IBN HALDUN UNIVERSITY
SCHOOL OF GRADUATE STUDIES
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MASTER THESIS

THE EFFECT OF GEOPOLITICAL LOCATION ON OPERATIONAL COST AND FLEET MANAGEMENT

SERHAN ZEYBEL

THESIS SUPERVISOR

ASST. PROF. AHMET KAPLAN

ISTANBUL, 2021

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A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Science in Management

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APPROVAL PAGE

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Air Transport Management.

Thesis Jury Members

Title - Name Surname	Opinion	Signature

This is to confirm that this thesis complies with all the standards set by the School of Graduate Studies of Ibn Haldun University.

Date of Submission Seal/Signature

PLAGIARISM CLEARANCE PAGE

I hereby declare that all information in this document have been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name Surname:

Signature:

ÖZ

JEOPOLİTİK KONUMUN OPERASYONEL MALİYET VE FİLO YÖNETİMİNE ETKİSİ

Zeybel, Serhan
Hava Taşımacılığı Yönetimi Yüksek Lisans Programı
Öğrenci Numarası: 188042006
Open Researcher and Contributor ID (ORC-ID): 000-0002-1629-3771
Ulusal Tez Merkezi Referans Numarası: 10394479

Tez Danışmanı: Dr. Öğr. Üyesi Ahmet Kaplan
Ocak 2021, 117 sayfa

Havayolu sektörü maliyetlerin karlılık üzerindeki etkisinin en fazla hissedildiği sektörlerden birisidir. Yapısı gereği ekonomik koşullardan ve rekabet durumundan etkilenen havayolu sektöründe filo yönetimi ve lokasyon seçimi, operasyonel maliyetler açısından önem arz etmektedir. Başarılı bir filo yönetimi ve lokasyon seçimi yapan havayolu şirketleri operasyonel maliyetlerini düşürmekte ve filosunu en optimum şekilde kullanabilmektedir. Bu çalışmada lokasyon seçiminin havayolu filo yönetimi ve operasyonel maliyetleri üzerindeki etkisi incelenmiştir. Bu kapsamda 8 merkezden, 10 farklı huba, 5 farklı uçakla uçuş senaryoları hazırlanmıştır. Hazırlanan bu senaryolar ise çok kriterli karar verme yöntemlerinden TOPSIS ile değerlendirilmiştir. Çok kriterli karar verme yönteminde alternatifler arasından belirlenen kriterlere göre değerlendirme yapılmaktadır. Çalışmada alternatifleri uçuş rotaları veya seferler, kriterleri de operasyonel maliyet kalemleri oluşturmaktadır. Ağırlıklandırma ise sektörde ortalama maliyetlere göre yapılmıştır. Bunun yanında lokasyonun operasyonel maliyetteki etkisini tam anlamıyla ölçmek amacıyla hubların bulunduğu ülkelerin GSYİH, HDI ve SDI değerlerinin ortalamasıyla lokasyon indeksi geliştirilmiş ve % 30 olarak karar verme sürecini etkilemesi sağlanmıştır. Araştırma sonuçlarına göre Istanbul, Londra ve Delhi gibi lokasyonlarda kurulacak havayollarının operasyonel maliyetlerinin daha düşük ve filo yönetiminin daha optimum olduğu görülmüştür. Bunun en önemli nedeni bu bölgelerden Avrupa'daki birçok merkeze uçuşun kolay ve daha az maliyetli olmasıdır. Araştırma ile elde edilen bulgular sektör yöneticileri ve araştırmacılar için bilgiler sunmaktadır.

Anahtar Kelimeler: Çok Kriterli Karar Verme, Filo Yönetimi, Havayolu, Jeopolitik, TOPSIS.

ABSTRACT

THE EFFECT OF GEOPOLITICAL LOCATION ON OPERATIONAL COST AND FLEET MANAGEMENT

Zeybel, Serhan
MSc in Air Transport Management
Student ID: 188042006
Open Researcher and Contributor ID (ORC-ID): 000-0002-1629-3771
National Thesis Center Referance Number: 10394479

Thesis Supervisor: Asst. Prof. Ahmet Kaplan
December 2020, 117 Pages

The airline industry is one of the industries where there is most impact of costs on profitability. Fleet management and location selection are important in terms of operational costs in the airline industry, which is affected by economic and competitive conditions due to its nature. Airline companies that make a successful fleet management and location selection can reduce their operational costs and use their fleet in the most optimum way. In this study, the effect of location selection on airline fleet management and operational costs was examined. In this context, flight scenarios were prepared from 8 centers, 10 different hubs and 5 different aircraft. These scenarios prepared were evaluated with TOPSIS, one of the multi-criteria decision making methods. In the multi-criteria decision-making method, the alternatives are evaluated according to the criteria determined. In the study, alternatives are flights, and the criteria are operational cost items. Weighting was made according to the average costs in the industry. In addition, in order to fully measure the impact of location on operational cost, the location index was developed with the average of GDP, HDI and SDI values of the countries where the hubs are located, and it was enabled to affect the decision-making by 30%. According to the results of the research, it has been observed that the operational costs of the airports to be established in locations such as Istanbul, London and Delhi are lower and the fleet management is more optimum. The most important reason for this is that flights from these regions to

many centers in Europe are easy and less costly. Findings obtained from the research provide information for sector managers and researchers.

Keywords: Airline, Fleet Management, Geopolitics, Multi Criteria Decision Making, TOPSIS.

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Lastly, I would like to present the greatest gratitude and thanks to my lovely father, mother, dear brother and my lover. Without their contribution and support to my life I wouldn't be on my carrier point today.

Best wishes to my precious classmates…

Hope to see the graduation of all of them…

Serhan ZEYBEL

İSTANBUL,2021

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CHAPTER I

INTRODUCTION

Airline companies, whose technology is constantly changing and developing, should realize their strengths and weaknesses, opportunities and threats in order to survive as a global player and maintain their competitive advantage and make their strategic analyses accordingly. In this context, one of the most important problems standing in front of airlines is operational costs and fleet management. Managing fleets in the best way and reducing operational costs is one of the most important issues of airline companies. In this context, airlines seek to use some of the advantages they have and seek to obtain new advantages. One of the advantages of airline companies is their geographical locations.

As the world is constantly changing and developing, it is important for airline companies to adapt to competition. Aviation is a complex high-cost and intense-competition service industry that uses advanced technology. Liberalization tendencies, high costs, low ticket fares, restrictive laws and regulations, strategic alliances, security needs and environmental awareness that have emerged with the phenomenon of globalization take competition to a higher level. Therefore, in order for the airline companies to keep up with this competitive structure, they should follow and control the airlines, which are the main point of passenger and goods transportation. For this reason, the optimization studies of airline companies on airlines and flights have become important. As airlines generally adopt a hub and spoke model, which hubs should be preferred at this stage is important in terms of both profitability and operational costs because the costs that airlines have to bear vary according to the hubs they choose.

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 cannot compete on price without reducing their costs and overheads. The airline industry relies on airport services, the provision of aviation fuel, labour, et cetera. Moreover, there may be airlines, particularly the legacy carriers which could also be dependent on costly distributive networks.

In this study, geopolitical impact of hub location and route selection on operational cost will be analyzed by optimization models. Five different aircraft, eight different locations and ten different hubs were selected for optimization. The main starting point of the study is where should the airline be located in order to reach 10 different hubs with the lowest operational cost with these five selected aircraft. During the selection of the hubs in the study, a coefficient was determined according to the GDP, HDI and SDI values of the country where the hubs are located. In this way, the geopolitical importance in terms of economic value of the hubs was also taken into account.

CHAPTER II

AN OVERVIEW OF AIRLINE INDUSTRY

2.1. The Concept of Transportation

Transportation is a service that enables people, other living and inanimate beings to move from one point to another. In other words, transportation is defined as a service that enables people and goods to be displaced to benefit against certain needs. This displacement can be on the earth (on land, air and water surfaces), underground (in the form of a tunnel or subway) or outside the world (space travel) (Kaya, 2012: 4).

Transportation systems are used for almost every situation that requires displacement. The required transportation infrastructure, means of transportation and the speed of transportation can change constantly. The benefits of transportation are mainly in the form of displacement and time savings. In addition to time benefit, transportation ensures the establishment of space and time relationships between geographical points (Kaynak, 2004: 5).

Activities that require transportation appear in every aspect of life, such as production, consumption, trade, defense, social life and services (tourism, financial, educational, sports, religious services, etc.). Transportation needs arise from the fact that people have to move themselves, and the goods and services they need, from one place to another in a large quantity and quickly (Kaya, 2012: 3).

Constantly developing transportation has been a vital factor for economic and sociocultural development for centuries. Nations, regions, cities, industries, institutions, businesses have developed or lagged due to the presence or absence of suitable transport facilities. Today, transportation is regarded as one of the basic tools that meet the civil life needs of people (Taaffe, 1996: 14; Crainic & Kim, 2007: 475).

2.2. The Concept of Airline Transportation

In the previous section, transportation was defined as a service that enables the displacement of people and goods to benefit against certain needs. The definition of airline transportation can be given in a similar way. Airline transportation can be defined as the displacement of people, cargo and mail by air to provide space and time benefits. In other words, replacing people and / or cargo with an aircraft is possible thanks to the air transportation service. Regardless of its purpose, displacement of people, cargo or mail with an aircraft is regarded as airline transportation (Gerede, 2010: 9).

Airline transport is at the center of the aviation system. Civil aviation activities such as design, production, maintenance, airport, ground services, navigation, communication and air traffic are all in order to carry out airline transportation safely and effectively (Wells, 1999: 25).

Airline transportation, it is the activity of transportation of passengers, cargo or mail with a commercial vehicle. In the 1st article of SHY-6A Commercial Air Operations Regulation, commercial airline transportation activities are expressed as the transportation of passengers, cargo and mail for a fee using all kinds of aircraft. Airline transportation is a fast way of transportation, but it is very expensive compared to other modes of transportation. Although it has a large capacity in terms of passenger transportation, a large part of airline transportation is cargo transportation. Airline companies can be in many different types, from airline companies that can make thousands of flights throughout the day with their fleet of hundreds of aircraft, to airline companies that operate only at certain times of the year with a single and relatively smaller aircraft. This sector has become an indispensable part of modern life today due to its large flight network, connecting cities, countries, even continents, and providing social or economic benefits (Sarılgan, 2011: 72).

Today, thanks to airline transportation, cooperation can be achieved on economical, technical, business and commercial issues between countries without regardless of distance, and people or products can be transported from one place to another in a short time in a comfortable and safe manner. It also contributes socially and culturally by bringing together people from different cultures, enabling them to get to know each other (Ball, Barnhart, Nemhauser & Odoni, 2007: 25).

Airline management is the transportation business that mainly produces markets and sells freight and postal services by using air transport vehicles for profit purposes. This definition contains a general description. Today, an airline company is in an effort to market the by-products of the services it provides to the passenger. It is even observed that some airline companies carry out transportation as a means, not as a goal (Button & Taylor, 2000: 212).

The service offered by the airline company to its customers involves the transportation of customers and their goods from one point to another at a determined price. In the airline industry, services similar to those offered by banks, insurance companies and even hairdressers. There is no recyclable product in this industry, which is paid by the customer and is likely to be sold or stored later (Guimera, Mossa, Turtschi & Amaral, 2005: 7798).

2.3.Development of Airline Transportation in the World

Aviation history has a history of more than two thousand years, from kites and tower jumping to supersonic and hypermomatic aircraft. Kites in China dating back several centuries BC are considered to be the first example of man-made flight studies (Kansu, Şensöz, Öztuna & Kaymaklı, 1971: 14).

Leonardo Da Vinci wrote the first scientific article about flying in the 15th century, trying to express his dream of flying in very logical but unscientific designs (Kansu, Şensöz, Öztuna & Kaymaklı, 1971: 15).

In the 18th century, the discovery of hydrogen gas led to the invention of the hydrogen balloon at the same time as the Montgolfier brothers designed the hot air balloon and launched manned flights. Balloons, both free-end and connected, began to be used for military purposes from the end of the 18th century, and the French government established Balloon Companies during the Revolution (Polmar, 2006: 55-56).

On June 4, 1783, the brothers Joseph-Michel and Jacques-Étienne Montgolfier displayed unmanned hot air balloons flying over Annonay, France. Until August 27 of the same year, Anne Jean and Nicolas-Louis Robert, together with the brothers Jacques Charles, flew the unmanned hydrogen filled balloons in the Paris skies (Grant, 2003: 29).

Experiments with the glider laid the groundwork for heavier-than-air aircraft design, and at the beginning of the 20th century, a controlled and powerful flight was made for the first time, with advances in engine technology and aerodynamics. Modern aircrafts similar to the structure today began to be built in 1909 (Torenbeek & Wittenberg, 2009: 32).

The first major vehicle in the air was rigid air balloons led by Ferdinand von Zeppelin, which became synonymous with planes and dominated long-haul flights until the 1930s. After World War II, flying balloons were replaced by aircrafts, respectively, and new and enormously powerful jet engines revolutionized both air travel and military aviation (Kansu et al., 1971: 17).

However, today the official and most accepted date in the aviation field is December 17, 1903. At that time, Orville and Wilbur Wright performed four 852 feet long flights on Flyer, the longest of which lasted 59 seconds. The Wright brothers' flights have combined power and control, setting a new standard for aviation (Grant, 2003: 29).

It can be said that the history of modern aviation started on December 17, 1903, with the first controllable flight attempt made by the Wright brothers. This flight experiment conducted by the Wright brothers lasted only 12 seconds with a 16 horsepower plane, but gained an important place as an indication that people could fly. Following this initiative, the interest in air transportation has grown steadily. Since the First World War, the aircraft was recognized as a military vehicle and caused important advances during the war. These developments have increased the interest in aviation and led to the commercialization of aviation (Kansu et al., 1971: 19).

The Paris Convention, which was signed in 1919 and entered into force in 1922, was one of the turning points of the air transport industry. With the Paris Convention, governments stated that they are aware of the importance of air transport in the country's development and the problems that may arise. The Paris Convention’s contribution to aviation has been mainly on technical issues such as route changes and passenger carrying capacities. States participating in the Paris Peace Conference discussed the issues of the International Civil Law on aviation, such as the sovereign rights of states on airfields, international registration and restrictions, which led to the International Civil Aviation agreement of 13 October 1919 (Grant, 2003: 35).

The Paris Convention on Civil Aviation, which regulates the International Public Law rules, followed by the Madrid Convention in 1926 and the Havana Conventions in 1929, and these International Public Law rules remained in force until the Chicago Convention of 17 December 1944 was adopted (Torenbeek & Wittenberg, 2009: 35).

During and after the Second World War, the USA became the only country that could use the air transport system in accordance with the required conditions at that time. At the Chicago conference held in 1944, the USA gained a strong position and asked for its own wishes at the conference, creating the international route model, organizing flight numbers, and carrying capacity. Provisional International Civil Aviation Organization (PICAO) was established with the Chicago contract signed at the end of the Chicago conference, which remained valid from 1945 to 1947 and was later replaced by the International Civil Aviation Organization (ICAO) (Kansu et al., 1971: 21).

World air transportation followed a steadily developing trend after 1945. The development of air transportation in the world tended to pause during the Second World War. Airline passenger transportation, which started at the end of the 1940s in the late 1940s with mass tourism, is a type of transportation that develops the opportunity of overseas or long distance travel. Organized travels, called package tours and ground services, have become a preferred mode of transportation for consumers who care about the time factor. The trend of liberalization experienced in the air transport industry spread rapidly all over the world. As a result of the tendencies of liberalization, globalization and commercialization, the high demand for supply has been created in the air transport as a result of the development of a variety of services suitable for passenger requests and needs. The increase in per capita income worldwide and the development of inter-regional trade and tourism have accelerated the growth rate in the demand for the industry (Polmar, 2006: 58).

The country where air transportation is the most developed in the world was the USA. The biggest reason for the development of the USA in this way was its liberalization efforts in aviation in 1978. Liberalization movements that took place in the USA in 1978 also affected Europe and started the liberalization process. The liberalization movements to airline companies to expand the flight networks increased their market shares and flight frequencies. However, liberalization movements started to become insufficient for the development of the aviation industry after a while and low-cost airline companies have emerged (Polmar, 2006: 59).

Airline transportation is becoming more important in the globalizing world, and the world states that are aware of this fact, are trying to support airline transportation with privatization, liberalization efforts. The Table 2.1 gives the number of airline passengers in the world. Accordingly, airline passengers, which were 310 million in 1970, reached 4.2 billion in 2018.

Table 2.1: Total Worldwide Airline Passengers in Years

Years	Passengers
1970	310.441.392
1980	641.872.888
1990	1.024.976.616
2000	1.674.064.712
2010	2.628.261.258
2011	2.786.953.830
2012	2.894.054.972
2013	3.048.275.073
2014	3.227.291.386
2015	3.466.478.485
2016	3.705.101.897
2017	3.973.790.463
2018	4.232.644.721

Source: https://data.worldbank.org/indicator/is.air.psgr/, Accessed: 17.11.2020.

The number of airline passengers in the world is also shown in the Figure 2.1 . Especially after 2010, a sharp increase in the number of passengers can be observed.

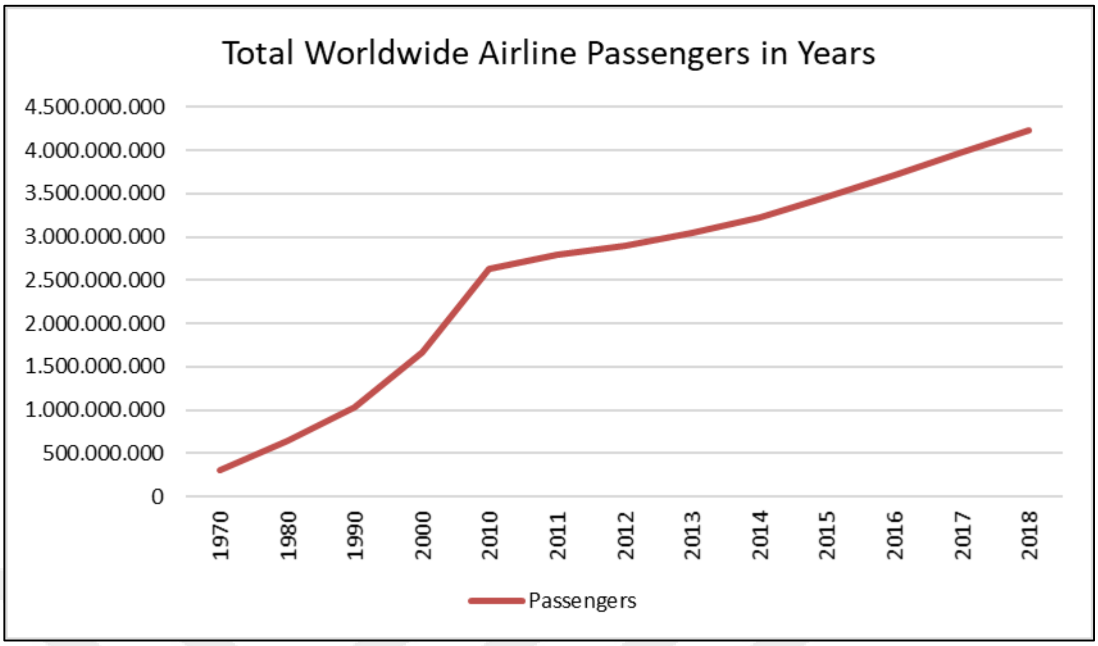

Figure 2.1: Total Worldwide Airline Passengers in Years

Source: https://data.worldbank.org/indicator/is.air.psgr/, Accessed: 17.11.2020.

2.4.Development of Airline Transportation in Turkey

The first winged flight was carried out on December 17, 1903 by the American Wright Brothers. Aircraft construction and aviation continued to develop rapidly from this date. The Wright Brothers, who came to Paris in 1907, carried out trial flights with motor aircrafts and pioneered the rapid development of aviation in Europe, especially in France. Five years later, with a decision taken by the Ottoman government in 1911, the Turks started their first aviation activities at the Flight Station established in Safraköy near Ayastefanos (today Yeşilköy), which laid the foundations of aviation history (Korul & Küçükönal, 2003: 29).

With the efforts of the then Minister of War Mahmut Şevket Pasha, it was decided to establish a commission to be sent to Europe in 1911 to establish an aircraft station in Yeşilköy and to train young officers as a pilot. Süreyya (İlmen) Pasha was appointed to take over the commission. In the same year, two officers named Feza Bey and Kenan Bey were sent to France to be trained as pilots. Subsequently, young officers such as Fethi, Fazıl and Mehmet were sent to France and England (Korul and Küçükönal, 2003: 30).

Turkey's first aircraft purchase decision, Sureyya Bey commission chaired by France and Germany took place in 1912, in a long and detailed research after. The eleventh Deperdussin, REP and Blériot type aircrafts brought from France followed by four Bristols ordered from the UK, and one Mars and one Harlan aircraft from Germany were added. With another decision taken by the Ministry of War, white moon and star motifs were painted in the tail sections and in a red area under the wings on the aircrafts. In the later periods, although the Ottoman Empire was in a serious economic and political crisis, it attached great importance to aviation and the first small fleet established achieved important victories in the Balkan Wars. Following the Balkan Wars, a Parseval-type air balloon was also purchased from Germany and added to the fleet as a symbol of Ottoman prestige (Keyüsk, 1950: 29).

After the beginning of World War I in 1914, Çanakkale was one of the bloodiest conflicts in the world history. The Ottoman Air Force used various new aircraft in this war. Among the new aircrafts purchased from German allies were Ponniers, Rumplers, Fokkers, Pfalz, Halberstadts and Albatross aircrafts, as well as Gotha W-13 type seaplanes (Erdemli, 2011: 45).

With the establishment of the Republic, aviation has also started to develop. With the establishment of modern, new airports, new aircraft were purchased and civil aviation was established, the first steps were taken towards the establishment of Turkish Airlines (Keyüsk, 1950: 30).

The Turkish airline market was liberalized in 1983. Private companies were accepted with the introduction of 1983 Civil Aviation Law, in which only public companies served the airports of the country. Since the regulation failed to create a competitive environment, Turkish Airlines' semi-monopoly was further strengthened. In 2003, barriers to market entry were erased and the industry turned into a more competitive market (Keyüsk, 1950: 30).

Currently in Turkey, Turkish Airlines, Onur Air, Pegasus Airlines, Anadolu Jet and Sun Express are operating. The foundation years of these companies and the number of aircraft in their fleets are given in the Table 2.2:

Table 2.2: The Fleets Of Airline Companies Operating in Turkey

Airlines	Foundation Year	Fleet
Turkish Airlines	1933	324
Pegasus Airlines	1990	84
Güneş Ekspres	1989	53
Onur Air	1992	27
Turistik Air Transport	2005	14
Hürkuş Air Transport	2001	9
MNG Airlines	1997	6
Tailwind Airlines	2009	5
ACT Airlines	2004	5
ULS Airlines	2004	3

Source: http://web.shgm.gov.tr/tr/kurumsal/4547-istatistikler, , Accessed: 17.11.2020.

In the Table 2.3, the number of airline passengers in Turkey is given. Accordingly, airline passengers, which were only 1 million in 1970, reached 115 million in 2018.

Table 2.3: Total Airline Passengers in Turkey in Years

Years	Passengers
1970	1.035.700
1980	1.253.700
1990	4.337.100
2000	12.187.891
2010	45.665.249
2011	53.500.303
2012	63.350.312
2013	74.413.805
2014	84.574.844
2015	96.604.665
2016	100.366.461
2017	107.917.326
2018	115.595.496

Source: https://data.worldbank.org/indicator/is.air.psgr/, Accessed: 17.11.2020.

The number of airline passengers in Turkey is shown in the Figure 2.2. Especially after 2000, a sharp increase in the number of passengers can be observed.

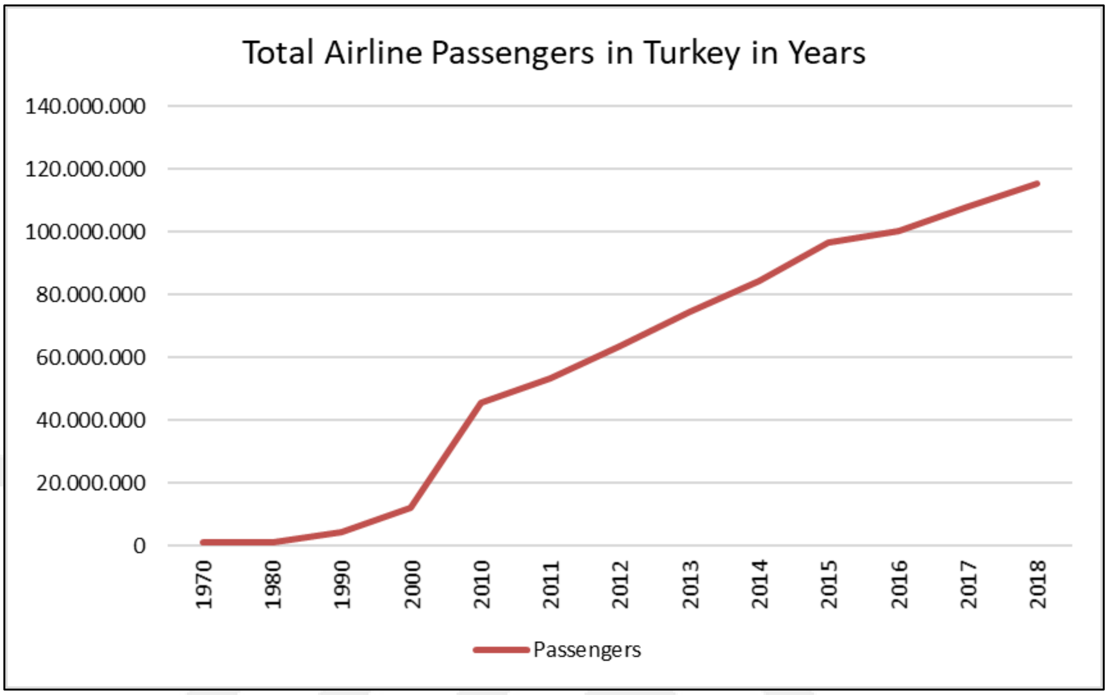

Figure 2.2: Total Airline Passengers in Turkey in Years

Source: https://data.worldbank.org/indicator/is.air.psgr/

CHAPTER III

IMPORTANCE OF GEOPOLITICAL LOCATIONS FOR AIRLINES

3.1. Definition of Geopolitical Location

Geopolitics, which can be considered as the science of politics developed on geography, has focused on the geographical reasons which should be the reason for the spreading of states, which geographical regions should be controlled for world domination (Hafeznia, 2000: 58).

Geopolitics, as one of the most popular concepts of international politics, has been a concept built on elements such as land, state borders and population, which are elements that are considered constant in terms of a realist view. However, this use of geopolitics has become insufficient with globalization. Despite the differences in its use throughout history, geopolitics has been the label of studies on the relationship between geography and politics in general (Alexander, 1961: 408).

The word geopolitics, which is formed by the combination of geo (place) and political (regulation of state affairs, politics), means the relationship between the policy applied in a state and the geography of that place. The word meaning of geopolitics is the determination of the country's foreign policy according to the economic and political geography data. Geopolitics explains the direction that all power elements give to politics with the value of the geographic platform and other geographical data (Hafeznia, 2000: 58).

The concept of geopolitics has been important in every period of history, it is a concept that still maintains its importance and determines the fate of political relations and orientations. Geopolitics investigates world geography, geographical structure and universal values, and conducts research on power and political levels in the world, region and country. Geopolitics is a science that evaluates the power of the world, the forces of the region, and that evaluates the power of the region, under which it is influenced by considering the unchanging and changing elements of the geopolitics of a nation, a group of nations, or the region for the purpose of policy making (Alexander, 1961: 409).

Geopolitics is a concept used in international relations since the end of the 19th century. Its establishment in the literature and its spread in the discipline of international relations were in use in the first half of the 20th century. The concept was used quite widely in national and international politics until World War II. This widespread use has increased so much that geopolitical concepts have often been considered sufficient for the explanation of any international event, and consequently excessive use of the concept of geopolitics has made it a level of analysis, making it a key element in the explanation of any foreign policy event (Guzzini & Guzzini, 2012: 22).

It was first used as a geopolitical concept in 1905 by the Swedish scientist Rudolf Kjellen in the book Stormakterna (Great Powers). According to the German scientist Friedrich Ratzel (1844-1904), who is considered one of the other founders of geopolitics and taught Political Geography at the universities of Munich and Leipzig, the state is an organism made up of a cell. The state aspires to develop and spread. Kjellen's viewpoint, which puts the state as an organism, has influenced German politicians and scientists, and Friedrich Ratzel has worked on the concept to create his own geopolitical arguments (Agnew, 2004: 42).

Classical geopolitical theory is embedded in the realist theory in international relations. The unitary and rational state, which does not change on the basis of inter-state discourse, was accepted as an analytical data with an assumption. In classical geopolitical discourse, the state is a spatial data defined within certain limits or an organism within the discourse of the German Geopolitical school. The main assumptions of classical geopolitics are that the state is a living organism and therefore the borders are flexible (Kelly, 2016: 61).

Neoclassical geopolitics differs from classical geopolitics in several respects. First of all, the state is no longer seen as a living organism. Therefore, the view on the borders of the state has lost its importance. The state does not necessarily have to expand its borders. The borders are now strategically valuable, orientable, and can be changed according to the interests of the state. However, under the influence of positivist thought, the state is an entity that looks after its interests and thinks about its security as if it were a human. The physical environment has begun to be handled as a geography that offers constraints and opportunities together (Guzzini & Guzzini, 2012: 23).

3.2. Importance of Geopolitical Location for Airlines

Along with the technological development, it has made it necessary to take into consideration not only physical but also human and economic geography in military and political fields. This is the basic dynamic that makes geopolitics a stand-alone branch of science. This interdisciplinary branch of science can be used directly in future forecasts of strategic industries that directly affect country policies or are directly affected by country policies. Among the industries that are directly affected by country policies or directly affect country policies are aviation and energy industries. These two industries, which directly determine the wealth and development of the countries, can be directly evaluated as a study element of the geopolitical discipline (Anaz & Akman, 2017: 304).

The aviation industry is directly related to all elements of geography. (Debbage, 2016: 43). When academic studies in Turkey and in the world are examined, it is observed that such studies are frequently included in the field of the energy industry. Especially petroleum sources, including studies published in the geopolitical concept of marketing Caspian oil to Turkey's geopolitical significance of space is available. With these studies, the concept of petropolitics has been put forward (Anaz & Akman, 2017: 303).

The aviation industry is directly related to geography due to its structure. Aviation technology used today cannot overcome geographical constraints. Commercial aircrafts used today can actively provide service within a certain flight distance. In addition, the aviation industry is directly related to human structures and the economic development of countries. The aviation industry directly causes the economic power of the countries to increase with the development of the commercial network of the countries (Debbage, 2016: 44).

With aviation geopolitics, it will be possible to determine in which direction world aviation will go, in which region and areas it will have the opportunity to grow and how these growth opportunities can be utilized.

Geographic location 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 (Lacoste, 2004: 7).

The biggest criterion of design for commercial passenger aircraft manufacturers is to carry the most passengers at the longest distance with the most appropriate fuel consumption. Commercial passenger aircrafts produced by world aircraft manufacturers can be evaluated in three segments in terms of the range they fly. These are short range 50-90 passenger capacity passenger aircrafts, which are grouped as Regional Jet (RJ), medium range 140-300 passenger capacity passenger aircrafts, which are Narrow Body (NB), and long range 300+ passenger capacity passenger aircrafts are Wide Body (WB) (Çakmak, 2016: 9).

NB commercial passenger aircraft make up the majority of the world passenger aircraft fleet. Boeing B737CL series aircrafts produced in 1984 have a maximum range of 4,444 km while Boeing B737MAX series aircrafts developed in 2014 have a range of 6,704 km. As the designs of commercial passenger aircraft have improved, it has become possible to carry more passengers at longer ranges. When we compare the flight time (FH), Boeing B737CL aircrafts in 1984 served at an active distance of 3-4 flight hours, while today this figure has increased to 4-6 flight hours (Çakmak, 2016: 9-10).

This physical constraint in aircraft designs directly affects the aviation industry. Thus, the geographical restrictions arising from this design play an important role.

CHAPTER IV

OPERATIONAL PROBLEMS AND OPERATIONAL COSTS OF AIRLINES

In this section, operational problems experienced by airline companies are discussed and operational cost items of airline companies are examined.

4.1. Operational Problems of Airlines

The first problem is the flight scheduling problem, which defines which flight destinations and how often flights will be served and how flights should be scheduled to meet this frequency. Boyd and Kallesen (2004) investigated the passengers' purchasing behavior on revenue management by considering two different types of flight class-specific and fare-based models. Lohatepanont and Barnhart (2004) developed an integrated model and solution algorithm that optimizes flight and aircraft types assigned to selected flights. As a result of the study carried out for American Airlines, it was stated that the potential improvement in the use of aircraft and the significant increase in revenue is over $ 200 million annually. Armacost et al. (2002) prepared models and algorithms to create the best or near-best flight layout design for fast package service. As a result of studies carried out in a cargo company (UPS), it has been reported that operational costs have been reduced by 7% and the number of required fleets by 10%.

The second problem is the aircraft scheduling problem. This problem consists of a series of decision processes. First, the assignment of fleets to flight routes is performed. Then, flight route plans are created for each aircraft, considering maintenance constraints. Daskin and Panayotopoulos (1989) showed that operating profit can be maximized by assigning aircrafts to their routes in a single hub and spoke layout structure. The problem is modeled as a mixed integer linear programming problem and solved by Lagrangian relaxation. Feo and Bard (1989) presented a model that developed a flight program that could accommodate both care centers and better meet the A-type control requirement. The problem has been formulated as a minimum cost integrated constrained multi-product flow problem for American Airlines. Since the relaxation of the linear problem is too great for the solution, a two-step heuristic method was used. Kabbani and Patty (1992) formulated the aircraft routing problem for American Airlines as the cluster determination problem, where each column represents the possible weekly flight route and the lines represent the flights. In the study, it was accepted that the maintenance was carried out every three days. Subramainan et al. (1994) solved the fleet assignment problem for Delta Airlines, allowing the business to save $ 100 million annually. Hane et al. (1995) modeled the fleet assignment problem as a large multi-product flow problem with side constraints in a time-expanded layout structure. The method used to solve the problem is the inner point algorithm and branching. The authors also used some layout pretreatment methods to reduce the size of the problem. Rushmeier and Kontogiorgis (1997) presented an advanced model for the solution and formulation of the large-scale fleet assignment problem encountered in airline scheduling. Studies for US Airways have shown that the business saves $ 15 million annually. Clarke et al. (1997) modeled the aircraft rotation problem as the side constrained Eulerian tour problem, which provides maintenance constraints and maximizes the uninterrupted flight value of connecting flights. The model was simplified by pre-process techniques and solved by Lagrangian relaxation and subgradient optimization. Desaulniers et al. (1997) examined the problem of daily aircraft routing and scheduling that maximizes profits from a heterogeneous aircraft fleet and presented two models. The linear relaxation of the first model was solved using the column derivation technique, and the linear relaxation of the second model was solved using the Dantzig-Wolfe decomposition approach. Gopalan and Talluri (1998) modeled the aircraft routing problem for US Airways and used a polynomial time algorithm for three-day maintenance control and balanced control requirement. In the model, flights and even fleets are exchanged in order to obtain proper aircraft maintenance routing. Barnhart et al. (1998) solved the integrated fleet assignment and aircraft routing problem by modeling string-based models using the branch-and-price approach. The downside of this model is that the flight program with hundreds of flights has millions of sequences (Rexing et al., 2000). As a result of the study, it was seen that the business saves around 50 million dollars annually and reduces operating costs. Cordeau et al. (2001) simultaneously modeled the aircraft routing and crew scheduling problem and used the Bender decomposition approach for solution. Sriram and Haghani (2003) examined the problem of maintenance scheduling and aircraft reassignment. The authors considered both type A and type B control in modeling, and used a heuristic method that combined the random search and depth first search approaches for the solution. Sarac et al. (2006) solved operational aircraft maintenance routing problem by modeling that considers maintenance slots and available man-hours in maintenance stations. Orhan (2007) discussed aircraft routes together with maintenance requirements, thus aiming to minimize maintenance costs as well as effective use of aircraft. In line with the stated goal, he proposed an integrated multi-purpose mixed integer linear modeling approach that minimizes the legally usable flight time of aircraft before entering maintenance. The approach also balances the number and / or duration of flights in line with the priorities of the decision maker, thus ensuring that aircraft utilization rates and maintenance costs are kept as equal as possible.

The third problem is the crew scheduling problem, which involves identifying crew members, called cockpit and cabin attendants, for each flight. The crew scheduling problem consists of two sub-problems: the flight sequence finding problem (crew pairing) and the crew assignment problem (Özdemir, 2009). In the first problem, the minimum cost sequential flight leg sequences are created in accordance with the regulations, while in the second, the team members who will take part in these sequences are assigned. In the solution of the first problem, individuals who make up the teams are not taken into account. Ryan (1992) solved the crew assignment problem to maximize the total satisfaction of the flight crew, first with the primal simplex algorithm, then with the branch and boundary approach to obtain integer results. Clarke et al. (1996), Hane et al. (1995) expanded their study by adding maintenance and team constraints to the model. Solutions that do not meet the constraints of care have been deemed unsuitable. The need for maintenance is classified according to the time they are performed, as short term and long term. In the study, it is not explicitly given how maintenance constraint and crew scheduling are combined with the fleet assignment model. Gamache et al. (1998) investigated the team assignment problem for Canada Air, ensuring that the problem remains under solvable conditions, maximizing the preferences of the most senior staff. Gamache et al., (1999) solved the large-size flight crew assignment problem with linear relaxation and column derivation approach and used local search algorithm to obtain integer solutions. Yan and Tu (2002) used the theoretical layout flow model and layout simplex algorithm to solve China Airlines' team scheduling problem. Özdemir (2009) developed a hybrid method by examining the studies on the flight sequence finding problem in the literature.

The fourth problem consists of the management of irregular operations, none of which involves solving previously unexpected problems, such as aircraft mechanical failure, lack of crew members, and bad weather. At this stage, the aircrafts are rerouted and the crew scheduling is done again. Bratu and Barnhart (2006) worked on two models with integrated recovery. The models considered both passenger recovery and aircraft and crew scheduling rules and regulations. The purpose function of both models includes operational costs and passenger recovery costs. Yu et al. (2003) examined the problem of team rescheduling in the face of unexpected events for Continental Airlines. The business saved $ 40 million annually as a result of the work. Abdelghany et al. (2008) adapted the integrated program simulation model and resource assignment optimization model as a tool for a decision support system for the recovery process of irregular operations. While the simulation model of the program lists the disrupted flights considering the severity of the disrupted operations, the optimization model offers new flight plans and effective recovery plans that minimize flight delays and cancellations by exploring possible resource changes. Tekiner et al. (2009) investigated the problem of finding a flight sequence when new flights are added to the regular flight schedule. In the study, keeping the cost increases at acceptable levels, the results obtained with the proposed model were compared with the traditional approach.

4.1.1. Flight Scheduling

Flight scheduling is the starting point for the planning and operations of the airline business. Flight scheduling studies start 12 months before flight operations and are completed 9 months before. The flight schedule shows the departure-arrival time of each flight leg, the flight points and the day of the week, the flight number and the fleet type to be used in the flight. The program is usually prepared for quarterly or six-month periods. There may be minor changes from month to month in the programs.

Flight scheduling also defines the competitiveness and position of the airline business between destinations. Therefore, it is a key determinant of the profitability of the airline business. Flight scheduling is mainly influenced by the aircraft and crew planning decisions of the airline and competitor airlines and affects the decisions made. In flight scheduling studies, factors such as various demands in the industry, program and resource availability constraints offered by competitors, market forecasts are taken into account. The limited resources in airline scheduling are aircraft, crew, maintenance facility, maintenance personnel, etc. Also, for flight scheduling design, it is necessary to know the correct estimation of passenger demand on flight lines, the capacity of the airline fleet, the cost of spoilage (spill) which is rejected (unrealized) income due to the capacity of the aircraft, and the recycling rates of rejected passengers. Therefore, flight scheduling is a critical process as it significantly affects the profitability and sustainability of the airline business (Chang, 2001; Barnhart et al, 2003; Liu, 2003; Gopalan & Talluri, 1998; Clarke et al, 1996).

4.1.2. Aircraft Scheduling

After airline companies complete their flight scheduling design, they solve the problems of fleet assignment and aircraft routing called aircraft scheduling. In fleet assignment, aircraft types, ie fleets, are assigned to the legs in the flight layout at the lowest cost. In the last step of aircraft scheduling, each aircraft in a certain fleet is assigned to the flight routes determined for the fleet at the fleet assignment stage. Flight scheduling studies start a few months before flight operations and end at the moment the flight takes place.

4.1.3. Fleet Assignment

In the fleet assignment problem, it is planned to assign aircraft types with different capacities to flights based on the characteristics, availability, operational costs and potential revenues of the aircraft. The purpose of the fleet assignment model 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. Flight operating cost represents the flight cost in the flight leg of a particular aircraft type. Flight operation cost for each aircraft type is determined separately for each flight leg (Liu, 2003; Sherali et al., 2006; Rosenberger, 2001; Barnhart et al., 2003). The core product of an airline business is seats on an airplane. Having a higher capacity aircraft or having extra aircraft available for the airline business means higher operating costs. On the other hand, aircraft seats are a perishable product. Before an aircraft leaves the airport, unsold seats are treated as trash items. Thus, the ideal strategy should be just to provide passengers with the right number of seats at the right price (Sherali et al., 2006).

Assigning an aircraft with a small seat capacity to a flight results in unintentional customer rejection due to insufficient capacity and, as a result, lost revenue. However, if an aircraft with a larger capacity than the passenger demand is assigned to the flight, not all seats will be available. In addition, higher operating costs will occur, as the larger aircraft whose capacity cannot be filled is preferred. Therefore, the fleet assignment problem is an essential part of the entire scheduling process of the airline business. Since many flights are scheduled every day, the number of flights can easily reach thousands in a major airline business. It affects other decision processes of the airline business such as fleet assignment, flight scheduling, crew scheduling, aircraft route assignment, maintenance planning and revenue management, and are affected by the decisions made in these processes. Therefore, solving the fleet assignment problem has always been a challenging process for airline companies. The inability to admit passengers due to the capacity limit of the aircraft is generally considered lost. In reality, passengers can make their flights using an alternative flight schedule in terms of their starting destination and time period. Thus, passengers can be recycled back as passengers of the airline business (Liu, 2003; Sherali et al., 2006; Rosenberger, 2001; Gopalan & Talluri, 1998).

Large airlines that fly international and domestic generally have more than one fleet. Fleet is the name given to a cluster of aircraft with the same capacity and operational characteristics. An airline's fleet type can usually consist of several aircraft groups such as Boeing 737, Boeing 757, Fokker 100, and Airbus 320. Examples of fleet capacities are the 169 seat capacity Boeing 757 and the 98 seat capacity Fokker 100. Examples of operational characteristics are the speed of the aircraft, the engine fuel burn rate, the cost of aircraft maintenance, the number of crews required for the flight, and the minimum turnaround time to complete the work that needs to be done to prepare for the next flight after the aircraft lands at the airport. In addition, the operational features include different flight costs depending on the aircraft type assigned to the flight leg and the charges paid to the airport depending on the aircraft weight. Two aircraft of the same fleet type may have different passenger capacities. For example, the Boeing 737-400 aircraft has a capacity of 150 passengers, and the Boeing 737-800 aircraft has a capacity of 165 passengers. Fleet assignment models may also include additional constraints that take into account maintenance requirement, noise restriction and airport gate availability (Gopalan & Talluri, 1998 Rosenberger, 2001 Liu, 2003).

Despite the impressive results, several critical challenges still exist in fleet assignment. Most of these difficulties arise from modeling acceptances. These (Barnhart et al., 1998 Sherali, et al., 2006). In most fleet assignment models, the flight scheduling is considered to be repetitive on a daily basis, although most airlines perform different flight scheduling on weekends. In most fleet assignment models, it is assumed that the demands at the destinations are known and are the same for every day of the week. But historical data show that demand changes day by day. As demands change on different days of the week, higher income can be obtained by assigning different fleet assignments for each day of the week. However, this extra flexibility significantly increases the numerical complexity during the fleet assignment phase.

In the fleet assignment model, it is accepted that the departure taxi time, which is the time to move on the ground until the aircraft leaves the runway after the aircraft doors are closed, and the landing taxi time, which is the time from the moment the aircraft leaves the runway to the moment the aircraft doors are opened to disembark the passengers, are generally considered to be stable. However, the density of flight routes and airports, weather conditions and new security practices cause major changes in flight and taxi times.

In most fleet assignment models, it is assumed that the number of passengers changing the flight preference and the costs generated by this can be calculated at the flight leg level. In reality, the passenger demand, the number of passengers changing the flight preference, and the income that can be obtained from each passenger are specific to the passenger's flight schedule, not the flight leg. As a result, the costs incurred specific to the flight leg can only be estimated approximately.

In fleet assignment problems, since the aircraft are not solved individually, but by considering the cluster of aircraft with the same characteristics, a suitable route program cannot be created for each aircraft. In addition, in such fleet assignment solutions, the maintenance requirement cannot be modeled exactly. Instead, the total maintenance constraint is used, providing the smallest number of maintenance opportunities. If the aircraft can stop at a maintenance station within a sufficient time interval, it has the opportunity for maintenance. However, in fleet assignment, it cannot be guaranteed that the maintenance opportunity is evenly distributed among each aircraft. While one aircraft may have more maintenance opportunities than necessary, another aircraft may not (Barnhart et al., 1998).

4.1.4. Aircraft Routing

In the fleet assignment problem, it is decided which type of fleet will fly on flight legs. In the aircraft routing problem, the flight legs of each aircraft in a fleet are determined. It is also decided where and when to apply the different levels of maintenance required by the national civil aviation authorities of the countries and aircraft manufacturers to each aircraft. Therefore, the aircraft routing problem is also called the aircraft maintenance routing problem. The main purpose of aircraft maintenance routing is to minimize operating costs by taking constraints into consideration (Clarke et al., 1997; Qi et al., 2004; Sriram & Haghani, 2003; Orhan et al., 2007).

Aircraft route is a sequence of flight legs. The destination of one flight leg in the array is the starting point of the next flight leg. The cycle is the flight routing that starts and ends at the same center. The cycle of each aircraft is completed with regular visits to the maintenance station (Barnhart et al., 2003a). Information regarding the maintenance encountered as the main constraint in solving the aircraft route problem in the aviation sector is explained under the following subheading.

4.1.5. Aircraft Maintenance

Aircraft maintenance consists of a number of controls with high man-hour usage, with the exception of unscheduled maintenance. The frequency of these checks varies depending on different periods, such as the total number of flight hours, the number of departures and landings, monthly, quarterly and annually. At the same time, these checks can only be carried out at certain airports with adequate maintenance equipment. By setting up maintenance centers for different fleets in one location, businesses can achieve small savings by pooling resources.

Airline operators are obliged to implement the maintenance programs required and approved by the aircraft manufacturers and the civil aviation authorities of the countries. The Federal Aviation Administration in America (FAA: Federal Aviation Administration) requires several types of aircraft maintenance checks. These controls, called A, B, C and D, vary according to their scope, duration and frequency. If the control is not carried out within a specially defined period, the civil aviation authorities of the countries may prohibit the flight of the aircraft and impose large penalties on businesses that do not comply with the regulations (Bazargan, 2004).

The first basic control actually required by the FAA is called the A control. It is performed every 65 flight hours. A check requires 10-20 man-hours and is the shortest maintenance with a 4-hour period. In many cases, only Type A control is considered when performing aircraft maintenance routing. This is mainly because the Type A control frequency is more frequent than the other controls. Maintenance practices in the airline industry are implemented with more stringent care than the requirements of FAA rules. In practice, control A is performed every 40-45 flight hours, depending on the daily utilization rate of the aircraft, at most every 3-4 calendar days (Sriram & Haghani, 2003).

The second primary maintenance is called B control. It is carried out every 300-600 flight hours. The B check requires the aircraft to stay in the maintenance hangar for 10-15 hours. The maintenance process requires 100-300 man-hours (Sriram and Haghani, 2003 Clarke et al., 1996). The most basic checks, called types C and D, are done every 1 and 4 years, respectively. In some cases, the aircraft may need to be out of service for up to 1 month. Some airlines divide the C check into a quarter C check. This situation is called balanced control. Thus, less time is spent on the aircraft to be serviced each time. However, the aircraft visits the control station more often. Type C and D control is costly to perform. It requires special equipment and a lot of manpower. Due to the fact that it covers fixed costs, it is assumed that there is a maintenance station for each fleet type where C and D type checks will be performed. Some airlines may have more than one type of C and D maintenance station per fleet. But typically this number is small (Gopalan & Talluri, 1998).

4.1.6. Crew Scheduling

In the crew scheduling problem, each flight leg in a particular flight schedule is assigned a crew to meet the crew requirement for the flight. Each flight leg in the flight schedule represents an aircraft leaving one airport and arriving at another. The crew requirement for a flight leg refers to the airline personnel such as pilot, co-pilot, flight engineer, flight cabin attendants required in the aircraft. The number of flight crew members required in flights varies depending on the size of the aircraft, the duration of the flight, the starting time of the flight during the day and the level of service to be offered. The crew scheduling problem is solved in two separate steps as the flight sequence finding problem (crew pairing) and the crew assignment problem (Clausen et al, 2009; Özdemir, 2009).

4.1.7. Crewpairing

The problem of finding flight sequence is also called crew pairing. In this problem, there is a sequential flight leg sequence that starts and ends at the airport in the city where the team lives for the same fleet type. Large airlines often have more than one crew base. The extent of the flight sequence finding problem may consist of flight sequences ranging from one to five days, depending on the airline. In this process, team members usually spend the night resting in some cities outside of the city where they live. Flight duty time (FDT) is the total time during which the flight crew member is exempted from all flight duties at the end of the same flight or flight sequences, starting with flight preparation and for a flight mission that consists of a single flight or flight sequences. Each flight mission time (FMT) created expires one hour before the scheduled flight time and 30 minutes after the engine shutdown time when a flight or sequence flight ends. When calculating the FDT, the start-up time 1 hour before the first flight leg, the flight time between two cities, the time between the arrival and departure of a city and the 30-minute closing time after the last flight leg are added to the work period. The flight time (FT) is from the moment an aircraft starts its first movement with its own power or by applying an external force, to the parking place (Bazargan, 2004).

The aim of finding flight sequence problem is to minimize the total crew cost to cover all flights in accordance with the rules of the union, civil aviation authority and the company. Crew costs include the total flight cost, accommodation, meals, and transportation costs incurred while waiting between connections. At the same time, an attempt is made to try to ensure that the time the team spends on the flight is the largest and the connection times between flights during the day are the smallest. Airline operators strive to keep the crew on the same aircrafts on many flight legs whenever possible. Thus, the risk of encountering problems arising from the inability of the crew to work in different aircraft to reach the mission flight as a result of events such as canceled connecting flights or flight delays is prevented. When faced with these situations, the team flies in the status of non-revenue-generating passenger and catches up with the aircraft they will take part in (Yu & Thengvall, 2002).

4.2. Operational Costs of Airlines

As in other sectors, the costs incurred to carry out activities in the aviation sector are a very important factor in the company strategy and decisions to be taken. In airline companies, costs are effective in determining the price of the product or service, but it is also an important indicator of the company's competitiveness. Cost classification in an airline company can be made in various ways for different purposes. The need for cost information in planning and decisions to be made in airline companies arises for three reasons. The first of these is that airline companies want to see their total expenses in detail in different expense categories as management decisions and accounting tools. In this way, changes and trends in costs over time can be detected. Airline companies can separate operating profit or loss from non-operating profit or loss by measuring costs in the company's core business areas such as flight operations and passenger services, and plan accordingly. The second important reason is the investments to be made. For aircraft purchases or a new line to be added to the flight network, details of cost information are required at the cost determination stage. The third and perhaps the most critical reason for determining cost items in airline companies is the price policies of the companies. In the aviation industry, where the profit margin is relatively low, the wage levels determined without cost analysis can result in loss. However, there is no single classification of expenses that can fulfill these three objectives at the same time. For example, an expense classification developed for general management purposes may not work as a pricing strategy. For this reason, airlines make expense classification in two or more ways in order to be decisive in decisions to be taken on different issues. Transport companies often model the cost classification established by ICAO. On the other hand, the accounting practices in the country of the airline company are also effective in cost classification approaches (Doganis, 2006: 24).

There is no single classification of expenses in airline companies that can serve the strategies and decisions to be determined in every field. For this reason, many airlines classify their expenses in various ways to be used in different stages of management according to different perspectives. However, airline companies divide total expenses into operating expenses and non-operating expenses as a general practice in cost classification (Oum and Yu, 2012: 98). In this way, the flight operations, which are the main field of activity of the company, and all the expenses incurred for the realization of these operations are determined. Separating operating expenses from other non-operating expenses is closely related to the company's revenue management policies. It is possible to make future decisions by determining whether each line meets its own operational expenses.

Operating expenses in airline companies can be divided into direct and indirect operating expenses. Direct operating expenses refer to all costs incurred for the execution of flight operations. Therefore, as long as the flight does not take place, there are no direct operating expenses. These expenses include flight crew fees, fuel and oil expenses, aircraft maintenance and depreciation expenses. Indirect operating expenses can be defined as expenses that are not directly related to the realization of flight operations. These expenses include passenger services, ticketing and flight expenses, station and ground handling expenses as well as general administrative expenses related to the passenger rather than the aircraft. Although this classification method is generally accepted by airlines, some differences may arise during its application. For example, some expense items such as maintenance management and cabin crew expenses are classified as direct expenses by some airline companies, while others may be classified as indirect expenses (Şengür, 2004: 65).

The most common airline cost classification used today is the classification made by ICAO (International Civil Aviation Organization). According to this classification, the costs of airline companies are divided into two as operating costs and non-operating costs. Operating costs are costs directly related to the flight services offered by the airline operator, while non-operating costs are costs not directly related to the flight services provided. Fixed costs are costs that do not change depending on the level of service production of the airline business, in other words, a particular flight or a series of flights. Costs that vary depending on the level of service production are variable costs (Uslu & Cavcar, 2003: 82).

There are extensive studies in the literature on the variables that affect airway costs. The majority of these articles 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: 87).

Airline costs, which are related to type of aircraft and type of flight that was planned between lines, vary according to capacity, occupancy rate and number of flights and are classified as follows (Banker & Johnston, 1993: 578-579):

- Fuel: The amount of fuel used by the aircraft type to be selected for the specified route.
- Flight activity staff (including flight crew, pilots, co-pilots, navigation pilots and flight engineers) fees,
- Aircraft traffic and shuttle service: Fees based on working hours of ground handling personnel serving the aircraft
- Promotions and sales activities: Sales agency working hours as well as wages of staff working in advertising and promotion

- Maintenance and repair: Wages based on labor hours related to the maintenance of flight equipment and ground equipment
- Depreciation: The depreciation amount based on the useful life of flight equipment (including aircrafts) and ground equipment
- Insurance: Insurance premiums of employees, passengers and flight equipment.
- Airport and FIR use: Landing and overhead costs
- Catering services: The cost of food and beverage consumed by the passengers
- Cleaning Expenses
- Financing Expenses

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. The items consisting of these expenses can be seen in the following list (Doganis, 2002: 23):

Direct Operating Costs:

- 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

4.2.1. Direct Operating Costs

Expenses related to the flight of the aircraft, which form the basis of operations in airline transportation, constitute direct operational expenses. These expenses are highly dependent on the type of aircraft flown. These can be grouped under three main headings.

4.2.1.1. Flight Operation Expenses

Flight operation expenses constitute the largest item among direct operating expenses in all airline companies. The reason why flight operation expenses constitute a large part of the operating expenses is that the salaries and fuel fees paid to the flight crew are included in this cost item. Flight crew expenses, which are a large part of flight operation expenses, include not only the flight crew fees, but also all other related travel expenses, insurance and other social security payments. Fuel expenses, which are another important expense item in this cost item, are closely related to the aircraft type and the distance flown. Likewise, going out of the planned rotation due to adverse weather conditions that occur from time to time can also increase fuel costs. Another important cost element here is airport and line charges. However, ICAO classifies these expenses as indirect operating expenses under ground and station expenses. Other expenses included in this item are aircraft insurance expenses and aircraft and flight crew rental expenses. However, rental expenses are included in depreciation expenses by some airline companies.

4.2.1.2.Maintenance Expenses

Maintenance and repair activities, which are vital for flight safety in airline companies, constitute an important part of total costs. ICAO practices collect all expenses for the lightest maintenance and the heaviest maintenance and repair activities under a single cost item. This cost item includes all the necessary facility, technical and administrative personnel and the expenses of the changed and repaired parts for the realization of maintenance and repair activities. The maintenance and repair activities that traditional airline companies usually carry out in-house can be outsourced to other companies through some airline companies. In such cases, the payments made to the service company are also included in maintenance expenses. It is also a common practice to calculate the maintenance costs for different aircraft types separately among airline companies. In this way, airlines can compare the maintenance and repair costs for each aircraft type they own.

4.2.1.3.Depreciation Expenses

Depreciation and rental costs of flight equipment are also subject to direct operating expenses. Airline companies allocate equal annual depreciation according to the remaining value between 0-15%. The depreciation period is usually 14-16 years for large-body long-range aircraft and 8-10 years for smaller and short-haul aircraft. However, there may be some differences in practice. For example, some airlines take into account the purchase price of the aircraft, while others take into account the current market price. Airlines, which depreciate the current price of the aircraft, can set aside more money for the purchase of new aircraft. These two different applications are related to the accounting policies of companies. On the other hand, some airlines also amortize the expenses related to adding a new route to the flight network and purchasing a new aircraft, as well as the training costs of the flight crew who receive certification training to serve a particular aircraft type. The purpose of this application is to spread these expenses over the years. In airline companies that have one type of aircraft in their fleets, the monthly rental prices and annual depreciation expenses are the same. In the ICAO application, other than flight equipment, ground equipment depreciation is also included in this expense item. However, ground equipment costs are not directly related to flight operations if they do not only serve a particular aircraft type.

4.2.2. Indirect Operating Costs

Indirect operational expenses include ground or terminal expenses and general expenses. The terms "indirect or location" are used for these expenses, because most of the ground expenses are related to the amount of traffic, not the realization of the flight operations, which is the main activity of the aircraft (O'Connor, 2001: 32). Indirect operating expenses can be generally divided into five main categories:

4.2.2.1.Ground Expenses

Ground expenses are the sum of the costs incurred for all services required to be received by the airline companies at the airports. This expense item includes the fees paid to ground handling companies, the salaries of the ground handling personnel, vehicle and equipment maintenance expenses, the rental fees of the waiting rooms and other airport charges. In addition, ground equipment, ground vehicles, building and office expenses are also included in this cost item. All kinds of insurance and maintenance expenses of each building and equipment and the rental fees paid for them are also included in this expense item. It is also a common practice for airline companies to outsource ground handling services to other companies at some airports. In such cases, the cost of the service received from other companies is also included in this expense item. On the other hand, landing fees and other airport charges are not covered by station and ground expenses.

4.2.2.2.Passenger Services Cost

The biggest expense item subject to passenger service expenses is the wages of passenger service personnel. The accommodation expenses incurred in the event that the working time of the team expires after the flight or the return trip cannot be made on the same day due to the tariff is also subject to this expense item. In airline companies with only one type of aircraft in their fleet, this expense item can be determined as direct expense, since the cabin crew will only serve for a certain type of aircraft. Catering services such as food and beverage provided to passengers during the flight and night stays of transit passengers are also included in this item. In addition, in the event that passengers who miss their connected flights due to a delay or cancellation of the flights, they wait at the airports, the accommodation expenses are also included in this expense item if their meals or travel cannot be provided.

4.2.2.3.Ticketing, Sales and Promotion Expenses

This item includes all expenses arising from ticketing, sales and promotional services. Commissions and all kinds of expenses paid to travel agencies are also included in this expense item. In addition, all payments made to personnel serving in ticketing, sales and promotion departments and the expenses of the offices and office vehicles used by them are also evaluated within this scope.

4.2.2.4.General and Administrative Expenses

General and administrative expenses generally do not have a large share in airline businesses. Because general expenses such as sales and maintenance overheads can be separated from general and administrative expenses by including them in the expenses related to their subjects.

4.2.2.5.Other Operating Expenses

This expense item includes expenses that cannot be included in the above-mentioned expense types. The costs incurred in return for the service provided in the airline transport sector, which provides transportation with high technology aircraft, are higher than other sectors. Especially when it comes to additional services provided during the flight other than transportation, the costs increase even more. However, low-cost airline companies were able to reduce costs by saving in various ways from the operating expenses detailed below.

When classified in general, it can be said that fixed costs are personnel payments (flight personnel), aircraft rent or amortization, training expenses, maintenance expenses, insurance expenses, and variable costs are operational costs (landing accommodation) and catering expenses (Öncü, Çömlekçi and Coşkun, 2010: 50). According to the interviews conducted with the company executives in their studies, Öncü et al. revealed that increasing sales revenues tend to generate income by demanding a fee for extra services because it is difficult due to competition conditions (Öncü et al., 2010: 54). On the other hand, for market segments with high product price sensitivity, only basic flight services are offered, passengers are provided with minimum comfort (such as narrowing the seat spacing) and paid catering services and privileged service categories are removed (first class, business class, etc.). It is stated that it is possible to increase the aircraft occupancy rates by emphasizing the price attractiveness through such practices (Tanrısevdi & Çulha, 2010: 66).

Lim and Hong (2014) discussed the hedging method used as one of the risk reduction methods by airline companies in their study. They investigated the effect of the hedging method, which is mainly used to prevent unexpected increases in fuel prices, on operational costs. It was stated that fuel costs have a large share in operational costs and the increases in fuel prices cannot be reflected in ticket prices due to their negative effect on competitive advantage. For this reason, they stated that airline companies make use of the hedging method to control fuel costs. In the study, the relationships between hedging strategies and operational costs of airline companies in the American airline industry were examined. For this purpose, as a result of the analysis made by American airline companies based on panel data between 2000 and 2012, they determined that fuel costs can be reduced with the hedging method. They stated that companies that do not use the hedging method are vulnerable to sudden changes in fuel prices, and that companies that successfully implement the hedging method can reduce their operational costs by an average of 12-14%. Additionally, Turner and Lim (2015) stated that as jet fuel prices constitute the majority of the operational costs of airline companies, the earnings of airline companies are affected by the fluctuations in fuel prices. In their studies, they investigated at what rates and maturities the hedging method should be used in order to minimize these effects. In their study, where they examined 20-year (1994-2014) data, they stated that it is the most effective method for airline companies to hedge with 3-month terms and futures contracts on heating fuel. They added that extending the term for more than 3 months will increase hedging rates, thus reducing the effectiveness of hedging. According to Malina et al. (2012: 435), even a small change in oil prices can cause big changes in costs, as fuel costs constitute 30-40% of the operational costs in the aviation sector. For this reason, airline companies use the hedging method in order to fix their costs and to avoid price increases during the year.

CHAPTER V

METHOD AND FINDINGS

5.1.Scope of The Study

Airline companies, whose technology is constantly changing and developing, should realize their strengths and weaknesses, opportunities and threats in order to survive as a global player and maintain their competitive advantage and make their strategic analyses accordingly. In this context, one of the most important problems standing in front of airlines is operational costs and fleet management. Managing fleets in the best way and reducing operational costs is one of the most important issues of airline companies. In this context, airlines seek to use some of the advantages they have and seek to obtain new advantages. One of the advantages of airline companies is their geographical locations. In addition, airlines aim to optimize fleet management and reduce operational costs. 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 cannot compete on price without reducing their costs and overheads. The airline industry relies on airport services, the provision of aviation fuel, labor, et cetera. Moreover, there may be airlines, particularly the legacy carriers which could also be dependent on costly distributive networks. In this study, geographical impact of hub location and route selection on operational cost will be analyzed by optimization models.

5.2.Importance of The Study

Aviation is a complex high-cost and intense-competition service industry that uses advanced technology. Liberalization tendencies, high costs, low ticket fares, restrictive laws and regulations, strategic alliances, security needs and environmental awareness that have emerged with the phenomenon of globalization take competition to a higher level. It is important to keep operational costs low, which is a high expense item for airline companies. Low operational cost is possible with an efficient fleet management and correct location-hub selection, because fuel costs, one of the biggest operational cost items of airlines, increase in direct proportion to the distance. Similarly, other costs vary depending on the distance between the departure and destination point. Therefore, positioning the airline at the right point and ensuring the optimum use of all fleets are important in terms of reducing airline operational costs.

5.3. Conceptual Framework

In this section, information about the concepts that will be covered in the research will be presented.

5.3.1. Airports and Hubs

5.3.1.1. Airports

Airports are classified according to different criteria. Criteria such as the size of the airport, runway characteristics, traffic volume, air traffic service standards, services provided or aviation organizations are factors in the classification of airports. For example, airports are divided into three according to the business type criteria (Advani, 1999: 37):

- Civil Airports
- Military Airports
- Technical Airports

Or, according to the building criteria, airports are divided into five (Advani, 1999: 38):

- Commercial Airports
- Cargo Airports
- Primary Airports
- Secondary Airports
- General Airports

As another criterion, according to the aviation authority American Federal Aviation Administration FAA, the airport classification is as follows: (Czerny & Zhang, 2011: 596)

- Commercial Service Airports: The airport that serves at least 2,500 passengers annually and is open to scheduled transportation.
  - Primary Commercial Airport: The airport that serves more than 10,000 passengers annually.
  - Non-Primary Commercial Airport: The airport that serves 2,500 to 10,000 passengers annually.
- Cargo Service Airport: The airport that serves only air vehicles carrying cargo more than 100 million pounds annually, among other air transportation services. An airport can be an airport that provides both commercial and cargo services.
- Reliever Airports: Airports that help reduce congestion at commercial airports.
- General Aviation Airport: It is the airport category with the widest scope and excluding other definitions. Private airports serving more than 2500 scheduled airline passengers annually are also considered within this scope.

Airports of different classes are operated with different methods in line with their goals and objectives. For example, while profit-oriented operating techniques are used at commercial airports, public service is at the forefront at military airports. For this reason, each airport should be marketed according to its purpose and targets.

5.3.1.2. Hubs

Air hub or hub airport is the name given to the airports used by airline companies outside their headquarters. It can be translated into Turkish as a transfer or transfer center. At the same time, hub is used as a term to express how connected an airport is with other airports. An airport is considered to be a larger HUB the more places it provides transportation and the higher the frequency of flights. Nowadays, just like airlines, airports are in competition among themselves. Therefore, they increase the number of connections and compete to become a better HUB (Cook & Goodwin, 2008: 1-3).

Hub refers to the place of transfer in transportation. In other words, passengers and cargo can switch from aircraft to subway, from subway to bus, from bus to train thanks to the hubs. Air hub, on the other hand, is called the airports that airlines attach secondary importance to apart from the epicenter in air transport. The world's largest airports are also defined as mega hubs (Cook & Goodwin, 2008: 1-3).

In the aviation industry, airports are classified according to hub types. American model hubs connect medium-haul flights to medium-haul flights. This situation arises from the large size of the USA because the flight time between two distant states can reach 6.5 hours. Moreover, the US aviation industry has the busiest air traffic in the world, with a potential of over 700 million passengers per year. In the European hub type, medium-haul flights are combined with long-haul flights. This is applied when one wants to go from a place that is not very central. For example, if one wants to fly from Mardin to Moscow, he should first fly to Istanbul and then transfer to Moscow from there. Here, this is called the European model hub type. The last type is the Persian Gulf and Asian hub type. In this model, long-distance flights are also connected with long-distance flights (Bania, Bauer & Zlatoper, 1998: 53-58).

There are two different hub models most commonly used in airlines. These are hub & spoke model and point-to-point model. In the hub & spoke model, the carrier initiates its operations from a specific center called “hub” and organizes flights along "spokes". Passengers who want to travel between different spokes first have to come to the hub and change aircrafts from there (O'Kelly, 1998: 171-174; Bania, Bauer & Zlatoper, 1998: 53-58).

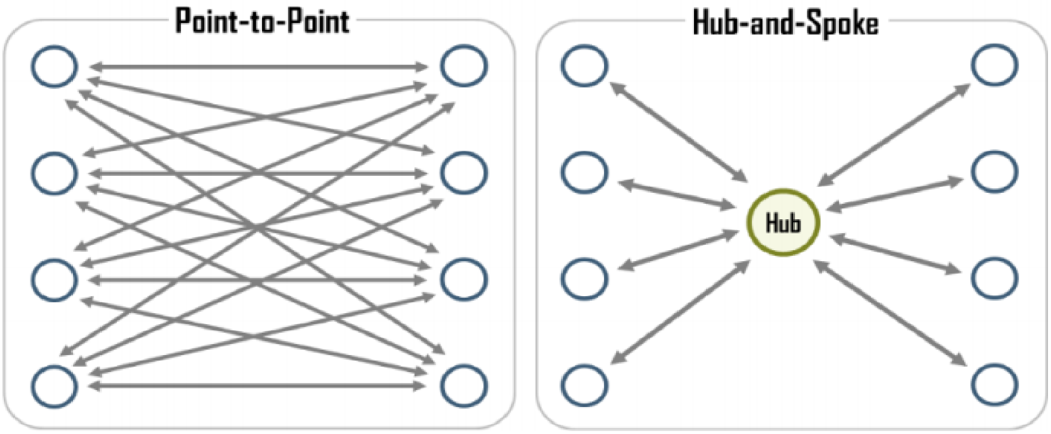

Figure 5.1: Point-to-Point and Hub and Spoke Models

Source: Atay, 2020: 101.

The "Hub & Spoke" business model, which spread rapidly after the domestic line deregulation in the USA in 1978 and the liberalization in the European Union in the 1990s, has many advantages as well as some disadvantages (O'Kelly, 1998: 171-174; Campbell, Ernst & Krıshnamoorthy, 2004: 373-390; Bania, Bauer & Zlatoper, 1998: 53-58; Cook & Goodwin, 2008: 1-3):

- Low resource utilization rate: Due to the wave system applied in the hub, the utilization of all kinds of resources used in ground services reaches its maximum in certain periods of the day (peak), while decreasing to quite low levels at other times of the day. Again, due to the same wave system, the aircraft and flight crew are used less than possible.

- Increasing commercial complexity: The use of specialized complex algorithms in inventory tracking and pricing, the need to perform complex market research and competitive analysis, and the difficulties in calculating profit and loss on a line-by-line basis are some of these business complexities.

- Increasing operational complexity: In order for transfer passengers and luggage to be transferred quickly, high-tech and costly baggage handling systems are required.

- Additional security measures and infrastructures (Ex: "Schengen" and "non-Schengen" distinction in the airports in the European Union): The chain delay risk is quite high due to the wave system.

These weak and high-cost points of the Hub & Spoke structure have unintentionally contributed to the birth and development of the low cost carrier business model. Low-cost carriers, who simplify and standardize their business models as much as possible, have achieved very low ground handling costs in addition to high rates of aircraft and crew utilization. However, the Hub & Spoke structure has many benefits and enables airline companies to operate in a more profitable and efficient manner (O'Kelly, 1998: 171-174).

In the Point-to-Point hub system, airlines cross over many hubs instead of using a central hub. Point-to-Point hub system is often preferred by low cost carriers as it provides a cost advantage. Rynair, easyJET and Wizzair are among the companies that use this method (O'Kelly, 1998: 171-174).

It is possible to compare the two models in many ways. In terms of cost, in the hub and spoke model, the carrier company can easily change the frequency of flights due to the decreasing demands in certain periods and shift their flights to more intense lines. In the point-to-point system, this situation is more difficult because a delay of one flight may disrupt other flights as a chain.

5.3.2. Capacity Planning

For airline companies, capacity planning is the schedule planning process. The schedule is related to the departure and arrival times of the flight, aircraft types, aircraft capacities, operation days, operation time zones and operational profitability. Determining the optimum (most appropriate) schedule is to pre-arrange the flights to points (Atay, 2020: 65).

There are two important factors to be considered in capacity planning. Profitability and applicability are among these factors (Atay, 2020: 65). Profitability is determined by comparing the cost of realizing the flight with the income obtained from flight services.

Feasibility refers to the possibility of making and realizing schedule planning suitable for the capacity. The Hub & Spoke model, which has been a prominent concept in capacity planning in recent years, will be discussed in this section.

Airline companies have been using the point-to-point flight model for many years in their flight network creation efforts. This model defines the round-trip flight network model for each point flown. If it is desired to fly to X destinations from a center, X * (X-1) flights are required in the flight network design. For example, if the Airline business wants to fly to 5 destinations from point to point, it must perform 5 * (5-1) = 20 flights in the flight network design. While this model is advantageous for some lines, in some lines where competition is experienced, this model imposes great costs on the airline business. Fuel cost, airport landing costs, personnel costs are among the costs of airline management. For this reason, airlines have started to use the Hub & Spoke method in order to gain cost advantage and to obtain more output with less input. This model increases the performance and efficiency of airline businesses. In the Hub & Spoke model, all flights are collected in a single center and when other destination flights are made from this point, 2 * (X-1) flights are required for flight network design. Let's explain this model with various examples:

X Airline is devising a route network that includes Paris (France), Istanbul (Turkey), Marrakech (Morocco) and New Delhi (India). If the point-to-point flight network model is created, the flights of the airline company will take place with 12 flights. In this case, the airline company must plan 12 flights. Many cost increasing factors such as aircraft type determination, crew planning, fuel planning will also affect the flight network. In the Hub & Spoke model, a single hub will be defined as the flight network center. In this model, if the flights are collected in Istanbul, the aircrafts that arrive in Istanbul first to go to New Delhi will transfer the passenger to New Delhi flight from here. In this model, operational advantage is achieved with the use of economic scale.

5.3.3. Hub Location Problem

Within the hub and spoke network structure, determining the location of the hub, the flights to be directed to this hub are generally included as the hub settlement problem in the field of operations research. There are three basic parameters in hub settlement problems. These parameters are as follows (Bania, Bauer & Zlatoper, 1998: 53-74):

- Number of node points
- Passenger traffic or demand quantities between node points
- Cost between node points.

It is possible to group hub settlement problems in 4 different ways in terms of purpose function (Campbell, 1994: 387-405):

- The p hub median problem is the problem of determining the locations of p main hubs to be opened in a way that minimizes the total transportation cost and assigning the node points to these bases in order to route the traffic between the starting-destination points.

- The p-center hub problem is similar to the p hub median problem. The aim is the problem of locating p number of hub bases in a way that minimizes the maximum travel cost and assigning other nodes to these bases. The cost of travel can be considered as the travel cost between the starting-destination points or the travel cost of each connection line.

- The hub coverage problem is the problem of the location of the main hub in such a way that the travel cost is equal to or below a certain value and minimizes the number of hubs to be opened.

- The fixed cost hub settlement problem is the problem of determining the number and location of the hubs bases in a way that minimizes the total cost and assigning the node points to these bases in order to route the traffic between the initial destination points.

The main hub settlement problem encompasses two sub-problems. These are hub location selection and assignment of nodal points to designated hubs. Some researchers have addressed only the assignment aspect of the problem. The best assignments will be influenced by the hub location choices, and the best hub location choices by the assignment decisions. Therefore, location selection and assignment problems should be handled together in hub network design (Bryan & O’Kelly, 1999: 275-295).

5.3.4. Main Hubs

The hubs to be examined in this study are discussed in two categories. There are 8 hubs in the first category, and these hubs constitute the hubs planned to be selected within the scope of the research. One of these hubs will be selected as the flight hub for the research. In the second category, there are hubs where flights are planned based on the number of past passengers and flights.

5.3.4.1. Geographically Selected Hubs Within The Context of the Establishment of The Airline

Geographically selected hubs within the context of the establishment of the airline are presented in Figure 5.2. These hubs are selected to examine effect on different distance in terms of geographic locations by taking into account geopolitical importance. Airport capacities, slot programs, official permissions and facility conditions are disregarded. The map below shows the airline's planned central hubs. The numbers on the map are as follows:

- 1: London
- 2: Istanbul
- 3: Doha
- 4: Nairobi
- 5: Beijing
- 6: Delhi
- 7: Tokyo
- 8: Cape Town

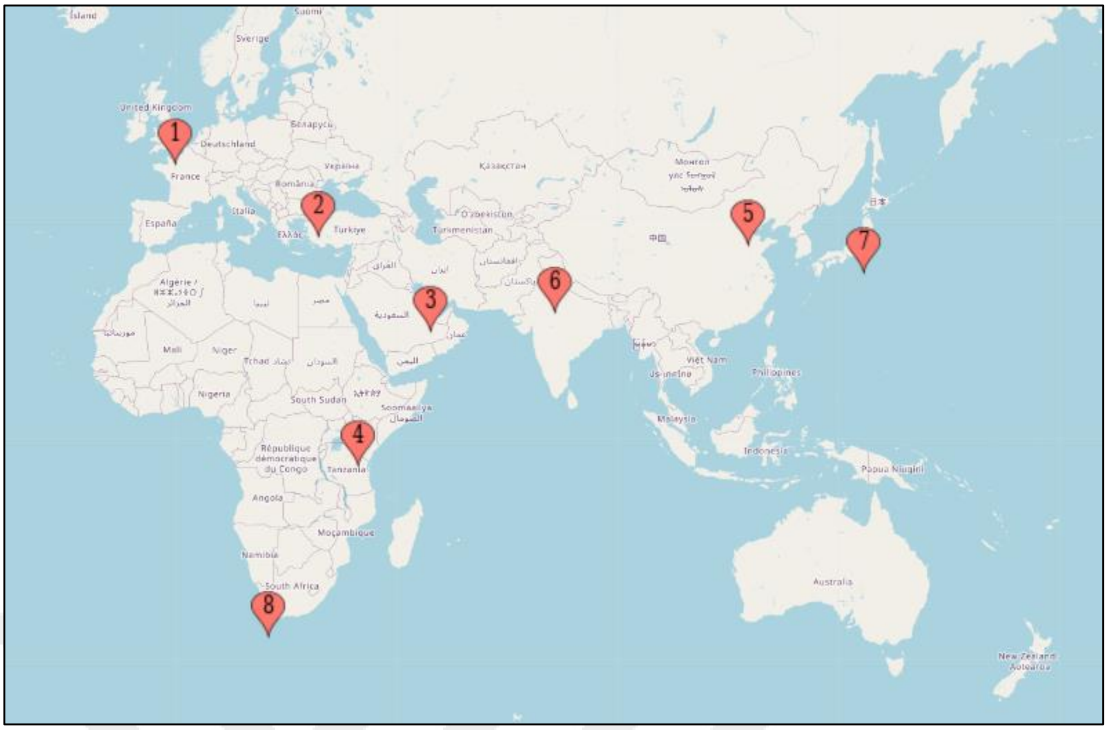

Figure 5.2: Planned Central Hubs

London: Heathrow Airport is one of the 6 main airports in London, the capital city of the UK. It is the busiest airport in the world according to international passenger traffic and the third busiest airport in the world according to total passenger traffic. London Heathrow Airport, which was established in 1930 and currently has 5 terminals, uses approximately 70 million passengers per year. Heathrow is the UK's only hub. Located in West London, the airport has an area of 1,227 hectares with two runways and four operational terminals. In 2018, 75 million passengers used Heathrow Airport and traveled to 183 destinations in 81 countries with 80 different airline companies. Operating with a 98 % capacity, Heathrow meets approximately 66 % of the international air transport volume (more than 25% of the UK's total trade volume) coming to England (https://aci.aero/news/2019/03/13/preliminary-world-airport-traffic-rankings-released/, Accessed: 28.12.2020).

Istanbul: Istanbul Airport was built on an area of approximately 76.5 million square meters on the Black Sea coastline between Yeniköy and Akpınar settlements on the European side of Istanbul. Istanbul Airport was opened to air traffic on 29 October 2018 and started to serve aircrafts. There are 6 runways, parallel taxiways, 6.5 million square meters of apron, VIP, cargo and general aviation terminals, and a state guesthouse with a total closed area of 1.9 million square meters, with an annual passenger capacity of up to 200 million. At Istanbul Airport, it serves its passengers with 14 check-ins and more than five hundred check-in points, 42 km long luggage belt system. It is the airport with the largest car parking area in Europe with a capacity of 70,000 vehicles (Kılıç & Turgut, 2019: 152).

Doha: Doha Hamad Airport, whose construction began in 2005 and was planned to open in 2009, officially welcomed its first passenger aircraft on 30 April 2014, after some expensive delays. The airport's actual opening took place on May 27, 2014. The airport currently serves around 35 million passengers a year. The amount of cargo processed reaches a remarkable size (1.8 million tons) (https://dohahamadairport.com/, Accessed: 12.11.2020).

Nairobi: Jomo Kenyatta International Airport is an international airport in Nairobi, Kenya's largest city and capital. Located 15 kilometers (9 miles) southeast of the Embakasi suburb, the central business district of Nairobi, the airport has scheduled flights in more than 50 countries. The airport was named after Jomo Kenyatta, who was Kenya's first president and prime minister (Chepchirchir, Omillo and Munyua, 2018: 13). Although the airport is the ninth busiest airport in Africa in terms of total passenger care, it served 7,039,715 passengers in 2019. The airport is the center of the flag carrier Kenya Airways and the low cost carrier Fly540 (Kinyua, 2020: 17).

Beijing: Beijing Daxing International Airport Beijing and Langfang is Beijing's second international airport, located on the border of Hebei Province. The name of the airport was announced on September 14, 2018. The terminal building has an area of more than 1,000,000 square meters and is the world's largest monolithic airport terminal (Ngo and Tian, 2020: 47). The airport, which is expected to serve Beijing, Tianjin and Hebei, is located 46 km south of Tiananmen Square, 26 km west of Langfang city center, 50 km northeast of Xiong'an New District and 65 km south of Beijing Capital International Airport. The port will serve as a hub for SkyTeam alliance airlines and some Oneworld members. Star Alliance members will fly from Beijing Capital International Airport (Liu et al., 2020: 17).

Delhi: India's busiest airport, Indira Gandhi International Airport (DEL), is located in the Delhi metropolitan area, and hosted approximately 60 million passengers in 2018. It is the hub for 60 carriers in total, including Air India, AirAsia India, GoAir, IndiGo, Jet Airways, SpiceJet and Vistara, Flights are made across Asia, Oceania, the Middle East, Europe, Africa and North America, as well as India. Indira Gandhi International Airport has three runways and two passenger terminals (https://www.newdelhiairport.in/, Accessed: 12.11.2020).

Tokyo: At Haneda Airport, which is in connection with metropolitan cities and regions around the world, 490 flights are made to approximately 49 airports per day. The number of passengers arriving and departing at Haneda Airport exceeds 80 million per year and 60% of the locals use this airport for their travels. With these features, Haneda Airport is an important center for domestic and international air transportation in Japan. The vast majority of flights from Haneda Airport have domestic connections. A maximum of 56 flights are operated daily to Europe, North America, the Middle East and Asia. Haneda Airport ranks 5th in the world in passenger and freight transportation (http://www.mlit.go.jp, Accessed: 10.11.2020).

Cape Town: Cape Town International Airport is the primary international airport serving the city of Cape Town and is the second busiest airport in South Africa and the fourth busiest in Africa. The airport, 20 km away from the city center, was opened to replace Wingfield Aerodrome. It handles flights to several destinations in Africa, Europe and Asia. On the other hand, Cape Town Airport has also direct flights to Johannesburg and Durban and other places around South Africa (https://www.capetown-airport.com/, Accessed: 10.11.2020).

5.3.4.2. Hubs with Scheduled Flights

Within the scope of the study, the hubs that are planned to operate from the central hubs mentioned in the previous section are as follows. While selecting these hubs, the number of passengers, point to point and transit passengers, the attractiveness of the past years and potential demand were taken into account. The map in Figure 5.3 shows the airline's planned scheduled hubs. The numbers on the map are as follows:

- 1: Chicago
- 2: Los Angeles
- 3: Beijing
- 4: Shanghai
- 5: Tokyo
- 6: Frankfurt
- 7: London
- 8: Paris
- 9: Amsterdam
- 10: Dubai

Figure 5.3: Planned Scheduled Hubs

Chicago: Chicago O'Hare International Airport is an international airport located in Chicago, Illinois, USA. In addition, it was among the busiest airports of the world in this area with a total of 84,65 million passengers it hosted in 2019 (https://www.flychicago.com/ohare/home/pages/default.aspx, Accessed: 10.11.2020).

Los Angeles: Los Angeles International Airport is an international airport located in Los Angeles, California, USA. The airport, better known as LAX, served more than 88 million passengers in 2019, becoming the second busiest airport in the USA and the 5th busiest airport in the world (https://www.flylax.com/, Accessed: 10.11.2020).

Shanghai: Shanghai Pudong International Airport is the international airport serving Shanghai city of China. The airport, which is about 30 km from the city center, is one of the busiest airports in Southeast Asia as well as China. Pudong International Airport hosted a total of 39 million passengers in 2019 (http://www.shairport.com/, Accessed: 10.11.2020).

Frankfurt: Frankfurt airport welcomed 61.7 million passengers in 2019. In addition, Frankfurt Airport is located in front of Munich Airport, which welcomes 42.3 million passengers, and is the airport with the highest passenger capacity in Germany. In air freight and postal transport, Frankfurt Airport ranks first with 2.1 million tons. Compared to airports on other continents, Frankfurt Airport is among the airports with the largest passenger capacity and cargo transportation. Although Frankfurt Airport exceeded the 60 million passenger threshold in 2016, it fell behind the amount (61 million) achieved in 2015 due to weather conditions and mandatory flight cancellations. On an average day, 1,268 aircraft take off and land at the airport. This value indicates that the aircraft lands and takes off at Frankfurt Airport every 51 seconds during the daily operation (18 hours) (https://aci.aero/news/2019/03/ 13/preliminary-world-airport-traffic-rankings-released/, Accessed: 28.12.2020).

Paris: Paris-Charles de Gaulle Airport is located in the Ile-de-France region and is the largest airport in France. It is named after Charles de Gaulle, the 18th President of France. The airport is one of the 50 most populous airports in the world in terms of passenger numbers and one of the busiest airports in Europe in terms of aircraft. According to cargo traffic, it is the busiest airport in Europe and the 6th busiest airport in the world (https://www.parisaeroport.fr/, Accessed: 10.11.2020).

Amsterdam: Amsterdam Schiphol Airport, located 17.5 km from Amsterdam, is one of the largest airports in the world. Amsterdam Airport welcomed 70.9 million passengers in 2018 (https://aci.aero/news/2019/03/13/preliminary-world-airport-traffic-rankings-released/, Accessed: 28.12.2020). In addition, the second largest airport of the Netherlands, which welcomes 4.7 million passengers, is located in front of Eindhoven Airport and is the airport with the highest passenger capacity in the Netherlands. In air freight and postal transportation, Amsterdam Airport ranks second with 1.6 million tons (http://www.turkinfo.nl, Access: 14.04.2017).

Dubai: Dubai International Airport is the international airport located in Dubai, the most populous city of the United Arab Emirates. Dubai International Airport, which is the 6th busiest airport in the world in terms of passenger numbers, ranked first in this list when only international passengers are considered. The airport is operated by the division of civil aviation and Dubai's international air transport. Emirates Airlines handles 60% of all passenger traffic and 38% of all aircraft movements at the airport (http://www.dubaiairport.com/, Access: 14.04.2017).

5.3.5. GDP, SDI and HDI

5.3.5.1. GDP

Gross domestic product (GDP) is the economic measure at market value of all final products produced in a given time period. Per capita GDP (nominal) does not reflect differences in living costs and inflation rates of countries. Therefore, the use of a GDP per capita basis at purchasing power parity (PPP) is arguably more useful when comparing living standards between nations, while nominal GDP is more useful for comparing national economies in the international market. In this definition, a certain time, it could be a month, three months, or a year. However, GDP is usually handled for a year. Final goods and services are the remaining value after deducting intermediate goods used for production from the total goods and services produced (Tacchella, Mazzilli & Pietronero, 2018: 862). The following formula is applied to find GDP data (Dunaev, 2004: 86-90):

GDP = Consumption + Investment + government spending + (export - import)

When depreciation (depreciation of capital) is deducted from GDP, net domestic product is obtained. “Gross” means that depreciation has been added to the capital stock.

- Domestic income is obtained when subsidies are added to indirect taxes from the net domestic product.
- National income is obtained when net external world factor income is added to domestic income.
- Personal income is obtained when transfer payments are added to the national income and corporate tax, non-distributed corporate profits and social security deductions are excluded.
- Disposable personal income is obtained from personal income when personal income tax is deducted.

In the above equation, consumption and investment are expenditures for final goods and services. The export minus the import part of the equality balances by reducing the part of the expenditures not produced domestically (imports) and adding the part of domestic production that is not consumed inside (export). Economists (since Keynes) have preferred to divide the general consumption concept into two as private consumption and public sector consumption.

Therefore, GDP is expressed as follows:

GDP = private consumption + investment + government spending + net exports

The top 10 countries in the GDP ranking are as follows:

Table 5.1: The Top 10 Countries in the GDP Ranking (Million USD - 2019)

Rank	Country	GDP
1	United States	21,427,700
2	China	14,342,903
3	Japan	5,081,770
4	Germany	3,845,630
5	India	2,875,142
6	United Kingdom	2,827,113
7	France	2,715,518
8	Italy	2,001,224
9	Brazil	1,839,758
10	Canada	1,736,426

Source: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD, Accessed: 17.11.2020.

5.3.5.2.SDI

Although SDI is based on the basic logic of the HDI, it aims to correct the HDI, which does not contain any indicators regarding ecological sustainability and therefore has ecological limitations. Hickel criticizes the HDI in terms of sustainability as follows: The ecological limitation of HDI is evident especially in today's climate crisis and ecological collapse problems. Since the HDI does not pay any attention to ecology, the resulting effects are dominated by income, which means that sustainability principles are violated. Top countries in the HDI are countries with high per capita income, but most contributing to climate change and other forms of ecological degradation. In this sense, the HDI supports a development model that is ecologically unsustainable (Hickel, 2020: 2-3). Despite these criticisms, Hickel aimed to preserve the basic logic of the HDI. SDI uses five indicators when assessing human development on ecological efficiency: education, life expectancy, income, CO2 emissions, and material footprint. The material footprint is measured by the total weight in tonnes of the materials consumed (biomass, fossil fuels, mines and building materials). The indicators chosen are suitable for measuring the ecological effectiveness of human development. The top 10 countries in the SDI ranking are as follows:

Table 5.2: The Top 10 Countries in the SDI Ranking (2019)

Rank	Country	SDI
1	Denmark	85,2
2	Sweden	85
3	Finland	82,8
4	France	81,5
5	Germany	81,1
6	Austria	81,1
7	Norway	80,7
8	Czech Republic	80,7
9	Netherlands	80,4
10	Estonia	80,2

Source: https://www.sdgindex.org/reports/sustainable-development-report-2019/, Accessed: 17.11.2020.

5.3.5.3. HDI

The HDI, developed by the Pakistani economist Mahbub ul Haq, has been calculated since 1990. At the time of its development, the idea that GDP did not adequately take into account the social or human dimensions of development was widely accepted among development economists. The aim of the HDI was to shift the focus of development economics away from national income accounts, which are evaluated solely in terms of economic expansion. In addition to economic growth, social outcomes should be taken into account (Morse, 2003: 184-187).

The HDI is calculated on three indicators that are considered indicators of human development: life expectancy at birth, education (average years of schooling and expected years of schooling), and income (per capita gross national income in purchasing power parity). Because these indicators are observable and comparable, the HDI is an objective measure of human development. In this respect, it differs from other human development criteria that use subjective well-being indicators (such as happiness or satisfaction from life) (Hickel, 2020: 4).

HDI gained recognition with the annual reports of the United Nations Development Program and became the most used measure of human development. The impact of the index was not limited to annual reports. The Millennium Development Goals announced in 2000 were influenced by the principles on which the index was based. The top 10 countries in the HDI ranking are as follows:

Table 5.3: The Top 10 Countries in the HDI Ranking (2019)

Rank	Country	HDI
1	Norway	0,954
2	Switzerland	0,946
3	Ireland	0,942
4	Germany	0,939
5	Iceland	0,938
6	Australia	0,938
7	Sweden	0,937
8	Singapore	0,935
9	Netherlands	0,933
10	Denmark	0,93

Source: http://hdr.undp.org/en/content/2019-human-development-index-ranking/, Accessed: 17.11.2020.

5.3.5.4. Location Index Value

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.

5.3.6. Information on Aircraft to be Used in Research

In this section, information about the aircraft to be used in the scenario is given. The aircrafts to be used in the scenario analysis were preferred because they are the most widely used aircrafts and therefore they provide easy access to ground handling and maintenance services. Range variety is aimed by using wide-body and narrow body aircraft in fleet in same time in terms of optimum range. The optimum range values will be used from the payload & range diagrams of the aircraft in question.

The payload values of the aircrafts represent the optimum distance that the aircraft can travel with a standard amount of passengers and cargo. In order to reach a distance greater than the optimum range value, aircraft have to reduce the amount of passengers and cargo. Therefore, it is not cost efficient for the aircraft to fly beyond the optimum range value. It is completely related with preferences of an airline company.

Figure 5.4 is a sample payload and range chart. Accordingly, point A represents the optimum payload and range of the aircraft. After point A, there is an inverse proportion between range and payload. Therefore, in this study, the optimum ranges corresponding to payload values are taken into consideration rather than the maximum ranges of the aircraft.

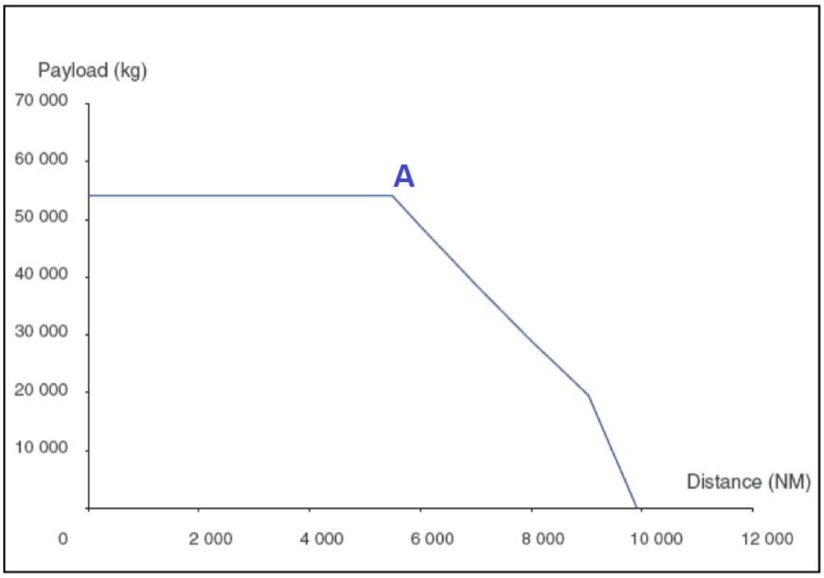

Figure 5.4: Payload & Range Diagram of Airbus A350-900

5.3.6.1. Airbus A350-900

Medium and long range, wide body Airbus A350-900 is a model inspired by nature with high technology materials. The A350-900, which is much lighter and more aerodynamic with its CFRP (carbon fiber reinforced plastic) structure, has been developed with green technologies. The A350-900 flies quietly with its new generation Rolls-Royce Trent XWB engines and saves fuel at a higher rate than older models. With its wide seat ranges, high ceiling and attractive ambient lighting, the Airbus A350-900 meets the expectation of excellent flight comfort.

Table 5.4: Technical Features of Airbus A350-900

First Use	2015
Wing Span (m)	64.75
Maximum Length (m)	73.88
Ground Clearance (m)	17.1
Maximum Speed (nmi/h)	594
Maximum Passenger	366
Optimum Range (nautical mile)	5.800
Fuel Consumption per nautical mile (lt)	5,80
Average Ground Handling	USD 4.222,96
Type	Wide-body

Figure 5.5: A Photo of Airbus A350-900

5.3.6.2.Airbus A330-200

The wide-bodied Airbus A330-200 offers a comfortable journey with its two-aisle cabin with large personal spaces for all passengers. Designed for long-haul flights, the aircraft stands out with its 4.7m shorter fuselage compared to the previous model and flies approximately 2,000 km longer. Equipped with the "fly-by-wire" digital control system like all other A330 aircraft, the aircraft increases efficiency by reducing costs. The A330-200 is preferred for long-range flights with its wide-body structure and high performance.

Table 5.5: Technical Features of Airbus A330-200

First Use	1998
Wing Span (m)	60.30
Maximum Length (m)	58.85
Ground Clearance (m)	17.39
Maximum Speed (nmi/h)	546
Maximum Passenger	406
Optimum Range (nautical mile)	4.650
Fuel Consumption per nautical mile (lt)	5,69
Average Ground Handling	USD 4.133,46
Type	Wide-body

Figure 5.6: A Photo of Airbus A330-200

5.3.6.3.Boeing 737-900 NG

Boeing 737-900 NG, one of the new generation members of the Boeing 737 family, can fly much longer distances with its increased range feature and extended body. The Boeing 737-900 NG impresses with its soft-lined exterior and aesthetic interior design. The Boeing 737-900 NG perfects the flight experience with its comfortable seat width and in-flight entertainment systems.

Table 5.6: Technical Features of Boeing 737-900 NG

First Use	2001
Wing Span (m)	35.80
Maximum Length (m)	42.1
Ground Clearance (m)	12.5
Maximum Speed (nmi/h)	511
Maximum Passenger	220
Optimum Range (nautical mile)	2.300
Fuel Consumption per nautical mile (lt)	2,53
Average Ground Handling	USD 2.464,49
Type	Narrow-body

Figure 5.7: A Photo of Boeing 737-900 NG

5.3.6.4.Airbus A321-NEO

Airbus A321-NEO stands out with its in-flight entertainment systems that provide an enjoyable journey, its extended body and environmentally friendly applications developed under the concept of green aircraft. Equipped with advanced avionic systems, A321-NEO is an environmentally friendly model with high-tech support while providing fuel saving and low carbon emission.

Table 5.7: Technical Features of Airbus A321-NEO

First Use	2016
Wing Span (m)	35.8
Maximum Length (m)	44.51
Ground Clearance (m)	11.76
Maximum Speed (nmi/h)	541
Maximum Passenger	244
Optimum Range (nautical mile)	2.400
Fuel Consumption per nautical mile (lt)	2,73
Average Ground Handling	USD 2.468,99
Type	Narrow-body

Figure 5.8: A Photo of Airbus A321-NEO

5.3.6.5.Airbus A320-NEO

The twin engine Airbus A320-200 NEO is a model designed for short-distance journeys with low passenger numbers. Made with composite materials to be stronger and lighter, the aircraft offers a safe and fast flight experience. Airbus A320-200 NEO, a commercial aircraft using "Wire by Fly" technology, provides maximum flight safety by operating with the control of both pilot and electronic systems. Designed in 2006, the aircraft stands out with larger winglets called "Sharklet", an increased luggage compartment and greater fuel savings.

Table 5.8: Technical Features of Airbus A320-NEO

First Use	2014
Wing Span (m)	33.91
Maximum Length (m)	37.57
Ground Clearance (m)	11.91
Maximum Speed (nmi/h)	515
Maximum Passenger	220
Optimum Range (nautical mile)	2.400
Fuel Consumption per nautical mile (lt)	2,97
Average Ground Handling	USD 2.424,99
Type	Narrow-body

Figure 5.9: A Photo of Airbus A320-NEO

5.4.Hypothesis

It is expected that airlines will reveal the lowest operational cost in location and hub selection and fleet management by using the TOPSIS method, one of the multi-criteria decision-making techniques.

5.5.Model

In this study, the geopolitical effect of the hub location and route selection on the operational cost will be analyzed by optimization models. Five different aircraft, eight different locations and ten different hubs were selected for optimization. The main starting point of the study is where the airline's hub center must be and which aircraft should be used in order to reach 10 different main hub centers with the lowest operational cost with these five aircraft selected.

In the study, the geopolitical impact of airline location and route selection on operational cost will be analyzed with the help of multi-criteria decision-making methods. 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. Multi-criteria decision-making methods, in other words, are divided into two as multi-purpose and multi-quality decision making based on more than one decision criteria. The most frequently used multi-criteria decision-making methods are ELECTRE, TOPSIS, VIKOR and PROMETHEE methods. Multi criteria decision making method is a decision-making method in which alternatives are evaluated according to many criteria. In this method, alternatives are classified according to their similar characteristics and the most suitable one is selected. Multi-criteria decision making can lead to different results. Even when different methods are applied to the same decision-making process, different results may occur. The most important reasons for this are that each decision-making method uses a different algorithm. Since there are more than one criteria in this study, multi-criteria decision making methods will be used.

The hubs to be examined as the center of the airline within the scope of the study are as follows:

- London
- Istanbul
- Doha
- Nairobi
- Beijing
- Delhi
- Tokyo
- Cape Town

The hubs to be flown from the main hub determined in the study are as follows:

- Chicago
- Los Angeles
- Beijing
- Shanghai
- Tokyo
- Frankfurt
- London
- Paris
- Amsterdam
- Dubai

The aircraft to be used in the study are as follows:

- Airbus A320neo
- Airbus A321neo
- Airbus A330-200
- Airbus A350-900
- Boeing 737-900 NG

The costs to be considered in the study are as follows:

- Maintenance costs
- F / R - ATC cost
- Insurance costs
- Ground handling cost
- Depreciation
- Fuel cost

Country coefficient will also be used in determining the hubs. The country coefficient is determined based on the GDP, SDI and HDI values of the country where the hubs are located. In this context, a flight cost has been formulated as follows:

Maintenance + Crew + Depreciation + F / R ATC + Ground Handling + Insurance Costs + (Distance * Fuel)

Operational cost items in the study are defined above. The weights of these operation cost items were determined based on the literature review and interviews with related departments of airlines. Then, flight routes were created from 8 different center locations to 10 different hubs with 5 different aircrafts, and the distances greater than optimum range values of the aircrafts were excluded from the calculation.

5.5.1. TOPSIS Method

Multi-criteria decision-making methods are divided into two as multi-purpose and multi-quality decision making. The most frequently used multi-criteria decision-making methods are ELECTRE, TOPSIS, VIKOR and PROMETHEE methods (Lu et al., 2007: 18).

Multi criteria decision making method is a decision-making method in which alternatives are evaluated according to many criteria. In this method, alternatives are classified according to their similar characteristics and the most suitable one is selected. Multi-criteria decision-making can produce consistently different results. Even when different methods are applied to the same decision-making process, different results can be produced because each decision-making method uses a different algorithm (Velasquez & Hester, 2013: 62-63).

TOPSIS method has been one of the most used methods in solving multi-criteria decision-making problems. The TOPSIS method, Technique for Order Preference by Similarity to Ideal Solution, ensures that alternatives are sorted by considering their relative proximity to the best solution and offers a solution proposal to decision makers (Velasquez & Hester, 2013: 62-63).

TOPSIS method was first created by Hwang and Yoon in 1981, based on the idea of the shortest distance from the positive-ideal solution and the furthest distance to the negative-ideal solution. It was then applied by Zeleny in 1982 and developed by Yoon in 1987 and by Hwang, Lai and Liu in 1994 (Hsieh, Lu & Tzeng, 2004: 573-584).

Using the TOPSIS method, sorting is made by evaluating the distance of alternative options to the ideal solution according to the maximum and minimum values taken by the criteria. In the TOPSIS method, while finding the proximity required for the best solution, both the distance to the positive-ideal solution and the distance to the negative-ideal solution are taken into account. The best solution in this method is the solution that maximizes the benefit criterion and minimizes the cost criterion. On the other hand, the negative or in other words, anti-ideal solution is the solution that maximizes the cost criterion and minimizes the benefit criterion. The ideal solution in the method is that the chosen alternative fulfills these criteria at ideal levels considering all the criteria. However, sometimes the ideal solution can be inaccessible. In this case, the point closest to the ideal is considered the ideal solution. With TOPSIS, the relative distances of all alternatives from the positive and negative-ideal solution are calculated using the Euclid distance and each criterion is assumed to have the same increasing or decreasing utility tendency. Since the method accepts the closest alternative to the positive-ideal solution as the best alternative, all alternatives can be ordered by comparing the relative distances (Velasquez & Hester, 2013: 62-63).

Positive ideal solution:

$$A^* = (x_1^*, \dots, x_j^*, \dots, x_n^*) \qquad (1)$$

The x_j^* value is the best value of the jth criterion for all alternatives (1).

Negative ideal solution:

A- = $(x_1^-, \dots, x_j^-, \dots., x_n^-)$ (2)

The x_j^- value is the best value of the jth criterion for all alternatives (2).

In the TOPSIS method, multi-criteria decision-making problem with m number of alternatives and n number of criteria can be represented with m points in n-dimensional space. The situation regarding a problem with two criteria and 4 alternatives is shown in the Figure 5.10.

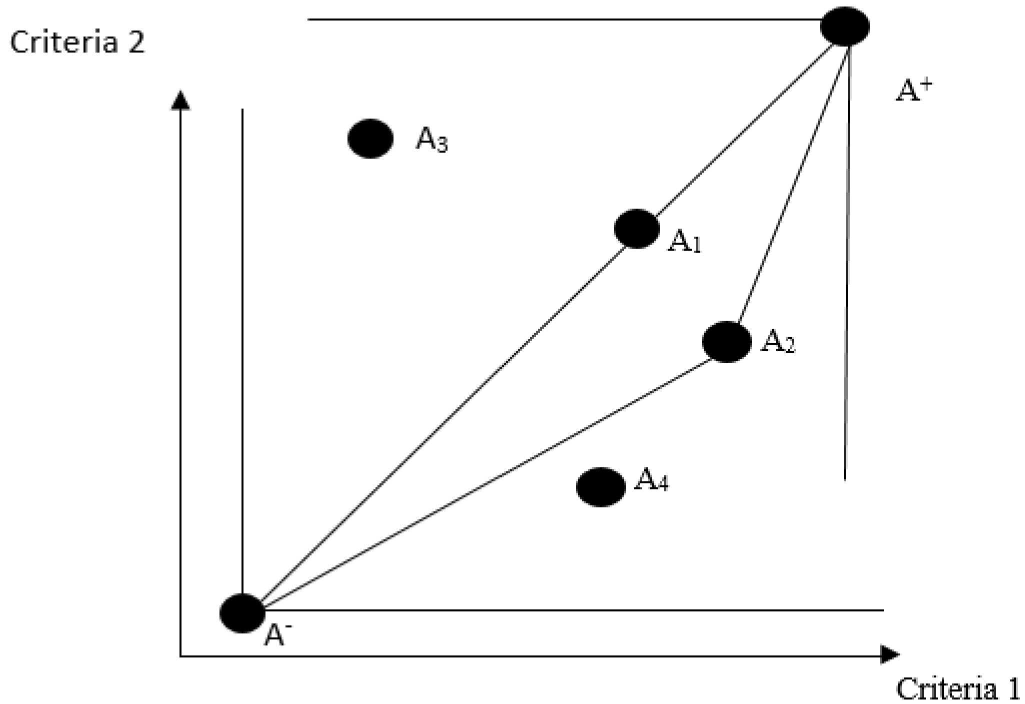

Figure 5.10: Positive-Ideal and Negative-Ideal Solutions in TOPSIS Method

In this method, it is assumed that the alternative that is the closest to the positive-ideal solution is also the alternative that is the furthest from the negative-ideal solution. TOPSIS method basically consists of 11 stages (Özden, 2009: 75).

In the first stage, the problems to be decided are defined. In this way, the final goal that decision makers want to achieve is shaped.

In the second stage, the criteria that the selected alternatives related to the problem should have are defined. In parallel with this, a list of criteria is created showing the characteristics that the criteria should have.

In the third stage, all alternatives to be considered are listed depending on the criteria.

In the fourth stage, a decision matrix is created regarding the determined alternatives. The rows of the decision matrix contain the alternatives whose advantages are to be listed, and the columns contain the criteria to be used in decision making (3).

$$X=\begin{vmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{vmatrix} \quad (3)$$

The decision matrix can also be expressed in tabular form.

Table 5.9: Decision Matrix in TOPSIS Method

Alternatives	Criteria			
	C_1	C_2	…	C_n
A_1	x_{11}	x_{21}	…	x_{1n}
A_2	x_{21}	x_{22}	…	x_{2n}
…	….	….	…	….
A_m	x_{m1}	x_{m2}	…	x_{mn}
Sum of Squares	b1 = $\sum_{k=1}^{m} x^2$(x=k1)	b2 = $\sum_{k=1}^{m} x^2$(x=k2)	…	bn = $\sum_{k=1}^{m} x^2$(x=kn)

In the fifth step, different criterion dimensions are transformed into dimensionless criteria. At this stage, the aim is to be able to evaluate independently of the unit of measure. Normalized decision matrix, in other words measure-free decision matrix, is expressed as R. The number of alternatives, m, and the number of criteria, are denoted by n. For example, the 1st criterion of the 2nd alternative is shown as R_{21}.

These values are calculated as follows:

$$R_{ij} = \frac{xij}{\sqrt{\sum_{k=1}^{m} x_{kj}^2}} \qquad (4)$$

To calculate the r11 value of the R matrix according to the equation, the x11 value of the decision matrix x is obtained by dividing the square root of the square sum of the 1st column values of the matrix (4). As a result of the calculations, the following decision matrix is obtained (5):

$$R=\begin{vmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{vmatrix} \qquad (5)$$

This normalized decision matrix can be expressed as a table in Table 5.10:

Table 5.10: Decision Matrix Normalized in TOPSIS

Alternatives	Criteria			
	C_1	C_2	…	C_n
A_1	R_11 = x_11/√(b_1)	R_12 = x_12/√(b_2)	…	R_1n = x_1n/√(b_n)
A_2	R_21 = x_21/√(b_1)	R_22 = x_22/√(b_2)	…	R_2n = x_2n/√(b_n)
…	…	…	…	…
A_m	R_m1 = x_m1/√(b_1)	R_m2 = x_m2/√(b_2)	…	R_mn = x_mn/√(b_n)

In the sixth stage, the weights of the criteria are determined. The importance of the criteria in decision making may differ. Due to these differences, each criterion may be given different weight. V matrix is created for these weights. When the number of criteria is n, the weights corresponding to the criteria vj = (w1, w2,…, wn) are shown in the Table 5.11.

Table 5.11: Criteria Weights in TOPSIS Method

Criteria	C_1	C_2	…	C_n
Weights	w_1	w2	…	w_n

The sum of the weight of the criteria must be equal to 1 (6):

$$\sum_{j=1}^{n} w_j = 1 \qquad (6)$$

In the seventh stage, each value determined in the fifth stage is multiplied by the relevant weights determined in the sixth stage and the normalized decision matrix is found (7). This formula is expressed as follows:

$$v_{ij} = r_{ij}.w_j \quad (7)$$

The matrix resulting from the calculation is as follows (8):

$$V = \begin{vmatrix} v_{11} & v_{12} & \dots & v_{1n} \\ v_{21} & v_{22} & \dots & v_{2n} \\ \dots & \dots & \dots & \dots \\ v_{m1} & v_{m2} & \dots & v_{mn} \end{vmatrix} \quad (8)$$

This normalized decision matrix is expressed in the Table 5.12:

Table 5.12: Weighted Normalized Decision Matrix in TOPSIS Method

Alternatives	Criteria			
	C_1	C_2	…	C_n
A_1	v_11= r_11.w_1	v_12= r_12.w_2		v_1n= r_1n.w_n
A_2	v_21= r_21.w_1	v_22= r_22.w_2		v_2n= r_2n.w_n
…				
A_m	v_m1= r_m1.w_1	v_m2= r_m2.w_2		v_mn= r_mn.w_n

In the eighth stage, ideal and negative ideal solutions are determined. The positive ideal solution (9) is shown as A *, and the negative ideal solution (10) as A-. Alternatives to positive and negative ideal solution are defined as follows:

Positive ideal solution:

$$A^* = \{ (\underset{i}{\text{maks}}\, v_{ij} \mid j \in J), \left(\underset{i}{\min}\, v_{ij} \mid j \in J^I\right), i = 1,2, \ldots, m\} = \{v_{1*}, v_{2*}, \ldots, v_{n*}\} \quad (9)$$

Negative ideal solution:

$$A^- = \{ (\underset{i}{\min}\, v_{ij} \mid j \in J), \left(\underset{i}{\text{maks}}\, v_{ij} \mid j \in J^I\right), i = 1,2, \ldots, m\} = \{v_{1*}, v_{2*}, \ldots, v_{n*}\} \quad (10)$$

J = {j=1,2,3,…,n ve j indicates the criterion that provides benefit}

J’ = {j=1,2,3,…,n ve j’ indicates the criterion that caused the loss.}

The positive and negative ideal solutions of the TOPSIS method are shown in the Table 5.13.

Table 5.13: Positive-Ideal and Negative-Ideal Solutions in TOPSIS Method

Alternatives	Criteria			
	C_1	C_2	…	C_n
A_1	$v_{11} = w_1 . r_{11}$	$v_{12} = w_1 . r_{12}$	…	$v_{1n} = w_1 . r_{1n}$
A_2	$v_{21} = w_1 . r_{21}$	$v_{22} = w_1 . r_{22}$	…	$v_{2n} = w_1 . r_{2n}$
…	…	…	…	…
A_m	$v_{m1} = w_1 . R_{m1}$	$v_{m2} = w_1 . R_{m2}$	…	$v_{mn} = w_1 . R_{mn}$
A* (positive ideal)	v_{1*} = Maks v_{i1}	v_{2*} = Maks v_{i2}	…	v_{n*} = Maks v_{in}
A^- (negative ideal)	v_{1-} = Maks v_{i1}	v_{1-} = Maks v_{i2}		v_{n-} = Maks v_{in}

In the ninth step, the n-dimensional Euclid (Euclidean) distance method is applied according to the measurement of the separation distance of each alternative from the ideal solution and the negative-ideal solution. The distance of each alternative from the ideal solution according to Euclid's understanding is indicated by S_i (11).

The equation for these distances is as follows:

$$S_{i*} = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_{j*})^2}, i = 1,2,3, \dots, m \quad (11)$$

Similarly, the distance S_1 of each alternative from the negative-ideal solution according to the Euclidean understanding is calculated as follows (12):

$$S_{i-} = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_{j-})^2}, i = 1,2,3, \dots, m \quad (12)$$

Ideal separation measures according to the TOPSIS method are shown in the Table 5.14:

Table 5.14: The Table of Positive-Ideal and Negative-Ideal Solutions in TOPSIS Method

Alternatives	Criteria	
	S_{i*}	S_{i-}
A_1	$S_{i*} = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_{j*})^2, i = 1,2,3, \dots,}$	$S_{1-} = \sqrt{\sum_{j=1}^{n}(v_{1j} - v_{j*})^2, i = 1,2,3, \dots,}$
A_2	$S_{2*} = \sqrt{\sum_{j=1}^{n}(v_{2j} - v_{j*})^2, i = 1,2,3, \dots,}$	$S_{2-} = \sqrt{\sum_{j=1}^{n}(v_{2j} - v_{j*})^2, i = 1,2,3, \dots,}$
…		
A_m	$S_{m*} = \sqrt{\sum_{j=1}^{n}(v_{mj} - v_{j*})^2, i = 1,2,3, \dots,}$	$S_{m-} = \sqrt{\sum_{j=1}^{n}(v_{mj} - v_{j*})^2, i = 1,2,3, \dots,}$

In the next step, the relative proximity to the ideal solution is calculated. At this stage, the relative proximity of each alternative to the ideal solution is calculated with the help of the following equation (13):

$$C_{i*} = \frac{S_{i-}}{S_{i*} + S_{i-}}, (i = 1, \dots, m) \quad (13)$$

In the last stage, alternatives are listed. Alternatives are ranked according to their degree of closeness to the ideal solution calculated within the framework of existing criteria. The best alternative is the one closest to the ideal solution. Therefore, the alternative to be chosen is the closest alternative to the ideal solution.

5.5.2. Alternatives

The alternatives of the research are the process of transportation by 5 different aircraft from 8 different locations to 10 different hubs. However, since the optimum range for maximum payload values of the aircraft are lower than the distance between some location and hub, a total of 140 alternatives were created. However, not all alternatives are considered in general but on the basis of location.

Table 5.15: Distance Between Planned Locations (Departure) and Planned Hubs (Destination)

DEPARTURE	DESTINATION	DISTANCE (Nutical Mile)
BEIJING	AMSTERDAM	4.878
BEIJING	DUBAI	3.639
BEIJING	FRANKFURT	4.853
BEIJING	LONDON	5.080
BEIJING	PARIS	5.103
BEIJING	SHANGHAI	974
BEIJING	TOKYO	1.329
CAPE TOWN	DUBAI	4.735
CAPE TOWN	PARIS	5.796
DELHI	AMSTERDAM	3.962
DELHI	BEIJING	2.371
DELHI	DUBAI	1.360
DELHI	FRANKFURT	3.810
DELHI	LONDON	4.191
DELHI	PARIS	4.088

Table 5.15 (Continued)

DEPARTURE	DESTINATION	DISTANCE (Nutical Mile)
DELHI	SHANGHAI	2.062
DELHI	TOKYO	3.678
DOHA	AMSTERDAM	3.062
DOHA	BEIJING	3.837
DOHA	DUBAI	235
DOHA	FRANKFURT	2.853
DOHA	LONDON	3.261
DOHA	PARIS	3.091
DOHA	SHANGHAI	3.648
DOHA	TOKYO	5.165
ISTANBUL	AMSTERDAM	1.359
ISTANBUL	BEIJING	4.398
ISTANBUL	CHICAGO	5.473
ISTANBUL	DUBAI	1.883
ISTANBUL	FRANKFURT	1.144
ISTANBUL	LONDON	1.550
ISTANBUL	PARIS	1.379
ISTANBUL	SHANGHAI	4.640
ISTANBUL	TOKYO	5.592
LONDON	AMSTERDAM	231
LONDON	BEIJING	5.080
LONDON	CHICAGO	3.953
LONDON	DUBAI	3.421
LONDON	FRANKFURT	408
LONDON	LOS ANGELES	5.444
LONDON	PARIS	216
LONDON	SHANGHAI	5.629
NAIROBI	AMSTERDAM	4.140
NAIROBI	BEIJING	5.734
NAIROBI	DUBAI	2.205
NAIROBI	FRANKFURT	3.915
NAIROBI	LONDON	4.243
NAIROBI	PARIS	4.027
NAIROBI	SHANGHAI	5.272
TOKYO	BEIJING	1.329
TOKYO	DUBAI	4.967
TOKYO	LOS ANGELES	5.455
TOKYO	SHANGHAI	1.848

5.5.2.1.Istanbul

It is possible to fly to all hubs except Los Angeles with the aircraft examined from Istanbul. However, it is possible to reach long distances such as Chicago and Tokyo by wide-body aircraft. There are a total of 31 alternatives from Istanbul location.

Figure 5.11: Possible Flights From Istanbul

5.5.2.2.London

It is possible to reach 8 hubs except Tokyo from London. There are a total of 22 alternatives from London location.

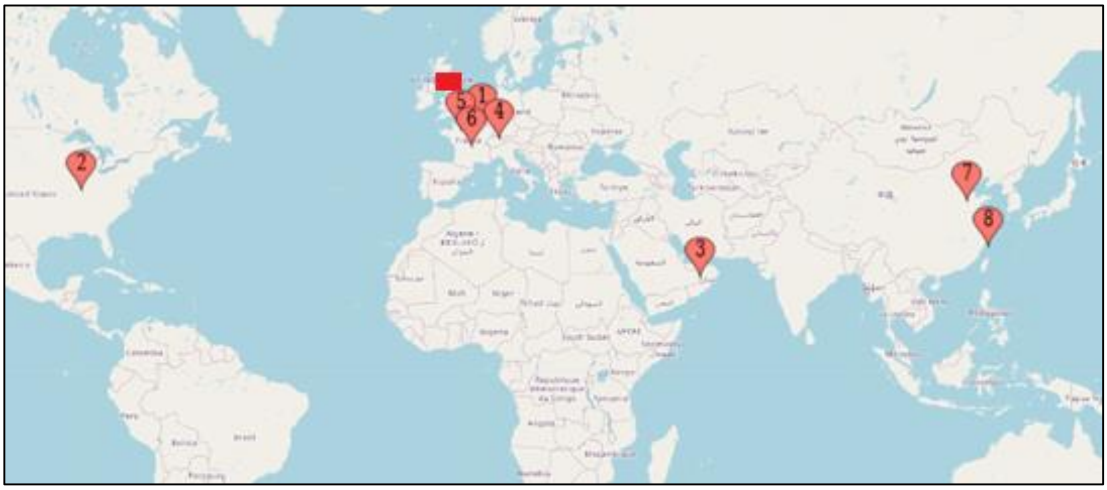

Figure 5.12: Possible Flights From London

5.5.2.3. Cape Town

From the Cape Town location, it is only possible to fly to Dubai and Paris hubs with Airbus A350-900. This location has 2 alternatives.

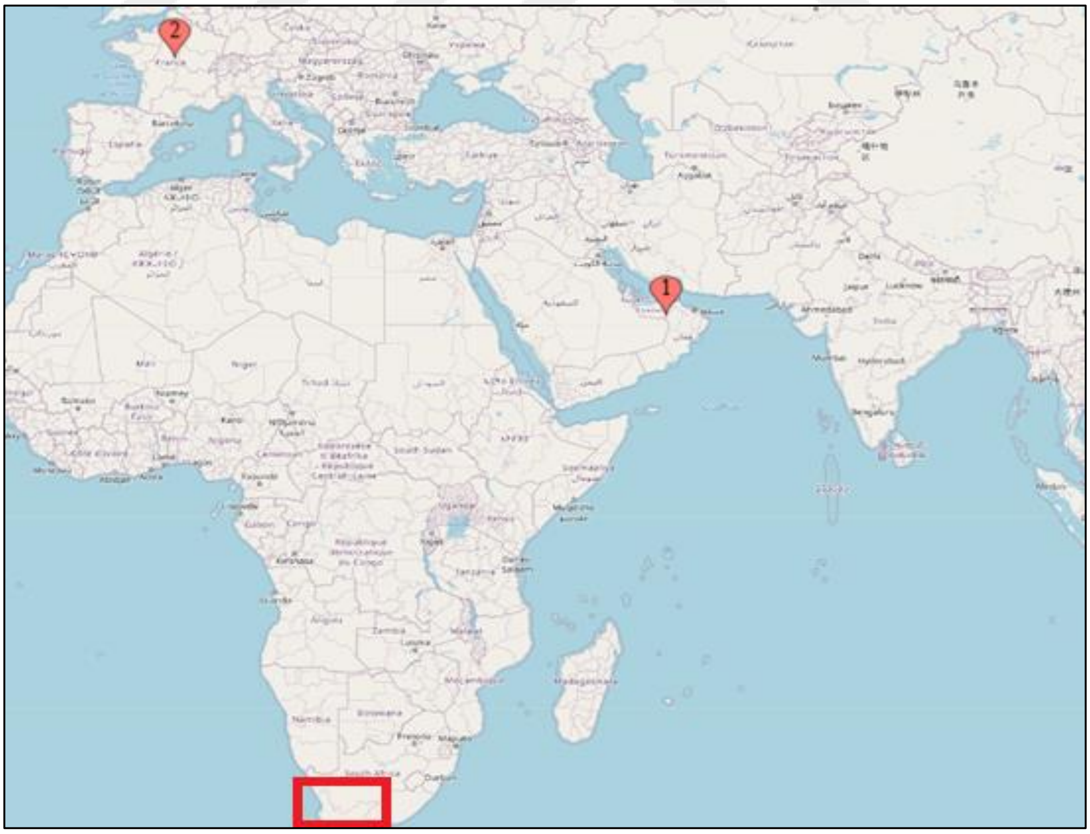

Figure 5.13: Possible Flights From Cape Town

5.5.2.4. Delhi

From the Delhi location, flights to 8 hubs are possible, except for Chicago and Los Angeles hubs. The Delhi location has a total of 24 alternatives.

Figure 5.14: Possible Flights From Delhi

5.5.2.5.Doha

From Doha location, flights to 8 hubs are possible, except for Chicago and Los Angeles hubs. Doha location has a total of 18 alternatives.

Figure 5.15: Possible Flights From Doha

5.5.2.6. Nairobi

From Nairobi location, flights to 7 hubs are possible, excluding Chicago, Los Angeles and Tokyo. There are a total of 15 alternatives.

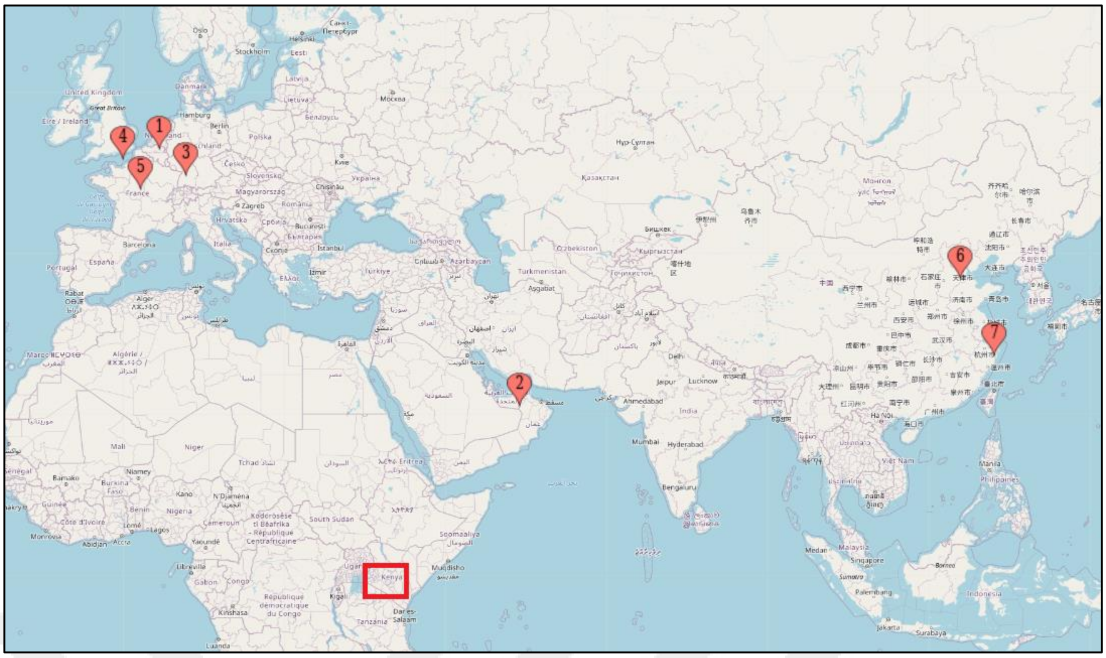

Figure 5.16: Possible Flights From Nairobi

5.5.2.7. Beijing

From Beijing location, flights to 7 hubs are possible, except for Chicago and Los Angeles hubs. Beijing location has 16 alternatives in total.

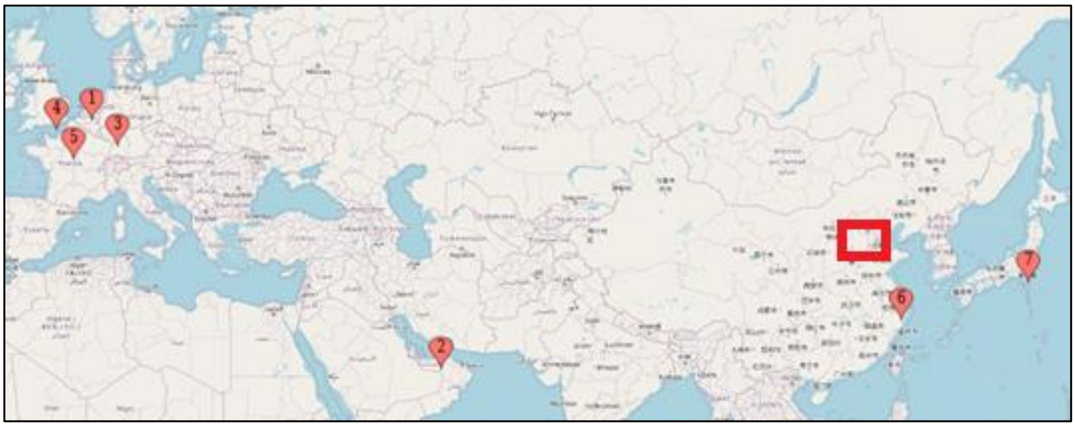

Figure 5.17: Possible Flights From Beijing

5.5.2.8. Tokyo

From Tokyo location, flights to 4 hubs are possible. Tokyo location has a total of 12 alternatives.

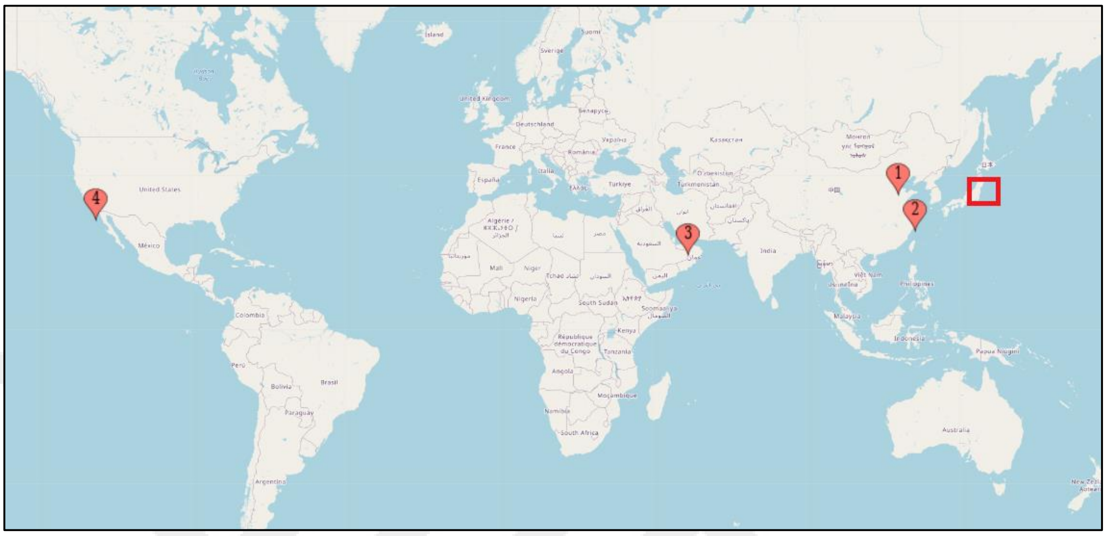

Figure 5.18: Possible Flights From Tokyo

5.5.3. Criteria

There are many factors that affect the operational costs of aircraft. In this study, the following operational costs are considered as criteria. For the costs of the flights, unit fuel cost for each aircraft type and ground handling costs by aircraft type for each location have been provided from the IOCC. Since the other cost items vary depending on the flight length and therefore the fuel amount, the ratio was made on the fuel cost according to the data obtained from the IOCC. Total fuel consumption is calculated based on the aircraft type and flight distance.

The location index value was calculated by taking the average of the GDP, SDI and HDI values of the hub location. The criteria used in the study are as follows:

- Maintenance costs,
- Crew costs,
- F / R - ATC costs,
- Insurance costs,

- Ground handling fee,
- Depreciation,
- Fuel,
- Location index value.

5.5.4. Weights

Determining the weights of performance criteria is another important step in multi-criteria decision-making methods. The most important reason for this is that people who are in a decision-making situation give different weights to each criterion. Giving these weights differently causes different cost rankings to be obtained.

The weights used in the multi-criteria decision making method in this study were determined by the data provided by the IOCC. The rates determined by Yükçü ve Fidancı (2018: 403) are also in line with the data provided by the IOCC. In the study, the weight of all operational cost elements was determined as 70 percent and the weight of the location index was 30%. In this context, operational costs have been proportioned to 70 percent. The reason why the location index was 30% is that the effect of location was determined as 30% in previous studies (Huston & Butler, 1991: 978).

The weights determined for the criteria 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

5.6. Findings

5.6.1.1.Istanbul

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 according to TOPSIS method.

Table 5.16: TOPSIS Output of Istanbul-Based Flights

Location	Destination Hub	Aircraft	TOPSIS Value
ISTANBUL	DUBAI	Boeing 737-900 NG	0,92
ISTANBUL	AMSTERDAM	Boeing 737-900 NG	0,92
ISTANBUL	AMSTERDAM	Airbus A321neo	0,92
ISTANBUL	AMSTERDAM	Airbus A320neo	0,91
ISTANBUL	DUBAI	Airbus A321neo	0,91
ISTANBUL	LONDON	Boeing 737-900 NG	0,90
ISTANBUL	DUBAI	Airbus A320neo	0,90
ISTANBUL	LONDON	Airbus A321neo	0,90
ISTANBUL	LONDON	Airbus A320neo	0,89
ISTANBUL	FRANKFURT	Boeing 737-900 NG	0,89
ISTANBUL	FRANKFURT	Airbus A321neo	0,88
ISTANBUL	FRANKFURT	Airbus A320neo	0,88
ISTANBUL	PARIS	Airbus A320neo	0,87
ISTANBUL	PARIS	Airbus A321neo	0,86
ISTANBUL	PARIS	Boeing 737-900 NG	0,85
ISTANBUL	AMSTERDAM	Airbus A330-200	0,83
ISTANBUL	AMSTERDAM	Airbus A350-900	0,82
ISTANBUL	FRANKFURT	Airbus A330-200	0,80
ISTANBUL	FRANKFURT	Airbus A350-900	0,80
ISTANBUL	LONDON	Airbus A330-200	0,79
ISTANBUL	LONDON	Airbus A350-900	0,78
ISTANBUL	PARIS	Airbus A330-200	0,75
ISTANBUL	PARIS	Airbus A350-900	0,74
ISTANBUL	DUBAI	Airbus A330-200	0,74
ISTANBUL	DUBAI	Airbus A350-900	0,73
ISTANBUL	BEIJING	Airbus A330-200	0,30
ISTANBUL	BEIJING	Airbus A350-900	0,29
ISTANBUL	SHANGHAI	Airbus A330-200	0,27
ISTANBUL	SHANGHAI	Airbus A350-900	0,26
ISTANBUL	TOKYO	Airbus A350-900	0,14
ISTANBUL	CHICAGO	Airbus A350-900	0,09

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.

Flights from Istanbul are shown in the Figure 5.19 (1: Amsterdam, 2: Paris, 3: Frankfurt, 4: London; 5: Dubai).

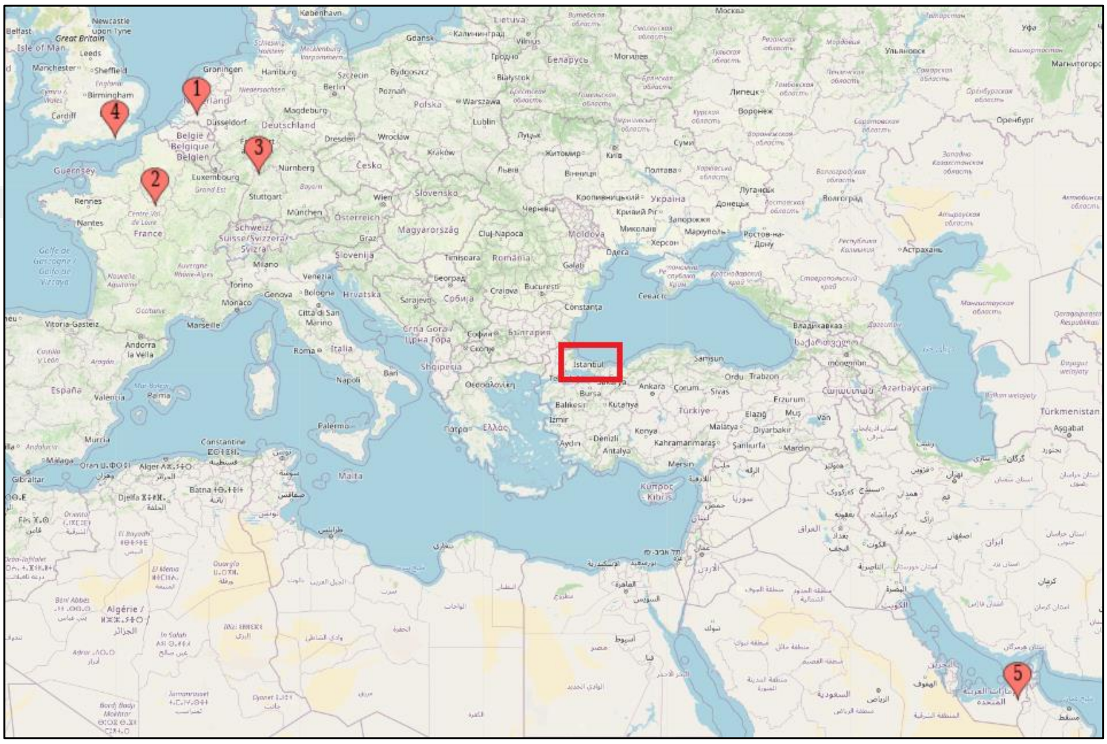

Figure 5.19: Flights From Istanbul According to TOPSIS Output

5.6.1.2. London

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.

Table 5.17: TOPSIS Output of London-Based Flights

Location	Destination Hub	Aircraft	TOPSIS Value
LONDON	AMSTERDAM	Boeing 737-900 NG	0,93
LONDON	AMSTERDAM	Airbus A321neo	0,93
LONDON	AMSTERDAM	Airbus A320neo	0,93
LONDON	AMSTERDAM	Airbus A330-200	0,92
LONDON	AMSTERDAM	Airbus A350-900	0,92
LONDON	FRANKFURT	Boeing 737-900 NG	0,89
LONDON	FRANKFURT	Airbus A321neo	0,89
LONDON	FRANKFURT	Airbus A320neo	0,89
LONDON	PARIS	Airbus A320neo	0,89
LONDON	PARIS	Airbus A321neo	0,88
LONDON	PARIS	Boeing 737-900 NG	0,87
LONDON	FRANKFURT	Airbus A330-200	0,85
LONDON	FRANKFURT	Airbus A350-900	0,85
LONDON	PARIS	Airbus A330-200	0,83
LONDON	PARIS	Airbus A350-900	0,83
LONDON	DUBAI	Airbus A330-200	0,46
LONDON	DUBAI	Airbus A350-900	0,45
LONDON	CHICAGO	Airbus A330-200	0,31
LONDON	CHICAGO	Airbus A350-900	0,30
LONDON	BEIJING	Airbus A350-900	0,21
LONDON	SHANGHAI	Airbus A350-900	0,17
LONDON	LOS ANGELES	Airbus A350-900	0,03

Flights from London are shown in the Figure 5.20 (1: Amsterdam, 2: Paris, 3: Frankfurt, 4: Dubai; 5: Chicago).

Figure 5.20: Flights From London According to TOPSIS Output

5.6.1.3. Cape Town

On flights based in Cape Town, only flights to Dubai can be made. Four aircraft other than the Airbus A350-900 are in use.

Table 5.18: TOPSIS Output of Cape Town-Based Flights

Location	Location	Destination Hub	Aircraft	TOPSIS Value
A141	CAPE TOWN	DUBAI	Airbus A350-900	1,00
A142	CAPE TOWN	PARIS	Airbus A350-900	0,00

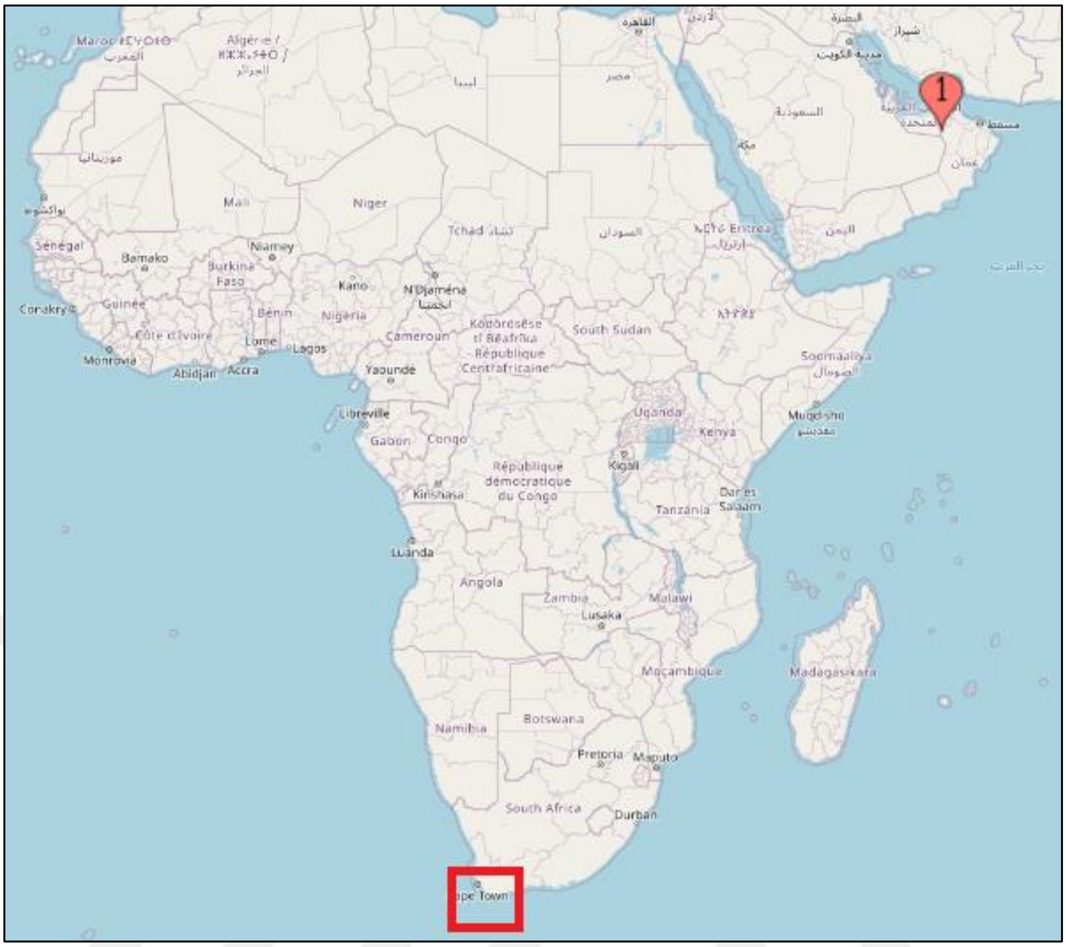

Figure 5.21: Flights From Cape Town According to TOPSIS Output

5.6.1.4.Delhi

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.

Table 5.19: TOPSIS Output of Delhi-Based Flights

Location	Destination Hub	Aircraft	TOPSIS Value
DELHI	DUBAI	Boeing 737-900 NG	0,94
DELHI	DUBAI	Airbus A321neo	0,93
DELHI	DUBAI	Airbus A320neo	0,93
DELHI	SHANGHAI	Boeing 737-900 NG	0,82
DELHI	SHANGHAI	Airbus A321neo	0,81
DELHI	SHANGHAI	Airbus A320neo	0,80
DELHI	BEIJING	Airbus A321neo	0,79
DELHI	BEIJING	Airbus A320neo	0,77
DELHI	DUBAI	Airbus A330-200	0,77
DELHI	DUBAI	Airbus A350-900	0,77
DELHI	SHANGHAI	Airbus A330-200	0,59
DELHI	SHANGHAI	Airbus A350-900	0,58
DELHI	BEIJING	Airbus A330-200	0,52
DELHI	BEIJING	Airbus A350-900	0,51
DELHI	AMSTERDAM	Airbus A330-200	0,27
DELHI	AMSTERDAM	Airbus A350-900	0,27
DELHI	LONDON	Airbus A330-200	0,23
DELHI	TOKYO	Airbus A330-200	0,19
DELHI	LONDON	Airbus A350-900	0,19
DELHI	TOKYO	Airbus A350-900	0,17
DELHI	FRANKFURT	Airbus A330-200	0,16
DELHI	FRANKFURT	Airbus A350-900	0,15
DELHI	PARIS	Airbus A330-200	0,06
DELHI	PARIS	Airbus A350-900	0,05

Flights from Delhi are shown in the Figure 5.22 (1: Dubai, 2: Shanghai, 3: Beijing, 4: Amsterdam, 5: London).

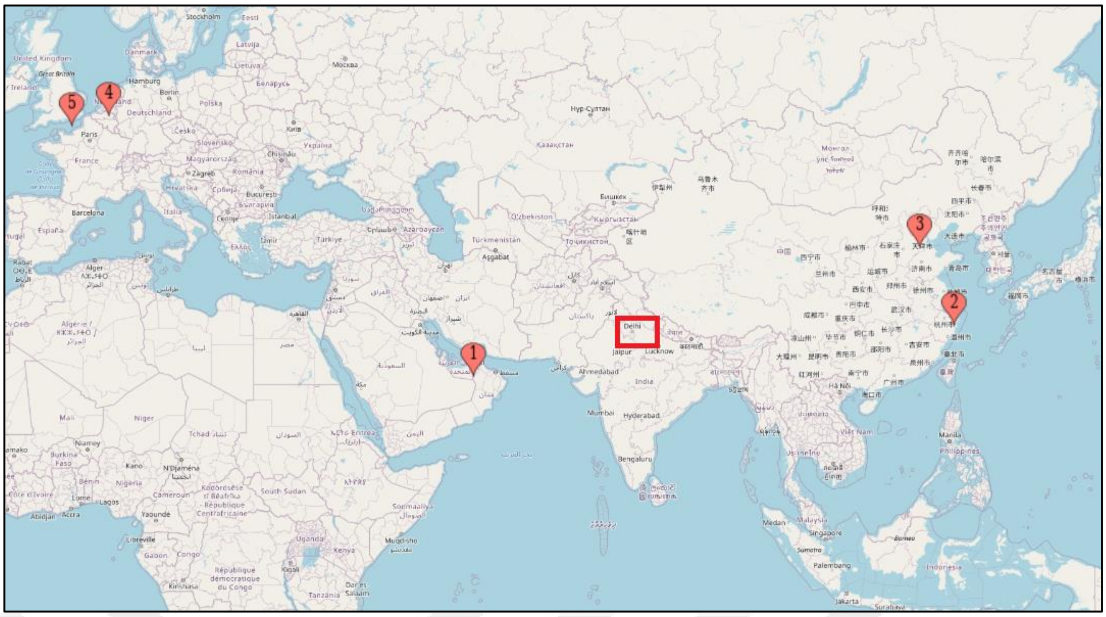

Figure 5.22: Flights From Delhi According to TOPSIS Output

5.6.1.5.Doha

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.

Table 5.20: TOPSIS Output of Doha-Based Flights

Location	Destination Hub	Aircraft	TOPSIS Value
DOHA	DUBAI	Boeing 737-900 NG	0,96
DOHA	DUBAI	Airbus A321neo	0,96
DOHA	DUBAI	Airbus A320neo	0,96
DOHA	DUBAI	Airbus A330-200	0,91
DOHA	DUBAI	Airbus A350-900	0,91
DOHA	AMSTERDAM	Airbus A330-200	0,46
DOHA	FRANKFURT	Airbus A330-200	0,45
DOHA	AMSTERDAM	Airbus A350-900	0,45
DOHA	FRANKFURT	Airbus A350-900	0,44
DOHA	LONDON	Airbus A330-200	0,41
DOHA	PARIS	Airbus A330-200	0,40
DOHA	LONDON	Airbus A350-900	0,39
DOHA	PARIS	Airbus A350-900	0,39
DOHA	SHANGHAI	Airbus A330-200	0,33
DOHA	SHANGHAI	Airbus A350-900	0,32
DOHA	BEIJING	Airbus A330-200	0,30
DOHA	BEIJING	Airbus A350-900	0,29
DOHA	TOKYO	Airbus A350-900	0,08

Flights from Doha are shown in the Figure 5.23 (1: Dubai, 2: Frankfurt, 3: Amsterdam).

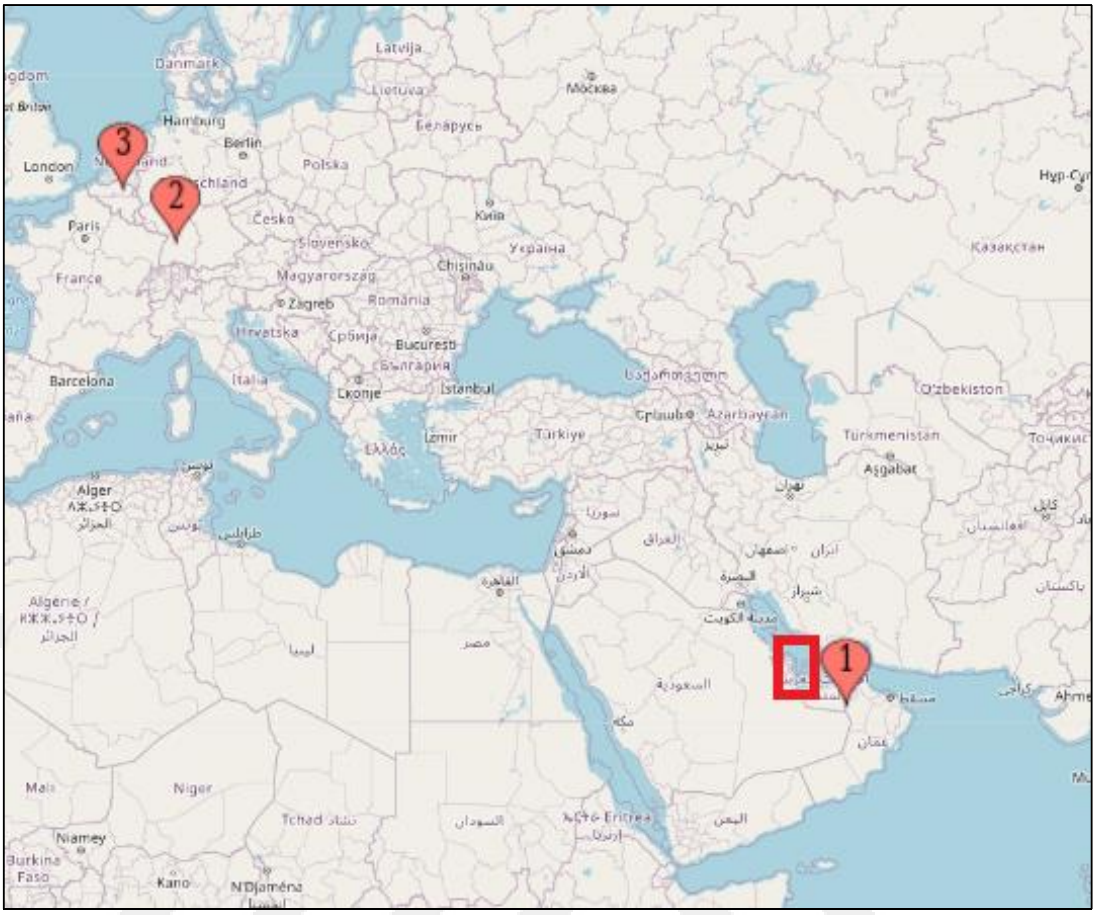

Figure 5.23: Flights From Doha According to TOPSIS Output

5.6.1.6. Nairobi

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.

Table 5.21: TOPSIS Output of Nairobi-Based Flights

Location	Destination Hub	Aircraft	TOPSIS Value
NAIROBI	DUBAI	Boeing 737-900 NG	0,94
NAIROBI	DUBAI	Airbus A321neo	0,94
NAIROBI	DUBAI	Airbus A320neo	0,93
NAIROBI	DUBAI	Airbus A330-200	0,74
NAIROBI	DUBAI	Airbus A350-900	0,73
NAIROBI	AMSTERDAM	Airbus A330-200	0,41
NAIROBI	AMSTERDAM	Airbus A350-900	0,40
NAIROBI	FRANKFURT	Airbus A330-200	0,38
NAIROBI	LONDON	Airbus A330-200	0,38
NAIROBI	FRANKFURT	Airbus A350-900	0,37
NAIROBI	LONDON	Airbus A350-900	0,35
NAIROBI	PARIS	Airbus A330-200	0,34
NAIROBI	PARIS	Airbus A350-900	0,33
NAIROBI	SHANGHAI	Airbus A350-900	0,20
NAIROBI	BEIJING	Airbus A350-900	0,18

Flights from Nairobi are shown in the Figure 5.24 (1: Dubai, 2: Amsterdam, 3: Frankfurt).

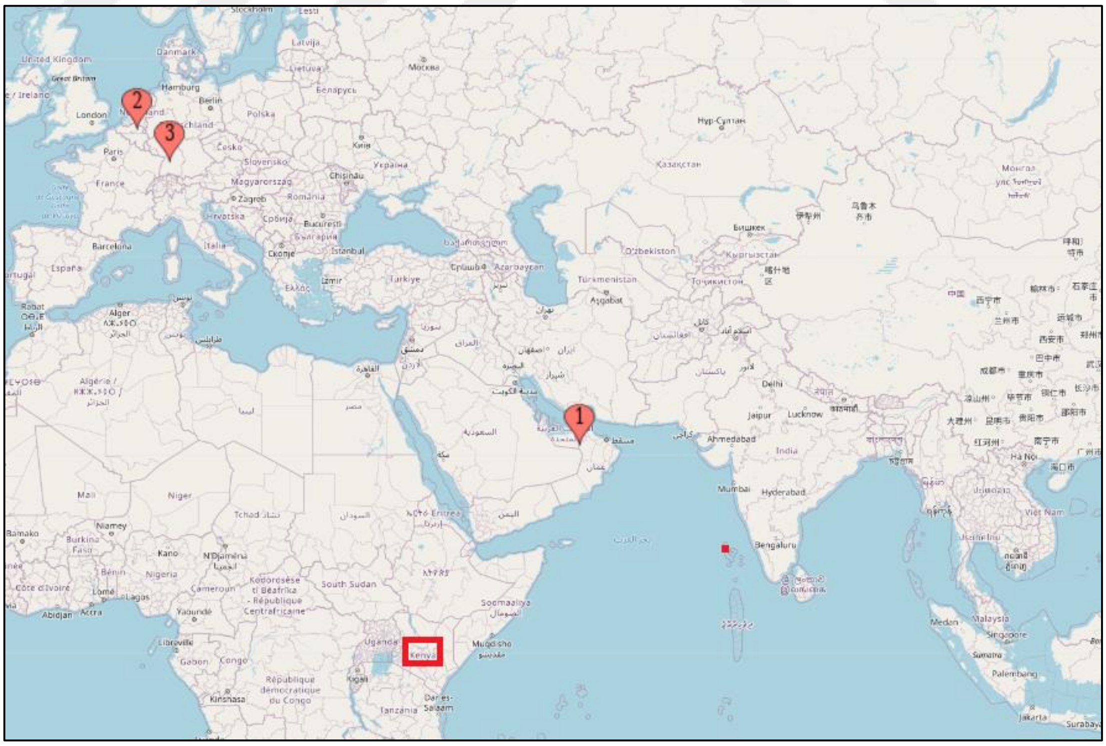

Figure 5.24: Flights From Nairobi According to TOPSIS Output

5.6.1.7. Beijing

When Beijing-based flights are examined, it is seen that four out of five aircraft can be used, and the use of the Airbus A320neo is not cost-effective. On both flights (Shanghai and Tokyo) that could use the Airbus A320neo, using other aircraft 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.

Table 5.22: TOPSIS Output of Beijing-Based Flights

Location	Destination Hub	Aircraft	TOPSIS Value
BEIJING	SHANGHAI	Boeing 737-900 NG	0,87
BEIJING	SHANGHAI	Airbus A321neo	0,87
BEIJING	SHANGHAI	Airbus A320neo	0,87
BEIJING	TOKYO	Boeing 737-900 NG	0,85
BEIJING	TOKYO	Airbus A321neo	0,85
BEIJING	TOKYO	Airbus A320neo	0,85
BEIJING	SHANGHAI	Airbus A330-200	0,82
BEIJING	SHANGHAI	Airbus A350-900	0,81
BEIJING	TOKYO	Airbus A330-200	0,73
BEIJING	TOKYO	Airbus A350-900	0,73
BEIJING	DUBAI	Airbus A330-200	0,37
BEIJING	DUBAI	Airbus A350-900	0,36
BEIJING	AMSTERDAM	Airbus A350-900	0,22
BEIJING	LONDON	Airbus A350-900	0,16
BEIJING	FRANKFURT	Airbus A350-900	0,11
BEIJING	PARIS	Airbus A350-900	0,04

Flights from Beijing are shown in the Figure 5.25 (1: Shanghai, 2: Tokyo, 3: Dubai, 4: Amsterdam).

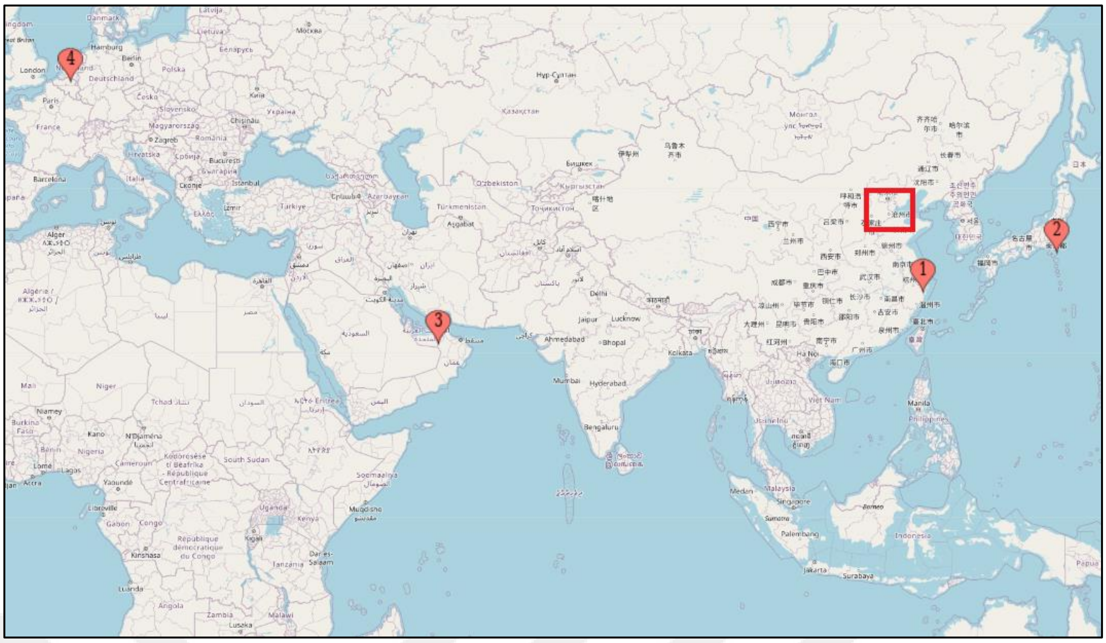

Figure 5.25: Flights From Beijing According to TOPSIS Output

5.6.1.8. Tokyo

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.

Table 5.23: TOPSIS Output of Tokyo-Based Flights

Location	Destination Hub	Aircraft	TOPSIS Value
TOKYO	BEIJING	Boeing 737-900 NG	0,90
TOKYO	BEIJING	Airbus A321neo	0,90
TOKYO	BEIJING	Airbus A320neo	0,90
TOKYO	SHANGHAI	Boeing 737-900 NG	0,89
TOKYO	SHANGHAI	Airbus A321neo	0,88
TOKYO	SHANGHAI	Airbus A320neo	0,88
TOKYO	BEIJING	Airbus A330-200	0,82
TOKYO	BEIJING	Airbus A350-900	0,81
TOKYO	SHANGHAI	Airbus A330-200	0,73
TOKYO	SHANGHAI	Airbus A350-900	0,73
TOKYO	DUBAI	Airbus A350-900	0,27
TOKYO	LOS ANGELES	Airbus A350-900	0,00

Flights from Tokyo are shown in the Figure 5.26 (1: Beijing, 2: Shanghai, 3: Dubai).

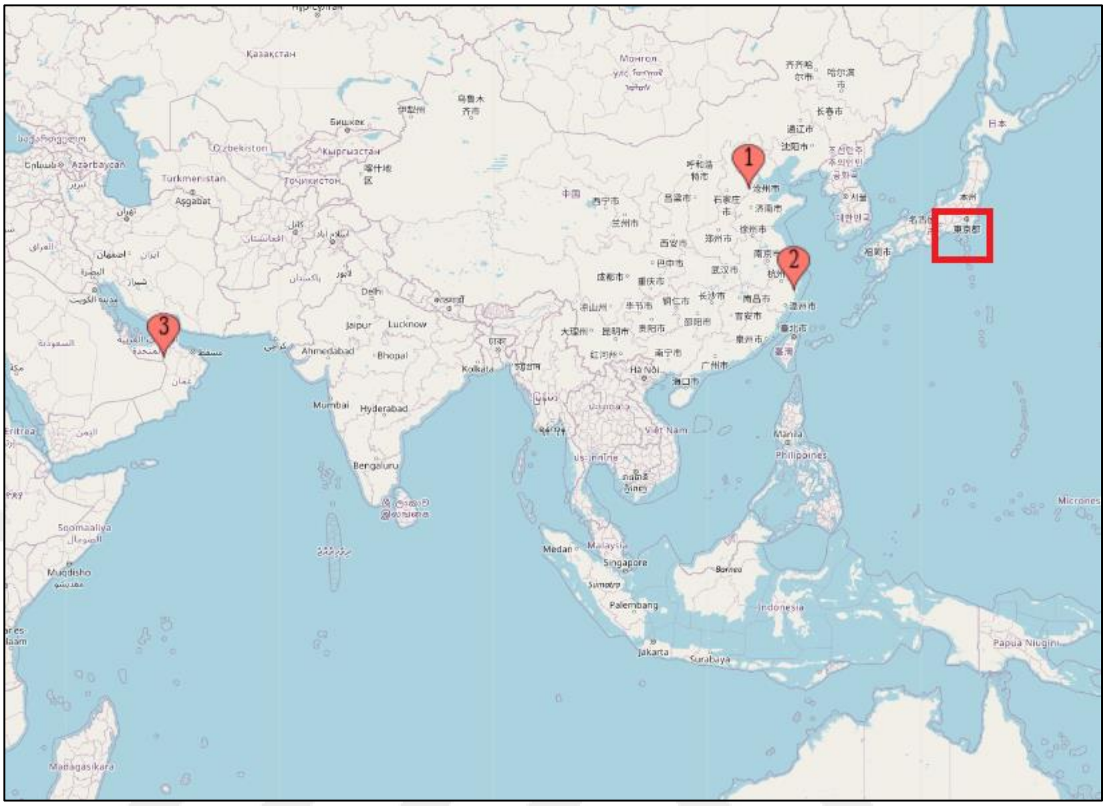

Figure 5.26: Flights From Tokyo According to TOPSIS Output

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.

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.

Table 5.24: TOPSIS Output of Possible Flights

Location	Destination Hub	Aircraft	TOPSIS 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	0,80
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	0,30
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	0,90
TOKYO	SHANGHAI	Airbus A321neo	0,88
TOKYO	DUBAI	Airbus A350-900	0,27
CAPE TOWN	DUBAI	Airbus A350-900	1,00

CHAPTER VI

CONCLUSION AND DISCUSSION

The increasing competition in air transport and the increasing costs of aircrafts forces airline companies, which are very sensitive to economic conditions, to use the available resources in the most appropriate way. Firms 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 cannot 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 geopolitical location in airlines on operational costs and fleet management is examined. In this context, 8 locations have been selected (Istanbul, London, Doha, Nairobi, Beijing, Delhi, Tokyo and Cape Town). The distances of flights from these eight locations to 10 hubs (Chicago, Los Angeles, Beijing, Shanghai, Tokyo, Frankfurt, London, Paris, Amsterdam and Dubai) have been calculated. Then, fuel and operational costs of five different aircraft (Airbus A320neo, Airbus A321neo, Airbus A330-200, Airbus A350-900 and Boeing 737-900 NG) were calculated, and the payload amount of each aircraft was determined. Then, the flights from each of the eight locations to each of the 10 hubs, with each aircraft, were analyzed. During this analysis, the optimum range for maximum payload value of the aircraft and the distance between the location and the hub are compared. The distances smaller than the optimum range for maximum payload value are taken into account. In the next stage, operational costs were calculated based on the distance between the locations and hubs of the aircraft.

Accordingly, the effect of operational cost items on total operational cost (criteria) and weights were determined. It was aimed to determine the most cost-effective flights by applying TOPSIS methods on the decision alternatives selected in line with the determined criteria and weights. In the study, alternatives express the flights and criteria express operational costs.

Among the 8 locations empirically examined using the TOPSIS method, it was determined from which center the least costly and best fleet-managed flights can be carried out for airline companies according to the determined criteria.

As an important criterion, an average of the GDP, Sustainable Development Index and Human Development Index scores of the countries where the hubs are located was taken and the effect of this average on the total decision-making process was determined as 30%. The 30 percent rate is the rate previously determined in a study conducted by Huston and Butler (1991). Huston and Butler (1991) determined the effect of location on airline selection as 30% in their study. The location Index included in the decision-making process determines the effect of location on hubs in more detail. It was ensured that the entire fleet was used and the least costly fleet was found during the assessment.

Only five types of aircraft were used in the study, and there is a limit for each aircraft to arrange only one flight to each point. If it is possible to fly to a point with more than one aircraft, the least costly one is preferred.

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 a healthy 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 investigating the effect of location on operational costs. In this respect, the study contributes to the literature. 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 by using TOPSIS method. 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. Wei (2006) explored how airport landing charges can affect airlines' decisions about aircraft size and flight frequency through a game-theoretic model. 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, fleet planning 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 thesis, location selection affects the costs of the airlines. 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.

Location and hub selection is an important phenomenon in airlines. It has been determined by the analysis that the location and hub selection and fleet management reduce the operational costs 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.

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, 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.

REFERENCES

Abdelghany, K. F., Abdelghany, A. F., & Ekollu, G. (2008). An integrated decision support tool for airlines schedule recovery during irregular operations. *European Journal of Operational Research*, *185*(2), 825-848.

Advani, A. (1999). *Passenger-friendly airports: another reason for airport privatization* (No. Policy Study No. 254).

Agnew, J. (2004). *Geopolitics: Re-visioning world politics*. Routledge.

Airports Council International, https://aci.aero/news/2019/03/13/preliminary-world-airport-traffic-rankings-released/, Accessed: 28.12.2020

Alexander, L. (1961). The new geopolitics: a critique: Ladis Kristof, The Origins and Evolution of Geopolitics. *Journal of Conflict Resolution*, *5*(4), 407-410.

Anaz, N., & Akman, E. (2017). Turkey's Soft Power Capacity: Geopolitics of Aviation and the Turkish Airlines. *The Arab World Geographer*, *20*(4), 303-316.

Armacost, A. P., Barnhart, C., & Ware, K. A. (2002). Composite variable formulations for express shipment service network design. *Transportation science*, *36*(1), 1-20.

Bailey, J. (2007). An airline shrugs at oil prices. *New York Times*, *29*.

Ball, M., Barnhart, C., Nemhauser, G., & Odoni, A. (2007). Air transportation: Irregular operations and control. *Handbooks in operations research and management science*, *14*, 1-67.

Banker, R. D., & Johnston, H. H. (1993). An empirical study of cost drivers in the US airline industry. *Accounting Review*, 576-601.

Barnhart, C., Belobaba, P., & Odoni, A. R. (2003). Applications of operations research in the air transport industry. *Transportation science*, *37*(4), 368-391.

Barnhart, C., Boland, N. L., Clarke, L. W., Johnson, E. L., Nemhauser, G. L., & Shenoi, R. G. (1998). Flight string models for aircraft fleeting and routing. *Transportation science, 32*(3), 208-220.

Bazargan, M. (2016). *Airline operations and scheduling*. Routledge.

Bergstra, J. A., & Burgess, M. (2019). A Promise Theoretic Account of the Boeing 737 Max MCAS Algorithm Affair. *arXiv preprint arXiv:2001.01543*.

Bilotkach, V., Gaggero, A. A., & Piga, C. A. (2015). Airline pricing under different market conditions: Evidence from European Low-Cost Carriers. *Tourism Management*, *47*, 152-163.

Boyd, E. A., & Kallesen, R. (2004). Practice papers: The science of revenue management when passengers purchase the lowest available fare. *Journal of Revenue and Pricing Management*, *3*(2), 171-177.

Bratu, S., & Barnhart, C. (2006). Flight operations recovery: New approaches considering passenger recovery. *Journal of Scheduling*, *9*(3), 279-298.

Button, K., & Taylor, S. (2000). International air transportation and economic development. *Journal of air transport management*, *6*(4), 209-222.

Çakmak, A. U. (2016). *Havacılık Jeopolitiği, Potansiyel Bölgenin Tespiti Ve Tespit Edilen Bölgedeki Bir Uçak Bakım Merkezinin Ekonomik Modellemesinin Yapılması* (Doctoral dissertation, Fen Bilimleri Enstitüsü).

Canevelli, M., Blasimme, A., & Cesari, M. (2017). Societal and global implications of the "dementia epidemic": The example of the London Heathrow airport. *European Journal of Epidemiology*, *32*(4), 347-348.

Catpetown Airport, https://www.capetown-airport.com/, Accessed: 10.11.2020

Chang, S. W. (2001). *Integrated approach to flight scheduling and fleet assignment* (Doctoral dissertation, University of Maryland, College Park).

Chepchirchir, A. B., Omillo, F., & Munyua, J. (2018). Effect Of Cost Leadership Strategy On Organizational Performance Of Logistics Firms At Jomo Kenyatta International Airport, KENYA. *European Journal of Management and Marketing Studies*.

Choochart, P., & Thipyopas, C. (2020). Study of Passenger Evacuation from the Airbus A330-300 Aircraft. In *Multidisciplinary Digital Publishing Institute Proceedings* (Vol. 39, No. 1, p. 25).

Clarke, L. W., Hane, C. A., Johnson, E. L., & Nemhauser, G. L. (1996). Maintenance and crew considerations in fleet assignment. *Transportation science*, *30*(3), 249-260.

Clausen, J., Larsen, A., Larsen, J., & Rezanova, N. J. (2010). Disruption management in the airline industry—Concepts, models and methods. *Computers & Operations Research*, *37*(5), 809-821.

Cordeau, J. F., Stojković, G., Soumis, F., & Desrosiers, J. (2001). Benders decomposition for simultaneous aircraft routing and crew scheduling. *Transportation science*, *35*(4), 375-388.

Crainic, T. G., & Kim, K. H. (2007). Intermodal transportation. *Handbooks in operations research and management science*, *14*, 467-537.

Cruz, B. S., & de Oliveira Dias, M. (2020). Crashed Boeing 737-Max: Fatalities Or Malpractice?. *GSJ*, *8*(1), 2615-2624.

Czerny, A. I., & Zhang, A. (2011). Airport congestion pricing and passenger types. *Transportation Research Part B: Methodological*, *45*(3), 595-604.

Daskin, M. S., & Panayotopoulos, N. D. (1989). A Lagrangian relaxation approach to assigning aircraft to routes in hub and spoke networks. *Transportation Science*, *23*(2), 91-99.

Debbage, K. G. (2016). The geopolitics of air transport. In *The geographies of air transport* (pp. 41-56). Routledge.

Deng, H., Yeh, C. H., & Willis, R. J. (2000). Inter-company comparison using modified TOPSIS with objective weights. *Computers & Operations Research*, *27*(10), 963-973.

Desaulniers, G., Desrosiers, J., Dumas, Y., Solomon, M. M., & Soumis, F. (1997). Daily aircraft routing and scheduling. *Management Science*, *43*(6), 841-855.

Doganis, R. (2002). *Flying off course: The economics of international airlines*. Psychology Press.

Doganis, R. (2006). *The airline business*. Psychology Press.

Doha Airport, https://dohahamadairport.com/, Accessed: 12.11.2020

Dubai Airport, http://www.dubaiairport.com/, Access: 14.04.2017

Dubois, T. (2019). Airbus A340 pilots waste safety margin at takeoff, BEA says: abnormal takeoff due to weak input on control stick; excessively slow rotation is common practice, BEA finds. *Aviation Week & Space Technology*.

Dunaev, B. B. (2004). Calculating gross domestic product as a function of labor and capital. *Cybernetics and Systems Analysis*, *40*(1), 86-96.

Erdemli, M. G. (2011). *Dünden bugüne Türk havacılık tarihi ve Eskişehir* (Master's thesis, Eskişehir Osmangazi Üniversitesi/Sosyal Bilimler Enstitüsü).

Feo, T. A., & Bard, J. F. (1989). Flight scheduling and maintenance base planning. *Management Science*, *35*(12), 1415-1432.

Fette, M. (2019). Die Airbus A350-XWB-Familie im Überblick. *Sonderprojekte ATZ/MTZ*, *24*(2), 40-41.

Fly Chicago, https://www.flychicago.com/ohare/home/pages/default.aspx, Accessed: 10.11.2020

Fly Los Angeles, https://www.flylax.com/, Accessed: 10.11.2020.

Gamache, M., Soumis, F., Marquis, G., & Desrosiers, J. (1999). A column generation approach for large-scale aircrew rostering problems. *Operations research*, *47*(2), 247-263.

Gamache, M., Soumis, F., Villeneuve, D., Desrosiers, J., & Gelinas, E. (1998). The preferential bidding system at Air Canada. *Transportation Science*, *32*(3), 246-255.

Gerede, E. (2010). The Evolution of Turkish Air Transport Industry: Significant Developments and the Impacts of 1983 Liberalization. *Journal of Management & Economics*, *17*(2).

Gopalan, R., & Talluri, K. T. (1998). The aircraft maintenance routing problem. *Operations Research*, *46*(2), 260-271.

Grant, R. G. (2003). Flight–100 years of aviation. *Aircraft Engineering and Aerospace Technology*.

Guimera, R., Mossa, S., Turtschi, A., & Amaral, L. N. (2005). The worldwide air transportation network: Anomalous centrality, community structure, and cities' global roles. *Proceedings of the National Academy of Sciences*, *102*(22), 7794-7799.

Guzzini, S., & Guzzini, S. (2012). Which geopolitics?. *The return of geopolitics in Europe*, 18-44.

Hacıoğlu, İ. (2011). Gelir yönetimi ve Türkiye'deki havayolu işletmelerinde gelir yönetimi üzerine bir uygulama, Trakya Üniversitesi Sosyal Bilimler Enstitüsü. *Basılmamış Yüksek Lisans Tezi*.

Hafeznia, M. R. (2000). A new definition of geopolitics. *Quarterly Journal of Geographic Research*, (58).

Hane, C. A., Barnhart, C., Johnson, E. L., Marsten, R. E., Nemhauser, G. L., & Sigismondi, G. (1995). The fleet assignment problem: Solving a large-scale integer program. *Mathematical Programming*, *70*(1-3), 211-232.

Hickel, J. (2020). The sustainable development index: Measuring the ecological efficiency of human development in the anthropocene. *Ecological Economics*, *167*, 106331.

Hsieh, T. Y., Lu, S. T., & Tzeng, G. H. (2004). Fuzzy MCDM approach for planning and design tenders selection in public office buildings. *International journal of project management*, *22*(7), 573-584.

Hussein, I. (2018). *Effects of Airport Development on the Kenyan Economy: A Case of Jomo Kenyatta International Airport* (Doctoral dissertation, Tangaza University College).

Huston, J. H., & Butler, R. V. (1991). The location of airline hubs. Southern Economic Journal, 975-981.

Japan Ministry of Land, Infrastructre, Transport and Toursim, http://www.mlit.go.jp, Accessed: 10.11.2020

Kabbani, N. M., & Patty, B. W. (1992). Aircraft routing at american airlines. Proceeding of the thirty-second annual symposium of AGIFORS. *Budapest, Hungary*.

Kansu, Y., Şensöz, S., Öztuna, Y., & Kaymaklı, H. (1971). *Havacılık tarihinde Türkler: En eski çağlardan 1. Dünya Savaşına kadar* (Vol. 1). Hava Kuvvetleri Basım ve Neşriyat Müd..

Kaya, E. (2010). Ulaştırma Kavramı ve Önemi. *Ulaştırma Sistemleri*, 2-24.

Kaynak, M. (2004). Uluslararası taşımacılık ve lojistik bağlamında avrasya ulaştırma koridorlarında bölgesel rekabet ve türkiye. *Ekonomik Yaklasim*, *15*(52-53), 3-34.

Kelly, P. (2016). *Classical geopolitics: a new analytical Model*. Stanford University Press.

Keyüsk, M. (1950). Türk Havacılık Tarihi I,(1912-1914). *Uçuş Okulları Basımevi, Eskişehir*.

Kiliç, D., & Turğut, M. (2019). Kentsel Lojistik Açisindan İstanbul Havalimani Ve Atatürk Havalimani'nin Değerlendirilmesi. *Journal of Economics & Administrative Sciences/Afyon Kocatepe Üniversitesi Iktisadi ve Idari Bilimler Fakültesi Dergisi*, *21*(2), 148-157.

Kinyua, J. K. (2020). *Determinants Of Implementation Of Safety Oversight Program In Aerodromes Towards Enhancing Safety. A Case Of Jomo Kenyatta International Airport* (Doctoral dissertation, University of Nairobi).

Klabjan, D. (2005). Large-scale models in the airline industry. In *Column generation* (pp. 163-195). Springer, Boston, MA.

Kohl, N., & Karisch, S. E. (2004). Airline crew rostering: Problem types, modeling, and optimization. *Annals of Operations Research*, *127*(1-4), 223-257.

Korul, V., & Küçükönal, H. (2003). Türk Sivil Havacilik Sisteminin Yapisal Analizi. *Ege Akademik Bakış Dergisi*, *3*(1), 24-38.

Kuruüzüm, A., & Irmak, S. (2008). Ekip Çizelgeleme Probleminin Küme Bölme Modeli İle Çözümü. *Journal of Aeronautics & Space Technologies/Havacilik ve Uzay Teknolojileri Dergisi*, *3*(4).

Lacoste, Y. (2004). Aviation and Geopolitics: Projections of Military Power. *Hérodote*, (3), 5-16.

Larsen, P. B., Sweeney, J., & Gillick, J. (2012). *Aviation law: Cases, laws and related sources*. Brill Nijhoff.

Lee, C. K. (2000). *A computerized analytical decision support system for evaluating airline scheduling interactions* (Doctoral dissertation, The Ohio State University).

Lettovský, L. (1997). *Airline recovery: An optimization approach* (Doctoral dissertation, Ph. D. dissertation, School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, Georgia).

Lim, S. H., & Hong, Y. (2014). Fuel hedging and airline operating costs. *Journal of air transport management*, *36*, 33-40.

Liu, J. (2003). *Solving real-life transportation scheduling problems* (Doctoral dissertation, University of Florida).

Liu, X., Zhang, T., Liu, X., Li, L., Lin, L., & Jiang, Y. (2020). Energy saving potential for space heating in Chinese airport terminals: The impact of air infiltration. *Energy*, 119175.

Lohatepanont, M., & Barnhart, C. (2004). Airline schedule planning: Integrated models and algorithms for schedule design and fleet assignment. *Transportation science*, *38*(1), 19-32.

Lu, J., & Ruan, D. (2007). *Multi-objective group decision making: methods, software and applications with fuzzy set techniques* (Vol. 6). Imperial College Press.

Malighetti, P., Paleari, S., & Redondi, R. (2009). Pricing strategies of low-cost airlines: The Ryanair case study. *Journal of Air Transport Management*, *15*(4), 195-203.

Malina, R., Albers, S., & Kroll, N. (2012). Airport incentive programmes: a European perspective. *Transport Reviews*, *32*(4), 435-453.

Morse, S. (2003). Greening the United Nations' human development index?. *Sustainable Development*, *11*(4), 183-198.

New Delhi Airport, https://www.newdelhiairport.in/, Accessed: 12.11.2020

Ngo, T., & Tian, Q. (2020). Corporate social responsibility awareness and performance: the case of Chinese airports. *International Journal of Productivity and Performance Management*.

O'Connor, W. E. (2001). *An introduction to airline economics*. Greenwood Publishing Group.

Öncü, M. A., Çömlekçi, İ., & Coşkun, E. (2010). A Research on Financial Strategies Applied by the Airlines Companies. *Ekonomik ve Sosyal Araştırmalar Dergisi*. 6 (2): 27- 58.

Oral, S., & Yüksel, H. (2006). Hizmet işlemleri yönetimi. *Kanyılmaz Matbaası, İzmir*.

Orhan, İ. (2007). Uçak bakım planlamasının en iyilenmesine yönelik bir karar destek tasarımı.

Orhan, İ., Kapanoğlu, M., & Karakoç, T. H. (2007). Flight-Hour Based Optimization for Aircraft Scheduling.

Oum, T. H., & Yu, C. (2012). *Winning airlines: Productivity and cost competitiveness of the world's major airlines*. Springer Science & Business Media.

Özdemir, U. (2009). Methodology for crew-pairing problem in airline crew scheduling. *Bogazici University*.

Özden, Ü. H. (2009). Türkiye'deki Mevduat Bankalarının Performansları: Çok Kriterli Karar Verme Yöntemleri ile Analiz. *Ankara: Detay Yayıncılık*.

Paris Aeroport, https://www.parisaeroport.fr/, Accessed: 10.11.2020

Policy, B. A. (2011). Geopolitics 2012. *The Boeing Company, Seattle*.

Polmar, N. (2006). *Aircraft Carriers: A History of Carrier Aviation and Its Influence on World Events, Volume I: 1909-1945* (Vol. 1). Potomac Books, Inc..

Qi, X., Yang, J., & Yu, G. (2004). Scheduling problems in the airline industry. In *Handbook of scheduling: algorithms, models, and performance analysis* (pp. 50-1). CRC Press.

Rexing, B., Barnhart, C., Kniker, T., Jarrah, A., & Krishnamurthy, N. (2000). Airline fleet assignment with time windows. *Transportation science*, *34*(1), 1-20.

Rosenberger, J. M. (2002). Topics in airline operations.

Rushmeier, R. A., & Kontogiorgis, S. A. (1997). Advances in the optimization of airline fleet assignment. *Transportation science*, *31*(2), 159-169.

Rutkowskı, M. (2020). Safety as an element of creating competitive advantage among airlines given the example of the Airbus A350 XWB and the Boeing 787 Dreamliner aircraft. *Journal of Silesian University of Technology. Series Transport*, *108*, 201-212.

Ryan, D. M. (1992). The solution of massive generalized set partitioning problems in aircrew rostering. *Journal of the operational research society*, *43*(5), 459-467.

Sarac, A., Batta, R., & Rump, C. M. (2006). A branch-and-price approach for operational aircraft maintenance routing. *European Journal of Operational Research*, *175*(3), 1850-1869.

Sarilgan, A. E. (2011). The Requirements Of Developing The Regional Airline Tranportation In Turkey. *Anadolu University Journal of Social Sciences*, *11*(1), 69-88.

Şengür, Y. (2004). *Havayolu taşımacılığında düşük maliyetli taşıyıcılar ve Türkiye'deki uygulamalarının araştırılması* (Master's thesis, Anadolu Üniversitesi).

Setiawan, D. M., Mahmudah, N., & Putra, E. L. (2019). Analisis Panjang Runway untuk Pendaratan dan Take-off Pesawat Airbus A330-200 dan A330-300. *Semesta Teknika*, *22*(1), 21-30.

SGI Index, https://www.sdgindex.org/reports/sustainable-development-report-2019/, Accessed: 17.11.2020.

Shanghai Airport, http://www.shairport.com/, Accessed: 10.11.2020

Shaw, T. L. (2004). Hybrid column generation for large network routing problems: With implementations in airline crew scheduling.

Sherali, H. D., Bish, E. K., & Zhu, X. (2006). Airline fleet assignment concepts, models, and algorithms. *European Journal of Operational Research*, *172*(1), 1-30.

SHGM, http://web.shgm.gov.tr/tr/kurumsal/4547-istatistikler

Sriram, C., & Haghani, A. (2003). An optimization model for aircraft maintenance scheduling and re-assignment. *Transportation Research Part A: Policy and Practice*, *37*(1), 29-48.

Subramanian, T., Boyd, J. M., Malstrom, S., Venkatesh, L. K., Schaeper, U., Elangovan, B., ... & Chinnadurai, G. (1994). Adenovirus E1B 19 kDa and Bcl-2 proteins interact with a common set of cellular proteins. *Cell*, *79*(2), 341-351.

Taaffe, E. J. (1996). *Geography of transportation*. Morton O'kelly.

Tacchella, A., Mazzilli, D., & Pietronero, L. (2018). A dynamical systems approach to gross domestic product forecasting. *Nature Physics*, *14*(8), 861-865.

Tanrısevdi, A., & Çulha, O. (2010). Düşük Fiyatlı Havayolu Taşımacılığı (Dfht) Sektörünün Genel Özellikleri Ve Uygulanan Pazarlama Karmalarının Yapısı: Türk Dfht Firmaları Üzerinde Bir Araştırma. *Elektronik Sosyal Bilimler Dergisi*, *9*(33), 65-100.

Tekiner, H., Birbil, Ş. İ., & Bülbül, K. (2009). Robust crew pairing for managing extra flights. *Computers & Operations Research*, *36*(6), 2031-2048.

Tiryaki, F., & Ahlatcioglu, M. (2005). Fuzzy stock selection using a new fuzzy ranking and weighting algorithm. *Applied Mathematics and computation*, *170*(1), 144-157.

Torenbeek, E., & Wittenberg, H. (2009). *Flight physics: essentials of aeronautical disciplines and technology, with historical notes*. Springer Science & Business Media.

Travis, G. (2019). How the Boeing 737 Max disaster looks to a software developer. *IEEE Spectrum*, *18*.

Turk Info, http://www.turkinfo.nl, Access: 14.04.2017

Turner, P. A., & Lim, S. H. (2015). Hedging jet fuel price risk: The case of US passenger airlines. *Journal of Air Transport Management*, *44*, 54-64.

UNDP, http://hdr.undp.org/en/content/2019-human-development-index-ranking/, Accessed: 17.11.2020.

Uslu, S., & Cavcar, A. (2003). Havayolu İşletmelerinde Bir Maliyet Unsuru: Avrupa Hava Sahası'nda Hava Trafik Yol Ücretleri. Sosyal Bilimler Dergisi. 2002-2003: 81- 94.

Velasquez, M., & Hester, P. T. (2013). An analysis of multi-criteria decision making methods. *International journal of* operations *research*, *10*(2), 56-66.

Wells, A. T. (2007). *Air transportation: A management perspective*. Ashgate Publishing, Ltd..

World Bank, https://data.worldbank.org/indicator/is.air.psgr/

Worldbank, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD, Accessed: 17.11.

Yan, S., & Tu, Y. P. (2002). A network model for airline cabin crew scheduling. *European Journal of Operational Research*, *140*(3), 531-540.

Yu, G., & Thengvall, B. G. (2002). Handbook of applied optimization, chapter Airline optimization. *Oxford University Press*, *10*, 689-703.

Yu, G., Argüello, M., Song, G., McCowan, S. M., & White, A. (2003). A new era for crew recovery at continental airlines. *Interfaces*, *33*(1), 5-22.

Yükçü, S., & Fidancı, N. (2018). Havayolu İşletmeciliğinde Maliyet Ve Fiyatlandırma Önerileri. Muhasebe ve Vergi Uygulamaları Dergisi, 394-407.

Zain, F. I., Belyamin, B., & Saryanto, S. (2019, October). Kajian Low Pressure Pada Hydraulic System Dan Penanganannya Pada Airbus A330. In *Seminar Nasional Teknik Mesin* (Vol. 9, No. 1, pp. 960-964).

Zuidberg, J. (2014). Identifying airline cost economies: An econometric analysis of the factors affecting aircraft operating costs. *Journal of Air Transport Management*, *40*, 86-95.

APPENDIXES
APPENDIXA VARIABLES USED IN THE RESEARCH

LOCATION	DESTINATION HUB	DISTANCE	AIRCRAFT TYPE	OPTIMUM RANGE	COSTS							INDEX
					MAINTANACE	CREW	F/R - ATC	INSURANCE	GROUND HANDLING	DEPRECIATION	FUEL	
ISTANBUL	DUBAI	1883	Airbus A320neo	2400	1.385	3.094	2.275	187	2.620	2.241	5.606	0,51
ISTANBUL	LONDON	1550	Airbus A320neo	2400	1.140	2.547	1.872	154	2.260	1.844	4.615	0,64
ISTANBUL	PARIS	1379	Airbus A320neo	2400	1.014	2.266	1.666	137	4.055	1.641	4.106	0,64
ISTANBUL	AMSTERDAM	1359	Airbus A320neo	2400	999	2.233	1.642	135	1.244	1.617	4.046	0,63
ISTANBUL	FRANKFURT	1144	Airbus A320neo	2400	841	1.880	1.382	114	2.615	1.361	3.406	0,68
ISTANBUL	DUBAI	1883	Airbus A321neo	2400	1.273	2.845	2.091	172	2.620	2.060	5.155	0,51
ISTANBUL	LONDON	1550	Airbus A321neo	2400	1.048	2.342	1.721	142	2.260	1.696	4.243	0,64
ISTANBUL	PARIS	1379	Airbus A321neo	2400	932	2.083	1.532	126	4.495	1.509	3.775	0,64
ISTANBUL	AMSTERDAM	1359	Airbus A321neo	2400	919	2.053	1.509	124	1.244	1.487	3.720	0,63
ISTANBUL	FRANKFURT	1144	Airbus A321neo	2400	773	1.728	1.271	105	2.615	1.252	3.132	0,68
ISTANBUL	BEIJING	4398	Airbus A330-200	4650	6.185	13.820	10.161	837	2.988	10.010	25.044	0,67
ISTANBUL	DUBAI	1883	Airbus A330-200	4650	2.648	5.917	4.350	358	3.630	4.286	10.722	0,51
ISTANBUL	LONDON	1550	Airbus A330-200	4650	2.180	4.871	3.581	295	2.315	3.528	8.826	0,64
ISTANBUL	PARIS	1379	Airbus A330-200	4650	1.939	4.333	3.186	262	6.635	3.139	7.852	0,64
ISTANBUL	AMSTERDAM	1359	Airbus A330-200	4650	1.911	4.271	3.140	259	1.590	3.093	7.739	0,63
ISTANBUL	FRANKFURT	1144	Airbus A330-200	4650	1.609	3.595	2.643	218	4.702	2.604	6.514	0,68
ISTANBUL	SHANGHAI	4640	Airbus A330-200	4650	6.526	14.581	10.720	883	3.087	10.561	26.422	0,67
ISTANBUL	BEIJING	4398	Airbus A350-900	5800	6.302	14.080	10.351	853	2.988	10.198	25.514	0,67
ISTANBUL	DUBAI	1883	Airbus A350-900	5800	2.698	6.028	4.432	365	3.630	4.366	10.924	0,51
ISTANBUL	CHICAGO	5473	Airbus A350-900	5800	7.842	17.522	12.882	1.061	4.092	12.690	31.750	0,89
ISTANBUL	LONDON	1550	Airbus A350-900	5800	2.221	4.962	3.648	300	3.210	3.594	8.992	0,64
ISTANBUL	PARIS	1379	Airbus A350-900	5800	1.976	4.415	3.246	267	6.635	3.198	8.000	0,64

LOCATION	DESTINATION HUB	DISTANCE	AIRCRAFT TYPE	OPTIMUM RANGE	COSTS							INDEX
					MAINTANACE	CREW	F/R - ATC	INSURANCE	GROUND HANDLING	DEPRECIATION	FUEL	
ISTANBUL	AMSTERDAM	1359	Airbus A350-900	5800	1.947	4.351	3.199	263	1.590	3.151	7.884	0,63
ISTANBUL	FRANKFURT	1144	Airbus A350-900	5800	1.639	3.662	2.693	222	4.702	2.653	6.637	0,68
ISTANBUL	TOKYO	5592	Airbus A350-900	5800	8.012	17.903	13.162	1.084	4.780	12.966	32.441	0,68
ISTANBUL	SHANGHAI	4640	Airbus A350-900	5800	6.648	14.855	10.921	899	3.087	10.759	26.918	0,67
ISTANBUL	DUBAI	1883	Boeing 737-900 NG	2300	1.181	2.639	1.940	160	2.620	1.911	4.782	0,51
ISTANBUL	LONDON	1550	Boeing 737-900 NG	2300	972	2.172	1.597	132	2.260	1.573	3.936	0,64
ISTANBUL	PARIS	1379	Boeing 737-900 NG	2300	865	1.932	1.421	117	4.955	1.400	3.502	0,64
ISTANBUL	AMSTERDAM	1359	Boeing 737-900 NG	2300	852	1.904	1.400	115	1.244	1.379	3.451	0,63
ISTANBUL	FRANKFURT	1144	Boeing 737-900 NG	2300	717	1.603	1.179	97	2.110	1.161	2.905	0,68
LONDON	PARIS	216	Airbus A320neo	2400	159	355	261	21	4.055	257	643	0,64
LONDON	AMSTERDAM	231	Airbus A320neo	2400	170	380	279	23	1.244	275	688	0,63
LONDON	FRANKFURT	408	Airbus A320neo	2400	300	670	493	41	2.615	486	1.215	0,68
LONDON	PARIS	216	Airbus A321neo	2400	146	326	240	20	4.495	236	591	0,64
LONDON	AMSTERDAM	231	Airbus A321neo	2400	156	349	257	21	1.244	253	632	0,63
LONDON	FRANKFURT	408	Airbus A321neo	2400	276	616	453	37	2.615	446	1.117	0,68
LONDON	DUBAI	3421	Airbus A330-200	4650	4.811	10.750	7.904	651	3.630	7.786	19.480	0,51
LONDON	CHICAGO	3953	Airbus A330-200	4650	5.559	12.422	9.133	752	4.092	8.997	22.510	0,89
LONDON	PARIS	216	Airbus A330-200	4650	304	679	499	41	6.635	492	1.230	0,64
LONDON	AMSTERDAM	231	Airbus A330-200	4650	325	726	534	44	1.590	526	1.315	0,63
LONDON	FRANKFURT	408	Airbus A330-200	4650	574	1.282	943	78	4.702	929	2.323	0,68
LONDON	BEIJING	5080	Airbus A350-900	5800	7.279	16.263	11.957	985	2.988	11.779	29.471	0,67
LONDON	DUBAI	3421	Airbus A350-900	5800	4.902	10.952	8.052	663	3.630	7.932	19.846	0,51
LONDON	CHICAGO	3953	Airbus A350-900	5800	5.664	12.655	9.304	766	4.092	9.166	22.933	0,89
LONDON	PARIS	216	Airbus A350-900	5800	309	692	508	42	6.635	501	1.253	0,64

LOCATION	DESTINATION HUB	DISTANCE	AIRCRAFT TYPE	OPTIMUM RANGE	COSTS							INDEX
					MAINTANACE	CREW	F/R - ATC	INSURANCE	GROUND HANDLING	DEPRECIATION	FUEL	
LONDON	AMSTERDAM	231	Airbus A350-900	5800	331	740	544	45	1.590	536	1.340	0,63
LONDON	FRANKFURT	408	Airbus A350-900	5800	585	1.306	960	79	4.702	946	2.367	0,68
LONDON	SHANGHAI	5629	Airbus A350-900	5800	8.065	18.021	13.249	1.091	3.087	13.052	32.655	0,67
LONDON	LOS ANGELES	5444	Airbus A350-900	5800	7.800	17.429	12.813	1.055	7.516	12.623	31.582	0,89
LONDON	PARIS	216	Boeing 737-900 NG	2300	135	303	223	18	4.955	219	549	0,64
LONDON	AMSTERDAM	231	Boeing 737-900 NG	2300	145	324	238	20	1.244	234	587	0,63
LONDON	FRANKFURT	408	Boeing 737-900 NG	2300	256	572	420	35	2.110	414	1.036	0,68
DOHA	DUBAI	235	Airbus A320neo	2400	173	386	284	23	2.620	280	700	0,51
DOHA	DUBAI	235	Airbus A321neo	2400	159	355	261	21	2.620	257	643	0,51
DOHA	BEIJING	3837	Airbus A330-200	4650	5.396	12.058	8.865	730	2.988	8.733	21.849	0,67
DOHA	DUBAI	235	Airbus A330-200	4650	331	738	543	45	3.630	535	1.338	0,51
DOHA	LONDON	3261	Airbus A330-200	4650	4.586	10.248	7.534	620	2.315	7.422	18.569	0,64
DOHA	PARIS	3091	Airbus A330-200	4650	4.347	9.713	7.141	588	6.635	7.035	17.601	0,64
DOHA	AMSTERDAM	3062	Airbus A330-200	4650	4.306	9.622	7.074	583	1.590	6.969	17.436	0,63
DOHA	FRANKFURT	2853	Airbus A330-200	4650	4.012	8.965	6.591	543	4.702	6.493	16.246	0,68
DOHA	SHANGHAI	3648	Airbus A330-200	4650	5.131	11.464	8.428	694	3.087	8.303	20.773	0,67
DOHA	BEIJING	3837	Airbus A350-900	5800	5.498	12.284	9.031	744	2.988	8.897	22.260	0,67
DOHA	DUBAI	235	Airbus A350-900	5800	337	752	553	46	3.630	545	1.363	0,51
DOHA	LONDON	3261	Airbus A350-900	5800	4.672	10.440	7.675	632	3.210	7.561	18.918	0,64
DOHA	PARIS	3091	Airbus A350-900	5800	4.429	9.896	7.275	599	6.635	7.167	17.932	0,64
DOHA	AMSTERDAM	3062	Airbus A350-900	5800	4.387	9.803	7.207	594	1.590	7.100	17.764	0,63
DOHA	FRANKFURT	2853	Airbus A350-900	5800	4.088	9.134	6.715	553	4.702	6.615	16.551	0,68
DOHA	TOKYO	5165	Airbus A350-900	5800	7.400	16.536	12.157	1.001	4.780	11.976	29.964	0,68
DOHA	SHANGHAI	3648	Airbus A350-900	5800	5.227	11.679	8.586	707	3.087	8.459	21.163	0,67

LOCATION	DESTINATION HUB	DISTANCE	AIRCRAFT TYPE	OPTIMUM RANGE	COSTS							INDEX
					MAINTANACE	CREW	F/R - ATC	INSURANCE	GROUND HANDLING	DEPRECIATION	FUEL	
DOHA	DUBAI	235	Boeing 737-900 NG	2300	147	329	242	20	2.620	239	597	0,51
NAIROBI	DUBAI	2205	Airbus A320neo	2400	1.621	3.623	2.664	219	2.620	2.624	6.565	0,51
NAIROBI	DUBAI	2205	Airbus A321neo	2400	1.491	3.331	2.449	202	2.620	2.413	6.036	0,51
NAIROBI	DUBAI	2205	Airbus A330-200	4650	3.101	6.929	5.094	420	3.630	5.019	12.556	0,51
NAIROBI	LONDON	4243	Airbus A330-200	4650	5.967	13.333	9.803	807	2.315	9.657	24.161	0,64
NAIROBI	PARIS	4027	Airbus A330-200	4650	5.664	12.655	9.304	766	6.635	9.165	22.931	0,64
NAIROBI	AMSTERDAM	4140	Airbus A330-200	4650	5.822	13.010	9.565	788	1.590	9.423	23.575	0,63
NAIROBI	FRANKFURT	3915	Airbus A330-200	4650	5.506	12.303	9.045	745	4.702	8.910	22.293	0,68
NAIROBI	BEIJING	5734	Airbus A350-900	5800	8.216	18.357	13.496	1.111	2.988	13.296	33.265	0,67
NAIROBI	DUBAI	2205	Airbus A350-900	5800	3.159	7.059	5.190	427	3.630	5.113	12.792	0,51
NAIROBI	LONDON	4243	Airbus A350-900	5800	6.079	13.584	9.987	822	3.210	9.838	24.615	0,64
NAIROBI	PARIS	4027	Airbus A350-900	5800	5.770	12.892	9.478	781	6.635	9.338	23.362	0,64
NAIROBI	AMSTERDAM	4140	Airbus A350-900	5800	5.932	13.254	9.744	803	1.590	9.600	24.017	0,63
NAIROBI	FRANKFURT	3915	Airbus A350-900	5800	5.609	12.534	9.215	759	4.702	9.078	22.712	0,68
NAIROBI	SHANGHAI	5272	Airbus A350-900	5800	7.554	16.878	12.409	1.022	3.087	12.224	30.584	0,67
NAIROBI	DUBAI	2205	Boeing 737-900 NG	2300	1.383	3.090	2.272	187	2.620	2.238	5.599	0,51
BEIJING	TOKYO	1329	Airbus A320neo	2400	977	2.184	1.605	132	2.438	1.582	3.957	0,68
BEIJING	SHANGHAI	974	Airbus A320neo	2400	716	1.600	1.177	97	1.574	1.159	2.900	0,67
BEIJING	TOKYO	1329	Airbus A321neo	2400	899	2.008	1.476	122	2.438	1.454	3.638	0,68
BEIJING	SHANGHAI	974	Airbus A321neo	2400	659	1.471	1.082	89	1.574	1.066	2.666	0,67
BEIJING	DUBAI	3639	Airbus A330-200	4650	5.118	11.435	8.407	692	3.630	8.282	20.722	0,51
BEIJING	TOKYO	1329	Airbus A330-200	4650	1.869	4.176	3.070	253	4.780	3.025	7.568	0,68
BEIJING	SHANGHAI	974	Airbus A330-200	4650	1.370	3.061	2.250	185	3.087	2.217	5.546	0,67
BEIJING	LONDON	5080	Airbus A350-900	5800	7.279	16.263	11.957	985	3.210	11.779	29.471	0,64

LOCATION	DESTINATION HUB	DISTANCE	AIRCRAFT TYPE	OPTIMUM RANGE	COSTS							INDEX
					MAINTANACE	CREW	F/R - ATC	INSURANCE	GROUND HANDLING	DEPRECIATION	FUEL	
BEIJING	DUBAI	3639	Airbus A350-900	5800	5.214	11.650	8.565	705	3.630	8.438	21.111	0,51
BEIJING	PARIS	5103	Airbus A350-900	5800	7.312	16.337	12.011	989	6.635	11.832	29.604	0,64
BEIJING	AMSTERDAM	4878	Airbus A350-900	5800	6.989	15.617	11.481	946	1.590	11.311	28.299	0,63
BEIJING	FRANKFURT	4853	Airbus A350-900	5800	6.953	15.537	11.422	941	4.702	11.253	28.154	0,68
BEIJING	TOKYO	1329	Airbus A350-900	5800	1.904	4.255	3.128	258	4.780	3.082	7.710	0,68
BEIJING	SHANGHAI	974	Airbus A350-900	5800	1.396	3.118	2.292	189	3.087	2.258	5.650	0,67
BEIJING	TOKYO	1329	Boeing 737-900 NG	2300	834	1.862	1.369	113	2.438	1.349	3.375	0,68
BEIJING	SHANGHAI	974	Boeing 737-900 NG	2300	611	1.365	1.003	83	1.574	989	2.473	0,67
DELHI	BEIJING	2371	Airbus A320neo	2400	1.743	3.896	2.864	236	1.524	2.821	7.059	0,67
DELHI	DUBAI	1360	Airbus A320neo	2400	1.000	2.235	1.643	135	2.620	1.618	4.049	0,51
DELHI	SHANGHAI	2062	Airbus A320neo	2400	1.516	3.388	2.491	205	1.574	2.454	6.139	0,67
DELHI	BEIJING	2371	Airbus A321neo	2400	1.603	3.582	2.633	217	1.524	2.594	6.490	0,67
DELHI	DUBAI	1360	Airbus A321neo	2400	919	2.054	1.510	124	2.620	1.488	3.723	0,51
DELHI	SHANGHAI	2062	Airbus A321neo	2400	1.394	3.115	2.290	189	1.574	2.256	5.645	0,67
DELHI	BEIJING	2371	Airbus A330-200	4650	3.335	7.451	5.478	451	2.988	5.396	13.501	0,67
DELHI	DUBAI	1360	Airbus A330-200	4650	1.913	4.274	3.142	259	3.630	3.095	7.744	0,51
DELHI	LONDON	4191	Airbus A330-200	4650	5.894	13.170	9.682	797	2.315	9.539	23.865	0,64
DELHI	PARIS	4088	Airbus A330-200	4650	5.749	12.846	9.444	778	6.635	9.304	23.278	0,64
DELHI	AMSTERDAM	3962	Airbus A330-200	4650	5.572	12.450	9.153	754	1.590	9.017	22.561	0,63
DELHI	FRANKFURT	3810	Airbus A330-200	4650	5.358	11.973	8.802	725	4.702	8.671	21.695	0,68
DELHI	TOKYO	3678	Airbus A330-200	4650	5.173	11.558	8.497	700	4.780	8.371	20.944	0,68
DELHI	SHANGHAI	2062	Airbus A330-200	4650	2.900	6.480	4.764	392	3.087	4.693	11.742	0,67
DELHI	BEIJING	2371	Airbus A350-900	5800	3.397	7.591	5.581	460	2.988	5.498	13.755	0,67
DELHI	DUBAI	1360	Airbus A350-900	5800	1.949	4.354	3.201	264	3.630	3.153	7.890	0,51

LOCATION	DESTINATION HUB	DISTANCE	AIRCRAFT TYPE	OPTIMUM RANGE	COSTS							INDEX
					MAINTANACE	CREW	F/R - ATC	INSURANCE	GROUND HANDLING	DEPRECIATION	FUEL	
DELHI	LONDON	4191	Airbus A350-900	5800	6.005	13.417	9.864	812	3.210	9.718	24.313	0,64
DELHI	PARIS	4088	Airbus A350-900	5800	5.857	13.088	9.622	792	6.635	9.479	23.716	0,64
DELHI	AMSTERDAM	3962	Airbus A350-900	5800	5.677	12.684	9.325	768	1.590	9.187	22.985	0,63
DELHI	FRANKFURT	3810	Airbus A350-900	5800	5.459	12.198	8.968	739	4.702	8.834	22.103	0,68
DELHI	TOKYO	3678	Airbus A350-900	5800	5.270	11.775	8.657	713	4.780	8.528	21.337	0,68
DELHI	SHANGHAI	2062	Airbus A350-900	5800	2.954	6.601	4.853	400	3.087	4.781	11.962	0,67
DELHI	DUBAI	1360	Boeing 737-900 NG	2300	853	1.906	1.401	115	2.620	1.380	3.454	0,51
DELHI	SHANGHAI	2062	Boeing 737-900 NG	2300	1.293	2.890	2.124	175	1.574	2.093	5.236	0,67
TOKYO	BEIJING	1329	Airbus A320neo	2400	977	2.184	1.605	132	1.524	1.582	3.957	0,67
TOKYO	SHANGHAI	1848	Airbus A320neo	2400	1.359	3.036	2.232	184	1.574	2.199	5.502	0,67
TOKYO	BEIJING	1329	Airbus A321neo	2400	899	2.008	1.476	122	1.524	1.454	3.638	0,67
TOKYO	SHANGHAI	1848	Airbus A321neo	2400	1.249	2.792	2.052	169	1.574	2.022	5.059	0,67
TOKYO	BEIJING	1329	Airbus A330-200	4650	1.869	4.176	3.070	253	2.988	3.025	7.568	0,67
TOKYO	SHANGHAI	1848	Airbus A330-200	4650	2.599	5.807	4.269	352	3.087	4.206	10.523	0,67
TOKYO	DUBAI	4967	Airbus A350-900	5800	7.117	15.902	11.691	963	3.630	11.517	28.815	0,51
TOKYO	BEIJING	1329	Airbus A350-900	5800	1.904	4.255	3.128	258	2.988	3.082	7.710	0,67
TOKYO	SHANGHAI	1848	Airbus A350-900	5800	2.648	5.916	4.350	358	3.087	4.285	10.721	0,67
TOKYO	LOS ANGELES	5455	Airbus A350-900	5800	7.816	17.464	12.839	1.057	7.516	12.649	31.646	0,89
TOKYO	BEIJING	1329	Boeing 737-900 NG	2300	834	1.862	1.369	113	1.524	1.349	3.375	0,67
TOKYO	SHANGHAI	1848	Boeing 737-900 NG	2300	1.159	2.590	1.904	157	1.574	1.876	4.693	0,67
CAPE TOWN	DUBAI	4735	Airbus A350-900	5800	6.784	15.159	11.145	918	3.630	10.979	27.469	0,51
CAPE TOWN	PARIS	5796	Airbus A350-900	5800	8.305	18.556	13.642	1.124	6.635	13.439	33.624	0,64

CURRICULUM VITAE

Personal Information:

Name – Surname: Serhan ZEYBEL

Education:

Msc. Air Transport Management, Ibn Haldun University, Turkey, 2021

Atlantic Flight Academy (ATPL A), Istanbul, Turkey, 2017

Yıldız Technical University, Metallurgical and Material Engineering, Istanbul, Turkey, 2013

Atakoy Cumhuriyet High School, Istanbul, Turkey, 2007

Mimar Sinan Primary School**,** Istanbul, Turkey, 2004

Private Yavuz Sultan Selim Primary School, Istanbul, Turkey, 2000

Work Experience:

20117 – Still First Officer A330, Turkish Airlines, Istanbul Turkey

2017 – 2017 First Officer A320, Atlasglobal Airlines, Istanbul, Turkey

2011 – 2016 Football Referee, Turkish Football Association

2009 – 2010 Ground Services Officer, Turkish Airlines, Istanbul

2013 – Still Apsis Insurance Agency, Co-Founder, Istanbul

2012 – Still Zeyhan Tourism Agency, Co-Founder, Istanbul