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An Optimization Modelling to Evaluate Flights Scheduling at Tourist Airports

Dimitrios J. Dimitriou

***Abstract*—**Airport's serving a tourist destination are an essential counterpart of the tourist demand supply chain, and their productivity is related to the region's attractiveness and is enhanced by the air transport business. In this paper, the evaluation framework of the scheduled flights between two tourist airports is taken into consideration. By adopting a systemic approach, the arrivals from an airport that its connectivity heavily depended on the departures of another major airport are reviewed. The methodology framework, based on inventory control theory and the numerical example, promotes the use of the modelling formulation. The results would be essential for comparison and exercising to other similar cases.

***Keywords*—**Airport connectivity, inventory control, optimization, optimum allocation.

I. Introduction

AIR connectivity, especially for south European countries, plays an important role in regional and economic development, and in many cases, it is the main source of income for residents. Despite an unstable economic environment, southern European islands have faced enormous growth in the tourist field during the last decade, which in turn, has significantly increased the demand for air travel.

Air connectivity and tourism are mutually interlinked. References [1] and [2] highlighted the relationship between tourism and air connectivity and concluded that any changes in aviation efficiency are closely linked to tourism development. On the one hand, new forms of tourism and new destinations influence air transport demand while, on the other hand, airports provide essential infrastructure to support regional, social and economic growth and become commercial entities in their own right, capable of generating returns on investment to the benefit of their shareholders, other stakeholders and to society as a whole [1].

The linkage between the two industries has been investigated in order to define the different tourism demand patterns and support decisions towards local market growth. In the complex aviation business environment, the behavioral aspects of demand and the business regulatory framework influence the decisions of strategic planning and the effective fund allocation of local airport infrastructures.

Despite recent economic uncertainty, air travel grew 2.5 times as fast as global Gross Domestic Product (GDP) over the last 20 years [3]. ATAG [4] announced that the overall economic activity generated by air transport is estimated at 3.4% of global GDP. This continuing trend of air traffic growth has, however, not been matched by an adequate expansion of air transport infrastructure, and the aviation industry is facing the challenge of dealing with a range of congestion problems [5].

Especially for Mediterranean countries, air transport for leisure purposes is the most important enabler to achieving economic growth and development. Air transport facilitates integration into the economy and provides vital connectivity on a national, regional, and international scale between countries, promoting tourism growth, and creating employment opportunities in tourist destinations.

D. J. Dimitriou is Assistant Professor in Department of Economics, Democritus University of Thrace, Greece, Panepistimioupoli, 69100 Komotini, (phone: +30 25310 39507, fax: +30 25310 39830, e-mail: ddimitri@econ.duth.gr).

II. Air Connectivity in Tourist Regions

The link between tourism and the aviation industry is on the top of the agenda for many academic institutes, professional bodies and regulatory authorities. Airports serving tourist destinations are essential counterpart of the tourist demand supply chain. The link between tourism and aviation industry is on the top of the agenda for many academic institutes, professional bodies and regulatory authorities [6].

Air connectivity facilitates and generates wider economic performance: it promotes higher investment both from within the country and from foreign direct investment; it improves tourism activity [7]. Moreover, air transportation and economic development interact with each other as aviation makes significant direct and indirect contributions to the economy and increases the cycle of economic activity. In particular, air connectivity, as an indicator of a network's concentration and its ability to move passengers from their origin to their destination is a vital component of a country's socioeconomic development, because it creates wider economic benefits of trade in services and goods, tourism, investment, productivity and innovation.

By understanding how air connectivity is measured, how it has changed, how it spurs economic growth, and what drives it, key aviation stakeholders can make strategic decisions on how to enable and unlock the air connectivity potential of a country. Air connectivity is a key driver for growth, especially for the attractive tourist destinations [7], [8].

III. Methodology Concept

The research question is the optimization of inbound flights from a tourist region (Hub Airport A) to reach the benefits of air connectivity of a greater hub airport (Hub Airport B). The optimization framework based on a hub and a spoke air transport network, ultimately examines the possible optimum allocation of connections between Hub tourist airport A and a

larger hub tourist airport B for improving the connectivity to tourist market of airport A.

The mathematical formulation of optimum allocation of the connection flights between a hub and a spoke tourist destination is comprised of three groups of conditions [9]:

Objective function: Maximization of connecting flights from flights arriving from airport A in terms of:

a) Domestic and international departures from airport B;
b) Short haul and long-haul destinations connected to airport B;
c) High demand air corridors, in other words major hubs at the intercontinental scale.

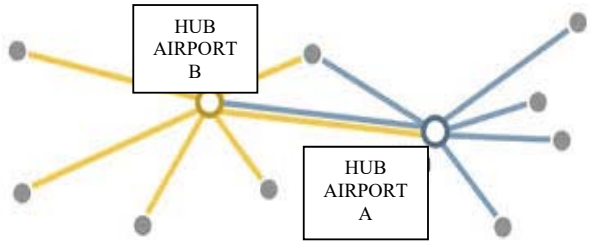

Fig. 1 Depiction of air connectivity between hub and spoke tourist airports

This formulation is very beneficial for island tourist destinations, where the dependency of airport A from airport B is too high. In other words, the connectivity of airport A depends on flights connecting with airport B, which provides a much higher number of flight connections with the tourist market.

IV. Modelling Formulation and Assumptions

The modelling formulation based on the inventory control theory, whereby developing an optimization structure the existing schedule services are evaluated over time.

The assumptions adopted regarding the operation characteristics of connection flights at airports are:

- Lower connection time is 60 min for scheduled carriers;
- Seat availability in connecting flights;
- Maximum transfer time up to the next arrival from when flights arrive from airport A to departure flights at airport B, despite the flight carrier;
- Additional cost or special offers for transfer passengers;
- All connectivity destinations attract demand;
- Domestic destination is less relevant than international destinations.

Based on the above assumptions, the optimum allocation of connecting flights is formulated as an optimization problem solved with linear programming based on objective function:

$$maxCFAF_{(i,j)} = \sum(DF_j - DF_j t_i) \quad (1)$$

Subject to:

$t_i > 1$
$t_i < +1$
$t_i < t_{AFi+1}$
$DF_j > DF_j,t_i$
$AF_i, DF_j, DF_j,t_i > 0$
AF_i, DF_j, DF_j,t_i is an integer number, 1,2,3…

where: $CFAF_{i,j}$ = sum of departures j from airport B for each flight i arrive from airport A during the same day (24 hours); DF_j = sum of departures from airport B for each day; DF_j,t_i = sum of departures from airport B; AF_i = arrival time of the flight i form airport A to airport B; t_{AFi} = arrival time of the flight AF_i form airport A to airport B; t_{AFi+1} = arrival time of the next flight of the AF_i form airport A to airport B.

Based on the above formulation, it is possible to illustrate results regarding on best connection flights between airport A and B and provide suggestions for the optimum scheduling of existing flights arriving from airport A that will increase attractiveness for both airports.

V. Case Study

Greece and Cyprus are among the top Mediterranean tourism destinations. The largest airports of each island are of vital importance with a strategic position. In this section, data analysis on air connectivity features between Athens International Airport as the main airport in Greece and Larnaca International Airport as the main airport of Cyprus is given in order to highlight the possibility of optimum air connectivity allocation between the two airports.

Greece and Cyprus main airports, two of the top Mediterranean tourism destinations, are two hubs of vital importance with a strategic advantage in the surrounding area. In analysis review the existing air transport and current leisure air connectivity between the two countries and specifically between Athens International Airport as the main airport in Greece and the Airports of Cyprus is analyzed. In order to capture these characteristics, a combined measure which assesses the base level of connectivity and the trends of leisure connectivity based on annual flights is analyzed. In portraying the air transport sector in these countries, this research assesses possible concerns in relation to current and potential future air connectivity gaps, enabling detailed analysis to identify trends and analyzing the connection by route and airline and the number of connecting vs. direct passengers in the two main hub airports.

Athens International Airport (ATH) in 2016 accommodated 20 mio total number of passengers (surpassing previous year traffic by 1.9 million (+10.7%). Both domestic and international passengers achieved high growth levels of 11.2% and 10.4%, respectively, reaching 7.15 million and 12.87 million [10]. This growth was driven by both Greek residents' dynamic growth of 15%, as well as that of foreign residents of 8%. In addition, 26% of the total accommodated pax were business travelers, while 23% were connecting passengers [10].

Larnaca International Airport (LCA) in 2016 accommodated 6.63 mio total number of passengers; thus, it is assumed that Athens International Airport serves as a hub airport, where Larnaca Airport serves as a spoke [11].

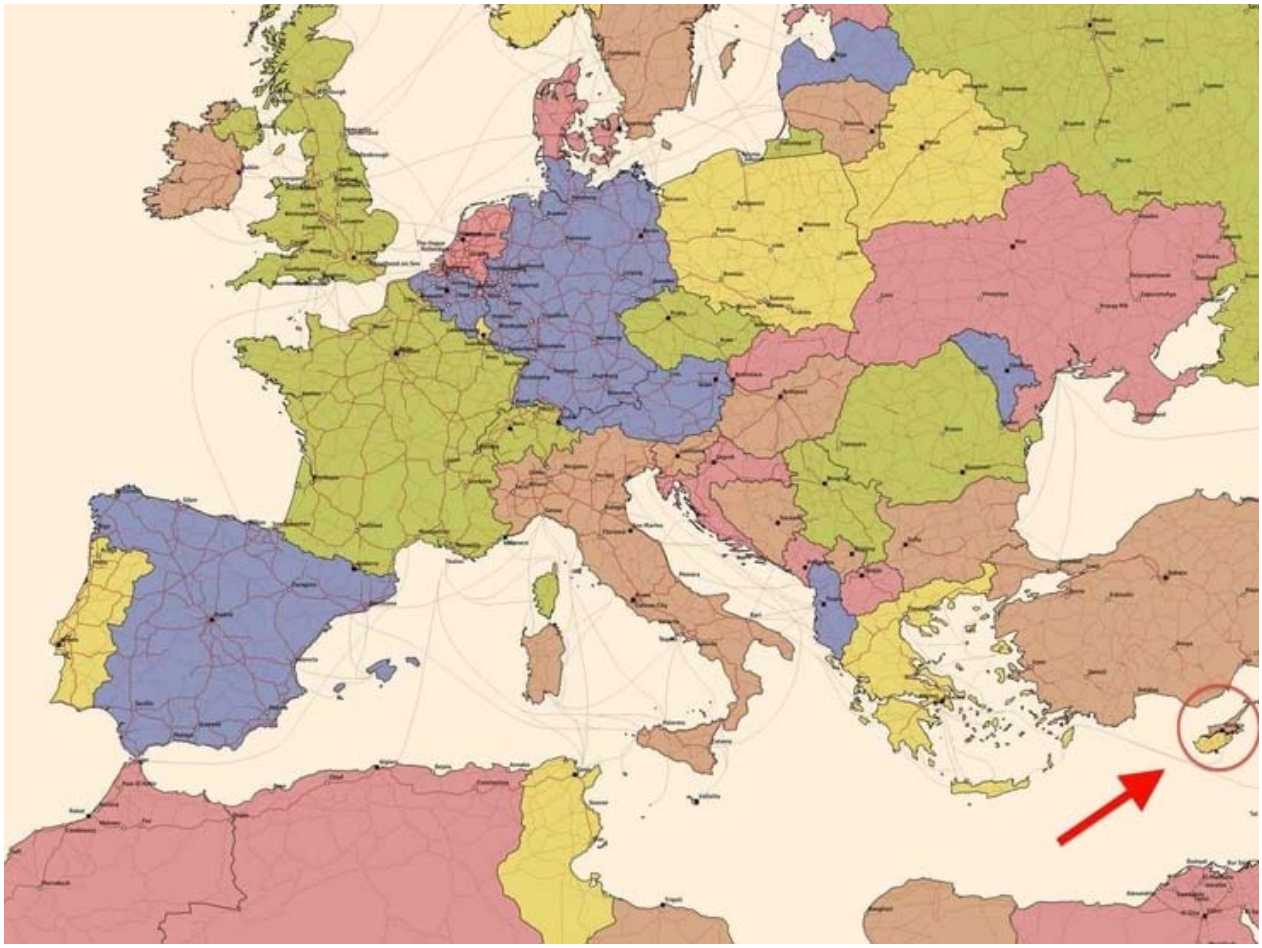

Fig. 2 Geographical location of Larnaca/Cyprus and Athens/Greece

Observations on data analytics on the specific window sample show there is a daily direct flight from Larnaca Airport to Athens International Airport. The carriers serving the direct connection between Larnaca and Athens are four, and they are Aegean Airlines, Cobalt, Blue Air and Hahn Air, while the connection between Pafos and Athens is served only by Cobalt.

There is finally a high diversification in fares. The lowest fare from Larnaca Airport for a one way route to Athens is 47€, offered by Blue Air and the highest fare is 162€, offered by Aegean Airlines.

The specific time window is the first weeks of June 2017 (and especially 15-6-2017 to 30-6-2017). Data analysis on direct flights, carriers serving this route, and the lowest fare and the highest fare are presented analytically in Table I.

The next step is to analyze how passengers may use this hub-and-spoke network. In order to optimize how this hub and spoke network may be used, a specific time window, thus a specific day (Monday 26th June) was selected to illustrate the results.

VI. Case Study Results

The analysis of the connecting flights at Athens airport for all flights arriving from Larnaca to Athens is given in Fig. 3.

Solving the optimization problem depicted in the objective function (1), the key results are depicted in Table III.

TABLE I
SCHEDULED FLIGHTS BETWEEN ATH AND LCA AIRPORTS FOR A TYPICAL DAY IN THE SUMMER SEASON (JUNE 15TH, 2017)

Direct flights	Scheduled Carriers	Lowest fare	Highest fare
13	4	Blue Air 95€	Hahn Air 205€
14	4	Blue Air 102€	Hahn Air 204€
9	4	Cobalt 67€	Hahn Air 118€
14	4	Blue Air 57€	Hahn Air 118€
12	4	Blue Air 57€	Aegean 146€
10	4	Cobalt 66€	Aegean 247€
9	4	Blue Air 52€	Aegean 162€
13	4	Blue Air 57€	Aegean 148€
14	4	Blue Air 72€	Aegean 182€
9	4	Cobalt 66€	Aegean 162€
14	4	Blue Air 52€	Hahn Air 118€
12	4	Blue Air 47€	Hahn Air 118€
10	4	Cobalt 67€	Aegean 138€
9	4	Blue Air 72€	Aegean 138€
13	4	Blue Air 72€	Aegean 162€
14	4	Cobalt 110€	Hahn Air 204€

TABLE II
CONNECTING FLIGHTS AT ATHENS AIRPORT FOR FLIGHTS ARRIVING FROM LARNACA (JUNE 15TH, 2017)

Arrival time at ATH	Number of scheduled domestic flights from ATH	Number of scheduled International flights from ATH
07:00	13	14
08:30	7	14
09:15	2	-
09:45	12	15
12:15	20	33
17:30	14	18
20:00	1	3
20:20	-	-
20:25	13	11
22:45	-	11

TABLE III
CONNECTING FLIGHTS FROM ATHENS AIRPORT

Flight	Arrival time at ATH	Domestic destinations in Greece	International destinations from ATH	Sum of Domestic and International
AF_1	06:55	14	24	38
AF_2	08:30	14	25	39
AF_3	09:15	42	37	79
AF_4	09:15	42	37	80
AF_5	09:45	45	40	85
AF_6	12:15	35	58	93
AF_7	17:30	18	25	43
AF_8	20:00	16	22	38
AF_9	20:20	14	21	35
AF_{10}	20:30	12	20	32
AF_{11}	22:45	3	3	6
Sum		255	312	567

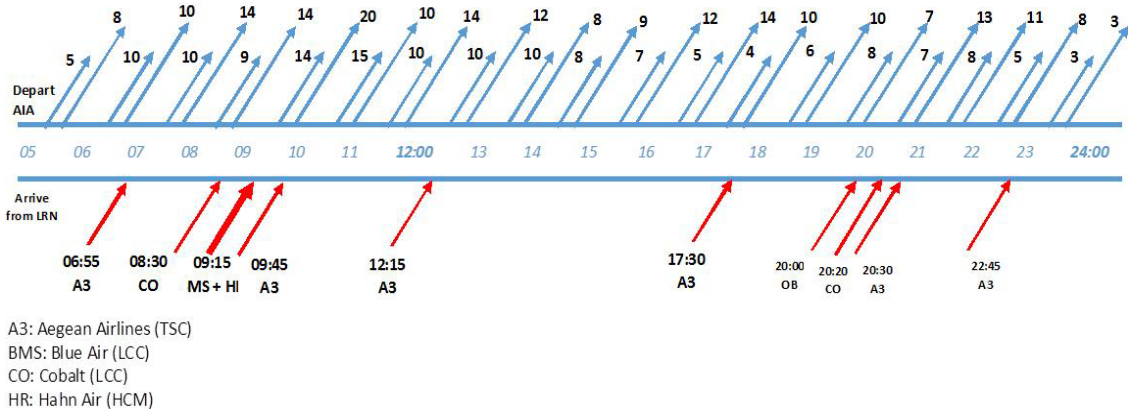

Fig. 3 Depiction of arrival and departure flights between Larnaca/Cyprus and Athens/Greece on June 15th, 2017

According to the above results, the key messages could be summarized as:

- the last flight at a late hour is not improving the connectivity and the only reasonable reason to exist is to serve the business traffic between Cyprus and Greece;
- flight AF5 presents the highest attractiveness because it provides the largest number of connections;
- the competition for flights AF_3, AF_4 and AF_5 is too high, arriving within 30 minutes of each other and providing the same level of connection options to passengers;
- the competition for flights AF_8, AF_9 and AF_{10} e is also very high, even though all are providing a low number of connection flights (less than 38).

The recommendations to air carriers, deals with the best allocation of arrival time for this air corridor, which could be summarized in the following:

- if flight AF_6 arrived 1 hour earlier, connection flights will be increased by 20 without essential competition from the previous flights;
- there are three flights between 20:00 – 20:00 providing connections to maximum 38 destinations, therefore it would be more beneficial to at least 1 to provide services in other time windows.

VII. CONCLUSION

Tourism and regional socioeconomic development is based on the optimization of air connectivity between hub and spoke airports serving tourist destinations. Airports serving tourism destinations develop hub and spoke networks to provide optimum connectivity between popular origins and destinations.

The main airports of Greece and Cyprus, two top Mediterranean tourism destinations, are both hubs of vital importance with a strategic advantage in the surrounding area. In this research paper, an overview of the existing air transport and current leisure air connectivity between the two countries and specifically between Athens International Airport as the main airport in Greece and the airports of Cyprus is analyzed. In order to capture these characteristics, a combined measure which assesses the base level of connectivity and the trends of leisure connectivity, based on annual flights, as wells at the key determinants for passengers travelling for leisure purposes, thus the fares and available capacity to the destinations are analyzed.

In portraying the air transport sector in these countries, this research assesses possible concerns in relation to current and potential future air connectivity gaps, enabling detailed analysis to identify trends and relationships, on passengers by route and airline, number of connecting vs. direct passengers in the two main hub airports.

The assessment concept and methodology provided is an essential tool for planners, economists, analysts and

researchers. The application results are essential for comparisons with other destinations and provide key messages regarding the relationship of air connectivity and air transport connectivity development in remote tourist destinations especially in the Mediterranean region.

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