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- Airbus (2003), *Global Market Forecasts 2003-2022*, Toulouse: Airbus.
- 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).

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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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Full Research Papers

Richard Moxon

The London multi-airport system is described and changes in ownership from state organisations to competing private enterprises are assessed. A taxonomy of United Kingdom government action related to airport planning policy is presented with critical analysis in relation to airport surface access strategy. Changes in public transport use by passengers and employees at London airports are quantified to illustrate the success or otherwise of government policy. Passenger groups (defined by nationality and trip purpose) driving the increase in public transport are identified. Current London airport surface access strategic targets for passengers and employees are compared with the early versions suggested by the government to highlight the changed airport approach. Emerging surface airport access issues at London's airports are discussed.

Danang Parikesit, Safrilah, Yusa C. Permana

Indonesian airports have been experiencing significant air traffic growth and are unable to cope with the increasing air passenger demand. There is an urgent need for an effective slot allocation strategy to manage the demand for airport capacity. This paper conducts a case study to examine the possibility of managing slot time allocation to maximize runways capacity by analysing disincentive strategy in balancing the usage of runways with Capacity Restraint and Demand Balanced approach. The research found that airlines willing to use slot time at the most demanded time interval should pay an additional 6.57% (CR approach) from total revenue gained by the government from slot sector and 6.55% (DB approach). The additional cost for less demanded slot time interval is only 0.09% (in both CR and DB approaches).Findings from this study should be considered as an initial step toward educating policy makers and airport authorities with the aims to creating better mechanism in Indonesia's airspace market.

Jong Hae Choi, Yong Wha Park, Sang-Yong Lee, Kwang Soo Lee

Network connectivity is core competitiveness of the aviation industry and opening a new route is one of critical ways to enhance network competitiveness. As many airport operators are becoming more interested in attracting airlines, there are vast needs to discuss the methods for estimating (predicting) potential demands for a new flight route or by increasing flight frequencies in existing routes. This study explores demand estimation models for a new air route. Similar to previous studies, this study classified potential demand for a new air route into four types (Local, Beyond, Behind and Bridge). Explanatory variables are identified and constructed for each type of demand, including distance, relative capacity compared with adjacent airports and detour ratio as main independent variables. One of the strengths of the suggested demand models can distinguish the generated demand from the converted or re-distributed demand. Based on this, the model is meaningful for an airport operator to develop an airport policy such as airport-usage charges and incentives to attract airlines. On the other hand, because of the strong recognition that demand estimation for a new air route is the area of airlines that decide on

whether or not to introduce a new route, simply developing demand estimation models from the perspective of an airport operator is not sufficient. Therefore this study is considered as the initial step for an airport operator in its efforts to attract airlines and market new air routes to enhance network connectivity of its airport.

Adam Seredyński Tobias Grosche, Franz Rothlauf

This paper evaluates the net impact of timetable synchronization on the connectivity of the key European carriers at their main hubs. We measure hub connectivity using a weighted connectivity score (WCS) that takes into account the number and the trip time related quality of flight connections. Based on WCS, we compare hub performance resulting from the existing schedule against a random expectation calculated from multiple randomized schedule simulations. In each simulated schedule scenario we randomly vary the flight departure and arrival times within the operation hours at a hub and at outbound stations keeping all other flight parameters from the real schedule unchanged. We observe that the timetable synchronization leverages hub connectivity of most analyzed airlines by 40% to 60%. The highest increase of connectivity is achieved by medium-sized carriers that operate peaky wave systems with flights concentrated in many short and non-overlapping banks, as well as by carriers that organize their flights in directional waves. The lowest increase is achieved by airlines that operate at highly congested airports. At most hubs, connections to long-haul flights operated with wide-body aircraft are better synchronized than connections between short-haul flights.

José-Luis Alfaro Navarro, María-Encarnación Andrés Martínez, Jean-François Trinquecoste

The existence of different types of intermediaries - e-tailers, traditional or offline retailers and multichannel retailers - engaged in the sale of airline tickets has enabled consumers to find different prices if they spend time searching for information. This has prompted internet marketing research to increasingly focus on the issue of pricing, analyzing the differences between these retailers with respects to price levels, price dispersion, pricing strategies, etc. Moreover, there are also studies examining the effects of culture on prices. However, there is no literature on the effects of the culture from the supplier point of view. This paper attempts to fill in the gap by studying whether the geographical locations of the travel agencies affect airline ticket prices. In particular, the study compares the price behavior of French and Spanish intermediaries operating exclusively online and those operating simultaneously in travel agencies and on the internet (offline and online). To this end, we consider three routes that connect Madrid, Paris and New York, with data starting four months prior to the departure date (December 16, 2013). The results show several differences in the price levels and price dispersion between intermediaries in relation to the type of retailer and their geographical locations.

Debbie Ancell

Airline competition with customer service as product differentiator has forced down costs, air fares and investor returns. Two passenger markets operate in aviation: (a) able-bodied passengers for whom airlines compete and (b) passengers with reduced mobility (PRMs) – disabled by age, obesity or medical problems – for whom airlines do not compete. Government interference in the market intended to protect a minority of narrowly-defined PRMs has had unintended consequences of enabling increasing numbers of more widely-defined PRMs to access complimentary airline provisions. With growing ageing and overweight populations and long-haul travelling medical tourists such regulation could lead to even lower investors' returns. The International Air Transport Association (IATA) (2013)

examined the air transport value chain for competitiveness using Porter's (2008) five forces but did not distinguish between able-bodied passengers and PRMs. Findings during an investigation of these two markets concurred with IATA-Porter that the markets for the bargaining powers of PRM buyers and PRM suppliers were highly competitive. However, in contrast to the IATA conclusions, intensity of competition, and threats from new entrants and substitute products for PRM travel were low. The conclusion is that airlines are strategically PRM defensive by omission. Paradoxically, the airline which delivers the best PRM customer service could become the least profitable.

Editorial

Selected papers from the 18th Air Transport Research Society World Conference, Bordeaux (France), 2014

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The 18th Air Transport Research Society World Conference (ATRS) was held in Bordeaux, France, from July 17 to July 20, 2014. The conference attracted some 347 participants, and 321 papers were presented. The guest editors have selected six papers to be included in this special issue. These papers cover a wide range of topics presented and discussed at the conference and offer important contribution to the literature on air transport.

Surface access strategy is essential for the success of an airport. In the first paper, **Richard Moxon** investigates trends in airport surface access at the London area airports. The paper examines changes in public transport use passengers and employees at London airports in relation to government policy actions. The paper also identifies and discusses emerging surface airport access issues at the London airports.

Continuing with airport management strategies, **Parikesit, Safrilah, and Permana** present a case study of Sukarno-Hatta International Airport (Indonesia) in an attempt to explore effective airport slot allocation strategies to cope with the increasing pressure on airport capacity in the fast growing Indonesian aviation market. The paper argues that the existing slot allocation system does not consider market demand, and suggests that airport slots should be allocated through an auction system. Based on results from a simulation of slot market values, the study suggests that slot auction system can generate substantial revenues to maintain and operate the slot time management system, and encourages efficient distribution of aircraft departure time.

Moving from managing airport demand to air service development and network competitiveness, **Choi, Park, Lee and Lee** develop the models for estimating the demand for a potential new route from an airport. The proposed methodology is applied to Incheon International Airport, and the results indicate that distance, relative capacity and detour

ratio among other factors have significant effects on the demand for a potential new route. The demand model may also help an airport operator develop airport charge policy as well as incentive schemes to attract airlines.

Seredyński, Grosche, and Rothlauf examine the connectivity of airlines at their hub airports in terms of flight schedules. In particular, the paper evaluates the net impact of timetable synchronization on the connectivity of the key European carriers at their main hubs. The authors measure hub connectivity using a weighted connectivity score (WCS) that takes into account the number and the trip time related quality of flight connections. Their results indicate that the timetable synchronization leverages hub connectivity of most of the analyzed airlines by 40% to 60%. At most hubs, connections to long-haul flights operated with wide-body aircraft are better synchronized than connections between short-haul flights.

In the fifth paper, **Navarro, Martínez, and Trinquecoste** investigate whether the geographical locations of the travel agencies affect airline ticket prices. The study compares the price behavior of French and Spanish intermediaries operating exclusively online and those operating simultaneously in travel agencies and on the internet (offline and online). In particular, the study examines air fares on three routes that connect Madrid, Paris and New York, and their results indicate that there are indeed differences in the price levels and price dispersion between intermediaries with respect to the type of retailer and their geographical locations.

The last paper addresses a topic that has not received much attention in academic literature. **Ancell** examines government policies and regulations that are intended to protect passengers with reduce mobility (PRMs). However, these policies and regulations have led to the unintended consequencies of enabling increasing numbers of more widely-defined PRMs to access complimentary service provisions, which could result in lower profitability for the airlines and their investors. The paper further reviews Porter's five forces of competitiveness as applied to the airline industry and test their validity for the PRM market.

We would like to extend our thanks to the authors and the reviewers for their contribution to this ATRS special issue of Journal of Air Transport Studies. We believe that these papers provide valuable contribution to our understanding of the airlines and airports and will encourage further research on the respective topics.

TRENDS IN AIRPORT SURFACE ACCESS IN THE LONDON MULTI-AIRPORT SYSTEM

Richard Moxon[1]

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Abstract

The London multi-airport system is described and changes in ownership from state organisations to competing private enterprises are assessed. A taxonomy of United Kingdom government action related to airport planning policy is presented with critical analysis in relation to airport surface access strategy. Changes in public transport use by passengers and employees at London airports are quantified to illustrate the success or otherwise of government policy. Passenger groups (defined by nationality and trip purpose) driving the increase in public transport are identified. Current London airport surface access strategic targets for passengers and employees are compared with the early versions suggested by the government to highlight the changed airport approach. Emerging surface airport access issues at London's airports are discussed.

Key words: *United Kingdom airport policy, airport surface access strategy, multi-airport systems, airport planning.*

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1. INTRODUCTION

London has moved from four government (national and local) owned airports before 1986 to the current market of six competing private enterprises designated as serving the capital. In parallel with this (since 1998) the United Kingdom government has chosen to publicise a variety of reports, guidance and policy relating to airport surface access. The regularity and detail of such publications has varied and they have not been mandatory in composition. In the last decade of numerous airport ownership changes in London, published research has not tracked the nature or the impact of government attempts to influence the move from private to public transport by airport employees and staff in the London multi-airport system.

This research aims to investigate trends in airport surface access at the London area airports since 1998. Objectives include: to identify individual airport surface access behaviour as a potential characteristic of the multi-airport system, to detail changes in airport ownership during this period, to produce a definitive classification of government action related to airport planning (critically assessed in relation to surface access) and to gauge the success of this intervention by quantifying changes in public transport use.

2. METHODOLOGY

Semi-structured interviews took place with senior operational and/or surface access managers at each of the London airports during 2014. Relevant literature relating to United Kingdom airports policy, airport surface access and multi-airport systems was reviewed. United Kingdom Civil Aviation Authority and London airport data and strategic documentation was gathered, adapted and interpreted.

3. THE LONDON MULTI-AIRPORT SYSTEM

There are now six facilities designated as 'London area airports' by the United Kingdom Civil Aviation Authority. They are shown in Figure 1 which also demonstrates their proximity to major roads (marked in yellow) and railways (marked in black) for surface access purposes.

The concept of the multi-airport system has been well documented in recent literature since around 2000. De Neufville defined a multi-airport system as a set of significant airports serving commercial air transport in a metropolitan area without regard to ownership or political control (United States of America. Federal Aviation Authority, 2000). The nature of the development of multi-airport systems was identified by Bonnefoy (2008) who noted that secondary airports in the system can emerge through construction of new facilities (London City) or through the emergence of an under-utilised facility in the catchment area (London Southend).

Figure 1: The London area airports

Source: Adapted from Google Earth (2014), UK Civil Aviation Authority (2014)

Passenger traffic handled by each of the London area airports since 1998 is shown in Figure 2. The annual passenger volumes show the marked negative impact of the economic crisis on passenger numbers at Heathrow, Gatwick and Stansted between 2008 and 2010. London Luton and London City demonstrated more resilience to traffic fluctuations during this time. Stansted still appears to be struggling to regain its lost share of the London market. The London area airports demonstrate typical multi-airport system characteristics identified by de Neufville and Odoni (2013). These include significantly differing levels of traffic and traffic specialisation (i.e. low cost carriers predominate at Stansted, London Luton and London Southend, network carriers at Heathrow whilst London City serves mainly short-haul business destinations).

Figure 2: London area airport traffic 1998-2014 and transfer passenger proportion 2014
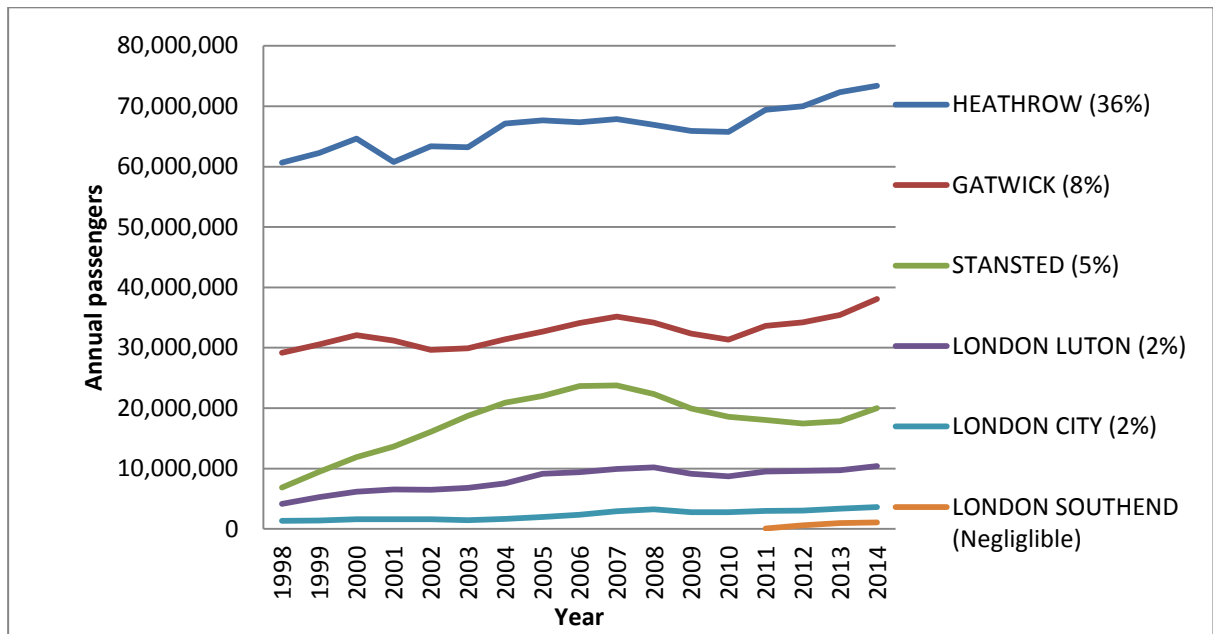
Also, there are limitations in traffic allocation to the primary airport (because of capacity constraint at Heathrow). It can be argued that Gatwick acts as a second primary airport in the system and the similarity of traffic evolution between it and Heathrow support this view. No published research currently exists that examines multi-airport airport system characteristics in relation to passenger and employee surface access behaviour.

The proportion of passengers transferring between aircraft at each airport is an important factor when considering airport surface access. This is because only those passengers who start or end their journeys in London will use a surface mode of transport to get to or from the airport. The proportion of transfer passengers (arriving and leaving by air) varies greatly between the London airports and ranges from 36% at Heathrow to a negligible volume at London Southend.

4. FROM STATE OWNERSHIP TO COMPETING PRIVATE ENTERPRISES IN THE LONDON MULTI-AIRPORT SYSTEM.

In 1986, an act of the United Kingdom's parliament mandated the dissolution of the government owned British Airports Authority (operator of seven United Kingdom airports including Heathrow, Gatwick and Stansted that all served London). This resulted in the creation of three separate London airport limited companies, each subsidiaries of the newly created BAA plc. Shares in BAA were then freely traded on the London Stock Exchange (Great Britain (a). The Airports Act, 1986). The act also required that UK airports in the ownership of local authorities with a turnover of more than one million pounds in two of the previous three years moved from direct local authority ownership and operation to airport companies. In the London multi-airport system, this meant that Southend and Luton airports were transferred to limited companies whose shares were initially held wholly by Southend Borough Council and Luton Borough Council respectively.

The result of the act was that the now privately owned Heathrow, Gatwick and Stansted airports had to survive without further subsidy from the United Kingdom government. It also meant that Southend and Luton airports were able to access private capital and move to private ownership if required because their local authority shareholders had the right to sell their shares to private companies (Humphreys, 1999).

The renamed London Southend airport is now leased and operated by the Stobart Group. Southend Borough Council sold the 150 year lease to Regional Airports Ltd. in 1994 which was then bought by the Stobart Group in 2008.

Whilst the rebranded London Luton airport has remained in the ownership of Luton Borough Council, it is operated, managed and developed by a private consortium under a public private partnership. In 2001, TBI plc (an airport operating company) became the majority shareholder and this company was in turn taken over by Abertis in 2005. The airport was then bought by Aena (the world's largest airport operator) in 2013.

London City airport began operations in 1988 on a former dock site in east London. It was constructed and wholly owned by John Mowlem and co. plc – a civil engineering company - and sold to Dermott Desmond (an Irish businessman) in 1995. It was then acquired in 2006 by a consortium seventy five per cent owned by Global Infrastructure Partners, a multi-national private equity firm specialising in infrastructure investment.

A consortium led by the Ferrovial group (a Spanish company investing in transportation infrastructure) successfully bid for BAA plc in 2006 when the company was de-listed from the London Stock Exchange. The United Kingdom government's Competition Commission subsequently ruled that there was a lack of competition at London's airports because of a BAA monopoly. This resulted in the forced sale of London Gatwick in 2009 to Global Infrastructure Partners and the forced sale of London Stansted in 2013 to the Manchester Airport Group.

5. UNITED KINGDOM GOVERNMENT AIRPORT PLANNING POLICY AND GUIDANCE: SPORADIC INCLUSION OF AIRPORT SURFACE ACCESS STRATEGY.

Between 1998 and 2014, a variety of airport planning related government reports, guidance documents, policies and laws were produced by the United Kingdom government. All but three of them covered airport surface access to a greater or lesser degree. All were applicable to the London multi-airport system and are shown in Table 1 with analysis of their content related to airport surface access and public transport use detailed in the following text.

The United Kingdom government published a white paper (a document that details preferred future policy) in 1998. Entitled 'A new deal for transport: better for everyone', it described a new approach for an integrated transport strategy to tackle the growing challenges of domestic congestion and pollution (Great Britain (b). Department of the Environment, Transport and the Regions, 1998).

In relation to airport surface access, the government's aspiration was an improvement at the local level for staff and passengers using public transport. Initiatives were to be implemented and funded by the airports themselves. The government required specifically that, 'all airports in England with scheduled passenger services should lead an Airport Transport Forum…which should have three specific objectives:

- to draw up and agree challenging short and long term targets for increasing the proportion of journeys to the airport made by public transport.

- to devise a strategy for achieving those targets, drawing on the best practice available. This is likely to involve a wide range of measures to address the needs of all those travelling to airports. Bus and coach services should be included as well as rail. This means that the management of traffic on local and trunk roads will be an important issue for some airports.

-to oversee implementation of the strategy. Implementation should include green transport plans to cover commuting and business travel for all employees based at airports.'

At a national and regional transport level in the 1998 document, the government also stated the importance of developing improved connection between airports and the public transport network, particularly for rail. In retrospect, it is striking that no specific mention was made of the now standard terminology of 'airport surface access strategy' or 'ASAS', although it is implied in the objectives noted for the Airport Transport Forums. Specific details of how to increase public transport use for airport journeys and what the strategy should look like were notably lacking whilst also requiring a strategy to be completed in 2000.

Table 1: Timeline showing key airport planning related United Kingdom government actions impacting London airports 1998-2013

Year of publication	Government Report	Guidance Document	White Paper (or policy document)	Act of Parliament (or law)
1998			'A new deal for transport: better for everyone'	
1999		'Guidance on airport transport forums and airport surface access strategies'		
2000		'Air transport forums practice guide'		
2003			'The future of air transport'	
2004		'Guidance on the preparation of masterplans'		
2006	'Air transport white paper progress report' 'The Stern review'* 'The Eddington transport study'			'The Airports Act'*

2012				'The Civil Aviation Act'*
2013	'Airports Commission: Interim report'		'Aviation policy framework'	

*=No reference to airport surface access

This problem was partly addressed in the following year by the government in response to airport feedback. 'Guidance on Airport Transport Forums and Airport Surface Access Strategies' contained the advice required for airport operators to devise targets to increase the proportion of staff and employees using public transport at airports and to create strategies to achieve them. It referred to the minimum strategy requirements being that targets 'should be realistic and deliverable'. Characteristics of a good strategy were noted as 'a set of performance indicators and other output measures which can be used to assess whether the strategy is delivering its stated objectives and targets'. More details of the recommended composition of an Airport Transport Forum were given, along with a clear statement that strategy targets are not statutory. Airport surface access strategies and specific measures to achieve them would not be prescribed by the government although some suggestions were provided (Great Britain (c). Department of the Environment, Transport and the Regions, 1999).

Further, less formal direction was provided in additional governmental guidance published in 2000. 'Airport transport forums good practice guide' gave further advice and cases of lessons learnt to date in the provision of Airport Surface Access Strategies in the United Kingdom (Great Britain (d). Department of the Environment, Transport and the Regions, 2000). In the case of the London multi-airport system these examples included Heathrow surcharging public and staff parking to fund increased spending on improving public transport. Luton Airport Parkway railway station had been newly built with a frequent free shuttle bus connecting it to the terminal. Gatwick airport encouraged staff cycling with the introduction of cycle racks, showers and cycle paths. Stansted was subsidising staff travel, providing discounts of up to 70% for staff travelling to or from work who purchased a monthly or annual 'Airport Travelcard'. It must be noted that the majority of the examples of good practice quoted related to Heathrow.

To address the pressure from growing demand for air travel at United Kingdom airports and the constrained airport capacity in London, the government published another white paper in 2003. 'The Future of Air Transport' detailed the preferred national framework for air transport for the next thirty years. In relation to London airports, two new runways were proposed. A second runway

should be provided at Stansted and a third at Heathrow. A second runway at Gatwick should be provided if the conditions (mainly environmental) for a third Heathrow runway could not be met.

The government also recognised the potential for passenger and air transport growth through further development at London City, London Southend and London Luton airports without new runways. Airport operators were expected to produce master plans taking account of recommended development proposals and 'any proposal for new airport capacity…must be accompanied by clear proposals on surface access.'

Once again, the requirement for airports to set up Air Transport Forums and produce an Airport Surface Access Strategy was reiterated (if more than one thousand passengers air transport movements were handled per annum). Short and long term targets for decreasing the proportion of airport journeys by car were required. Proposals from airports to increase the proportion of passenger and staff journeys by public transport were also expected (Great Britain (e). Department for Transport, 2003).

'Guidance on the preparation of Master Plans' was produced by the government in 2004. It responded to feedback from airports requesting clarification on the purpose, timetable and scope/content of the required documents. Surface access was addressed explicitly and it was noted that, 'the split between use of public and private transport by air passengers and those working at the airport will affect the scale of any new investment in surface access that is required to accompany proposed airport expansion'. The development of both short and long term airport surface access strategies in line with master plans to 2030 was required (Great Britain (f). Department for Transport, 2004).

A review of strategic development since the airport white paper of 2003 was published in the 'Air transport white paper progress report' of 2006. The government noted a 'positive start' by airports in developing surface access strategies. London Luton airport was highlighted as an example of best practice to date. It had increased the percentage of passengers travelling by public transport between 2003 and 2005 by 4%. Airports were now required to produce airport surface access strategies with specific targets for increasing public transport modal share (Great Britain (g). Department for Transport, 2006).

In 2006, a further act of Parliament, 'The Airports Act' (amongst other things) gave new powers to airports to curtail airport aircraft noise and emissions but made no mention of the environmental impact of airport surface access (Great Britain (h). The Airports Act, 2006).

A similar omission is noticeable in the Stern Review Report of the same year. It was commissioned by the government to report on the economic impact of responding to the threat of climate change by moving to a low carbon economy. It recommended that any carbon consuming activity is priced to reflect its true cost to society and the environment. Whilst aviation policy is considered from the perspective of aircraft emissions, airport surface access is ignored (Great Britain (i). The Stern Report Review, 2006).

An additional government commissioned report was authored by Sir Rod Eddington (the outgoing chief executive of British Airways) in 2006. His remit was to advise on how United Kingdom productivity, stability and growth were affected by long-term transport policy. 'The Eddington Transport Study' makes many references to airports, with a special consideration of the potentially high magnitude of social and economic returns on investment in airport surface access (Great Britain (j). Department for Transport, (2006). Importantly, one of three strategic economic priorities highlighted for the country is good quality connections between urban areas and international airports.

Government policy or official guidance did not then significantly revisit airport planning until 2012. The Civil Aviation Act of this year reformed the economic regulation of Heathrow, Stansted and Gatwick and increased the focus of the Civil Aviation Authority on passengers' interests at these airports. Whilst winter operational resilience was emphasised, the importance of airport surface access to the passengers' experience remained unmentioned (Great Britain (k). The Civil Aviation Act, 2012).

Also in 2012, the government set up the politically autonomous Airports Commission which would 'take a fresh and independent look at the UKs future air capacity needs'. The first interim report of the commission was published in 2013 and marked a turning point in setting out 'the nature, scale and timing of steps needed to maintain the UK's status as an international hub for aviation' (Great Britain (l). Airports Commission, 2013). The report noted that 'there is a clear case for one net additional runway in London…by 2030' and 'there is likely to be a demand case for a second additional runway by 2050, or…earlier.'

Specifically in relation to London airport surface access, the Airports Commission recommended improvements to Gatwick Airport railway station in addition to enhanced road and rail access there. An upgraded rail link between London and Stansted was suggested as well as better rail access to Heathrow from the south and the provision of smart ticketing at all airport stations allowing access to all train services by cards containing microchips. A comprehensive strategy for motorway access to London Luton was also suggested. London airports wishing to promote the development of

additional runways were invited to submit details of proposed airport surface access strategies to the commission to support them. The interim report concluded with the short listing of three runway expansion options for further consideration in the London multi-airport system – two at Heathrow and one at Gatwick.[2]

The 'Aviation Policy Framework', also promoted in 2013 noted that a decade had passed since the 2003 publication of the Air Transport White Paper. It did not mention that it was the current government (at the time) that chose to disregard the previous administration's recommendations contained within the original 2003 document (Great Britain (m). Department for Transport, (2013). However, it did summarise the current approach to aviation policy and significantly noted that this policy framework now replaced all previous guidance on airport transport forums, master plans and airport surface access strategies. Whilst the list is 'not prescriptive or exhaustive', surface access strategies should now 'include:

-analysis of existing surface access arrangements;

-targets for increasing the proportion of journeys made to the airport by public transport by passengers and employees; cycling and walking. There should be short- and long-term targets;

-consideration of whether freight road traffic can be reduced;

-consideration of how low carbon alternatives could be employed;

-short-term actions and longer-term proposals and policy measures to deliver on targets such as:

-proposed infrastructure developments e.g. light rail;

-car/taxi sharing schemes;

-improved information provision on public transport, cycling and walking options;

-car park management;

-through-ticketing schemes;

-indication of the cost of any proposals;

-performance indicators for delivering on targets;

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[2] The final report of the Airports Commission was published in 2015 during the review of this paper. The shortlisted schemes were: an extended existing runway at Heathrow, a new runway at Heathrow and a new runway at Gatwick. The Commission endorsed the provision of an additional runway to the north-west of Heathrow to provide additional capacity in the London multi-airport system. Each of three alternative short-listed schemes had been appraised in respect to surface access. The first stated surface access strategy objective was 'to maximise the number of passengers and workforce accessing the airport via sustainable modes of transport'. The surface access assessment concluded that all three proposed schemes had met this objective with similar levels of success. It noted that the Gatwick scheme forecast the highest public transport mode share but that the favoured Heathrow scheme expected to provide the greatest number of passengers switching to sustainable modes of transport (Great Britain (n). Airports Commission, 2013).

-monitoring and assessment strategies (internal and external);

-green transport incentive schemes for employees.'

Evidence of the United Kingdom government's recognition of the need for airports to develop more robust surface access strategies for employees and passengers did not become apparent until 1998. In the subsequent years, ten government publications (including externally commissioned and in-house reports, guidance documents, policy statements and laws) have been created in relation to airport planning, all of which relate to the London airports. Of these, three make no reference to airport surface access. The remaining seven indicate consistent government focus on airport surface access between 1998 and 2004. The following years saw the issue ignored until 2013, with the exception of the white paper progress report in 2006. Throughout this period, specific targets for the proportion of airport employees and passengers travelling by public transport have never been mandated.

6. HOW SUCCESSFUL HAVE THE AIRPORTS BEEN IN SHIFTING PASSENGERS AND EMPLOYEES FROM PUBLIC TO PRIVATE TRANSPORT?

A common theme was revealed in the review of government actions relating to airport planning strategies at London airports. This was the repeatedly stated requirement for the airports to facilitate a change in surface access modal choice from private to public transfer for both their passengers and employees. It is assumed by the United Kingdom Civil Aviation Authority that public transport includes rail (heavy, light and underground), bus (local stopping services including hotel buses) and coach (long distance and express bus services). Taxis are categorised as private transport. This is not the definition used by all of the London airports considered in their own communications and publications and this can lead to difficulties in meaningful comparison without further adaptation of data.

Figure 3 shows the passenger public transport use since 1998. All airports in the system are now easily reached by public transport. This data was collected by the United Kingdom Civil Aviation Authority using a common sampling methodology for all of the airports considered, with the exception of London Southend airport. London Southend provided data from passenger surveys undertaken in-house in 2013 as no government funded passenger surveys have taken place there.

Stansted airport had the highest proportion of passengers using public transport at the end of the trend analysis period. The opening of a new bus and coach station in in 2007 following the introduction in 2006 of three express coach companies competing on price, frequency, fleet and service quality drove this (Stansted Airport (a), 2014). The proportion of passengers using public transport at Stansted has consistently increased each year since 2006 with a notable decline in

2014. There was an increase in public transport use every year following the changed ownership of 2006 which contrasts with a fall following further ownership change in 2013.

The ownership of London City changed in 2006 but this does not explain the step change in public transport use in the following four years. The opening of the Docklands Light Railway in the same year provided London City with a direct link to the London Underground train network. This followed the opening of the Jubilee Line Extension in late 1999 which operated close to the airport with a direct bus link. Both infrastructure developments resulted in a large shift of passengers to public transport at the airport. Government survey data has shown this trend somewhat reversed from 2010 which contradicts the airport's own survey results showing public transport being used by 60% of passengers in 2013 and 61% in 2014 (London City Airport (a), 2014).

Figure 3: Passenger public transport use at London airports 1998-2014
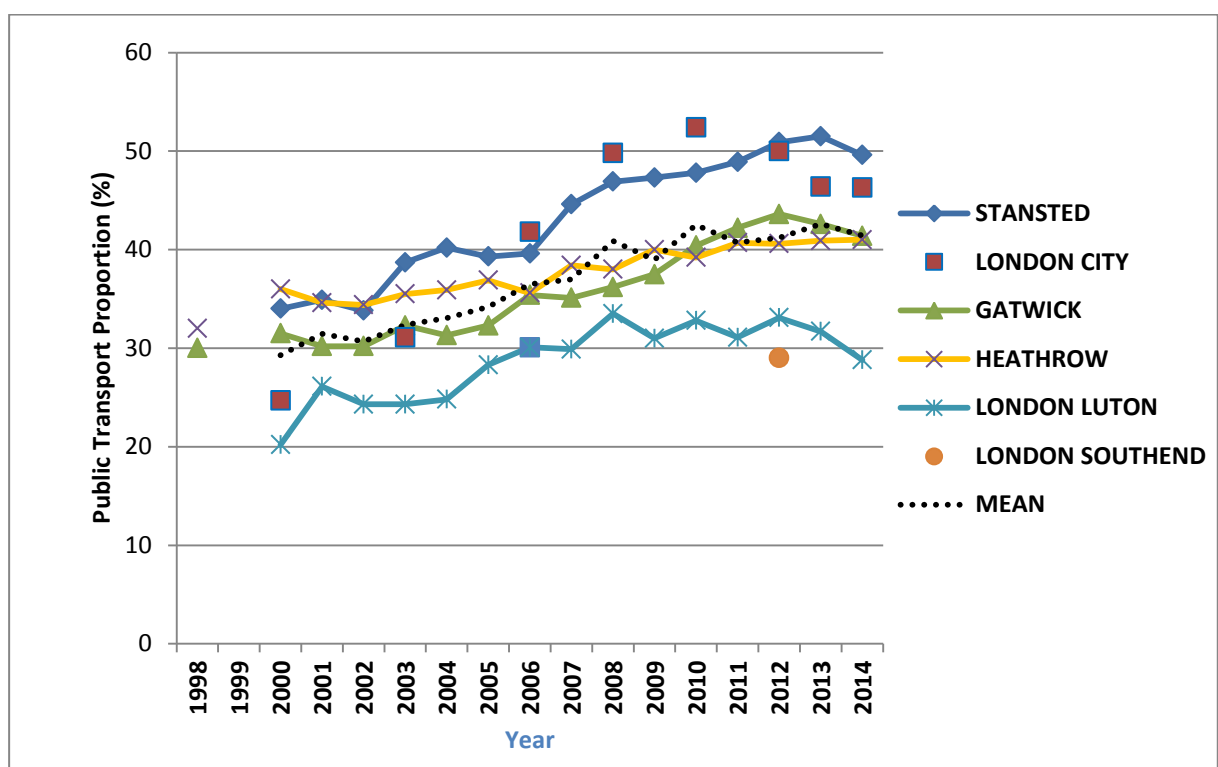
Source: United Kingdom Civil Aviation Authority (2014), London Southend airport (2014)

Public transport use by passengers grew consistently from 2003 to 2012 at Gatwick airport albeit with a minor stall in 2007. A recent proportional decline is visible in 2013 and 2014. Airport ownership changed in 2006 and 2009, the latest owners appearing to be more successful in shifting passengers to public transfer up to 2013.

London Luton airport changed ownership in 2001, 2005 and 2013. It had the lowest proportion of passenger public transport use of all London airports in both 2000 and 2014, peaking in 2008 with the introduction of more frequent bus shuttle connections to Luton Airport Parkway railway station which originally opened in late 1999. The bus was provided by the train operating company First Group and ran every ten minutes to and from the airport from 05:00 to 00:00 (London Luton Airport, 2014). No trend growth is apparent beyond 2008 with oscillations around 32% up to a clear reduction in public transport use in 2014 and little evidence of ownership change impacting public transport use.

London Southend's own survey shows public transport use in 2012 at 29% following the opening of a new dedicated airport railway station in 2011 developed by the new airport ownership of 2008.

Following ownership change 2006, Heathrow airport saw growth in passenger public transport use to 2011 but little change since. The airport has not shown the marked recent shift away from public transport visible at Stansted, Gatwick and London Luton in 2014.

It is possibly useful to examine Figure 3 from the perspective of the characteristics of multi-airport systems discussed in section 3. The two primary airports in the system are Heathrow and Gatwick. It can be seen that the proportion of passengers using public transport at these two airports has consistently been close to the mean proportion for all airports in the system. Those airports designated as secondary airports in the system (Stansted, London City, London Luton and London Southend) show a much greater deviation from this mean - both higher and lower - with a more volatile trend.

Table 2 shows how absolute passenger numbers using public transport have increased between 2003 and 2014. This is overlooked in the literature and the industry and can yield surprising results. The airports have experienced volatile traffic growth over the period. Some have also seen marked changes in the proportion of transfer passengers who by definition do not use surface access as they both arrive and depart by aircraft. A good example is Stansted, where the transfer passenger proportion dropped by 8.7% between 2003 and 2014. This is because of the growing dominance of low cost carriers at the airport, with similar reductions at Gatwick and London Luton of 7.5% and 4.6% respectively.

By contrast, the transfer passenger rate remained steady at Heathrow and London City. The greatest increase in absolute passenger numbers using public transport was at Gatwick with 6.3 million more doing so in 2014 than in 2003 despite the airport not having the highest proportional shift. London City had the smallest absolute increase in passenger numbers using public transport even though it saw the greatest proportional modal shift; a result of its relatively small size.

Table 2: Change in passenger public transport use 2003 to 2014 at London airports[3]

	Net passenger shift to transport 2003-2014 (%)	Increase in annual passengers using transport 2014 vs 2003 (M)
STANSTED	10.6	3.1
LONDON CITY	14.5	1.2
GATWICK	9.1	6.3
HEATHROW	5.5	5.0
LONDON LUTON	4.5	1.4

Source: Adapted from United Kingdom Civil Aviation Authority (2014)

Airport access statistics were also analysed and adapted to assess if any particular passenger market segment was driving the shift towards increased public transport use. Nationality and trip purpose were considered as these are determined during government surveys at the airports. The four market segments were UK passengers on business trips, foreign (i.e. non-UK) passengers on business trips, UK passengers on leisure trips and foreign passengers on leisure trips. Table 3 shows for 2003 and 2014, the proportion of non-transfer passengers in each group and the proportion of passengers choosing to use public transport taken by each group. This is reported for each airport.

Thus the change in proportion of passengers in each market segment can be ascertained (e.g. the proportion of Gatwick non-transfer passengers who were UK nationals on a business trip fell from 11.2% in 2003 to 9.7% in 2014). Table 3 also shows the proportion of public transport users in each market group (e.g. 12.2% of public transport users were UK nationals on a business trip at Gatwick compared to 9.7% in 2014).

A significant contributor to the growth in public transport use at Gatwick and Heathrow has been the proportional increase in foreign leisure passengers at these airports and also this group's increased propensity to use public transport to travel to and from them.

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[3] Excludes London Southend airport as no data available

Table 3: Airport market segmentation and public transport use 2003 vs 2014

Airport	Nationality and trip purpose	2003		2014		Change from 2003 to 2014	
		Proportion of non-transfer passengers (%)	Proportion of public transport users (%)	Proportion of non-transfer passengers (%)	Proportion of public transport users (%)	Proportion of non-transfer passengers (%)	Proportion of public transport users (%)
Gatwick	UK Business	11.2	12.2	8.2	9.7	-3.0	-2.5
	UK Leisure	70.3	54.2	65.3	45.7	-5.0	-8.5
	Foreign Business	5.4	9.6	5.7	10.3	0.3	0.7
	Foreign Leisure	13.1	24.0	20.7	34.3	7.6	10.3
Heathrow	UK Business	22.8	16.3	16.9	12.5	-5.9	-3.8
	UK Leisure	34.3	34.8	37.7	30.5	3.4	-4.3
	Foreign Business	17.5	17.7	14.4	16.2	-3.1	-1.5
	Foreign Leisure	25.4	31.1	30.9	38.5	5.5	7.4
London City	UK Business	37.5	29.6	26.2	26.7	-11.3	-2.9
	UK Leisure	26.3	28.6	29.1	31.7	2.8	3.1
	Foreign Business	22.1	19.5	26.0	20.5	3.9	1.0
	Foreign Leisure	14.1	22.3	18.7	21.1	4.6	-1.2
London Luton	UK Business	18.5	13.5	11.5	7.7	-7.0	-5.8
	UK Leisure	61.6	49.2	65.5	55.3	3.9	6.1
	Foreign Business	5.9	7.8	4.9	6.9	-1.0	-0.9
	Foreign Leisure	14.0	29.6	18.1	30.1	4.1	0.5
Stansted	UK Business	12.2	8.8	8.7	5.8	-3.5	-3.0
	UK Leisure	56.1	44.3	51.4	41.9	-4.7	-2.4
	Foreign Business	4.5	5.7	6.2	8.1	1.7	2.4
	Foreign Leisure	26.5	41.2	33.7	44.3	7.2	3.1

Source: Adapted from United Kingdom Civil Aviation Authority (2014)

An increased proportion of UK leisure passengers using public transport is notable at London City and London Luton. At Stansted, the growth has come mainly from foreign passengers, both business and leisure passengers. This information could help the airports understand where to focus their surface access product developments and marketing to encourage public transport use in targeted groups.

Trends in employee public transport use are shown in Figure 4. All airports use their own methodologies for ascertaining this data thus comparison between airports is less robust than for passengers. Surveys generally take place sporadically thus trend analysis is harder. Only, Heathrow and London Luton report consistent growth in the proportion of employees using public transport.

Figure 4: Employee public transport use at London airports 1997 to 2013 with current approximate airport employee numbers.

Legend:
- LONDON CITY (2,000)
- HEATHROW (76,000))
- GATWICK (21,000)
- LONDON LUTON (8,000)
- LONDON SOUTHEND (1,000)
- STANSTED (10,000)

Y-axis: Public Transport Proportion (%)
X-axis: 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
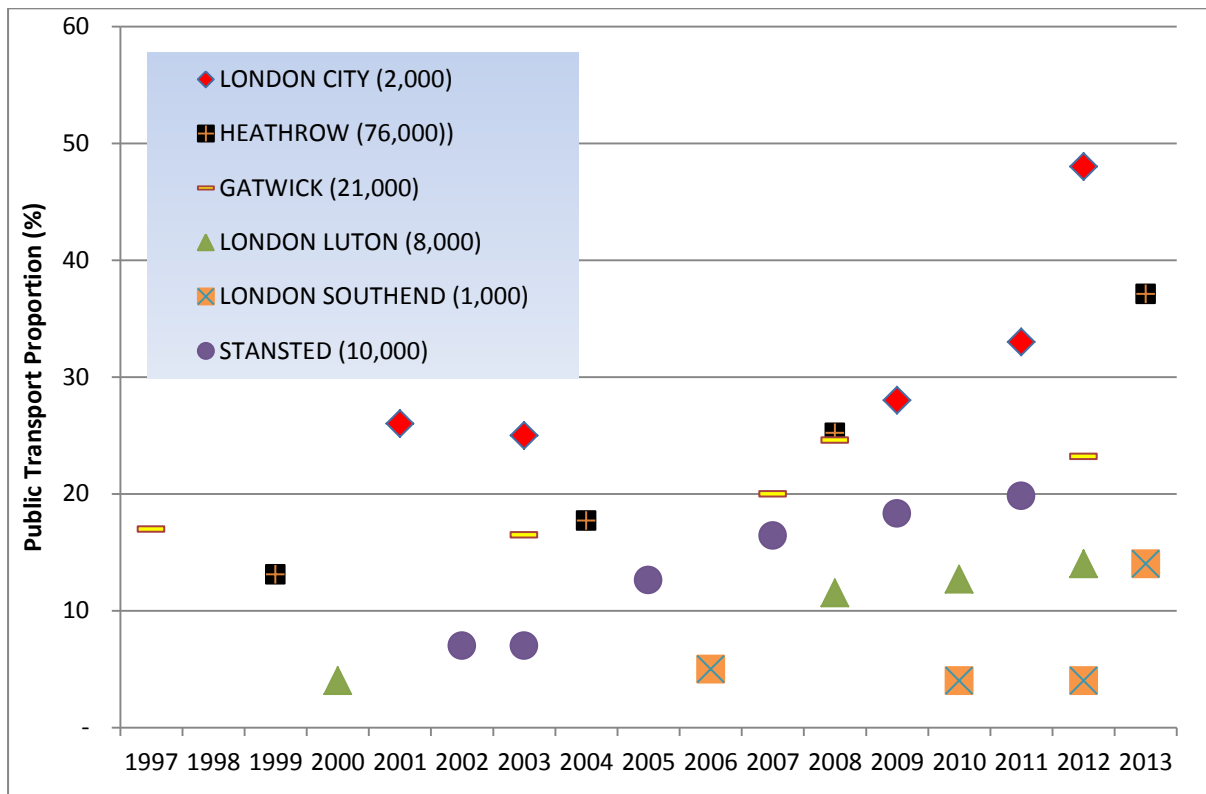
Source: Airports (2014)

Conclusions regarding further characteristics of the multi-airport system are harder to draw for employees than passengers when considering airport surface access. Again, the secondary airports show much greater deviation and volatility in the annual proportion of employees using public transport than at Heathrow and Gatwick (the primary airports). As the airports do not conduct surveys every year no mean is calculated for the system.

Heathrow, Gatwick and Stansted airports all offer staff subsidies to reduce the cost of commuting by train, bus and coach. In addition, Heathrow fund free local bus travel (available to all bus users, not just airport workers) to discourage short car journeys around the airport perimeter. London Southend's employees have access to discounts on some local buses but awareness and take up remains low. London City does not subsidise employee use of public transport. London City claims the highest proportion of staff using public transport at 48% in 2012 but it should be noted that passenger use was overestimated compared to government data. Heathrow and London Luton show linear growth. London Southend and London Luton have the lowest proportion of employees using public transport at 14% each. Employee numbers suggest that the smaller airports like

London City and London Southend show the greatest range in employee public transport use with the larger airports grouped within this range.

7. CURRENT AND PREVIOUS TARGETS FOR PUBLIC TRANSPORT USE.

All of the airports shared their current airport strategic access strategy targets for passengers and employees before, during or after interview. These are compared with those in place in 2003 as described by Humphreys and Ison. Table 4 shows passenger targets in 2003 and 2014.

Table 4: London airports passenger surface access targets 2003 and 2014

	2003	2014
LONDON CITY	Encourage more local bus services to divert into LCA	70% public transport by 2023
GATWICK	40% public transport by 2008	40% public transport by 40 mppa*
HEATHROW	40% public transport by end of 2007	> 40% public transport by 2019
LONDON LUTON	30% public transport (no target year)	40% public transport by 2017
STANSTED	25% public transport by 2005	43% public transport by 35 mppa*
LONDON SOUTHEND	No specific target	> or = 20% public transport by 1.5 mppa* and 25% by 2mppa*

Source: Humpheys and Ison (2003), Airports (2014)

*mppa= millions of passengers per annum

All London airports now have specific and measurable targets in place for passenger public transport use. Humphreys et al. (2005) critically assessed the nature and practicality of the surface access targets then in place in the United Kingdom. London City has moved from a vague statement in 2003 to a target that may appear unattainable in comparison with their competitors. However, this airport classifies the black London taxi as public transport and by their own measure exceeded the target stated for 2023 by 2.3% in 2013.

With hindsight, it is clear that Gatwick airport did not meet the stated target of 2003. The airport has also moved from a time bound target to traffic volume related one, which may or may not be more achievable depending on the accuracy of the airport's own forecasts. Heathrow's 2003 target was also not met and remains time bound and little changed in 2014. London Luton has introduced a time bound target whilst Stansted has also moved to a traffic volume related goal. London Southend gives two targets depending on the strength of continuation of recent rapid growth since becoming a base for the low cost carrier easyJet.

The targets for employees are shown in Table 5 and demonstrate that all London airports have also moved to specific and measurable goals for employees between 2003 and 2014.

Table 5: London airports employee surface access targets 2003 and 2014

	2003	2014
LONDON CITY	Encourage more local bus services to divert into LCA	40% single occupancy private vehicle by 2023
GATWICK	12% of staff living in Crawley/Horley** use local bus. Double staff cyling by 2008	40% public transport by 40 mppa*
HEATHROW	2.6% staff cycling by 2003. 2000 car sharers with 65% actively sharing by 2003	<45% single occupancy private vehicle by 2019
LONDON LUTON	6% public transport (no target year)	< or = 60% single occupancy private vehicle by 2017
STANSTED	88% arrive as car drivers by 2003. 25% arrive as car passengers by 2004. Double cycling by end of 2003	< or = 70% single occupancy private vehicle by 35 mppa*
LONDON SOUTHEND	No specific target	Sustain < or = 65% staff single occupancy vehicle

Source: Humpheys and Ison (2003), Airports (2014)

*mppa= millions of passengers per annum **Crawley/Horley are towns adjacent to Gatwick

Gatwick is now unique in London in both setting a public transport use target for employees linked to traffic volume and also having identical targets for all airport users. Only 24% of staff at Gatwick used public transport for work access in 2012 (Gatwick Airport, 2014) so 40% seems an unrealistic target with traffic in 2014 at 38.1 million passengers. All of the other airports focus on the reduction of the use of single occupancy private vehicles by employees getting to and from their work and quote more realistic targets. London City's target is close to being already achieved as 41% of staff drove to work in 2013 and it would be surprising if none of them car shared (London City Airport, 2013). Heathrow had 51% single car occupancy by staff in 2013 (Heathrow Airport (a), 2014) and a very successful car share scheme. For London Luton it was 66% in 2012 (London Luton Airport, 2012) and 69% at Stansted in 2013 (Stansted Airport (b), 2014). London Southend met its quoted target in 2013 with 61% of staff using single occupancy vehicles (London Southend Airport, 2013).

8. EMERGING SURFACE ACCESS ISSUES AT LONDON AIRPORTS

Eight semi-structured interviews with each of the London airports explored current issues in surface access and several key themes emerged (Gatwick Airport, London City Airport (b), Heathrow Airport (b), London Luton Airport, Stansted Airport (a), London Southend Airport (2014)). Two interviews took place at both London Southend and London Luton. Interview questions can be found in Appendix A.

Walking and cycling are increasingly acknowledged by London airports as a desirable access mode for airport employees on environmental and staff wellbeing grounds. Current walking and cycle use amongst airport staff is shown in Figure 5. Smaller airports like London Southend, London City and London Luton are located very close to residential areas. This allows easy access by employees who are not then reliant on public transport and can access their workplace by walking or cycling without requiring access to a private vehicle. London City noted the value of local staff able to walk or cycle to work as a key contributor to operational resilience. They are less vulnerable to delay during bad weather or because of security alerts that impact other modes of transport. London Luton offer free maintenance and bicycle lights as well as discounted bicycle purchase for staff. Parking racks and showers for cyclists have been expanded. London City plan to further encourage local staff to walk and cycle to work with an imminent £100,000 investment to improve routes. Heathrow operate a 'cycle hub' providing cycle sales, repairs, secure storage and free buses to central terminals. More remote airports like Stansted are less attractive to walkers and cyclists because of longer travel times. The airport is aware that interfaces between airport and local authority roads can be unattractive to potential users from a road safety and personal security perspective.

Figure 5: Current staff walking and cycling to work proportions at London airports
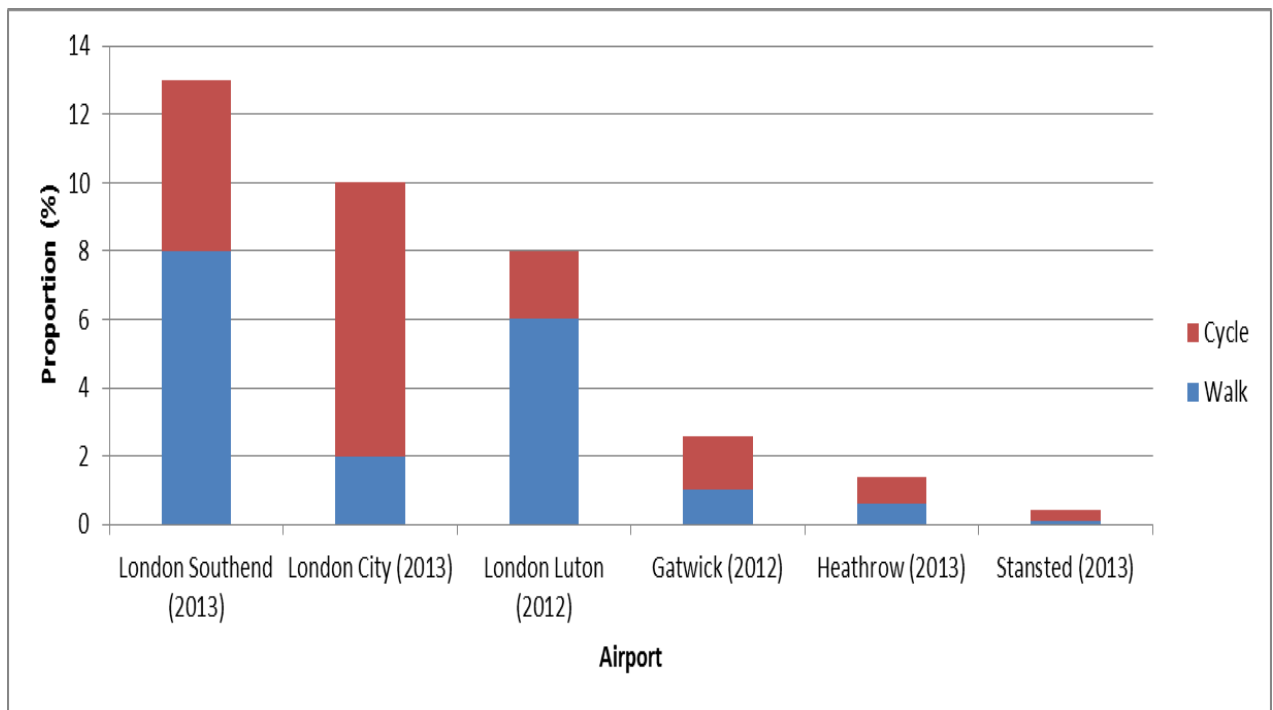
Source: Airports (2014)

Those airports with connections to main network railway lines serving multiple destinations paid particular attention to effective communication between train station and airport operational staff so as not to discourage train use. The availability of rail ticket purchasing opportunities and train information were maximised in the terminals. For example at Stansted, train tickets are for sale on board arriving aircraft during the journey, in airside arrivals routes from the aircraft as well as the baggage reclaim hall, landside arrivals and the train station. The objective is to raise train usage. Train information is also available in the landside arrivals hall and will soon be visible in the baggage reclaim halls and on the airport travel information smart phone application.

Concern was also raised about the generally inadequate provision of early and late trains. This precluded train use for employees who needed to be at work before and after flight operations as well as passengers unable to use public transport to connect with early flight departures and late flight arrivals. This has resulted in Gatwick, Stansted, London Southend and London Luton working with the train operating companies and the Department for Transport to try and enable the provision of services more suitable for use early and late in the day by both employees and passengers.

A similar challenge is faced by London City and Heathrow with Transport for London services. Some specific examples were described. Whilst flight departures begin at Heathrow at 06:00, the first underground train does not leave central London until 05:12 (minimum 50 minute journey time) and the first Heathrow express train until 05:07 (15 minute journey time). At Stansted, the last flight arrival is at 23:50 and express train services to London cease at 00:30.

Ticket barriers required by some train operating companies at airport railway stations are unpopular with passengers (and airport surface access managers). There is a view that they may discourage train use for bigger groups and those with special needs or large amounts of luggage.

All of the London airports except London Gatwick have a headline target related to reducing the proportion of staff using single occupancy vehicles to get to work. Car sharing is actively promoted at Heathrow, the scheme being the largest in the world with 8000 members of which 2000 actively car share. A car share scheme is also promoted at Gatwick, Stansted and London Luton but surprisingly (given the nature of their targets) not at London City or London Southend. It was confirmed that informal employee car sharing takes place at these two airports.

Passenger drop-off and pick-up charges were introduced for private vehicles at the terminals of London Luton in 2009 and Stansted in 2012. The intent is to reduce private vehicle usage, reduce airport emissions and to increase revenue. Such charges have not been well received by passengers or airlines and remain a contentious issue with severe penalties for over-staying the standard drop-off or pick-up period. There is no evidence that the introduction of these charges has resulted in an increase in public transport use at these airports. No other London airport discussed plans to operate such a scheme although Heathrow later publicised the possibility of this.

9. CONCLUSION

United Kingdom government policy has repeatedly (albeit with some notable periods of silence) raised the issue of airport surface access strategy since the publication of the policy document 'A new deal for transport: better for everyone' in 1998. Guidance to airports now covers a much more detailed range of issues to cover and these were definitively stated in 'The aviation policy framework' of 2012. In parallel with this direction, the London airports have faced unprecedented changes in ownership, a continuing very public debate about London airport capacity and a volatile economic environment.

London airports have taken the guidance on board and all produce and regularly update their airport surface access strategies. All have been successful in decreasing the proportion of passengers and employees using private vehicles to access them although there have been varying

degrees of success in evidence. Some of the early access targets were not met and this has perhaps resulted in a more pragmatic approach. A move is evident towards setting future passenger surface access targets that are related to a particular annual passenger volume at the airport, rather than a specific year. In the case of employees, the focus at London airports is now on targeting single occupancy private vehicles. This reflects the continuing lack of early and late bus, coach and train services at all London airports.

Future surface access issues highlighted for consideration in the London airports during this research are:

-Further reflection on methods of charging private vehicles to drop off and pick-up passengers.

-Investigation of methods to quantify and discourage the proportion of empty taxi journeys between London and the airports and vice versa. The nature of the concession arrangements at all London airports results in any taxi being allowed to drop passengers off at the airport but only a limited number of taxis being permitted to pick-up passengers (and being charged for this access).

-More ambitious targets for staff and passenger airport access as conditions of planning approval for airport expansion.

-Further recognition of the environmental (as well as the commercial) advantages of passenger parking as a substitute for passenger drop off and pick-up.

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APPENDIX A : Semi-structured interview starter questions

Private vehicles

How does private vehicle passenger pick-up / drop-off work at your airport?

What plans do you have to charge for private pick-up / drop-off?

What plans do you have to change the current arrangement for charging private vehicles?

What arrangements are in place for employee car sharing?

What incentives to you have to encourage employees to use public transport?

Rail

Is the airport station manned/monitored by airport or train company staff?

When do train tickets/information become available for arriving air passengers on their journey to the station from the aircraft?

What changes would you like to see in train operating times and why?

What concerns do you have about revenue protection barriers at the railway station?

Taxis

What is the nature of the airport concession with taxi operators?

How are taxi numbers managed at the airport?

How concerned are you about taxis operating empty in one direction between the airport and the city or vice versa?

Data

What additional historical data can you share regarding your airport's passenger and employee surface access behaviour?

How do you plan to develop the provision of airport surface access information to passengers?

Bus and Coach

What operational impact do bus/coach services have at the airport?

What future plans do you have regarding these services?

Cycling and Walking

How important is employee cycling and walking to/from work at the airport and why?

General

What emerging issues would you like to highlight?

What explanations do you have regarding surface airport trends at your airport?

AN ASSESSMENT OF DISINCENTIVE POLICY ON SLOT ALLOCATION SYSTEM IN INDONESIAN AIRPORTS

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ABSTRACT

Indonesian airports have been experiencing significant air traffic growth and are unable to cope with the increasing air passenger demand. There is an urgent need for an effective slot allocation strategy to manage the demand for airport capacity. This paper conducts a case study to examine the possibility of managing slot time allocation to maximize runways capacity by analyzing disincentive strategy in balancing the usage of runways with Capacity Restraint and Demand Balanced approach. The research found that airlines willing to use slot time at the most demanded time interval should pay an additional 6.57% (CR approach) from total revenue gained by the government from slot sector and 6.55% (DB approach). The additional cost for less demanded slot time interval is only 0.09% (in both CR and DB approaches). Findings from this study should be considered as an initial step toward educating policy makers and airport authorities with the aims to creating better mechanism in Indonesia's airspace market.

Keywords: *airport capacity, slot time allocation, slot pricing, disincentive strategy, slot auction.*

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1. THE NEEDS FOR EXPANDING THE INDONESIA'S AIRPORT CAPACITIES

In the last 5 years, the number of domestic and international flights in Indonesia is increasing up to 36.94% and 29,19%, respectively, while the increase of passenger's number is 70.72% in domestic and 39.06% in international flight (The Directorate General of Air Transportation). The reliability in travel time, constant travel frequency, the emergence of low cost air carriers in line with competitive in ticket price combined with highly dynamic economic activities in Indonesia led to the significant growth of domestic and international flight as well as the number of passengers as shown in Table 1 and Table 2.

Table 1: Indonesia's Yearly Domestic Flights and Passengers Number

YEAR	NUMBER OF FLIGHTS	NUMBER OF PASSENGERS
2009	812,231	70,934,675
2010	950,153	90,596,305
2011	1,064,373	117,827,572
2012	1,008,111	124,590,275
2013	1,112,237	121,103,078

Table 2: Indonesia's Yearly International Flights and Passengers Number

YEAR	NUMBER OF FLIGHTS	NUMBER OF PASSENGERS
2009	105,785	13,350,430
2010	142,057	18,719,784
2011	143,383	20,589,765
2012	167,038	23,461,775
2013	136,668	18,565,598

Aware with the statistical data that stated promising number of air transportation's passengers in the future, the Ministry of Transportation (MoT) in their 2010-2014 strategic plan formulates a strategy to expand air transportation capacity. The strategy was manifested by forming IASM (Indonesian Airport Slot Management) to improve flight's safety and security, optimizing airport capacity and facilities, slot time standardization refers to IATA's regulation and cost efficiency, extending runway's length and width to meet the landing and take-off needs of larger aircraft types,

operating additional terminals and airports in dealing with increasing demand in air transportation and improving airport capacity and also maximizing operational hours for busy airports.

Some efforts of MoT in realizing the principal strategies listed above reflected in the following points:

a)   Juanda Airport in East Java operates the second terminal with the aim of capacity and performance improvement;

b)   Mutiara SIS AlJufri Airport in Palu with approximately 138% increase in passenger's movement from 2009 until 2013 operates a renovated terminal;

c)   Additional slot time in several airports. Sultan Mahmud Badaruddin II airport in Palembang, Sultan Syarif Kasim II airport in Pekanbaru, Supadio airport in Pontianak, and Minangkabau airport in Padang extends the operating hours until 24.00;

d)   Additional 270 m length for Iskandar Airport's runway in Pangkalan Bun;

e)   Halim Perdanakusuma airport was re-activated to serve regular flights in order to help reducing high number of aircraft movements in Sukarno Hatta Airport;

f)   Revitalization in both air side and land side in Sukarno Hatta Airport.

Sukarno-Hatta International Airport (SHIA) or known as Cengkareng (CGK) by the locals is Indonesia's main gateway into the world. SHIA has two effective runways to serve passenger flights, runway 07R/25L and 07L/25R that operated 24 hours a day (runway utilization shown in **Figure 1**). In June 2013 (latest data from ministry of transportation), 17,294 aircrafts which carrying 2,764,786 passengers were arrived and 17,036 aircrafts (carrying 2,462,722 passengers) departed from SHIA.

With a significant growth in aircraft and passenger movement, soon the existing runways in SHIA will be overloaded during peak hour therefore there is necessity to optimize the current slot is become an urgent decision.

The paper will address first step to one main option to maximize the use of current slot, which is an auction. Auction is discussed as an effective and fair solution to allocate and re-allocate slots and hence generating optimum capacity as efficient as slot trading regime. (Brueckner[1] and econ report[2]). For the preliminary study to define the mechanism of the auction, the bidding price is considered as a serious issue and need to be determined carefully. By learning on the actual movements, the paper will trying to specify not only the equitable range for bidding price, but also the prospect of which slot decided to be auctioned by distributing demand for the air transportation.

Fig. 1 Soekarno Hatta International Airport Ultilization
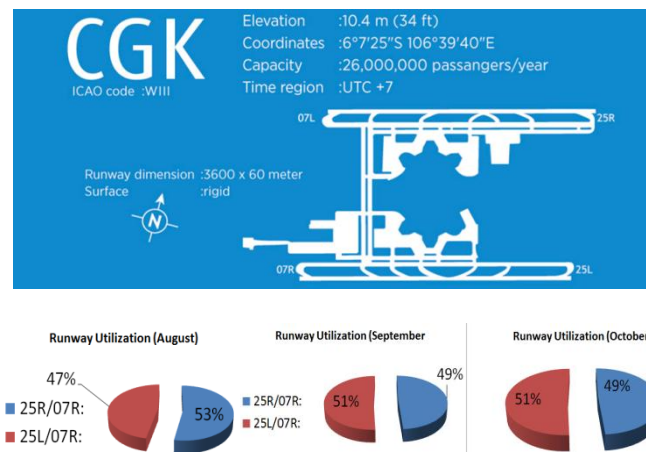
Source: http://soekarnohatta-airport.co.id (modified)

2. CURRENT SLOT TIME ALLOCATION PROCEDURE IN INDONESIA

The grandfather rights, the rights where the airline posesses the right for slot time they previously held oin the previous year season, slot has been for long time became one of internationally agreed major clauses in the airport slot allocation system. The Indonesian air transportation regulation which adopt the international standard in turn also adopt such system for Indonesian slot allocation system.

The application of grandfather rights itself may help to ease and simplify the slot allocation system in many airports globally. But the system itself is not a perfect solution. In congested airport the application of such system cause some questions. As is highlighted by Starkie et al[3] the application "property rights" over slot time "*Can put the airline as the slot holder a substantial competitive advantage over their rivals*". Another issue over the grandfather rights is the inneficiency over the slot usage. Castelli[4] argue in their paper that the excercising of grandfather right "*can inducing airlines to use slots ineffciently for not loosing them.*" Further Castelli also argue that further application of the system will cause barrier for the market, causing market immobility and prevent a fair competition among the airlines which further cause the slot time as a scarce resouce become innefficiently used .

The Indonesian Airport Slot Allocation system is highly regulated by the government with the private sector only served as the airline operators. The slot allocation in Indonesia is regulated by Directorate General of Air Transportation, Indonesian Ministry of Transportation. The Indonesia Airport Slot Management or IASM is the body under Directorate General of Air Transportation which

directly control slot allocation system for domestic flight in Indonesia. For the International flight, the task is still hold by the national flag Carrier, Garuda Indonesia.

The latest regulation concerning the slot allocation system is issued by the Director General of Air Transportation in the form of KP Num. 280 year 2015 [5]which in it covers major update in slot time allocation regulation based on international standard and the previously issued KP Num. 401,402 and 569 Year 2011 concerning about the regulation on slot coordinator.

As with international system, the Indonesian slot allocation system is based on 6 monthly slot allocation system or the "season" system. The grandfather rights in Indonesia applies to all slot time already allocated in the previous years season. The airline which held the rights for the respective slot must be able to must operates within the allocated slot time for at least 80% throughout the season periods (80-20 rule). If by case the airline failed to meet the 80% standard or by their own decission they wish to release their rights on the allocated slot then their rights for the allocated slot can be revoked (use it or lose it), the detail of slot management on Figure 2. The unallocated or released slot will be available for new applicant based on first come first served system.

In Indonesia itself there are eight airports declared as slot coordinated airport and thus the slot regulation is to be under the IASM. These airports are:

1.   Kuala Namu International Airport, North Sumatera
2.   Sultan Mahmud Badaruddin II, South Sumatera
3.   Soekarno-Hatta International Airport, Jakarta
4.   Sepinggan International Airport, East Kalimantan
5.   Juanda International Airport, East Java
6.   I Gusti Ngurah Rai International Airport, Bali.
7.   Sultan Hasanuddin International Airport, South Sulawesi
8.   Sentani International Airport, Papua.

Fig. 2 Slot Time Management in Indonesia (Based on KP 280 Year 2015)

Slot Clearance Application
- Submitted by email to scr@iasmslot.com
- submitted no later than 30 days prior to the operational planning
- used for one flight number on the same day

Airlines ⟶ IASM

Slot Clearance Approval
- based on NAC (Notice of Airport Capacity), domestic flight route on March, 29th to March 28th the next year, slot period (summer and winter seasons) for international flights, Aeronautical Information Circular (AICs) and avoid similar callsign
- valid until March, 28th the next year
- preferred to scheduled flights, better on time performance, first come first serve rule
- If 80% of the slots are not used (off slot) within 180 days, the airlines will lose the priority for the next period

IASM

Slot Approval Reporting

IASM ⟶ Airport slot time organizer

Regular Slot Monitoring
- at least once in a month
- regarding to airport data administration, ATS flight data, airlines website and handling agents

UPKS ⟶ Airport slot time organizer

Performance Monitoring
- at the end of each period
- used for historical data record
- if there are 20% off slot, the airline considered not eligible to get historical data and hence get low priority

UPKS (Implementation Unit of Slot Coordination)

Performance report published on IASM website

Airlines use the approved slots appropriately

License remains valid

Improper use of Slots
- Delay tolerance time for less than 3 hours flight is 15 minutes before and after scheduled slots
- Delay tolerance time for more than 3 hours flight is 15 minutes before and 30 minutes after scheduled slots
- The discrepancy between schedule and operational may not exceed than 30 days (with earlier notice) or 21 days without early notice
- the airlines should use minimum 80% of slot approved within 90 days

Revoked license

3. THOUGHT TO OPTIMIZE THE USE OF SLOT TIME ALLOCATION

With the current procedure, infrastructure and their high demand, SHIA, as with many other airport faces critical air traffic and slot allocation problems, still require the additional slot or else, maximizing the capacity by managing the existing slot better. The pricing strategies seems promising and fair, those airlines who wants to use peak hours should pay much more than other who willing to use off-peak hours and generates well distributed demand. The concept of price itself is as explained by Weber[6] is the concept of trades of goods and services between two economics agents. The prices of the products itself may be determined either by their real value or nominal value. In relation to this conditions the slot itself became an important product as they are very important for airline operation but their availability is restricted by the capacity of the airport and airport networks itself.

Polsby[7] explains that there are multiple potential benefits resulted from the slot time pricing . Some of those are the incentive for airline to spread their schedule, less congested airport during the usual peak hour, and the ability of fund gathering to improve the physical capacity of the airport itself. The pricing mechanisim itself can be in the form of peak hour charge during operation or slot auction during the slot allocation process. The implementation of the scheme sholud be carried out in careful manners as there are multiple potential conflicts that may arise from the peak hour charging.

4. LESSONS LEARNED FROM INDONESIAN TELECOMMUNICATION SECTOR

In Indonesia, the demand for telecommunication sector is high and hence resulting enormous potential in secondary market for its radio frequency spectrum [8]. One of the famous telecommunication frequencies is 2.1 GHz frequency (known well as 3G frequencies) and the government decided to conduct auction as an effort in structuring the use of 2.1 GHz frequency. The decree was issued as a guideline in radio frequency spectrum auction and provide general rule of the auction, detail frequency auctioned, permit fee, auction procedure and decision-making[9]. In relation with tariff issues, the decree state that the permit fee value determined greater than reserve price for the auction while the permit fee itself consist of two components, upfront fee and BHP (concession fee). By understanding the steps to calculate the BHP, the government will be able to set the reserve price as well and get the least or minimum revenue from each block of 2.1 GHz frequency.

According to the decree of Minister of Communication and Information Technology Num. 7 year 2009[10] amended to Num. 76 year 2010[11] about non-tax revenue in communication and information technology department and Num. 24 year 2010[12] which is a refinement of previous decree Num. 19 year 2005[13] about tariff guidelines on non-tax revenue, in every utilization of radio frequency spectrum required to pay BHP, as the embodiment of economic value of radio frequency, in advance every year, sixty days after payment notification letter (SPP) issued, otherwise the application will be revoked.

Tariff/BHP calculated per frequency used, per station, per location per year and based on formula given below:

$$\text{BHP idr} = \frac{\text{Ib x HDLP x b)+(Ip x HDDP x p}}{2}$$

Ib=bandwidth occupied fare index

HDLP=bandwidth base fare

b=Bandwidth kHz

Ip= frequency emittance fare index

HDDP=emittance base fare

P=emittance (EIRP)[dBm]

Zoning for frequency listed on decree of Minister of Communication and Information Technology Num. 19 year 2005, while the value of HDLP and HDDP were determined on decree of Minister of Communication and Information Technology Num. 76 year 2010. The brief comparison between HDLP and HDDP base price listed on Table 3 and vary depending on the location determined by the government.

Table 3 HDLP and HDDP Base Price based on Location

PROVINCE	ZONE	SEGMENTATION	HDLP (RP/KHZ)	HDDP (RP/KHZ)
DKI Jakarta	1	VLF: 9 − 30 KHz	20.961	191.629
		LF: 30 − 300 KHz	15.725	142.844
		MF: 300 − 3000 KHz	15.249	140.403
		HF: 3 − 30 MHz	14.581	135.353
		VHF: 30 − 300 MHz	12.888	119.665
		UHF: 300 − 3000 MHz	11.772	109.481
		SHF: 3 − 30 GHz	9.681	89.364
		EHF: 30 − 275 GHz	6.101	54.188
Balikpapan	2	VLF: 9 − 30 KHz	16.769	153.303
		LF: 30 − 300 KHz	12.572	114.275
		MF: 300 − 3000 KHz	12.199	112.322
		HF: 3 − 30 MHz	11.665	108.282
		VHF: 30 − 300 MHz	10.310	95.732
		UHF: 300 − 3000 MHz	9.418	87.585
		SHF: 3 − 30 GHz	7.745	71.491
		EHF: 30 − 275 GHz	4.881	43.350
Padang	3	VLF: 9 − 30 KHz	12.576	114.977
		LF: 30 − 300 KHz	9.429	85.707
		MF: 300 − 3000 KHz	9.149	84.242
		HF: 3 − 30 MHz	8.749	81.212
		VHF: 30 − 300 MHz	7.733	71.799
		UHF: 300 − 3000 MHz	7.063	65.688
		SHF: 3 − 30 GHz	5.809	53.618
		EHF: 30 − 275 GHz	3.661	32.513
Bengkulu	4	VLF: 9 − 30 KHz	8.384	76.652
		LF: 30 − 300 KHz	6.286	57.138
		MF: 300 − 3000 KHz	6.099	56.161
		HF: 3 − 30 MHz	5.832	54.141
		VHF: 30 − 300 MHz	5.155	47.866
		UHF: 300 − 3000 MHz	4.709	43.792
		SHF: 3 − 30 GHz	3.873	35.745
		EHF: 30 − 275 GHz	2.440	21.675
Gorontalo	5	VLF: 9 − 30 KHz	4.192	38.326
		LF: 30 − 300 KHz	3.143	28.569
		MF: 300 − 3000 KHz	3.050	28.081
		HF: 3 − 30 MHz	2.916	27.071
		VHF: 30 − 300 MHz	2.578	23.933
		UHF: 300 − 3000 MHz	2.354	21.896
		SHF: 3 − 30 GHz	1.936	17.873
		EHF: 30 − 275 GHz	1.220	10.838

To summarize, the value of reserve price in 2.1 GHz frequency's auction was based on the highest demand on it and determined by divided the market into zones with each price range.

5. SLOT CAPACITY OPTIMIZATION SCENARIO

The research is based on August-October 2010 flight movements data on Soekarno-Hatta International Airport. The purpose of this research for researching and testing the feasibility of slot auctioning in Soekarno-Hatta airport. The result of this research may not be used directly for the application of slot auctioning but can be used as the baseline for further research and development of slot auctioning system either in Soekarno-Hatta or other congested airport.

The data used in this research consist of 24 hours flight movement based on slot clearance and actual landing and take off activities in Soekarno-Hatta airport. The data that are used are flight clearance data with assumption that actual landing and take off time is the result inter-reaction with inconsistent external factors that are not significantly affect the implementation of slot time.

The data is first sorted into one month-daily data with each day consist of twenty-four hourly interval starting from 00.00-00.59 until 23.00-23.59. This resulted with each month (August, September and October) having their own data set. The pattern of the actual data is however rather inconsistent, with some intervals in one month period having a normal, bi-normal or skew distribution. For the development of the equation, it is assumed that the data is having a normal distribution.

Based on the assumption that the data having normal distribution then the pattern or average daily movement in Soekarno hatta Airport can be retrieved. Paired sample test then carried out to find the correlation among the monthly data. Paired samples t test on data results are as follow:

a)   The population correlation (ρ) is different from 0 p=0.00,and it is able to reveal a statistically reliable difference   between the mean number of August (M = 34.23, s = 21) and September (M = 41.66, s = 24.50) Landing and Take Off Movements, t(23) = 8.144, p = .00, a = .05.

b)   The population correlation (ρ) is different from 0 p=0.00 and it is able to reveal a statistically reliable difference   between the mean number of September (M = 41.66, s = 24.50) and October (M = 40.37, s = 23.22) Landing and Take Off Movements, t(23) = 3.231, p = .04, a = .05.

c)   The population correlation (ρ) is different from 0 p=0.00 and it is able to reveal a statistically reliable difference   between the mean number of August (M = 34.23, s = 21) and October (M = 40.37, s = 23.22) Landing and Take Off Movements, t(23) =9.044, p = .00, a = .05.

Based on this result, the 3 month data can be treated as a single data for the next analysis. The result of data analysis can be seen in Figure 3.

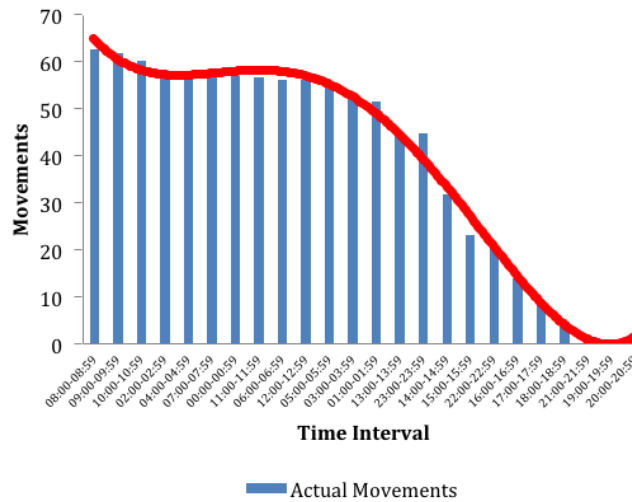**Fig. 3 Actual Average 3 Months Landing-Take Off Movements**

Figure 3 represents average hourly movements for slot time interval represented by the number of aircraft movements within one hour interval. The data shows that between August-October 2010 the highest demand happened in time intervals 08.00-08.59 followed by time interval 09.00-09.59 and 10.00-10.59. The lowest demand level occured in the 19.00-19.59 and 20.00-20.59 time interval.

The next phase af analysis is to determine the price of aircraft movement according to available data. For this research there are two approaches to be used. The first is based on the Capacity Restraint (CR) of the airport and the second is based on the Balanced Demand (BD) approach.

The next analysis conducted with the following conditions:

a)   Polynomial equation is the best fit for this data set, then it will be used for further analysis. The equation for demand curve in figure 2 is $f x = f(x) = 0,0024236x^4 - 0,1149683x^3 + 1,58436926x^2 - 8,2256893x + 71,616609$ with $R^2 = 0.9936$.

b)   represents price to pay with x represents slot time interval.

c) $x = 0$ represents the lower end of the first interval and x=24 represents the higher end of last interval represents total revenue from slot allocation (A).

d)   The integration of y=f(x) from x=0 to x=24 (total area) represents total revenue from 24 hours movement (set by the government which aims to be earned from slot allocation system).

5.1 Capacity Restraint (CR) Approach

The idea to improve runways capacity is to distribute the use of slots into less demanded slots by giving disincentive to airlines, which tends to favor high demand slot periods. Setting the baseline is needed to determine which time intervals should 'share' their movements. The actual design capacity for Soekarno Hatta airport is actually 82 aircraft movements per hour for two runway. In the application, due to safety and technical consideration, the capacity is still set at 52 in 2013 and increased into 64 in 2014. There is a target to further increase the capacity into 72 movements per hour. For this research, the airport capacity is set at 2012-2013 treshold, which is 52 aircraft movements per hour and plotted into existing chart (Figure 4). This is considering the fact that data being used is 2010 thus the most recent capacity should not be used.

Fig. 4 Capacity Restraint Approach

In this approach, it is assumed that :

- T0 : Begining of time interval-1, which is equal to zero.
- T1 : Intercept point between movements f(t) and design capacity. Derived by setting f(t) = 52 (designed capacity).
- T2 : End of interval-24 which is equal to 24.
- A1 : Revenue from aircraft movements above designed capacity
- A2 : Gap revenue of aircraft movements below designed capacity
- D : Designed Capacity

The price can then be calculated based on the following equation

a) $A1.P1 = A2.P2$

b)   Basic movement revenue = $(T0 - T1)D$

c)   Movement price above designed capacity = $A1/\Sigma M$ for $T0 - T1$

d)   Movement price below designed capacity = $A2/\Sigma M$ for $T1 - T2$

$$\int_0^{T1} M\text{-}D\ dT \cdot P1 = \int_{T1}^{T2} D\text{-}M\ dT\ P2 \dots\dots (1)$$

The calculation results for Capacity Restraint pricing are as followed:

- Designed Capacity (D)   : 52 movements
- T1   : interval 12.2
- Basic Movement revenue (T0-T1).D : 634.556 unit area
- A1   : 80.4 unit area
- A2   : 354.1 unit area
- P1   : 4.4 P2
- Movement price above designed capacity   : 0.114 unit area/movement
- Movement price below designed capacity   : 1.093 unit area/movement
- Basic Movement price   : 0.903 unit area/movement

5.2 Balanced Demand (BD) Approach

The balanced demand approach comes with aims to prioritize demand balancing. The analysis set up based on the idea that area above balanced demand curve is equal to an area below the balanced demand (and also bounded by demand curve on first quadrant). Wherever those two curves intersect, we called it as balancing point which we believe is the proper starting line to the next steps of analysis.

Fig. 5 Balance Demand Approach
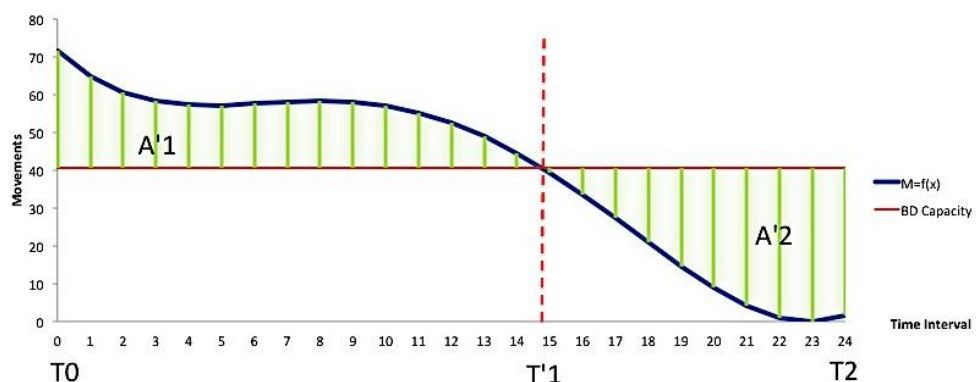
In this approach, it is assumed that :

- T0   : Beginning of time interval-1, which is equal to zero
- T'1   : Intercept point between movements f(t) and balanced demand capacity.
- T2   : End of interval-24 which is equal to 24
- A'1   : Revenue of aircraft movements above BD capacity
- A'2   : Gap revenue of aircraft movements below BD capacity

- D' : Balanced Demand Capacity

The price can then be calculated based on the following equation

a) A'1=A'2

b) Basic movement revenue= (T0-T1).D'

c) Movement price above balanced demand = A'1/ΣM for T0 – T1

d) Movement price below balanced demand =

A'2/ΣM for T1 – T2

$$\int_{0}^{T'1} M - D' \, dT = \int_{T1}^{T'2} D' - M \, dT \quad \dots\dots(2)$$

The calculation results for Balanced Demand pricing are as followed :

- Balanced Demand Capacity (D') : 40.6 movements
- T'1 : interval 14.78
- Basic Movement revenue (T0-T'1).D' : 600.056 unit area
- A'1=A'2 : 235.49 unit area
- P1 : P2
- Movement price above designed capacity : 0.286 unit area/movement
- Movement price below designed capacity : 1.195 unit area/movement

Basic Movement price : 0.728 unit area/movement

6. IMPROVING RUNWAYS CAPACITY: DISINCENTIVE PRICING STRATEGY

As one of the main problems in the Soekarno Hatta airport is the air traffic congestion due to the tendency of the airline to operate at "peak hour period", some form of regulation is needed to control this tendency. One of which is the disincentive system. To calculate the disincentive this research are using the runway capacity as the baseline.

Based on the previous analysis there are two baseline that will be used in this analysis, the Designed Capacity and Balanced Demand baseline. To calculate the price some assumtion is made regarding the time interval located in the intersection point between the demand and capacity graph which is at T1 = 12.2 and T'1 = 14.78. In this case it is assumed that the disincentive will be applied for both interval-13 (T=13) in the CR scenario and interval -15 (T = 15) in the BD scenario .

For the disincentive, the applied price will be the movement price above capacity and added in it the basic price. The calculation result can be presented in Table 4.

Table 4 Price Comparison between CR and BD Approach

INTERVAL NUMBER	ACTUAL MOVEMENT	FINAL PRICE (IN UNIT AREA)		PERCENTAGE COMPARED TO A	
		CR SCENARIO	BD SCENARIO	CR SCENARIO	BD SCENARIO
1	62,77	63,83	63,63	6,57%	6,55%
2	61,91	62,96	62,76	6,48%	6,46%
3	60,27	61,28	61,10	6,31%	6,29%
4	57,96	58,94	58,76	6,07%	6,05%
5	57,78	58,75	58,57	6,05%	6,03%
6	57,20	58,16	57,98	5,99%	5,97%
7	57,15	58,11	57,93	5,98%	5,97%
8	56,80	57,76	57,58	5,95%	5,93%
9	56,16	57,11	56,93	5,88%	5,86%
10	56,13	57,08	56,90	5,88%	5,86%
11	55,55	56,49	56,31	5,82%	5,80%
12	52,98	53,87	53,70	5,55%	5,53%
13	51,60	52,47	52,31	5,40%	5,39%
14	44,90	49,09	45,52	5,05%	4,69%
15	44,89	49,08	45,51	5,05%	4,69%
16	31,87	34,84	38,09	3,59%	3,92%
17	23,15	25,30	27,66	2,61%	2,85%
18	20,40	22,30	24,38	2,30%	2,51%
19	13,96	15,27	16,69	1,57%	1,72%
20	8,65	9,45	10,33	0,97%	1,06%
21	4,77	5,21	5,70	0,54%	0,59%

		FINAL PRICE (IN UNIT AREA)		PERCENTAGE COMPARED TO A	
INTERVAL NUMBER	ACTUAL MOVEMENT	CR SCENARIO	BD SCENARIO	CR SCENARIO	BD SCENARIO
22	1,70	1,85	2,03	0,19%	0,21%
23	1,01	1,11	1,21	0,11%	0,12%
24	0,77	0,84	0,92	0,09%	0,09%

The pricing analysis above is sorted based on number of interval (1st to 24th interval), changing number of interval into the actual time give the better understanding about the relation between time interval and pricing strategy (Figure 6 and Figure 7).

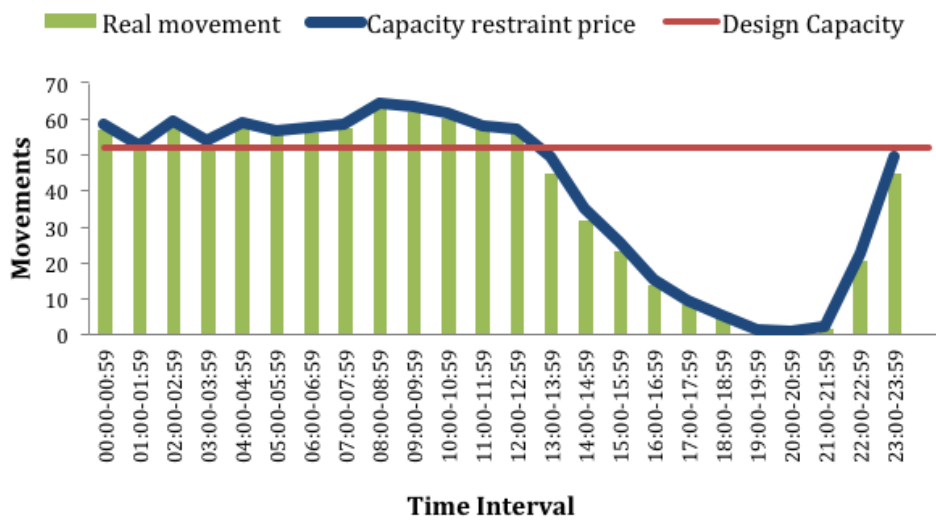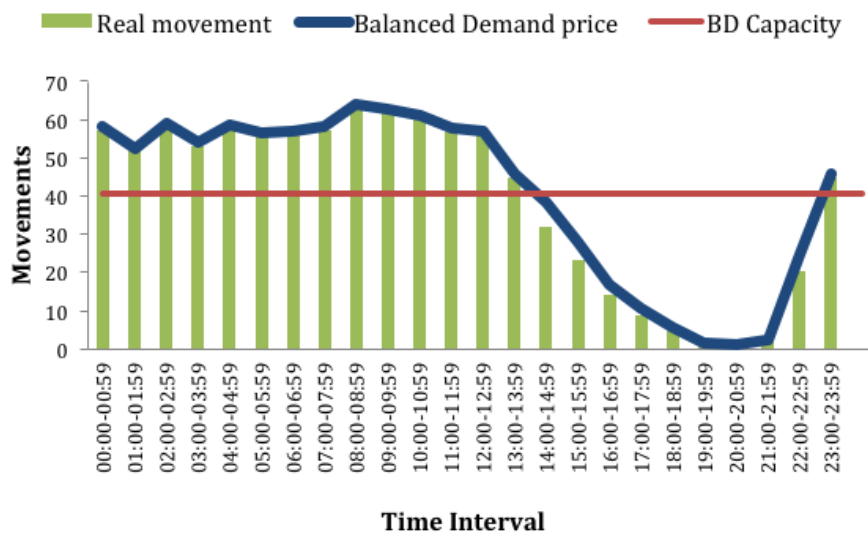## Fig. 6 Capacity Restraint Approach (with actual time)

Fig. 7 Balanced Demand Approach (with actual time)

7. IMPLEMENTATION CHALLENGES

There are several challenges and problems to be solved for the disincentive strategy can be properly implemented and show its positive effects for the Soekarno-Hatta International airport and other airports in Indonesia.

The first challenge is to overcome the unique condition of Soekarno Hatta International airport. This airport serves both as the main international hub for Indonesia and also main hub for the domestic flights. Most domestic flights making Soekarno-Hatte airport as their main connection hub airport. Such condition causing huge number of short haul flights, dominating the allocation of slot in this airport especially between morning and early evening hours.

The second challenge is the improvement of coordination among stakeholders in slot time coordination and air transport operation. Currently there are several civil enclave airport in Indonesia which need some upgrade in the air traffic system and operational management due to the high air traffic freuecy of the respective airports. But due to its status as civil enclave there are some restriction for forther development. This challenges must be solved due to the position of Soekarno Hatta airport as main hub airport for domestic flights. Disruption of inappropriate operation from these airports may cause disruption on Soekarno Hatta operation.

Third challenge is related to the nature of slot allocation system in which the slot capacity of the airport is the result of interrelation among air traffic capacity, runway capacity and the apron capacity. Currently Soekarno-Hatta Airport facing acute problem to increase its apron capacity. The problem worsened by the fact that most airline making Soekarno-Hata airport as their base, causing sharp decline in apron capacity in the evening thus resulting disruption of operation during night time peak hour traffic.

8. POLICY RECOMMENDATIONS AND WAY FORWARD

The above analyses and simulations have demonstrated that the current aircraft movement pattern have responded to the existing demand for air transport. In a demand responsive environment, it is clear that passenger prefer a certain time to depart and arrive in SHIA. This demand has been met by airlines by adjusting their timetable and airport usage. The peaking of air traffic and the statistical test of indifference arrival/departure pattern clearly indicate the presence of such phenomena.

The current slot allocation mechanism which is based on the first-come-first-served basis has not been able to cope with managing the existing demand from both the passengers and airlines. The results have indicated that during the peak time, the air traffic movement exceeded the design capacity, thus exposing the airport to a serious safety issue.

The research found that existing slot time allocation does not consider market mechanism, and thus creating an opportunity to regulate the slot time based on auction system. Despite the fact that airport slot allocation is indeed a complicated undertaking due to the network effect, regulating slot time in SHIA will generate the demand for reallocation of slot time in preceeding and subsequent airports. SHIA is the most important airport in Indonesia, and therefore managing the capacity of existing runways is critical for both SHIA air traffic safety and redistributing the air traffic to manage the air traffic demand to other Indonesian airports. Already there are concerns with other airports such as Surabaya (SUB) and Makassar (UPG) for managing their runway capacity and terminals.

Simulating slot time market value reveals that the auction system can generate substantial revenues to maintain and operate the slot time management system, and is able to encourage evenly distribution of aircraft departure time. This research is initial step toward educating policy makers and airport authorities in Indonesia that the economics of air space is present in the national airport markets. The estimated value of the auction can be tested further with various instruments. The next step for the authority is to estimate the airspace value that can be labelled in each time interval, and therefore the government will be able to estimate the economic value of one of their national resources, time.

The simulation shows that in the event of the slot pricing and auction to be implemented in Soekarno-Hatta airport, the airlines that are willing to use slot time at the most demanded time interval should pay an additional 6.57% (CR approach) from total revenue gained by the government from slot sector and 6.55% (DB approach). It is to be rememberred that the current

regulation does not generate revenue from the slot allocating process therefore further research is needed to calculate the potential revenue of slot allocation process.

The government must be able to distribute the air traffic burden especially thee domestic flights from the Soekarno Hatta International airport. Better coordination among the stakeholders also needed to better spread the demand for slot time especially for flights to eatern part of Indonesia. Upgrade of the existing airport especially for their apron and terminal capacity might be needed to tackle the slot capacity limitation problem. Development of new airport can also be considered especially for area which the airport can no longer be further upgraded or developed.

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DEMAND ESTIMATION FOR A NEW AIR ROUTE

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ABSTRACT

Network connectivity is core competitiveness of the aviation industry and opening a new route is one of critical ways to enhance network competitiveness. As many airport operators are becoming more interested in attracting airlines, there are vast needs to discuss the methods for estimating (predicting) potential demands for a new flight route or by increasing flight frequencies in existing routes.

This study explores demand estimation models for a new air route. Similar to previous studies, this study classified potential demand for a new air route into four types (Local, Beyond, Behind and Bridge). Explanatory variables are identified and constructed for each type of demand, including distance, relative capacity compared with adjacent airports and detour ratio as main independent variables. One of the strengths of the suggested demand models can distinguish the generated demand from the converted or re-distributed demand. Based on this, the model is meaningful for an airport operator to develop an airport policy such as airport-usage charges and incentives to attract airlines.

On the other hand, because of the strong recognition that demand estimation for a new air route is the area of airlines that decide on whether or not to introduce a new route, simply developing demand estimation models from the perspective of an airport operator is not sufficient. Therefore this study is considered as the initial step for an airport operator in its efforts to attract airlines and market new air routes to enhance network connectivity of its airport.

Keywords: *Estimation, Demand, Opening a New Route, Airport Operator, Enhance Network Connectivity.*

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1. INTRODUCTION

Regional hub airports can create enormous economic value by attracting air traffic demand into the hub airport on the basis of stronger network competitiveness than adjacent airports. Therefore ultimate competitiveness of an airport can be evaluated by network connectivity, and the network connectivity is a key success factor for an airport to achieve a hub airport position in a region.

Generally, network connectivity of an airport is composed of the number of non-stop destinations to/from the airport and the frequency of flights and wave structure of an airport.

Thus, for an airport operator, it is an important task to attract airlines to open new flight routes and or to increase flight frequencies in existing flight routes, which would directly contribute to enhance network connectivity of an airport. Demand estimation is important, as predicting the potential demand is definitely a basic step to determine the feasibility of opening a new route or increase frequencies. However, because there had been a strong recognition that opening new routes and increasing frequency of flights were mainly decision-making area of the airline for a long time, it might be questioned whether demand estimation could be the working area of an airport operator. Especially how competent an airport operator can be in producing accurate estimation results was very doubtful. In fact, due to the lack of the academic studies on methodologies for estimating demand from opening a new route or increasing flight frequency, it has been widely accepted that there were some issues including the asymmetry of information between the airport operators and the airlines with respect to developing new air-routes.

As aforementioned, however, because opening new routes and increasing flight frequency in existing routes are very important to an airport operator, the challenge to develop a scientific methodology for demand estimation can give rise to great insights for most airport operators. Moreover this challenge can also lead to the expansion of information sharing among players of a market, and this sharing can definitely make a contribution to decrease monopolistic profit that can be easily generated when information is exclusive to a specific player in the aviation industry.

In this study, the methodology to estimate potential demand for a new flight route is introduced. The case of increasing frequency of flights in existing routes can be discussed in a further study. Section 2 represents the insights of the previous studies and Section 3 examines factors to establish a significant estimation model. Section 4 suggests a statistical model to estimate demand from a new flight route. Finally in Section 5, evaluation and possible application areas of this study are discussed.

2. REVIEW OF RELATED LITERATURE

Most researches on demand estimation in the aviation industry have focused on the area of total demand of an airport or a country, which generally apply time-series approaches focusing on recent trend. Abdelghany et al. (2010) presented a time-series modeling approach to forecast total demand of an airport in short-term. Interestingly, their model used various external factors, such as seasonality, fuel price, airline strategies, incidents and financial conditions, giving great implications to establish explanatory variables in this study.

On the other hand, there have been numerous studies on the comprehensive competitiveness of airport network in terms of connectivity. Park et al (2006) proposed a 'Hub index' to evaluate network connectivity. Their index is composed of time connectivity, space connectivity and relative strength. Lee et al (2014) suggested 'Continuous Connectivity Index' which supplemented 'Hub index' by incorporating airline flight schedules. These studies are helpful to understand a general concept of airport connectivity.

The most difficult task in this study is to identify and construct explanation variables. Review of previous studies show that a wide range of variables being considered. For example, Wilken et al (2006) considered airport network density, catchment area of airport, existing traffic volume, airline services and prices in the case of German air passengers choosing transit airports. Grosche et al (2007) suggested distance, population and catchment area as critical variables.

Koo et al (2013) considered capacity in terms of number of available seats at an airport as an explanatory variable reflecting the supply side. Their study is different from other studies in that it explicitly considered a supply aspect in determining possible air demands by analyzing the relationship between available flight seats and the number of passengers in the tourism markets of Japan, Australia and China. In short term, available seats are generally static because of schedule commitments, but, because of elastic passenger demand corresponding to economic conditions, available seats can take critical role as an explanatory variable in a supply aspect so as to find the market equilibrium.

Nicolau (2011) showed that there was higher level of risk aversion and diminishing sensitivity in a demand aspect and that air passengers tend to react more strongly to price increase than price decrease. Thus, price can help enhance the consistency of the demand model as an explanatory variable. Malighetti et al. (2010) also suggested a similar finding that the increasing complexity and dynamism of the air transport industry will enhance the role of pricing.

In short, previous studies on demand estimation in the aviation industry have applied some common variables, such as population, distance, price, capacity (available seats, frequency). These variables were also considered in estimating demand in this study.

3. POTENTIAL DEMANDS FOR A NEW ROUTE

3.1 Types of Potential Demand

Potential demand for a new air route was classified into following four types in this study. These types can have a significant meaning to an airport operator, because some of them are the stimulated demand and others are the substituted or re-distributed demand. This difference can affect the airport usage policy such as a landing charge and incentives. For example, it may be desirable to offer more incentives to an airline that stimulates more a newly generated demand.

3.1.1 Local Demand

The first type of demand is direct "Local demand" converted from traffic previously connecting through a hub airport (Figure 1). When there is no direct route from AAA (the airport under consideration) to ZZZ (a potential new destination), passengers travelling between AAA to ZZZ have to connect through another airport. Under this circumstance, a new direct flight between AAA and ZZZ will attract and convert some of these "connecting" traffic into direct "Local Demand".

How many "Local demand" will be converted depends on variables, such as characteristics of the destination city, origin/destination airports, etc. These variables are essential factors to establish an estimation methodology, and are discussed in Section 3.2.

In fact, the first type of demand is indiscriminate from existing demand from the perspective of an airport operator, because these passengers already use the airport. However, this kind of demand from a new air route can increase the economic value of the airport, because "Local demand" generally create more economic value than "transit demand".

On the other hand, a new air route can stimulate traveling demand, attracting new passengers to take new direct route to ZZZ. This additional demand is a definitely the newly generated demand. However this study will not consider such stimulated demand, because the amount of this demand can be too small, considering the complexity of estimating such stimulated demand.

Fig.1. Local demand for a new route
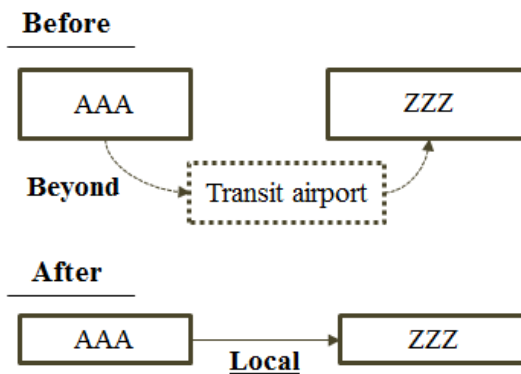
3.1.2 Beyond Demand

The second type of demand is "Beyond demand" re-distributed from existing "Beyond demand". (refer to Fig.2.) If there is a new route from AAA to ZZZ, some passengers will select ZZZ as a new transit place to go to their destinations. This type of demand is the re-distributed demand, creating no changes in the number of passengers or economic value from the perspective of AAA.

How many "Beyond demand" using ZZZ as a transit place will be re-distributed is closely related with the detour ratio of 'AAA-ZZZ-final destinations' and frequencies both 'AAA-ZZZ' and 'ZZZ-final destinations'.

Fig.2. Beyond demand for a new route
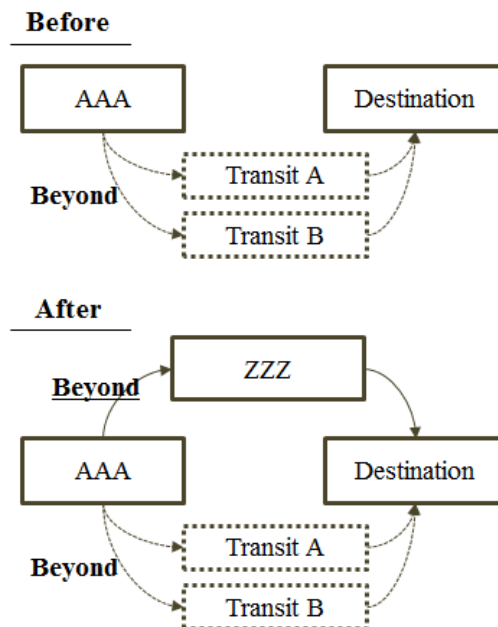
3.1.3 Behind Demand #1

The third type of demand is "Behind demand" which was originally "Behind demand"of competing airports. (refer to Fig.3.) When a new route is open between AAA and ZZZ, some of "Behind demand" of competing airports can be moved into "Behind demand" of AAA. This type of demand seems the most important to AAA, because this type is the newly generated demand from the perspective of AAA, which means the generated economic value.

How many passengers will use AAA as a new transit place to go to ZZZ is closely related with the attractiveness of AAA as a transit place. Thus relative competitiveness AAA compared with competitors, such as 'Transit A', and detour ratio of 'origins-AAA-ZZZ' should be considered as variables to establish an estimation methodology.

Fig.3. Behind demand #1 for a new route
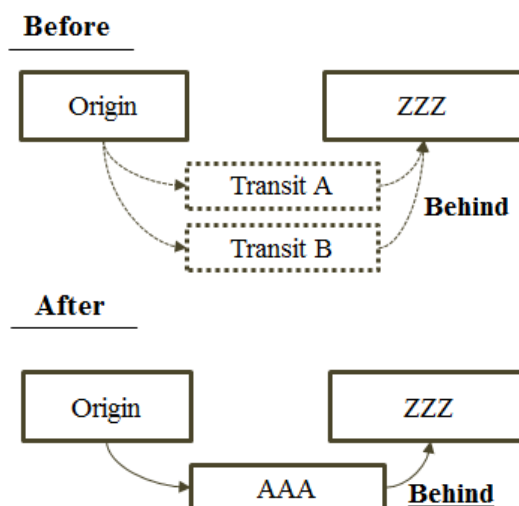
3.1.4 Behind Demand #2

The fourth type of demand is "Behind demand", which was originally "Local demand" of competing airports. (refer to Fig.4.) When a new route is open between AAA and ZZZ, some of "Local demand" of competing airports can be moved into "Behind demand" of AAA. However there is low possibility that the total amount of this kind of demand will be significant, because "Local demand" of competing airports is a passenger who has already made a decision to take a direct flight in spite of numerous options to take a transit flight. Thus it does not seem reasonable to assume that the passenger can change his/her decision, just because there emerges one more option to take a transit flight.

Fig.4. Behind demand #2 for a new route
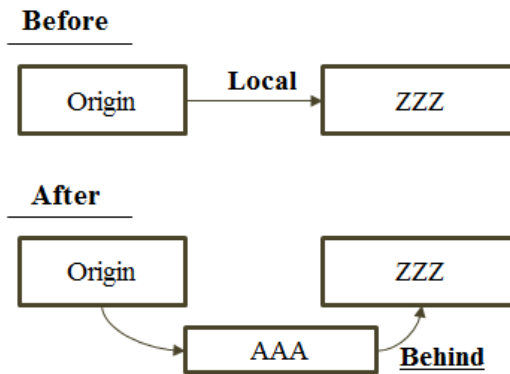
3.1.5 Bridge Demand

The fifth type of demand is "Bridge demand". When a new route is open between AAA and ZZZ, AAA can be used as a new bridge point and then this will consist of "Bridge demand". (refer to Fig.5.)

In fact, this fifth type of demand is also the newly generated demand from the perspective of both an airport operator and an airline. However, it can be reasonable selection not to deal with this type of demand, considering that "Bridge demand" originally is not significant type of demand. Therefore this study does not include this type of demand.

Fig.5. Bridge demand for a new route
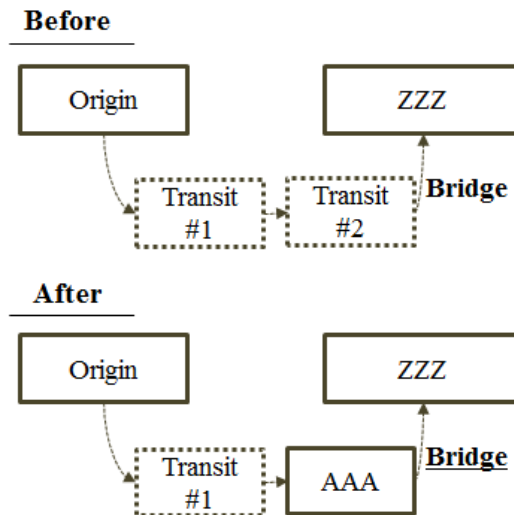
3.2 Factors to Estimate Demand for a New Route

There can be a lot of factors to establish an estimation methodology for a new air route, as shown by Section 2. Therefore this study concentrates on finding out 'appropriate' factors. The meaning of 'appropriate' requires that it be i) statistically significant, ii) available to get historical data and iii) easy to process the estimation procedure. This Section examines 'appropriate factors' as variables to estimate demand of each type.

3.2.1 Local Demand

Even if there is a direct flight between AAA and ZZZ, some passengers continue to take transit fights, mainly because of price difference between a direct flight and a transit flight. Thus it is unreasonable assuming that all the "Beyond demand"(AAA-transit airport–ZZZ) will be moved into "Local demand"(AAA-ZZZ). Therefore it is necessary to find out which factors will affect "Beyond demand" to move into "Local demand". (refer to Fig.6.) First of all, distance should be considered, because the shorter distance between AAA and ZZZ means the more passengers taking direct flights. For example, if it takes 3-hour stand-by time for a transit flight to go only 2-hour flight distance, almost all passengers will select direct flights. Therefore the distance from AAA to ZZZ must be an important factor as an explanatory variable.

Fig.6. Structure of Local demand for a new route
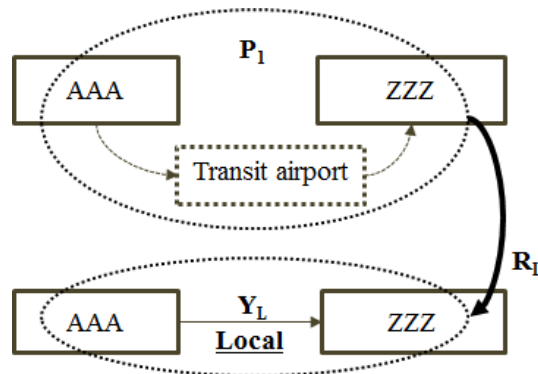
The relative capacity is also an important factor. If there are the more seats provided by direct flights, this can naturally lead to the more direct passengers, not only because of more capacities, but also because of lower price as the result of more capacities. In this regard, relative capacity compared with competing airports can take a role as a proxy index of price, which is usually hard to attain accurate historical data.

Based on this, "Local demand", which is converted from "Beyond demand", can be represented by a below equation.

(Local demand = Potential demand×Convert rate)

Potential demand means existing "Beyond demand" between AAA and ZZZ, and Convert rate can be measured from multiple linear regression function that uses distance and relative capacity as independent variables. In this study, the total number of seats provided in AAA airport compared with competing airports is used as relative capacity. The idea of continent (Europe, Asia, North America, South America, Africa, Oceania) is applied to define 'competing airports'. This means that competing airports of AAA are the airports that are located in the same continent as AAA. In short, the equation to estimate converted 'Local Demand' is shown as following equation (1).

$$Y_L = P_1 \times R_L = P_1 \times (a_1 \times X_1 + a_2 \times X_2 + \varepsilon) \quad (1)$$

Where

Y_L : *Local demand*

P_1 : *Potential demand*

R_L : *Convert rate*

X_1 : *Distance,* X_2 : *Relative capacity*

Hypotheses to verify are as below.

$H_0 : a = 0,\ H_1 : a \neq 0$ (a)

266 historical data of recent 3 years' operation data of Incheon International Airport(ICN) are used to verify whether a_1 and a_2(coefficients) have statistical significance or not. The examples of these data are represented by Table 1. It is necessary to check whether there is multi-collinearity between 2 independent variables(X_1, X_2) to use linear regression model and as shown by Table 2, there is no multi-collinearity. In addition, there are strong linear relationships between independent variables. (refer to Fig.7.)

Table 1 Historical Data Example - Local Demand

Airport*	Convert rate**	Distance*** (miles)	Relative capacity****
HKG	93%	1,270	3
BKK	87%	2,281	4
LAX	82%	5,987	5

* Top 100 direct destinations from ICN in recent 3 years
** Local[ICN-ZZZ] / (Local + Beyond[ICN-ZZZ])
*** Great-circle distance between ICN and destinations
****Relative capacity

1	ICN's capacity less than 50% of adjacent airports
2	ICN's capacity less than 85% of adjacent airports

3	ICN's capacity between 85% and 115% of adjacent airports
4	ICN's capacity more than 115% of adjacent airports
5	ICN's capacity more than 150% of adjacent airports

Table 2 Correlation Coefficient – Local Demand

Pearson's coefficient	Relative capacity
Distance	-.399

In Section 4, the multiple regression analysis to fit the statistically significant model between the alternative hypothesis and the null hypothesis is carried out, and significant figures of coefficients, including a_1 and a_2, are obtained as a result.

Fig.7. Scatter Plot – Local Demand
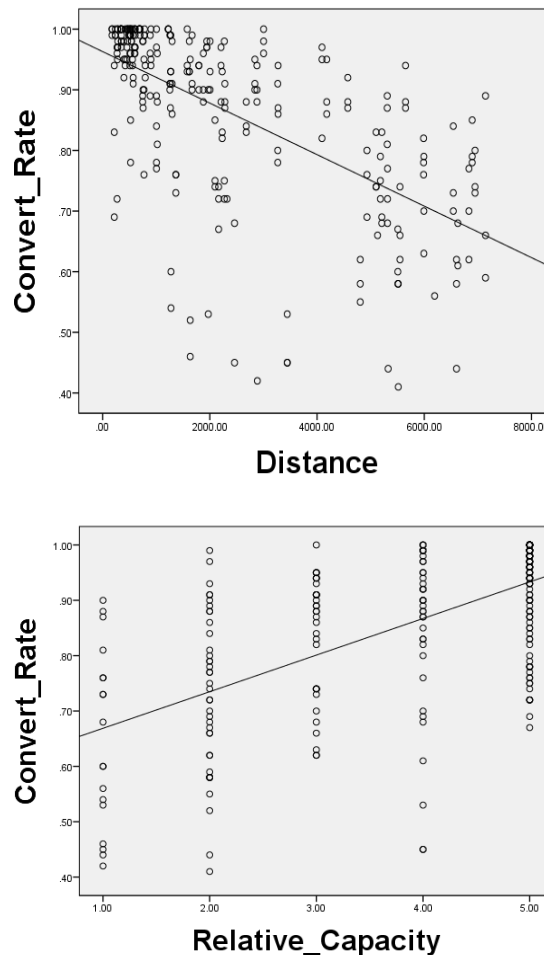
3.2.2 Beyond Demand

The attractiveness of ZZZ as a transit place is closely related with the location itself and network competitiveness of ZZZ, such as flight frequencies between ZZZ and final destinations. (refer to Fig.8.) Therefore it is necessary to find out which factors will motivate the passengers using other airports to change their transit airports into ZZZ.

Fig.8. Structure of Beyond demand for a new route
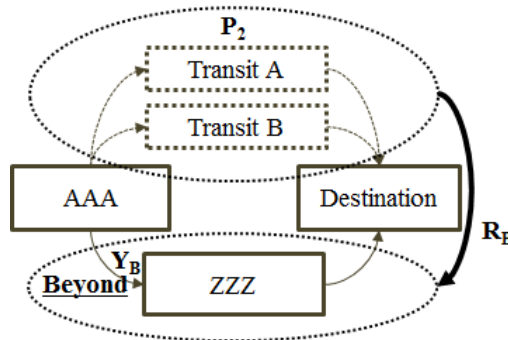
Based on this, "Beyond demand", which uses ZZZ as a new transit place, can be represented by a below equation.

(Beyond demand =

Potential demand×Redistribution rate)

Potential demand means existing "Beyond demand" between AAA and final destinations. Distribution rate is closely related with attractiveness of ZZZ as a transit place to go to such destinations. In this study, in order to assess attractiveness of ZZZ regarding final destinations, detour ratio of 'AAA-ZZZ-final destinations' are used. Detour ratio definitely is a good index of attractiveness as a transit place, because smaller detour ratio generally means the more efficiency, which can affect passengers to change their transit airports. Detour ratio 'AAA-ZZZ-final destination i' can be shown by following formula (2).

$$D_i = \frac{\text{Distance of AAA-ZZZ + Distance of ZZZ-Destination i}}{\text{Distance of AAA-Destination i}} \quad (2)$$

Where

Distance : Great-circle distance

In short, the estimation equation of this type of demand is as following equation (3)

$Y_B = P_2 \times R_B = P_1 \times (\beta/\alpha_3 \times D_i)$ (3)

Where

Y_B : *Behind demand*

P_2 : *Potential demand*

R_B : *Redistribution rate*

D_i : *Detour ratio via ZZZ from AAA to destination i.*

$H_0 : \alpha=0$, $H_1 : \alpha \neq 0$ (b)

109 historical data of recent 3 years' operation results of ICN are used to verify whether this model has statistical significance or not. The examples of these data are represented by Table 3. In ahead of creating a scatter plot to determine the presence of linear relationship between two variables, log transition is committed as a following formula (4), because log transition is more helpful to get an appropriate equation.

$\ln(R_B) = -\alpha_3 \times \ln(D_i) + \ln(\beta)$ (4)

Scatter plot shows that there is a negative linear relationship between independent variables. (refer to Fig.9.) The procedure to estimate "Beyond demand" is as below steps.

i) Find potential demand by each destination of 'Beyond demand' of AAA .

ii) Find distribution rate by each destination as a detour ratio of 'AAA-ZZZ-each destination'

iii) $\sum_{i=1}^{n} (Potential\ Demand\ of\ Destination\ i) \times (Detour\ Ratio\ of\ Destination\ i)$

Table 3 Historical Data Example – Beyond Demand

Destination *	Transit airport**	Occupancy rate of the transit airport ***	Detour ratio ****
LHR	AMS	8.9%	101%
LHR	FRA	5.7%	103%
JFK	SFO	20.5%	118%
JFK	HNL	7.0%	127%

* Destination cities from ICN
** Transit airport to the destination from ICN
*** The occupancy rate of using the transit airport among total transit demands
**** Detour ratio from ICN to destination when using transit flight

In Section 4, the multiple regression analysis to fit the statistically significant model between the alternative hypothesis and the null hypothesis is carried out, and significant figures of coefficients, including α_3 and β, are obtained as a result.

Fig.9. Scatter Plot - Beyond Demand
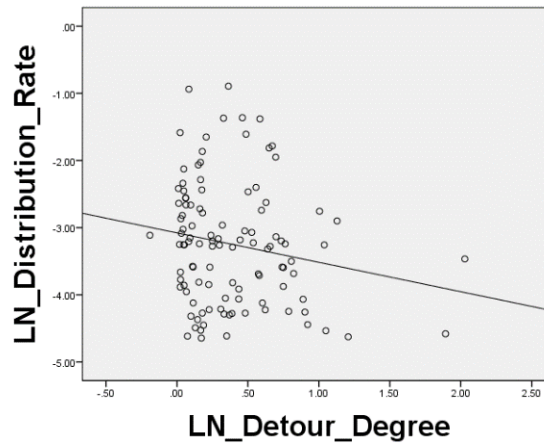
3.2.3 Behind Demand #1

This type of demand is newly generated because it was originally demand of other airports. (refer to Fig.10.)

This type of demand can also represented by a below equation.

(Behind demand =

Potential demand×Transfer rate)

Potential demand means existing "Behind demand" of ZZZ of using other airports as transit places.

Fig.10. Structure of Behind demand #1 for a new route
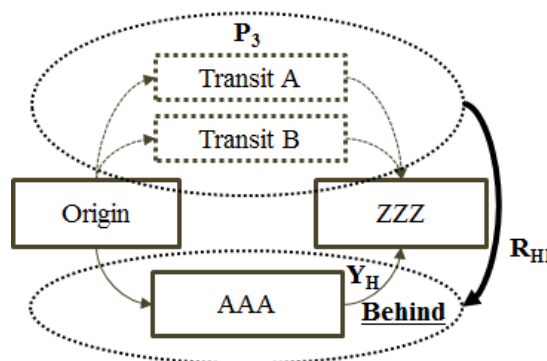
In ahead of making an estimation, it seems reasonable to narrow range of potential demand into demand that has a possibility to be moved into "Behind demand" of AAA. This study adopts the range of maximum detour ratio 3, because, if the ratio is more than 3, there will be little possibility

for passengers to select the airport as a transit place. Detour ratio 3 is similarly adopted in previous studies including Park et al.(2006) and Lee et al.(2014).

This demand is closely related with the attractiveness of AAA as a new transit place, because it is a kind of competition to take over transit passengers. To assess how many passengers will select AAA as a new transit airport, this study uses two dimensions of approach. The first dimension is the strength of AAA itself as a transit place to go to ZZZ. It can be measured by the detour ratio from 'origins-AAA-ZZZ', the same as Section 3.2.2. The other dimension is a relative perspective. In this regard, related capacity competitiveness is an essential factor to take over existing transit demand of other airports. Moreover, as represented in Section 3.2.1, a capacity variable can additionally be used as a proxy index of price. The estimation equation of the third type of demand is as following equation (5)

$$Y_H = P_3 \times R_{H1} = P_3 \times (a_4 \times X_4 + a_5 \times X_5 + \varepsilon) (5)$$

Where

Y_H : Behind demand

P_3 : Potential demand

R_{H1} : Transfer rate

X_4 : Detour ratio, X_5 : Relative capacity

Hypotheses to verify are as below.

$H_0 : a=0$, $H_1 : a \neq 0$ (c)

72 historical data of recent 3 years' operation results of ICN are used to verify whether this model has statistical significance or not. The examples of these data are represented by Table 4. As shown by table 5, it seems that there is no multi- collinearity among independent variables. In addition, it seems that there are strong linear relationships between independent variables. (refer to Fig.11.)

Table 4 Historical Data Example – Behind Demand #1

Destination*	Origin**	Transfer Rate***	Detour ratio****	Relative Capacity*****
BKK	JFK	20.5%	1.589	6
HKG	LAX	20.4%	2.387	6
HNL	PEK	45.2%	1.216	7
SGN	YYZ	13.0%	1.412	3

* Destination cities when transferring at ICN
** Origin cities when transferring at ICN
*** The occupancy rate of using ICN as a transit airport among existing transit demands within detour ratio 3 via ICN
**** Detour ratio via ICN from a origin to a destination
***** Relative capacity: Sum of Relative capacity of both Origin-ICN and ICN-destination

Table 5 Correlation Coefficient – Behind Demand #1

Pearson's coefficient	Relative capacity
Detour ratio	-0.0899

In Section 4, the multiple regression analysis to fit the statistically significant model between the alternative hypothesis and the null hypothesis is carried out, and significant figures of coefficients, including a_4 and a_5, are obtained as a result.

Fig.11. Scatter Plot-Behind Demand #1
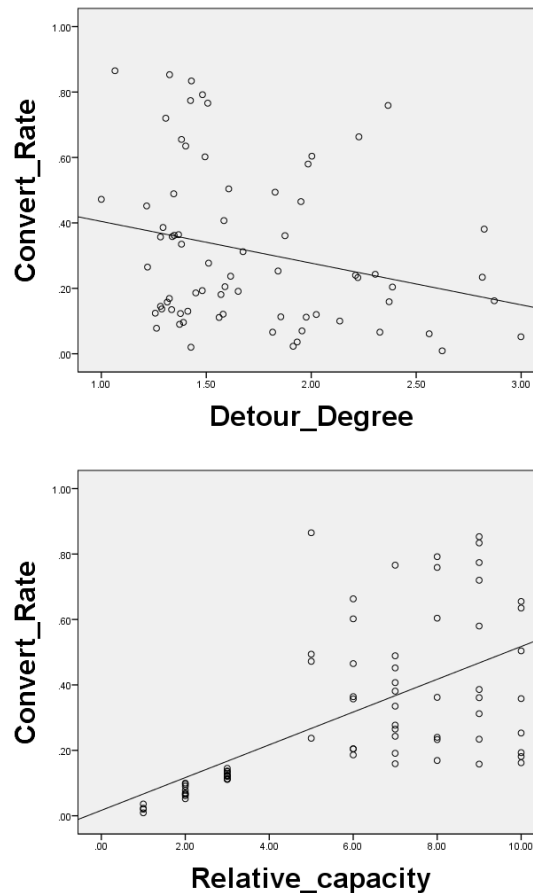
3.2.4 Behind Demand #2

When there is a new route from AAA to ZZZ, there can also be "Behind demand", which is moved from "Local demand" of competing airports. (refer to Fig.12.) As the same as the case of 'Behind demand #1 estimation', it is reasonable to assume that only the demand within detour ratio 3 via AAA has a possibility to be moved. The estimation equation of the fourth type of demand is as following equation (6)

$Y_H = P_4 \times R_{H2}$ (6)

Where Y_H : Behind demand

P_4 : Potential demand

R_{H2} : Transfer rate

As represented in Section 3.1.4, there is low possibility that the total amount of this kind of demand will be significant. Therefore this study used empirical figures to measure transfer rate(R_{H2}), instead of establishing statistical model to assess it. For example, the average of past transfer rates from empirical cases of opening new routes in AAA airport can be used.

Fig.12. Structure of Behind demand #2 for a new route
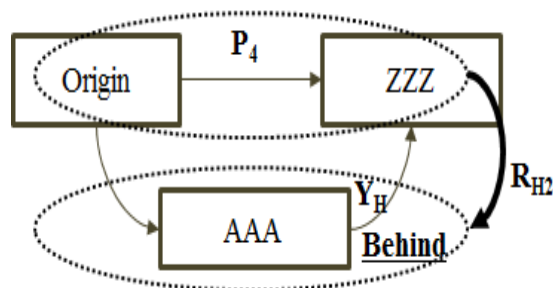
4. SUGGESTION OF ESTIMATION METHOD

In previous Sections, the types of potential demand for a new air route and appropriate explanatory variables are established. In this Section, the variables are verified by a statistical tool to judge whether they are statistically significant or not as independent variables.

4.1 Statistical Review

4.1.1 Local Demand

The equation that needs statistical verification is as following equation (1).

$$Y_L = P_1 \times R_L = P_1 \times (a_1 \times X_1 + a_2 \times X_2 + \varepsilon) \quad (1)$$

Where

Y_L : Local demand

P_1 : Potential demand

R_L : Convert rate

X_1 : Distance, X_2 : Relative capacity

Using 266 historical data of ICN, multiple regression analysis is conducted and the result is proved to be statistically significant. (refer to Table.6.) Therefore, H_0 hypothesis(H_0 : a_1 and $a_2=0$) is rejected and H_1 hypothesis(H_1 : a_1 and $a_2 \neq 0$) is accepted. As a result, significant figures of a_1 and a_2 of ICN are obtained.

Table 6 Statistical Review – Local Demand

R	R^2	Adjusted R^2	Standard error
.727a	.528	.525	.10022

a. Estimation Value : (Constant), Distance,
Relative capacity

	Coefficients			t
	B	Standard error	β	
(Constant)	.757	.025		29.979
Distance	-2.950E-005	.000	-.433	-9.110
Relative_ Capacity	.045	.005	.418	8.791

Dependent variable: Convert Rate

4.1.2 Beyond Demand

The equation that needs statistical verification is as following equation (4).

$$\ln(R_B) = -\alpha_3 \times \ln(D_i) + \ln(\beta) \quad (4)$$

Where

R_B : *Redistribution rate*

D_i : *Detour ratio via ZZZ from AAA to destination i*

Using 109 historical data of ICN, simple regression analysis is conducted and the result is proved to be statistically significant. (refer to Table.7.) Therefore, H_0 hypothesis(H_0 : α_3=0) is rejected and H_1 hypothesis(H_1 : $\alpha_3 \neq 0$) is accepted. As a result, significant figures of α_3 and β of ICN are obtained. Removing log transition is as below equation (3-1)

$$Y_B = P_2 \times R_B = P_2 \times (1/\alpha_3 \times D_i) \quad (3\text{-}1)$$

Where

Y_B : *Behind demand*

P_2 : *Potential demand*

4.1.3 Behind Demand #1

The equation that needs statistical verification is as following equation (5)

$$Y_H = P_3 \times R_{H1} = P_3 \times (\alpha_4 \times X_4 + \alpha_5 \times X_5 + \varepsilon) \quad (5)$$

Where

Y_H : Behind demand

P_3 : Potential demand

R_{H1} : Transfer rate

X_4 : Detour ratio, X_5 : Relative capacity

Using 72 historical data of ICN, multiple regression analysis is conducted and the result is proved to be statistically significant. (refer to Table.8.) Therefore, H_0 hypothesis(H_0 : $α_4$ and $α_5$=0) is rejected and H_1 hypothesis(H_1 : $α_4$ and $α_5$≠0) is accepted. As a result, significant figures of $α_4$ and $α_5$ of ICN are obtained.

Table 7 Statistical Review – Beyond Demand

R	R^2	Adjusted R^2	Standard error
.727a	.528	.524	2.32496

a. Estimation Value : LN(Detour ratio)

	Coefficients			
	B	Standard error	B	t
LN(Detour Ratio)	-4.584	.417	-.727	-10.998

* Dependent variable: Distribution Rate

Table 8 Statistical Review – Behind Demand #1

R	R^2	Adjusted R^2	Standard error
.756a	.571	.559	.15992

a. Estimation Value : (Constant), Detour Ratio, Relative capacity

	Coefficients			
	B	Standard error	β	t
(Constant)	.121	.085		1.430
Detour Ratio	-0.085	.040	-.166	-2.096
Relative_ Capacity	.062	.007	.718	9.045

* Dependent variable: Transfer Rate

4.1.4 Behind Demand #2

The transfer rate(R_{H2}) from existing "Local demand" into "Behind demand #2" of ICN is calculated by the average of historical figures from empirical cases of opening a new air route at ICN. Since Mar, 2001 when ICN started its operation, there have been almost 100 newly open air routes and the average figure of transfer rate from those open routes can be used as R_{H2} of ICN. If the figure is the same as θ, the estimated "Behind demand #2" of ICN moved from existing "Local demand"s of ZZZ for a new air route is estimated by below equation (6-1)

$$Y_H = P_4 \times \theta \quad (6\text{-}1)$$

Where

Y_H : Behind demand

P_4 : Potential demand

θ : The average of historical transfer rate

4.2 Suggestion of Estimation Method

Using the independent variables and coefficients established in previous Sections, this study suggests demand estimation method for a new air route as following equation (7).

Potential demand = Local demand +
Beyond demand + Behind demand

$$= P_1^{a)} \times (a_1 \times X_1^{b)} + a_2 \times X_2^{c)}) + P_2^{d)} \times e^{(a3 \times \ln(X3))\ e)} +$$

$$P_3^{f)} \times (a_4 \times X_4^{g)} + a_5 \times X_5^{h)}) + P_4^{i)} \times \theta^{j)} \quad (7)$$

Where

a) Existing 'Beyond demand' of AAA, AAA to ZZZ

b) Great-circle distance, AAA to ZZZ

c) Flight seats provided in AAA, AAA to ZZZ

*expressed as a relative index by comparison with competing airports

d) Existing 'Beyond demand' of AAA

e) Detour ratio of 'AAA-ZZZ- existing destinations of AAA'

f) Existing 'Behind demand' of ZZZ within detour ratio 3 when using AAA as a transit point

g) Detour ratio 'existing origins of ZZZ-AAA- ZZZ'

h) Sum of relative capacity both existing origins of (Origin to AAA) and (AAA to ZZZ)

*expressed as a relative index by comparison with competing airports

i) Existing 'Local demand' of ZZZ within detour ratio

3 when using AAA as a transit point

j) Average of historical transfer rates from 'Local demand' of new destinations to 'Behind demand' of AAA for historical new air routes at AAA

Actually the amount of potential demand from above equation (7) is the figure of one-way direction (AAA→ZZZ). Therefore, to estimate total round-trip amount, it is necessary to multiply the amount from equation (7) by 2, although there can be a slight difference of demand between first-way(AAA→ZZZ) and second-way (ZZZ→AAA).

The newly generated demand from the perspective of AAA is as following equation (7-1). This amount can also be a whole new demand to an airline, only if the airline has no direct route between AAA and ZZZ in other airports.

Newly generated demand (Airport perspective) =

$$P_3^{f)} \times (\alpha_4 \times X_4^{g)} + \alpha_5 \times X_5^{h)}) + P_4^{i)} \times \theta^{j)} \qquad (7\text{-}1)$$

5. CONCLUSION AND RECOMMENDATIONS

To evaluate a potential new air route at an airport, four types of potential demands must be considered. The first one is the direct "Local demand" that are converted from connecting traffic through another airport; the second one is re-distributed "Beyond demand"; the third one is "Transferred Behind demand"; and the fourth one is "Transferred Bridge demand". The estimation of the potential demand is critical in making the decision whether to start a route or not.

In short, this study develops the models for estimating each type of demand for a new air route. The proposed methodology is applied to Incheon International Airport, and the results indicate that explanatory variables, such as distance, relative capacity and detour ratio, are statistically significant.

The suggested estimation methodology can offer important insights. At first, this methodology has good explanatory power to estimate potential demand from a new air route, using linear regression model. Secondly independent variables in this methodology are closely related with each type of potential demand and these variables can be attained through existing tools such as Sabre MIDT, OAG, etc. Moreover, the assumptions used in this study appear to be reasonable and the methodology reflects real market trend. Finally the methodology provides distinction between the

newly generated demand and the converted or redistributed demand from the perspective of an airport.

Yet, this study definitely has limitations, such that it can take too much time to obtain appropriate data and to conduct estimation procedures. Besides, there are some unclear points, including the definition of 'competing airports' and less sophisticated concept of 'relative capacity'.

However, it is certain that this attempt to estimate potential demand for a new air route from the perspective of an airport is valuable. Also this attempt is definitely important step for an airport operator in its efforts to attract airlines and marketing air routes in order to enhance network connectivity of the airport.

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IMPACT OF TIMETABLE SYNCHRONIZATION ON HUB CONNECTIVITY OF EUROPEAN CARRIERS

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ABSTRACT

This paper evaluates the net impact of timetable synchronization on the connectivity of the key European carriers at their main hubs. We measure hub connectivity using a weighted connectivity score (WCS) that takes into account the number and the trip time related quality of flight connections. Based on WCS, we compare hub performance resulting from the existing schedule against a random expectation calculated from multiple randomized schedule simulations. In each simulated schedule scenario we randomly vary the flight departure and arrival times within the operation hours at a hub and at outbound stations keeping all other flight parameters from the real schedule unchanged.

We observe that the timetable synchronization leverages hub connectivity of most analyzed airlines by 40% to 60%. The highest increase of connectivity is achieved by medium-sized carriers that operate peaky wave systems with flights concentrated in many short and non-overlapping banks, as well as by carriers that organize their flights in directional waves. The lowest increase is achieved by airlines that operate at highly congested airports. At most hubs, connections to long-haul flights operated with wide-body aircraft are better synchronized than connections between short-haul flights.

Keywords: *Hub connectivity, airline timetable synchronization, connection building, hub wave system.*

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1 INTRODUCTION

1.1 Motivation

Connectivity and hub-and-spoke networks play an important role in the air transport industry. Concentration of many flight operations at hub airports allows airlines to maximize the number of transfer connections and city-pairs served by their network and, thus, to increase their offer to passengers. To fully utilize the hub potential for generating connecting flights, the departures and arrivals at hub should be temporarily synchronized so that the passengers from incoming flights could transfer to a maximal number of outgoing flights with convenient transfer times.

The design of the timetable has a direct impact on airline's connectivity at a given hub. Other factors that impact the hub connectivity (like total number of flight movements, geographic location, destination portfolio, demand distribution, curfews, slot restrictions etc.) have more exogenous character and can be usually influenced only to a limited extend within one or even several planning periods. In this context, improving the timetable synchronization can be seen as the most relevant means the carriers have to maximize their connectivity of a given hub.

The impact of timetable synchronization on the hub performance is difficult to measure and to isolate from other factors that determine the hub connectivity of a given airline. Any hub will generate a certain number of connections even with a random or counter-productive scheduling of flight operations. Since the number of hub connections increases over-proportionally to the number flights served at the hub, a large hub with a non-connectivity driven or simply poorly designed timetable may offer more and better connections than a smaller, well-optimized hub system.

1.2 Objective and Methodological Outlook

The objective of this paper is to evaluate the net impact of timetable synchronization on the overall airline connectivity at hubs. Similar to previous studies, hub connectivity is measured using a weighted connectivity metric based on the number and the quality of flight connections. We assess the impact of timetable synchronization on airline hub connectivity by comparing the existing connectivity from the published schedule to the expected connectivity resulting from a random temporal flight scheduling.

The expected airline connectivity at hub is calculated from multiple simulation runs. In each simulated schedule scenario we randomize only the flight departure and arrival times. All other parameters of the existing schedules (like frequencies per route, origin/destination portfolio, fleet types, block times, terminals etc.) are kept unchanged. The simulations take into account airport operating hours (congestion and night flight limitations) at analyzed hubs and all outstations. As

result, each simulation generates a feasible schedule scenario that is further analyzed just like the existing schedule using a fully defined connection builder (e.g. minimum connection time exceptions and traffic restrictions applicable to any specific flight combination) with parameter settings calibrated in previous research (Seredynski et al., 2014). This allows us to use an advanced connectivity metric to evaluate hub connectivity and, by comparing it with the random expectation, to better assess what share of the airline connectivity is leveraged by the hub timetable synchronization.

1.3   Literature Review and Contribution

Many studies examine airline connectivity at hub airports. In general, connectivity is measured by summing up the (weighted) number of connections or origin and destination (O&D) pairs available at the corresponding hubs. The main differences in the published approaches are (a) the algorithms and parameters that are applied to construct the connections and (b) the assessment or weighting of the individual connections.

Typically, connection time, geographical detour or trip time related quality features are used as the main parameters for connection building. Some studies apply maximum acceptable thresholds directly on connection time and detour (Bootsma, 1997; Danesi, 2006; Dennis 1994; Doganis and Dennis 1989; Lee et al., 2014) Others combine these two parameters to limit the maximum acceptable trip time of a connection Allroggen et al., 2015; Burghouwt and de Wit, 2005; Burghouwt and Veldhuis, 2006; Burghouwt, 2007; De Wit et al., 2009; Grosche et al., 2015; Suau-Sanchez and Burghouwt,2012; Veldhuis,1997). In some approaches, the above parameters are complemented or even replaced by benchmarking each connection to the fastest connection on the corresponding O&D. Connections that don't satisfy certain benchmark criteria are disqualified (Grosche and Klophaus, 2015; Malighetti et al., 2008; Paleari et al., 2010; Redondi et al., 2011). The settings of the connection building parameters or rules vary a lot among the studies. For example, maximum connection time ranges from 90-180 minutes (Danesi, 2006; Dennis, 1994; Doganis and Dennis 1989) to 180-720 hours (Bootsma, 1997; Burghouwt and de Wit,2005). Few studies use parameter settings calibrated against ticket or booking data (Allroggen et al., 2015; Grosche et al., 2015). In most other cases the parameters are chosen according to the authors' discretion.

The total number of hub connections that satisfy the above criteria can serve as a simple connectivity metric (Dennis 1994; Doganis and Dennis 1989). However, most of the above mentioned studies further evaluate the generated connections and put a higher weight to faster connections that are more attractive to passengers. Typically, a value between 0 (the slowest possible connection allowed by the connection building) and 1 (a perfect connection) is assigned to

each connection and the aggregated hub connectivity metric is calculated as a weighted sum of all connections served at the respective hub. In addition to such measures, some researchers include supplementary metrics and/or weighting criteria to further assess the competitive position of hubs (e.g. average frequency, connection time, detour, trip time (Redondi et al., 2011), connected seat capacity (Grosche and Klophaus, 2015), O&D traffic volume –(Grosche et al., 2015), GDP or wealth adjusted population data for origins or destinations (Allroggen et al., 2015; Malighetti et al., 2008)).

Burghouwt and Redondi (2013) provide a detailed overview and comparison of various methods to measure hub connectivity. One of the interesting conclusions of their work is that, although the analyzed approaches use very different parameters, the resulting hub performance measures are all strongly correlated with the size of the hubs and lead to a similar performance ranking of the analyzed European hubs.

The studies briefly reviewed above provide a valuable contribution to research area of airline network planning. The proposed measures of hub connectivity can be used in many practical applications, especially to benchmark the competitive position of airlines and hubs on certain markets or to evaluate the network performance of various schedule scenarios. However, because of the underlying scale effects it is difficult to isolate the net impact of airline timetable design on the resulting hub connectivity.

Only selected studies (Danesi, 2006; Dennis, 1994; Doganis and Dennis, 1989; Rietveld and Brons, 2001) aim to evaluate how the timetable synchronization impacts airline connectivity at hubs. In all these approaches, the quality of hub timetable synchronization is calculated as a ratio between the observed connectivity at a hub and the connectivity that would result from a random (or rather uniform) scheduling a departure and arrival flights along the timeline. Early studies (Dennis, 1994; Doganis and Dennis, 1989) use the number of hub connections that satisfy assumed minimum and maximum connection time (set to 90 minutes) restrictions as the hub connectivity performance indicator. The number of connections is compared to the number expected to occur if the arrival and departure times were uniformly distributed across a typical airport operation period (7:00-22:00). Danesi (2006) proposed an enhancement of this approach and developed a "weighted connectivity ratio" index. This approach allows to apply various connection building parameters depending on the market type (e.g. continental, intercontinental) and to classify connections in various quality levels depending on their detour and connecting time. Rietveld and Brons (2001) assumed that the expected average transfer time for an airport-pair connected via a given hub depends on the frequency of the most frequent leg and the minimum connection time at the hub.

The authors compared the observed average transfer times for selected hubs and airport-pairs with the respective expectation resulting from a uniform distribution of flights and calculated a coefficient of timetable coordination.

The above approaches to measure the impact of timetable synchronization on hub connectivity are limited to simple connectivity metrics and they are further biased by simplifying assumptions (e.g. airport operation hours ignored, MCT globally fixed etc.). The methodology presented in this paper overcomes these limitations and allows to use any, even complex connectivity metrics to measure how the timetable synchronization impacts airline connectivity at hubs.

1.4 Organization of the Paper

The next section presents the methodological set-up of the analysis. We present the settings of the connection building algorithm and introduce the weighted connectivity score (WCS) to measure hub connectivity. WCS takes into account the number and the trip time related quality of hub connections. We also discuss the assumptions and settings of the schedule randomization used in the simulations. In section 3, we present the results and discuss the impact of timetable synchronization on connectivity of the top European network carriers at their main hubs. Given the importance of long-haul operations, in a dedicated analysis we examine the connectivity and timetable synchronization for long-haul and short-haul flights separately. Finally, we investigate the sensitivity of key results with respect to different connection building parameters and connectivity metrics. We conclude with a brief discussion of the key observations.

2 ANALYSIS SET-UP

2.1 Connection Builder

The connection builder (CB) applied in this paper generates single-stop, online connections. All connections are feasible with regard to traffic restrictions on the given airport-pair level (freedoms of the air). In addition, for each connection the individual minimum connection time (retrieved from the full list of exceptions) is applied. The maximum acceptable geographical detour factor, defined as the ratio between the total distances of the connecting flights and the direct distance between the given origin and destination (O&D) airports, is globally restricted to 2.0 and further limited by the next parameter described below.

The key parameter of the CB applied is the maximum connection lag (*maxConLag*). The detailed introduction of this parameter is given in (Seredynski et al., 2014). Connection lag is the sum of connection time and the additional flight time due to geographical detour. It can be interpreted as the difference between the total travel time of a given connection compared to the travel time of a

hypothetical "ideal" connection involving no geographical detour and no connecting time. By setting a maximum value *maxConLag* as a parameter of a CB, a limit to the acceptable total trip time of each connection is set. This approach works similarly as the trip time related parameters used in several other studies e.g. (Allroggen et al., 2015; Burghouwt and de Wit, 2005; Burghouwt and Veldhuis, 2006; Suau-Sanchez and Burghouwt, 2012; Veldhuis, 1997) but it allows us to use parameter settings calibrated with the passenger booking data from previous research (Seredynski et al., 2014). We choose the parameter setting of *maxConLag* according to Figure 1. The solid line (set II) represents values of *maxConLag* over O&D distance that cover approximately 95% of the global bookings for two-segment, online and code-share connections. This setting is used to generate the base set of connections used in this study. In addition, to generate connection sets for the sensitivity analysis, we chose additional settings of *maxConLag* that result in approximately 98% (set I) and 90% (set III) of the bookings, represented in Figure 1 by dashed lines.

We apply one more CB restriction to disqualify non-competitive connections. If two connections on the same origin and destination airport pair (O&D) use the same flight leg, the faster option is more preferable for passengers (Coldren et al., 2003; Garrow, 2010). Of all connections that share a common flight leg (in- or outbound) and connect the same O&D, usually the fastest two options (#1 and #2 in Figure 2) attract most passengers (Seredynski et al., 2014). Other connection options are not attractive to passengers and they are hardly valuable from a network planning perspective. Hence, we limit the set of generated connections to the most competitive ones by allowing only the fastest (#1) and the second-fastest (#2) connections.

Figure 1. Connection builder settings: Maximum acceptable connection lag depending on the O&D distance.
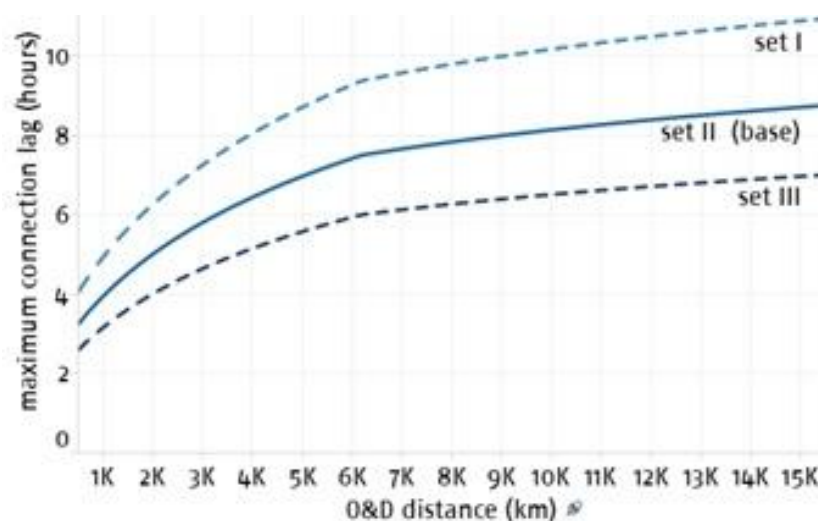
2.2   Connectivity and Timetable Synchronization Measures

Most of the studies reviewed in section 1.3 measure airline connectivity at hubs by analyzing the number and the quality of available connections. The quality of the connections are usually evaluated with some trip time related (e.g. connection time, detour) parameter. In this study we follow a similar approach and propose a trip time dependent quality measure. The quality of each connection is computed according to the following *score* function:

$$score_c = 1 - \frac{ConLag_c}{maxConLag_c}$$

Figure 2. Connection builder settings: Fastest (\#1) and second-fastest (\#2) connections sharing a common leg on a given O&D (ORG-DST)

a) Inbound perspective   b) Outbound perspective
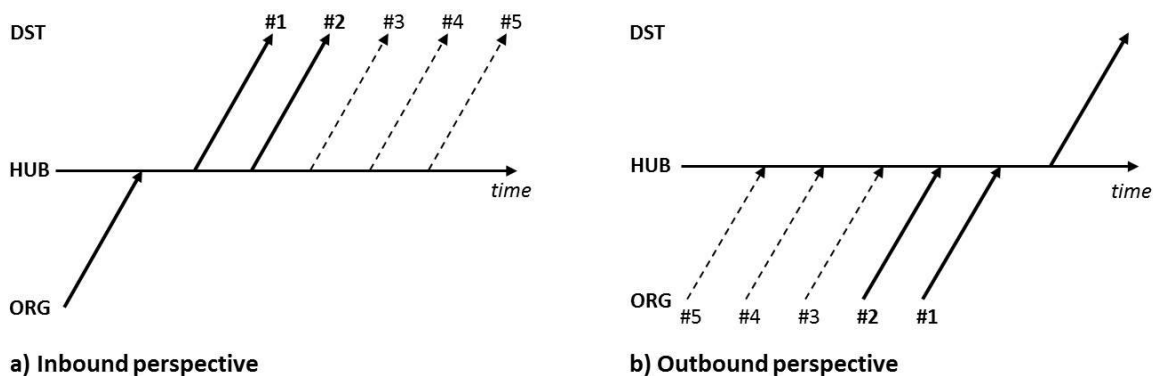
The *score* of a given connection *c* depends on its connection lag (*ConLag*) and on the *maxConLag* parameter applicable to this connection based on its O&D distance (see Figure 1). It ranges between 0 (if the connection lag approximates the respective maximum allowed) and 1 (if the connection lag approximates zero); so the faster the connection c the higher the score.

The overall airline connectivity is calculated as the total score of all connections generated at the corresponding hub. Since fast connections get a higher score, they have a higher weight in the hub's total score than slower connections. Therefore, the overall connectivity of an airline at a given hub is referred to as weighted connectivity score (*WCS*).

$$WCS = \sum_c score_c$$

For each airline hub, *WCS* for the existing schedule (*WCS_{obs}*) is calculated. Analogically, for each randomized variation *i* of the departure/arrival times of flights at the hub, the weighted connectivity score of the hub resulting from a corresponding flight schedule scenario is calculated (*WCS_i*). Having N different variations (randomized schedule scenarios), the overall, average weighted connectivity score (*WCS_{random}*) for the hub is calculated as:

$$WCS_{random} = \frac{\sum_i^N WCS_i}{N}$$

WCS_{random} can be interpreted as the expected level of airline connectivity at the given hub assuming a random temporal distribution of flights. The ratio between the observed hub performance WCS_{obs} and the random expectation WCS_{random} is defined as timetable synchronization index (*Sync*).

$$Sync = \frac{WCS_{obs}}{WCS_{random}}$$

Sync measures how much better is the connectivity resulting from the real airline schedule at a given hub compared to a random expectation.

2.3   Timetable Randomization and Simulation Design

The analysis is based on Innovata flight schedule data for one day of operations (5 June 2013). Connections are generated for the real schedule and for one hundred (N=100) randomized schedule scenarios. To create a schedule scenario for a given hub, all flights operated by the corresponding airline are rescheduled to a randomly drawn five-minute interval. Each rescheduling has to satisfy the operating hours of the hub as well as of the origin or destination airport. For each flight, the time period within which the flight can be rescheduled is determined by the block time, the time zone difference and the operating hours of the respective airports.

As we are not aware of any publicly available source on airport operating hours and detailed night flight limitations we derive this information from the schedule data. We assume that all airports operate with no limitations during the day from 7:00 to 22:00 local time. For the remaining period, we check how many flights are scheduled at what time. The longest period of time with no scheduled operations at a given airport is assumed as being not available for flight rescheduling. For the remaining time periods between day and night we calculate the number of flights per hour and put this number into relation to the average number of flights per hour at the airport during the day. The resulting ratio is used as a base to calculate the probability of time interval selection for the simulations. For example, if the average number of flight movements operated per hour during the day is 50 and only 5 movements are scheduled between 23:00 and 0:00 then the probability of flights being rescheduled to the time intervals within this hour is ten times lower than the probability of flights being rescheduled to any time interval within the day period. This procedure ensures that the generated schedule scenario do not violate any major airport capacity and curfew restrictions; neither in the peak times during the day (the randomized timetables are per design more "flat" than the real schedules) nor during the night (the night flight limitations are taken into account).

As example, Figure 3 shows three example wave patterns of airline timetables at their hubs resulting from a randomized schedule scenario (right), compared to the actual timetable (left). The

horizontal line represents the local time at hub in 20-minute intervals; arrivals are plotted below the horizontal line, departures above it. Each rectangle represents one flight. The color coding of each rectangle shows the direction of a given flight (blue=north, red=east, yellow=south, green=west). Long-haul flights (distance greater than 4000 km) operated with a wide-body aircraft are highlighted with wider rectangles.

Figure 1. Wave patterns of selected carriers at their main hubs based on the actual schedule (left) and on a selected randomized schedule scenario (right).
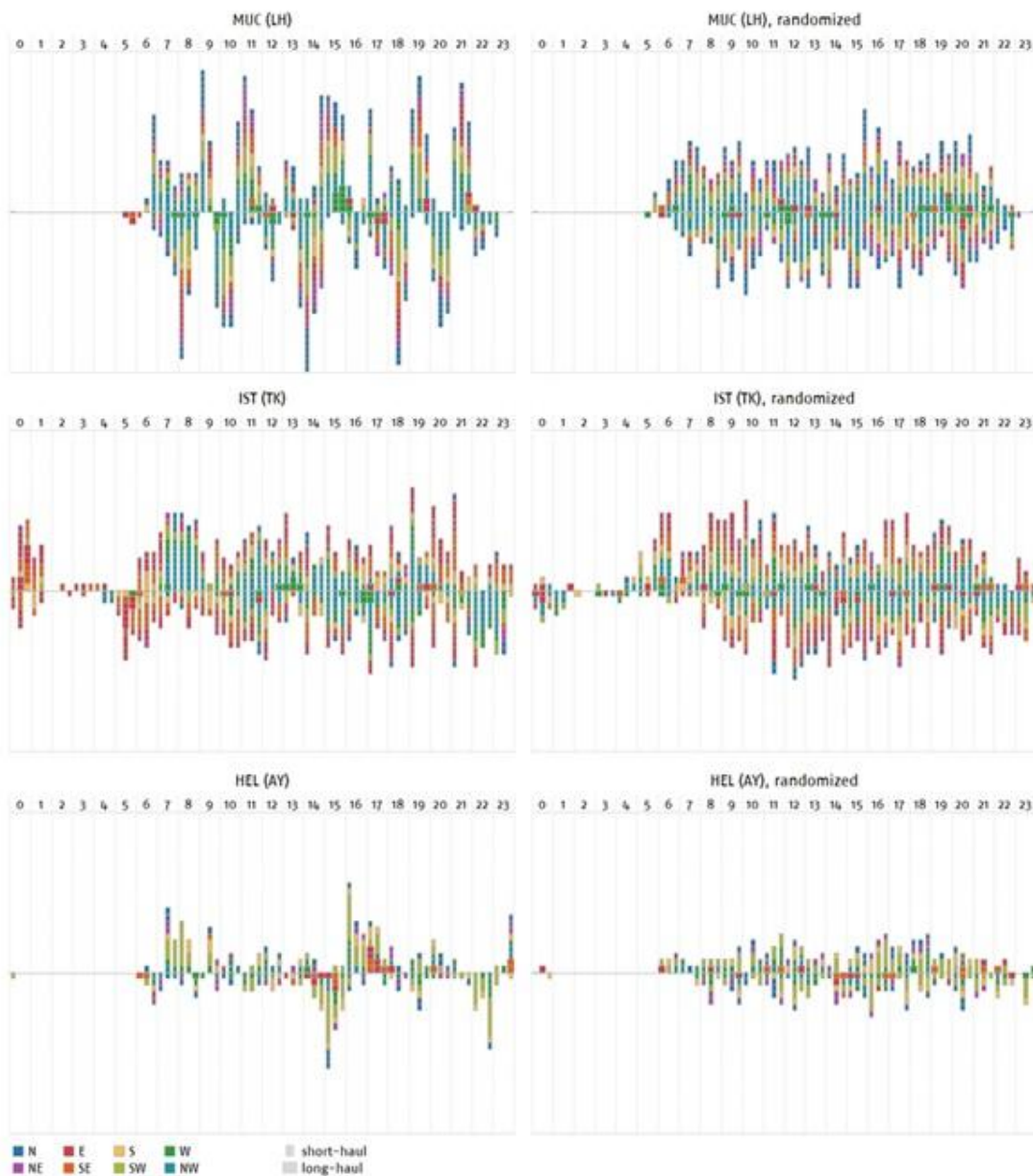
The selected examples presented in Figure 3 represent three different types of connectivity-driven hub wave systems. The Lufthansa (LH) flights in MUC[4] are organized in several waves of inbound and outbound flights. Individual waves are short (1-2 hours) and hardly overlap. This is a typical example of a connectivity driven system that aims to maximize the number of fast connections at a hub serving a star-shaped, largely short-haul network (theoretical considerations on the design of hub wave systems can be found e.g. in (Goedeking, 2010). The wave pattern of Turkish Airlines (TK) in IST shows no evident departure or arrival peaks or periods of no activity. Instead, TK flights are organized in directional waves. For example, flights from south-east arrive (red) arrive between 5:00 and 7:00 and flights to north-west (green) depart between 7:00 and 9:00. This structure aims to maximize connectivity between Asia or Middle East and Europe, the key transfer market of TK. The number of waves in IST is lower than in MUC and individual waves are longer (up to few hours); this results in longer connection times and slower connections. The timetable of Finnair (AY) in HEL is also designed to maximize connectivity between Europe and Asia but AY clearly focuses on fast connections. AY operates only one dominant wave in the afternoon (arrivals between 14:00 and 15:00 and departures between 16:00 and 17:00) and two smaller waves late in the evening and early in the morning.

In the randomized schedule scenarios, departures and arrivals are distributed more evenly during the day and no wave patterns can be identified. Like in the real schedules, no night flights are allowed in MUC and HEL, and only a limited number of flights are randomly rescheduled outside of the normal operation hours (1:30 and 5:00 in IST, 5:30-6:30 in MUC, 00:00-1:00 in HEL).

It is worth to point out that the resulting distribution of the randomized departures and arrivals is not uniform; more departures are positioned in the morning and more arrivals are positioned in the evening. This can be explained by the night flight restrictions on many European airports. For example, very late departures from MUC would result in curfew violation at arrival to many European destination airports. Analogically, early arrivals to MUC would imply departures before the begin of operations at many European origin airports. The impact of operation hours at outstations on the pattern of randomized timetables are stronger for HEL and IST than for MUC (and most other airports analyzed in this paper) due to their more distant geographic location. For example, most European flights cannot arrive in IST before 10:00 or depart after 20:00 because of night flight restrictions at many European airports.

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[4] See appendix A for the list of airport and airline codes

3   RESULTS

3.1   Hub Connectivity and Timetable Synchronization

Figure 4 shows the results for the dominant carriers at the top 15 European hubs by WCS_{obs}. It plots the actual (WCS_{obs}) and the expected (WCS_{random}) hub connectivity scores (dark and light bars respectively) on the left scale, and the timetable synchronization index $Sync$ (bubbles) on the right scale. Detailed results in table form are provided in the appendix B (Table B 1). LH in FRA offers by far the highest connectivity (WCS_{obs} =13,200). AF in CDG ranked second with WCS_{obs} of 9,000. KL in AMS, LH in MUC and TK in IST followed with WCS_{obs} ranging between 7,900 and 8,300. BA in LHR ranked sixth with WCS_{obs} of 6,500. Smaller hubs offered lower connectivity, WCS_{obs} of approx. 3,000 or less. In the reminding part of the paper we will refer to the top six hubs as "big hubs" and to the remaining hubs as "medium hubs".

Figure 2. Weighted connectivity score (WCS) and timetable synchronization index (*Sync*) of the 15 analyzed European hubs.
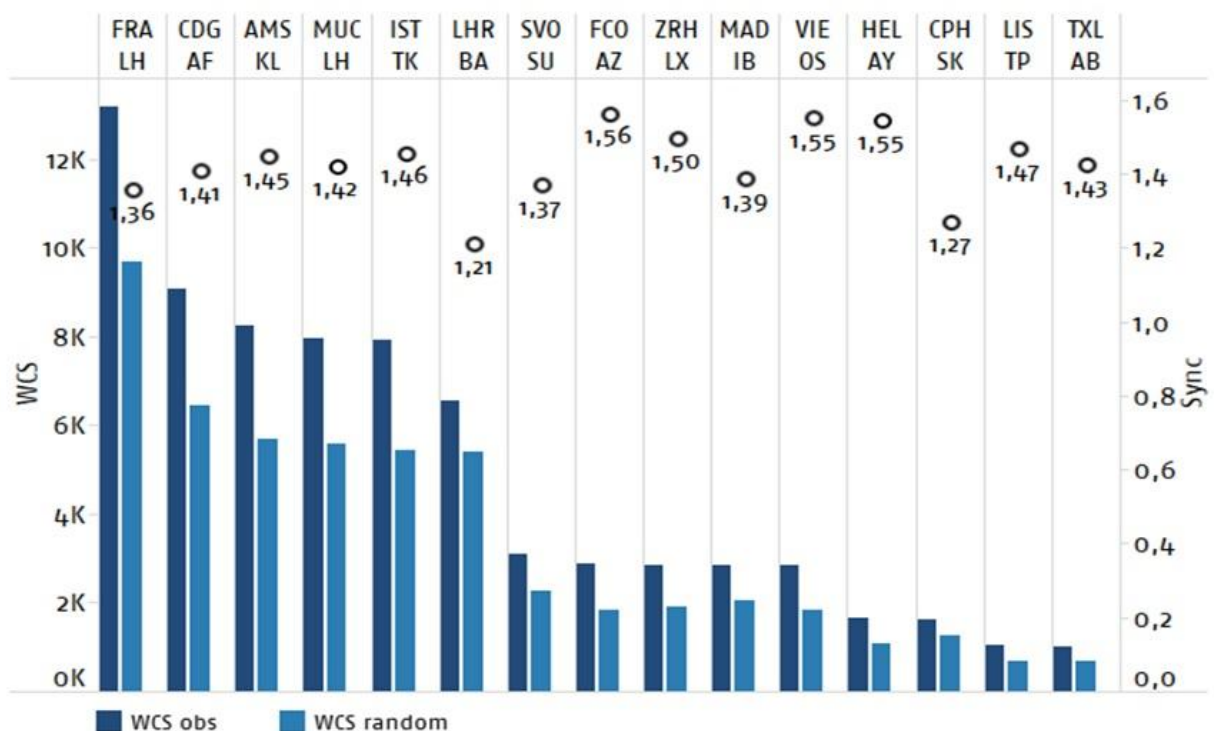
Timetable synchronization leverages the connectivity (measured with WCS) of the analyzed airline hubs by approx. 45% on average. There are of course considerable differences between individual carriers. The highest values of the timetable synchronization index $Sync$ can be observed for medium sized airlines: AZ in FCO, OS in VIE, AY in HEL and LX in ZRH. The temporal synchronization of flight arrivals and departures contributes to more than 50% increase of hub

connectivity of these carriers. Four of the big airline hubs: KL in AMS, TK in IST, LH in MUC and AF in CDG also show a high level of timetable synchronization with *Sync* ranging between 1.40 and 1.45. It is worth to point out that the flat wave structure of TK in IST, strongly focused on the directional connectivity, results in a similar *Sync* as the peaky wave structures of AF in CDG, KL in AMS and LH in MUC that operate more multidirectional waves (compare Figure 3 and Figure 5). Timetable synchronization of LH in FRA contributes to 36% increase in connectivity. Lower *Sync* for LH in FRA than for AF in CDG and KL in AMS that serve comparable networks can be explained by LH's rather flat wave system in FRA with a lot of overlap between individual waves. This is partly a consequence of a high congestion in FRA. At LHR, BA operates no evident wave system. Only the long-haul flights to Asian and African destinations form a connectivity driven wave pattern early in the morning (arrivals) and late in the evening (departures). On a side note, this is a typical timing pattern for flights from/to these regions also at all other big European hubs (see Figure 3 and Figure 5). The timetable synchronization index for BA in LHR equals 1.21, the lowest value of all analyzed hubs. LHR is the most congested airport in Europe so obviously the lack of a more connectivity driven wave system of BA in LHR is largely caused by the airport capacity shortage.

Figure 3. Wave patterns of selected carriers at their main hubs.
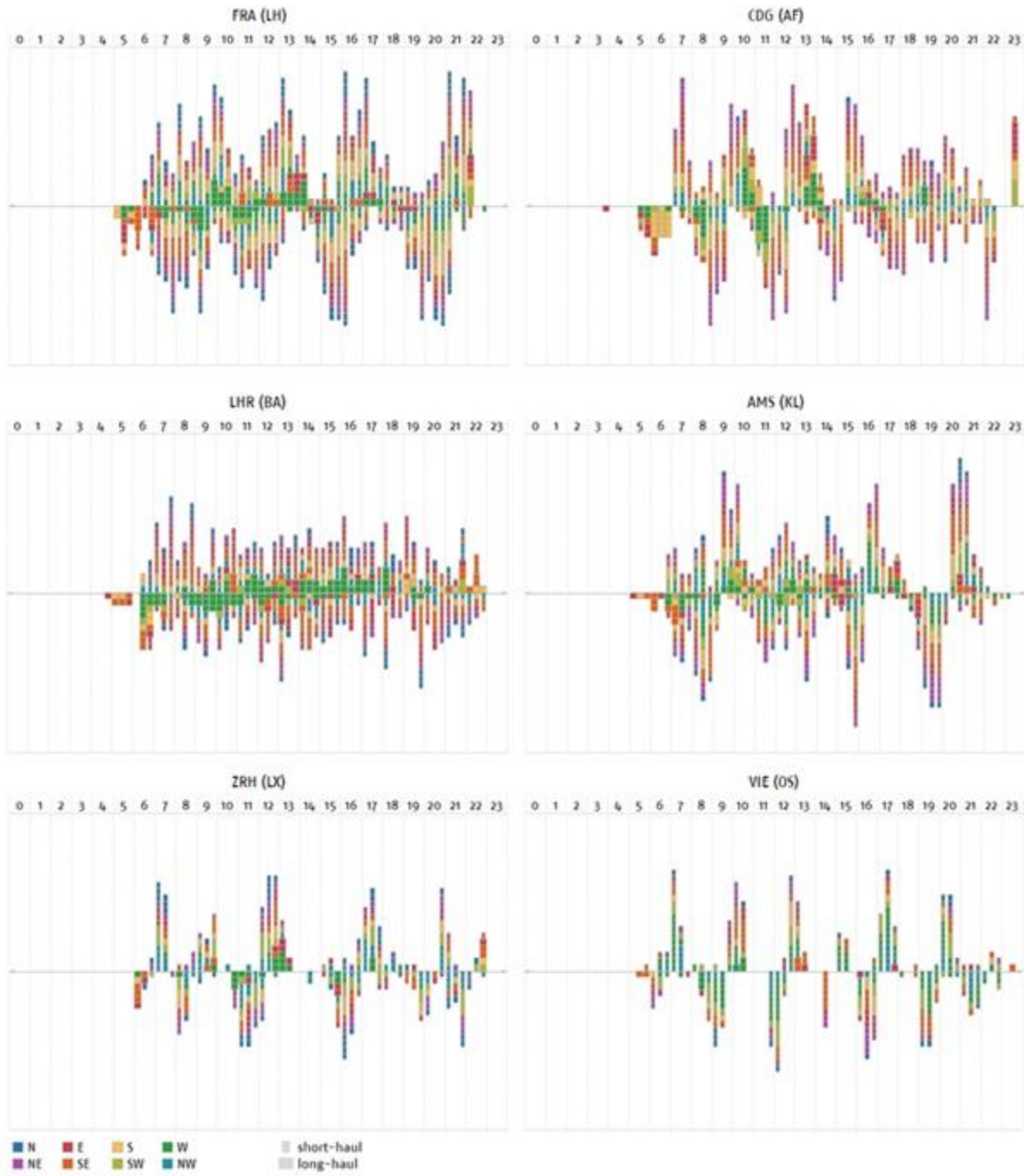
3.2   Long-haul Connectivity

Long-haul flights served with wide-body aircraft play a particularly important role for most network carriers, see e.g. (Burghouwt, 2014). Many long-haul operations fully depend on flights connecting at the hub to feed and de-feed with transfer passengers. Consequently, most carriers aim to maximize especially the connectivity on their long-haul flights by optimized temporal coordination of their feeder and de-feeder flights. Therefore, we further focus our analysis on the hub connectivity WCS_{obs} generated by long-haul flights (O&D distances greater than 4000km operated by a wide-body aircraft). We analyze what portion of airline connectivity at their hubs (WCS_{obs}) is generated by long-haul flights and we compare the impact of timetable synchronization ($Sync$) on connectivity of long-haul vs. short-haul flights.

Figure 4. Weighted connectivity score (WCS_{obs}) and timetable synchronization index ($Sync$) of the 15 analyzed European hubs. Long-haul vs. short-haul flight connectivity.
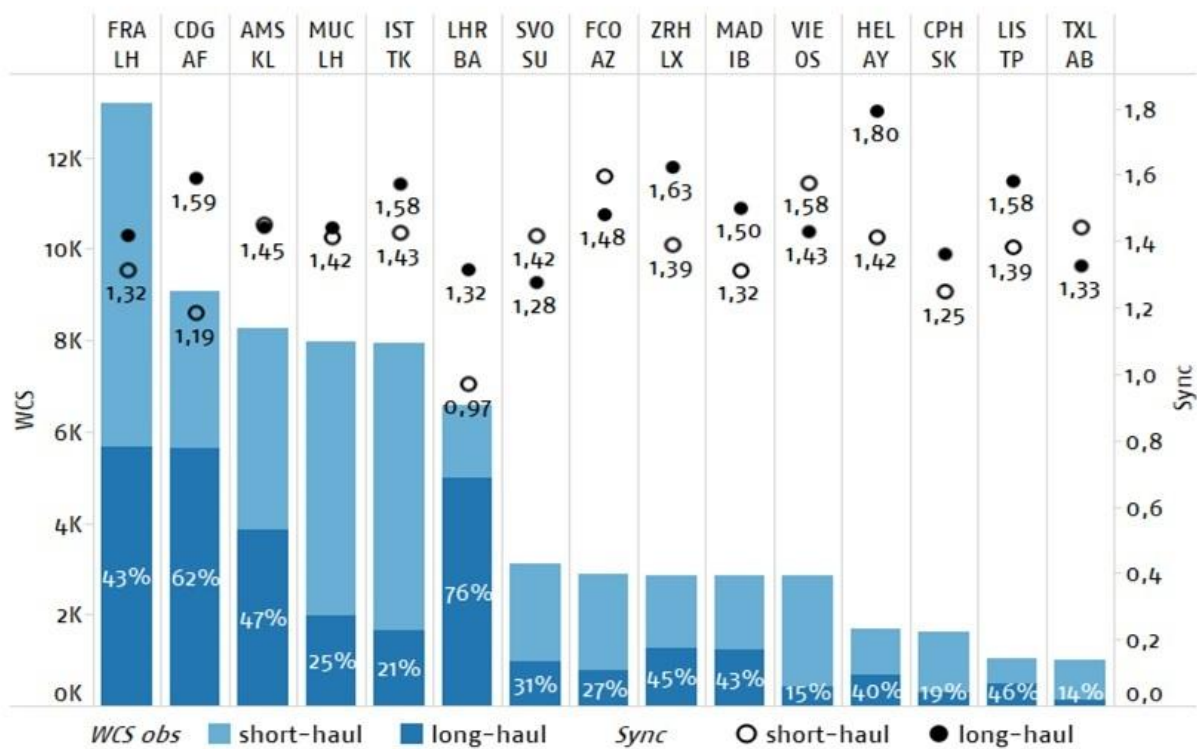
Results are illustrated in Figure 6. The share of WCS_{obs} generated by long-haul flights (dark blue bars) is very different across the analyzed airline hubs. It ranges from 76% for BA in LHR and 62% for AF in CDG to less than 20% for OS, SK and AB in VIE, CPH, and TXL respectively. At FRA, AMS, ZRH, MAD, HEL and LIS this share ranges between 40% and 50%; in MUC, IST, SVO and FCO between 20% and 30%. Detailed results are provided in the appendix B (Table B 2).

As expected, for most of the analyzed carriers the level of timetable synchronization for long-haul flights is higher than for short-haul flights. The differences are particularly interesting for AF in CDG ($Sync_{long-haul}$=1.59 compared to $Sync_{short-haul}$=1.19) and BA in LHR $Sync_{long-haul}$=1.32 compared to $Sync_{short-haul}$=0.97). In case of BA the temporal synchronization index for the short-haul flights is even slightly below the random expectation. These results suggest that both AF and BA focus mainly on their long-haul connectivity. The highest $Sync$ in our analysis can be observed for the long-haul flights in HEL ($Sync_{long-haul}$=1,80), where AY operates a specific system of one dominant and two supplementary waves focused on the Europe to Asia connectivity, see Figure 3.

Interestingly, for some carriers (OS, AZ, SU and AB) the temporal schedule synchronization appears to leverage the connectivity of short-haul flights stronger than of the long-haul flights. These carriers, with exceptions of SU, operate a very peaky wave systems (see e.g. OS in VIE in Figure 5) that result in a good connectivity of all flights, short-haul as well as long-haul. This is particularly true in the case of AZ in FCO and OS in VIE where $Sync$ equals respectively: 1.6 and 1.58 for the short-haul flights and 1.48 and 1.43 for the long-haul flights. Consequently, higher $Sync_{short-haul}$ than $Sync_{long-haul}$ for these carriers is a result of a very good temporal synchronization of the short-haul network rather than a poor synchronization of the long-haul connections.

3.3   Sensitivity to Parameter Settings of WCS

The above analyses built upon the base CB setting of maximum connection lag (see set II in Figure 1). *MaxConLag* also serves as a parameter of the weighted connectivity score *WCS*, see section 2.2. Using less restrictive settings of *maxConnLag* (set I) would result in slower connections getting a relatively higher score. Analogically, more restrictive parameter settings (set III) would result in relatively lower scores of slower connections. Consider for example, two connections between Gothenburg and Barcelona with connection lag of 2 and 3 hours respectively. The maximum connection lag allowed for these connections (2000km O&D distance) is roughly 6 hours if we use set I, 5 hours if we use set II (the base one), and 4 hours if we use set III. Depending on the used parameter set, the resulting score for the first (faster) connection equals 0.67 (set I), 0.6 (set II) and 0.5 (set III), and for the second (slower) connection it equals 0.5, 0.4, and 0.25 respectively. The relative quality difference between these two connections is greater if the score is calculated using the more restrictive set III (0.5 vs. 0.25) than if it is calculated using the less restrictive set I (0.67 vs. 0,5). As result, choosing more restrictive (more trip time sensitive) parameters of *WCS* assigns relatively higher weight to faster connections.

Results of applying the three different parameter sets (I, II, and III, worldwide connecting passenger coverage of approx. 98%, 95% and 90% respectively) to the connectivity analysis of the

European carriers are shown in Figure 7. Hub connectivity resulting from the real schedule WCS_{obs} is plotted on the left axis (bars) and the timetable synchronization index $Sync$ on the right axis (bubbles). Detailed results are given in the appendix B (Table B 3). For all analyzed hubs the timetable synchronization index $Sync$ is highest if calculated using WCS based on set III (the most trip time sensitive set, lowest passenger coverage, relatively lower score assigned to slow connections). This is expected since most carriers aim to optimize not only the number of available connections but also the quality of the connections in terms of their overall trip time.

The sensitivity of $Sync$ to the parameter settings of WCS (sets I, II, and III) differs across the analyzed hubs. For OS in VIE and LX in ZRH Sync calculated with set III is more than 0.2 higher than $Sync$ calculated with set I; 1.69 vs. 1.45 (OS) and 1.62 vs. 1.39 (LX). For the biggest airline hubs (LH in FRA and MUC, AF in CDG, KL in AMS) the difference between set I and set III is lower and ranges between 0.07 and 0.11; for TK in IST it equals 0.05 and for BA in LHR only 0.01. A higher sensitivity to the parameter settings of WCS (larger differences) is observed for carriers that focus on fast connections, see wave-patters in Figure 3 and Figure 5. For example, OS and LX both operate a system of many short (1-2 hours) and almost non-overlapping waves that results in very short connection times. The systems of LH, AF and KL are characterized by longer and more overlapping waves that lead to slower connection times. The flat wave-structure of BA in LHR does not facilitate fast connections.

Figure 7. Weighted connectivity score (WCS_{obs}) and timetable synchronization index ($Sync$) for the 15 analyzed European hubs calculated using three different parameter sets of WCS.
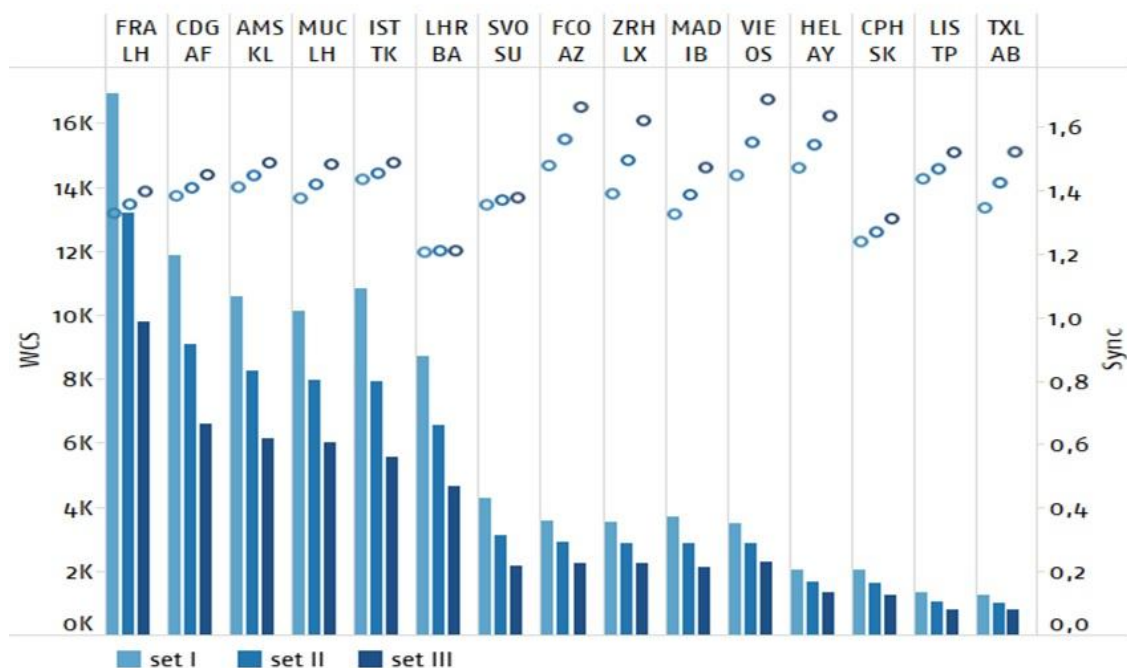
The analysis of the overall connectivity performance of hubs and the according ranking also depends on the parameter settings of *WCS*. Choosing more trip time sensitive parameters of *WCS* leads to a relatively lower weighting of slow connections. Thus, it "rewards" carriers that focus on fast connections. Overall, the hub performance ranking based on *WCS* calculated on sets I, II and III is similar; with LH in FRA being the top airline hub, AF in CDG ranked second, KL in AMS, LH in MUC and TK in IST better than BA in LHR and way better than the remaining medium hubs. However, there are some differences when comparing individual hubs. For example, TK in IST scores slightly better than KL in AMS and LH in MUC if *WCS* is based on the least restrictive set I (relatively high weight assigned to slow connections) but KL and LH (that offer faster connections than TK) score considerably better if *WCS* is based on the more trip time sensitive set III. Similar differences can be observed when comparing LX in ZRH and OS in VIE (focused on fast connections) with SU in SVO or IB in MAD (slower hubs). It is worth to point out, that other studies on hub connectivity also lead to different hub performance rankings depending on the connectivity measure applied. Burghouwt and Redondi (2013) compared the connectivity of European hubs according to various metrics. They found that e.g. LHR (that serves no connectivity driven wave pattern and generates mainly slow connections) scored higher than AMS and MUC according to the less trip-time sensitive connectivity metric of Burghouwt and de Wit (2005) but these hubs ranked in reverse order according to the more restrictive metric of Danesi (2006). This confirms our observations that using a more trip time sensitive measure results in relatively higher connectivity performance indicators of hubs that focus on fast connections. It is therefore recommended for the airline analysts and network planners to use a broad set connectivity metrics and/or settings that put a different weight to various aspects of connection quality rather than to focus only on one aggregate performance indicator.

4   CONCLUSIONS AND FUTURE RESEARCH

This paper analyzed the net impact of timetable synchronization on the connectivity of the top European carriers at their main hubs. For each carrier, we evaluated its hub connectivity resulting from the existing schedule and compared it to the average connectivity calculated from one hundred randomized schedule scenarios. In each schedule scenario, we randomly varied the flight departure and arrival times within the operation hours at a hub and at outbound stations keeping all other parameters of airline schedule unchanged. We measured hub connectivity using the weighted connectivity score (*WCS*) calculated as a quality-weighted number of airline online, single-stop connections generated at a given hub.

Using the base parameter setting of *WCS* selected for this study, we observed that the timetable synchronization leverages the hub connectivity of most analyzed carriers by 40%-60%. In general, airlines that operate systems of many short and non-overlapping hub waves achieve the highest increase of their hub connectivity. Such design of timetable is not possible at highly congested airports where airlines have to manoeuvre within limited airport capacity. Especially at such airports, it is important to identify flights with the highest connectivity potential and to leverage this potential by a careful and systematic coordination within the available slot framework. Typically, long-haul flights contribute most to the airline connectivity at hubs and they are also best coordinated within the timetables of the analyzed European carriers. Taking the directionality of inbound and outbound flights into account, airlines have to plan their directional traffic flows to not dilute flights with a good detour factor with long connection times and vice versa. With a well panned directional wave structure an airline can greatly improve its connectivity even on a strongly congested airport. This is for example the case of TK in IST; although its wave structure is rather flat, TK leverages its connectivity comparable or even better than the other big European carriers that operate more multi-directional and peaky wave systems at their main hubs. A good temporal coordination of directional waves is also a prerequisite to utilize the competitive advantage of medium-sized airlines in their strategic market, e.g. connecting traffic between Europe and North-East Asia in case of AY in HEL or between Europe and South America in case of TP in LIS.

The application of the approach presented in this paper can help airlines to better assess how their timetable leverages connectivity at their hubs and/ sub-networks. It can be used to benchmark and monitor the performance of competitors and to evaluate various schedule scenarios, especially when re-designing the airline network at strategic level.

This study has some limitations and can be enhanced in future research and in practical applications. In this paper we focused on the online connectivity of the analyzed carriers. To our knowledge, for most carriers the online perspective remains the primary performance indicator by the design of timetables at strategic level. However, given the increasing role of globalization and airline partnerships, the analysis can be extended in practical applications to take into account airline connectivity with its code-share and/or alliance partners. In such analysis it is recommended to take into account various degrees of airline partnership. Some airlines partner only on specific flights. Some don't partner at all, even if they belong to the same global alliance. Consequently, additional steps and assumptions might be needed to differentiate what share of partner connectivity (e.g. within an alliance) is leveraged by the joined coordination of timetables and what share is determined by the level of partnership (or lack of it) between the corresponding partners or alliance members.

The *WCS* connectivity metric used in this study was calculated based on the number of airline connections at hub and their quality in terms of trip time. There are of course many other factors that determine the attractiveness flight connections to passengers and their value for an airline. Since the randomized schedule scenarios can be analyzed in a similar way as the existing schedules the *WCS* connectivity metric can be enhanced with additional weighting criteria (e.g. seat capacity, flight distance, demand potential of origins and destinations, O&D traffic volume, number and quality of competing connections on an O&D (Allrogeen et al., 2015; Grosche et al., 2015; Redondi et al., 2011) or even replaced by performance indicators calculated based on more complex models used in network planning such as e.g. itinerary choice modeling combined with demand estimations (Grosche, 2009; Lieshout et al., 2005).

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Appendix A

Table A 1. Airline and airport codes.

Airline	Hub
LH - Lufthansa	FRA - Frankfurt
AF - Air France	CDG - Paris Charles de Gaulle
KL - KLM Royal Dutch Airlines	AMS - Amsterdam Schiphol
LH - Lufthansa	MUC - Munich
TK - Turkish Airlines	IST - Istanbul Atatürk
BA - British Airways	LHR - London Heathrow
SU - Aeroflot	SVO - Moscow Sheremetyevo
AZ - Alitalia	FCO - Rome Fiumicino
LX - Swiss International Airlines	ZRH - Zurich
IB - Iberia	MAD - Mardid Barajas
OS - Austrian Airlines	VIE - Vienna
AY - Finnair	HEL - Helsinki Vantaa
SK - SAS Scandinavian Airlines	CPH - Copenhagen Kastrup
TP - TAP Portugal	LIS - Lisbon
AB - Air Berlin	TXL - Berlin Tegel

Appendix B

Table B 1. Weighted connectivity score (WCS) and timetable synchronization index (Sync) of the 15 analyzed European hubs.

Airline	Hub	WCS obs	WCS random	Sync
LH	FRA	13178	9693	1.36
AF	CDG	9078	6432	1.41
KL	AMS	8268	5701	1.45
LH	MUC	7961	5597	1.42
TK	IST	7943	5450	1.46
BA	LHR	6575	5419	1.21
SU	SVO	3113	2268	1.37
AZ	FCO	2892	1850	1.56
LX	ZRH	2846	1903	1.50
IB	MAD	2845	2047	1.39

Airline	Hub								
OS	VIE	2844		1830		1.55			
AY	HEL	1669		1079		1.55			
SK	CPH	1615		1270		1.27			
TP	LIS	1032		702		1.47			
AB	TXL	998		699		1.43			

Table B 2. Weighted connectivity score (WCS obs) and timetable synchronization index (Sync) of the 15 analyzed European hubs. Long-haul vs. short-haul flight connectivity.

Airline	Hub	WCS obs total	WCS obs long-haul	WCS obs short-haul	% share obs long-haul	% share obs short-haul	Sync total	Sync long-haul	Sync short-haul
LH	FRA	13178	5685	7493	43%	57%	1.36	1.42	1.32
AF	CDG	9078	5651	3427	62%	38%	1.41	1.59	1.19
KL	AMS	8268	3864	4404	47%	53%	1.45	1.45	1.45
LH	MUC	7961	1990	5971	25%	75%	1.42	1.44	1.42
TK	IST	7943	1648	6295	21%	79%	1.46	1.58	1.43
BA	LHR	6575	4975	1600	76%	24%	1.21	1.32	0.97
SU	SVO	3113	969	2144	31%	69%	1.37	1.28	1.42
AZ	FCO	2892	788	2104	27%	73%	1.56	1.48	1.60
LX	ZRH	2846	1271	1575	45%	55%	1.50	1.63	1.39
IB	MAD	2845	1222	1622	43%	57%	1.39	1.50	1.32
OS	VIE	2844	432	2413	15%	85%	1.55	1.43	1.58
AY	HEL	1669	670	999	40%	60%	1.55	1.80	1.42
SK	CPH	1615	307	1309	19%	81%	1.27	1.36	1.25
TP	LIS	1032	477	555	46%	54%	1.47	1.58	1.39
AB	TXL	998	144	854	14%	86%	1.43	1.33	1.45

Table B3. Weighted connectivity score (WCS obs) and timetable synchronization index (Sync) for the 15 analyzed European hubs calculated using three different parameter sets of WCS.

Airline	Hub	WCS obs set I	WCS obs set II (base)	WCS obs set III	Sync set I	Sync set II (base)	Sync set III
LH	FRA	16913	13178	9782	1.33	1.36	1.40
AF	CDG	11883	9078	6613	1.39	1.41	1.45
KL	AMS	10597	8268	6131	1.41	1.45	1.49
LH	MUC	10115	7961	5998	1.38	1.42	1.49
TK	IST	10831	7943	5575	1.44	1.46	1.49
BA	LHR	8711	6575	4658	1.21	1.21	1.21
SU	SVO	4281	3113	2141	1.36	1.37	1.38
AZ	FCO	3573	2892	2227	1.48	1.56	1.67
LX	ZRH	3519	2846	2239	1.39	1.50	1.62
IB	MAD	3677	2845	2105	1.33	1.39	1.48
OS	VIE	3466	2844	2285	1.45	1.55	1.69
AY	HEL	2032	1669	1329	1.47	1.55	1.64
SK	CPH	2049	1615	1226	1.24	1.27	1.31
TP	LIS	1319	1032	782	1.44	1.47	1.52
AB	TXL	1239	998	772	1.35	1.43	1.52

AIRLINE FARES: A COMPARISON BETWEEN SPANISH AND FRENCH TRAVEL AGENCIES

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ABSTRACT

The existence of different types of intermediaries - e-tailers, traditional or offline retailers and multichannel retailers - engaged in the sale of airline tickets has enabled consumers to find different prices if they spend time searching for information. This has prompted internet marketing research to increasingly focus on the issue of pricing, analyzing the differences between these retailers with respects to price levels, price dispersion, pricing strategies, etc. Moreover, there are also studies examining the effects of culture on prices. However, there is no literature on the effects of the culture from the supplier point of view. This paper attempts to fill in the gap by studying whether the geographical locations of the travel agencies affect airline ticket prices. In particular, the study compares the price behavior of French and Spanish intermediaries operating exclusively online and those operating simultaneously in travel agencies and on the internet (offline and online). To this end, we consider three routes that connect Madrid, Paris and New York, with data starting four months prior to the departure date (December 16, 2013). The results show several differences in the price levels and price dispersion between intermediaries in relation to the type of retailer and their geographical locations.

Keywords: *Price, e-tailers, multichannel retailers, location.*

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1. INTRODUCTION

The internet has revolutionized distribution channels, affecting both business models and consumer purchasing behavior. The internet provides more detailed and immediate information about consumer decision-making behavior (e.g. products searched, products bought, pages visited, and so on). At the same time, the nature of the environment and information management tools provide a more flexible and easier way to change prices more regularly (Huang et al., 2005).

In order to analyze price behavior, many papers consider the price level or price dispersion with respect to different types of retailers. This study focuses on both price level and price dispersion with respect to e-tailers and multichannel retailers, more specifically, in the case of airline fares, as an increasingly large proportion of the air tickets are sold online. We must take into account that the 72% of the European Union population used internet at least once in 2013 and 47% of the population aged between 16 and 74 years old purchased something on internet at least once in the last year (Digital Agenda for Europe Scoreboard 2014). Hotel and travel booking account for 54% of the goods and services sold on internet to personal consumers in 2014.

Moreover, the growth of internet as a sales channel has led to a process of globalization in terms of the products marketed through this channel. Thus, customers from different countries and geographical locations can simultaneously access the internet to purchase airline tickets. As a result, research has been developed that studies how culture influences the management and purchase of airline tickets via this channel. In this regard, we have studied retailers from two countries, France and Spain, in order to analyze the effect of the retailers' geographical location on price behavior.

Although many studies that analyze the online purchase channels, most of them focus on the effect of the demand characteristics and there are few studies that consider the behavior taking into account the supplier characteristics. To this end, we analyze price behavior taking into account price variability and price level in order to determine if the retailer type and geographical location significantly affect these prices. Specifically, we have studied Spanish and French travel agencies that also have websites to sell their products, as well as one virtual travel agency that operates in the Spanish and French markets using different domains (.es and .fr, respectively). Thus, in Section 2 we carry out a literature review in order to establish the state of the research on the topic considered in this paper. In Section 3 we explain the procedure used to obtain the information and in Section 4 the main results obtained. Finally, Section 5 describes the main conclusions and future research lines arising from the main limitations of this paper.

2. LITERATURE REVIEW

Internet allows consumers to have more information about products and prices thus are able to make better choices. One of the sectors most affected by the emergence of internet as sales channel is the airline industry considering the price as a key element in the election of the sale channel. In this sector, as in other, internet has led to the emergence of three types of retailers: pure-play internet e-tailers; traditional or offline retailers; and multichannel retailers (Zettelmeyer, 2000).

This situation has led several authors to study the differences in price level and price dispersion between online and offline retailers, although there is some disagreement in the results. Thus, Bailey (1998), Erevelles et al. (2001), Clay et al. (2002) and Lee and Gosain (2002) studied different kinds of products and concluded that price dispersion is higher on the internet, while the results of Morton et al. (2001) and Brown and Goolsbee (2002) attested to a lower dispersion on the internet. Moreover, the results of other papers show different behavior depending on the dispersion measurement or other characteristics. For example, Brynjolfsson and Smith (2000) concluded that when they used market-share weighting the price dispersion is lower on the internet and without this weighting the price dispersion is higher on the internet. Ancarani and Shankar (2004) revealed similar findings, whereby in terms of price range the results show higher dispersion online, but the opposite is true in terms of price standard deviation. Scholten and Smith (2002), on the other hand, concluded that the dispersion is the same in both channels. Andrés et al. (2014) showed that in the case of airline tickets, average prices are lower on Internet than in other sales channels.

In the literature on airline pricing, there are many papers analyzing the price level (Morton et al., 2001; Ancarani and Shankar, 2004; Stylianou et al., 2005; Zettelmeyer et al., 2006; Huang and Swaminathan, 2009; Gaggero and Piga, 2010; Alfaro et al., 2015); price evolution (Friesen, 2005; Alegre and Sard, 2008; Gillen and Mantin, 2009; Clark and Vincent, 2012); or price dispersion (Kannan and Kopalle, 2001; Clemons et al., 2002; Kung et al., 2002, Huang et al., 2005; Bakos et al., 2005; Stylianou et al., 2005; Alderighi, 2010; Gaggero and Piga, 2011; Obermeyer et al., 2013; Hernandez and Wiggins, 2014) in relation to different kinds of intermediaries.

Furthermore, there is growing consensus in the literature related to the importance of the role of cultural differences in consumer behavior. In this sense, Hofstede (1980, 21) defined culture as: "the collective programming of the mind which distinguishes members of one group or category of people from another". In addition, he considered five cultural dimensions: power distance, individualism, masculinity, uncertainty avoidance and long-term orientation. There are basically two

lines of analysis regarding the effect of culture on customers: one studies the online travel planning behavior and the other considers the role of cultural differences in individuals' use of computers, internet use, online search behaviors and perceived risk of using the internet to purchase goods and services. In terms of the former, the papers of McLellan and Fousher (1983), Richardson and Crompton (1988), Luk et al. (1994), Pizam and Sussmann (1995), Pizam and Jeong (1996), Huang et al. (1996), Armstrong et al. (1997), Sussmann and Rashcovsky (1997), Kozak and Nield (1998), Kozak (2001), Yoon (2009), Ruiz et al. (2013) and Jordan et al. (2013) stand out. The general conclusion of these papers is that culture has a clear influence on consumer behavior, with all papers revealing a significant difference in consumer behavior based on nationality. With respect to the other line of research, the papers of Jarvenpaa et al. (1999), Chen and Gursoy (2000), Park and Jun (2003), Gursoy and Umbreit (2004) and Li and Kirkup (2007) concluded that culture moderates the relationship between the individual and their use of the internet.

On the other hand, Clay and Tay (2001) analyzed the online price dispersion of textbooks in a cross-country market. They concluded that there is substantial price dispersion across the countries studied, specifically, USA, Canada, UK and Germany. However, many studies are limited to English speaking countries (Li, 2014) and others are focused on comparing disparate cultures such as Asian versus Western cultures, with scant research into differences between European cultures (Ruiz et al., 2013). Moreover, most papers consider the customer's point of view but do not examine the influence of culture on the prices offered by different retailers.

Thus, this paper analyzes the effect of cultural differences on airline ticket prices, contributing to the literature in two ways: First, we have taken a supply side perspective by analyzing the effect of travel agency geographical location on the price level and dispersion established by the retailer. Second, we have studied two European cultures, specifically those of Spain and France. Although, a priori, it might seem that Spanish and French cultures are too similar for comparison, the results do not support this. Finally, we have included two kinds of retailer in our study: travel agencies selling online as well as in a physical location (multichannel travel agency); and online travel agencies that have no physical premises. Unfortunately we have no information about purely offline travel agencies because it is more difficult to secure their collaboration, particularly when using two geographical locations.

3. DATA

In this paper we have examined the price of several flights through web pages devoted to booking and purchasing tickets. In order to include a sufficient number of flights and an in-demand route, we chose three routes: from Madrid to Paris; Madrid to New York; and Paris to New York, without stipulating a specific airport in the case of the latter destination. These routes consist of flights between the two capitals cities of the countries analyzed in this paper – France and Spain - and between the capital cities of these two countries and the high-demand destination of New York.

Firstly, we selected the companies that offer the specific flights analyzed in this paper and chose seven flights for each route, operated by different companies. For the Madrid-Paris route, we selected only direct flights operated by Air France (two flights at two different times), Iberia (two flights at two different times), Vueling and Easyjet (two flights at two different times). For the Madrid-New York route we chose direct flights with British Airways, Iberia, Finnair and American Airlines, as well as others that offer flights with a stopover, such as Aer Lingus, Turkish Airlines and Swiss. For the last route, we used direct flights operated by Iberia, Finnair, Air France and Luthansa, as well as flights with a stopover operated by Aer Lingus, Lot Polish and Swiss.

In order to find the price of the different flights, we used two types of intermediaries: those that only operate on the internet and those that operate in both traditional and virtual channels. We used only one online travel agency, lastminute, as we required an online travel agency that sells flights in different countries using different domains. Thus, lastminute offers their products in France on the www.lastminute.fr website, while in Spain the website is www.lastminute.es. In terms of travel agencies that use physical premises as well as a website to sell their products, we included the Spanish travel agencies Barcelo viajes, Nautalia and El Corte Inglés, while the French travel agencies included were Havas voyages, Look voyages and Promovacances.

The time period studied included flights departing on December 16, 2013 and returning five days later on December 21, 2013, in order to avoid peak holiday times and to obtain a representative sample of the off-peak season. The timeframe for the airfares in our database ranges from August 26 to two days before departure, because Nautalia, El Corte Inglés, Havas voyages and Look voyages do not sell flights any closer to the departure. Flight prices were monitored daily.

Finally, in the data analysis, for each kind of route and travel agency, we used the average price available each day among the prices offered by the different companies. However, in order to limit the possible options we have considered only flights with a maximum of one stopover for the specific route. The data analysis has been developed so as to study each route individually; analyzing all routes simultaneously would not have been logical. Accordingly, the Madrid-Paris route

is referred to as route 1, the Madrid-New York route as route 2 and the Paris-New York route as route 3. The main results obtained appear in the following section.

4. RESULTS

The data is analyzed in terms of price level and price dispersion. To analyze the price level we used the average price available each day and with this information we developed analyses of variance (ANOVA). We used the coefficient of variation to measure price dispersion as this is the best way to make comparisons.

To analyze the price average we have developed several analyses of variance (ANOVAs) in order to evaluate the differences in the average price with regards to the factors considered. In this case, we have examined two factors, each with two categories; the first factor is the country where the travel agency markets their product, that is, the geographical location. In this respect, we included Spanish and French travel agencies although the data were obtained via the internet. In terms of the online travel agencies we have differentiated based on their web domain. The other factor is the channel through which the products are marketed. In this regard, we distinguished between agencies with physical premises as well as online services, and those that only sell online, that is, between multichannel travel agencies and online travel agencies.

First, we develop an ANOVA for two factors to know, on the one hand, the main effects of both factors over the price and, on the other hand, if the interaction between factors is significant because as we have two factors, we can have a simultaneous influence of the two factors in the price. The results of this analysis for each route appear in tables 1, 2 and 3.

Table 1. Two-way ANOVA for flight price: route 1

	Sum of squares type III	df	Mean square	F	Sig.
Adjusted model	79950.580	3	26650.193	5.680	.001
Intersection	42966459.463	1	42966459.463	9157.502	.000
Geographical location	59606.947	1	59606.947	12.704	.000
Type of retailer	16546.527	1	16546.527	3.527	.061
Location * Retailer	4720.736	1	4720.736	1.006	.316
Error	4147675.752	884	4691.941		
Total	62645989.064	888			
Adjusted total	4227626.332	887			

Source: Own elaboration

Table 2. Two-way ANOVA for flight price: route 2

	Sum of squares type III	df	Mean square	F	Sig.
Adjusted model	2675259.483	3	891753.161	5.021	.002
Intersection	1.457E9	1	1.457E9	8203.251	.000
Geographical location	79240.137	1	79240.137	.446	.504
Type of retailer	2305013.795	1	2305013.795	12.978	.000
Location * Retailer	106555.681	1	106555.681	.600	.439
Error	1.570E8	884	177616.010		
Total	2.180E9	888			
Adjusted total	1.597E8	887			

Source: Own elaboration

Table 3. Two-way ANOVA for flight price: route 3

	Sum of squares type III	df	Mean square	F	Sig.
Adjusted model	3497502.030	3	1165834.010	8.956	.000
Intersection	1.193E9	1	1.193E9	9165.776	.000
Geographical location	33775.772	1	33775.772	.259	.611
Type of retailer	2911581.146	1	2911581.146	22.367	.000
Location * Retailer	304286.782	1	304286.782	2.338	.127
Error	1.151E8	884	130175.516		
Total	1.789E9	888			
Adjusted total	1.186E8	887			

Source: Own elaboration

The results in these tables show that average flight prices differ significantly when taking into account the two factors separately but the interaction, that appears in the table as Location*Retailer, is not significant. Therefore, we analyze the individual effects since consider the interactions, when these are not significant in any of the case, complicate the results interpretation. Thus, in the case of route 1, average prices differ significantly in relation to the geographical location. For the other routes, the type of retailer is the factor with significant differences. Nevertheless, in route 1 the differences between average prices in function of the type of retailer are significant at the 6% level and, therefore, we include this factor in the subsequent analysis. These results are to be expected as significant differences are only found for the Madrid-Paris route, whereas for the other routes the differences in the average price are not significant.

These results require the development of single-factor ANOVAs that separately examine the factor with significant differences for each route. Furthermore, it should be borne in mind that the factors used only have two values and, therefore, it is not possible to develop a post-hoc analysis. First of all, we identify the statistic that can be used to carry out the analysis of variance for one factor by checking for variance homogeneity. In order to do so, we have used the Levene statistic, the results of which can be observed in Table 4.

Table 4. Variance homogeneity test

Factor	Route	Levene statistic	df1	df2	Sig.
Geographical location	**1**	80.352	1	886	.000
Type of retailer	**1**	4.048	1	886	.045
Type of retailer	**2**	18.032	1	886	.000
Type of retailer	**3**	22.075	1	886	.000

Source: Own elaboration

The results in Table 4 verify that the variances are not homogeneous and, therefore, that we can use the Welch statistic to perform the analysis of variance in all of the cases.

Table 5. Flight price analysis of variance

Factor	Route	df1	df2	Welch	Sig.
Geographical location	**1**	1	819.989	12.472	.000
Type of retailer	**1**	1	354.110	3.205	.074
Type of retailer	**2**	1	529.986	18.032	.000
Type of retailer	**3**	1	536.073	31.294	.000

Source: Own elaboration

The results in Table 5 verify the results in Tables 1, 2 and 3 since when we analyze the factors separately, the difference in the average price according to the type of retailer for route 1 is significant, but at a significance level of 7.4%. With regards the geographical location, the results for route 1 show significant differences in the averages. For the other routes, there are significant differences in the average price in relation to the type of retailer. After analyzing these results, we calculated the average price for the flights in relation to the different options for these factors. The results are shown in Table 6.

Table 6. Average prices

		Multichannel agency	Online agency	Total
Route 1	**Spain**	252.182	236.889	248.359
	France	265.779	261.135	264.618
	Total	258.981	249.012	256.489
Route 2	**Spain**	1561.485	1418.527	1525.745
	France	1514.371	1422.009	1491.281
	Total	1537.928	1420.268	1508.513
Route 3	**Spain**	1433.096	1258.108	1389.349
	France	1376.104	1286.615	1353.732
	Total	1404.599	1272.362	1371.540

Source: Own elaboration.

The lowest price for all routes was found via the online travel agencies although, as we have shown in Table 5, the differences in the average prices for routes 2 and 3 are significant only at the 5% level.

Taking into account the geographical location of the travel agency, the lowest price for route 1 was offered by the Spanish agencies, while the lowest price for the other two routes was offered by the French agencies. These differences, however, are not significant. In addition, the lowest average price for all flights was found via the Spanish online travel agency.

Another important aspect in the analysis of price behaviour is price dispersion; however, there is no consensus in the literature as to the most accurate measurement to use in order to measure the variability. In this paper, we have used the coefficient of variation because this measurement of relative dispersion allows us to better compare the results obtained in function of the different factors considered. Table 7 shows the price dispersion in relation to the geographical location of the travel agencies and the type of retailer.

Table 7. Price dispersion (variation coefficient)

		Multichannel agency	Online agency	Total
Route 1	**Spain**	0.233	0.230	0.234
	France	0.281	0.332	0.294
	Total	0.260	0.294	0.269
Route 2	**Spain**	0.300	0.224	0.289
	France	0.284	0.229	0.273
	Total	0.293	0.226	0.281
Route 3	**Spain**	0.260	0.200	0.255
	France	0.290	0.228	0.278
	Total	0.275	0.214	0.267

Source: Own elaboration

The results in terms of price dispersion do not demonstrate a clear behavior pattern. Thus, for routes 1 and 3 the highest price dispersion in relation to the geographical location is found for French travel agencies, while for route 2, Spanish travel agencies show the highest dispersion. In terms of the type of retailer, the results show that for route 1 the highest dispersion is found in online travel agencies' prices, while for the other two routes, this dispersion is highest for the multichannel travel agencies. Surprisingly, however, if we consider the two factors together, it is always the Spanish online travel agencies that show the lowest price dispersion.

5. CONCLUSIONS

The emergence of the internet as sales channel, driven by customers attempting to find the lowest prices, has prompted many research papers to analyze the price in the online purchase process. These papers consider different aspects related to prices and work under the assumption that culture is a key factor determining customer behavior. However, there are few papers in the literature that examine the effect of culture from the perspective of the seller.

Consequently, this paper contributes to the literature by analyzing the effect of the geographical location of the travel agencies and the type of retailer on price behavior. In order to analyze the price behavior we included three different routes for six multichannel travel agencies and two online agencies. Specifically, we studied price level and price dispersion using the average price and coefficient of variation respectively.

The results show that the price level is lower for the online travel agencies and that the lowest average price was found for Spanish online travel agencies. However, in terms of price dispersion there is no clear behavior pattern: the highest or lowest values of the coefficient of variation change according to the different routes. One element to highlight is that the lowest price dispersion was found in Spanish online travel agencies' prices. This indicates, therefore, that this kind of travel agency offers the lowest prices and that these prices do not change notably.

The main limitation of this paper, which at the same time opens up future research lines, is related to the information gathered. First, it would be beneficial to collect information from a travel agency that only sells its products out of its physical premises. These days, however, it is very difficult to find such a travel agency and it would be practically impossible for them to collaborate with us. Second, we could expand the analysis by including information about more routes and travel characteristics. For example, we could examine destinations with different characteristics (tourist/non-tourist), different dates of travel, and so on. Finally, with regards to online travel agencies we have considered only lastminute because it is the most obvious example of a website with different domains in Spain and France, although further research would allow us to find other online travel agencies and thus to collect more information from this kind of travel agency.

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THE PARADOX OF COMPETITION FOR AIRLINE PASSENGERS
WITH REDUCED MOBILITY (PRM)

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ABSTRACT

Airline competition with customer service as product differentiator has forced down costs, air fares and investor returns. Two passenger markets operate in aviation: (a) able-bodied passengers for whom airlines compete and (b) passengers with reduced mobility (PRMs) – disabled by age, obesity or medical problems – for whom airlines do not compete. Government interference in the market intended to protect a minority of narrowly-defined PRMs has had unintended consequences of enabling increasing numbers of more widely-defined PRMs to access complimentary airline provisions. With growing ageing and overweight populations and long-haul travelling medical tourists such regulation could lead to even lower investors' returns. The International Air Transport Association (IATA) (2013) examined the air transport value chain for competitiveness using Porter's (2008) five forces but did not distinguish between able-bodied passengers and PRMs. Findings during an investigation of these two markets concurred with IATA-Porter that the markets for the bargaining powers of PRM buyers and PRM suppliers were highly competitive. However, in contrast to the IATA conclusions, intensity of competition, and threats from new entrants and substitute products for PRM travel were low. The conclusion is that airlines are strategically PRM defensive by omission. Paradoxically, the airline which delivers the best PRM customer service could become the least profitable.

Keywords: *disabled passengers, costs, regulation, competitiveness.*

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1. INTRODUCTION

Historically, airline profits have been very thin improving from 3.8% in 1996-2004 to 4.1% in 2004-2011 according to the International Air Transport Association (IATA) briefing on profitability and problems in the air transport value chain (IATA, 2013). Airline industry returns are not regarded as 'normal' for investors whose support is needed to keep pace with industry improvements. Net profit per passenger of $US2.56 makes the industry vulnerable to rises in costs, taxes, demand and inefficiently designed regulations which affect the allocation of risk (*ibid*). Generally, airlines compete for passengers. However what is not recognised is that there are actually two passenger markets – one for able-bodied passengers and another for passengers with reduced mobility (PRMs). The composition of the PRM market has evolved from the lone wheelchair traveller to increasing numbers of mobility-impaired elderly, obese and medically incapacitated passengers who require airline assistance beyond that required by able-bodied passengers. PRMs often request discounts for their travel companions and for the additional seat sometimes needed for obese passengers. PRM service expectations can be extremely high. Chan and Chen's (2012) study of expectations of elderly travellers found their wants included "special services … seat selection… exclusive Customs counter [and] priority boarding … [furthermore] current air transport services do not meet their demands." (Chang and Chen, 2012: 27).

The International Air Transport Association (IATA) (2013) examined the air transport value chain for competitiveness using Porter's (2008) five forces but did not distinguish between able-bodied passengers and PRMs. The purpose of this paper is to review the five forces of competitiveness as assessed in Porter's airline industry competitiveness report (IATA, 2013) and test their validity for the PRM market.

2. GOVERNMENT AND AIRLINE PRIVATISATION

Many airlines were once owned and controlled by governments which starved them of the investment needed to grow and compete (Doganis, 2001). Doganis in his text on aviation evolution, noted that privatisation preparations should have included identification of "any explicit or hidden subsidies provided by government or government enterprises… [and]…since the airline will no longer receive direct or hidden subsidies it should not be required to undertake any non-commercial activities ... any obligations placed upon the airline which impose a loss should ideally be paid for by central or local government." (Doganis: 2001:196-7). At the time of privatisations many people relied on state subsidies for financial and social support. This financial assistance would eventually continue from many newly-privatised industries – but not for airlines. State aid to airlines should have been "considered as partial or even full compensation for past or present costs and penalties

imposed on state airlines by government actions." (Doganis, 2001: 203). "As recently as the 1980s, the flag carriers were habitually regarded, and often regarded themselves, as having as their primary function the fulfilment of some public need … an aim that had little to do with their own business. They were often perceived as a mere extension of a state service." (Kangis and O'Reilly, 2003: 105). This philosophy has subsequently been absorbed into social and human rights legislation.

3. GOVERNMENT REGULATION, PRM AND AIRLINES

Within the European Union (EU), governments wanted to ensure that after privatisation the airlines continued with social obligations. Article 2(a) of EU Regulation (EC) No 1107/2006 states:

"Disabled person" or "person with reduced mobility" means any person whose mobility when using transport is reduced due to any physical disability (sensory or locomotor, permanent or temporary), intellectual disability or impairment, or any other cause of disability, or age, and whose situation needs appropriate attention and the adaptation to his or her particular needs of the service made available to all passengers." (EU, 2006). Disability has now evolved into a social and economic issue instead of a medical issue. In the United Kingdom (UK) for example wheelchair users comprise less than 8% of the total population (Papworth Trust, 2012) and the 'disabled person' definition has been widened to include the increasing numbers of people with the disabilities of ageing, obesity and medical problems.

In the UK and in other jurisdictions, disability regulation provides for complimentary cargo space for medical equipment and up to two mobility aids per PRM (Civil Aviation Authority (CAA), 2010: 12) "subject to advance warning of 48 hours and to possible limitations of space on board the [small] aircraft, and subject to the application of relevant legislation concerning dangerous goods." (CAA, 2012: 4). Airlines are not allowed to limit the number of disabled passenger or mobility devices on larger aircraft. Some of these mobility aids (e.g. electric mobility scooters) can weigh up to 175kg (almost twice the 100kg standard airline weight for passenger and luggage combined (CAA, 2010)) and absorb two cubic meters of revenue-earning cargo space. Darcy (2007) in his survey of disabled passenger needs noted that one couple had a disabled person's hoist, a commode, two portable ramps, two wheelchairs and back pillows all of which would have consumed complimentary space and weight. In 2014, according to the British Healthcare Trade Association (BHTA) (the body representing assistive technology organisations), there are an estimated 300,000 mobility scooters in use in the UK (a 230,000 increase in five years). However, these devices are increasingly being used by the elderly and obese and consequently, whether the person is qualified disabled or not, they are entitled to free air freight if they self-declare to be a PRM. Unlike the issue of disabled

parking permits in the UK (of which 2.58 million are issued mostly for older people) (Department of Transport, 2013), PRMs are not required to provide proof of disability in order to access the complimentary services with quicker access through security on departure and clearance through Customs and Immigration on arrival. One in four Britons believed disabled people often overstated the level of their physical disabilities (Papworth Trust, 2012) which is consistent with observed PRM service abuse (Gatwick Airport, 2009; Airport Operators Association (AOA) 2009). There is currently no process to record the matching of genuinely disabled PRMs with the services required and therefore actual cost per PRM is unknown.

Cambridge Economic Policy Associates (2010:24) in a report for the UK Department for Transport noted that "the provisions regarding passengers with reduced mobility suggest that policy makers have taken a view that airlines operating in a competitive market would not make adequate provision for such passengers." This is an acknowledgement that there are two types of passengers – one for which there is a market and another which needs regulation to ensure its functioning – and that there are additional costs involved. However, unlike UK ground transport, there was no provision for subsidy of any of the extra airline services, facilities and freight required.

4. AIRLINE COMPETITION

One characteristic of State-owned industry is that true competition is largely absent (Kangis and O'Reilly, 2003) and once freed from government control, airlines had to compete in a global marketplace. In general, State aid is no longer permitted within the EU however as an example UK railways receive subsidies from the State and registered disabled people and pensioners receive free, subsidised or discounted fares on railways and buses which are not available for airline travel. The International Transport Forum (ITF) report on mobility rights, obligations and equity in an ageing society (ITF, 2011) challenged whether these policies can continue with an annual cost of €1.19 billion for free ground travel to citizens aged over 60 and disabled people. It notes that "the 'right' to accessible public transport … cannot be achieved without imposing obligations on those responsible for transport delivery" (*ibid*: 5).

The airline market is complicated. Before aviation deregulation and liberalisation around the mid-1980s onwards, many suppliers of air services such as airports and ground handling were also government-owned and often subsidised (Doganis, 2001). This meant that international airlines began to face the same problems as other globalising industries with marketplace pressures, requirements for product differentiation and the need to reduce unit costs to maintain competitiveness (Oum and Yu, 1998). The arrival of low-cost, low-fare carriers created an additional challenge for the established, legacy carriers with their higher overheads and historic

government influence. When demand falls, airlines cut their prices and capacity which is not always reflected in parts of the supply chain where, as an example and counter-cyclically, "airports raise charges to recover fixed costs when demand falls [causing a rise in airline costs] which accentuates the decline in airline returns. Airports have transferred volume risk onto airlines and …yet airlines are probably the least able in the air transport supply chain to be able to bear this risk." (IATA, 2013: 27). High airport costs are reflected in airline fares which can dent airline competitiveness and profitability.

In a perfect market, demand from consumers for a homogenous product at an agreed price is met by the output of suppliers maximising their profits. There are few barriers to entry and exit. However, in aviation competition is never perfect because it is influenced by government policies. While acknowledging that economic regulation is still necessary where competition is insufficient IATA notes that "market forces are starting to have an influence in some sectors, but in most these forces are either inadequate or absent." (IATA, 2013: 41). Competing airlines with differentiated products are keen to attract customers from rivals and in the long run, the reduction in barriers has attracted new entrants with lower costs and lower fares.

Hong (2009) in his assessment of global competitiveness measurement for tourism noted that a single performance criterion – financial profitability – was insufficient for determining the competitiveness of an industry. In aviation, there are other criteria including the accident rate, customer service complaints and productivity of labour (Doganis, 2001). Abeyratne (2001) in his discussion of ethical and moral considerations of airline management widened the criteria to include productivity of revenue and capital as well noting that "when economic theory relating to competitiveness is blended with social justice, which is the human element of commercial aviation practice, the picture can become somewhat more murky from a competition perspective… [and yet] …competitiveness is a critical driver of successful industry." (*ibid*: 348). Social justice is not necessarily a corporate aim however it is often a government aim which is why safeguards were placed into many privatising parastatals. "The future cost of air transport thus has important implications for social and spatial equity…[and] the transformation of many people's desire for air travel into a consumer expectation, a norm, or even a 'right'." (Shaw and Thomas, 2006:209).

5. PRM AIRLINE COSTS

Poria *et al.,* (2009) in their exploratory study of the flight experiences of disabled people inventoried some of the additional equipment which would make flying easier for PRMs. In addition to lifting armrests which enable easier transfers into and out of seats, these included first aid accessories, accessible lavatories, on board wheelchair, spacious sitting space and "if possible, upgrades to business class" (*ibid*: 224). In addition to these facilities, there is the opportunity cost of freight space in the hold, additional fuel to carry extra weights and the possibility of having to schedule an extra crew member or two to assist with the increasing numbers of elderly and obese passengers – particularly in the event of an evacuation.

While airport costs are fully reimbursed and airports can claim tax deductions for capital improvements, airlines do not get reimbursed for the additional costs of carrying PRMs. The on-board costs have to be covered in general ticket prices which are under pressure because of competing forces from low-cost carriers and carriers operating from low-cost countries. With thin profits per seat, rising fuel costs and likelihood of charges for CO_2 emissions, airlines are facing squeezed margins while maintaining competitiveness and fulfilling the legislated requirements. This leaves the airlines facing a growing volume of increasingly ageing, obese and medical PRMs without state subsidies but with legislated unrecoverable costs.

6. PRM MARKET

Worldwide, the PRM market is growing. In the UK estimates of the size and type of disabilities in the PRM travel market vary. According to the UK ODI (2012) there are 11 million disabled people in the UK of whom 5.3 million are over the state pension age and are disabled. The most common impairments for disabled adults of state pension age are mobility based (Papworth Trust, 2012; Chang and Chen, 2012; Lipp and van Horn, 2013) and the higher the level of mobility impairment the more expensive the air travel enabling processes. There are also 19 million people aged 60+ who are forecast to rise to 22.5 million by 2020 (UK ODI, 2012). In 2009, according to the UK CAA (2010) Heathrow (UK's largest airport) processed 650,000 PRMs annually (0.95 of total passengers); Gatwick Airport 324,000 PRMs (0.93%) and Manchester 181,000 (0.84%). Similarly, in the United States (US) – wheelchair assists from 2002 to 2011 increased over 13% each year (Lipp and van Horn, 2013) with just one airline alone at Newark averaging 35,000 per month most of which were for elderly travellers who needed help to cover the long distances to the gate, avoid waiting in lines or navigate the airport without assistance (*ibid*). The same survey notes that the use of mobility aids is rising faster than wheelchair use. These findings were supported by Chang and Chen's (2012) Taiwan survey of 203 travellers over 65 years of age which found that elderly passengers had

difficulties with vision, hearing, cognitive capabilities, physical strength and the ability to walk long distances in the terminal – all of which could give them access to the regulated, specialised individual assistance required from the airline, increased luggage allowance and status recognition. These provisions are usually available to passengers who pay higher ticket prices for differentiated services.

Obese passengers pose challenges for airlines. The World Health Organisation (WHO) (2013) estimated that "more than 1.4 billion adults were overweight in 2008 and more than half a billion obese." Furthermore, this number has been estimated to have doubled between 1980 and 2008 (*ibid*). Unlike passengers, the airline industry is silent on obesity (Small and Harris, 2011) as it is regarded as a sensitive issue. However, these passengers often need higher-priced or extra seats providing extra width and leg room. Airlines have varying charging policies for obese passengers who must be able to sit in the seat for which they have paid with both armrests down. Some carriers require the purchase of a second seat and others offer it at a discounted fare.

Medical tourists are another evolving group projected to increase particularly to long haul destinations (including India for cardiology, bariatric surgery and hip replacement and Pakistan for organ transplantation) (Lunt *et al.,* 2013; Gan and Frederick, 2013). Any medical condition can pose on-board service challenges as well as the risk of additional costs from medical emergency aircraft diversions which are not reimbursed by the PRMs. In a study (Hung *et al.*, 2013) of medical diversions of one Hong Kong carrier over five years researchers found that the most common diversion cause was suspected strokes, followed by chest pains and deaths – conditions common to ageing, obese or medical passengers.

The PRM statistics quoted do not separate the elderly, obese or medical tourists – only those who needed airport assistance – and do not state how many were accompanied by mobility aids or medical equipment carried free of charge. Statistically and erroneously PRMs are counted homogenously. The US-based Open Doors Organisation (ODO) (2007) study of a survey of 1,032 American adults with disabilities noted that "Air travellers say they would take 2 more flights per year if airlines were to accommodate their needs as a person with a disability. This translates into 18.8 million more flights and means that air spending by the disability community could more than double if airlines were to make necessary accommodations." *(ibid)*. In a competitive market, the prospect of 18.8 million more passengers would normally encourage new industry entrants and increase competition among incumbents.

7. PRM MARKET VALUE

Disabled people's day-to-day living costs – for basic requirements such as mobility aids, care and transport – are 25% higher than those of non-disabled people (Papworth Trust, 2012). Estimates of PRM spending power vary and in the UK it is estimated at around £80 billion per year (Papworth Trust, 2012; Office for Disability Issues (ODI), 2012). In the US there are now estimated to be 54 million Americans with disabilities with an estimated spending power of $220 billion (Business Disability Forum, 2014). According to Lipp and van Horn (2007) in their report of a quantitative survey to identify the travel habits of US adults with disabilities the US PRM airline market has the potential for an additional $4 billion of PRM spend. However, this optimism conflicts with the often stated facts that people with disabilities are twice as likely to be in poverty as non-disabled adults (Papworth Trust, 2012). On the other hand the newly-retired often have considerable pension spending power although those over 65 years are more price-sensitive (Gan and Frederick, 2013).

8. PORTER'S COMPETITIVE FIVE FORCES

According to Porter (2008), the underlying economic and technological characteristics of an industry determine the strength of the five basic competitive forces which can help gauge its attractiveness and profit potential (Figure 1). They are: threat from new entrants and the difficulty accessing the market, bargaining power of suppliers and buyers to determine which party has the upper hand, the threat from substitute products which could undermine an industry by affecting the price and finally rivalry between existing competitors as a means of assessing the competitiveness intensity of the industry (Porter, 1980). The forces are graded, high, medium or low according to the force they exert on the industry. Two approaches are available: offensive (where the organisation tries to influence the balance of existing forces or exploit a change in the competitive balance before rivals recognise it) or defensive (where its capabilities provide the best defence against the competitive forces (*ibid*)). However, governments also influence an industry's structure and rivalry with policies which impact on a firm's strategy through market regulation, tax regime and anti-trust laws (*ibid*).

Figure 1: five forces of competitiveness
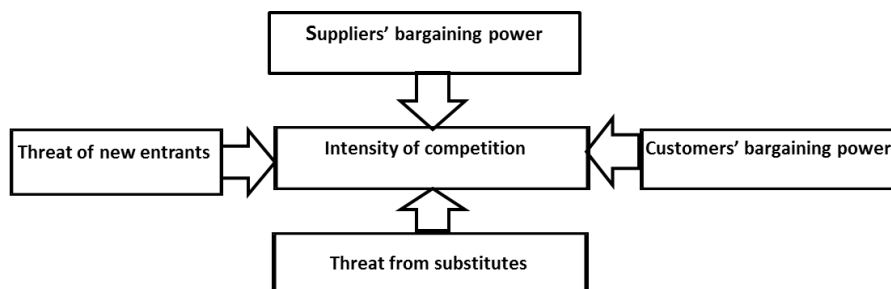
9. AIRLINES, PORTER AND COMPETITIVENESS

In 2013 IATA hired expert Michael Porter to report on profitability and the air transport value chain which included an examination of competitiveness of the airline sector using his five forces on a homogenous passenger market. The forces were individually ranked as high, medium or low depending on their competitive influence. IATA-Porter's findings have been used as the basis for secondary research in this study.

10. FINDINGS

10. 1 Threat from new entrants

The IATA-Porter report (2013) noted that the threat of new entrants in aviation is 'high' with only limited incumbency advantages for existing carriers. New entrants to any industry have to consider the incumbents' reaction in order to retain and enlarge their customer base. They signal their willingness to compete by advertising.

Despite the attractiveness of a potential market of 18.8 million more passengers (ODO, 2007) no airline advertising campaign has yet signalled the airlines' willingness to compete for PRMs nor advertised legislated service improvements and supporting products (e.g. on board wheelchair or lifting armrests). Furthermore, the removal of industry barriers and arrival of low-cost low-fare carriers has not sparked a price war for PRMs.

The changing market has changing costs. Flights comprising a mix of able-bodied passengers and PRMs could require extra crew members for safe evacuation and customer service as well as more on-ground services the cost of which would further reduce airline revenues unless ticket prices were increased. If more PRMs travelled with the airline offering the best customer service, that airline

would carry disproportionately high costs. Increasing fares to cover these costs would make the airline uncompetitive. Low-cost low-fare carriers would therefore be unlikely to chase this market and by increasing the number of seats per aircraft (thereby squeezing space) they could actively discourage mobility impaired PRMs.

On the other hand, if flights were to comprise only PRMs and their attendants then the threat of new airline entrants to the incumbents could only come from airlines which specialised in PRM travel. There would be few economies of scale available and with unequal access to distribution channels and high overheads from such a specialised service their prices would be higher and uncompetitive. Economies of scale are available as a means of lowering costs by using more information technology for ticketing, booking, check-in and boarding. However the PRMs are a group which requires the more individualised services and facilities usually offered by premium brands as product differentiation for enhanced ticket prices. There are no economies of scale in airline support for PRMs since each must be treated as an individual. Porter (2008) discussed the supply side economies of scale for production of larger volumes and the demand-side benefits of scale whereby "buyers may trust larger companies more for a crucial product." (*ibid*: 26). PRMs may trust a larger airline with an established reputation, higher costs and fares rather than a low-cost carrier unless the passengers are income-constrained in which case they may have reduced choice (Nimrod and Rotem, 2012). Because of the foregoing cost implications and in contrast to the IATA rating of 'high', the threat from new entrants for the PRM market is judged low.

10. 2 Bargaining power of PRM suppliers

The main airline suppliers for PRM services are the airport, ground handlers and fuel companies. Porter (2008) noted that powerful suppliers capture more of the value for themselves by charging higher prices, limiting quality or services or shifting costs to industry participants. IATA-Porter (2013) noted that airport services including handling were "more concentrated and consolidation has taken place leaving 3-5 major international companies" (IATA: 2013:34). In the UK two PRM ground handlers serve the top six airports.

Encouragement from the UK Government (ODI, 2012) outlines opportunities for businesses to access the disabled peoples' 'market'. Airline PRM suppliers include airports as well as manufacturers of on-board wheelchairs, airport mobility buggies, ambulift vehicles for lifting immobile passengers and providers of PRMs' services. To cover the costs of UK PRM ground handling, a charge is levied on each departing passenger ticket (IATA, 2013). The ground handling companies and the airports that rent them space and provide utilities are entitled to profit from supplying these services. IATA (2013) noted that ground handling faced the lowest volatility on

returns and that "returns are more volatile in the services sector, but there is little sign of these suppliers bearing much of the risk of the ups and downs of the air transport cycle." (*ibid*: 27). Since the ground handlers are fully reimbursed, and the airlines do not negotiate directly with them, the bargaining power of these suppliers is high.

Fuel is another supply impacted by PRM needs. PRMs with heavy mobility scooters (and other aids) or an obese passenger (with or without mobility aids) require more fuel to transport them than a passenger of standard weight with baggage (100kg). The additional weights affect global competitiveness because some carriers have lower fuel prices and operating costs than others. Emissions trading companies profit because of the additional emissions produced from the extra weight. While airlines cannot levy extra charges for PRMs' needs, the fuel companies are able to charge for all the fuel needed irrespective of how it is used. Their bargaining power is also high because airlines are captive to the airport, the PRM contractors and the fuel companies the bargaining power of airline PRM suppliers is high which accords with IATA's general findings.

10.3   Bargaining power of PRMs as buyers

Airline tickets are a price sensitive purchase absorbing a considerable share of discretionary spending. Air travel is mostly a standardised product which is contrary to what many PRMs need. In a normal market powerful customers can capture more value by forcing down prices, demanding better quality or more service and playing industry participants off against one another all at the expense of industry profitability (Porter, 2008). However, the PRM market is not normal.

PRMs have the protection of regulation to enable their equal treatment without meeting the cost of any negative externalities (i.e. costs not fully counted in the ticket price). The concept of PRM travel as a "right" to access social justice (Abeyratne, 2001) places the costs of negative externalities with the airline. Any attempt to charge PRMs for their extra services or freight would be against many Regulations in multiple jurisdictions. Furthermore, "Any state intervention to internalise the adverse externalities will raise fares and reduce availability to lower income groups" (Shaw and Thomas, 2006:209). This would impact on any PRMs already faced with 25% higher living costs, lower incomes and declining health, factors of ageing which were noted by Nimrod and Rotem (2012) in their study of successful ageing among older tourists. Indeed disability writers and researchers Lipp and van Horn (2013) indicate that "airlines risk being overwhelmed by the coming 'silver tsunami'" (*ibid*: 2).

In agreement with IATA, the bargaining power of PRMs as buyers is 'high and fragmented' because of legislated protection.

10.4   Threat from substitutes

A substitute performs the same or similar function as a product by a different means for example video conferencing for travel (Porter, 2008) and with the increasing arrangement of technological travel substitutes some PRMs may swop actual for virtual travel. However, much depends on the motive for the journey – whether for relaxation, visiting friends and relations, business or to save time – and also on the PRM's disability. Elderly people may have time to spare and desire for new experiences (Fleischer and Pizam, 2002) in which case virtual cannot compete with actual for the experience. If the PRM was seeking medical treatment then time may be of the essence. Short haul PRMs often have the alternative of travelling by car or ship, or by subsidised bus or train. However long haul journeys have reduced choice – airplane or boat. For these reasons and in contrast to IATA, the threat to aviation from competitive substitution in the PRM market is low whereas IATA found the threat to be 'medium and rising' for the mainstream passenger market.

10.5   Intensity of competition

According to Porter (2008) rivalry can take many forms including discounting prices, developing new products, advertising campaigns and improving services. Rivalry often intensifies over time but it can be destructive to profitability if it is reliant solely on price because "price competition transfers profits directly from an industry to its customers. Price cuts are usually easy for competitors to match making successive rounds of retaliation likely" (*ibid*: 32). If industry price cutting is continual customers who focus on price usually pay less attention to the product and services (Porter, 2008) until something goes adrift. PRMs need a certain level of service for comfort (Lipp and van Horn, 2013). Customer service complaints are one measure of industry competitiveness. In the US PRM customer service complaints in 2006 rose with most complaints related to failure to provide adequate assistance to persons with wheelchairs (US Department of Transportation, 2006) and damage to wheelchairs.

In alignment with new market entrants, incumbent airlines are not exhibiting the Porter characteristic of chasing competition for PRMs. Rivalry among airline competitors for the PRM market would be considered 'low' in contrast to IATA which ranked rivalry for all passengers as 'high'.

11. DISCUSSION

The IATA (2013) report fails to acknowledge the existence of two passenger markets and within the PRM market, the potential for increasing costs imposed on the airlines from growing numbers of elderly, obese and medical travellers with heavy mobility aids.

Airlines are not competing for PRMs although PRMs are a considerable and growing market. The threat from new entrants, substitute products and rivalry are actually 'low' rather than 'medium' or 'high' as IATA found (Table 1).

Table 1: comparison of IATA industry rating and PRMs' market using Porter's five forces of competitiveness

FORCE	INDUSTRY COMPETITVENESS RATING (IATA, 2013)	PRM MARKET COMPETITIVENESS RATING
Threat of new entrants	High	Low
PRM suppliers' bargaining power	High	High
PRM buyers' bargaining power	High	High
Threat from substitutes	Medium and rising	Low
Intensity of competition	High	Low

Figure 2: Porter's five forces model of airline industry competition adapted for PRM market
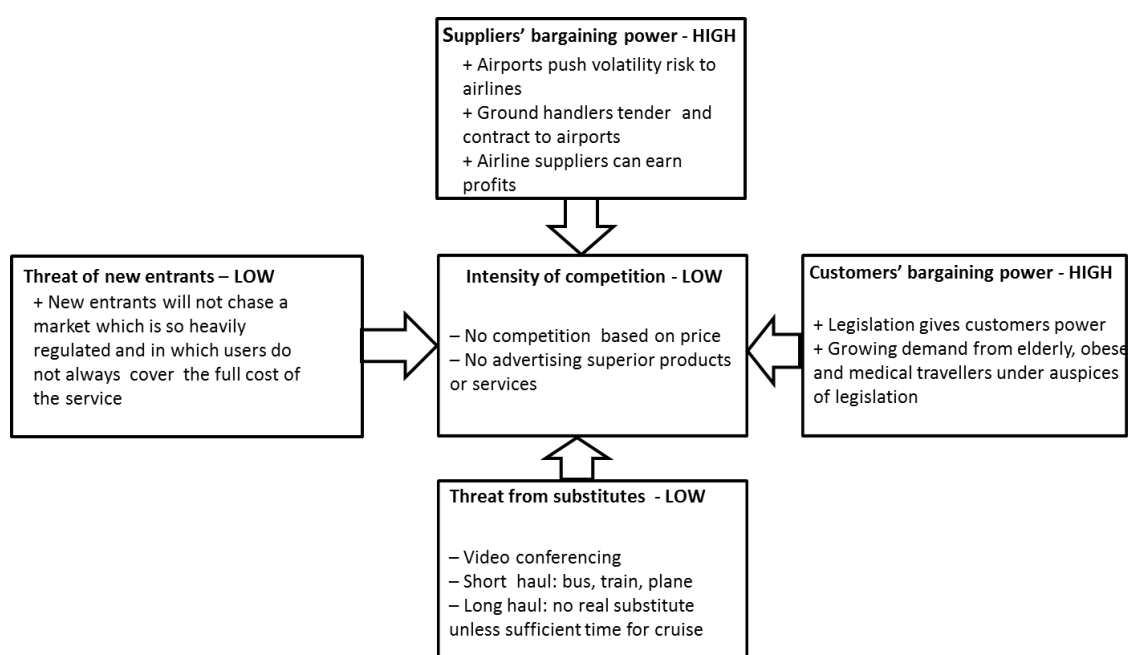
The bargaining powers of buyers and suppliers for PRMs accord with the IATA findings i.e. 'high' (Figure 2).Porter's five forces are an appropriate lens with which to examine the PRM airline market (Figure 2).

Porter (2008) says that companies must find a position in their industry where the competitive forces will do them the most good or the least harm. Reshaping the forces as Porter recommends would not assist either airline costs or revenues as long as regulation skews the marketplace. Porter's recommended offensive strategies advised neutralising supplier power, expanding services to counter competitor power, tempering price wars, increasing costs of competing to scare new entrants and limiting the threat of substitutes by offering better value. These are inappropriate given the increasing numbers of passengers claiming mobility impairment and the unknown quantities, space and weight of accompanying aids and medical equipment as well as the inability of airlines to charge for the additional services and freight.

Ticket prices differentiate passengers. They pay more for features such as personalised customer service, extra luggage allowance, wider seats and more leg room. This is available in the higher priced cabins for which higher fares are paid. However, these features are what many PRMs require without additional charges. According to ODO (2012), the top features or services that airlines would need to offer to encourage more frequent PRM travel include: "1) more accommodating staff, 2) guaranteed preferred seating, and 3) a designated employee at check-in and arrival" (*ibid*) all of which take the PRM out of the mainstream where the efficiencies lie. Social justice is not being served by making one passenger group (higher fares, more space and differentiated enhanced services) pay for what another group (PRMs) acquires free of charge. In the lean principle, customers should only receive those services for which they are willing to pay however there are disabled PRMs with high dependency on non-rechargeable added-value items who would probably never be able to afford to fly if the full price of their travel was charged. The ITF (2011) raised the question of which body is responsible for the costs on land transport (the state or local governments) but that issue has not been raised for airlines.

Governments have recognised that PRMs need protection and regulated accordingly however, one of the unintended consequences places the additional costs of carrying PRMs onto the airlines without any compensating subsidies. There are hidden costs including opportunity costs of increased numbers of PRMs as well as adding to the turnaround times for low-cost, low-fare carriers, scheduling extra crew members to assist with any on board service or emergency evacuation or leaving behind perishable cargos or other passengers' luggage to accommodate PRMs' mobility aids. The growth in the sales of personal electric mobility scooters – which a self-declared PRM can

demand be transported free of charge – also has the potential to further reduce airline revenues. The ITF (2011) report raised the question of whether a 'right' to transport confers priority over other passengers. Bhatta (2013) in his examination of pay-as-you-weigh pricing of an air ticket noted that "an airline cannot provide travel service if it is not able to make profits by providing that service" (*ibid*: 107). In the past 40 years the airline industry has more than halved the cost of air transport in real terms with improvements in fuel efficiency, asset use and productivity of labour, capital and revenue only to realise that "these efficiency gains have ended up in lower air transport costs [and customer fares] rather than improved investor returns" (IATA, 2013: 41).

No other disabled-persons' supply industry has had regulated market impediments. The airline industry's focus on reducing costs has not fed through to improved returns for investors for many reasons including the foregoing hidden costs. With the increasing disabling of the population through ageing, obesity and medical conditions, it is predictable that more PRMs will become disabled in the context of air travel and take advantage of additional, complimentary services and allowances without proof of genuine need.

The profitability criteria on which successful airlines are judged by investors is too narrow for PRMs' airline choice – "…over a third of disabled people said that good disability service was the primary reason for choosing a provider or product. Two thirds choose businesses where they have received good customer service related to their disability. Companies that tell disabled people about the accessibility of their products attracted those consumers." (Business Disability Forum, 2014: n.p.). Using these criteria ageing, obese and medical passengers will patronise the airline with the best customer service – one of the industry's product differentiators.

12. CONCLUSION

In the airline industry passengers are differentiated by what they pay. Higher prices give extended legroom, wider seats, individual service, increased luggage allowance and status recognition. However many PRMs, protected by regulation, require the benefits of higher ticket prices without paying the price. The competitive airline market has been undermined by regulations which were originally established to enable a disabled minority to participate in mainstream life. They now apply to a significant and growing minority incapacitated by ageing, obesity and medical conditions and accompanied by weighty equipment. Unlike other transport facilities and services airline PRMs cannot be mainstreamed. Each PRM has to be treated as an individual (a concept which negates the idea of 'mass transport') and with the unrecoverable, complimentary freight and other services significant numbers of PRMs could threaten airline viability.

Protective PRM regulation has had unintended consequences and is an example of inefficiently designed regulation. This matters because society, the airline industry and the PRMs have an interest in participating in a fully functioning market such as that which operates for other PRM-supply industries. An airline PRM market, just like those of other suppliers to disabled people, has to have the prospect of either a profit or government support. Furthermore making the PRM provisions accessible without proof opens them to abuse. Because PRMs are a self-determined market their numbers are possibly far greater than those described in official statistics and as the population ages, girths expand and medical tourism becomes more financially accessible, there will be more people claiming disability in order to access the services and provisions that the airline industry must supply free of charge.

Analysis using Porter's five forces has shown that offensive pursuit of the expanding PRM market is not appropriate for airlines because of the unrecoverable costs. An industry where net profit per passenger is only $US2.56 is indeed vulnerable to fluctuations in demand and to the vagaries of inefficiently designed regulation with no provision for the increasing quantity of mobility aids, escalating fuel costs or growing numbers of immobile passengers. In the competitive transport value chain airline investors alone bear the cost of social justice for PRMs. Unaware of the mix and numbers of PRMs, airlines are pursuing a passively defensive strategy neither advertising nor destructively competing in a low-margin industry. Paradoxically, the airline offering the best PRM customer service will attract the most PRMs. It will also incur higher costs, return lower shareholder rewards and impair its ability to remain competitive.

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