EVALUATION OF THE OPERATIONAL AND FINANCIAL EFFICIENCY OF THE EUROPEAN COUNTRIES' BIG SCALE FLAG CARRIER AIRLINES USING DATA ENVELOPMENT ANALYSIS

Tüzün Tolga İNAN[1]

Citation/©: İnan, T. T. (2020). Evaluation of the operational and financial efficiency of the european countries' big scale flag carrier airlines using data envelopment analysis. *Hitit University Journal of Social Sciences Institute, 13*(2), 310-330. doi: 10.17218/hititsosbil.772897.

Abstract: Civil Aviation Industry has entered into a great development trend, especially since the 1978 deregulation period. Strategies implemented by airlines are of great importance in this development trend. Although airline partnerships cause airlines to lose their brand values, more successes are achieved under operational and financial criteria. For this reason, airline partnerships have been a strategy used by both large and small scale airlines in European aviation for the last 10 years. When it is examined the 10 biggest airlines of Europe excluding low-cost carriers, it is seen that only Turkish Airlines have not in a partnership. The aim of this study is to analyze the impact of partnerships established on the airlines' operational and financial efficiency. While the number of revenue passengers and the total number of landings are operational inputs, the available seat kilometer and revenue passenger kilometer are financial outputs. While the results obtained from these data help to determine how efficient the biggest airlines in Europe are, on the other hand, it expresses how important it is in its different criteria.

Keywords: *Revenue Passenger, Number of Landing, Available Seat Kilometer, Revenue Passenger Kilometer, Data Envelopment Analysis.*

Atıf/©: İnan, T. T. (2020). Avrupa ülkelerinin büyük ölçekli bayrak taşıyıcı havayollarının operasyonel ve finansal verimliliğinin veri zarflama analizi ile incelenmesi. *Hitit Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 13*(2), 310-330. doi: 10.17218/hititsosbil.772897.

Avrupa Ülkelerinin Büyük Ölçekli Bayrak Taşıyıcı Havayollarının Operasyonel ve Finansal Verimliliğinin Veri Zarflama Analizi ile İncelenmesi

Özet: Sivil Havacılık Endüstrisi özellikle 1978 deregülasyon döneminden itibaren büyük bir gelişim trendi içerisine girdi. Bu gelişim trendi içerisinde havayollarının uyguladığı stratejiler büyük önem ifade etmektedir. Özellikle havayolu ortaklıkları havayollarının marka değerlerini yitirmelerine neden olsa da operasyonel ve finansal kıstaslar altında daha başarılar sonuçlar elde edilmesi sağlanmıştır. Bu nedenle havayolu ortaklıkları özellikle son 10 yıldır Avrupa Havacılığında hem büyük hem küçük ölçekli havayollarının faydalandığı bir strateji olmuştur. Düşük maliyetli taşıyıcılar hariç Avrupa'nın en büyük 10 havayolunu incelediğimiz zaman sadece Türk Hava Yolları'nın bir ortaklık içerisinde yer almadığını görmekteyiz. Bu çalışmada amaç, kurulan ortaklıkların havayollarının operasyonel ve finansal verimliliklerine etkisini analiz etmektir. Toplam gelir getiren yolcu sayısı ve toplam iniş sayısı operasyonel girdileri oluştururken, arz edilen toplam kilometre ve yolcu başına gelir kilometre ise finansal çıktıları oluşturmaktadır. Bu veriler neticesinde çıkan sonuçlar Avrupa'nın en büyük havayollarının hangi ölçüde verimli olduğunu saptamamıza yardımcı olurken, bir yandan farklı ölçütlerinde ne denli önemli olduğunu ifade etmektedir.

Makale Geliş Tarihi: 24.7.2020 Makale Kabul Tarihi: 27.9.2020

[1] Dr. Öğr. Üyesi, Bahçeşehir Üniversitesi, Uygulamalı Bilimler Yüksekokulu, Pilotaj Bölümü, tuzuntolga.inan@sad.bau.edu.tr, https://orcid.org/0000-0002-5937-9217

Anahtar Kelimeler: *Gelir Getiren Yolcu Sayısı, Toplam İniş Sayısı, Arz Edilen Toplam Kilometre, Yolcu Başına Gelir Kilometre, Veri Zarflama Analizi.*

1. INTRODUCTION

Airline partnerships are significant for increasing the operational efficiency of airlines by developing the number of routes and frequency of flights. Airlines all over the world have improved several collaboration conditions, generally applied to partnerships on account of eliminating diversified regulative and financial barriers. Commonly, airline partnerships cover any partnership regulations among two or more airlines including mutual operations with the proclaimed purpose of enhancing competitiveness and whole efficiency (Morrish and Hamilton, 2002, p. 403). The induration of worldwide airline sector has followingly overspread the creation of partnership categories. These partnership categories are principally related to multilateral and formal systems of airlines that have set up ranges of communities by one and all (Kleymann and Seristö, 2017). In addition to airline partnerships particularly pending the recent two decades, three worldwide alliance groups (Star Alliance, SkyTeam, Oneworld) have began overpowering stakeholders of worldwide airline sector. The impetus that mentioned worldwide alliance categories have extended actually staggering. More particularly from five airlines primarily modeling Star alliance community in 1997, now there have overall 62 airlines joined these three worldwide agreement communities. Alternative stunning form related to worldwide alliance groups were the reality that among 2012 and 2016, these three alliance groups transported more than sixty percent of the whole worldwide passenger transportation (Flight Airline Business, 2017). Except that existence of regular applications in worldwide airline industry, airline partnerships have composed a grand exploratory subject for diverse researchers and managers. Exploratory endeavors about particular area of working have earned an actually crucial develop, hence a huge spectrum of directions wraparound such as; air transportation systems (Bissessur and Alamdari, 1998, p. 351; Dennis, 2000, p. 80; U. S. D. O. T., 2000; Dennis, 2005, p. 179; Gillen, 2005, p. 59; Iatrou and Oretti, 2016), airline economics (Oum et al., 2000; Brueckner, 2001, p. 1481; Kleymann and Seristö, 2017; Vinod, 2005, p. 72; E. C., 2010; U. S. D. O T., 2010), airline operations (Oum and Park, 1997, p. 137; Oum and Zhang, 2001, p. 291; Brueckner and Pels, 2005, p. 33; Button, 2009, p. 63) etc.

In that situation, the influence of carrier communities as for several perspectives inside and/or outside the airline sector has an exclusive position between academicians. However, the quantification of these influences have covered a critical defiance for academicians that has attituded across the application of several methodologic approximations. In general, a reasonably contentious subject about airline agreements and airline sector is the only concerned with performance assessment. The best widespread applied evaluation of efficiency in airline sector is financial efficiency that is generally evaluated by cursors such as network profit share, turning on equity and hedges, liquidity flux etc. The other significant evaluation of performance is operational efficiency that is generally applied to a kind of productivity. Afterward, the concept of airline fertility has had several fractional dimensions as substantial emergence of labor fertility (per worker foundation) and aircraft usage (e.g. load factor) (Kleymann and Seristö, 2017). For all regarding the efficiency evaluative techniques applicated by carriers, Francis et al. (2005, p. 213) assigned benchmarking techniques at a high level and completely admitted. Many academicians have interested in evaluation of airline performance and benchmarking by applying a broad order of suitable processes. Between the diversified benchmarking processes performed for airline efficiency evaluation, Data Envelopment Analysis (DEA) has earned a high importance related with the aspect of time period and benchmarking. Actually, several investigative endeavors

according with airline efficiency applied the methodological access of DEA is constantly rising, hence emphasizing the arised attention upon the specific exclusive issue. The investigative endeavors directed in the outline of evaluating airline efficiency applicated DEA have firstly centered on operational fertility that is apart from applied to as performance. However former convenient exploratory has researched the influences of an extensive order of financial and operational outlooks on carrier performance applied DEA, the potency effect of community affiliation about airline performance did not enough allocution in present literature. In that situation, the existing research firstly purposes to explore the influence of partnership affiliation about the performance of grand international airlines. Furthermore, airline performance is additionally connection with freight traffic income margin and the continent what for airlines' existed (America, Europe, Asia, Oceania). The research subscription related to this connection is triplicate and described as mentioned below:

- Interpret the impact of airline partnership affiliation about airline performance which is possible for enforcing a diversified DEA methodological access and a better ultimate process about the studies of Min and Joo (2016, p. 103) that covered this identical subject.

- Evaluate the impact of the air cargo traffic income margin on carrier performance, hence assaying to confirm the indications about inquiry endeavor of Hong and Zhang (2010, p. 139).

- Confront the performance of airlines belong to diverse continents with a view to adjust statistically prominent distinctions in an akin method to Joo and Fowler (2014).

2. BACKGROUND

How operational performance is influenced profitability in airline transactions? The service literature about airlines focalize firstly on the connection among fertility and profitability or the connection between service, standards and profitability. The total effect of operational efficiency on airlines' profitability in service arrangements has greatly failured. This can be connected firstly to the investigative on the impellent strengths of profitability in services is completed firstly with marketing researchs who focus primarily on the correlation among quality and profitability (Nelson et al., 1992; Fornell, 1992, p. 15; Anderson et al., 1994, p. 56; Rust et al., 1995, p. 62; Loveman, 1998, p. 23). Conversely, accounting and operations management academics were interested in the influence of fertility on profitability (Schefczyk, 1993, p. 305; Smith and Reece, 1999, p. 151). So, it is important to analyze the potential effect of "focus" on profitability (Skinner, 1974). According to Skinner (1974), an airline which focuses on a tight product mix for a specific niche market is going to evaluate alternative airline operated to attain an extensive outcome. The significance of focusing on airline services have been debated by Heskett (1986), Swamidass (1991, p. 799) and Roth and Menor (2003, p. 151) related with restricted empirical inquiries. Specifically, operational performance was examined by Huete and Roth (1988) in banks, with McLaughlin et al. (1995, p. 1187) in the health care sector and eventually by Boyer et al. (2002, p. 181) owing to the research of Sotheby's. Although, mentioned above three research could not test the connection among focalize and financial efficiency. By the way, the air transport market has passed on considerable change. Deregulation phase in Europe, North America and Australia have overspread to an importantly improved rivalry and along with deregulation phase, many European airlines that were anciently state-owned have been wholly or partly privatized. Also, regulations after the events of September 11 have influenced the environment where air services are ensured. To sum up, the big-scale market entrance of low-cost carriers (LCCs) has risen rivalry and influenced the prices payed for functionary airlines. As an outcome of these and other

progress, it is likely that the identified capacity of the worlds' airlines has varied (Barbot, Costa and Sochirga, 2008, p. 271).

Commercial aviation in civil aviation started in 1910 when DELAG began making operations connection to eight German cities. Air transport was immensely coordinated by governments that supervision flight arrangement, type of aircraft and airlines authorized to work jointly by the destinations they worked on. These judgments were related to political concerns than the real demand that obtained in civil aviation sector. Administrations engrossed domestic flights and mutual arrangements enduring in order to arrange international flights. This continuity ended in a disturbed and insecure transport system, however, air transportation ratios were superior which solely the flag carrier airline could afford to utilize from these chances. In Europe, the constitution of the European Economic Community in 1957 was noticed as the beginning date about the liberalization of air transportation. The initial phase was the operation of a common market that simplified the freecycle and the application of agreed transportation strategy. Air transportation request has risen exceptionally since 100 years, primarily filled by the unification of recent technologies and substructure which have effected in recoveries about safety, speed and comfort. This processing has overspread to various airlines being established that one by one, it has been authorized a progressive decline in operational expenses which jointly with the immense improvement of tourism sector. This immense improvement has transformed their distribution of duties inside produces of massif consumption. In this recent continuity, airlines have to select among two operational systems. These are classified as; hub and spoke (HS) and point-to-point (PP). The ancient intensifies its operations in specific traffic centers or hubs in which passengers are redelivered and forwarding other destination airports. These airlines shuttered an extensive market with more organized flight periodicity. Ordinarily, over the ocean or extended range flights which operate in hubs are raised with this flight periodicity. These flights are worked a few capacities by regional partners or shareholders because of the lack of wide body aircraft. Regional partners or shareholders generally can use narrow body aircraft because of lower operational costs. At current times fundamentally, legacy airlines (full service carriers) are operated with HS strategy, however, low cost carriers are operated with PP strategy (Maasoumi et al., 2015). The accomplishment of this framework lays organizing arrivals and departures to decrease the time gap among them and the selection of airport tangle (Martinez, 2003).

Considering Planas and Lewkowycz (2009, p. 44), it is primarily designated with subsequent as enlarge the number of destinations deliver particularly adjusted appropriately flights to decrease waiting times in the hub. By this way, the occupation ratio is generally upper than intensifying traffic linkage. Hence, the expenditure per passenger is preferable for commuting the ratios that included advanced management. Owing to billing subjects, linkages, baggage, incidents, administration of income and business, etc., the replacement of time-period usually liable to performance substructure. So, a crucial mass function is necessary, and economies of measure are upper level whether management is at sufficient. Though, these are not about the advantages. The probable blockage and ensuing delays are agreed in the hubs as a conclusion of increments in traffic and repression control of air traffic. It is required to induce the demand in order to dense hedges in substructure to adsorb expansion. Furthermore, because of the existence of hubs, passengers usually seek to use more than one route for decreasing the ticket prices. This situation is possible despite an increase in distance, take-offs and landings. Guiding larger fuel consumption for every passenger and destination, whether the travel is short. PP system was firstly applied in air transportation owing to not having adequate flights to set up more complicated operational systems. Thus, aircraft fly directly to their route and whence do not perform stopovers at hubs. The emphasis of the arrangement is time period necessary for

processes decreased inasmuch as there are no traffic linkages between operations of luggage and passenger. Ordinarily, it attained lower operating costs and gaining of worth additional services by decreasing expenditure workforce and operational whereat it flies to subsidiary airports. This airline market contains charter, low cost and private flights requested by authoritative ensuring a particular strategy that solely works about profitable destinations and have not interested related to linking to other destinations. These airlines generally employ workers fewer than the number of ten. Airlines should describe their development strategy according to an operational framework in researching the highest profitability. Alderighi et al. (2005, p. 330), implemented research with the outline about selecting three strategies such as; HS, PP and multi-hub for achieving the outcome about national market dimension factor to adjust this determination. Academicians have started to monitor attention in examining the productivity of airlines more than two decades that broadcasting of various researchers such as Caves et al. (1981), existed one of these precursors. In former investigative, Fethi et al. (2000) debated which international center may conceive airlines for region inequalities. Scheraga (2004, p. 50), debated about sophisticated interest in international operations that may stimulate under operational efficiencies owing to cabotage and institution claims. Separation against geographic districts on account of rivalry law, strategies in air transportation and airport substructure restraints can potency influence the operating performance of international airlines. Although in recent years, civil aviation sector has gone to a gradual progress of liberalization and protection inside the sectors' level has slowed. It is a conjecture that the impact of international work on performance might have get assertive. For instance, Singapore Airlines is a powerful international center is completely respected as the top performance airlines together. Furthermore, China has exported big amounts of yields to North American and Europe besides becoming a demand for a grand domestic cargo transportation system since years. This situation was ensured Chinese airlines by chance to improve their air cargo system. Thus, Chinese airlines proposed also passenger and cargo services. So, this situation heightened the both services' similarity if cargo traffic has risen its percentage with enhancing the operating performance (Wu, He and Cao, 2013, p. 36). Scheraga (2004, p. 52) with Hong and Zhang (2010, p. 140), recommended that heightening the percentage of cargo transportation could be useful. For instance, the cargo process includes smaller input and over resilient transportation procedures than passenger services. Gathering passenger and cargo services might affect advanced freight elements in order to carry near baggage in passenger aircraft.

Conversely, cargo trend is more imbalanced than passenger flows (cargo is generally carried solely method, however, passengers generally have circle trip) and in this way, cargo business might ensue in inferior load factors and worse performance. Thus, cargo sector could potency influence load elements in both way, however, Scheraga (2004, p. 54) with Hong and Zhang (2010, p. 141) solely debated about a positive effect. It is supposed which there may subsist an adverse u-shaped connection among operational performance with percentage of cargo strategy. While exact percentage is fewer than optimum percentage, increasing cargo percentage might be useful. When the exact percentage is upper than the optimum percentage, percentage might not increase. The other competing benefit of China is the source of plentiful workforce. Because of the giant population with the available phase of industrialization, wages of laborers in China are relatively fewer than several other countries in the world. This situation could potency influence Chinese airlines' operational performance in both directions. First of all, fewer wages might aid airlines shearing their operational expenses related to their capitals. However, secondly fewer personnel expenditures stimulate more caution to personnel resource management about laborer fertility. Diverse manpower business tactics could be performed for liable fewer wages to develop

operational performance. Whether that is the status, afterward Chinese airlines could demand to proceed by their elevated workforce concentrated procedures. Whether it does not, afterwards the personnel shift system might be required. Top knowledge related with the impact of wages related to operational performance did not research inside airline sectors' situation, while the influence about profitability has been debated (Wu, He and Cao, 2013, p. 37). This recent field of expense possessions have rising potency in order to additionally expense restrictions inasmuch as the fast progress of information technology. Airlines require large expenses circulation in fields of ticketing, sales and presentation. Therefore, websites can increase airlines' marketing strength. For instance; the websites serve airlines marketing their labor-intensive universal in a cost-effective mode. The websites have different, significant and much slender advantages. Permitting of passengers to reserve straight over website, a database could be improved which authorizes airlines to present labor-intensive much pitched to passenger requirements at that authorizing them proactively marketing to these passengers. The use of website might ensure surroundings much vigorous and market-centered pricing. An airline could answer much rapidly to competitors' price shearing or deficiencies on recent reservations that could ordinarily consequence about undisposed of seats. To sum up, airlines might be benefit other cross-sell yields and labor-intensives using their websites (Doganis, 2001). India's civil aviation started operations in harshed civil aviation markets' (Bloomberg Business, 2015), despite the existence of costly taxes (Economic Times, 2012) and immensely fare-susceptible customers. Elevated fuel costs (50% over the cost in West Asian and European countries (BS reporter, 2011)), rising capacity and concentrated cost rivalry excited from ultimate universal stagnation have effected in sustained damages for generality about airlines. Such as the Kingfisher Airlines blocked up its processes in 2012 and flag carrier airline Air India recovered out (India Today, 2012) this duration by Indian administration's immunization about giant liquidity flows ($263.3 million in 2010-2011). The whole value of grand carriers in India is forecasted approximately $13 billion. This value in India has greater volume than adjacent countries. The reason for this situation is airlines' have beared from rivalry and economical repression by upper temporarily in fuel and foreign exchange ratios about financial grief (Merkert and Hensher, 2011, p. 689).

3. THE DIVISION OF CIVIL AVIATION SECTOR

In general, the civil aviation sector includes passenger and cargo transportation. Following 20 years air cargo sector is going to increase its capacity nearly two times among the ratio of all over the world GDP development, because of the quick enlargement of international commerce. International commerce has developed quicker than civil aviation passenger statistics. To sum up, the act of air cargo among air transportation sector will have progressively enlarged. Also, in the following years, air cargo development will be anticipated to be powerful. Accordingly, Boeing's prediction, world flyaway cargo is going to expanded approximately 6.4% per year following twenty years that value is quicker than either GDP increase or air passenger increase. So, an akin expectation was delivered by Airbus (2019). Furthermore, to elevated development, air cargo has happened foremost considerable determiners of the status in world economy. Airfreight might be carried near baggage of passenger aircrafts' and/or cargo aircrafts' configurations which are merely for that usage. For instance, in Hong Kong among 55% and 60% of air cargo has transported near baggage in cargo compartment of the passenger aircraft, hence two divisions (cargo and passenger) overlapped at a considerable aspect. For the passenger/cargo (combinational) airlines, passenger income for a lot of airlines has substantially greater than cargo income. When it is examined the best ten combinational airlines related with percentage of income, the cargo income percentage has approximately %35 and the passenger income percentage has approximately %65. These top 10 passenger/cargo airlines are; EVA Air, China

Airlines, Lan Chile, Asiana, Korean Air, Cathay Pacific, Singapore All Airlines, China Eastern, Emirates and Thai Airways (Hong and Zhang, 2010, p. 143). These airlines are flag carriers that carried both passengers and cargo. In addition to this information, the selected airlines for DEA analysis have carried both passengers and cargo like these airlines. The difference between the selected airlines is they do not allocate enough budget for the transportation of cargoes like passenger transportation.

4. THE SELECTED AIRLINES FOR DEA

In this DEA five airline partnerships or airlines are examined that included Turkish Airlines, Lufthansa, International Airlines Group, Air France - KLM Group and Aeroflot Group. These airlines are located in European Continent both carrying the most passengers and also giving the best service airlines according to evaluated in SKYTRAX World Airline Awards. Skytrax is a rating organization that examined more than 20 million data from a lot of countries (SKYTRAX World Airline Awards, 2019). Furthermore, these airlines are flag carriers. Low cost airlines such as Ryanair and easyJet have big passenger circulation like selected airlines, but they cannot be evaluated in the DEA Analysis. Because they are not used wide body aircraft and their service level is not included luxury details that presented in business and first-class services. Such as; refreshments, meal types, in-cabin service entertainments etc.

These five airlines' data are obtained from their websites. These websites are related to annual reports of airlines which includes financial and operational data. Airlines have two strategies in general. These are classified as; full service and low cost strategies. Full service carrier strategy is implemented by flag carrier airlines because of the luxury service standards and usage of wide body aircrafts. Therefore, these airlines are chosen for the DEA analysis.

5. DATA ANALYSIS – SAMPLE OF DATA

This study includes yearly data released by Available Seat Kilometer, Revenue Passenger Kilometer, Revenue Passenger (000), Number of Landings from 2011-2019 from 5 airline companies. The descriptive statistics of the original data are shown in Table 1. No transformation (log, ln, exponential etc.) is needed because the variables are distributed in a similar range. The inputs are selected as Revenue Passenger (000) and Number of Landings because of they are related with operational process. The outputs are selected as Available Seat Kilometer and Revenue Passenger Kilometer because they are related to financial throughputs. The inputs have created the outputs by using of passenger transportation. All data were taken from investors, shareholders and annual reports of airlines' web sites (lufthansagroup, 2019; iairgroup, 2019; airfranceklm, 2019; aeroflot, 2019; turkishairlines, 2019). Lufthansa Group comprises Lufthansa German Airlines, SWISS and Austrian Airlines. International Airlines Group comprises British Airways, Iberia, Aer Lingus, Sun Air of Scandinavia, BA City Flyer, LEVEL and Vueling Airlines. Air France - KLM comprises Air France, KLM, Transavia, Air Corsica, Martinair and Servair. Aeroflot Group comprises Aeroflot, Pobeda Airlines, Rossiya Airlines and Aurora Airlines. Turkish Airlines is not a group company and it only operates AnadoluJet as a subsidiary company under its structure.

Table 1. Descriptive Statistics of the Inputs and Outputs in Between 2011-2019

2011-2019 Mean±SD Med (Min-Max)	Inputs	Outputs		
	Revenue Passenger (000)	**Number of Landings**	**Available Seat Kilometer**	**Revenue Passenger Kilometer**
Turkish Airlines	143909±38792	113064±32820	57406±15034	420119±83233
	153209(81193-187696)	119372(58933-153186)	61248(32649-75114)	462767(270618-493876)
Lufthansa	293509±39888	235449±35997	103346±5819	945272±96117
	273973(258263-359567)	220395(200394-296511)	104593(91243-109670)	1001961(840945-1067362)
International Airlines Group	272750±46560	223142±42483	86206±24827	627260±127001
	272702(213193-337754)	221996(168617-285745)	88333(51687-118253)	660438(437411-775486)
Air France KLM Group	272354±27171	232575±26820	89661±10678	650004±28508
	276897(205177-299489)	235715(170321-263578)	89836(76053-104205)	650412(616029-685669)
Aeroflot Group	125852±41797	100649±35941	38656±14590	53241±105791
	120287(60004-190856)	93856(46077-156250)	37064(16391-60719)	390 (229-286700)

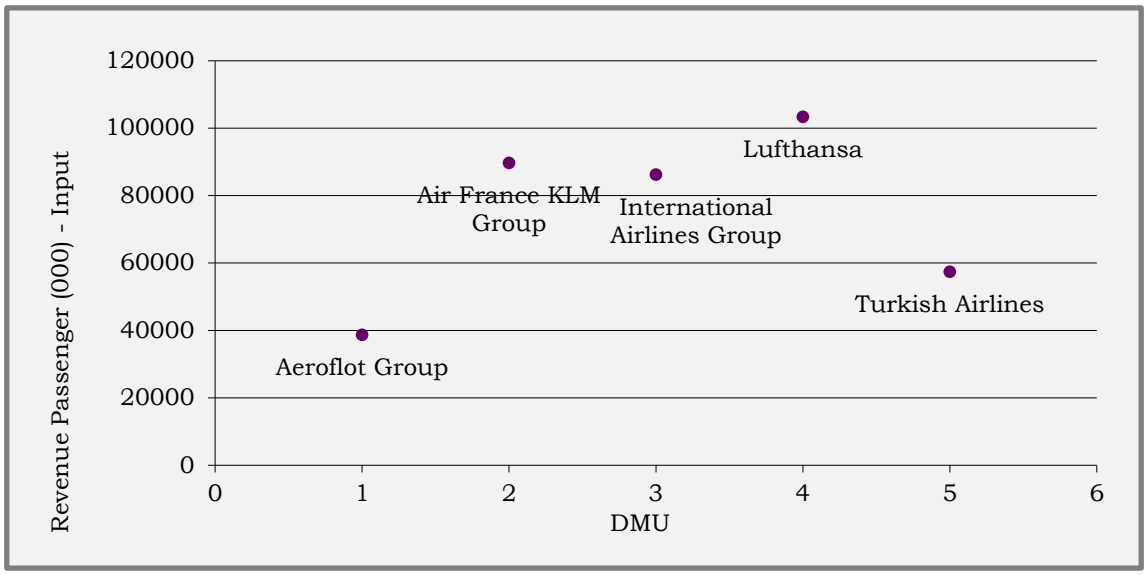

Figure 1. The mean of revenue passenger (000) for DMUs

In figure 1, the first ranking airline with the number of revenue passenger (000) is Lufthansa Group. The second ranking airline is Air France - KLM Group with a slight difference bigger than International Airlines Group. The fourth ranking airline is Turkish Airlines and the fifth ranking airline is Aeroflot Group. Aeroflot Group is the smallest airline as the number of revenue passenger, approxiamately %50 smaller than the fourth ranking airline which named as Turkish Airlines.

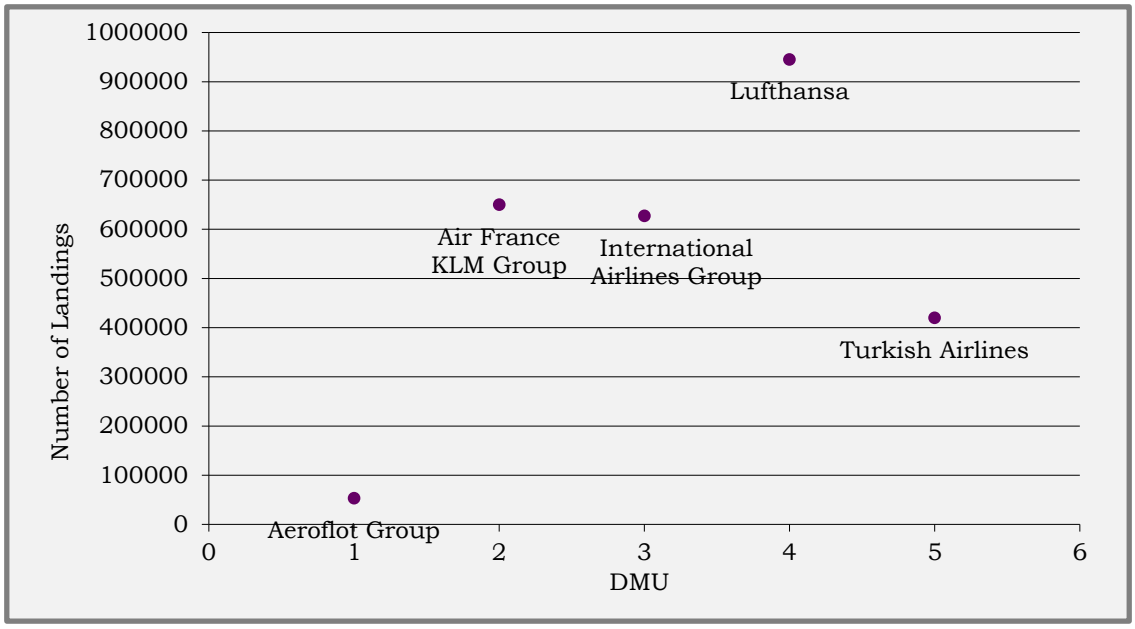

Figure 2. The mean of number of landings for DMUs

In figure 2, the first ranking airline with the number of landings is Lufthansa Group. The second ranking airline is Air France - KLM Group with a slight difference bigger than International Airlines Group. The fourth ranking airline is Turkish Airlines and the fifth ranking airline is Aeroflot Group with a very small number of landing. Aeroflot Group is the smallest airline as the number of landings, more than %500 smaller than the fourth ranking airline which named as Turkish Airlines.

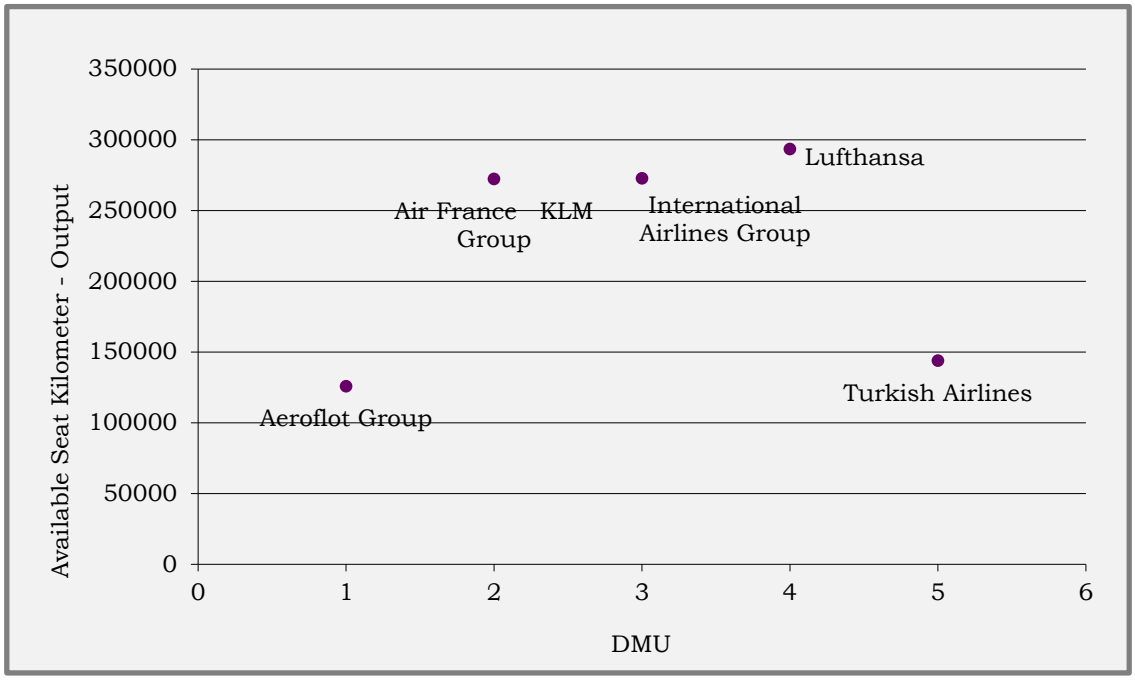

Figure 3. The mean of available seat kilometer for DMUs

In figure 3, the first ranking airline with the available seat kilometer is Lufthansa Group. The second ranking airline is International Airlines Group with a very slight difference bigger than Air France - KLM Group. The fourth ranking airline is Turkish Airlines with a slight difference bigger than Aeroflot Group. Aeroflot Group is the smallest airline with the ranking of available seat kilometer as revenue passenger and number of landings data.

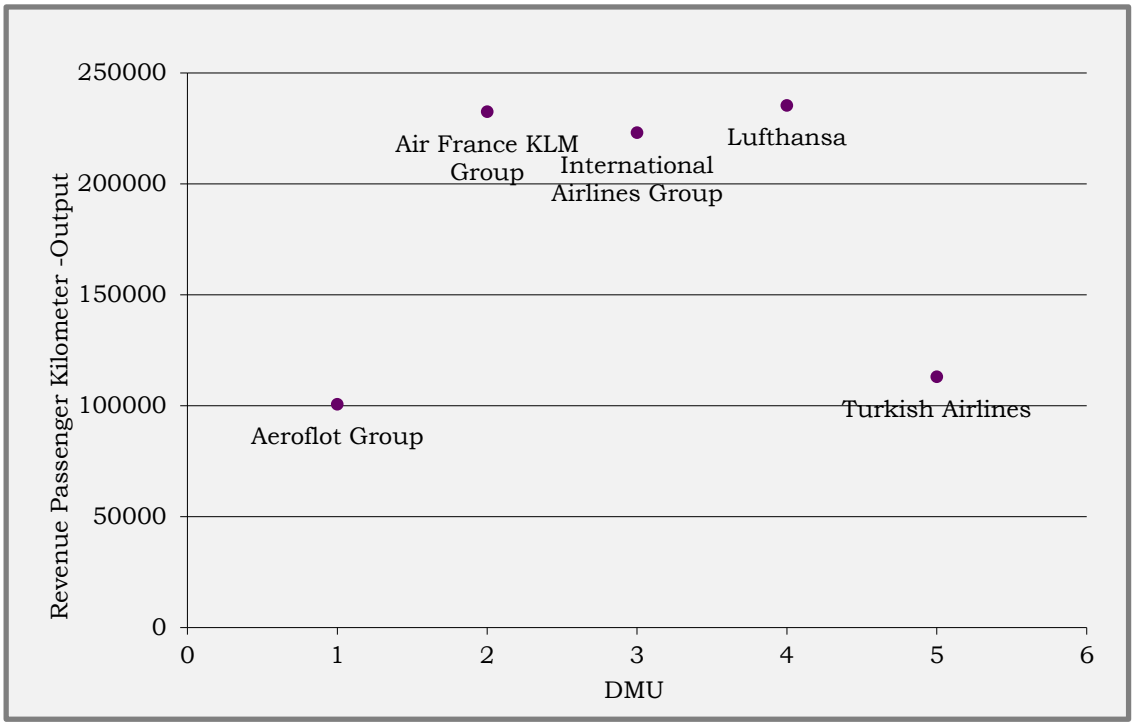

Figure 4. The mean of revenue passenger kilometer for DMUs

In figure 4, the first ranking airline with the revenue passenger kilometer is Lufthansa Group is a slight bigger than Air France - KLM Group. Air France - KLM group is also a slight more efficient than International Airlines Group. The fourth ranking airline is Turkish Airlines with a slight bigger than Aeroflot Group. Aeroflot Group is the smallest airline with the revenue passenger kilometre as revenue passenger, number of landings and available seat kilometre data. The Spearman's correlation analysis is utilized to investigate the relationships between inputs and outputs (Table 2).

It is found that there is a positive strong statistically significant correlation between inputs and outputs. For this reason, these variables can be included in DEA together to compute airline efficiencies (İnan, 2019, p. 68).

Table 2. Correlation Analysis Between Inputs and Outputs

2011-2019 r; p	**Input**		
		Revenue Passenger (000)	**Number of Landings**
Output	**Available Seat Kilometer**	1,000; <0,001	0,900; 0,037
	Revenue Passenger Kilometer	0,900; 0,037	1,000; <0,001

It is found that there is a positive strong statistically significant correlation between inputs and outputs. For this reason, these variables can be included in DEA together to compute airline efficiencies (İnan, 2019).

6. METHODOLOGY

DEA is a nonparametric approach to measure efficiency. DEA includes a linear programming solving problem for each decision-making unit (DMU). In DEA, technical efficiency (TE) can be measured under two assumptions: constant return-to-scale (RTS) and variable return-to-scale (VRS). The TE measure substituting to CRS supposition symbolizes overall technical efficiency (OTE) that measures inefficiencies because of the input/output configuration and as well as the extent of operations. The efficiency measure substituting to VRS supposition symbolizes pure technical efficiency (PTE) that measures inefficiencies because of solely managerial underperformance (Kumar and Gulati, 2008, p. 49). In this study, input oriented Charnes-Cooper-Rhoes (CCR-I) and Banker- Charnes, Cooper (BCC-I) models are utilized to obtain efficiency measures under CRS and VRS assumptions. Input oriented models are used when it is intended to produce the most output with the least input (Charnes et.al., 1978, p. 434). CCR models are used in the calculation of relative total activities under the assumption of constant return by scale, that is, based on the assumption that all DMUs operate at an optimal scale. However, in real life, there are systems with variable returns to scale. In 1984, Banker, Charnes and Cooper developed the BCC model, known by the initials of their names, to determine the efficiency of systems with scale-based returns (Banker et. al., 1984, p. 1087). The CCR-I and BCC-I models are given Table 3. Where n is the number of DMUs, s is the number of outputs, X_{ij} is the jth DMU of ith input and Y_{rj} is the jth DMU of rth output. θ_k is the kth DMU of efficiency score under $\theta_k^* = 1$ condition. u_r is the kth DMU weight of rth output, v_i is the kth DMU weight of ith input. ε is the positive very small number. λ_{jk} is the kth benchmark of the the DMU. MaxDEA software is used for DEA.

Table 3. CCR-I and BCC-I Models

CCR-I	BCC-I
$\min\theta_k$	
$\sum_{j=1}^{n} \lambda_{jk} X_{ij} \leq \theta_k X_{ik}$	$\max \sum_{r=1}^{s} u_r Y_{rk} - u_k$
$\sum_{j=1}^{n} \lambda_{jk} Y_{rj} \geq Y_{rk}$	$\sum_{r=1}^{s} u_r Y_{rj} - \sum_{i=1}^{m} v_i X_{ij} - u_k \leq 0$
$\lambda_{jk} \geq 0$, if CRS	$\sum_{i=1}^{m} v_i X_{ik} = 1$
$\sum_{j=1}^{n} \lambda_{jk} = 1$, if VRS	$u_r, v_i \geq \varepsilon > 0$

Where n is the number of DMUs, s is the number of outputs, X_{ij} is the jth DMU of ith input and Y_{rj} is the jth DMU of rth output. θ_k is the kth DMU of efficiency score under $\theta_k^* = 1$ condition. u_r is the kth DMU weight of rth output, v_i is the kth DMU weight of ith input. ε is the positive very small number. λ_{jk} is the kth benchmark of the the DMU. MaxDEA software is used for DEA.

7. DEA RESULTS

The airline companies which has efficiency score lower than 1 are evaluated as inefficient whereas airline companies with efficiency score equal to 1 is determined as efficient. According to table 4 comparison of efficiency scores show the results of DEA. According to this result, it was revealed that there is no connection between high operational and financial data with efficiency scores. As a result of CCR-I model with CRS, 1 of 5 airline company is found to be effective and 4 of them are ineffective. Aeroflot Group is found effective for CCR-I model. BCC-I model with VRS, 4 of 5 airline companies found to be effective and 1 of them is ineffective**.** Because the efficiency score

of 4 effective airlines are computed as 1. Aeroflot Group, Air France KLM Group, International Airlines Group, Lufthansa are found effective for BCC-I model. If a DMU is fully efficient according to the BCC model and inefficient according to the CCR model, it can be said that the DMU works efficiently locally, but not generally. Therefore, Air France - KLM Group, International Airlines Group, Lufthansa are found efficient locally but not generally. Turkish Airlines is found inefficient for both locally and generally.

Table 4. Comparison of Efficiency Score

		CCR-I		BCC-I	
NO	**DMU**	**Efficiency Score**	**Benchmark (Lambda)**	**Efficiency Score**	**Benchmark (Lambda)**
1	**Aeroflot Group**	1,000	Aeroflot Group (1,000)	1,000	Aeroflot Group (1,000)
2	**Air France - KLM Group**	0,996	Aeroflot Group (2,310)	1,000	Air France KLM Group (1,000)
3	**International Airlines Group**	0,994	Aeroflot Group (2,217)	1,000	International Airlines Group (1,000)
4	**Lufthansa**	0,875	Aeroflot Group (2,339)	1,000	Lufthansa (1,000)
5	**Turkish Airlines**	0,770	Aeroflot Group (1,143)	0,775	Aeroflot Group (0,877); International Airlines Group (0,122)

A substantial part of information that can be obtained by the application of DEA is the construction of the benchmark set for each inefficient unit. The benchmark set comprises of the fully efficient (efficiency score=1) units that operate closer to the corresponding inefficient one. In Table 4, the benchmark set for BCC-I consists of Aeroflot Group and International Airlines Group. An interpretation of the benchmark set is that if someone wishes to improve certain metrics for a particular inefficient airline, he/she could investigate the properties of the corresponding airline in its benchmark set, to look out for opportunities for improvement. In the context of airline efficiency analysis, it can be considered that the airlines in the reference set; precedes the airlines examined and is closer to the airlines passed. Consequently, for Turkish Airlines it would be preferable to investigate the properties of version Aeroflot Group and International Airlines Group. Lambda values are a measure of the relative importance of the other DMUs comprising the benchmark set of a DMU. More specifically, lambda is a vector describing the weights of efficient DMUs used for that DMU to obtain the maximum efficiency score.

8. CONCLUSION

This study reveals that the Aeroflot Group which has the lowest numbers is the most efficient airline in the analysis consisting of the number of revenue passengers and the number of landings in terms of operational parameters; available seat kilometer and revenue passenger kilometer in terms of financial parameters. Especially the average results were taken between the years 2011 and 2019, makes the research stronger. The reason for the study to be determined as the beginning of 2011 is that International Airlines Group started its operations as of January 1, 2011. The reason for choosing relevant parameters for analysis is due to the availability of relevant data on investors, shareholders and annual reports of airlines. The reason for not selecting the

load factor data is due to the fact it is obtained by dividing the available seat kilometer to the revenue passenger kilometer. Since the CCR-I efficiency scores of Air France - KLM Group and International Airlines Group are almost 1 in Table 4, these airlines can also be evaluated as effective. However, the low efficiency scores of Lufthansa Group and Turkish Airlines especially on the basis of CCR-I Efficiency Score can be explained as both of these airlines have flied too many destinations all over the world. Especially that Turkish Airlines is the most destination point flying airline in the world can explain why it is the lowest in terms of efficiency score. Although Turkish Airlines especially in African flights, have low efficiency scores as revenue passenger, available seat kilometer and revenue passenger kilometer data, Turkish Airlines make these flights have done for to improve the flight network and to stay as the airline flying the most routes in the world (318 destinations in 126 countries). By this way, this status has created a brand image. While Turkish Airlines has flied to 318 destinations in 126 countries, Aeroflot Group has flied to 159 destinations in 54 countries. So, it can be explained the Turkish Airlines' inefficiency and Aeroflot Group's efficiency scores in more detail with the number of destinations. In order for Turkish Airlines to be efficient, it is necessary to be applied the strategy of Aeroflot Group on a general basis according to CCR-I Results. Furthermore, in order to be efficient on a local basis according to BCC-I results Turkish Airlines should apply the strategy of Aeroflot Group and International Airlines Group.

Acknowledgement

The author would thank to the previous researchers who studied airline alliances and partnerships. I hope this article will support to civil aviation sector in the subject of airlines partnerships.

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Appendix A.

CCR-I Results

NO	DMU	Proportionate Movement (Revenue Passenger)	Slack Movement (Revenue Passenger)	Projection (Revenue Passenger)	Proportionate Movement (No. of Landings)	Slack Movement (No. of Landings)	Projection (No. of Landings)
1	Aeroflot Group	0	0	38656.450000	0	0	53241.389500
2	Air France - KLM Group	-334.656387	0	89325.899169	-2426.129724	-524550.075188	123028.239532
3	International Airlines Group	-503.385648	0	85702.725463	-3662.778027	-505559.499883	118038.055423
4	Lufthansa Group	-12916.684948	0	90429.426163	-118144.585738	-702579.513193	124548.123291
5	Turkish Airlines	-13202.706409	0	44202.960258	-96623.103670	-262615.762652	60880.578122

NO	DMU	Proportionate Movement (Available Seat Kilometer)	Slack Movement (Available Seat Kilometer)	Projection (Available Seat Kilometer)	Proportionate Movement (Revenue Passenger Kilometer)	Slack Movement (Revenue Passenger Kilometer)	Projection (Revenue Passenger Kilometer)
1	Aeroflot Group	0	0	125851.550000	0	0	100648.712500
2	Air France - KLM Group	0	18459.343073	290813.120851	0	0	232575.333333
3	International Airlines Group	0	6267.476615	279017.365503	0	0	223141.777778
4	Lufthansa Group	0	897.031556	294405.809333	0	0	235448.555556
5	Turkish Airlines	0	0	143909.000000	0	2025.783162	115090.005385

Appendix B.

BCC-I Results

NO	DMU	Proportionate Movement (Revenue Passenger)	Slack Movement (Revenue Passenger)	Projection (Revenue Passenger)	Proportionate Movement (No. of Landings)	Slack Movement (No. of Landings)	Projection (No. of Landings)
1	Aeroflot Group	0	0	38656.450000	0	0	53241.389500
2	Air France KLM Group	0	0	89660.555556	0	0	650004.444444
3	International Airlines Group	0	0	86206.111111	0	0	627260.333333
4	Lufthansa Group	0	0	103346.111111	0	0	945272.222222
5	Turkish Airlines	-12904.183738	0	44501.482929	-94438.385923	-201878.500966	123802.557555

NO	DMU	Proportionate Movement (Available Seat Kilometer)	Slack Movement (Available Seat Kilometer)	Projection (Available Seat Kilometer)	Proportionate Movement (Revenue Passenger Kilometer)	Slack Movement (Revenue Passenger Kilometer)	Projection (Revenue Passenger Kilometer)
1	Aeroflot Group	0	0	125851.550000	0	0	100648.712500
2	Air France KLM Group	0	0	272353.777778	0	0	232575.333333
3	International Airlines Group	0	0	272749.888889	0	0	223141.777778
4	Lufthansa Group	0	0	293508.777778	0	0	235448.555556
5	Turkish Airlines	0	0	143909.000000	0	2641.926722	115706.148944

GENİŞLETİLMİŞ ÖZET

Giriş

Havayolu ortaklıkları, güzergâh sayılarını ve uçuş sıklığını geliştirerek havayollarının operasyonel verimliliğini artırmak için önemlidir. Genel olarak havayolu ortaklıkları, iki veya daha fazla havayolu arasındaki rekabet edilebilirliği ve tam verimliliği artırma amacını taşıyan karşılıklı operasyonlar dâhil olmak üzere herhangi bir ortaklık düzenlemesini kapsar. Dünya çapında havayolu sektörünün rekabet düzeyinin artması müteakip olarak ortaklık kategorilerini de beraberinde getirmiştir. Son yirmi yıldır gelişen havayolu ortaklıklarına örnek olarak dünya çapında üç ittifak grubu (Star Alliance, SkyTeam, Oneworld), dünya çapında havayolu sektörünün paydaşlarını güçlendirmeye başlamıştır. Özellikle 1997 yılında Star Alliance topluluğunu modelleyen beş havayolunun sayışı günümüzde 62 havayoluna ulaşmıştır. Dünya çapındaki ittifak gruplarıyla ilgili çarpıcı durum, 2012 ve 2016 yılları arasında bu üç ittifak grubunun tüm dünyadaki yolcu taşımacılığının yüzde altmışından fazlasını taşıdığı gerçeğidir.

Genel Çerçeve

Hava taşımacılığı pazarı önemli bir değişim geçirmiştir. Avrupa, Kuzey Amerika ve Avustralya'daki deregülasyon aşaması önemli ölçüde gelişmiş bir rekabete yayılarak, eskiden devlete ait olan birçok Avrupalı havayolları büyük ölçüde özelleştirilmiştir. Bu özelleşme sonucunda düşük maliyetli taşıyıcıların büyük ölçekli pazara girişi rekabeti arttırarak, biletler için ödenen fiyatları etkilemiştir. Ancak gerçekleştirilen analizde geniş gövde uçakların kullanımı ve konfor-hizmet düzeyinin ölçülebilir olması nedeniyle bayrak taşıyıcı geleneksel havayolları çalışmamızın içeriğini oluşturmaktadır.

Veri Zarflama Analizi için Seçilmiş Havayolları

Bu analizde Türk Hava Yolları, Lufthansa, International Airlines Group, Air France - KLM Group ve Aeroflot Group'u içeren beş havayolu ortaklığı veya havayolları incelenmektedir. Avrupa Kıtası'nda bulunan bu havayolları, SKYTRAX Dünya Havayolu Ödüllerine göre hem en çok yolcu taşıyan hem de en iyi hizmeti veren havayollarını içermektedir. Skytrax, birçok ülkeden 20 milyondan fazla veriyi inceleyen bir derecelendirme kuruluşudur. Ryanair ve easyJet gibi düşük maliyetli havayolları, seçilen havayolları gibi büyük yolcu sirkülasyonuna sahiptir, ancak bu havayolları VZA Analizinde değerlendirilememektedir. Çünkü bu havayolları geniş gövdeli uçaklar kullanılmamakta ve hizmet seviyelerinde iş ve birinci sınıf hizmetlerde sunulan lüks ikramları (ikramlar, yemek çeşitleri, kabin içi servis eğlenceleri vb.) tercih etmemektedir.

Bu beş havayolunun verileri web sitelerinden elde edilmiştir. Bu web siteleri, finansal ve operasyonel verileri içeren havayollarının yıllık raporları ile ilgilidir. Havayollarının genel olarak iki stratejisi vardır. Bu stratejiler; tam hizmet ve düşük maliyetli olarak ikiye ayrılır. Tam hizmet taşıyıcı stratejisi, lüks hizmet standartları ve geniş gövdeli uçakların kullanımı nedeniyle bayrak taşıyıcı havayolları tarafından uygulanmaktadır. Bu nedenle, bu havayolları VZA analizi için seçilmiştir.

Veri Analizi - Veri Örneği

Bu çalışma, 5 havayolu şirketinden 2011-2019 arası Arz Edilen Koltuk Kilometresi, Gelir Getiren Yolcu Kilometre, Yolcu Başına Gelir Kilometre ile ilgili yıllık verileri içermektedir. Analiz için seçilen havayollarını incelersek; Lufthansa Group; Lufthansa German Airlines, SWISS ve Austrian Airlines'dan oluşmaktadır. International Airlines Group; British Airways, Iberia, Aer Lingus, Sun Air of Scandinavia, BA City Flyer, LEVEL ve Vueling Airlines'tan oluşmaktadır. Air France - KLM; Air France, KLM, Transavia, Air Corsica, Martinair ve Servair'den oluşmaktadır. Aeroflot Group;

Aeroflot, Pobeda Havayolları, Rossiya Havayolları ve Aurora Havayollarından oluşmaktadır. Türk Hava Yolları bir grup şirketi olmayıp, sadece AnadoluJet'i kendi bünyesinde bir yan kuruluş olarak işletmektedir.

Metodoloji

VZA, verimliliği ölçmek için parametrik olmayan bir yaklaşımdır. VZA, her karar verme birimi (DMU) için doğrusal bir programlama çözmeyi içerir. VZA' da, teknik verimlilik (TE) iki varsayım altında ölçülebilir. Bunlar; sabit ölçeğe dönüş (RTS) ve değişken ölçeğe dönüş (VRS) olarak ikiye ayrılır. Bu çalışmada, CRS ve VRS varsayımları altında verimlilik ölçümleri elde etmek için girdi odaklı Charnes-Cooper-Rhoes (CCR-I) ve Banker-Charnes, Cooper (BCC-I) modelleri kullanılmıştır. Girdi yönelimli modeller, en az girdiyle en fazla çıktıyı üretmek amaçlandığında kullanılır. CCR modelleri ölçeğe göre sabit getiri varsayımı altında, yani tüm DMU'ların optimum ölçekte çalıştığı varsayımına dayalı olarak göreli toplam faaliyetlerin hesaplanmasında kullanılır. Bu doğrultuda 1984 yılında Banker, Charnes ve Cooper, ölçek tabanlı getirili sistemlerin verimliliğini belirlemek için isimlerinin baş harfleriyle bilinen BCC modelini geliştirdiler.

VZA Sonuçları

Verimlilik puanı 1'in altında olan havayolu şirketleri verimsiz olarak değerlendirilirken, verimlilik puanı 1'e eşit olan havayolu şirketleri verimli olarak değerlendirilir. Tablo 4'e göre verimlilik puanlarının karşılaştırılması VZA sonuçlarını göstermektedir. Bu sonuca göre, yüksek operasyonel ve finansal veriler ile verimlilik puanları arasında bağlantı olmadığı ortaya çıkmıştır. CRS ile CCR-I modeli sonucunda 5 havayolu şirketinden 1'i etkili, 4'ü etkisiz bulunmuştur. Aeroflot Grubu, CCR-I modeli için etkili bulunmuştur. VRS'li BCC-I modeline göre, 5 havayolu şirketinden 4'ü etkili, 1'i etkisiz bulunmuştur. 4 etkili havayolunun verimlilik skoru 1 olarak hesaplandığından BCC-I modeli için Aeroflot Group, Air France KLM Group, International Airlines Group ve Lufthansa Group etkili bulunmuştur. Bir DMU, BCC modeline göre tamamen verimli ve CCR modeline göre verimsiz ise, DMU'nun yerel olarak verimli çalıştığı ancak genel olarak çalışmadığı söylenebilir. Bu nedenle, Air France - KLM Group, International Airlines Group, Lufthansa yerel olarak verimli bulunurken genel bazda bulunmamıştır. Türk Hava Yolları ise hem yerel hem de genel bazda verimsiz bulunmuştur.

Sonuç

Bu çalışma en düşük sayıya sahip olan Aeroflot Grubunun operasyonel parametreler, gelir getiren yolcu sayısı ve iniş sayılarından oluşan analizde finansal parametreler, arz edilen koltuk kilometre ve gelir getiren yolcu kilometre verileri açısından operasyonel parametreler altında en verimli havayolu olduğunu ortaya koymaktadır. Özellikle 2011-2019 yılları arasında alınan ortalama sonuçlar araştırmanın doğruluk oranını daha da güçlendirmektedir. Çalışmanın 2011 yılı başı olarak belirlenmesinin nedeni, International Airlines Group'un 1 Ocak 2011 itibariyle faaliyetlerine başlamış olmasıdır. Air France - KLM Group ve International Airlines Group'un CCR-I verimlilik skorları Tablo 4'te neredeyse 1 olduğu için bu havayolları da etkili olarak değerlendirilebilir. Ancak Lufthansa Grubu ve Türk Hava Yolları'nın özellikle CCR-I Verimlilik Skoru bazında düşük verimlilik skorları, her iki havayolunun da tüm dünyada çok sayıda güzergâha uçmuş olmasıyla açıklanabilir. Özellikle Türk Hava Yolları'nın dünyada en çok uçan havayolu olması, verimlilik puanı açısından neden en düşük olduğunu açıklayabilir. Türk Hava Yolları özellikle Afrika uçuşlarında gelir getiren yolcu kilometre olarak düşük verimlilik puanlarına sahip olmasına rağmen, Türk Hava Yolları bu uçuşları uçuş ağını iyileştirmek ve en çok rotaya uçan havayolu olarak kalmak amacıyla gerçekleştirmektedir. Böylelikle bu durum bir marka imajı oluşturmuştur. Türk Hava Yolları 126 ülkede 318 noktaya uçarken, Aeroflot Grubu

54 ülkede 159 noktaya uçmaktadır. Böylece Türk Hava Yolları'nın verimsizliği ve Aeroflot Grubu'nun verimlilik puanları, güzergâh sayısı ile daha detaylı açıklanabilir. Türk Hava Yolları'nın verimli olabilmesi için, Aeroflot Grubu'nun stratejisini CCR-I sonuçlarına bağlı genel bazda uygulaması gerekmektedir. Ayrıca, BCC-I sonuçlarına göre yerel bazda verimli olabilmek için Türk Hava Yolları, Aeroflot Grubu ve Uluslararası Havayolları Grubu'nun stratejisini uygulamalıdır.