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

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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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