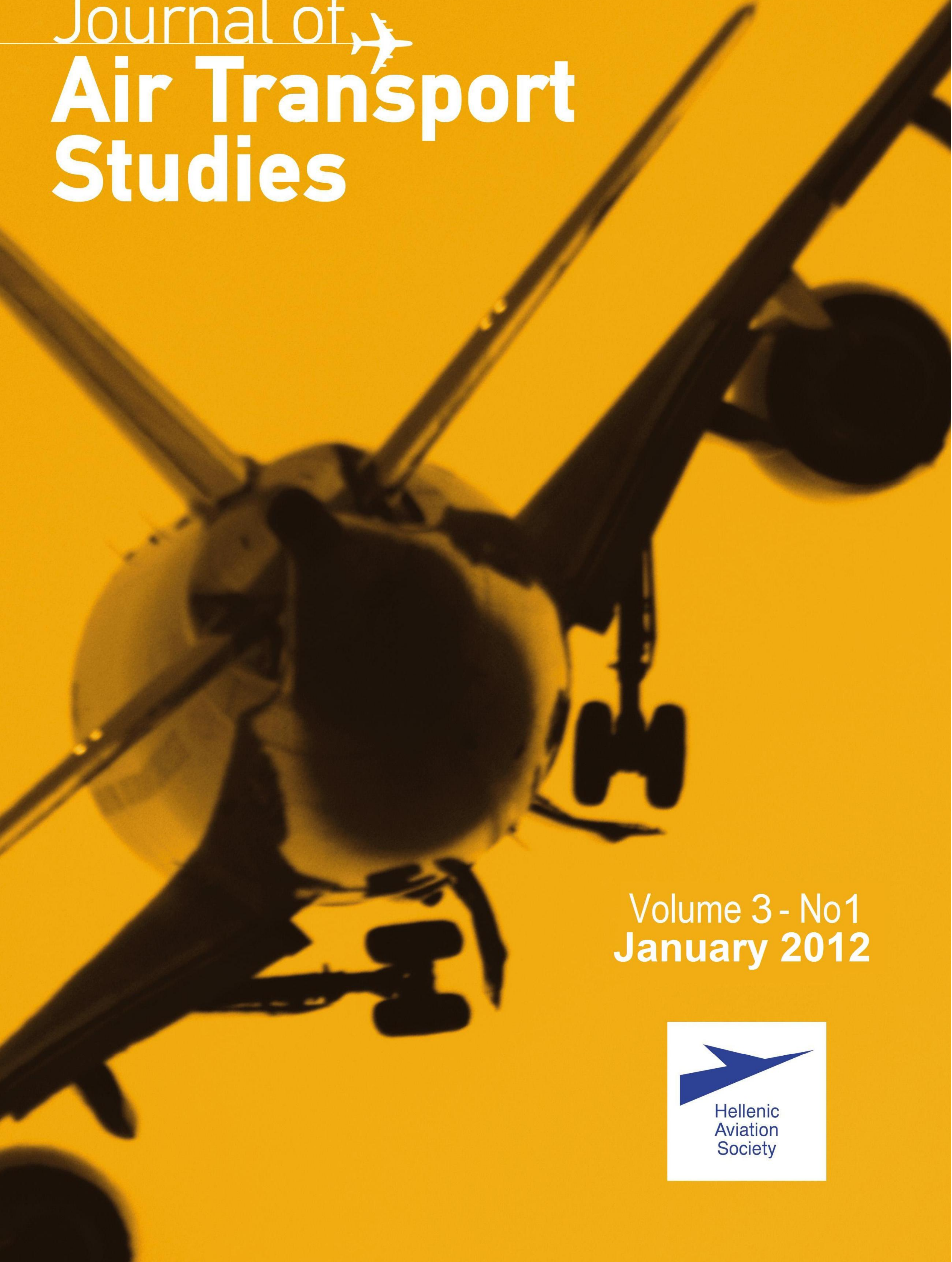
# Journal of Air Transport Studies



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The *Journal of Air Transport Studies* (JATS – ISSN: 1791-6771) is a peer reviewed journal aiming at publishing high quality research related to air transport. JATS is interested in publishing papers primarily focusing on economics, geography, policymaking, management, marketing, operations, technology, logistics/supply chain management and modelling.

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- Fragoudaki, A., Keramianakis, M. and Jancovich, S. (2005) The Greek PSO Experience. *4th International Forum on Air Transport in Remoter Regions*. Stockholm, May 24-26.
- Forsyth P. (2002a), 'Privatization and Regulation of Australian and New Zealand Airports', *Journal of Air Transport Management*, 8, 19-28.
- Papatheodorou, A. (2008) The Impact of Civil Aviation Regimes on Leisure Market. In Graham, A., Papatheodorou, A. and Forsyth, P. (ed) *Aviation and Tourism: Implications for Leisure Travel*, Aldershot: Ashgate, 49-57.
- Skycontrol (2007) *easyJet welcomes European Commission's decision to limit PSO abuse in Italy*. 23rd April. Available from: http://www.skycontrol.net/airlines/easyjet-welcomes-european-commissions-decision-to-limit-pso-abuse-in-italy/ (accessed on 22/08/2008).

*Conference Reports* should be between 1,000 and 1,500 words. They should provide factual information (e.g. conference venue, details of the conference organizers), present the various programme sessions and summarize the key research findings.

*Book Reviews* should be between 1,000 and 1,500 words. They should provide factual information (e.g. book publisher, number of pages and ISBN, price on the publisher's website) and critically discuss the contents of a book mainly in terms of its strengths and weaknesses.

*Industry Perspectives* should be up to 1,000 words and provide a practitioner's point of view on contemporary developments in the air transport industry. Contributors should explicitly specify whether their views are espoused by their organization or not.

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In addition, it is found that airline customers have a number of complaints, many of which are not communicated to the airline, and it is demonstrated that these complaints impact on loyalty. It is therefore argued that airlines and researchers alike need to study customer complaints in relation to loyalty in greater detail. Taking into account the bad economic situation in Greece, in combination with the airline deregulation, the results of this research is of high significance to Greek airline companies, in order to “tie” their customers and maintain their market share.



The dynamical behaviour of groups of airspace sectors, e.g. Functional Airspace Blocks, is not trivial to be analysed without appropriate theoretical tools. In this paper, we suggest a discrete model based on cellular automata and multi agent systems to express the congestion dynamics and complexity in the controlled airspace. Discrete time simulations have been performed with random selected scenarios of traffic and with independent sector parameters to investigate the impact of availability of local sectors on the whole state of the airspace. Obtained results show the existence of a traffic threshold that leads to a theoretical saturation of airspace. The test scenario showed a phase transition phenomenon towards the congestion of the European airspace at the resulting traffic threshold circa 50 000 flights. Validation using real data shows the predictive abilities of the model.



The deregulation of air transport has increased competition between air carriers, resulting in lower fares and increased volumes of passengers. Subsequently, the fare reduction has altered the market structure with the establishment of new carriers, strategic alliances and mergers, and the bankruptcy of several traditional airlines which were unable to adapt to the new environment. The emergence of low cost carriers (LCCs) is one important outcome of the deregulation. LCCs entered the market by offering a differentiated product based on bare services offered at significantly lower prices. The main target was travellers with increased sensitivity in pricing and less demand for all-around services. The rise in terms of passengers and flights dictated a better utilization of the fleet, requiring reduced turnaround times at airports. Many central airports had very little flexibility and capacity necessary to facilitate additional timeslots. As an answer to inadequate capacity combined with higher taxes and fees, most LCCs have chosen to use secondary or regional airports. This choice has altered the balance and strategic importance between airports and increased their importance for air carriers. This paper examines the evolution and development of LCCs globally, along with the consequences of their expansion to the traditional carriers, the market and the passengers. Emphasis is given to the relationship between LCCs and airports which has resulted in an additional increase in air travel. The prospects of Greece as a market for LCCs are also being discussed.



The opinion of passengers on the degree of importance of the components is required in order to prioritize services. A low service level can, besides causing inconvenience for terminal users, increase the waste of resources and increase costs if there is no adequate planning. Hence, outlining passenger profiles at the airport is relevant to strategic planning of airport activity management. It is believed that individual characteristics could influence opinion on the degree of importance or about the quality of airport services. This article shows that the check-in and the departure lounge were considered the most important areas in the airport terminal by passengers. Finally it was noted that the age and reason for travel influenced the passengers' perception about the check-in area and the frequency of flying influenced the perception of the departure lounge.

# Editorial

This issue of the *Journal of Air Transport Studies* includes five papers. Evangelinos, Stangl and Obermeyer examine peak-load pricing and airline reactions at European airports. They find that airlines would subsidize price reductions at off-peak times with price increases during peak times on certain routes, suggesting a peak-load pricing regime would encourage new competitors to enter the market at off-peak times. Subsequently, Polydoropoulou, Chortatsiani and Kamargianni consider airline customer satisfaction and loyalty. The results of the research indicate that the majority of passenger complaints are not communicated to the airline; this finding has significant implications for customer loyalty.

In the following contribution, Ben Amor and Bui adopt a complex system approach to model airspace congestion dynamics. The test scenario shows a phase transition phenomenon towards the congestion of the European airspace at the resulting traffic threshold of circa 50,000 flights. Then, Katarelos and Koufodontis provide useful insights into the business relations between the low-cost carriers and airports in the context of the air transport deregulation. Finally, Bandeira and Correia explore the relationship between the profile of departing passengers and their perception of the airport terminal. The research shows that the check-in counters and the departure lounge are considered to be the most important areas in the airport terminal by passengers. The age and reason for travel influence the passengers' perception about the check-in area, while the frequency of flying influences the perception of the departure lounge.

May we take this opportunity to thank all our authors and referees for their support in publishing this fifth issue of our Journal. Our continuing partnership with Air Transport News in conjunction with the open access character of the journal aim at ensuring that JATS can get a significant exposure to the academic and business audience and raise its profile accordingly. Enjoy reading!

*Dr Andreas Papatheodorou, Editor-in-Chief*
*Dr Kostas Iatrou, Associate Editor*
*Dr Zheng Lei, Assistant Editor*

# PEAK-LOAD PRICING AND AIRLINE REACTIONS AT EUROPEAN AIRPORTS

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ABSTRACT

Conventional wisdom in the economics of pricing holds that peak-load pricing can enhance welfare in cases where demand peaks are clearly identifiable and highly predictable. However, this pricing tool has not found acceptance among airlines in the past. In the very few cases in which peak-load pricing has been introduced, regulators have faced strong opposition from airlines. Recent research has focused on whether airlines could pass the additional costs associated with peak-load pricing on to passengers. Expanding on this work, this paper assesses how peak-load pricing would impact airline costs and forecasts how airlines would react to the implementation of a peak-load pricing regime. We use a simultaneous autoregressive model to predict airline pricing reactions. Our findings indicate that for certain routes, airlines would subsidize revenue decreases in off-peak times with price increases during peak times. This finding corroborates the perception held by airlines that a peak-load pricing regime would encourage new competitors to enter the market at off-peak times.

Keywords: Price differentiation, peak-load pricing, special interest groups, pricing behaviour, airline reactions

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## 1. INTRODUCTION

Although the global financial crisis has had a negative impact on the aviation sector, one can assume that a return to stability will lead the long-run growth trends in air transport to continue. According to ICAO forecasts (2007) the air transport passenger market is expected to increase at the rate of 4.6 per cent annually (in terms of passenger-kilometres). The problems associated with managing this growth are even more acute if one considers air freight, which is expected to expand at 6.6 per cent annually. In the absence of sufficient capacity expansion, this demand growth may be counterproductive for air transport. First, passengers will likely deal with considerable delays. Second, environmental costs are expected to rise. Third, air carriers will bear additional costs resulting from delays. At present, several European Airports already face severe capacity problems. A forecast of demand growth to the year 2025 without additional capacity growth predicts excess demand of around 3.7 million flights (see EUROCONTROL, 2004, pp. 2-11). In concrete terms, this means that in year 2025, more than 60 European airports are expected to face severe capacity problems in their peak hours and at least 20 airports will have to cope with capacity problems not only during a few peak hours, but around 10 hours per day. In Germany, for instance, this would translate in a situation in which all six major airports (including Berlin-Brandenburg International Airport, which is currently under construction) face excess demand during peak times (see Röhl, 2007, p. 8). In light of these expected supply bottlenecks, it is highly necessary to introduce capacity management systems that will mitigate the negative impacts of excess demand.

Alongside administrative measures to handle increasing capacity, airport expansion programmes represent one possible solution. Yet expanding an airport is no easy task. In every single case in Germany in which plans have been made to expand airport capacity, significant legal and bureaucratic challenges have arisen. In addition, the ability of environmental organizations to intervene in the legal process with various objections renders timely airport expansion projects a near impossibility. The construction of the new Munich airport, for instance, took a total of 29 years: although construction itself was completed in 6 years, 23 years were needed to work through the 5,724 separate legal challenges (see Röhl, 2007). It is clearly recognizable, therefore, that in the short and medium term, capacity expansions will not be capable of bringing the scarcity problem under control.

From an economic perspective, pricing measures are another means of handling excess demand. Efficient airport pricing is a well analysed topic in the literature. Wolf (2003, pp.

121-131), for instance, states that marginal-cost pricing (first-best solution) leads to the well-known problem of deficit. To cope with this issue, he analyses several price differentiation schemes, concluding that Ramsey pricing schemes are the appropriate second-best solution for achieving full-cost recovery and the minimization of welfare losses. In addition, he mentions that in the short run, peak-load pricing could be a valuable instrument for coping with capacity problems. In this way, economization measures to ration demand in the short to medium term could represent a viable coping strategy. Given certain assumptions concerning demand and technology, airports could price at marginal costs during off-peak times and at marginal plus capacity costs during peak times.[1] This pricing structure assumes that peaks are clearly recognizable. Therefore, peak-load pricing is of no use if an airport is highly congested with continued excess demand during the whole day. In addition, peak-load pricing can also function as a signal for capacity expansion. This is the case when in spite of peak-load pricing, excess demand at certain times exists, thus indicating that airport capacity is insufficient.

In addition, slot allocation mechanisms, such as auctions or slot trading, are also widely discussed in the economic literature on scarcity at airports. The current administrative system in Europe for allocating slots based on grandfather rights is problematic from an economic perspective, since it does not ensure that slots are allocated to those who value them most (Menaz & Matthews, 2008). Furthermore, administrative rationing has been criticised by anti-trust authorities (see Starkie, 1998, p. 113). The auctioning or trading of slots can, however, generate an efficient (1st Best) outcome as shown, for instance, in Brueckner (2009), Verheof (2010) and Basso & Zhang (2009). Despite their theoretical efficiency these mechanisms have been barely applied at all in practice. This might be due to practical barriers such as the complementary nature of slots or market power concerns (see Menaz & Matthews, 2008). Furthermore, Forsyth and Niemeier (2008) point out that the structure of the airport charges is of similar importance as efficient slot allocation processes. In particular they show that a combination of a slot allocation process and peak-load pricing can lead to more efficient airport utilisation. In this paper we do not cover the slot allocation process itself but focus on peak-load pricing instead.

However, pricing measures such as peak-load pricing are extremely difficult to implement. This is mainly due to lack of acceptance by existing users. Schank (2005, pp. 417-425) demonstrates that peak-load pricing in Boston and London failed because of lack of

[1] For an in-depth treatment of peak-load pricing, see e.g. Crew et al., 1995.

acceptance by user groups, who managed to form effective opposition to the pricing scheme. In New York, peak-load pricing at La Guardia airport resulted in the relocation of almost all commuter flights to Teterboro, a regional airport located in New Jersey. These empirical findings are not only confirmed in individual cases. In general, peak-load pricing is officially opposed by the IATA (2000, p. 1; Forsyth & Niemeier, 2003, p. 16) based on the argument of cross-subsidization.

Starkie (2005, p. 6-7) gives the following reasons for the failure to implement efficient pricing structures:

- First, governmental ownership induces a situation in which a majority of airports do not seek profit maximization (see also Forsyth & Niemeier, 2003, pp. 14-15);
- Second, it is very difficult for airport managers to reject the traditional charging scheme, which is based on the partly erroneous assumption that aircraft weight correlates with runway damage;
- Third, airlines oppose such pricing instruments, although they use similar pricing schemes themselves (yield management);
- Fourth, airport managers are unwilling to adopt such pricing schemes as they are thought to undermine capacity expansion efforts, in turn preventing higher passenger volumes over the long run.

One institutional argument in particular should be pointed out. The nature of the regulatory regime in place can play an important role for efficient pricing (see Laffont & Tirole, 2000, pp. 66-67). In this regard, Starkie (2005) highlights the possible inefficiencies of price-cap regulation. According to empirical observations, price-cap regulated airports tend to engage in capacity expansion programmes rather than implement peak-load pricing. The regulatory environment may weaken incentives for the adoption of efficient pricing structures. First, in several cases, airport price-cap regulations have been accompanied by the introduction of sliding scales. Second, the majority of price-cap regulated airports are subjected to single-till regulation. Regardless of the specific regulatory conditions, the role of special interest groups is essential. In other words, carriers (especially legacy carriers) attach high importance to the prevention of peak-load pricing and to the preservation of the existing pricing scheme. [2] Looking for reasons as to why carriers oppose peak-load pricing, researchers have focused lately on the impact that peak-load pricing has on airline profits. In

[2] For an overview of positive economic theory in transport infrastructure pricing, see e.g. Knockaert et al., 2009.

this respect, it is crucial to identify whether airlines can shift additional cost burdens to passengers or not. Forsyth (2008) notes in this connection that additional costs during peak times cannot be fully passed on to passengers, at least not in all cases. By contrast, savings from lower charges at off-peak times can be fully passed through to passengers (due to competitive pressures), thus resulting in lower air fares. It is therefore essential to study the impact of peak-load pricing on airlines' costs as well as to analyze which business strategies can help airlines to cope with peak-load pricing. This paper is organized as follows: Section 2 identifies the effects of peak-load pricing on airline costs; section 3 addresses possible user reactions (including pricing reactions) to peak-load pricing; and section 4 concludes.

## 2. THE EFFECTS OF PEAK-LOAD PRICING ON AIRLINE COSTS

In order to study the effects of peak-load pricing to airline costs, we must first classify airline costs. Traditionally, the ICAO takes into account only operating costs and leaves out extraordinary costs. Operating costs can be useful in benchmarking airline cost efficiency, and, at the same time, reveal differences between airlines. Table 1 shows the main elements of airline operating costs for international scheduled operations, for US and European airlines.

Table 1: Operating Airline Cost Shares for International Scheduled Operations

| Direct operating costs | US [%] | EU [%] |
|---|---|---|
| Flight operations | 41.7 | 40.5 |
| • flight crew | | 8.0 |
| • fuel and oil | | 22.7 |
| • airport and en-route charges | | 9.8 |
| Maintenance | 10.0 | 10.5 |
| Capital costs & insurance | 6.1 | 5.5 |
| Rentals | 7.9 | 4.9 |
| Sum | 65.7 | 61.4 |
| Indirect operating costs | | |
| Station and ground | 17.0 | 11.5 |
| Passenger-services | 5.6 | 12.3 |
| • cabin staff | | 7.1 |
| • other passenger services | | 5.2 |
| Sales, ticketing and promotions | 5.4 | 11.1 |
| General and administration | 6.3 | 4.7 |
| Sum | 34.3 | 39.6 |
| Total | 100.0 | 100.0 |

Source: AEA (2007), ATA (2007)

Direct operating costs are mainly related to aircraft type and represent almost two third of all operating costs. Within this cost category, flight operations represent the highest cost element and vary in accordance with distance travelled (mainly due to increasing fuel consumption). Direct operating costs also vary significantly according to the type of routes flown and business model of the carrier. For instance, long-haul operations tend to have a higher operating cost share than short-haul operations. In addition, this cost share rises to up to 80 per cent for charter and low-cost carriers (mainly due to indirect operating cost savings).

An alternate, highly instructive approach for classifying costs employs the standard notion of fixed and variable costs and is grounded in the concept of escapability. According to this concept, costs are classified into three major categories:

- The first category is costs related to flight hours (flying costs, representing around 30 to 45 per cent of total costs). These include expenditures for fuel, flight personnel, direct maintenance, passenger services and finally airport and ATM charges. Such expenditures are mainly related to aircraft use, which means that they are escapable if a flight does not take place.
- The second category is fleet-related standing costs (representing around 25 to 30 per cent of total costs). These costs are only escapable in the medium term, which is typically one year. This cost category includes aircraft capital expenditures, wages, as well as overhead costs for maintenance. These costs correlate positively with the activity level of the carrier, which means carriers can save on these expenses only by reducing their activity level.
- The third cost category is fixed indirect costs (representing around 25 to 35 per cent of total costs). These costs are only escapable in the long run, and include expenses for administration, sales, marketing as well as ground station activities.

This cost classification scheme seems to be more useful for assessing the impact of peak-load pricing on airline costs. For ultimately, carriers pay close attention to the revenues generated by each single flight when scheduling their networks. In order to keep a certain city pair on a flight schedule, it is essential that the flight cover at least flying costs.[3] For this reason, carriers aim to achieve high load factors. The introduction of peak-load pricing would therefore cause a shift in the break-even point towards higher load factors in the peak period

[3] Due to the fixed nature of schedules, short run marginal costs are very low. Therefore, every additionally ticket sold makes an additional contribution to cost recovery. Peak-load pricing is, however, a pricing scheme which cannot be implemented in the short run, but rather in the medium run. We therefore regard flying costs to be the relevant factor for airlines in decisions concerning when to schedule flights under a peak-load pricing scheme.

and vice versa in the off-peak period, since peak-load pricing raises costs for the airline in the peak period and reduces them in the off-peak period.

However, the additional cost burdens of peak-load pricing will impact carriers in different ways. To evaluate these impacts, we must therefore begin by differentiating air carriers according to the following criteria:

1. the degree of slot scarcity faced by the carrier at the airport in question;
2. the significance of airport charges for the carrier;
3. the level of charges at the airport.

The degree of slot scarcity is the first criterion that can have a decisive impact on the level of peak-load pricing.[4] As excess demand at peak times varies at different airports, the amount of the charge during the peak period will vary respectively.[5] We therefore conclude that carriers using an airport as their home base that is slot congested at certain times of day will bear greater financial burdens than other carriers. In addition, when comparing two airports that both have excess demand in the peak period, we conclude that the carrier at the airport with higher peak demand will have to pay more for airport charges if peak-load pricing is implemented. Finally, due to the cost relatedness of the pricing scheme, airport cost efficiency can result in cost differences for carriers even if airports have similar slot scarcity.

The second criterion is the share of airport charges as a percentage of airline operating costs. As shown in table 1, airport charges (including ATM charges) represent 9.8 per cent of total operating costs. This figure is an average value and reflects predominantly the cost situation of an international carrier. Depending on geographical factors and the carrier's business model, this cost share can increase up to 20 per cent. First, airport-charges cost share increases for short-haul flight operations and decreases for long-haul operations.[6] Therefore, if a carrier offers predominantly short-haul flights, it is expected that the airport-charges cost share will rise for operating decisions and vice versa. Second, airport charges are the dominating factor when low-cost carriers decide whether a destination will be served or not.

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[4] We regard in this case only airports at which peak-load pricing can bring desirable results. This does not include airports without any capacity problems, or airports with permanent excess demand.

[5] We note in this case that the form of regulation in place can be a serious barrier to the implementation of peak-load pricing. There are also many cases in which peak-load pricing could lead to huge profits. Regulatory regimes aiming at cost recovery would prevent the implementation of peak-load pricing.

[6] For the short-haul operations of British Midland and KLM UK, the airport-charge cost shares in 1999 were 15 and 23.4 per cent, respectively (see Doganis, 2002, p. 146).

Third, despite the internationally similar tariff structure (two-part tariff), the charge level varies immensely from airport to airport. Table 2 shows these differences for a standard aircraft type.

As depicted in table 2, the implementation of peak-load pricing at a high cost airport like Paris CDG or Vienna would burden carriers operating from these airports more than others. In addition to table 2, US carriers have lower airport-charge cost shares (currently 2.2 percent of total operating costs, see ATA, 2010). The reason for this is twofold: First, carriers in the US often operate their own terminals. Second, parts of airport charges are paid directly by passengers. In this way, US carriers currently have a cost advantage compared to European carriers.

Table 2: Representative Airport Charges for a B747-400 with 395t MTOW, 335 passengers and 3h parking time for winter 2010/11, in USD

| | Charge in US $ | | | |
|---|---|---|---|---|
| Airport | Weight based | Passenger based | Total Charge | Ratio of the Components |
| Tokyo NRT | 8,649 | 7,537 | 16,186 | 53 : 47 |
| London LHR | 2,742 | 12,363 | 15,105 | 18 : 82 |
| Paris CDG | 3,755 | 10,359 | 14,114 | 27 : 73 |
| Buenos Aires EZE | 3,153 | 10,218 | 13,371 | 24 : 76 |
| Vienna | 4,387 | 8,454 | 12,841 | 34 : 66 |
| Amsterdam | 4,763 | 7,058 | 11,821 | 40 : 60 |
| Frankfurt | 1,359 | 10,379 | 11,738 | 12 : 88 |
| Atlanta | 1,363 | 10,050 | 11,413 | 12 : 88 |
| Chicago | 3,111 | 7,705 | 10,816 | 29 : 71 |
| London LGW | 4,410 | 6,033 | 10,443 | 42 : 58 |
| Madrid | 5,119 | 5,026 | 10,145 | 50 : 50 |
| Bangkok | 1,892 | 7,739 | 9,631 | 20 : 80 |
| Singapore | 3,600 | 5,981 | 9,581 | 38 : 62 |
| Manchester | 4,261 | 4,354 | 8,615 | 49 : 51 |
| Nairobi | 1,880 | 6,700 | 8,580 | 22 : 78 |
| Rome FCO | 1,461 | 6,422 | 7,883 | 19 : 81 |
| Hong Kong | 3,560 | 0,990 | 4,550 | 78 : 22 |

Source: Own calculations

The third criterion is the extent to which the peak-load pricing scheme is applied. As table 2 shows, the degree of variability – that is, the ratio between the fixed (aircraft-related) and variable (passenger-related) components of the charge – fluctuates significantly between airports. Although lately a shift towards greater variability has occurred, European airports still charge a certain fixed amount based on aircraft MTOW. Applying peak-load pricing only to the fixed cost component would severely discourage full-service carriers (FSCs) from expanding flight frequency (see Brueckner, 2010; Givoni & Rietveld, 2009), as FSCs typically operate large networks and also commit themselves to offering frequent flights in order to minimize the passengers' schedule delay.

## 3. AIRLINE REACTIONS TO PEAK-LOAD CHARGES

In spite of the fixed nature of airport charges over the short run, airlines have certain opportunities for countering their impact on cost structures. Over the medium-term carriers can implement various strategies to steer direct and indirect operating costs, thus allowing the impact of additional peak-load expenses to be mitigated. In this regard, we draw a distinction between operational measures (such as the choice of aircraft size and location effects) and pricing measures. In particular, we discuss how airlines can evaluate the best strategies to implement.

### 3.1 INCREASE IN AIRCRAFT SIZE/REDUCTION OF FLIGHT FREQUENCY

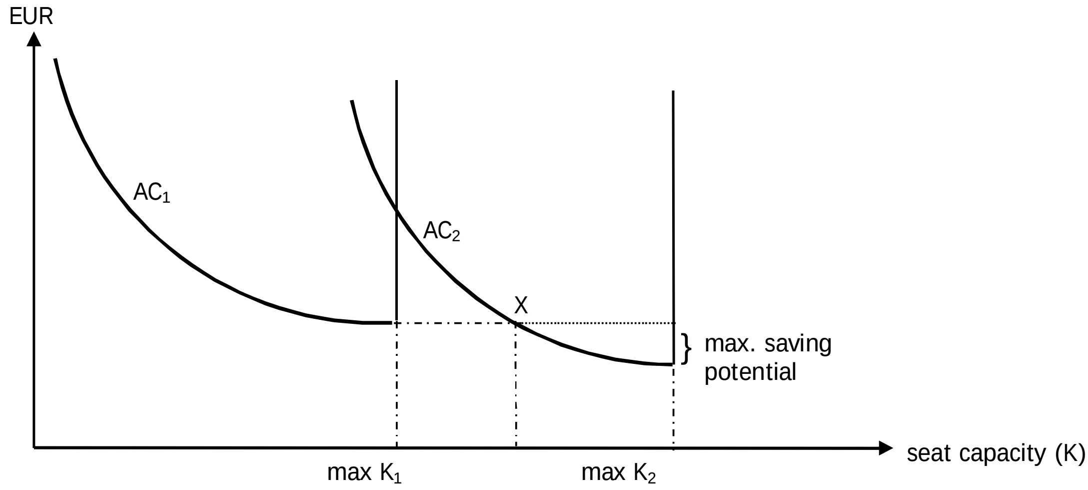
From the regulator's point of view, one of the desirable airline reactions would be the use of larger aircraft[7] combined with a reduction in flight frequency during peak periods. Aircraft size is an important determinant of unit costs per passenger, because it has a direct influence on operational costs and hourly productivity. Cost advantages are achieved with larger aircraft due to several factors; aerodynamic benefits and larger, more efficient engines, for example, reduce fuel consumption per weight unit. Furthermore, a larger aircraft also leads to higher labour productivity. Thus, costs per seat-kilometre decrease with increasing aircraft size. Figure 1 illustrates this interrelation.

The average cost curve for smaller aircraft ($AC_1$) reaches its minimum at the point of maximum seat load capacity. Assuming a utilization factor beyond X, the use of the larger aircraft would decrease average costs. In addition, the extent to which it is possible to compensate for increased airport charges depends not only on the cost advantages attained but also on prevailing passenger preferences and demand characteristics. If the increase in charges is very large compared to total costs, then these charges can only be offset through

[7] A better usage of airport capacity would be achieved not only by a cutback in frequency, but also by the fact that larger aircraft have lower wake-vortex separation requirements and lower runway occupancy times. Consequently, larger aircraft typically occupy runways for a shorter time than lighter ones (see Wolf, 2003, p. 65 ff.; Doganis, 1992, p. 83).

sufficient passenger load and adequate marginal return per seat.[8] Hence, a half-empty aircraft would be less cost efficient than two smaller, highly utilized aircrafts.

Figure 1: Economies of Size & Fill in Relation to Increased Aircraft Size




Source: Own illustration, based on Button (1982), p. 79.

If an airline pools two flights together during the peak period (assuming identical demand for each flight), it can be expected that some time-sensitive passengers will be lost. To pre-empt this disadvantage it is necessary to choose an aircraft according to the future demand situation. Based on current average load factors of 70–80 per cent (see AEA, 2008, p. 8), this would mean additional cost benefits (see Wei, 2006). However, if an airline loses many time-sensitive passengers, financial penalties are likely. In this regard, so-called high-yield traffic is the most likely customer segment to be lost, as these customers are more sensitive to flight frequencies (see Hanlon, 1996, p. 167; NERA, 2004, p. 83 ff.). Yet a cutback in frequencies seems to be a reasonable option for certain sub-segments. On routes dominated by business travellers or hub flights with quick transfer guarantees, frequency reductions would lead to lower revenues. In such markets, airlines will be unwilling to change frequencies. The implementation of such strategies is more probable in the case of point-to-point short-haul flights due to the larger impact of increased charges.

[8] The most cost-effective combination in general is maximum range with a full payload. Hence, a suitable traffic density is necessary to tap the full cost advantages from maximum load (see Doganis, 2002, p. 122).

High frequencies imply both greater flexibility and more flight hours. The higher the aircraft utilization, the lower the average costs. Consequently, lower frequencies are more costly and a cutback in frequency can have negative effects on productivity, especially on short- and medium-haul flights (see Doganis, 2002, p. 133 ff.). Ultimately, therefore, the airline reaction will be determined by the interplay of these various factors. However, there are two additional factors that hinder a possible implementation of lower frequencies:

1. Airport schedules: Existing schedules mean frequency changes can only be implemented in the medium to long run.
2. Large aircraft availability: Not all carriers can switch to larger aircraft. Because of their homogenous fleet structures, low-cost carriers in particular have a limited ability to introduce larger aircraft compared to FSCs.

In summary, the feasibility of introducing lower frequencies and larger aircraft depends strongly on specific market and demand characteristics. For example, Givoni & Rietveld (2009) have shown that service frequencies are not only significant in terms of the time and price elasticity of passengers.[9] They are also an important instrument in competition, and can strongly influence a carrier's choice of aircraft.

## 3.2 TEMPORAL AND SPATIAL RELOCATION EFFECTS

A further possible reaction of carriers is the reassignment of flights to off-peak times. While such a reassignment is a primary goal of peak-load charges, it can only be achieved if monetary incentives are strong enough to motivate a rescheduling of arrival and departure times. The primary aims in flight scheduling are to achieve high aircraft utilization; the optimal timing of flights to cater to passenger time preferences; and high market shares. These considerations as well as several operational and external conditions (e.g. night-flight restrictions, maintenance requirements and the availability of slots) can considerably impede flexible flight planning (see Lüking, 1993, p. 249, 253 ff.).

In general, peak flights are strongly favoured by passengers. Therefore, the loss in revenue connected with rescheduling to off-peak times should not be underestimated. Alongside this expected commercial disadvantage, aircraft size is also of importance. On routes with high demand, rescheduling to lower demand periods can require flights to be combined or the operation of smaller aircraft in order to reach an adequate load factor. Hence, extensive

[9] For a theoretical discussion, see Fischer, 1997, pp. 101-114.

rescheduling towards off-peak periods would be connected with demand losses and cost disadvantages due to a decrease in the usage of aircraft and flight crews. Because of the required adjustment in fleet structure, rescheduling seems to be a less attractive solution as a response to peak charges. Savings in the off-peak period have to be substantial to compensate for the operational and commercial disadvantages.

Similarly, in the case of frequency reductions, the ability of rescheduling to be implemented is limited by existing slot allocation procedures in Europe. Currently allocation of slots at Community airports primarily takes place according to Council Regulation (EEC) No 95/93. At airports with serious capacity shortages (declared as coordinated airports) air carriers need permissions to use the facilities for take-off and landing at a particular time, which are allocated bi-annually by an independent coordinator for the entire respective flight plan (summer or winter season).[10] Therefore, at slot coordinated airports, the rescheduling of flights can only be implemented in the next period while taking into account the associated condition of slot pairing. Furthermore, rescheduling to off-peak at the airport of origin can potentially lead to increased activity during peak times at the destination airport. Hence, it might become very difficult to find slots at the destination airport.

According to the current allocation principles air carriers can claim slots in the next scheduling period if they are utilized for at least 80% otherwise the slots will be returned to the slot pool for reallocation to competitors (so-called grandfather right and use-it-or-lose-it rule). From this it follows that, because of competition issues, there are serious doubts that airlines will be willing to give up their valuable peak-time slots. There is evidence that established carriers use slots as a barrier to entry in order to increase demand for their own services (see Starkie, 1998, p. 113). This argument is even stronger if one takes into account that during peak periods, carriers realize scarcity rents (see for instance Menaz and Matthews, 2008).

Another alternative mainly applicable to low-cost carriers is the relocation of operations to less congested secondary airports with available capacity and no peak charges. In contrast to the relocation of flights to off-peak periods, this approach enables more attractive flight times. However, due to expected demand losses (especially in transfer traffic), airlines have

[10] The mentioned regulation act should ensure, that the allocation happens in a neutral, transparent and non-discriminatory way. For further details see Council Regulation (EEC) No 95/93 of January 1993 on common rules for the allocation of slots at Community airports and amending acts, basically Regulation (EC) No 793/2004.

only shown minor interest in pursuing such a strategy to date. The use of peripheral airports is a reasonable alternative only for charter airlines or some low-cost airlines, as their supply of short- and medium-haul point-to-point flights is mainly directed at the price-sensitive segment of leisure travellers. We would not expect FSCs that use the airport as base station to implement such a strategy.

### 3.3 PRICING STRATEGIES

Compared to other operational conditions, pricing strategies can be changed relatively fast. The question as to whether carriers can shift additional cost burdens to passengers without significantly eroding demand hinges on several factors. The demand characteristics and preferences of customers are of high relevance in this regard, yet also important are route lengths, the commercial and operational significance of a route in an airline's network as well as the market structure and competitive environment in the given city pair.

In terms of demand characteristics, it is assumed that long- and short-haul passengers will be affected differently depending on the customer segment and airline business model in question. The share of business and leisure travellers that fly a route determines to large degree how much an airline can increase fares without incurring revenue losses. Low-cost and charter airlines, which cater first and foremost to the price-sensitive group of leisure travellers, would be particularly limited in their ability to pass additional costs to passengers. Therefore, compared to FSCs, they would have to bear a large proportion of increased costs themselves, which also means they would be faced with a competitive disadvantage (for an analytical and simulative analysis, see e.g. Fu et al., 2006).

Differences may also arise in the ability to shift costs in relation to route distance. Given the fixed character of airport charges, a peak premium will affect ticket prices very differently. First, in the case of long-haul flights, supplementary charges represent a lower percentage of the overall ticket cost, and there are possible advantages due to economies of size and fill. Apart from this, flight distance is a key determinant of demand elasticity, which is lower for long-haul flights because of the limited number of alternatives (see e.g. Brons et al., 2002, p. 172). As a result, in long-haul markets the potential to pass on costs is much larger than in short-haul ones. For short-haul operations, it is crucial to consider both the degree of competition with other modes of transport as well as the ratio of business to leisure passengers on a certain route. The higher the share of business travellers, the easier it is to shift additional costs. In domestic markets with a low share of business travellers, cost shifting is apparently difficult to implement. Here, complete cost shifting to passengers would imply that the required price premium per passenger is sufficiently high enough to offset both the peak charge and losses due to decreased demand. If the cost increase is really high (and this can be expected in short-haul markets), then a result would be the phasing out of some routes, especially point-to-point flights without a commuter function.

Aside from demand related issues, factors like market structure and competitive behaviour can considerably affect an airline's scheduling and pricing policy. The oligopolistic market structures and tendencies towards collusive behaviour that often characterize the airline sector (see Starkie, 2002, p. 64) seem in general to provide carriers with possibilities for fare increases. Depending on the commercial importance of a route and the intensity of competition, certain strategic relationships among the actors can also limit the potential for a rise in prices. If there is a leader–follower situation, the follower would prefer a limited scope for cost shifting, because this would compel the leader to maintain fare levels. Such a dynamic can be observed in the case of feeder flights (see Stangl, 2008. pp. 75–88). In addition, the current slot allocation system in Europe seems to enhance airlines' opportunities for increasing fares. Quite in contrast to other situations of scarcity, the slot allocation system has the ability to weaken competition among carriers, thus offering a certain leeway for price increases (see Lüking, 1993, p. 271).

The complete transfer of savings to passengers in the off-peak period also seems to be an unlikely outcome. A carrier has little motivation to reduce fairs if sufficient load at current fares can be achieved. In this regard, competition takes place predominantly with regard to non-pricing criteria such as flight frequency and service amenities. However, market entries can change such an equilibrium (e.g. when low-cost airlines enter the market; see Forsyth & Niemeier, 2003, p. 11). Furthermore, if sub-markets are characterized by low passenger volumes, then a partial pass-through of cost savings would seem to be reasonable in order to capture additional demand. In-house capacity policies as well as strategic interactions among market actors are thus significant determinants of airline behaviour. The extent to which an airline is ultimately able to pass on cost increases to customers in the medium to the long term therefore varies according to the structure of the market and demand factors, which vary in relation to the sub-market.

For this reason, conclusions about the degree of cost shifting that will be possible can only be drawn for the different sub-markets. Conceivably, carriers might prefer to first exploit internal cost-saving potentials on short-haul routes instead of adopting pricing measures that risk a decrease demand and loss of market share. This would result in an increase in market concentration (due to relocation or market entries and exits), in turn encouraging higher fares (especially those charged by the hub carrier). The attendant increase in competition in other markets could encourage fare reductions (see De Wit & Burghouwt, 2007, p. 111). Such displacement effects are possible across specific routes or flights, as carriers seek to fully tap price-inelastic customer segments. This is confirmed by experiences at Heathrow airport, where peak passenger charges were redistributed not directly but passed on to all passengers (see Doganis, 1992, p. 97). Finally, the degree to which cost shifting is possible determines the ability of a scarcity-based charging policy to enhance relocation and the more efficient use of airport capacity. Particularly in long-haul segments and for routes with a large share of price-inelastic business travellers, the effectiveness of peak-load pricing seems to be very limited. The low time sensitivity of passengers and the necessity of changes within the hub and spoke scheduling facilitate the shifting of costs to ticket prices, which already tend to be very high in the absence of opportunities for market entry (see Lüking, 1993, p. 123f.). We therefore conclude that peak-load pricing will have only limited effects with respect to a change in supply behaviour.

As pointed out previously, the introduction of peak-load pricing schemes at airports can reduce profits if the airlines are unable to offset additional capacity costs in the peak period by means of operational cost reductions or pricing measures. Yet the fact that airlines oppose the introduction of peak-load pricing might also be driven by additional competitive considerations. Under a peak-load pricing scheme, airport capacity during off-peak periods is priced only at marginal costs. Airlines may fear that this will encourage additional carriers, particularly low-cost airlines, to enter the market.

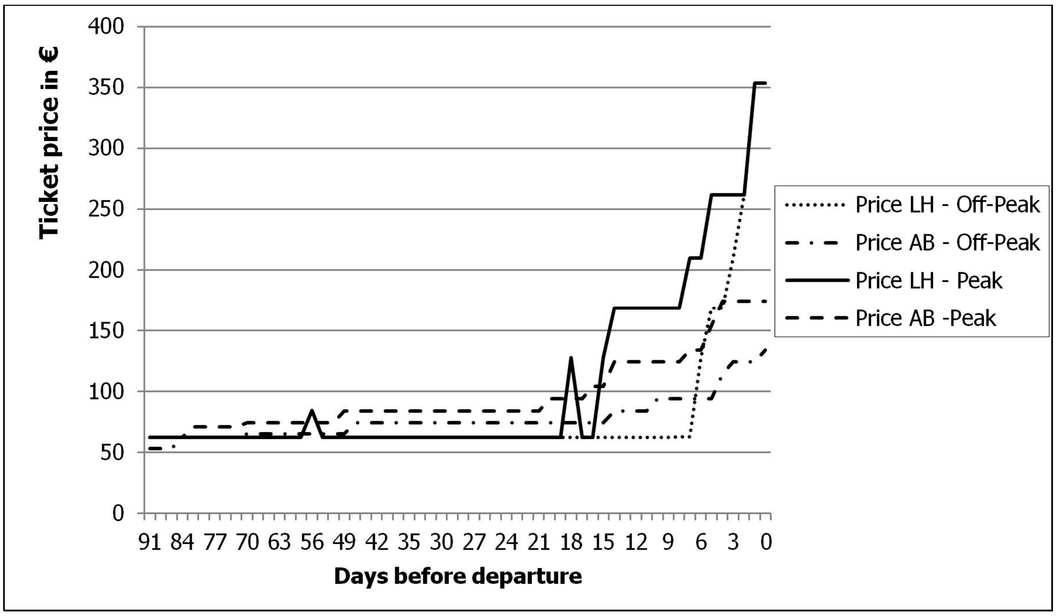
We hypothesize that airlines face tough competition over passengers in off-peak periods. Consequently, each airline will react to a competitor's price adjustments. If so, we should observe significant pricing interdependencies in off-peak periods, with this effect weakening during peak periods. To test our hypothesis, we investigated the pricing behaviour of Lufthansa (LH) and Air Berlin (AB) for the airport-pair Berlin-Tegel (TXL) – Frankfurt/Main (FRA). For this purpose, we collected the lowest offered fares of both airlines in a peak and an off-peak period starting three months prior to departure.[11] The main elements of the chosen flights can be seen in table 3.

[11] More precisely, we collected prices over 91 days prior to departure for flights on 25 August 2008.

Table 3: Flight times and aircraft types for the Berlin-Tegel – Frankfurt/Main route

| Airport Pair | Peak Flight Time (Aircraft) | Off-Peak Flight Time (Aircraft) | Carrier |
|---|---|---|---|
| TXL - FRA | 17:20 (A 321)<br>16:55 (B 737-800) | 21:15 (A 321)<br>21:25 (B737-800) | Lufthansa (LH)<br>Air Berlin (AB) |

Figure 2: Plotted peak and off-peak prices of Lufthansa and Air Berlin




The gathered peak and off-peak ticket prices for Lufthansa and Air Berlin are plotted in Figure 2. From the figure it is evident that the peak and off-peak prices follow nearly the same trend line until three weeks before departure. Furthermore, as the departure date comes closer, peak prices rise faster than off-peak prices. In terms of differences, Lufthansa's prices increase very sharply as the departure comes closer, while Air Berlin increases its prices more gradually. The summarized statistics in table 4 shed light on the average price and distribution. Average peak prices are higher than average off-peak prices. Lufthansa's average prices and price dispersion are generally higher than Air Berlin's.

Table 4: Descriptive statistics of peak and off-peak prices for Lufthansa and Air Berlin

| Variable | Arithmetic Average | Coefficient of Variation |
|---|---|---|
| Lufthansa off-peak price ($p_{off}^{LH}$) | 83.54 | 0.76 |
| Air Berlin off-peak price ($p_{off}^{AB}$) | 77.19 | 0.22 |
| Lufthansa peak price ($\mathrm{p}_{\mathrm{peak}}^{\mathrm{LH}}$) | 106.62 | 0.73 |
| Air Berlin peak price ($p_{peak}^{AB}$) | 96.71 | 0.33 |

With the help of an econometric model, we analyse if carrier price-setting behaviour is substantially different between peak and off-peak periods. For our analysis we employ a seemingly unrelated regression model (SUR) analogous to the one used by Pels and Rietveld (2004) to analyse the London—Paris market. Our econometric model is described by the following SUR equations.

(1) $p^{AB}_{off_t} = \alpha^{AB}_{off} + \beta^{AB}_{off_1} days_t + \beta^{AB}_{off_2} days^2{}_t + \beta^{AB}_{off_3} p^{AB}_{off_{t-1}} + \beta^{AB}_{off_4} p^{LH}_{off_{t-1}} + \beta^{AB}_{off_5} p^{AB}_{peak_{t-1}} + \beta^{AB}_{off_6} p^{LH}_{peak_{t-1}}$

(2) $p^{LH}_{off_t} = \alpha^{LH}_{off} + \beta^{LH}_{off_1} days_t + \beta^{LH}_{off_2} days^2{}_t + \beta^{LH}_{off_3} p^{AB}_{off_{t-1}} + \beta^{LH}_{off_4} p^{LH}_{off_{t-1}} + \beta^{LH}_{off_5} p^{AB}_{peak_{t-1}} + \beta^{LH}_{off_6} p^{LH}_{peak_{t-1}}$

(3) $p^{AB}_{peak_t} = \alpha^{AB}_{peak} + \beta^{AB}_{peak_1} days_t + \beta^{AB}_{peak_2} days^2{}_t + \beta^{AB}_{peak_3} p^{AB}_{off_{t-1}} + \beta^{AB}_{peak_4} p^{LH}_{off_{t-1}} + \beta^{AB}_{peak_5} p^{AB}_{peak_{t-1}} + \beta^{AB}_{peak_6} p^{LH}_{peak_{t-1}}$

(4) $p^{LH}_{peak_t} = \alpha^{LH}_{peak} + \beta^{LH}_{peak_1} days_t + \beta^{LH}_{peak_2} days^2{}_t + \beta^{LH}_{peak_3} p^{AB}_{off_{t-1}} + \beta^{LH}_{peak_4} p^{LH}_{off_{t-1}} + \beta^{LH}_{peak_5} p^{AB}_{peak_{t-1}} + \beta^{LH}_{peak_6} p^{LH}_{peak_{t-1}}$

The variables $p^{i}_{off_t}$ and $p^{i}_{peak_t}$ denote the price charged by carrier i in time period *t* for an off-peak and a peak flight, respectively. Each single price is regressed on the number of days until departure as well as on the lagged off-peak and peak prices of the considered carrier and its competitor. This allows us to investigate the airline's price responses in the short-run. The estimation results are shown in table 5. A regression of the residuals on the lagged residuals and the other explanatory variables does not reveal any autocorrelation.[12] The high values for the adjusted R² imply a good fit of the model.

Table 5: Estimation results for price setting behaviour

| Equation (TXL-FRA) | AB Off-Peak | LH Off-Peak | AB Peak | LH Peak |
|---|---|---|---|---|
| Variable | Estimate (Standard Error) | | | |
| Constant | 18.9033 (6.23)*** | -124.094 (29.32)*** | 35.8761 (10.67)*** | -34.7766 (41.96) |
| Days until departure | 0.0998 (0.10) | -0.0216 (0.48) | -0.2874 (0.17) | -1.2550 (0.68)* |
| (Days until departure)$^2$ | -0.0016 (0.001) | 0.0055 (0.004) | 0.0016 (0.002) | 0.0146 (0.01)** |
| AB Off-Peak | 0.3728 (0.11)*** | 1.1838 (0.48)** | -0.4101 (0.17)** | -0.6141 (0.68) |
| LH Off-Peak | 0.0488 (0.01)*** | 0.9472 (0.07)*** | 0.0235 (0.02) | 0.1823 (0.09)* |
| AB Peak | 0.2431 (0.08)*** | 0.5984 (0.04) | 0.9724 (0.13)*** | 1.6349 (0.52)*** |
| LH Peak | 0.0269 (0.02) | -0.2320 (0.10)** | 0.0527 (0.04) | 0.3405 (0.15)** |
| $R^{adj}$ | 0.9752 | 0.9589 | 0.9774 | 0.9432 |

* significant at 10%; ** significant at 5%; *** significant at 1%

[12] For details on the methodology, see Pels & Rietveld, 2004. Results are not presented here but are available upon request.

The constants are highly significant except for Lufthansa in the peak period. The number of days until departure and its squared value are significant only for Lufthansa in the peak period. However, the p-value for the respective parameter of Air Berlin is close to the 10% significance level. Therefore, it seems that Air Berlin and Lufthansa significantly adjust their prices in the peak period but not in the off-peak period according to the number of days before departure. Even though, this adjustment process is different for the two carriers; Lufthansa increases its price in a quadratic fashion as the departure day comes closer while Air Berlin follows a more linear price trend.

While in the peak period the number of days before departure but not the lagged prices of the competing carrier seem to be the predominant influence on price setting, this picture reverses in the off-peak period. In the off-peak period Air Berlin adjusts its price in period $t$ according to its own prices in the former peak and off-peak period as well as in response to the off-peak price of Lufthansa. Moreover, Lufthansa reacts to the off-peak price of Air Berlin and to its own peak and off-peak prices. In the peak period Air Berlin independently sets its own peak and off-peak prices and does not react to Lufthansa's price while Lufthansa takes both Air Berlin's peak price and its own lagged prices into account. Apart from the two exceptions $\beta_{off_6}^{LH}$ and $\beta_{peak_3}^{AB}$, all significant price reactions on the lagged variables are positive.

We can draw three major conclusions from these results. First, in the peak period Lufthansa as well as Air Berlin increase their prices significantly as the departure date comes closer. This effect is reinforced by the positive reactions to their own lagged peak-period prices. Second, both carriers are close competitors in the off-peak since they react on each other's prices positively, e.g. if Lufthansa reduces its price in the off-peak period Air Berlin will follow and vice versa. But this effect is less significant in the peak period, when only Lufthansa reacts to Air Berlin's price but Air Berlin does not react to Lufthansa's price. Third, interpreting the negative impact of the Lufthansa's lagged peak price on its off-peak price and the negative impact of Air Berlin's off-peak price on its peak price is less obvious. These price trends are an indication of cross-subsidization between off-peak and peak flights.

The results support our thesis that airlines try to attract passengers in off-peak periods by adjusting prices according to the prices of their competitors. This effect is less evident during peak periods. Furthermore, the results indicate that tickets during off-peak periods might be cross-subsidized by higher prices during the peak period. Hence, we can infer from this result that if airlines face competition in the off-peak period, they will tend to cross-subsidize between peak and off-peak periods. Yet to do so, an increase in peak prices is probably necessary. Particularly in the case of routes with a high proportion of price sensitive customers,[13] airlines will struggle to increase prices substantially without incurring significant passenger losses. For this reason, carriers may fear that peak-load pricing schemes will induce increased competition during the off-peak periods.

## 4. CONCLUSIONS

In this paper we sought to identify the reasons for airline opposition to peak-load pricing. We first considered the effects of peak-load pricing on airline costs. Due to varying business models and differences in route networks, airlines have different cost structures. This, in turn, means the introduction of peak-load pricing will "hurt" carriers in different ways. Trip length (short haul vs. long haul), service quality (FSC vs. LCC) and the geographic base (European vs. non-European) are significant factors that lead to different cost structures. We subsequently reviewed possible airline reactions to peak-load pricing. Although airlines have a relatively strong ability to influence direct operational costs, they often face diverse external constraints, which hinder an effective response to pricing signals. Due to operational factors (e.g. fleet management and vehicle schedules), regulatory conditions, as well as company-specific restrictions, carrier freedom of action is constrained in the near term. However, in the medium to long run, airlines have a wide spectrum of opportunities to react effectively to the implementation of peak pricing structures at airports.

Given the very low marginal costs for the transport of additional passengers and the relevance of pricing policies that encourage high load, demand circumstances play a key role. They define not only the potential for price reductions, but also the extent to which price adjustments are feasible. Furthermore, carrier flexibility to introduce route and flight time changes varies considerably. It is assumed that carriers who offer international long-haul services are less flexible with respect to flight time adjustments. However, due to the lack of travel alternatives for passengers, there is greater flexibility for pricing measures in the long-haul market than there is in the short-haul one.

[13] Here, for instance, we think of routes with a low share of business customers and a high share of leisure customers, respectively.

In contrast to the use of larger aircraft, there is little practical incentive to rescheduling operations to off-peak periods. The operational and commercial disadvantages of rescheduling to off-peak turn out to be higher than the operating cost savings. The disadvantages also tend to outweigh the benefits in the case of secondary airport use; only cost-oriented carriers, such as charter airlines or LCCs, can be expected to derive a net benefit from relocating flights to secondary airports.

A key constraint to the implementation of operational changes is the current slot allocation procedure. Because of the existence of so-called “grandfather rights” and resulting tendencies to strategically hoard slots, legacy carriers in particular have few incentives to adjust their operating schedules. If the monetary inducements of peak charges are not sufficient to mitigate hoarding behaviour, subsidiary measures such as a slot reservation fee, the tightening of the so called “use-it-or-lose-it” rule, as well as the allowance of slot trading would be beneficial. Such measures would augment the monetary incentives of peak charges.[14] Taking into account these difficulties, it is assumed that under the current regulatory environment, limited options are available to motivate carriers to change their operations. In this connection, additional important factors include the role of an airport in a carrier’s network as well as the availability and accessibility of adequate secondary airports.
The ability of carriers to implement price changes hinges to large extent on the sub-market in question. If increases in costs can be passed along to customers, carriers will probably prefer to do this rather than extensively re-structure their operations. Consequently, given the unchanged slot rents during peak periods, rescheduling to less usage intensive times probably won’t take place. The goal of peak charges – to force the effective rationing of demand – would not be achieved.

Furthermore, it is still an open question as to whether carriers oppose peak-load pricing schemes merely because of their potential to reduce profits, or whether additional competitive considerations play a role, for marginal-cost pricing during off-peak periods seems to be an invitation for low-cost carriers to enter the market. Using a simultaneous pricing model for a domestic airport pair in Germany, we showed that competition in the off-peak period may lead to cross-subsidization between peak and off-peak periods. Although this may not hold for all airport-pairs the finding remains that incumbent airlines will suffer

[14] Furthermore, remuneration mechanisms are possible, e.g. certain discounts, bonuses, or a lowering of other charging elements would offer additional incentives towards a modification of operating patterns.

losses.[15] Precisely this finding seems to be in-line with Forsyth's (2008) conclusion that the introduction of peak-load pricing leads to higher consumer surpluses and lower airline profits.

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[15] This result also suggests that there are some possible demand interdependencies between peak and off-peak periods, an issue which is not touched in this paper, however.

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# FLYER'S CORNER: SOME SIMPLE TRUTHS ABOUT SCHEDULED AIR TRAVEL

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## ABSTRACT

Airlines in a state of crisis need to take steps to ensure revenues keep coming in. Repeat business and eventually loyalty is critical in that respect. This paper considers airline customer buying behaviour and preferences and post-flight attitudes with a view to identifying what makes the air travel product more appealing to customers. A structured web-based purpose-designed instrument was used to collect travel and traveller data and perceptions and the findings are prioritised using a consensus decision making approach. A major issue is identified and a two-step model is developed to demonstrate its significance for airline customers' loyalty. Specific airline customer communications and other priorities and preferences are identified. In addition, it is found that airline customers have a number of complaints, many of which are not communicated to the airline, and it is demonstrated that these complaints impact on loyalty. It is therefore argued that airlines and researchers alike need to study customer complaints in relation to loyalty in greater detail. In view of both the economic situation in Greece and airline deregulation, this research is of significance to Greek airlines seeking to "tie" their customers and maintain market presence.

Keywords: Airline Customers, Satisfaction, Complaints, Loyalty

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## 1. INTRODUCTION

For a great deal of sectors, “crisis” is interpreted as a sharp decline in GDP or indeed spending specific to the sector. A “crisis” may be seen as the end of a business cycle, provided this is signalled by some prominent event or events. Depending on sector among others, it can be overcome in due course, aided by such initiatives as Keynesian approaches (Keynes, 1936; Woodford, 1999), or other government or corporate efforts to re-establish equilibrium.

For the aviation world and commercial airlines in particular, crisis may mean a sharp change in revenue or cost streams or volatility that may last from a few weeks to more than a year. These can have a multitude of originating factors. Reduced load factors of some duration, due to a broader economic “crisis” or downturn (with their impact exacerbated by the significant fixed cost element of aircraft leases, trained personnel payroll, slots rental and the like), fuel price volatility, industrial action, airspace disruptions (such as those that resulted from the Icelandic volcano eruption in 2010 or the World Trade Centre attacks in 2001) can all lead to a “crisis”.

A company’s typical response to a crisis is to minimise costs, followed by some efforts to maintain revenues. For airlines, this is where loyalty comes in. On the critical assumption that passengers have a real choice of carrier, and given that occasional travellers have been found to be significantly more price sensitive (Gomez et al., 2006), airlines need to strive to maintain the regular patronage of regular flyers. Indeed, to this precise end they have almost invariably devised some incentive programme and most have now joined an international alliance one of the primary purposes of which is to extend the reach of such programmes.

This paper builds upon the multi-step airline choice (Suzuki, 2007) and traveller perception, satisfaction and loyalty models (Gomez et al. 2006; Oyewole, 2001; Hess et al., 2007; Espino et al., 2008) literature to explore the real issues of concern to travellers. It is argued that there is a significant wealth of information on matters of interest to travellers (delays, luggage handling etc.) that can affect re-purchase and loyalty. This takes the shape of complaint material and appears to be understudied in terms of utilizing models for traveller behaviour. One or a series of specific negative travel experiences, it is argued, can act as a disincentive to repurchase or recommend an airline that can easily counterbalance costly positive actions such as price discounts or incentive programmes.

Section 2 considers the study's design, section 3 presents key passenger buying habits and perceptions, section 4 builds a customer loyalty model to demonstrate the concepts discussed and section 5 presents the study's conclusions and implications.

## 2. RESEARCH METHODOLOGY

To collect the data, a structured web-based purpose-designed instrument was used. It begins by collecting some general information about respondent's general profile and long distance travel behavior. The second questionnaire section asks about the airline travel offering, as perceived by the traveller, including her involvement in its production/consumption. The third section focuses on the respondent's last trip. This helps to sharpen information and perception recollections, an approach used extensively in the transportation literature (Ben-Akiva et al., 2002). The fourth section considers matters to do with the current economic crises. The last section collects socioeconomic control data identified by the literature as pertinent to air travel analysis (Dolan et al., 2006; Polydoropoulou et al. 2010). Most questions were either multiple choice or answerable on a 7-point scale (from -3: not at all to +3: completely).

The data was collected in May 2011 and 188 responses were received, essentially from within Greece. As can be seen from Table 1, a reasonably stratified sample was achieved according to a number of dimensions, except for a higher than average number of student traveller cases (48%). These are not necessarily all from the authors' research location base (i.e. the island of Chios) since only 8.5% of reported “last trips” landing or departing at Chios. Given sufficient controls, these were all maintained in the sample. With an average of 8 trips in the last year, respondents generally appear to be experienced air travellers, although most of them (62%) are not Frequent Flyer Programme (FFP) (incentive programme) members.

In the exploratory section of the study, tabulation based diagrams were used to aid concept presentation. To prioritise the issues to consider, a consensus decision making approach was employed, with people combining transport research skills, air traveller profiles and general business acumen singling-out those results that appear below. Tests were subsequently carried out to discern the robustness of results where named factors were ranked and the significance of any differences to the values attached to each studied.

In the explanatory section of the study, a two-step model is used to demonstrate factor interaction.

Table 1: Key Sample Characteristics

| | | Percent (N. obs. 188) | | | Percent (N. obs. 188) |
|---|---|---|---|---|---|
| Gender | Male | 55% | Complaints | Yes | 13% |
| | Female | 45% | | No | 87% |
| Age | 18-26 | 54% | Satisfaction | 1 (Dissatisfied) | 10% |
| | 27-40 | 23% | | 2 (Quite satisfied) | 19% |
| | More than 41 | 23% | | 3 (Satisfied) | 26% |
| Educational level | Bachelor | 66% | | 4 (Very satisfied) | 45% |
| | Master | 27% | Air Company (last trip) | Aegean | 40% |
| | Doctoral | 7% | | Olympic | 27% |
| Occupation | Public Services | 10% | | Other | 33% |
| | Private sector | 30% | Trips in the last 12 months | | 8 trips on average |
| | Businessperson | 12% | FFP membership | Yes | 38% |
| | Student | 48% | | No | 62% |
| Monthly family income | <€1000 | 22% | Monthly family income (cont.) | | |
| | €1000-€2000 | 16% | | €3000-€4000 | 18% |
| | €2000-€3000 | 18% | | More than €4000 | 26% |

## 3. DATA ANALYSIS

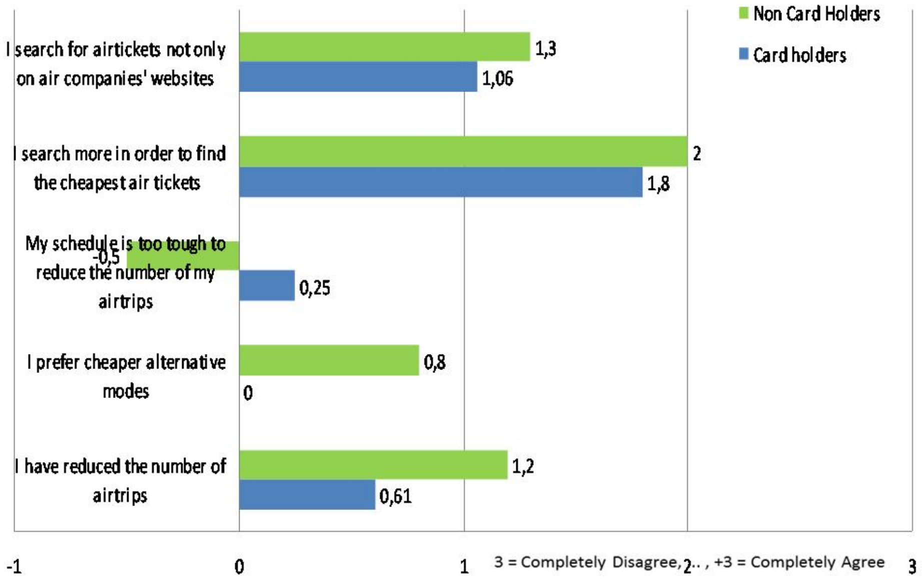
### 3.1 TRAVEL BEHAVIOR AND ECONOMIC CRISIS

From the airline customers' views, the current economic crisis (in Greece) has affected both the demand for air travel and the price sensitivity of travellers. Experienced travellers (incentive programme members) exhibit those behaviours marginally less, as they report tougher time constraints and a lower transport mode substitution (Figure 1).

### 3.2 BOOKING

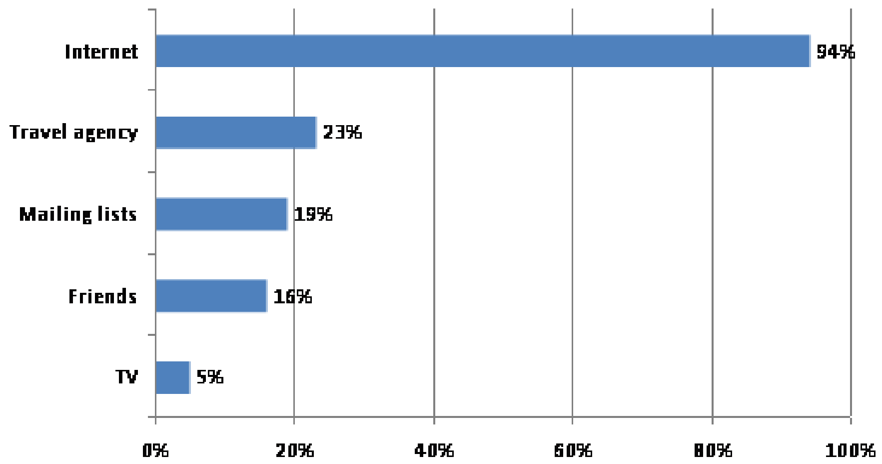
The front end of the air travel business has clearly moved to the e-business era. Some 94% of respondents use the web to inform themselves about available flights and fares while 53% use it to book a flight (Figures 2, 3). Interestingly, it is not young age that makes the “modern” traveller, with on-line buyers being on average older (at 33 years) than traditional buyers (at 29.5 years).

Figure 1: Attitudes about air trips during economic crisis



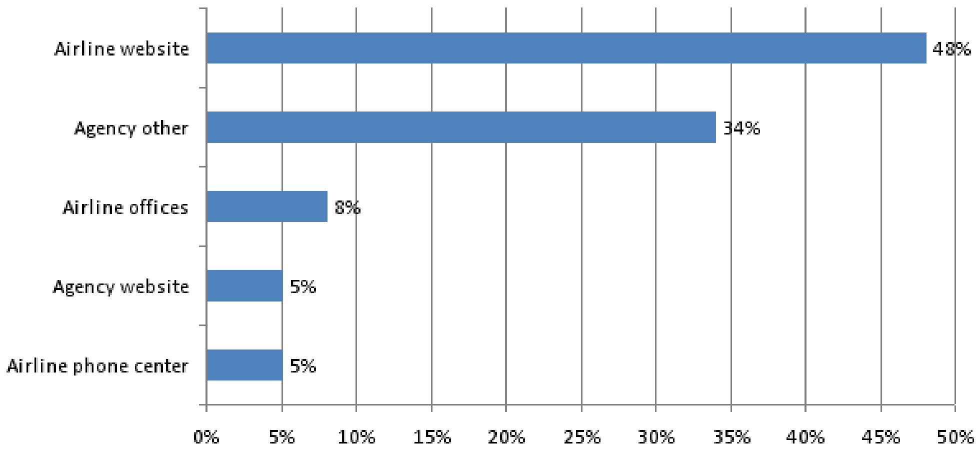

To the extent that e-booking can reduce airline costs and that extending it does not lead to reduced availability of more traditional ways of booking for those that need them, there is still ample scope for increasing the take-up of e-booking.

Figure 2: Information about air tickets




Subsequent research can look into ways of encouraging this, including dealing with price incentives, differential approaches to cancellations and ticket modifications, trust and confidence issues with regard to e-payments and other similar parameters (Papola and Polydoropoulou, 1996).

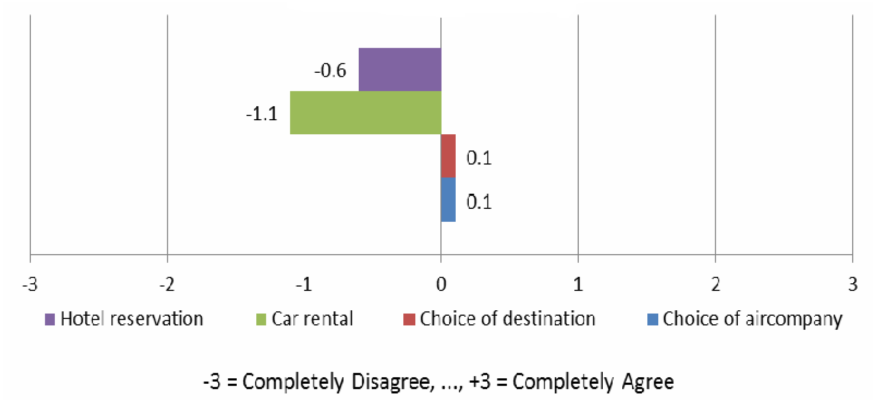
Figure 3: Air ticket booking




## 3.3 AIRLINE ADVERTISEMENT AND INFORMATION POLICY

Flyers feel that traditional advertising is inconsequential for services pertaining to a specific journey. Any impact should therefore probably be sought in brand profile building (Figure 4).

Figure 4: Advertisements' effects




Passengers have clear and specific preferences on advertising communications. They wish to receive ticket offer information by email (75% overall and 90% for incentive programme members) and incentive programme information on their mobile telephone (88%) (Figures 5, 6).

Given that incentive programme information is generally not more urgent or critical than ticket offers, an explanation might be that programme members are prepared to allow a more "intimate" or close communication with their airline. Carefully designed such communications can logically be expected to positively impact loyalty among others.

Figure 5: Flyer’s willingness to receive information

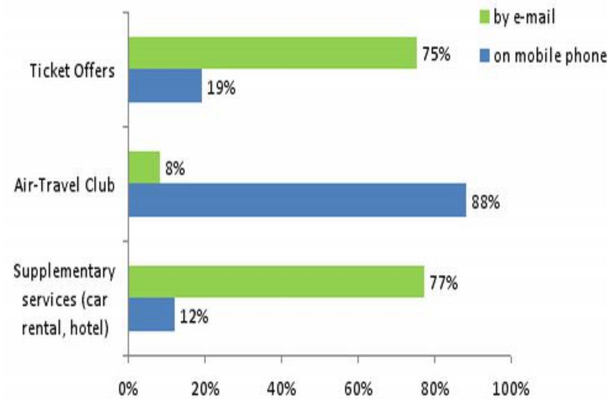
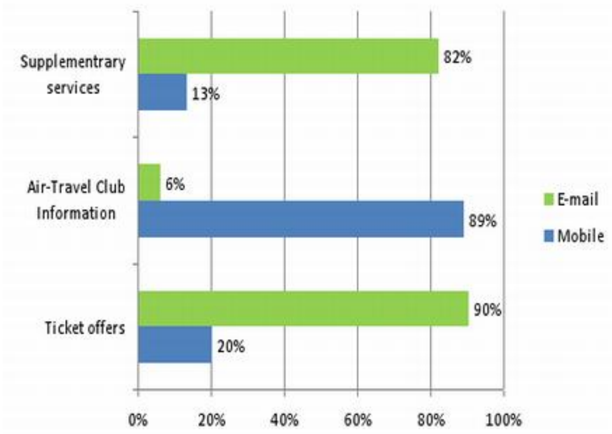



Figure 6: FFP member’s willingness to receive advertisements




### 3.4 CRITERIA FOR SELECTING AN AIRLINE TO FLY

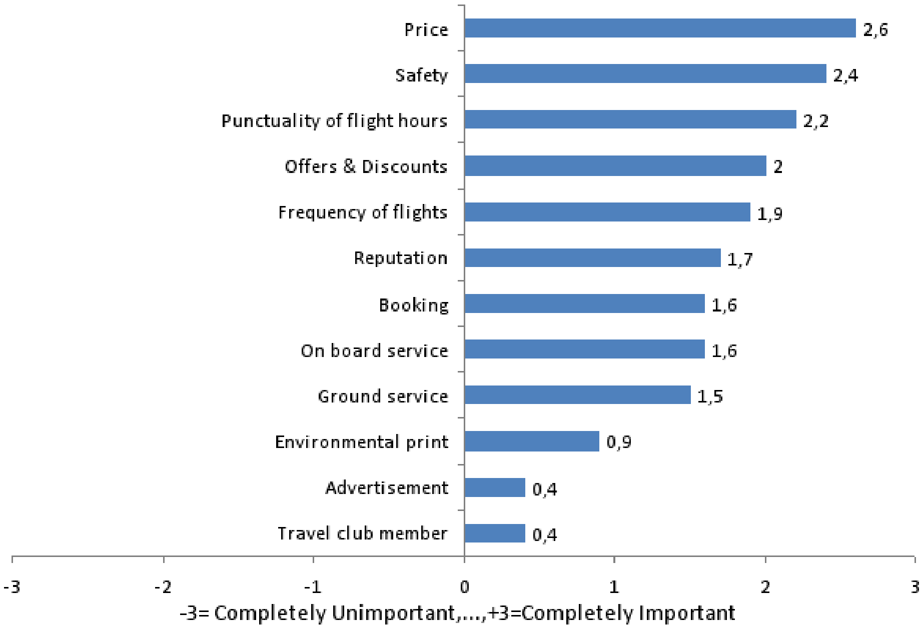
Air travellers consider multiple factors each time they select an airline carrier (Polydoropoulou et al., 2007; Hess et al., 2007; Nako, 1992).

Interestingly, this research shows that incentive programme membership is ranked lower than even environmental footprint. This is likely the result of a moderately experienced (in terms of average trips per year or incentive programme membership) air travel study sample, as described in section 2, and the recent redesign of major Greek airlines' incentive programmes to essentially reward only truly regular or premium class flyers, or in non-financial ways (eg. lounge access). If it takes some 25 low cost fares to accumulate incentive mileage sufficient for a 26th journey (equivalent to a 4% discount) and then fees and charges are still due, the discount may fall to under 3% or even 2% in some cases. Hardly an incentive to stick to a carrier and allowing all sorts of factors such as specific ticket price, punctuality etc. to make the difference for a broad range of passengers.

## 3.5 SATISFACTION FROM AIRLINE SERVICES AND COMPLAINTS

Passenger satisfaction is a compound concept (Figure 7). There exists a very interesting combination of generally reported satisfaction (Figure 8) and a strong stream of airline reported and non-reported complaints (Figure 9).

Figure 7: Ranking of factors affecting satisfaction




Airlines are apparently leaving flyers content with overall service provision, the highest scoring factors being booking, welcoming on board and the courtesy of stewardesses, and the lowest scoring being price, food & beverages and on-board entertainment. The booking process, in particular, is an excellent example of how the sector can push forward on matters it sets its mind to (en bloc, as Ott (1993) found). A key component is automated reservation systems, which was one of the early tools airlines used to (perhaps forcefully) enhance customer loyalty with the onset of deregulation in Europe and elsewhere (Lee et al., 1996). This was seamlessly evolved to the e-business era with the advent of (cost reducing) e-booking and more recently and for limited circumstances, e-check in. Another example is the development of (the now omni-present) incentive programmes (Clemes et al., 2008; Miller, 1993). In both cases, the initiatives were taken in the early 1990s in response to deregulation and rising competition, so one could anticipate that an increase in (market) pressures of various sorts might drive the development of further satisfaction and loyalty seeking initiatives.

Figure 8: Flyer's satisfaction from airline services

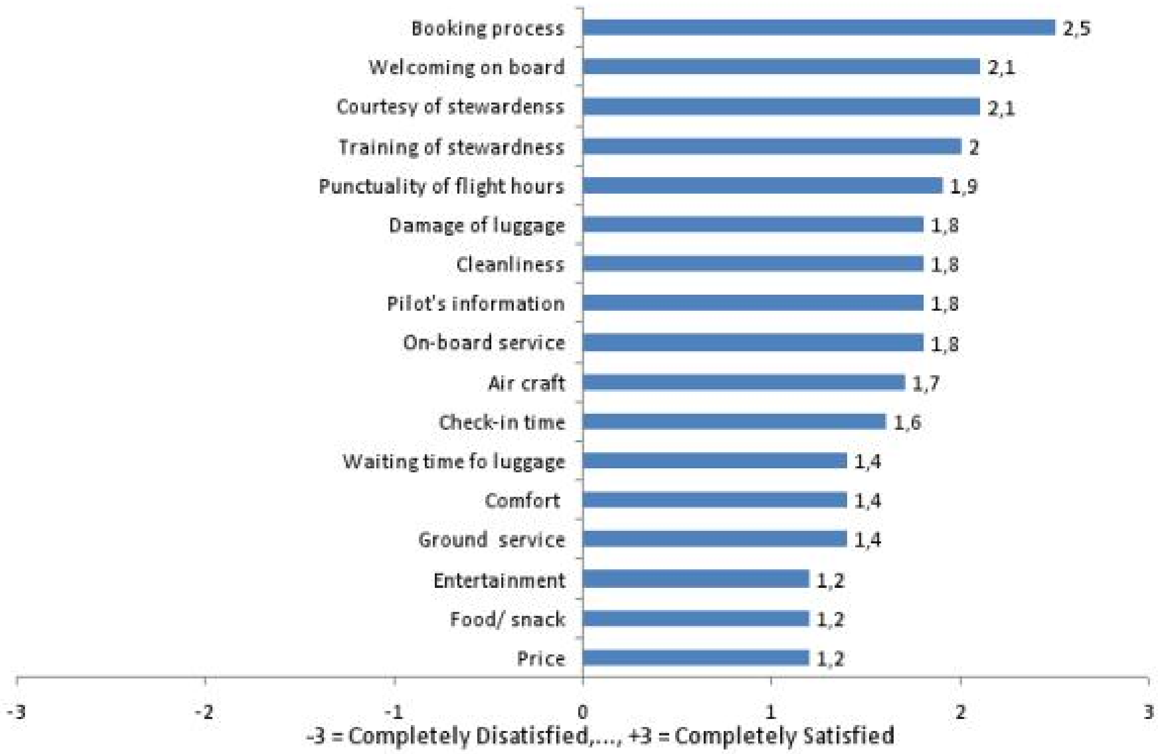
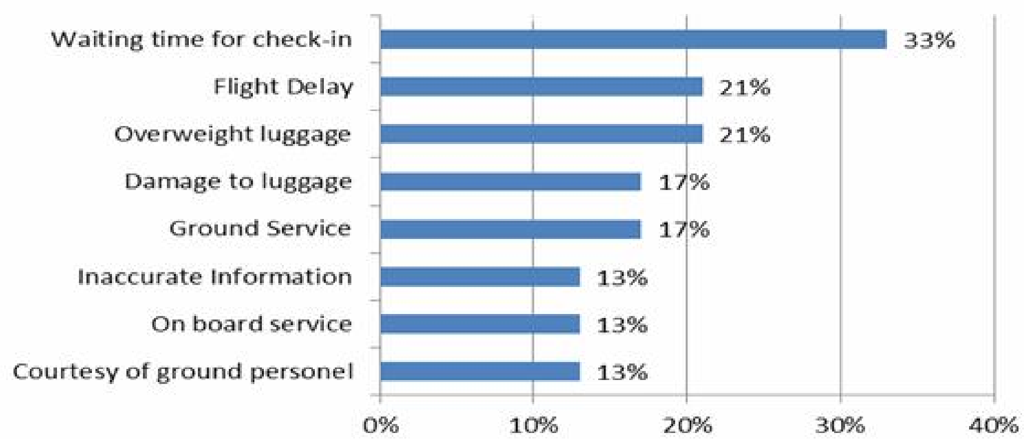



Figure 9: Emphasis of complaints (% in terms of passengers who have complaints)




The arguably unfinished state of this process then, perhaps so ad-infinitum, or indeed management or other issues, may be among the reasons why, at the same time, travellers have a significant number of concerns and complaints. Indeed, some 13% of respondents reported a complaint about their last flight, this percentage obviously rising significantly if, say, data had been collected for the last 5 or 10 flights. Slightly more than half of those who had a complaint (55%) were experienced travellers (incentive programme members). Most interestingly, the majority of passengers with complaints (61%) did not bother to report them to the airline.

Customer complaints are personal. They can be voiced to company staff or even put on paper. They are also by their nature specific, much more so that "low satisfaction" is. This means they are to easier understand and, more importantly, set about to dealing with them, although as the data collected during this study suggests, they remain largely (61%) unreported and therefore outside the sphere of airline knowledge.

It was therefore decided to take this finding one step further and consider whether complaints affect customer loyalty. There is significant academic scope for research in this area, with current research carefully mapping complaints without linking them to subsequent subject behaviours (eg. Özlem, 2007).

## 4. A PRELIMINARY PARAMETRIC MODEL TO PREDICT CUSTOMER LOYALTY

This section presents a preliminary model developed for predicting a customer loyalty. A loyalty index is created as the outcome of a two-step process. In the first step a factor analytic model is estimated to produce a factor from two variables namely customer repurchase and recommendation to others. In the second step the fitted values of the loyalty index is used as the dependent variable of a regression model. Independent variables are travel characteristics (chosen airline company), satisfaction level (overall satisfaction, complaints) and socioeconomic characteristics (income).

The resulting model is as follows:

$$LOYALTY = -1.860 + 0.459*Satisfaction - 0.567*Complaints - 0.329*Income + 0.612*Aegean + 0.374*Olympic$$

Table 2 presents the model's estimation results. The model's overall fit is moderate. However, the coefficients are statistically significant at a 95% level of confidence, while their signs are intuitively correct. Flyer satisfaction and complaints impact loyalty as expected (Fornell et al., 1996; Spreng, et al., 1995; Garow, 2010). "High" income has a negative effect on loyalty, possibly due to reduced time flexibility (time of flight determines airline), a different booking process (eg. through a secretary) or other factors. The airline each passenger last flew also reenforces loyalty provided it was a major one, perhaps on the basis of “once you will fly with us, you will always fly with us” and/or limited alternatives (for the 21 islands with airports, traveller choices are essentially a sub-hour flight or a multi-hour boat trip (Kitrinou et at., 2010; Polydoropoulou et al., 2011) while the market is big enough to support only a very limited number of airlines). In general, Aegean customers seem to be more loyal than Olympic Air customers compared to customers of all other airlines.

Table 2: Model Estimation Results

| Coefficient Names | Coefficient Estimates | t-test |
|---|---|---|
| Satisfaction (overall satisfaction)<br>(7pt Likert Scale: -3=completely dissatisfied,..,+3=completely satisfied) | 0.459 | 8.001 |
| Complaints<br>(1= yes, 0= o/w) | -.567 | -3.155 |
| Income (Monthly Family Income more than €4000)<br>(1=yes, 0=o/w) | -0.329 | -2.64 |
| Aegean (passengers who travelled with Aegean at their last trip)<br>(1=yes, 0=o/w) | 0.612 | 4.566 |
| Olympic (passengers who travelled with Olympic at their last trip)<br>(1=yes, 0=o/w) | 0.374 | 2.495 |
| Constant | -1.860 | -4.638 |
| <u>Statistics</u> | | |
| Number of Observations | 188 | |
| R-square | 0.403 | |
| Adjusted R-square | 0.387 | |

Although the sample used in this research is not extensive, on the basis of the above there is evidence to suggest that customer complaints do have a predictive value for airline passenger behavioural loyalty, as satisfaction does. Moreover, the results obtained create several avenues for future research.

## 5. CONCLUSIONS

Airlines in a state of crisis need to take steps to ensure revenues keep coming in. Repeat business and eventually loyalty is critical in that respect. This paper considers airline customer buying behaviour and preferences and post-flight attitudes. Specific communications and other priorities and preferences are identified.

Analysis shows that the current economic crisis has affected both the demand for air travel and the price sensitivity of travellers. However, experienced travellers and incentive programme members exhibit those behaviours marginally less, due to tougher time constraints and limited travel mode alternatives.

Nowadays passengers seem to be familiar with the e-services that airline companies offer. The vast majority of the participants use the internet to be informed about flights and fares, while they are willing to receive ticket offer information by email and incentive programme information on their mobile telephone. Interesting is the fact that the participants who use e-booking and e-services are older than traditional buyers. Airlines should encourage more of their passengers to become members of incentive programmes in order to achieve a more close communication with them.

Concluding, it is found that airline customers have many complaints, many of which are not communicated to the airline, and it is demonstrated that these complaints impact on loyalty. It is therefore argued that airlines and researchers alike need to study customer complaints in relation to loyalty in greater detail. Such efforts may benefit from methodological approaches segmenting customers and/or providing value-added propositions based on the Delta Model (Hax et al., 2001) or the Rhombus Model (Litinas et al., 2010).

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# A COMPLEX SYSTEM APPROACH IN MODELING AIRSPACE CONGESTION DYNAMICS

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ABSTRACT
The dynamical behaviour of groups of airspace sectors, *e.g.* Functional Airspace Blocks, is not trivial to be analysed without appropriate theoretical tools. In this paper, we suggest a discrete model based on cellular automata and multi agent systems to express the congestion dynamics and complexity in the controlled airspace. Discrete time simulations have been performed with random selected scenarios of traffic and with independent sector parameters to investigate the impact of availability of local sectors on the whole state of the airspace. Obtained results show the existence of a traffic threshold that leads to a theoretical saturation of airspace. The test scenario showed a phase transition phenomenon towards the congestion of the European airspace at the resulting traffic threshold *circa* 50 000 flights. Validation using real data shows the predictive abilities of the model.

Keywords: Air Traffic Management, Air Traffic Control, Complex Systems, Airspace availability, complex networks, Multi Agent Systems, cellular automata.

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## 1. INTRODUCTION

Most of new policies trying to improve the Air Traffic Management (ATM) system tend to maintain its classical structure. Innovation in this field is basically focused on equipment, information and communication technologies, task automatization and improvement of Human-machine interfaces [Watkins et al., 2002]. Nevertheless, different actors of airspace traffic consider that the current system has attained its limits and congestion is more and more difficult to resorb. Empirical studies show that more and more network-effects are observed in the operational context demonstrating the qualitative changes in the airspace availability ([Mayer et al., 2003], [Daniel, 1995], [Brueckner et al., 1992]).

Delay cost is evaluated to be between 7 and 11 billion euros per year and according to the Institute of Air Transportation (IAT) 60% is due to ATC (Air Traffic Control) [ITA, 2000]. The ATM system is composed of numerous processes and various actors having different and divergent objectives: pilots try to be on time, companies focus on economic aspects (reducing costs and maximizing benefits) and controllers must guarantee the security of the traffic. In our approach, even if we tried to include indirectly some ATM aspects, we are basically concerned with the ATC subsystem, in particular the *en route* control. In fact, en route control in Europe is the main responsible of traffic delays leading to costs of several billion euros per year [Golaszewsk, 2002]. This is not the case in the USA where delays are caused by the airport saturation.

Air Traffic Management (ATM) can be modelled as a set of components of different subsystems in mutual interactions in order to accomplish the mission of simultaneously maintaining safety and sustaining growth. The ATM system is considered as a complex system because its behaviour depends on a complex combination of various sub-systems performing complicated functions. The evaluation of the impact of each function on the overall ATM system cannot be performed unless a specific approach is used. Understanding the mechanisms by which complexity may be reduced in the particular domain of ATM may provide important solutions to optimize the dynamics of the system and its structure.

## 2. OVERVIEW OF THE ATM SYSTEM

The Air Traffic Management system is a complex network composed of several heterogeneous and mutually interacting subsystems. The complexity of the ATM can be related to the following factors: system size, diversity of users, safety constraints and uncertainty (weather, human factor, technical factor...). This complexity can be also related to the Air Traffic Control (ATC) subsystem representing the rigidly structured air space and the largely centralised, human operated control hierarchy ([Delahaye et al., 2005], [Histon et al., 2002]). ATC, in which we observe complex phenomena, is composed of services provided by the controllers on the ground to ensure the safety and the efficiency of aircraft's motion, and are provided throughout the controlled sectors. In fact, aircraft tend to fly along fixed corridors and at specific altitudes, depending on their route. The entire path of the aircraft is pre-planned (flight plan) and only minor changes are permitted online. The ATC is in complete command of the air traffic and ultimately responsible for safety. All requests by the aircraft have to be cleared by the ATC.

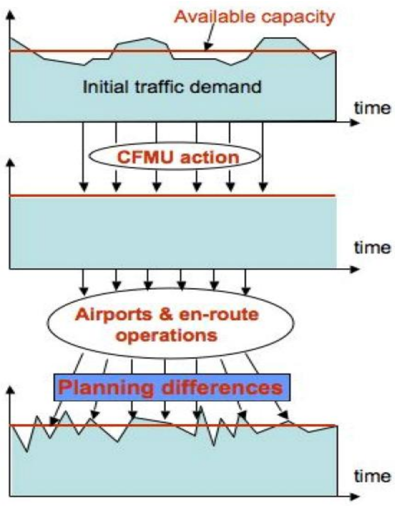
Airspace is composed of controlled airspace and uncontrolled airspace. A controlled airspace is a set of controlled sectors, each of which being associated to a team of air traffic controllers. These air traffic controllers are persons who operate the air traffic control system to expedite and maintain a safe and orderly flow of air traffic, and help prevent mid-air collisions. They apply separation rules to keep each aircraft apart from others in their area of responsibility and move all aircraft efficiently through "their" airspace and on to the next. [Tran Dac, 2004]

Aircraft follow a planned trajectory to join two airports. They are monitored and guided throughout the whole flight time by air traffic controllers. Computers, communication links and radar screens all provide up-to-date information. Technology quite often has not one but two back-up systems to cover any possible breakdowns. The whole organisation is based upon international regulations and determined routines. During the flight different services are furnished by three kinds of control activities: Tower Control where controllers direct aircraft that are taking off or landing at airports, Approach Control where controllers handle aircraft that are transitioning from the en-route portion of flight into the airspace around or near an airport and En-route Control where controllers handle aircraft that are operating on the main travel portion of their flights, typically at a high altitude.

As specified in the introduction, in this work, we are especially interested in the study of the behaviour of the en route sectors because, in Europe, en route control is the main responsible for the airline delays and traffic congestion. We include the effects of approach and tower control sectors using a non-local interaction rules.  As we can see in Figure 1, the initial traffic demand exceeds the declared capacity of a sector at a specific moment. The Central Flow Management Unit (CFMU), an operational unit of EUROCONTROL[3], manages air traffic demand in order to avoid airspace congestion due to this difference and to optimize the utilization of resources. Despite the regulation and the planning made by the CFMU there are always differences between planned and real traffic. These differences are specific to each sector and the resulting effect of these local states and their interactions between them on the whole availability of airspace are difficult to determine.

By considering the densely interconnected system of ATM as a network where components properties are heterogeneous and individual and by applying appropriate theories we are able to model the emergence of global properties in the system from the local behaviour of its component (typically the availability and congestion of the airspace). By this way we can take into account the coordination requirements representing the interactions between controllers in adjacent sectors, which is an important factor in ATC complexity [Histon et al., 2002]. It is also important to note that these interactions are closely dependent of the airspace design. In fact the topological structure of airspace defines the structure of the sectors coordination network. The space-time analysis that we propose in this paper is a general approach focusing on the intricate relation between these two fundamental aspects.

Figure 1 Real versus planned traffic in a congested sector




[3] EUROCONTROL is the European Organization for the Safety of Air Navigation

## 3. BOTTOM-UP MODELING OF THE ATM SYSTEM

ATM simulation requires a modelling approach and simulation framework taking into account particularities and properties of this system. ATM being a complex system where the objective is to guarantee the security and fluidity of the traffic by optimizing the use of the shared resources between different actors having divergent constraints (companies, air traffic controllers, pilots, passengers...) needs to be studied using appropriate Tools [Boccara, 2004].

In various natural and artificial contexts, we observe phenomena of high complexity. However, research in physics, biology and in other scientific fields showed that the elementary components of complex systems are quite simple. It became crucial for scientific research dealing with complex systems to determine the mathematical mechanisms to understand how a certain number of such elementary components, acting together, can produce the complex behaviours observed in these systems.

Cellular automata studied by Stephen Wolfram [Wolfram, 1984] represent an attempt to design the simplest mathematical model able to generate a high complexity. One of the most important current problems consists in finding general laws being able to be applied to study the majority of complex systems. A cellular automaton is, in the simplest case, one line made up of empty boxes. Each box carries one value 0 or 1. Thus, the system configurations are an ordered sequence of 0 and 1 evolving over time. At each time step, the value of each site is updated according to a specific rule. The rule depends on the value of a cell, and of its two closest neighbours.

According to Wolfram [Wolfram, 1986], [Wolfram, 1994] Cellular Automata (CA) are microscopic models for complex natural systems containing large numbers of simple identical components with local interactions. Even if the construction of the cellular automata is very simple, their behaviour can be very complex [Wolfram, 1994], [Wolfram, 2002]. There are fundamental reasons showing that there is no general method which can universally be applied to predict the behaviour of these systems. Compared with reality the cellular automata appear simplistic. However, they are currently considered as a fundamental tool in modelling and simulating complex phenomena, in particular concerning the auto-organized systems. The use of the cellular automaton makes it possible to reduce the complexity of modelling to what is necessary to generate the phenomenon. It is a paradox of complex systems: the behaviour of the system is unpredictable and complex (at a long term level) whereas the laws (or rules) which controlling it are simple and deterministic. Moreover, cellular automata represent a powerful simulation tool. In fact a convincing simulation of large dataset requires computing power of parallel computers. However, the local nature of interactions between cells makes the programming of cellular automata easy "to be parallelized". The dynamic theory of systems was developed to describe the global properties of the solutions of equations.

A combination of Cellular Automata (CA) formalism and Multi Agent Systems (MAS) allows a coherent mathematical and computational representation of the physical model. In fact, CA permit the representation of the entities composing the system and the evolution of their state over time whereas MAS are well adapted to express the interactions between the entities and their behaviour [Weiss, 1999], [Fikes, 1982]. We will use in our model this combination to rebuild the real system from the basic components.

*a. WHY CA AND MAS IN ATM MODELING?*

The interest in combining MAS and CA is to introduce the mobility of the components representing the cells of CA. These components are called *agents* in MAS and they are able to move, communicate, transmit information, take decisions and influence their environment. Generally, agents are used in social sciences to represent individual or collective decisions in a population and more generally they have socio-economical attributes. But multi agent simulations in social sciences are often non-spatial which is not the case in ATM. In fact, in ATM modelling we need to represent:

The physical and geographical system (airspace) and its properties:

- structure dynamics : evolution of the merging and splitting schemes of the sectors.
- routes and sectors topology (shape of the sectors, average number of neighbours, routes configuration,...).
- the technical system : aircrafts, communication systems...
- human system : controllers, pilots, ...

In order to provide an efficient and realistic simulation of the ATM behaviour it is important to include the relations between its three basic subsystems. In fact, the components of technical subsystem (aircrafts) interact with the physical subsystem (sectors) and the human subsystem (controllers, pilots). The human subsystem is particularly important because it supervises the two other subsystems in order to accomplish the global mission of the ATM system: manage the continuous increase of the traffic volume while guaranteeing the security and the fluidity of the traffic. These aspects can be easily integrated by combining CA and the multi agent paradigm.

Actually, complexity of ATM (combination of a natural and an artificial complex system) is such that even a MAS/CA simulation is insufficient to capture all the aspects and specificities of the system. A realistic representation of ATM needs the representation of hierarchy and heterogeneity of the different subsystems. Nevertheless, in our work we are especially interested in observing qualitatively the behaviour of the system while reproducing in a simplified way its basic mechanisms.

Here is the list of the important aspect which must be considered in the modelling of the ATM system:

- the different kind of entities in the system;
- the different hierarchical levels in the system;
- the topology of the entities;
- the different kind of relations between the entities;
- the process determining the state of the entities;
- the process determining the changes in their spatial location.

The simulation of the behaviour of such a system needs a rigorous formulation of these aspects. The simulation of the management of shared resources requires also the integration of the interaction between the agents and the dynamical resources. A first method that could be used to represent these interactions emphasize on processes determining interactions between agents and resources. These agents are cognitive agents having a representation of the resource and possess their own rules to reach their objectives. Each agent acts on the resource according to his rules and modify the resource for other agents. In our context we are facing the problem of the management of renewable common resources (airspace) in confrontation with different actions and situations which may lead to a satisfactory use (or not) of the resource for the different agents (pilots, controllers, companies,...).

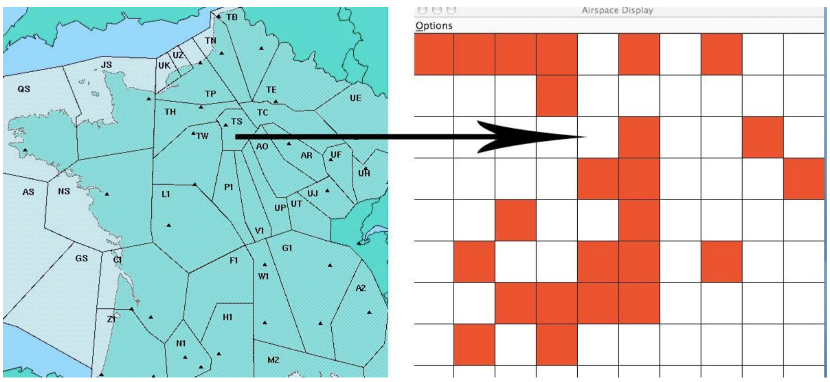
The multi-agents universe offers also an interesting ability to simulate the message exchange in communication networks (controller/controller communication and pilot/controller communication). These communications may represent information exchange, negotiation between the agents (collaborative decision making) or services exchange.

*b. MULTI AGENT MODEL FOR CONGESTION DYNAMICS IN THE ENROUTE AIRSPACE*

In the following, the physical model corresponds to the en route part of the controlled airspace. The mathematical model is represented by the objective correspondence between sectors and cells of a cellular automaton (Figure 2). The computational model corresponds to a multi agent system implementing the functions of the cellular automaton. Each sector is an environment agent integrating the operational rules of air traffic control. Similarly, each aircraft is a mobile agent following predetermined trajectory and communicating with sectors.

As seen in section 2, there is a significant difference between the planned traffic and the realized one [Gwiggner et al., 2006]. This difference leads to the congestion of a certain number of control sectors. In order to reduce the congestion and to keep a certain fluidity of the traffic, the controllers in the saturated sectors may reduce the speed of the aircraft or deviate from its trajectory to an available control sector. To be able to take into account these particularities of the ATC system, we integrated these aspects in the rules implemented in the cellular automaton where cells represent the controlled sectors.

Figure 2: Correspondence between sectors and sites




The algorithm for implementing air traffic control rules is as follows:

- Each sector is an agent modelling its behaviour of air traffic control in the operational context.
- The state of this binary valued agent: 0 if it is available (able to provide control service to an entering aircraft) and 1 if not (the sector is congested).
- An aircraft entering in sector $S_a$ at time *t* is transferred to the following sector $S_b$ according to the flight plan and the following rules :
  - at time $t + \Delta_a$ if $S_b$ is available; where $\Delta_a$ is the needed time to cross the sector $S_a$;
    - if $S_b$ is congested at time $t + \Delta_a$, the aircraft is delayed (by decreasing the speed) by one time unit, then transferred to sector $S_b$ if $S_b$ is available at time $t + \Delta_a + 1$;
- Otherwise, the aircraft is rerouted to one of the neighbouring and non-congested sectors with probability $p_1$.
- An aircraft may be subject to delays other than those imposed by sectors for security reason. That is why an aircraft may have randomly a delay while arriving to a sector with probability $p_2$ (this allows to take into account uncertainties related to the meteorological conditions, take-off delays, ...)
- The aircraft may increase its speed if it was already delayed with probability $p_3$.

*c. SIMULATION OF THE MODEL*

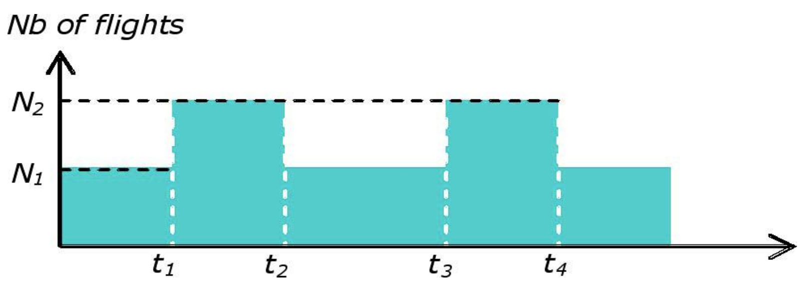
The model was implemented using Repast (Recursive Porous Agent Simulation Toolkit) [North et al., 2006]. A part of the controlled airspace, representing the en route part is modelled using a square grid of size *spaceSizeX*spaceSizeY*, each corresponds to a sector. The crossing time of sectors is uniformly distributed in *[minCrossingTime, maxCrossingTime].* The sector status is determined as follows:

- a sector *s* is available at time *t* if it contains a number of aircrafts inferior to its capacity *Cs* ; the maximum number of aircraft that a controller is able to manage simultaneously.
- sector capacities are distributed uniformly in *[min-Capacity,maxCapacity].*

Traffic pattern was generated randomly. The variable *nbPairsOrigDest* represents the number of origin-destination couples (*input-cell, output-cell*). The trajectory obtained is a segment having as extremities *Orig. cell* and *Dest. cell*. The flight plan generated is consequently composed of the list of sectors crossed by the segment. In order to take into account the fluctuation of the traffic during the day we used a particular distribution of flights where the traffic is doubled in two different time windows.

Let *nbFlights* = $\sum_{0}^{24} N_t$ be the total number of flight of the day (crossing the studied *en route* airspace). The distribution of the flights is introduced such that the traffic is doubled during the intervals (Figure 3): [ $t_1$ = 6h; $t_2$ = 8h] and [ $t_3$ = 18h; $t_4$ = 20h].

Figure 3 The distribution of the daily Traffic




The simulation shows the existence of a phase transition phenomenon concerning the congestion of the airspace due to a critical density of the traffic [Ben Amor et al., 2007]. For example, for a given parameterization we notice that while varying the number of flights we obtain a behaviour of the system totally different when a certain threshold is reached. In fact, for $n$ < 50,000 (in particular for $n$ = 30000 representing the mean volume of the daily traffic in Europe) and the other parameters being fixed according to the mean observed values in the real operational context, we obtain some local congestions that are quickly resorbed by the collaboration between sectors (Figure 4). When n ≈ 50,000, we can identify a phase transition phenomenon where the system is trapped in a situation where the congestion propagates through the whole area and local rules are unable to resorb this congestion (Figure 5). This phenomenon reflects situations where the system needs an external help to resorb the congestion (delaying take-off at the airports, change the routing plans for aircrafts on the ground, etc...)

Figure 4: The system absorbs the local congestion when *nbFlights* is inferior to the threshold

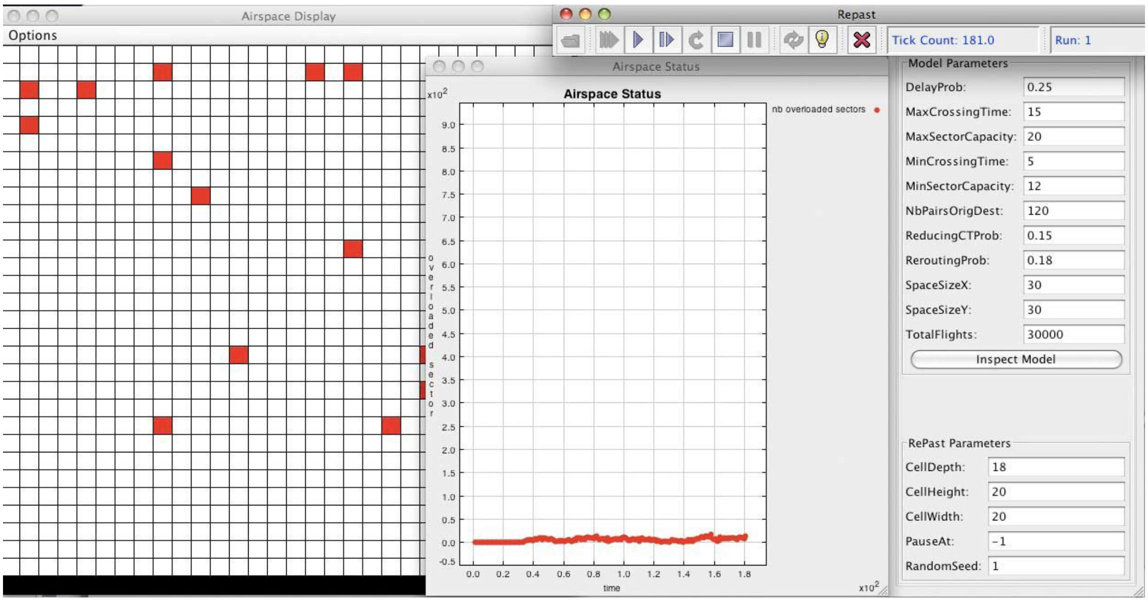
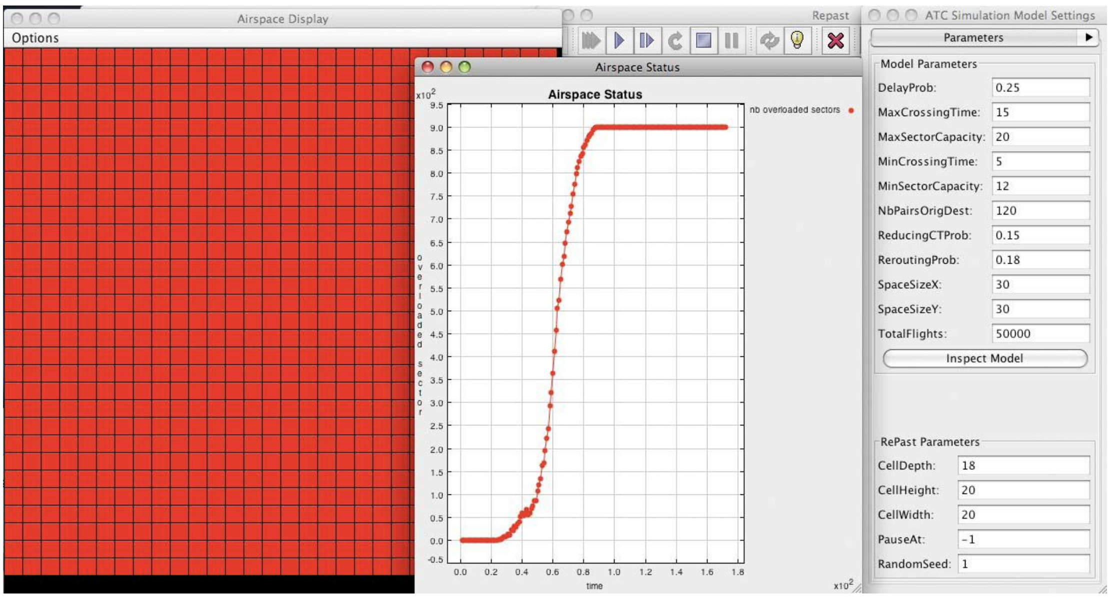



Figure 5: Phase transition phenomenon observed when the threshold of the parameter *nbFlights* is reached



## 4. VALIDATION WITH REAL DATA

In order to validate the model, from the qualitative point of view[4], we used the real data relative to a one-day traffic. To be useful we applied some treatments on these data in order to gather from different files the needed information implementing the model. We used in particular the following files:

- the file *ALL-FT.20070624*,traffic file of the CFMU giving the profile of all flight of the day (June 24th 2007). This file contains among other information the following parameters for each flight: departure and arrival airport, aircraft identity, company, type of aircraft, followed route, requested flight level, regulations (in particular rerouting), ATFM sent and received messages.
- the file *Airblock.296*, environment file of the CFMU giving the set of the elementary structural units of airspace, and their geographical coordinates.
- the file *Aircraft.296* giving for each aircraft its identity, type and performance.
- the file *Airport.296* containing the name, ICAO code and geographical coordinates of all airports in the world.
- the *Airspace.296* giving for each airspace entity its identity, name, type and the number of elementary sectors composing it.
- the file *Capacity.296* giving the capacity and specifying the type of the concerned element (control centre, elementary sector, composed sector...) and the time unit.
- the file *Configuration.296* giving for each control centre its configurations during the day and the name of the sectors in the different configurations.
- the file *Flow.296* giving the traffic flows existing between the different airports.
- the file *NavPoint.296* giving the number of beacons and for each its name, type and coordinates.
- the file *OpeningScheme.296* giving the opening schemes (merging and splitting of the sectors) of different control centres during the day.
- the file *routes.296* giving the available routes network during the day.
- the file *Sector.296* giving the number of the elementary sectors and for each its name and air blocks composing it.
- the file *TrafficVolume.296* dividing the traffic into traffic volumes and giving complementary information about the flows.
- the file *reroutingStats* giving statistics about the realized rerouting procedures.

[4] Correspondence concerning the simulated scenario and the realized traffic between the shape of the graphs giving the evolution of the number of congested sectors.

- the file *OverloadHourly* giving the total number of hours of congestion where the traffic exceeded the capacity by 1%, 20%, 40%, 60% et 80%. It provides also the different kind of regulation procedures realized to resorb the exceeding traffic.

In order to rebuild the realized traffic and represent the evolution of congestion level over time we need to elaborate a simulation scheme and manage the dependencies between the data contained in the different files. For example, the evolution of capacity depends on the opening schemes of the different centres which implies the reading of the file *OpeningScheme* and determine the structural entity to which the capacity is applied. Similarly, to determine the geographical location of a sector we need to open the file containing the list of *airblocks* composing it. More generally, the figure 6 gives the global map of dependencies between the different files. The figure 7, provides a general view of the simulation interface.

Figure 6 : File Dependencies Map

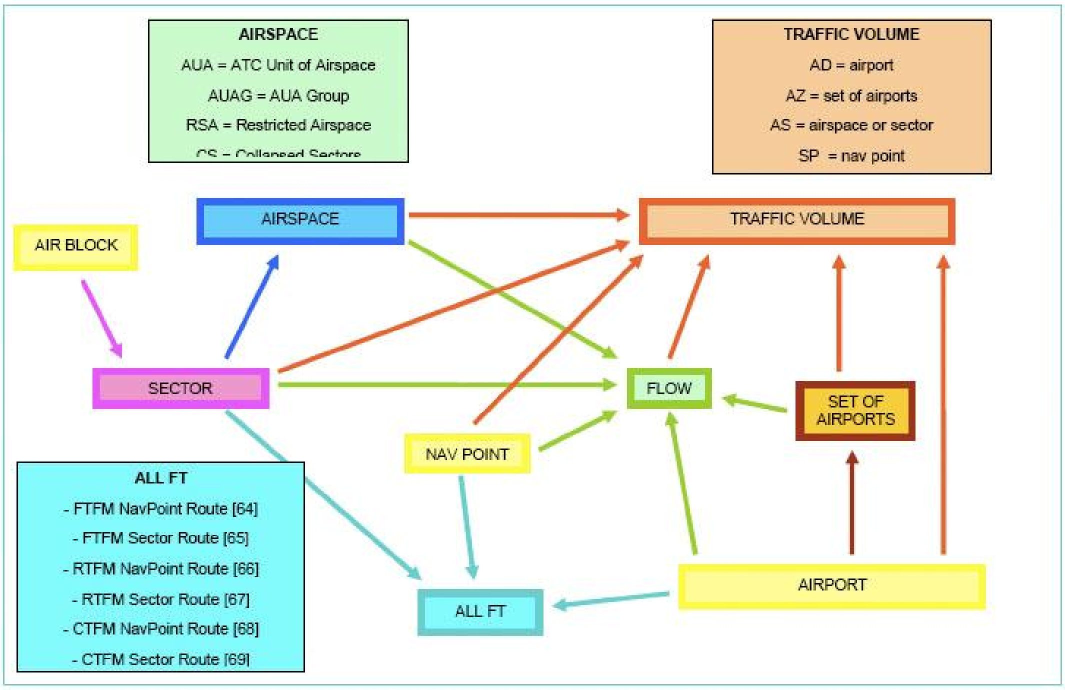
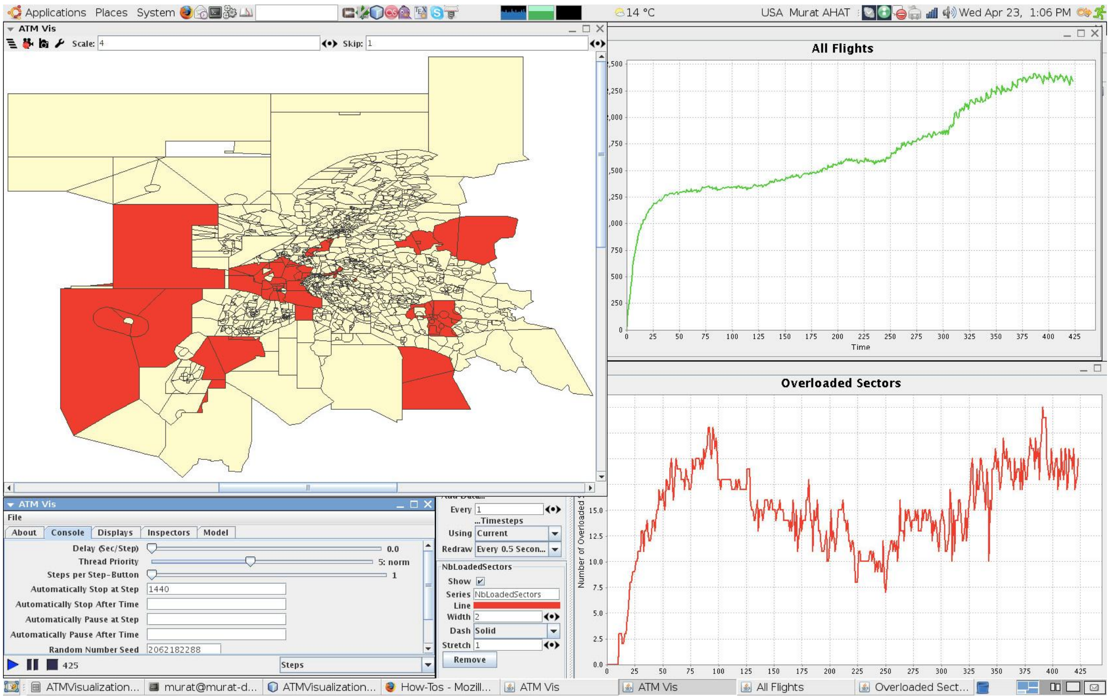


Figure 7: Evolution of the Congestion in the Airspace




The simulation using real data showed a similarity between the shape of the graph giving the observed congestion level of en route sectors in the European airspace (figure 9) and the graph given by the simulated scenario of the model using the following parameterization (figure 8) :

- probability of delay of aircraft on take-off : 0,25.
- capacity interval : [12-20].
- probability of regulation using speed : 0,15.
- sector crossing time interval : [5-15].
- rerouting probability : 0,18.

Nevertheless, even if the two graphs (observed and simulated congestion) are similar, they have mainly two differences:

- at the quantitative level, there is an important difference between the observed and the simulated congestion. By comparing the graph representing the evolution of the real number of congested sectors to the graph simulated congestion, we notice that the real congestion level is clearly inferior to the simulated congestion.
- the sharpness of certain peaks in the congestion are more important in the simulated

congestion.

The difference between the observed congestion and the simulated one is not surprising. Considering the sensitivity of the ATM system (as any complex system) to the initial conditions, the quantitative prediction is very hard to establish. The main objective of our model is essentially oriented to the reconstruction of congestion dynamics (the aspect of the congestion graph).

This quantitative difference may be explained also by the use of the instantaneous capacity (number of aircraft simultaneously present in the sector) and we do not integrate the hourly capacity (amount of the traffic that could be managed by a sector in one hour). Concerning the small differences in the peaks related the abrupt changes in the number of congested sectors we can provide these two elements of explanation:
1) the difference is basically due to the difference in the rerouting procedure used in the model compared to the real procedures. In fact, in the model we considered only the tactical rerouting but in the real operational context the flow managers using short term predictive tools are able to display specific online procedures to apply strategic rerouting schemes.
2) other real factors which are difficult to capture in the model may also provide a part of the explanation of this difference, e.g. the traffic management by controllers. Actually, controllers do not systematically apply a rerouting scheme when the sector is overloaded. It was shown by empirical studies that controllers are able to manage sometimes a certain traffic load which is more important than the declared theoretical capacity.

Despite these differences, our proposed model reproduced dynamics of the congestion which is very close to the real context. More, it allows testing hypothesis and different scenarios by varying the simulation parameters. Thus we noticed concordant observations with empirical studies. In particular, we tested the effects of the variation of the size of the sectors and noticed that there is a minimal size of sectors under which the propagation is amplified.

Figure 8: Simulated congestion - Traffic of June 24th 2007

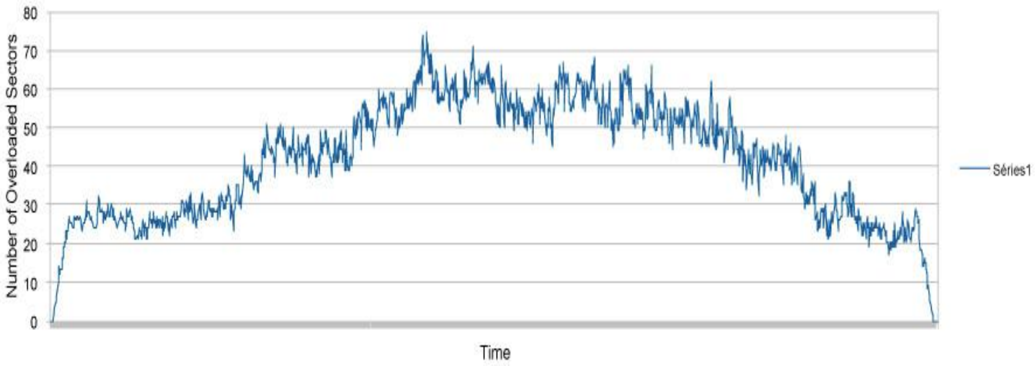
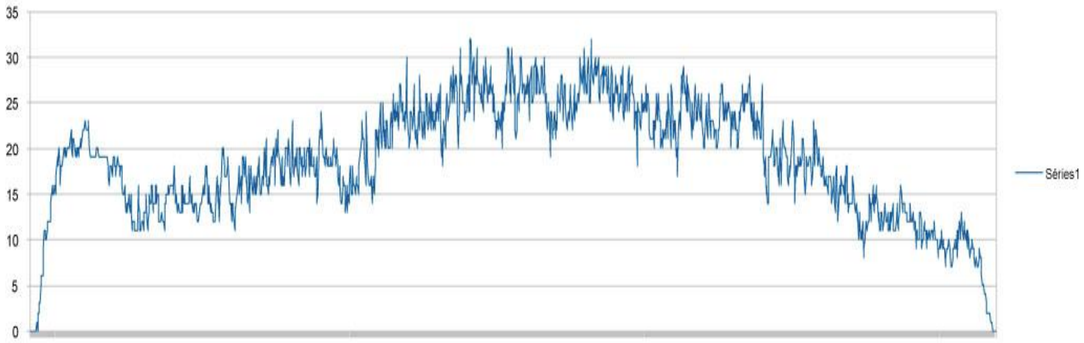



Figure 9: Observed congestion - Traffic of june 24th 2007




## 5. CONCLUSION AND FUTURE WORK

The systemic approach we used to model the dynamics of availability in ATC showed the complex nature of the behaviour of the system illustrated by the phase transition phenomenon which occurs when specific thresholds of key parameters (*i.e.* number of flights and crossing time) are reached.

Validation using real data of sectors shows the ability of the model to reproduce congestion dynamics similar to the real system. In a future work we aim to provide a mathematical model providing more precise quantitative predictions. To achieve this goal we need, from a mathematical point of view, to formalize and generalize the neighbourhood concept using pre-topology theory in order to express different kind of connections between sectors and to consider a more realistic neighbourhood basis.

Although airspace is a common resource, ATM in the European Union is still organised in a fragmented way. Every time a plane enters the airspace of a Member State, it is serviced by a different air navigation service provider on the basis of different rules and operational requirements. In order to improve capacity and efficiency while minimizing costs of air navigation services, European Member States provided a key mechanism integrated to Single European Sky (SES) and called Functional Airspace Blocs (FABs). This implies an operational organisation of airspace independently from country boundaries.

From a managerial and operational point of view, our model showed in particular the interest of the single sky and Functional Airspace Blocs (FABs) concepts. In fact, according to the simulations it is clear that a functional and operational segmentation of the controlled airspace is more efficient to guarantee a performing traffic management, by reducing conflicts due the heterogeneity of rules and operational requirements.

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# BUSINESS RELATIONS BETWEEN THE LOW COST CARRIERS AND AIRPORTS AS A CONSEQUENCE OF THE AIR TRANSPORT DEREGULATION

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ABSTRACT

The deregulation of air transport has increased competition between air carriers, resulting in lower fares and increased volumes of passengers. Subsequently, the fare reduction has altered the market structure with the establishment of new carriers, strategic alliances and mergers, and the bankruptcy of several traditional airlines which were unable to adapt to the new environment. The emergence of low cost carriers (LCCs) is one important outcome of the deregulation. LCCs entered the market by offering a differentiated product based on bare services offered at significantly lower prices. The main target was travelers with increased sensitivity in pricing and less demand for all-around services. The rise in terms of passengers and flights dictated a better utilization of the fleet, requiring reduced turnaround times at airports. Many central airports had very little flexibility and capacity necessary to facilitate additional timeslots. As an answer to inadequate capacity combined with higher taxes and fees, most LCCs have chosen to use secondary or regional airports. This choice has altered the balance and strategic importance between airports and increased their importance for air carriers. This paper examines the evolution and development of LCCs globally, along with the consequences of their expansion to the traditional carriers, the market and the passengers. Emphasis is given to the relationship between LCCs and airports which has resulted in an additional increase in air travel. The prospects of Greece as a market for LCCs are also being discussed.

Keywords: Low Cost Carriers, Airports, Greek Air Travel

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## 1. INTRODUCTION

The new global regulations have effectively deregulated the air transport market. The establishment of a competitive environment opened the way for Low Cost Carriers (LCCs) as a cheaper and simpler alternative model for passengers choosing air travel. Passengers as consumers have now more choices between different service levels and corresponding prices. LCCs appeared first in US market and later in Europe and the rest of the world. Today most countries and regions are served by LCCs together with traditional carriers, altering the industry structure in a global scale. In order to achieve low cost, LCCs have formed strategies that either reduce any cost that can be trimmed down or completely remove parts of their services.

For LCCs, airports were initially a substantial obstacle; costs were too high to suit their business model and operation from many airports was very limiting, especially in saturated markets. Airports located in capitals and other major cities could not offer capacity at reasonable pricing, usage period and hours. On the other hand, secondary and regional airports had both the unused capacity and the willingness to negotiate and offer competitive low fees. Any cost reduction achieved through better contracts with the airports allows LCCs to offer lower ticket fares. Lower fares combined with the use of additional airports and the enlargement of catchment areas has resulted in increasing of the passenger volume. Of course traditional carriers have also taken measures to remain competitive in the evolving market conditions. This paper examines the emergence and expansion of LCCs, their effect on traditional carriers' strategies, on consumer habits, on airport strategies, and finally their entrance and presence in the Greek market.

## 2. AIR TRANSPORT DEREGULATION

Since 1944 air transport is regulated by the Chicago Convention. The deregulation started at national level, first from the USA, followed from Canada, Australia, Japan, Taiwan, South Korea, and UK. Gradually most countries allowed the operation of new airlines along with their flag carriers. Deregulation was introduced in order to create "more competitive aviation services" (Iatrou and Oretti 2007). The main idea was to establish a global aviation market without entry restrictions. This would allow free and open competition, leading to more efficient airlines and improved consumer choices (Iatrou and Oretti 2007).

The aviation market has changed radically in the last two decades. The renegotiation of previous bilateral agreements has placed the previously protected national carriers into a competitive and turbulent deregulated market. At the same time new strong competitors are appearing, pressuring airports for even more operational freedom (Delfmann 2005). As the deregulation allows for more choices and options, it also increases the uncertainty and reduces the predictability of the environment. In the aviation industry, the airlines were the first ones to adapt new strategies better suited to a competitive environment, while airports took much slower steps to meet the new conditions (Delfmann 2005).

## 3. THE EMERGENCE AND THE CONCEPT OF LOW COST CARRIERS

During the 1990s LCCs entered and occupied a firm position in many markets. Previously dominant oligopolies were replaced by open competition (Lawton 2004). Deregulation encouraged many LCCs to set up extensive networks with scheduled flights (Lei και Papatheodorou 2010). The expansion of the LCCs is often considered as one of the most important recent advances in the European aviation (Pels et al 2009). The presence of the LCCs forced traditional flag carriers to lower their prices and restructure their business (Lei και Papatheodorou 2010). These actions led to more attractive prices in the whole industry which in turn increased passenger volumes (Barrett 2004).

The cost strategy adopted by LCCs is based in a simpler service model. Any service that can be avoided or reduced is not included in the base price of the ticket. Typical examples are flight with only one seating class (economy), dense seating pitch, limited additional services during flights, and abandonment of the transfer concept (Pels et al 2009). The choice of favorite seat, the free newspapers, the baggage handling between carriers, the frequent flyer rewards, and the dedicated airport lounges are all sacrificed in order to keep cost as low as possible. Wherever some additional services are still offered they are charged as extras. The distribution and sales cost is also kept at a minimum by the use of internet sales, proprietary boarding control, and limited marketing budget. Fleet is typically based on a single aircraft type allowing for more efficient maintenance and lower operational costs. The intensive negotiations between LCCs and airports for fees and itineraries are in contrast with the previously nonexistent competition between airlines and airports (Barrett 2004).

In the 1970s, Southwest became the first LCC in North America and the LCC concept was developed as an attractive strategy for short haul connections. In the US market where the competition is increasingly open, LCCs meet favorable conditions to expand. As long as they keep their operational model simple, they have certain efficiency and cost advantages over their competitors. While traditional carriers spend money and resources to organize multi-segment flights, flight seating flexibility, and baggage handling, all LCCs have to do is to board their customers into a single flight where everyone travels in the same class and has the same destination.

## 4. GLOBAL EXPANSION OF LOW COST CARRIERS

In Dublin Ryanair serves 25% of passengers by using only 11% of check-in desks and the aim is to completely abolish the remaining desks and replace them with self-service procedures. Each desk can serve annually 130,000 passengers in comparison to only 48.000 served by the desks of traditional carriers. At Stansted airport, where all airlines operate under the same principles, Ryanair serves over 110,000 passengers at each desk while the competition only reaches 70 (Barrett 2004). Another indication of Ryanair's effectiveness is the number of passengers served by each employee. At Ryanair each front office worker can check-in 8,000 passengers while the same worker at a national carrier can only reach 873 passengers on average (Barrett 2004).

Increased levels of competition have led to very low airfares especially for destinations that are simultaneously served by LCCs and traditional carriers. This observation is also true for adjacent airports (Lian and Rønnevik 2010). Many flag carriers were not prepared to compete in a deregulated market and soon they were facing serious problems. Sabena and Swissair declared bankruptcy in 2001, followed by other national carriers, with most recent example that of Malev in 2012. Other traditional airlines adjusted their strategies and concentrated in cost reductions as an answer to the LCCs (Barrett 2004). Charter airlines were also affected and in many cases they are facing direct competition by LCCs. In many popular vacation destinations, LCCs offer frequent and flexible itineraries allowing shorter vacations with smaller budget. In areas such as coastal Spain, LCCs are the preferred method of air travel, further limiting the market share of both flag carriers and charter airlines (Martinez-Garcia and Royo-Vela 2010). Affordable prices and frequent connections have contributed to the popularity of weekend travel in Europe and have influenced positively real estate and timesharing activities. According to a survey in UK over 800.000 residents had a second home abroad, an increase of 45% compared to the figures only three years earlier (Lei and Papatheodorou 2010). It is widely accepted that LCCs do not follow the typical hub and spoke network scheme used by other carriers. Instead they favor point to point connections based on secondary or regional airports. Table 1 shows the strategies used by LCCs to lower their costs.

Table 1: Cost reduction strategies adapted by LCCs

| Areas | Goal and result of strategy |
|---|---|
| Sales | Limited or no use of intermediaries |
| | Direct sales through internet |
| Passengers | Reduction of additional services at airports and during flights |
| | Single cabin layout |
| Aircraft manufacturers | Negotiation for big discounts |
| Personnel and aircraft | Intensive utilization of aircraft and crews |
| | Use of single aircraft type and interchangeable crews with common type ratings |
| | Procedures for restructuring |
| Airports | Negotiation for low fees and pressure for indirect subsidiaries |
| | Use of secondary airports with excess capacity |
| | Creation of competition between airports |

For many decades European flag carriers enjoyed several privileges, including the de facto control of major airports. Since they had been operating on marginal profitability, it has often been argued that high salaries, benefits, and pensions combined with governmental protection resulted in very low productivity. At the same time, possibilities for entrance of competitors and introduction of cost strategies were practically nonexistent (Barrett 2004). According to data from ACI (2010) the LCCs' market share increased from approximately 10% to over 30% in 2006. In regions such as Asia and Australia the trend remains significant. During 2001 and 2009 LCCs had a steady increase of 38% on average annually, compared to the total increase in the region that did not exceed 6%. During the same period, the number of cities connected by LCCs increased from 48 to 576. LCC expansion is not uniform in every continent. Combined with recent economic crisis, several regions have witnessed a sudden halt in growth. According to the European Low Fare Airline Association (EFLAA 2010a), during 2009 the members of the organization carried almost 9% more passengers compared to 2008. The activities of LCCs showed a slight decline during 2009 in most major markets, including Germany, Italy, Spain, and UK. Domestic flights seem to be more resistant to the effects of economic turbulence. For example, in UK, during the first years after 9/11 LCC capacity grew enormously. In 2007 it reached a peak and after a couple of years of decline, in 2009 it had dropped back to the levels of 2006 (Centre for Asia Pacific Aviation 2010).

In any case, LCCs seem to have acquired a reasonable share that is steadily around 30% of the total intra-European capacity (EFLAA 2010b). LCCs managed to seize most of the capacity growth in Europe between 2000 and 2009. Focus has now moved to the promising markets of Eastern Europe. According to Boeing Corporation, the global expansion of LCCs is one of the main reasons for the predicted growth of aviation (Boeing 2010). Growth rates are expected to be much higher for LCCs compared to traditional carriers and charter companies, based on recent analysis released by Boeing and other stakeholders. The following table (2) shows the airline market status before and after the deregulation.

Table 2: Airlines Before and After the Deregulation

| Before Deregulation |
| --- |
| Government support and privileges for flag carriers |
| Obstacles for entry of new airlines |
| Price regulation and limited competition |
| High costs for human resources |

| After Deregulation |
| --- |
| Removal of state intervention |
| Increase of competition |
| Bankruptcy of traditional carriers |
| Appearance of LCCs |
| Significant reduction in average airfares, up to 80% in Europe |
| Increase in passengers |
| Further adoption of point-to-point model |
| Traditional carriers either turned into LCCs or restructured their business model closer to that of LCCs |

In Canada, during the last decade, competition from LCCs has led into a series of mergers and a complete re-structuring of the market (Lawton 2004). In Asia, in competitive markets such as Southeast Asia and Japan, new carriers have appeared for the first time after many years. The same is true for many European countries as well. In Spain, world's second most popular tourist destination, more than one third of tourists are carried by LCCs. In some regions such as Catalunia, LCCs have larger market share than traditional airlines. Girona in Spain is a typical example of low cost airport that expanded rapidly and assisted significantly the growth of tourism in the region (Martinez-Garcia and Royo-Vela 2010). According to Fageda and Fernandez-Villadangos (2009), the competition has not affected most of the passengers travelling to and from the major airports, where traditional carriers are based. The benefits are more clearly visible at the airports used mainly by LCCs. Based on data from the Spanish market, Fageda and Fernandez-Villadangos argue that the presence of LCCs results in lower airfares for any carrier that serves the same destinations as the LCCs. Flag carriers such as Alitalia in Italy have concentrated their operations around major cities like Rome and Milan, allowing LCCs to create new direct connections between secondary airports. A new generation of previously unimportant and nowadays rapidly growing airports has emerged: Bologna, Venetia, Pisa, Torino, and Genoa (Barrett 2004).

## 5. RESPONSE OF TRADITIONAL CARRIERS TO LOW COST RIVALS

Traditional airlines tried to maintain their market position by various strategies. One of them was the establishment of their own LCCs while another one was the spontaneous cost reduction. Many carriers in North America and Europe tried to create their own LCC brands as a direct answer to the aggressive LCCs. While holders of AOC, these LCCs were actually business units or "airlines within airline" of their parent company. To counter the rise of LCCs, Continental airlines established Continental Lite in 1993. First class was removed from the aircraft, no meal was served and flights were typically less than two and a half hours. Even though Continental Lite operated with no less than 100 airplanes, the attempt proved to be both short-lived and extremely costly. Delta Air Lines made two similar attempts. Delta Express was created in 1996 to compete with Southwest, Air Tran and JetBlue. It was replaced by Song in 2003; Song was also 3 years later absorbed back to Delta. US Airways created Metrojet in 1998 to compete with Southwest and Delta Express. Metrojet ceased to exist shortly after 9/11 (Vasigh et al 2008).

Following the examples from the other side of the Atlantic, British Airways and KLM bouth introduced their own LCCs. In 1997 British Airways created Go Fly operating from London Stansted. The company advertised its ties to British Airways and was profitable in 2000. However the new management of British Airways blamed Go as one of the reasons for the main company's declining passenger volumes and decided it did not suit their revised business model. Go was bought and subsequently merged by EasyJet. In 2000 KLM created Buzz in order to compete with LCCs such as EasyJet, Ryanair and Go in the British market. Not following one of the main operational rules of LCCs, Buzz maintained two separate small fleets of BAe 146s and Boeing 737-300s. Without economies of scale, the operational costs were quite high and Buzz was soon to follow the fate of Go. Ryanair bought Buzz, kept it under the brand for a year and finally absorbed the short-lived rival (Vasigh et al 2008).

The above examples show that in both sides of the Atlantic the experiments of the traditional carriers with their own LCCs were disappointingly unsuccessful. Part of the result can be explained by the fact that operation of these LCCs was newer low enough, especially in terms of labor cost. Since this strategy did not bring the expected results, the next approach was to limit their service contents. However, providing a stripped product would bring their services closer to the ones offered by LCCs. Since LCCs had a much lower structural and operational cost, this would have been a very risky strategy. As most reactions towards LCCs proved to be partly or completely futile, many traditional carriers tried to compete them by actually avoiding competition; concentrating on long haul flights and international routes where LCCs were in disadvantage due to legal restrictions. (Vasigh et al 2008).

## 6. EUROPEAN AIRPORTS

### 6.1 Current trends and overview

In 2010 more than 1,600 airports in all continents were members of the Airports Council International (ACI). Over 98% of global air passengers travel through ACI members. The 4.9 billion passengers travelling in 77 million flights are expected to double in next 15 years. According to data available, the global financial crisis starting from 2009 and the increasing oil prices have limited the recent growth rate. Half of the airports witnessed increase in terms of passengers served. Several major airports showed a decline, while smaller ones strengthened their position. At the same time, the increase in passenger volume is higher than the increase in aircraft movements (6.6% and 2.4% respectively in 2007), which indicates both a preference for larger capacity aircrafts and better utilization of fleets (ACI 2010).

In ACI's statistics for 2010, five European airports are among the 15 largest ones. The sizes of the airports seem to be directly related to long distance flights. Recent research (Gillen 2007), argues that European airports as a whole have three distinct characteristics. First, there are a large number of airports with scheduled flights, disproportionate to the size or population of the countries. Countries like Greece, Norway, or Sweden have 38, 51 and 44 airports respectively, while France and Germany have 68 and 48. Second, the density of the airports results in low utilization. In Ireland, two thirds of the airports serve less than 100,000 passengers annually and this is also true for most French airports. Third, the major central airports depend on an effective and extensive rail network that expands their catchment area and allows for combined air and high speed ground travel. The ownership of the airports varies; Spain, Portugal, Sweden or Greece have publicly funded and operated airports, while UK has privatized them. In Germany and France airports are in the responsibility of the local governments.

### 6.2 Financial aspects of the airport operations

During the new millennium, European airports are facing two main challenges: pressure for cost reduction in terms of ground handling and fees, and adoption of new strategies to reduce delays. Additional problems are related to pollution, land use and other environmental factors. Although most airports are still under state control and are often used as instruments for national and regional development, the new trend adopted by most stakeholders dictates the sustainable operation of all airports. Even during periods when all airlines recorded high loses (e.g. after 9/11) all major European airports managed to remain profitable. Airports have two sources of income: aeronautical from flights and commercial from other activities. Commercial revenues have grown significantly during last decades and today contribute by over 50% in total income. While at the same time labor cost has decreased, investment depreciation has increased steadily, reaching nowadays over one quarter of total cost.

### 6.3 Airports and destinations

Between 1994 and 2003 passenger traffic increased globally by 5% annually. During the same period many European airports had very high growth rates. Typical examples are London Stansted (46%), Antalya (26%), Prague (18%), Vilnius (13%), Warsaw (12%), Barcelona (11%), Madrid (11%), Paphos (9%), and Budapest (8%). An average annual growth of 10% means that these airports effectively doubled their customers within the decade. Besides the increase in passenger volumes, the airports also expanded their connections: Stansted served 28% more destinations, Bratislava 20%, Palma de Majorca 7%, Munich 6%, Ljubljana 6%, Prague 5%, and Budapest 3% (ACI 2010). From a statistical point of view, there seem to be a positive correlation between increase in number of destinations and number of passengers. In most cases, new destinations were the result of new routes established by LCCs.

### 6.4 Dynamics of Point-to-Point networks

Traditional carriers expanded their networks based on hub and spoke models. However, as Chang and lee point out, the establishment of those networks was mostly based in experience and intuition with reasonable cost being the main target (Chang και Lee 2010). In the past, point-to-point networks were the choice for regional airlines serving small and medium distance connections. LCCs adopted the same model as one of their main strategic tools. Point-to-point flights have typically higher operational costs in comparison with services based on a hub model. On the other hand, they have the advantages of higher reliability and more convenient schedules. Since LCCs do not need to worry about connecting flights, they have greater flexibility in the selection of suitable airports, including secondary and regional airports with additional advantages. According to a research conducted in 2005, for the management of LCCs there are three main factors considered for the selection of an airport. First, the air travel demand must be high enough, second, the facilities must allow for a short turnaround time, and third, there must be availability in slots (Chang & Lee, 2010). In general, LCCs are not willing to share an airport with many competitors, although they prefer airports with good land connections. Table 3 shows the status of airports before and after the deregulation.

Table 3: Airports Before and After Deregulation

| Airports Before Deregulation | Airports After Deregulation |
|---|---|
| Lack of price competition. Higher prices for airfares. | Airport restructuring into a more dynamic environment |
| Very limited incentives for productivity and efficiency | Airports are transformed from public facilities to modern business units |
| Seasonal use by charter flights | Airports help the expansion of LCCs |
| Limited vertical integration between airports and airlines | Competition between airports intensifies |
| Limited commercial revenues | Commercial revenues increase, especially at the airports used by LCCs |
| At regional airports the low revenues are not enough to cover operational expenses. | Airports start to see passengers as their own customers as well |
| Regional airports act as feeders to major airports. | Regional airports support their own networks. Their location is turned into an asset. |

## 7. INTERACTION BETWEEN LCCs AND AIRPORTS

According to studies, airports had very high initial capital cost and low marginal cost for each additional flight and passenger. Based on calculated economies of scale, the marginal cost decreased sharply for the first one million annual passengers, continues to decrease until three million passengers and remains relatively stable after that. The 25 largest airports – which represent 2% of the 1192 airports with international flights – serve more than 32% of total air traffic. The global uneven distribution of passengers is one of the biggest challenges for any airport. Since an airport needs a critical mass of passengers before it can become economically viable, the target is to cover initial costs and sustain expected damages over a period of growth leading to a next stage of profitable operation (Francis et al 2003). Traditionally, airlines were the customers of airports. However, as the commercial revenues have started to form a significant source of income, airports are gradually treating passengers as if they were their own customers. At the same time, airlines consider passengers as their exclusive customers, brought to the airports by them. These views create a complicated and specialized relationship between three elements (Gillen and Morrison 2003). For the regional and the smaller airports, limited number of flights is translated into equally limited aeronautical and commercial revenues. The possibility to attract LCCs is becoming an important solution and while there is extensive research around LCCs, there is not enough knowledge for their exact effects on airports (Francis et al 2003).

After deregulation, airports have started transforming themselves from state controlled and financed facilities into competitive business units. Flag carriers that enjoyed a dominant position in major airports and monopolies in regional ones are now forced to share their former back yard with other carriers, including LCCs (Fageda and Fernandez-Villadangos 2009). This interaction is often accompanied by tension and disagreement (Barrett 2004). Although LCCs are attractive for airports, they do not have the stability associated with flag carriers. Airports have to develop scenarios and assess the possibilities of LCcs withdrawing from destinations or from the market altogether (Gillen and Morrison 2003).

Whatever they may chose airports have no other option than to adjust into the new highly competitive environment of deregulation and LCCs (Barrett 2004). The value and importance of an airport for a LCC is based on its location and catchment area. When two or more airports share the same area, they directly compete with each other. During 2002 Southwest was invited by more than 140 airports and only very few "lucky ones" were included in the company's network (Fageda and Fernandez-Villadangos, 2009). In Europe, LCCs such as Ryanair are in continuous negotiations with airports. Large airports in the vicinity of metropolitan areas often sign up attractive contracts with favorable terms and acceptable collectable fees. On the other hand, abandonment of Rimini in favor of Ancona in Italy by Ryanair demonstrates the power LCCs exercise over smaller airports. (Fageda and Fernandez-Villadangos, 2009). Table 4 shows what LCCs demand and what they offer to an airport in order to establish cooperation.

Table 4: What LCCs Ask and what they Offer to Airports

| What LCCs ask from airports |
|---|
| Excess capacity |
| Fast and effective ground services |
| Short turn-around time of 25 minutes |
| Good local transportation |
| Low airport fees |
| Suitable slots |
| Possibilities to increase the catchment area |

| What LCCs offer to airports |
|---|
| Increased traffic |
| Increased market share |
| Increase in aeronautical revenues |
| Increase in commercial revenues |
| Enlargement of catchment area |
| Above average increase in vehicle rentals |
| Reduction in the capital costs |

The presence of an LCC leads to a significant increase in terms of passengers. Even if the airport agrees to lower fees in order to attract an LCC, the passenger volume increase could alone result in an overall positive situation, due to the associated commercial revenues. Furthermore, it can be argued that the bare services model used by LCCs creates opportunities for airports to increase their ground sales and services. Since commercial revenues at smaller airports are usually less than 35% of total revenues, this appears to be a realistic expectation (Graham 2001). From a certain point of view, this could be explained as a strategic choice between aeronautical and commercial revenues, where airports choose a different mix and balance between their main sources of income. According to Barrett (2004) such trends are visible during last two decades.

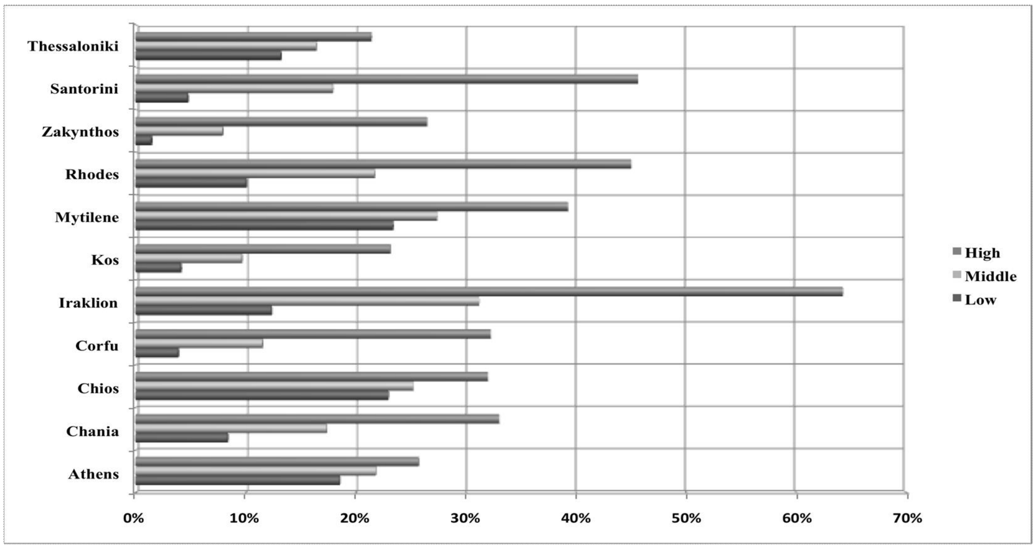
Traditionally, secondary airports have a limited role either as passenger feeders to central airports, or as points serving seasonal charter flights (Fageda and Fernandez-Villadangos 2009). LCCs offer the possibility of a more autonomous development with increased passenger volume and larger catchment area (Lei και Papatheodorou 2010). Airport managing companies favor the use of secondary airports as supplemental to their main hubs. This can be observed in cases such as Stansted for Heathrow and Hahn for Frankfurt (Barrett 2004).

From the passengers' point of view, the selection of remote airports by LCCs in conjunction with the other existing airport and airline management strategies has both positive and negative outcomes. First, it has made lower airfares a reality. Second, it has moved passengers from congested central hubs to smaller and friendlier facilities. And third, in many cases it has increased the land travel distances and time (Barrett 2004). Passengers, including both leisure and business travelers have in general accepted the inconvenient locations even though many secondary airports are very far away from the metropolitan areas they are supposed to serve (Lawton 2004). Additionally, the expansion of the catchment area can lead to overlapping between airports, causing intense competition not only between main and secondary airports but between regional airports as well. Although the situation may not be desirable for the airports, it does offer more choices to the passengers (Francis et al 2003).

## 8. CAPACITY AND SEASONALITY OF GREEK AIRPORTS

The analysis of 11 Greek airports shows that there is high seasonality in most of them. An interesting observation is the very low utilization of the available apron capacity.

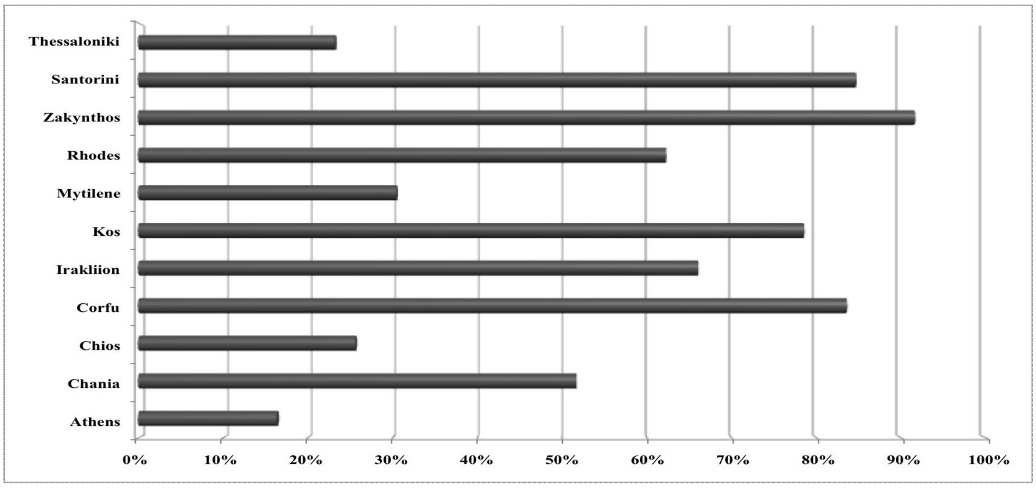
Figure 1: Apron Utilization by Airport




Source: Katarelos, E. and Lagoudis, I. (2011)

The seasonality can also be observed in figure 2, especially in the island airports of Zakynthos, Santorini, Corfu, and Kos.

Figure 2: Seasonality of Greek Airports



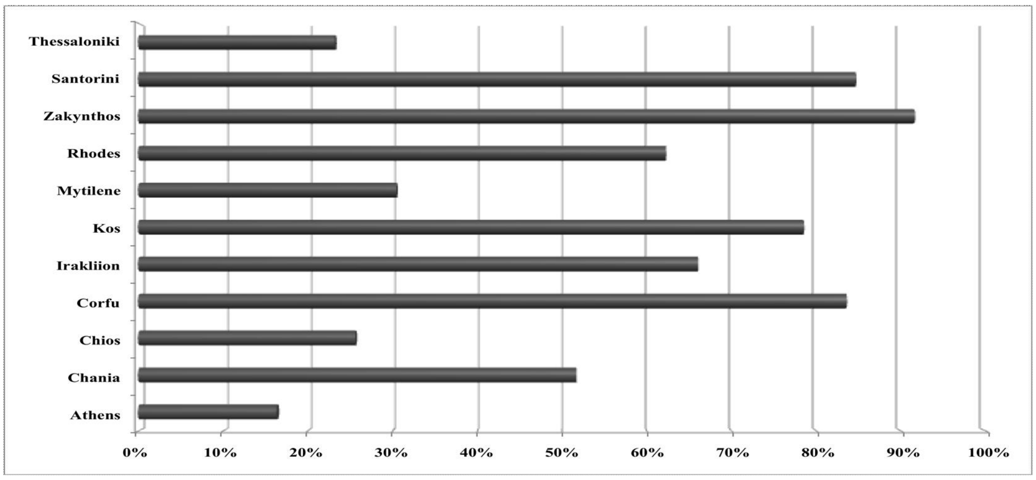

Source: Katarelos, E. and Lagoudis, I. (2011)

During high season all Greek airports, with the exception of Heraklion, utilize less than 50% of their apron capacity; actually most of their capacity remains completely unused form extended periods of time. Figure 3 shows the predictions of Greek airport utilization up to year 2030, based in three scenarios and historical data of 18 past years. It can be argued that current capacity is enough to sustain a steady increase for the next twenty years. Capacity issues would become a problem only in the most optimistic scenario of 7.5% annual increase and even then, it would need at least a decade before full capacity is reached in most airports (Katarelos and Lagoudis 2011).

## 9. RECENT TRENDS IN GREECE

Although the use of secondary airports is one of the main strategies for LCCs, they have not adopted that particular rule in the case of Greece. Almost all non seasonal flights connect the main hub of Athens and a few others the secondary hub of Northern Greece, Thessaloniki. All other LCC flights to Greece are seasonal. These include some promising links to regional airports that could potentially serve large catchment areas, such as the airport of Volos, located in the mid-distance between Athens and Thessaloniki. The lack of suitable airports in combination with a non-existent national regional development strategy, are possibly two of the main reasons for this unusual choice of LCCs, a “paradox” as described by Papatheodorou and Arvanitis (2009).

Figure 3: Greek Airports and Future Capacity Scenarios




Source: Katarelos, E. and Lagoudis, I. (2011)

The recent inauguration of flights to Volos from Ryanair in May 2010 and the presence of Air Berlin at the same airport are currently seasonal. It is argued that although the potential exists, Volos fails to extend the catchment area both towards Athens and towards Thessaloniki, the two main metropolitan areas of Greece with a combined population of over 6 million people. The land travel distance exceeds two hours in either direction and the airport which has a mixed military and civilian usage, lacks necessary passenger infrastructure. Responding to these shortcomings, the authorities have initiated the construction of a new terminal building in order to improve passenger services. Additionally, the airport is located outside the 100 km radius exclusive zone of Athens International Airport where current legislation prohibits the operation of any public airports with commercial flights and activities. Although it is not forbidden for private sector to build and operate a private airport inside this zone, under current conditions it seems highly unrealistic that any entrepreneurs would be willing to make investments of the necessary scale. Besides, the main idea around secondary airports is the use of existing ones and the utilization of their idle capacity and not the creation of new airports. As Papatheodorou and Arvanitis (2009) observe, the area surrounding Volos has the potential to support scheduled flights that would not be limited to seasonal and recreational demand. It is also interesting to note the announcements accompanying the launch of the new connections to Volos; Ryanair stresses the importance and the direct and indirect benefits of the flights for the local economy, which would "create 200 new jobs" and "boost the Greek economy" (Ryanair 2010).

It could be argued that even if Ryanair or any other LCC manages to pay very low fees for the use of the airport of Volos, or if the construction of specific infrastructure becomes an indirect form of subsidies, the investment could still have significant long term benefits for the region. This is true for other continental Greek airports as well. Most of them are in parallel use by civil aviation and military with limited commercial infrastructure. The cost to further develop these airports is not prohibiting and the excess capacity can be utilized with relatively limited efforts. Since they are not attractive for traditional carriers and some of them are not near popular tourist destinations, they could be a good choice for LCCs for two reasons. First, especially in Greece, even less favorable regions have great potential for development and are near various interesting sites. Both conditions are met by the airport of Volos and obviously Ryanair and Air Berlin have taken them into account. Second, charter operators and mostly the big tour operators do not offer any guarantees or stability regarding their presence and therefore their activities are not only seasonal, but also have high risks as instruments of long term development.

The above example of Volos describes the local perspective and the effects of the local airport. On the other side of the same issue are the European airports and their prospective to remain competitive. Any new destination linked to them, is measured in additional aeronautical and commercial revenues as explained earlier. The strategy of expansion to new destinations is more critical for secondary airports that have committed to LCCs in order to remain viable. According to the point-to-point model, the second European member of the link will be another secondary airport in another country. For each flight from Volos to Frankfurt Hahn or Milano Bergamo, all three airports have their share in benefits and revenues. The main items of the negotiations between LCCs and airports and possible outcomes for each issue are summarized in Table 5.

Table 5: Greek Airports and Cooperation with Low Cost Carriers

| What LCCs ask from Greek Airports | Estimate of Greek airports' potential |
|---|---|
| Excess capacity to accommodate increased demand | Exists or may increase |
| Fast and effective ground facilities | Exist or can be created |
| Suitable time slots | Exist due to seasonality and excess capacity |
| Good local connections | In some cases needs improvement |
| Lower airport fees | Limitations in pricing policies due to current legislation and ownership of the airports |
| Capital assets | Can be raised |
| Enhanced facilities for ground transportation | Possible to develop |

As a general conclusion from the above table, Greek airports seem to have the potential for cooperation with LCCs. During the recent past, one of the reasons limiting the ability or the willingness of the local airports to negotiate openly with LCCs was the legal actions of many traditional airlines against any contract between LCCs and airports. Their main argument was that the low fees were in fact disguised public subsidies, forbidden by European aviation framework. Recent decisions of the European Commission and the European Court (ECFI - European Court of First Instance), in December 2008 regarding the airport of Charleroi in Belgium, and in January 2010 regarding the Bratislava airport in Slovakia, rule that in both cases the agreements between the airports and the LCCs are in accordance with the European market and competition principles (EU Market Economy Investor Principle) (EU 2010). However, for one LCC, Ryanair, there are still several open cases with the question of illegal public subsidies in the agreements between Ryanair and the airports of Alghero, Pau, Lübeck, Frankfurt Hahn, Berlin Schönefeld, Aarhus, and Tampere (EU 2010). According to the view for the side of the LCCs, the very low fees offered by some airports are part of perfectly fair and legal commercial agreements that reflect the current market conditions and trends and are balanced by the benefits of increased traffic and the creation of new jobs (Ryanair 2010). In reality, until today, 2012, there has not been any pre-mature termination of any agreement as a response to exposure of anti-competitive or other unfair practices.

Currently, the initiative is in the hands of the airlines. LCCs evaluate and select routes and airport pairs based on their own cost and efficiency targets. The authors suggests that it is in the best interest of the airports to become actively involved in this process and interact dynamically with airlines and local communities in order to promote or support the expansion of suitable connections with other cities.

## 10. CONCLUSIONS

Increase in number of destinations is a strategy mostly used by smaller European airports. LCCs seem to prefer secondary airports for the deployment of their point-to-point network model. Airports are interested in utilizing their excess capacity, while LCCs aim to minimize their overall costs. When everything turns out as intended airports, LCCs, passengers, and local economies can all benefit. To minimize the risks associated with the preferred form of long term cooperation between airports and LCCs market conditions must be carefully assessed. LCCs typically negotiate significant airport and landing fee discounts; airports expect positive results from the increase in traffic and commercial revenues.

Greece has a relatively high number of airports, 39 in total. Since most of them have very low utilization, LCCs appear to be an attractive opportunity. Greece uses almost exclusively the hub and spoke model and point to point connections only exist in few subsidized PSO lines. After deregulation, the emergence of private carriers in Greece offered lower airfares, however the competition currently is quite limited and airfares relatively high. LCCs offer connections mostly to the main hubs and only recently they have experimented with a couple of regional airports. The majority of the smaller airports struggle to cover at least part of the operating costs and theoretically any airport chosen by an LCC would potentially have enough excess capacity to share.

A central issue that determines the relationship between LCCs and airports is the fact that LCCs demand a long term contract to be signed. Under current legislation, most Greek airports cannot sign such contracts which may additionally include special clauses. If and when these obstacles are removed it would be possible for regional airports to offer incentives to LCCs in order to attract them, as it has happened in other European countries. Under current status, both the autonomy of the airports as well as their readiness to enter a more competitive market is questionable. The centrally organized and applied state management and development schema is considered to be both restrictive and ineffective. Each airport should be assessed and as a unique business unit in order to select the most suitable long term strategy.

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# QUALITATIVE ANALYSIS OF THE RELATIONSHIP BETWEEN THE PROFILE OF DEPARTING PASSENGERS AND THEIR PERCEPTION OF THE AIRPORT TERMINAL

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ABSTRACT

The opinion of passengers on the degree of importance of the components is required in order to prioritize services. A low service level can, besides causing inconvenience for terminal users, increase the waste of resources and increase costs if there is no adequate planning. Hence, outlining passenger profiles at the airport is relevant to strategic planning of airport activity management. It is believed that individual characteristics could influence opinion on the degree of importance or about the quality of airport services. This article shows that the check-in and the departure lounge were considered the most important areas in the airport terminal by passengers. Finally it was noted that the age and reason for travel influenced the passengers' perception about the check-in area and the frequency of flying influenced the perception of the departure lounge.

KEYWORDS: Passengers' opinion; passengers' profile; AHP; airport terminal; independence test.

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## 1. INTRODUCTION

In recent years, structural changes such as commercialization, privatization, and globalization, together with increased competition between airports, have encouraged airports and aviation authorities to place more emphasis on quality (Graham, 2008). In this context, establishing measures to evaluate operational performance of airports is one of the major problems facing airlines and airport operators today (Correia, 2009). Airport managers have to struggle with the decision of prioritizing resources. Although they are motivated to offer a reasonable level of service (LOS) to passengers, there is a growing worldwide tendency for cost reduction. In this scenario, an effort to determine the importance that various passenger groups attribute to airport components would provide a useful indication of where airport managers should invest their limited resources such as funds, employees and their own attention.

The airport terminal may be considered a set of subsystems that interact between themselves to allow a change from land mode to air and vice versa. Various components are installed and different services are produced around these movements – passenger departure and/or arrival – in order to meet client expectations. Some services and areas of the terminal on general are used by passengers, following the flow of departure or arrival. A low level of service can result in, besides inconvenience to terminal users, the waste of resources and increased costs if there is no adequate planning. Hence, service level targets are important because they have serious implications for costs and the airport's economy, as well as the "image" transmitted to the clients and to society (Bandeira, 2008; Ashford *et. al.*, 1997).

Besides the operational and financial concerns, outlining the profile of passengers at the airport contributes to the drawing up of a strategic plan for the management of airport activities. It is believed that individual characteristics related to the frequency of flying, the reason for flying, income, age, and other factors may influence the opinion of the degree of importance or the quality of the services in an airport. The answers to these questions make all the difference in airport planning and in this article are expected to broaden this understanding.

## 2. LITERATURE REVIEW

Brink and Madison (1975) presented one of the first studies done in the area of airport service levels. They considered that passengers' perceptions of the airport terminal, besides being influenced by the technical and operational conditions, also depend on subjective factors and each person's individual characteristics. Some criteria and characteristics proposed by the research include the purpose of the trip, the frequency of flying, costs of air tickets and airport services. Other authors, such as Omer and Khan (1988) Müller and Gosling (1991) and Ndoh and Ashford (1994) concerned themselves mainly with the method used to collect and analyze passengers' opinions; that is, using a model than can transfer linguistic judgment into quantitative values. Lee and Kim (2003) state that passengers may have different perceptions about services and installations related to departure and arrival processes in an airport terminal. In other words, the route the passenger takes and the services related to their objective – departure, connection, arrival – influence the perception of the service level of the airport. In another study, Seneviratne and Martel (1991) developed a study in which they presented a selection of components of greater importance in the terminal assisted by a passenger opinion poll in some Canadian airports. According to these authors, passenger needs can change according to the installations. A manual of service quality in airports developed by Airports Council International (ACI, 2000) states that the detailing of the types of clients and services enables comprehension of the different processes in which quality of the services must be acquired.

Despite the important effort made by the researchers and entities cited above, there is a major lack of studies which research and identify whether there is a significant relationship between the evaluation of the service level and the social and economic profile of the users interviewed. This study intends to approach this question, the development of which will be detailed in the following sections.

## 3. RESEARCH METHODOLOGY

Field research was carried out through interviews with 270 passengers in departure lounges at the São Paulo/Guarulhos International Airport between August 2006 and October 2007. For the size of the sample a 6% error margin was allowed and a confidence interval of 95%. Initially the degree of importance of the passenger departure terminal areas at the airport in question was sought, and their respective indicators. The Analytic Hierarchy Process (AHP) method was employed to get the degrees of importance for the attributes according to the passengers' opinion.

The interviews observed passenger characteristics such as income, age, reason for travel, frequency of travel, and type of trip. Each one was divided into classes, as shown in Table 1.

Table 1: Characteristics and classes analyzed

| CHARACTERISTICS | CLASSES |
|---|---|
| HOUSEHOLD INCOME | 1. *Income up to US$ 40,000*<br>2. *Income from US$ 40,000 to US$ 80,000*<br>3. *Income above US$ 80,000* |
| AGE | 1. *Aged up to 30*<br>2. *Aged between 30 and 50*<br>3. *Aged above 50* |
| REASON FOR TRAVEL | 1. *Business travel;*<br>2. *Leisure*<br>3. *Family reasons* |
| FREQUENCY OF TRAVEL | 1. *1x a year*<br>2. *3x to 6x a year*<br>3. *Over 6x a year* |

A statistical treatment was applied to the sample (for each variable used) to identify whether the responses were significant as regards the degree of importance of the indicators linked to these areas. As of this point, it was possible to compare passengers' opinions against their different profiles through the AHP method. In addition, it was checked whether these qualitative variables influenced or not opinion as to the degree of importance. In this case, the independence test from the Chi-squared method was used. There follows a description of the methods used for the current study.

### *3.1 APPLICATION OF THE AHP METHOD*

This work used the hierarchical structure of the method to get the global weights for the airport components. A scale of percentage values was used to get the weights, corresponding to the values from the fundamental Saaty scale so that the passengers could relate the scale to some kind of linguistic or verbal concept during interviews (Bandeira, 2008). Table 2 shows the scales cited.

Table 2: Relation between the Percentage Scale and the Fundamental Scale

| Percentage Scale | | Fundamental Scale (Saaty) | Degree of relative importance |
|---|---|---|---|
| TPS Components | | Weights | Definition |
| A* | B* | | |
| 90% | 10% | 9 | A is extremely more important than B. |
| 80% | 20% | 7 | A is much more important than B. |
| 70% | 30% | 5 | A is more important than B. |
| 60% | 40% | 3 | A is a little more important than B. |
| 50% | 50% | 1 | A and B are of the same importance. |
| 40% | 60% | 1/3 | B is a little more important than A. |
| 30% | 70% | 1/5 | B is more important than A. |
| 20% | 80% | 1/7 | B is much more important than A. |
| 10% | 90% | 1/9 | B is extremely more important than A. |

*A and B represent airport terminal components.

Source: Bandeira, Correia and Wirasinghe (2007)

The individual values for each passenger were aggregated in this research in a geometric average. In the case of an arithmetic average, which gives equal weight to all the averages, the results would be biased, as there would be a tendency to disproportionately value a set of weights supplied by the passengers. The Equation (1) shows the geometrical average used to get the final average of the weights given by the passengers.

$$w_f(C_i) = \sqrt[s]{\prod_{k=1}^{s} P_{d_k}} \qquad (1)$$

In which:

$C_i$: *Component i;*

$P_{d_k}$: *Weight given by the passenger $d_k$;*

$d_k$: *Passenger (1...k)*

*s: Number of passengers;*

As the AHP method is based on peer to peer comparisons, judgments are put in a squared matrix *n x n*, where the lines and columns correspond to the *n* criteria analyzed for the problem in question.

Considering $A = \lfloor a_{ij} \rfloor$, with *i*, *j* = 1. 2. ..., *n*, called the "decision matrix", each line *i* supplies the reasons between the weight of the criterion or sub-criterion for the index *i* for all the rest. The matrixes are always reciprocal, such that $a_{ij} = \frac{1}{a_{ji}}$, and positive.

Hence, the value $a_{ij}$ represents the relative importance of the criterion for the line *i* given the criterion for the column *j*, where only the principal diagonal assumes values equal to 1. Peer to peer comparisons are made at all levels of the matrix *A*. Therefore, if all the judgments are perfect, in all comparisons it would be possible to see that $a_{ij} \times a_{jk} = a_{ik}$, for any *i, j, k* = 1. ..., *n*, therefore, following this procedure, matrix A, would be consistent.

Take *n* as the number of elements to be compared, $\lambda_{máx}$ the auto-vector of A and *w* the correspondent proper vector or vector of priorities. If the judgments made by the decision maker are perfectly consistent, the result is $\lambda_{máx} = n$ e $a_{ij} = \frac{\varpi_i}{\varpi_j}$. However, almost always some inconsistency is seen in the judgments, which is nevertheless admitted by the AHP method.

The inconsistency can be measured in the following way: the closer the $\lambda_{máx}$ value is to $n$, the greater the consistency of the judgments. Saaty (1980) showed that A being a value matrix, the vector that satisfies Equation (2) will be found.

$$\mathrm{A}W = \lambda_{máx} x W \quad (2)$$

In which:

*A:* *Decision matrix;*
*$\lambda_{máx}$:* *Maximum autovalue of A;*
*W:* *Autovector of A associated to $\lambda_{máx}$.*

After the normalization of *W*, in (2), the auto-value $\lambda_{máx}$ is gotten from Equation (3).

$$\lambda_{máx} = \frac{1}{n} \sum_{i=1}^{n} \frac{[A\overline{w}]_i}{\overline{w_i}} \quad (3)$$

In which:

*A:* *Decision matrix;*
*$\lambda_{máx}$:* *Maximum autovalue of A;*
*W:* *Autovector of A associated to $\lambda_{máx}$;*
*n:* *Order of the decision matrix;*
*$W_i$:* *Normalized Vector W.*

It was observed, furthermore, that small variations in $a_{ij}$ caused small variations in $\lambda_{máx}$, in which the auto-vector's deviation in regard to *n* (the order of the matrix number) is considered a measurement of consistency. It can be said that the auto-vector gives the order of priority and the auto-value is the measurement of consistency of the judgment. For Gomes et al. (2004) it is possible to state that $\lambda_{máx}$ allows an evaluation of the proximity of the scale developed by Saaty (1980) with the scale of reasons or quotients that would be used if matrix *A* were totally consistent. This can be done by means of a consistency index (CI). Therefore, according to Saaty's theorem, "*A* is consistent if, and only if, $\lambda_{máx} \geq n$."

So, if "*A is* consistent if, and only if $\lambda_{máx} = n$", the value ($\lambda_{máx} - n$) is an indicator of the consistency of judgments after the formation of *A* and the obtaining of normalized *W*. The closer to zero such a difference is, the greater the consistency of judgments will be. It must be stressed that this value must serve as a warning to the decider and/or analyst, not only as an excluding situation. Therefore, the magnitude of the perturbation in matrix *A* is calculated using the relation of the Equation (4).

$$CI = \frac{\lambda_{máx} - n}{n - 1} \qquad (4)$$

Based on the theorems describes, Saaty (1980) proposed the calculation of the reason of consistency (CR) for the decision matrix *A* in Equation (5).

$$CR = \frac{CI}{IR} \qquad (5)$$

In which:

*CR*: *Consistency ratio;*
*CI*: *Consistency Index;*
*IR*: *Random Index.*

The greater the CR, the greater the inconsistency of the matrix will be. Generally, an inconsistency considered acceptable for $n > 4$ is a CR $\leq$ 0.10. The random index has been calculated for matrixes squared by an order of *n* by the Oak Ridge National Laboratory, in the United States (Saaty, 1991; 2005). Table 3 shows the values for IR for the matrixes of order *n x n*.

Table 3: IR Values for Matrixes Squared by an Order of *n x n*

| *n x n* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| IR | 0 | 0 | 0.58 | 0.89 | 1.11 | 1.25 | 1.35 | 1.40 | 1.45 | 1.49 |

Source: Saaty (1991)

Having done all this analysis of the judgment for matrix *A*, and given that this matrix is coherent the results are normalized by the Equation (6). So, the priority vector for sub-criterion *i* ( $A_{ij}$ ) in relation to criterion ( $C_i$ ) is presented in Equation (7).

$$v_i(A_1) = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad (6)$$

$$v_i(A_j) = \frac{\sum_{j=1}^{n} vi(A_j)}{n} \quad (7)$$

In which:

*i: 1...., n;*
$v$ *: Vector ;*
*A: Criterion for the second level (sub-criterion s);*
*n: Nº of criteria for one and the same level.*

The following formulas, Equations (8) and (9), do the evaluations.

$$\varpi_j(C_i) = \frac{C_{ij}}{\sum_{i=1}^{m} C_{ij}} \quad (8)$$

$$\varpi(C_i) = \sum_{j=1}^{m} \frac{\varpi_i(C_i)}{m} \quad (9)$$

In which:

*j: 1...., m;*
$\varpi$ *: Vector;*
*C: First level criterion;*
*m: Nº of criteria for one and the same level.*

Finally, a process of aggregation allows the generation of final values for the weights of the airport components, ordering them through the following additive function of the Equation (10).

$$f(A_j) = \sum_{i=1}^{m} w(C_i) \times v_i(A_j) \quad (10)$$

In which:

*j:* 1...., *m;*

For the purposes of calculation, the areas of the terminal were designated with criteria for the first level, and their respective indicators in criteria for the second level or sub-criteria. The modeling indicated the importance and intensity of each one of the airport terminal components.

### 3.2. STATISTICAL TREATMENT OF THE SAMPLE

Considering that for the AHP method binary correlations may indicate whether an element is preferable or equivalent in importance in regard to another, there are two possible situations to be tested.

The first situation was to verify whether the percentage of equivalence found in the binary comparisons was statistically significant. Hence, a designation was made for each binary correlation for the number *n* of interviews in the sample and the parameters *m*, $P_1$ e $P_{2.}$ which were calculated according to the frequency *f* observed for a certain airport component, if it was equivalent or preferable to the other.

In which:

$P_1$: *Population proportion regarding the first element of the binary comparison;*

$P_2$: *Population proportion regarding the second element of the binary comparison;*

*m*: *Population proportion regarding the equivalence of the binary comparison;*

In this case, there is the first test of the hypothesis, in which the nullity hypothesis is $H_0$: $m \geq P_1 + P_2$ and the alternative hypothesis is $H_1$: $m < P_1 + P_{2.}$ where P1 and $P_2$ are popuational proportions from the sample, and *m* is equal to the proportion of the sample when in comparison between two airport components. This test evaluated whether the degree of equivalence (equality) between the components was statistically significant, considering α = 5%. Therefore, the nullity hypothesis was only rejected if $Z^* < -Z_{5\%.}$, where Z* is the confidence interval.

For the rejected hypothesis $H_{0.}$ the second hypothesis test is applied, with $H_0'$: $P_1 = P_2$ e $H_1'$: $P_1 \neq P_{2.}$ to verify whether there had been any significant differences between the proportions isolated for preference in airport components observed in the binary comparisons. Hence, the nullity hypothesis was rejected if $|Z| > Z_{2.5\%,}$ with α = 5%. Therefore, in this second situation the hypothesis $H_0'$: $P_1 = P_2$ is accepted if a component does not present relative preponderance in a comparison; or $H_0'$ is rejected if one component is preferable to another one.

### *3.3. CHI-SQUARED METHOD FOR ANALYSIS OF QUALITATIVE VARIABLES*

Chi-squared ($\chi^2$) is a non-parametric method used to test hypotheses in order to verify a dispersion value for two nominal variables and to evaluate the association between qualitative variables.

The main principle of this method is to compare proportions; that is, the possible divergences between the frequencies observed and expected for a certain event. Hence, it can be said that two groups behave in a similar way if the differences between these frequencies in each category are very small or close to zero (Spiegel, 1972).

One measurement of the discrepancy between the frequencies observed and those expected is provided by the statistic $\chi^{2.}$ expressed by Equation 11. The results obtained are in the Contingency Table.

$$\chi^2_{\text{sample}} = \sum_{i=1}^{k} \frac{(o_i - e_i)^2}{e_i} \qquad (11)$$

In which:

$o_i$ : *Frequency observed;*

$e_i$ : *Frequency expected;*

*k:* 1...., *k;*

*i:* 1...., *i;*

For the application of the method, it is necessary that the sample be relatively large with sample N > 40 or at least 5 observations in each plot formed by the variable analyzed. Furthermore, the data analyzed must be independent of each other and the observations must have frequencies or counts where each observation belongs to one and only one category.

It is stressed that if the significant value of $\chi^2$ was gotten from one small sample (N < 40) and/or from a small expected frequency in a plot (typically when less than 5) for formula for the obtaining of $\chi^2$ may produce a greater-than-real value (Spiegel, 1972). In this case the Yates Correction must be applied (or a continuity correction). The statistics for the test are shown in Equation 12.

$$\chi^2_{corrigido} = \sum_{i=1}^{k} \frac{(|o_i - e_i| - 0.5)^2}{e_i} \quad (12)$$

To evaluate the condition of independence or dependence of the qualitative variables, two hypotheses are tested:

$$H_0: \chi^2_{sample} \leq \chi_c^2$$
$$H_1: \chi^2_{sample} > \chi_c^2$$

So that $\chi_c^2$ is the critical Chi-squared measurement with degrees of liberty GL given as in Equation 13:

$$GL = (l-1)*(c-1) \quad (13)$$

In which:

l*: Number of lines formed by the classes for one variable x;*
c*: Number of columns formed by classes for a variable y;*

That is, for the current research, the hypotheses cited indicated:

$H_0$: The inherent characteristic for the passenger does not influence the opinion given to the degree of importance of the airport component.

$H_1$: The inherent characteristic for the passenger does influence the opinion given to the degree of importance of the airport component.

So, from the null independence hypothesis, $H_0$ is accepted when the value of $\chi^2_{sample}$ found is less than or equal to the value of $\chi_c^2$ designated. $H_0$ is rejected when the value of $\chi^2_{sample}$ is greater than the value of $\chi_c^2$ designated. In the latter, $H_1$ is accepted and it is assumed that the variables in question present a dependency relationship.

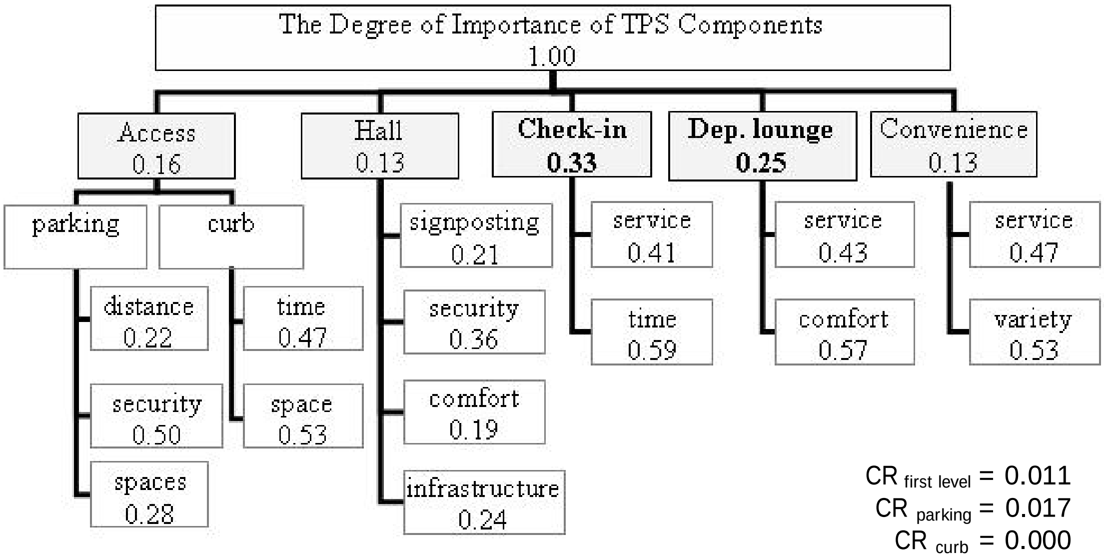
## 4. GLOBAL TPS RESULTS

The hierarchical structure presented the values of the priority vectors found for the areas of the terminal and its respective indicators. The chart below in Figure 1 shows the global values associated to the TPS areas.

Through analysis of these results it was possible to ascertain that the consistency ration (CR) for the resultant matrixes is within the limit recommended by Saaty (1990; 1991). Hence, the results found through the AHP method are significant.

In decreasing order to evaluate the degree of importance given by the intensity of the vectors found, the weights are as follows: the departure lounge (0.25), access area (parking and curb) (0.16), concessions areas (0.13) and lobby (0.13). Among the indicators listed by area, time spent in the check-in line (0.59) stood out – with a priority vector of greatest intensity – and the comfort of the departure lounge (0.57).

Figure 1: Hierarchical Structure with Global Values associated to the Degree of Importance




$CR_{\text{first level}} = 0.011$
$CR_{\text{parking}} = 0.017$
$CR_{\text{curb}} = 0.000$
$CR_{\text{lobby}} = 0.011$
$CR_{\text{check-in}} = 0.000$
$CR_{\text{departure lounge}} = 0.000$
$CR_{\text{concessions}} = 0.000$

The check-in and departure lounge areas were given the highest values; that is, both areas jointly represent 58% of the degree of global importance for TPS. This is why the next step is to analyze whether the qualitative characteristics (income, age, travel frequency, and reason for travel) have an influence in passengers' decision making as to the degree of importance.

Firstly, the percentages "greater importance" and "equal importance" among the indicators were observed in terms of how significant they were. This analysis was necessary, as the intention was to demonstrate whether there is a dependency association in the results of these observations and the passenger's qualitative characteristics. Finally, the "Chi-Squared Method" was used by means of the independence test, for the composition of the final results.

## 5. RESULTS OF THE STATISTICAL ANALYSIS OF THE DEGREE OF IMPORTANCE

Figure 2 indicates the percentage importance for the indicators for the check-in area. The time taken in processing the line was given the greatest importance in regard to airline service. However, this percentage was very close equivalence for other services in terms of importance.

Figure 2: Percentage Importance for Indicators for the Check-in Area

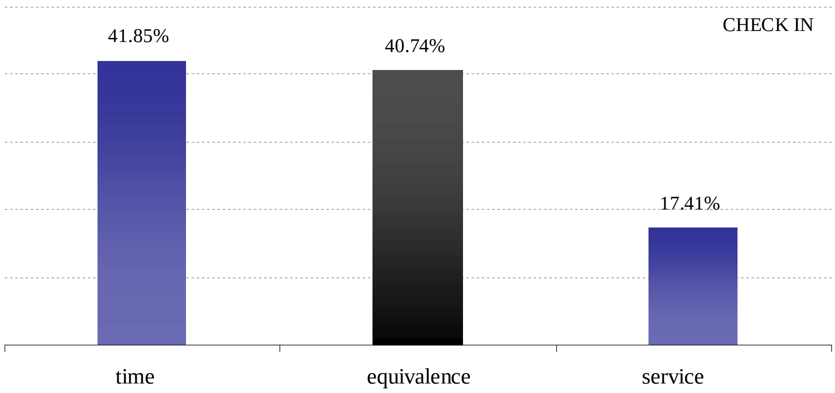



Table 4: First Hypothesis Test – Check-in area

| | Number of Passengers | | | | | | | Is Z significant for α = 5%? | |
|---|---|---|---|---|---|---|---|---|---|
| | *A* | *M* | *B* | *n* | *(A+B)* | *m* | *($P_1 + P_2$)* | *Z** | Result |
| CHECK IN | time | equivalence | service | | | | | | |
| | 113 | 110 | 47 | 270 | 160 | 0.407 | 0.592 | -6.192 | Reject $H_0$ |

Table 5: Second Hypothesis Test – Check-in area

| | Number of Passengers | | | | | | Is Z significant for α = 5%? | |
|---|---|---|---|---|---|---|---|---|
| | A | M | B | n | $P_1$ | $P_2$ | Z* | Result |
| CHECK IN | time | equivalence | service | | | | | |
| | 113 | 110 | 47 | 160 | 0.706 | 0.294 | 11.455 | Reject $H_0$ |

In which:

*A*: *Nº of interviewees that consider the first element of the binary comparison preferable to the second;*

*M*: *Nº of interviewees that consider the two components to be equivalent in importance;*

*B*: *Nº of interviewees that consider the second element of the binary comparison preferable to the first;*

*n:* *Set of interviewees formed by the sum of A and B;*

Tables 4 and 5 present the tests for the hypotheses that prove the significant difference in the percentages found for the check-in area. Although the percentage for equivalence of importance (40.74%) is close to the percentage for greater importance in the time spent in the line (41.39%), the results indicate that there is a statistical difference between them, as shown in Table 4. The results also show that there is a statistical difference between the importance of the indicators for time of processing the line and the service provided by the airline, where the former was considered more important than the latter, as shown in Table 5.

Figure 3 indicates the percentage of importance for the indicators for the departure lounge area. Most interviewees attributed greater importance to comfort in relation to the service offered by the airline's staff.

Figure 3: Percentage of Importance for the Indicators for the Departure Lounge Area

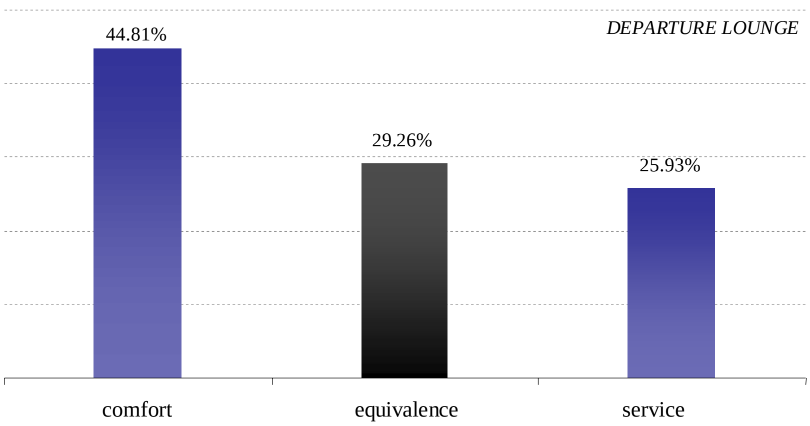



Table 6: First Hypothesis Test – Departure lounge area

| | Number of Passengers | | | | | | | Is Z significant for α = 5%? | |
|---|---|---|---|---|---|---|---|---|---|
| | *A* | *M* | *B* | *n* | *(A+B)* | *m* | *(P1 + P2)* | *Z** | Results |
| DEPARTURE LOUNGE | comfort | equivalence | service | | | | | | |
| | 121 | 79 | 70 | 270 | 191 | 0.293 | 0.707 | -14.982 | *Reject $H_0$* |

Tables 6 and 7 present the hypotheses tests that proved the significant difference in the percentages found for the departure lounge area. The results indicate that there is a statistical difference between the importance of the indicators for overall comfort and overall service, where the former was considered more important than the latter.

Table 7: Second Hypothesis Test – Departure lounge area

| | Number of Passengers | | | | | | Is Z significant for $\alpha$ = 5%? | |
|---|---|---|---|---|---|---|---|---|
| | *A* | *M* | *B* | *n* | *(A+B)* | *m* | *Z** | Results |
| DEPARTURE LOUNGE | comfort | equivalence | service | | | | | |
| | 121 | 79 | 70 | 191 | 0.634 | 0.366 | 7.658 | *Reject $H_0$* |

In which:

*A*: *Nº of interviewees that consider the first element of the binary comparison preferable to the second;*

*M*: *Nº of interviewees that consider the two component to be of equivalent importance ;*

*B*: *Nº of interviewees that consider the second element of the binary comparison preferable to the first;*

*n:* *Set of interviewees formed by the sum of A and B.*

## 6. RESULTS OF THE INDEPENDENCE TEST

This topic covers the following results:

(i) Comparative analysis of the degree of importance given by passengers according to qualitative characteristics: household income, age, reason for traveling, and frequency of travel. For this analysis the AHP method was used, grouping passengers' opinions into classes in a certain characteristic. These results are presented in Figures 4 to 7.

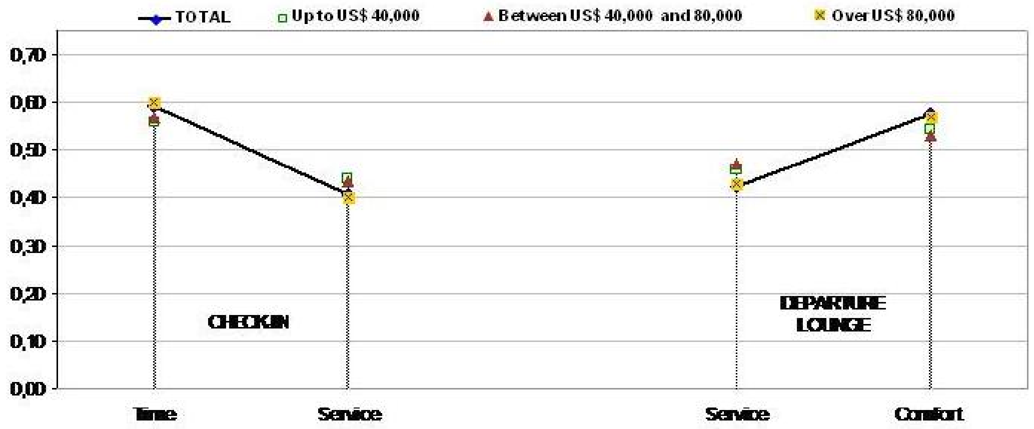
(ii) Next, by way of independence test contingency tables a relation between the qualitative characteristics and opinion given on the degree of importance by the passengers was looked for. The opinion on the degree of importance was divided into three classes: passengers who attributed greater importance to any degree of an indicator x in regard to another, y, passengers who attributed the same importance to the two indicators, and passengers who attributed less importance to the indicator x in regard to another, y. These results are presented in Tables 10 to 14.

*6.1 VARIABLES: INCOME AND DEGREE OF IMPORTANCE*

Figure 4 presents the differences between the intensity of the priority vectors among the three classes of income – income up to US$ 40,000/year, income between US$ 40,000 and 80,000/year, and income above US$ 80,000/year.

At the check in, the group of people with an income above US$ 80,000/year gave greater importance to the indicator for processing time, while the group of people with an income of up to US$ 40,000/year gave greater importance to service. In the departure lounge the group of people with an income above US$ 80,000/year gave greater importance to the indicator comfort; while the group of people with an income of up to US$ 40,000/year gave greatest importance to service.

Figure 4: Preferences related to Income




Given the preference among passengers according to the classes designated for household income, the Chi-Squared Method was used to ascertain whether this variable influenced passengers' opinion. To such an end, contingency tables were drawn up with the expected and observed values – Tables 8 and 9 – for the check-in and departure lounge areas. All the results in both tables accept the hypothesis $H_0$ concluding that passenger income does not influence opinion on the degree of importance given to indicators for the check-in and departure lounge.

Table 8: Expected values based on the Independence Hypothesis

Check-in Area

| Time in line *vs.* Service at the counter – Check-in area | | | | | |
|---|---|---|---|---|---|
| | Score Frequency | | | | |
| Income/year | less important [1] | equal [2] | more important [3] | Total | % |
| Up to US$ 40,000 | 42 | 57 | 22 | 121 | 0.45 |
| Expected value | 50.64 | 49.30 | 21.06 | | |
| $\chi^2$ partial | 1.47 | 1.20 | 0.04 | | |
| Between US$ 40 and 80,000 | 35 | 33 | 14 | 82 | 0.30 |
| Expected value | 34.32 | 33.41 | 14.27 | | |
| $\chi^2$ partial | 0.01 | 0.00 | 0.01 | | |
| More than US$ 80,000 | 36 | 20 | 11 | 67 | 0.25 |
| Expected value | 28.04 | 27.30 | 11.66 | | |
| $\chi^2$ partial | 2.26 | 1.95 | 0.04 | | |
| Total | 113 | 110 | 47 | 270 | |

*$\chi^2$ Total= 6.99*

*$\chi^2$ Tabled **α**=5% = 9.48 e GL = 4*

[1]wait time é less important than the service at the counter
[2]wait time and service at the counter are of equal importance
[3]wait time is more important than the service at the counter

Table 9: Expected values based on the Independence Hypothesis

Departure lounge area

| Comfort *vs.* Service – Departure lounge area | | | | | |
|---|---|---|---|---|---|
| | Score Frequency | | | | |
| Income/year | less important [1] | equal [2] | more important [3] | Total | % |
| Up to US$ 40,000 | 37 | 36 | 48 | 121 | 0.45 |
| Expected value | 31.37 | 35.40 | 54.23 | | |
| $\chi^2$ partial | 1.01 | 0.01 | 0.71 | | |
| Between US$ 40 and 80,000 | 22 | 21 | 39 | 82 | 0.30 |
| Expected value | 21.26 | 23.99 | 36.75 | | |
| $\chi^2$ partial | 0.03 | 0.37 | 0.14 | | |
| More than US$ 80,000 | 11 | 22 | 34 | 67 | 0.25 |
| Expected value | 17.37 | 19.60 | 30.03 | | |
| $\chi^2$ partial | 2.34 | 0.29 | 0.53 | | |
| Total | 70 | 79 | 121 | 270 | |

*$\chi^2$ Total= 5.43*

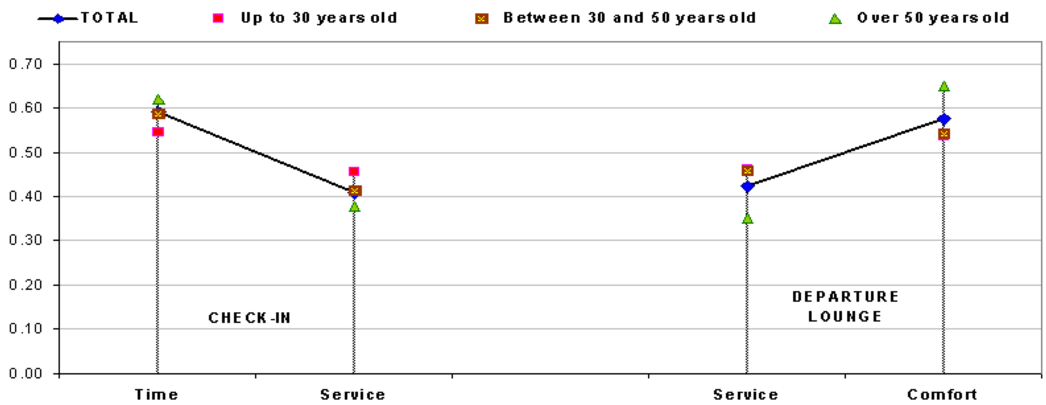
*$\chi^2$ Tabled **α**=5% = 9.48 e GL = 4*

1 comfort is less important than the service at the counter
2 comfort and service at the counter are of equal importance
3 comfort is more important than the service at the counter

### *6.2 VARIABLES: AGE AND DEGREE OF IMPORTANCE*

Figure 5 presents the differences between the intensity of priority vectors among the age ranges (up to 30, between 30 and 50, and above 50 years old). People over 50 years old attributed greater importance to the indicators for wait time, comfort at the check-in and departure lounge, respectively, so showing an inverse relation with the group of people aged up to 30 years old.

Figure 5: Preferences related to Age




Given the preference among passengers according to the classes designated for age, the Chi-Squared Method was used to ascertain whether this variable influenced passengers' opinion. To such an end, contingency tables were drawn up with the expected and observed values – Tables 10 and 11 – for the check-in a departure lounge areas.

Table 10: Expected values based on the Independence Hypothesis Check-in area

| Wait time *vs.* service at the counter – Check-in area | | | | | |
|---|---|---|---|---|---|
| | Score Frequency – check-in | | | | |
| Age | less important [1] | equal [2] | more important [3] | Total | % |
| Up to 30 | 30 | 51 | 17 | 98 | 0.42 |
| Expected value | 37.37 | 42.77 | 17.86 | | |
| $\chi^2$ partial | 1.45 | 1.58 | 0.04 | | |
| $\chi^2$ partial corrected | 1.26 | 1.40 | 0.01 | | |
| Between 30 and 50 | 46 | 50 | 20 | 116 | 0.49 |
| Expected value | 44.24 | 50.63 | 21.14 | | |
| $\chi^2$ partial | 0.07 | 0.01 | 0.06 | | |
| $\chi^2$ partial corrected | 0.04 | 0.00 | 0.02 | | |
| Over 50 | 14 | 2 | 6 | 22 | 0.09 |
| Expected value | 8.39 | 9.60 | 4.01 | | |
| $\chi^2$ partial | 3.75 | 6.02 | 0.99 | | |
| $\chi^2$ partial corrected | 3.11 | 5.25 | 0.55 | | |
| Total | 90 | 103 | 43 | 236 | |

*$\chi^2$ Total=13.97 e $\chi^2$ Yates correction =11.64*

*$\chi^2$ Tabled $\alpha$=5% = 9.48 e GL = 4*

[1]wait time é less important than the service at the counter
[2]wait time and service at the counter are of equal importance
[3]wait time is more important than the service at the counter

Table 11: Expected values based on the Independence Hypothesis

Departure lounge area

| Comfort *vs.* service – Departure lounge area | | | | | |
|---|---|---|---|---|---|
| | Score Frequency – Departure Lounge | | | | |
| Age | less important [1] | equal [2] | more important [3] | Total | % |
| Up to 30 | 30 | 28 | 40 | 98 | 0.42 |
| Expected value | 27.82 | 30.31 | 39.86 | | |
| $\chi^2$ partial | 0.17 | 0.18 | 0.00 | | |
| Between 30 and 50 | 46 | 50 | 20 | 116 | 0.49 |
| Expected value | 44.24 | 50.63 | 21.14 | | |
| $\chi^2$ partial | 0.07 | 0.01 | 0.06 | | |
| Over 50 | 4 | 6 | 12 | 22 | 0.09 |
| Expected value | 6.25 | 6.81 | 8.95 | | |
| $\chi^2$ partial | 0.81 | 0.10 | 1.04 | | |
| Total | 67 | 73 | 96 | 236 | |

*$\chi^2$ Total= 2.77*

*$\chi^2$ Tabled $\alpha$=5% = 9.48 e GL = 4*

[1] comfort is less important than the service at the counter
[2] comfort and service at the counter are of equal importance
[3] comfort is more important than the service at the counter

The result presented in Table 10 for the check-in area rejects the nullity hypothesis and accepts hypothesis $H_1$. That is, it concludes that age interferes in passengers' opinion about the degree of importance of the indicators wait time and service at the counter. For the departure lounge area the result in Table 11 accepts the hypothesis $H_0$, where we can conclude that passenger age does not influence opinion about the degree of importance given to the indicators for the departure lounge.

### *6.3 VARIABLES: REASON FOR TRAVELING AND DEGREE OF IMPORTANCE*

Figure 6 presents the differences between the intensity of priority vectors for the reason for travelling (business, pleasure, and family). Business travelers gave greater importance to the indicator wait time at the check-in, unlike the other two classes, who gave greater importance to service at the counter.

In the departure lounge area, while the passengers travelling for family reasons gave greater importance to the indicator service, others, traveling for business and pleasure, preferred comfort. Given the preference among passengers according to the classes designated for the reason for travelling, the Chi-Squared Method was used to ascertain whether this variable influenced passengers' opinion. To such an end, contingency tables were drawn up with the expected and observed values – Tables 12 and 13 – for the check-in and departure lounge areas.

Figure 6: Preferences related to Reason for Travelling

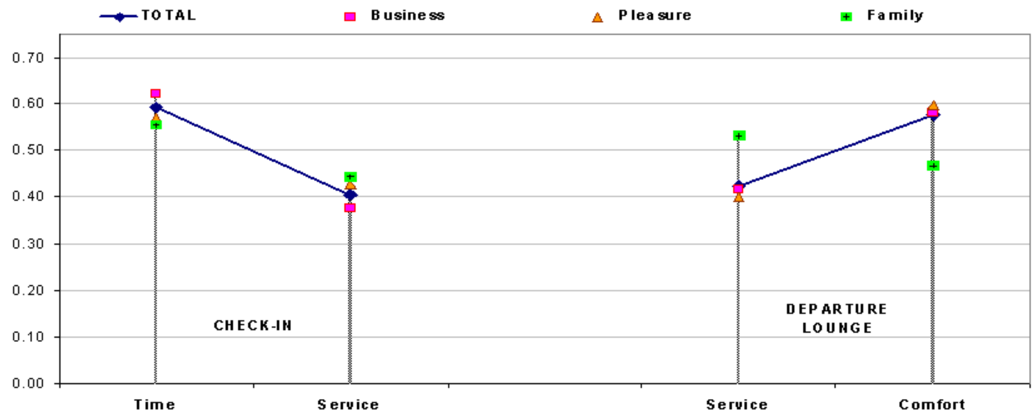



Table 12: Expected values based on the Independence Hypothesis

Check-in area

| Wait time *vs.* Service at the counter – Check-in area | | | | | |
|---|---|---|---|---|---|
| | Score Frequency – *check-in* | | | | |
| Reason for Travelling | less important [1] | equal [2] | more important [3] | Total | % |
| Business | 53 | 27 | 21 | 101 | 0.47 |
| Expected value | 43.22 | 39.46 | 18.32 | | |
| $\chi^2$ partial | 2.21 | 3.93 | 0.39 | | |
| $\chi^2$partial corrected | 1.99 | 3.63 | 0.26 | | |
| Pleasure | 32 | 42 | 14 | 88 | 0.41 |
| Expected value | 37.66 | 34.38 | 15.96 | | |
| $\chi^2$ partial | 0.85 | 1.69 | 0.24 | | |
| $\chi^2$ partial corrected | 0.71 | 1.47 | 0.13 | | |
| Family | 7 | 15 | 4 | 26 | 0.12 |
| Expected value | 11.13 | 10.16 | 4.72 | | |
| $\chi^2$ partial | 1.53 | 2.31 | 0.11 | | |
| $\chi^2$ partial corrected | 1.18 | 1.86 | 0.01 | | |
| Total | 92 | 84 | 39 | 215 | |

*$\chi^2$ Total=13.26 e $\chi^2$ Yates correction =11.24*

*$\chi^2$ Tabled $\alpha$=5% = 9.48 e GL = 4*

[1]wait time is less important than the service at the counter
[2]wait time and service at the counter are of equal importance
[3]wait time is more important than the service at the counter

The result presented in Table 12 for the check-in area rejects the nullity hypothesis and accepts hypothesis $H_1$. That is it concludes that the reason for traveling – Business, Pleasure or Family - interferes in passengers' opinion about the degree of importance of the indicators wait time and service at the counter.

For the departure lounge area the result in Table 13 accepts the hypothesis $H_0$, where we can conclude that the passenger's reason for traveling does not influence the opinion about the degree of importance given to indicators for the departure lounge.

Table 13: Expected values based on the Independence Hypothesis
Departure lounge area

| Comfort *vs.* Service – Departure lounge area | | | | | |
|---|---|---|---|---|---|
| | Score Frequency – DEPARTURE LOUNGE | | | | |
| Reason for Travelling | less important [1] | equal [2] | more important [3] | Total | % |
| Business | 28 | 25 | 48 | 101 | 0.47 |
| Expected value | 25.84 | 30.07 | 45.10 | | |
| $\chi^2$ partial | 0.18 | 0.85 | 0.19 | | |
| Pleasure | 18 | 29 | 41 | 88 | 0.41 |
| Expected value | 22.51 | 26.20 | 39.29 | | |
| $\chi^2$ partial | 0.90 | 0.30 | 0.07 | | |
| Family | 7 | 15 | 4 | 26 | 0.12 |
| Expected value | 11.13 | 10.16 | 4.72 | | |
| $\chi^2$ partial | 1.53 | 2.31 | 0.11 | | |
| Total | 55 | 64 | 96 | 215 | |
| | | | | | *$\chi^2$ Total=5.82* |
| | | | | | *$\chi^2$ Tabled $\alpha$=5% = 9.48 e GL = 4* |

[1] comfort is less important than the service at the counter
[2] comfort and service at the counter are of equal importance
[3] comfort is more important than the service at the counter

### *6.4 VARIABLES: FREQUENCY OF TRAVEL AND DEGREE OF IMPORTANCE*

Figure 7 presents the differences between the intensity of priority vectors among the frequency of travel (1 time/year, 2 to 6 times/year and more than 6 times/year).

It was noted that in the check-in area the group that travels only 1 time/year gave greater importance to service, unlike the other groups. In the departure lounge area it was noted that people who travelled more than 6 times/year gave greater importance to the indicator comfort, unlike those who travelled only 1 time/year. Such a difference could be explained by the greater demands made by passengers that travel more frequently, as they spend longer inside the terminal.

Given the preference among passengers according to the classes designated for age, the Chi-Squared Method was used to ascertain whether this variable influenced passengers' opinion. To such an end, contingency tables were drawn up with the expected and observed values – Tables 14 and 15 – for the check-in and departure lounge areas.

Figure 7: Preferences related to Frequency of Travel

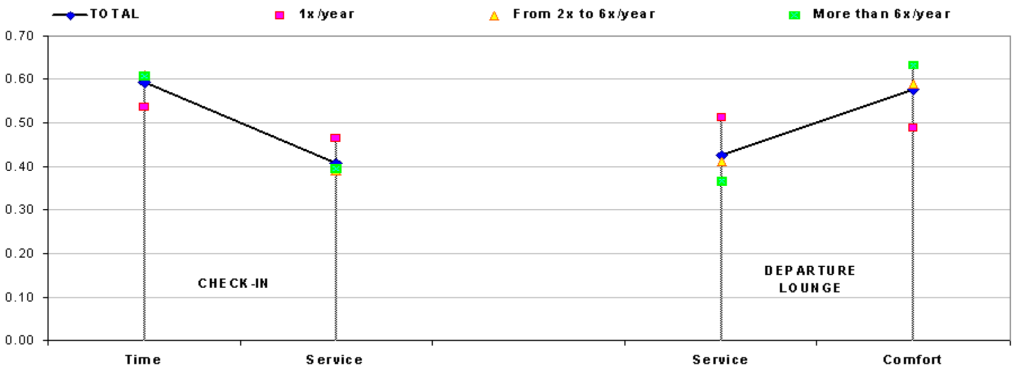



Table 14: Expected values based on the Independence Hypothesis

Check-in area

| Wait time *vs.* Service at the counter – Check-in area | | | | | |
|---|---|---|---|---|---|
| | Score Frequency – check-in | | | | |
| Frequency of travel | less important [1] | equal [2] | more important [3] | Total | % |
| 1x/year | 18 | 32 | 13 | 63 | 0.23 |
| Expected value | 26.23 | 25.76 | 11.01 | | |
| $\chi^2$ partial | 2.58 | 1.51 | 0.36 | | |
| From 2 to 6x/year. | 71 | 63 | 25 | 159 | 0.59 |
| Expected value | 66.20 | 65.02 | 27.78 | | |
| $\chi^2$ partial | 0.35 | 0.06 | 0.28 | | |
| More than 6x/year | 23 | 15 | 9 | 47 | 0.17 |
| Expected value | 19.57 | 19.22 | 8.21 | | |
| $\chi^2$ partial | 0.60 | 0.93 | 0.08 | | |
| Total | 112 | 110 | 47 | 269 | |
| | | | | *$\chi^2$ Total = 6.74* | |
| | | | *$\chi^2$ Tabled **α**=5% = 9.48 e GL = 4* | | |

[1] wait time is less important than the service at the counter
[2] wait time tem equal importance than the service at the counter
[3] wait time is more important than the service at the counter

The result indicated in Table 14 for the check-in area accepts hypothesis $H_0$, where we can conclude that frequency of travel for passengers at São Paulo / Guarulhos International Airport does not influence opinion on the degree of importance for the indicators wait time and service at the counter.

For the departure lounge area, the result found in Table 15 rejects the nullity hypothesis and accepts hypothesis $H_1$. That is, it concludes that frequency of travel at the airport studied does interfere in passengers' opinion on the degree of importance of the indicators wait time and service at the counter.

Table 15: Expected values based on the Independence Hypothesis

Departure lounge area

| Comfort *vs.* Service – Departure lounge area | | | | | |
|---|---|---|---|---|---|
| | Score Frequency – Departure Lounge | | | | |
| Frequency of travel | less important [1] | equal [2] | more important [3] | Total | % |
| 1x/year | 26 | 15 | 22 | 63 | 0.23 |
| Expected value | 16.39 | 18.50 | 28.10 | | |
| $\chi^2$ partial | 5.63 | 0.66 | 1.33 | | |
| From 2 to 6x/year. | 35 | 50 | 74 | 159 | 0.59 |
| Expected value | 41.38 | 46.70 | 70.93 | | |
| $\chi^2$ partial | 0.98 | 0.23 | 0.13 | | |
| More than 6x/year | 9 | 14 | 24 | 47 | 0.17 |
| Expected value | 12.23 | 13.80 | 20.97 | | |
| $\chi^2$ partial | 0.85 | 0.00 | 0.44 | | |
| Total | 70 | 79 | 120 | 269 | |
| | | | | $\chi^2$ *Total=10.26* | |
| | | | | $\chi^2$ *Tabled* $\alpha$*=5% = 9.48 e GL = 4* | |

[1] comfort is less important than the service at the counter
[2] comfort is of equal importance to the service at the counter
[3] comfort is more important than the service at the counter

## 7. CONCLUSIONS

The passengers' opinions on the degree of importance of the components are required in order to be able to prioritize services. Furthermore, it has become necessary to get information on the quality of the services and/or map the profile of the passengers interviewed in order to contribute to the management of the airport as regards decision making.

There have been many studies that have reported the relationship that exists between individual characteristics and the perception of passengers about the degree of importance or about the quality of the services at an airport. However, these studies have not statistically proven whether this hypothesis is significant in their analyses. This proof could make a big difference when resources are limited or if a new airport terminal is being planned. Therefore, knowing that individual characteristics influence passengers' perception contributes more precisely to airport planning.

Unlike other studies, this article has presented, in a pioneering form, a qualitative analysis of the relationship between the passengers' profiles and their perception of the airport terminal. The results obtained have made it possible to ascertain whether there was dependency or independency between the individual characteristics of the passengers and their perception of the terminal. This made it possible to ascertain that "Age" and "Reason for Travelling" influence passengers' perceptions of the check-in area and that "Frequency of travel" influenced perception of the departure lounge area. The final results also indicate that the check-in and departure lounge were the most important areas in the airport terminal in the passengers' opinion.

Finally, it can be said that this kind of analysis can achieve great results in airport planning projects which are designed to direct their resources to a certain passenger audience or to attract potential clients with a certain profile. We suggest that airport operators develop this kind of analysis periodically, since variations on the competitive scenario, economic development, and airport passengers´ profile might have an important influence on the passenger perceptions. However, the methodology provided in this paper is robust and valid under different scenarios.

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