firefighting services) and hangars also use energy (ICAO, 2022).

However, airports consume a significant amount of energy, which is CO2 emissions from power generation. The airport industry, like many other industries, is facing the effects of increasing environmental pressure. Therefore, the global community is currently paying more attention to the impact of airports on the environment (Baxter, Srisaeng, & Wild, 2018: 334). Energy efficiency is a fundamental factor in achieving environmental targets, optimizing the expenditures required to meet energy requirements, and achieving sufficient energy security at the airport (Rubeis et al., 2016: 261).

Dağlı and Rodoplu (2021) revealed that the use of solar energy within the scope of energy management at the airport both saves energy and contributes to reducing the environmental impact of airports. It is foreseen that the use of solar energy systems will become more widespread in other airports around the world in the future. With the development of the aviation industry and especially the increase in the number of airports, it is important for airports to turn to alternative renewable energy sources within the scope of sustainable energy management. It is also possible to evaluate some other renewable energy sources at the airport. (1) Integrated wind turbines mounted on the large roofs of airport buildings can be used. (2) It can be converted into fuel that can be used in various applications (heating, cooling, electricity) of airport buildings. (3) Geothermal energy systems can be used for heating and cooling airport buildings. (4) Hydroelectricity can be utilized at some airports surrounded by oceans (Yıldız et al., 2020: 167). *Water Control Management*

There are many reasons for water pollution in airports. Anti-icing agents, waste water consumed by passengers and employees, rain water and sewers all constitute water pollution (Ankaya, Yazıcı and Aslan, 2018: 163). In addition, airports are potential settings for the implementation of policies and technologies aimed at conserving water, mostly due to their large consumption for non-potable purposes such as water cooling systems, fire control, cleaning and washing of vehicles, runways and aircraft. Alternatives that require more intervention in airport infrastructure, such as the reuse of wastewater and the use of rainwater for toilet flushing, are usually only implemented in the construction of new terminals (Carvalho, vd., 2013: 28). However, nowadays, considering the global water problems and the climate crisis, it is obligatory to develop these systems at almost all airports.

Biological Monitoring

The effects of airport activities on plants and animals in the region should not be ignored. The ecological impacts of airports arise as a result of airport construction works and daily activities. Therefore, it can have negative effects on plants and animals in the region. Aircraft noise causes the animal communities in the region to be frightened, to migrate and change their settlement areas. In addition, it creates behavioral changes in all animals, especially livestock, due to physiological reasons. The use of the area allocated for the construction of the airport leads to the change of vegetation living on the same land, the migration of animals living in the region, and the deterioration of the ecological balance (Korul, 2014: 116).

Bird Control

Many airports are located near wet areas, bodies of water or sea shores without environmental concerns in mind. The airport and its surrounding area may be favored by waterfowl, bird birds and their raptors during the breeding season, local movements and migrations. Approach paths to these airports may pass through areas with frequent breeding or migratory bird concentrations or where seasonal bird flight paths pass. Due to the increase in population size of some bird species, such a location leads to problems with reduced flight safety (Matyjasiak, 2008: 11). In order to keep the birds under control at the airports, methods that direct the behavior of the birds are applied. These techniques listed below do not harm the birds, but encourage them to stay away from the area (Mayntz, 2019).

- Using sonic cannons, recorded predator calls and other noise makers to annoy birds,
- Using lasers at dawn and dusk to simulate predators and scare off birds,
- Flying trained hawks over roost areas to disturb birds before they nest,
- To train dogs to monitor habitat and to teach birds that the area has many predators.

4. Green Business Strategy

In green businesses, the term 'green' has almost the same meaning as sustainability and is often used interchangeably. This term also covers a wide area such as scarcity of energy resources, environmental friendliness, pollution-free, social or political stability (Hasan et al., 2019: 327). The understanding of green business, adopted within the framework of environmental sustainability, is aimed at protecting the natural balance of the activities of the enterprises, minimizing the damage to the environment; It is a modern understanding that enterprises carry out production, human resources, marketing, financing and R&D activities in an environment-oriented manner (Şenocak and Bursalı, 2018: 162). Green businesses focus on environmentally friendly activities such as green practices throughout society. Green practices in businesses have significant effects on the use of natural resources at different stages of activities and production.

Green businesses specifically (Čekanavičius, Bazytė and Dičmonaitė, 2014: 76);

- Interested in and supporting environmental activities,
- Tendency to protect environmental quality,
- Having a permanent commitment to environmental principles in business activities,

- Business or organization that prepares a plan and takes action to reduce its environmental impact on the area it is directly related to,
- It can be defined as an enterprise whose activities do not have a negative impact on the environment.

Today, environmental problems, the impact of which is felt globally, has become a problem that businesses that have an economic and social impact on society cannot ignore. In the literature, the concept of green businesses refers to the environmentally sensitive activities of businesses. The increasing harmful effects on the biophysical environment have required many small firms to take a more strategic stance towards taking advantage of green-related opportunities. In this sense, the green business strategy emerges as an important strategy to support the green practices of businesses. The green business strategy is the inclusion of environmental elements in the basic strategic functional areas of the business, such as production, marketing, finance, purchasing, human resources, research and development, which aim to protect the natural environment (Leonidou et al., 2017: 585).

Green business strategies today have two conflicting symbols. The first is the industrial worldview, the second is the ecological worldview. Finding a middle ground between these two views is essential for today's environmental problems. It is clear that the ecological worldview cannot be duly followed and fully realized in the contemporary business world. Therefore, green businesses have to make some vital concessions in their day-to-day practices. Green business is based on the corporate vision of the company aimed at surrounding its operation. Environmentalization means that the company takes into account the needs of the ecosystem with which it interacts. A good example is British Airways, which is concerned and taking action for society and the environment. Accordingly, it is important to determine the following environmentally friendly strategies (Zsolnai, 2002: 657);

- To take environmental factors into account when making commercial decisions,
- Working constructively with organizations dealing with the environment,
- Announcing the environmental activities of the enterprise to employees and customers,
- To consider environmental rules and regulations,
- Constantly redefining and applying the standards of the enterprise according to environmental legislation,
- To provide support and advice on environmental issues related to the activities of the enterprise,
- To use natural resources efficiently.

It suggests that businesses need to balance four components to help green industries thrive: (1) enabling technological systems (2) an innovative and customized business model (3) an underpinning market adoption strategy, and (4) favorable government policies (Nair and Paulose, 2014).: 176-177).

Green business strategies are also seen as an opportunity to reduce costs or save money (Karagülle, 2012: 457). Studies show that environmentally friendly company activities in the local context provide financial gains (Bıçakcıoğlu, Theoharakis, & Tanyeri, 2019: 58). Ullah et al. (2022) revealed that the impact of financial resources on green business strategy (environmental, social and economic) and competitive strategy (cost leadership and differentiation strategy) have a significant mediating role (Ullah et al., 2022: 15). It is seen that green business strategies are very effective in reducing costs and gaining competition strategies.

5. Green Business Strategy in Airport Environmental Management System

According to 2021 data, it is known that 41,820 airports (CIA) in the world cause environmental problems and solutions need to be developed. The 'Eco-Airport' project developed in Japan regarding the environmental problems of airports draws attention. Eco-Airport is an airport project that implements measures to protect the environment and produce a healthy environment in and around the airport. As an environmentally friendly eco-airport, it increases energy efficiency and reduces CO_2 emissions. With these studies, the eco-airport aims to realize a low carbon society, a recycling-oriented society and a society intertwined with nature (TIAT, 2022). According to the project, the basic planning steps of Japan's Narita Airport as an environmentally friendly airport are shown in figure 2 (Oto, 2010: 1211).

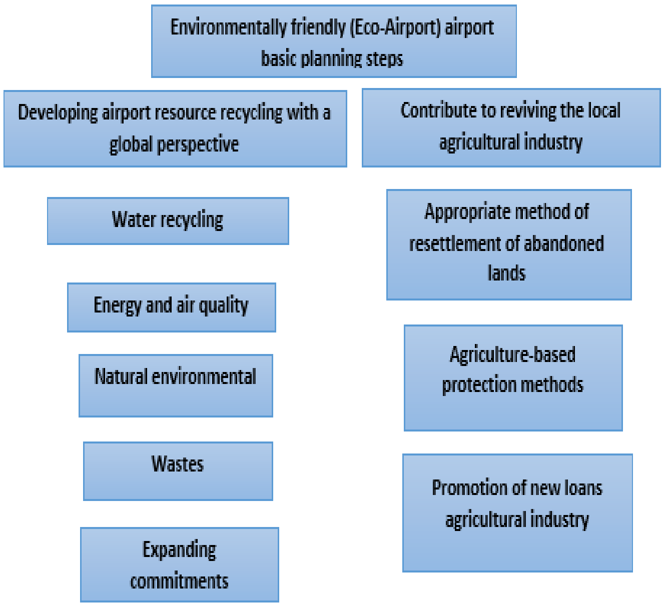

Figure 2: Eco-Airport Eco-Friendly Airport Basic Planning Steps: Narita Airport Example

Eco-airport airport contributes to lift the local agriculture industry while producing solutions to the environmental problems of airports from a global perspective. This project is important not only for the sector but also for the society to maintain a quality life. It also provides practical and ready-to-use information to support the development of airport infrastructure projects. In this direction, an eco-airport vision is created with the master plan and decisions that concern the whole society are taken. As seen in Figure 3, the eco-airport master plan deals with (1) community environment initiatives (2) resoure recycling initiatives (3) environment management (4) climate change initiatives that concern the whole world. The master plan aims, in collaboration with stakeholders, to take measures to reduce the environmental impact of airport operations on local communities and to pursue the development of a sustainable society by addressing environmental issues on a global scale (NAA, 2018).

Figure 3: Eco-Airport Master Plan

The fact that airports cause environmental problems is gaining importance day by day with the development of aviation. While the development of the industry is supported by governments and businesses, solutions are sought for environmental problems posed by growing or newly established airports. Environmental management techniques that will minimize the environmental impact of airports and increase the quality of life both locally and globally are discussed. Environmental issues covering various fields of expertise such as health, safety, energy, air and water quality, waste, noise and resource use control are recommended to be developed at airports (Korul, 2004: 113). In this study, it is explained that the green business strategy can be seen as an important alternative for the solution of airport environmental problems. With the green business strategy, it is possible to use resources effectively and to minimize the damage to the environment. It may be possible to reduce waste, consider the environment in energy use, protect the ecological balance, and create green workplace opportunities and conditions.

Considering the elements of green business strategies, it is important to integrate these elements with the airport environmental management system. The main elements of green business can be listed as follows (Çavuş and Tancı, 2013: 74-75).

- Preferring the use of renewable energy and raw material resources,
- Investing in environmentally friendly clean technologies,
- Reducing waste,
- Developing recovery and recycling processes and methods,
- To constantly review all activities of the enterprise, from the use of energy and raw materials to the ways of managing waste, in accordance with acceptable ecological indicators and compliance with environmental law, and make necessary corrections,
- To develop a green marketing approach, which aims to respond to the spread of green consumption awareness and the increasing expectations of the public within the framework of total quality understanding,
- To create green workplace and working conditions.

Integrating the green business strategy with airport environmental management systems can be recommended at the very beginning of the activities to eliminate or minimize environmental problems. Table 2 presents how the green business strategy can be implemented in the airport environmental management system from the perspective of an airport operator.

Table 2. Green Business Strategy in Airport Environmental Management System

Airport Environmental Management System	Green Business Strategy
Noise Control Management	-Developing and supporting technologies that will provide noise control in aircraft operations -Construction and monitoring of the runways in a way that does not cause noise at the airport -Making and monitoring noise measurements -Airports should not be built inside city centers.
Water Pollution Control Management	-Reducing water use -Supporting innovative water waste technologies to recycle water -Recycling of rain water and wastewater for reuse within the terminal
Air Pollution Control Management	-Supporting the use of fuels that are less harmful to the environment -Carrying out activities for the protection of forest areas -Investing in clean technology (Dogan, 2018).
Waste Control Management	-Supporting the reduction of waste, the storage of materials that can be separated and reused, and the rapid disposal of waste that will not be used -Improving waste separation at source -Supporting recycling -Collection of construction waste for recycling (ICAO, 2022).
Energy Control Management	-Reducing energy consumption with passive design approaches -Using systems that will provide minimum energy consumption in energy-requiring systems -Using systems such as photovoltaic solar panels, trigeneration systems on roofs, -Preferring insulated materials and light colored materials for energy conservation on facades -Adoption of transparent design approaches in order to make the most of daylight and to establish visual contact with the outdoors (Çelik and Görgülü, 2021)
Bird Control	-Watching the movements of the birds -Eliminating food sources accessible to birds at airports
Environmental Awareness	-Supporting the use of sustainable, environmentally friendly and low-VOC materials

Unless the activities at the airports are completely stopped, it is not possible to talk about the elimination of environmental problems. But controlling these problems can only be possible by adopting green business practices by influential businesses in airport operations. Accordingly, the implementation of the four effective components of the green business strategy in the airport environmental management system is essential. Activation of technological systems can be effective in water, air, energy control and waste management, especially in noise management. The innovative approach supported by the management should be adopted by the employees, and green practices should be integrated in business models and market strategies. It is not possible for the green business strategy to be effective in the airport environmental management system only with the actions of the businesses that carry out the airport activities. The government's environmental management policies may also be effective in carrying out these activities. In order for the government to protect natural resources and provide solutions to problems that threaten public health, they can set restrictions and rules on activities for businesses in the sector.

When green business strategies are applied in the success of airport environmental management systems, businesses can also use energy, air, water management, etc. can generate savings. Not only that, they can reduce the cost of capital assets (facilitating access to mutual funds) and workforce inputs (loyalty, performance improvement) (Yahya et al., 2022: 39501).

6. Conclusion

Airports cause environmental problems that can affect the entire ecosystem, especially the region where they are located. In other words, it is thought that green business strategies can be an alternative for airport environmental problems. Environmental problems in airport activities, which also cause global environmental effects, are taken under control by establishing an environmental management system within the airport. In order to understand the importance of the airport environmental management system and to implement it successfully, the green business strategy alternative has been evaluated. Green strategies are one of the most important environmental issues in business research. It is an important issue that what should be done in the good management of activities in airports in terms of noise pollution management, water, air, soil pollution management, waste management and energy management, or how businesses will successfully implement the airport environmental management system.

In this study, green business strategies are recommended for airports to achieve successful results in environmental management systems. Especially with the global climate crisis, it is emphasized that solutions for environmental problems should be produced all over the world, while airports are working to make themselves more environmentally friendly. In this direction, it will be effective to reduce energy consumption with the airport environmental management system, reduce the effects on water and air quality and reduce pollution, reduce waste, improve construction and project techniques, and reduce resources through green business strategies. A green business strategy will enable new practices in businesses that can provide a variety of opportunities to reduce costs, improve the airport's sustainable image, provide better access to communities and even positively impact socially connected activities in the region. In order to achieve this, actions and public policies should be prepared to support new technologies, promote environmental awareness, create a sustainable policy framework.

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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