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Full Research Papers should contain original research not previously published elsewhere. They should normally be between 4,000 and 7,000 words although shorter or lengthier articles could be considered for publication if they are of merit. The first page of the papers should contain the title and the authors' affiliations, contact details and brief vitae (of about 50 words). Regarding the following pages, papers should generally have the following structure: a) title, abstract (of about 150 words) and six keywords, b) introduction, c) literature review, d) theoretical and/or empirical contribution, e) summary and conclusions, f) acknowledgements, g) references and h) appendices. Tables, figures and illustrations should be included within the text (not at the end), bear a title and be numbered consecutively. Regarding the referencing style, standard academic format should be consistently followed. Examples are given below:

- 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).

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

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

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

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Full Research Papers

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The growing demand for mobility in general and for air transport in particular puts increasing pressure on today's transportation providers. Supplying sufficient capacity, hence alleviating potential congestion of the entire system, and ensuring seamless and efficient operation of the overall transport system are two of the main challenges for the future. The integration of transport modes along the entire passenger journey can help to streamline the current system and thus increase existing capacities as well as passenger comfort level. Today, there are already some approaches in place that interlink different transport modes by providing single ticketing, or specially dedicated interchange platforms. Four such intermodal transport models are assessed within this paper. For this purpose, a set of key performance indicators is developed and applied to evaluate the intermodal transport performance of each concept. Aspects such as journey time and costs as well as baggage through-handling are considered and data for each concept acquired. Based on the evaluation, the AIRail concept is ranked highest since it best meets the criteria of a seamless passenger journey. However, the results show that there is potential for improvement within each investigated concept.

Sumana Chaudhuri and Ranjan Chaudhuri

One of the central tenets of the cost benefit analysis (CBA) literature is the divergence between a project's financial returns and social evaluation of what is desirable from the larger economic priorities and social goals of development. This article focuses on building a base of CBA for Delhi International Airport Limited (DIAL) as a case for Brownfield PPP Airport Project in India. The process of evaluation of the relative merits of the project in terms of the accrued benefits and costs, serves as a template for future frame of reference in similar PPP airport projects.

Florian Piekert, Nils Carstengerdes, Sebastian Schier, Reiner Suikat and Alan Marsden

Europe's SESAR Program develops a wide range of solutions to increase the performance of the Air Traffic System. At airport level, the Airport Operations Center (APOC) is expected to provide the most benefit in adverse weather conditions, being the ultimate communication platform to pursue the Total Airport Management (TAM) Collaborative Decision Making Process. It will increase mutual and common situation awareness and allows the joint definition and implementation of the operational strategy. The assessment of APOC benefits in a live airport environment is rather limited and requires implementation and "right" weather and traffic situations. This work argues for validation trials in high fidelity artificial airport environments as a more reliable and less costly alternative which allows comparison between operations before and after implementation of new solutions. Based on requirements provided by SESAR concept documentation and from live operations this work presents an approach for such a high fidelity artificial environment.

Hyun-jung Kim, Nam-ok Jo, Kyung-shik Shin, Jin-seo Park, Ga-ram Sim and Je-chul Kim

Qualitative research methods based on literature review or expert judgement have been used to find core issues, analyze emerging trends and discover promising areas for the future. Deriving results from large amounts of information under this approach is both costly and time consuming. Besides, there is a risk that the results may be influenced by the subjective opinion of experts. In order to make up for such weaknesses, the analysis paradigm for choosing future emerging trend is undergoing a shift toward implementing qualitative research methods along with quantitative research methods like text mining in a mutually complementary manner. The change used to implement recent studies is being witnessed in various areas such as the steel industry, the information and communications technology industry, the construction industry in architectural engineering and so on. This study focused on retrieving aviation-related core issues and the promising areas for the future from research papers pertaining to overall aviation areas through text mining method, which is one of the big data analysis techniques. This study has limitations in that its analysis for retrieving the aviation-related core issues and promising fields was restricted to research papers containing the keyword "aviation." However, it has significance in that it prepared a quantitative analysis model for continuously monitoring the derived core issues and emerging trends regarding the promising areas for the future in the aviation industry through the application of a big data-based descriptive approach.

Lu Yang

Taiwan is a small island with a relatively large number of airports. These airports show great disparity in terms of passenger volume and cargo tonnage. This paper in the first part evaluates the efficiency and productivity of Taiwanese airports using a panel data set, to verify the ones with lower efficiency performances. DEA (Data Envelopment Analysis) and Malmquist index methods are applied. In the second stage the changes of these scores are analyzed in different regression methods to test the influence of the Three Link agreement between China and Taiwan. It reveals that airports in Taiwan with routes to China have lower efficiency scores but their productivity grows faster than that of the other airports. This paper also confirmed that airports on offshore islands have higher efficiency scores and productivity.

Wali Mughni

Pakistan is an emerging economy where the aviation policy, promulgated in April 2015, was designed to dramatically boost aviation activities, which in turn was expected to enhance the country's economy. Ownership and market access liberalization, stringent adherence to international standards, subsidies, taxes and duty exemptions/reduction, emphasis on education, investor friendly environment, greater safety and security assurance, and above all, travel and business friendly culture was the strategic direction that Pakistan's forward looking National Aviation Policy anticipated to achieve. Well after a year of promulgation, poor internal and external stakeholder buy-in of the policy continues to mar expectations of the industry's stability, growth and prosperity. This paper critically looks at stakeholder apprehensions and suggests possible remedial measures that may be adopted for a course correction.

Nur Khairiel Anuar, Romano Pagliari and Richard Moxon

The purpose of this study was to investigate the impact of different wayfinding provision on senior driving behaviour and road safety. A car driving simulator was used to model scenarios of differing wayfinding complexity and road design. Three scenario types were designed consisting of 3.8 miles of airport road. Wayfinding complexity varied due to differing levels of road-side furniture. Experienced car drivers were asked to drive simulated routes. Forty drivers in the age ranges: 50 to 54, 55 to 59 and those aged over 60 were selected to perform the study. Participants drove for approximately 20 minutes to complete the simulated driving. The driver performance was compared between age groups. Results were analysed by Mean, Standard Deviation and ANOVA Test, and discussed with reference to the use of the driving simulator. The ANOVA confirmed that age group has a correlation between road design complexity, driving behaviour and driving errors.

Luciana Padovez, Max Well Elias and Mauro Caetano

According to the strategic innovation paradigm, service companies have their innovative efforts guided by market needs, so customer demand is crucial to successful innovation. However, the service literature about air transportation has been focusing on the evaluation of service quality delivered instead of the identification of market demands. This study applied the Hierarchical Model of air transportation service quality evaluation adapted to identify customer' expectations in a Brazilian domestic airport. The results indicate that customers have higher expectations regarding airline employees' conduct and expertise, which suggests areas where investments should be prioritized in order to optimize efforts on service innovation.

EDITORIAL

SELECTED PAPERS FROM THE 19ᵀᴴ AIR TRANSPORT RESEARCH SOCIETY WORLD CONFERENCE, SINGAPORE, 2015

The 19th Air Transport Research Society World Conference (ATRS) was held in Singapore, from July 2nd to July 5th, 2015 and attracted almost 200 papers. This special issue of the Journal of Air Transport Studies collects eight selected papers covering a wide range of topics presented and discussed at the conference.

In the first paper, **Marcia Urban, Annika Paul and Mara Cole** introduce and apply a quantitative assessment approach to a set of existing intermodal approaches. The paper presents guidance in identifying potential improvements in intermodal connections. The comparison identified the Frankfurt airport high-speed rail and airport (AIRail) connection as the best performing approach.

Sumana Chaudhuri and Ranjan Chaudhuri presents in the second paper a cost benefit analysis for the modernization of the Delhi Airport project. Delhi airport will be capable to cope with the demand for the next few years, when a shortage of capacity may occur. In the analysis provided by the authors the Delhi Airport project has positive net present values as well as greater than the unity benefit-cost ratios.

European SESAR program is the topic of the paper authored by **Florian Piekert, Nils Carstengerdes, Sebastian Schier, Reiner Suikat and Alan Marsden**. The work suggests that the benefits of using an airport operation center are better assessed in a high fidelity artificial airport rather than in a live airport environment. The research concludes by proposing an approach to set a high fidelity artificial environment.

Hyun-jung Kim, Nam-ok Jo, Kyung-shik Shin, Jin-seo Park, Ga-ram Sim and Je-chul Kim make use of big data methodologies in order to establish trending topics in the aviation sector. By establishing a quantitative research approach, the authors extract and monitor the current core areas of aviation research.

The impact of policy over airport efficiency and productivity is evaluated in the work by **Lu Yang**. The effect of the three link agreement between China and Taiwan over the efficiency of Taiwanese airports is estimated applying a two stages DEA approach. The author finds a positive impact of the policy over the productivity of the airports. Moreover, the work shows that the efficiency gap between big and small Taiwanese airports is also increasing.

Wali Mugnhi critically discusses the effects of the Pakistan's national aviation policy. One of the main aims of the aviation policy was to develop an efficient transportation structure to foster economic activity through different strategic measures. Despite this, the Pakistani aviation sector is currently presenting different levels of criticality. In this light, the author presents a set of possible remedial measures to be adopted.

The wayfinding provision is a basic prerequisite on driving behaviours and road safety. In the seventh paper, **Nur Khairiel Anuar, Romano Pagliari and Richard Moxon** study the airport road access wayfinding and the relations between senior driving behaviours and airport road access wayfinding design. The authors find that seniority, complexity of road design and increased traffic congestion distract the drivers and may result in unintentional movements and in exceeding speed limits.

Luciana Padovez, Max Well Elias and Mauro Caetano adapt and apply a hierarchical model of air transportation service quality evaluation to identify customer' expectations in a Brazilian domestic airport. The research aims to assist airlines and airport managers in prioritizing actions and investments in order to meet consumer's needs. The results of the application show that consumers have high expectation on airline employees, mostly valuing their conduct and expertise.

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 works are providing a valuable contribution to the aviation practitioners as well as encouraging further research on the respective topics.

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TOWARDS SEAMLESS PASSENGER TRANSPORT: PERFORMANCE OF INTERMODAL APPROACHES

Marcia Urban[1], Annika Paul[2], Mara Cole[3]

ABSTRACT

The growing demand for mobility in general and for air transport in particular puts increasing pressure on today's transportation providers. Supplying sufficient capacity, hence alleviating potential congestion of the entire system, and ensuring seamless and efficient operation of the overall transport system are two of the main challenges for the future. The integration of transport modes along the entire passenger journey can help to streamline the current system and, thus, increase existing capacities as well as passenger comfort level. Today, there are already some approaches in place that interlink different transport modes by providing single ticketing, or specially dedicated interchange platforms. Four such intermodal transport models are assessed within this paper. For this purpose, a set of key performance indicators is developed and applied to evaluate the intermodal transport performance of each concept. Aspects such as journey time and costs as well as baggage through-handling are considered and data for each concept acquired. Based on the evaluation, the AIRail concept is ranked highest since it best meets the criteria of a seamless passenger journey. However, the results show that there is potential for improvement within each investigated concept.

KEYWORDS

Intermodal Passenger Transport; Key Performance Indicators; Benchmarking; Intermodal Approaches; Quantitative Assessment; Performance Assessment.

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1. INTRODUCTION

The air transport system faces great challenges in the future. Capacity shortages within the transport system, for example at airports, complicate the provision of fast door-to-door travel. Passengers complain about time-consuming and inconvenient connections during airport access. In order to enhance and optimize the current transport system, the European Commission, therefore, defined ambitious goals for the air transport system within the Flightpath 2050 document. One of these goals states that 90 per cent of European passengers should be able to complete their door-to-door journey in Europe within four hours (European Commission, 2011). Building on this vision, the Strategic Research and Innovation Agenda (ACARE, 2012) outlines requirements for a seamless intermodal passenger journey in more detail and highlights areas which yield optimization potential towards the four hour door-to-door goal. To this end, the overall passenger journey can be broken down into several process steps, each demonstrating different potential for efficiency improvement.

Passengers access the airport via different transport modes (public transport, private car, taxi etc.). The respective level of connectivity in terms of quantity and quality supplied shapes passenger behaviour and travel times. Furthermore, arrival times differ by passenger type. Leisure passengers, for example, allow more time for airport access and arrive early at the airport since they incorporate potential delays in public transportation or during airport processes in their planning. Business passengers, on the contrary, who are often frequent travellers, are more accustomed to travel related processes and can, hence, anticipate travel process duration more accurately. At Munich Airport, for example, more than 60 per cent of leisure passengers arrive at least 90 minutes prior to departure compared to only about 32 per cent of business travellers. About 35 per cent of the latter arrive 30 to 60 minutes before their flight (Munich Airport, 2010). When investigating overall journey times, the flight time is an important factor to be considered. An analysis of the distribution of the stage length of European flights to the overall travel time shows that about 35 per cent of intra-European flights cover a distance up to 500 kilometres (OAG, 2012) which corresponds to a block time of about 70 minutes. Another 33 per cent of flights take place up to 1000 kilometres and have a respective block time of 105 minutes. In regard to the four hour door-to-door goal and the current distance distribution for intra-European flights, a large share of passengers already spends between 30 per cent and 44 per cent of these four hours in the aircraft.

Since passengers spend a high amount of their overall journey in waiting for or interchange between the different modes of transportation, there is optimization potential in increasing

the efficiency of modal interchange and reducing passenger waiting as well as queuing times. This paper introduces an assessment framework with the purpose to better understand how intermodal approaches can improve the passenger journey and to identify gaps impeding the provision of a seamless intermodal journey. For this purpose, a set of key performance indicators is developed (section 2) which are then applied to investigate the performance of four different intermodal concepts already in place (section 3). The results are presented and discussed in section 4.

2. KEY PERFORMANCE INDICATORS AND INTERMODAL APPROACHES BENCHMARKING

The key performance indicators, defined within this section, are based on the SRIA (2012) goals in regard to intermodal performance, a stakeholder analysis concerning respective requirements (Urban et al., 2014) as well as studies in the field of intermodal applications for seamless passenger travel (e.g. ORIGAMI 2013, KITE 2007). Table 1 depicts the set of key performance indicators used for the analysis. Each indicator is assigned to high-level assessment parameters (left column). The data for all metrics, outlined in the third column, is collected for each of the four intermodal approaches.

Table 1: Indicator set for the analysis of seamless intermodal transport

High-level assessment parameters	Key performance indicators (KPI)	Metrics
Joint booking and ticketing	– Booking of entire journey via a single platform or contact point	– Yes/no
	– Availability of single ticketing	– Yes/no
	– Availability of different ticket types, e.g. digital, print	– Score
Liability issues	– Availability of single contact point for information and complaints	– (0) no, (1) partly, (2) yes
	– Availability of delay compensation	– Ticket price/ delay of journey time
	– Responsibility across transport chain	– (0) mode-specific, (1) partly bundling of modes, (2) single point

Predictability of passenger journey	– Information about expected delays	– (0) no, (1) mode-specific inform., (2) single information platform
	– Provision of faster alternative routes	– Same as above
	– Information about baggage location	– Same as above
	– Information about additional transport-related services and products	– Same as above
Integrated journey planning	– Planning tool including all available journeys	– (0) mode-specific, (1) partly bundling of modes, (2) single point
	– Comparison of price and time for available alternatives	– (0) no comparison, (1) only for one variable (2) for both variables
	– Planning via different devices/distribution channels	– Available channels/ possible channels
Journey time and costs	– Price of different alternatives considered in the analysis	– Price (in €)
	– Travel time along the journey	– Minutes
	– Number of interchanges along the journey	– Number of interchanges
	– Interchange time between journeys	– Minutes
Quality of physical platform for interchange between modes	– Number of level changes between modes	– Number of level changes
	– Wayfinding aids between modes	– (0) none, (1) mode-specific, (2) integrated wayfinding
	– Distance between physical infrastructure of different transport modes	– Metres
Baggage through-handling	– Luggage transfer without passenger involvement	– (0) passenger responsibility, (1) rail station/ car parking/ bus stop, (2) city station, (3) door to aircraft handling
	– Cost of baggage through handling	– Price (in €)
	– Number of alternatives available for baggage handling	– Score

Based on the data collected, the approaches are ranked on a scale from 0 to 4 for each metric. The best performing approach(es) receive(s) a value of 4 and the worst performing approach(es) receive(s) a value of 1.

Table 2: Example benchmarking of KPI "Price of different alternatives"

Intermodal approach	Price of different alternatives considered in the analysis (in €)	Ranking
AIRail	50	3
SkyFerry	60	2
Bus&Fly	70	1
CarSharing	40	4

In the example in Table 2, which concerns the ticket price of different alternatives (exemplary values), the CarSharing alternative has the lowest price with 40 Euros and the Bus&Fly alternative has the highest price with 70 Euros. Therefore, these approaches receive the scores 4 and 1, respectively. For some of the intermodal approaches no data is available for certain key performance indicators. In this case, a value of 0 is assigned and the specific metric is not further considered in the evaluation. Subsequently, the scores for all metrics are merged in an overall assessment.

3. SELECTED INTERMODAL APPROACHES AND AIRPORTS

Four currently operated approaches are selected for application and validation of the key performance indicators. These concepts include air transport and another different transport mode. Moreover, they provide first indications on the current status of implemented intermodal transport solutions. Table 3 summarizes the considered approaches and respective characteristics which will be evaluated in the following section. Each approach has been structured according to pre-defined characteristics such as involved operators or the ticketing process to ensure the comparability in the subsequent assessment. In the following paragraphs, a short overview for each approach is provided.

Table 3: Overview of selected intermodal approaches
Source: Urban et al. 2014

Approaches / *Characteristics*	AIRail	SkyPier Ferry Transfer	Bus&Fly	CarSharing
Modes involved	air, rail	air, sea (boat)	air, road (bus)	air, road (car)
Operator(s)	Deutsche Lufthansa, Deutsche Bahn, Fraport	Hong Kong Int. Airport, various airlines, ferry operator	Iberia, Alsa, Avanza	DriveNow, Car2Go, Munich Airport
Price incl. air fare	train trip included: one ticket, one price	separate price for ferry and flight	bus trip included: one ticket, one price	separate price for car sharing service and flight
Ticketing process	integrated ticketing and booking available	separate tickets, flight ticket mandatory for ferry	integrated ticketing and booking available	car sharing offer independent from flight ticket
Baggage handling	no through-handling available; check-in at airport	upstream check-in possible at selected ports for selected airlines	no through-handling available; check-in at airport	no through-handling available; check-in at airport
Physical inter-change platform	AIRail Terminal incl. check-in and baggage drop-off	Dedicated SkyPier at Hong Kong Int. Airport	Check-in and baggage drop-off at Iberia Terminal (T4) at Madrid (MAD)	Dedicated parking space between two airport terminals
Connection frequencies	2-13 connections per day (depending on route)	ferry shuttle every 1-1.5 hrs each day, not coordinated with flight plan	2-4 connections per day (depending on route)	individual scheduling dependent on car availability

The AIRail approach represents a potential solution for a smooth intermodal cooperation along the transport modes rail and air. It is based upon the cooperation between Deutsche Bahn, Fraport and Deutsche Lufthansa. Fraport provides the infrastructure at Frankfurt International Airport connecting the train platform with the airport gate. Deutsche Lufthansa purchases entire carriages on trains of Deutsche Bahn. One key characteristic of the approach is the integrated ticketing and booking option which allows passengers to travel with only one ticket. Furthermore, train connections to and from the airport are treated like actual flights in the schedule of Lufthansa and intermodal connections are guaranteed. Thus, the passenger has only one focal point providing journey-related information and being responsible for cancellation or delay issues.

Air and maritime transport means are combined within the SkyFerry approach at Hong Kong International Airport. SkyFerry offers a connection from several ports in the Pearl River Delta to the airport via small boat ferries. A baggage service is offered at selected ports. The ferry shuttles operate with high frequencies but independent from flight schedules. However, the passengers need a separate ticket for the ferry transport which is exclusively sold to passengers holding a valid flight ticket.

An approach, which links road and air transport, is operated by Iberia in cooperation with the two bus companies ALSA and Avanza. Similar to the AIRail approach, Bus&Fly includes a selected set of cities and locations in the geographical area surrounding Madrid airport and provides bus connections aligned with the Iberia flight schedule. The approach enables integrated ticketing and booking for the entire journey as well as the provision of delay management and guaranteed connections.

Another type of intermodal airport connection is offered by the two car sharing providers DriveNow and Car2Go in cooperation with Munich Airport. Passengers can book cars in advance, use the reserved car for the individual travel to the airport and then park the car in a dedicated parking space for car sharing vehicles close to the terminal. The car sharing service differs from public transport in terms of individuality. The passenger can book his journey at any time and is not restricted by the schedule of public transport. The passenger has to manage the journey to the airport independently and the service requires separate payment and ticketing.

4. ASSESSMENT RESULTS

This section discusses the results from the quantitative assessment of the performance of the four selected intermodal transport approaches in detail, applying the key performance

indicator set outlined in Table 1. The combination of the findings for each indicator yields a high-level comparison in terms of intermodal performance as shown in Figure 1.
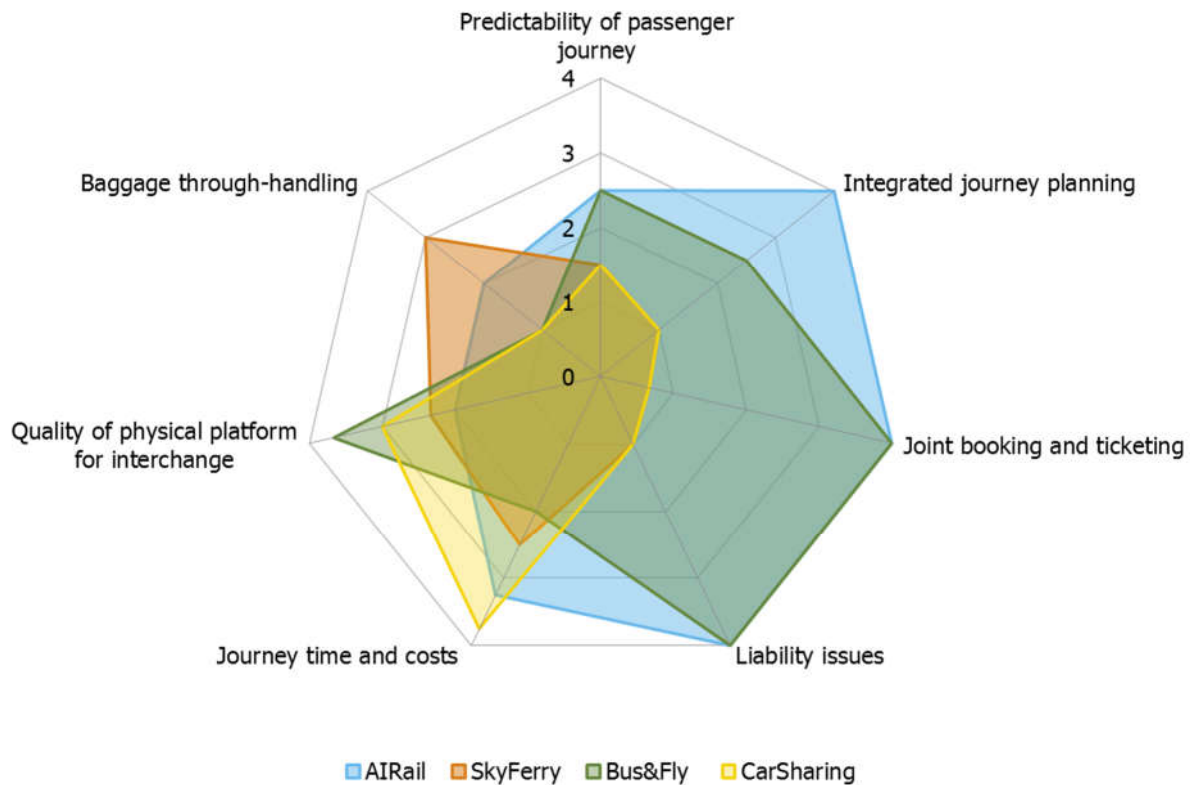
Figure 1: Assessment results for intermodal approaches

The results show that the AIRail approach is the best performing intermodal approach out of the four selected ones with an overall ranking of 67 per cent of the maximum attainable score of 100 per cent, i.e. the concept achieved 62 points out of a maximum of 92 points. However, each of the approaches has different strengths and weaknesses (see Figure 1). In the category "baggage through-handling" AIRail receives a lower score than the SkyFerry approach and in the category "quality of physical platform for interchange" the AIRail approach performs worst. This is due to long walking distances and a high number of required level changes between the rail stop and airport terminal. The Bus&Fly approach receives an overall score of 61 per cent, the SkyFerry 41 per cent and the CarSharing 40 per cent out of potential total points. On a more detailed level, the parameter "quality of physical platform for interchange between modes", for example, is made up of three different key performance indicators (Figure 2):

- The number of level changes a passenger has to conduct to change between modes
- The availability of wayfinding aids across modes

- The distance between the physical infrastructures of involved transport modes.

For each aspect, data is collected and the approaches are rated accordingly (as described in section 2). Regarding the number of level changes, the Bus&Fly approach performs best, and receives a score of 4, since the bus arrives on the same level as the flight departure area. The AIRail approach performs worst since passengers have to overcome the highest amount of level changes, as outlined above. Furthermore, within all approaches there are mode-specific wayfinding aids and no uniformity across transport modes. Overall, the best performing approach in terms of "quality of the physical interchange platform between modes" is the Bus&Fly approach.
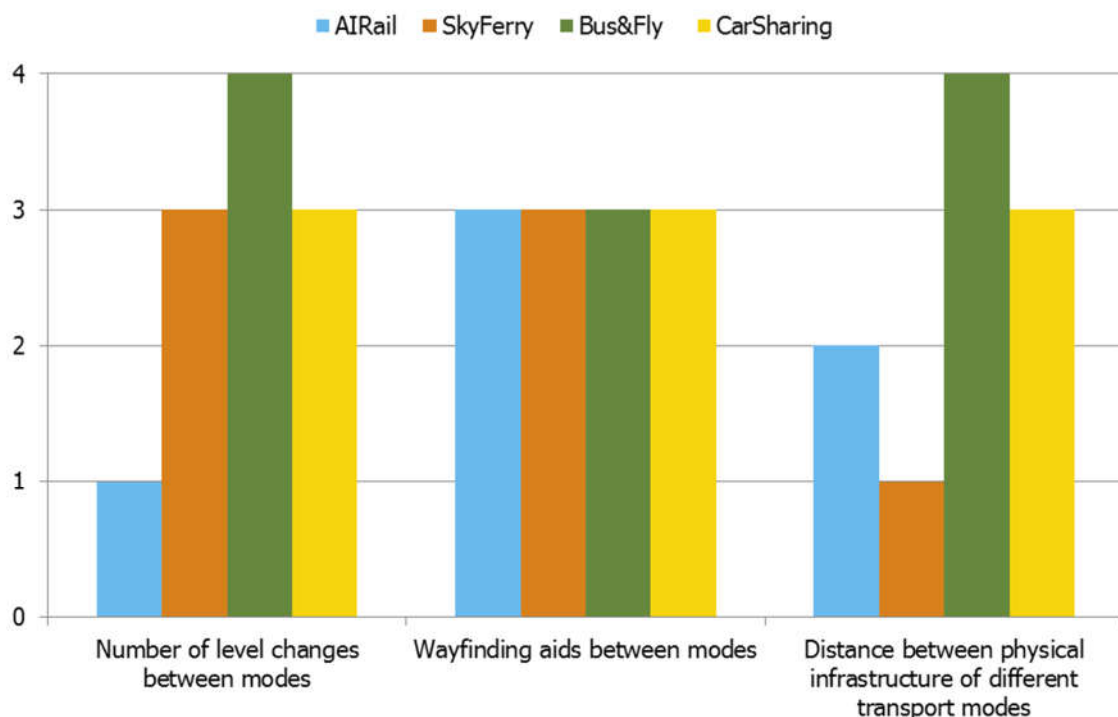
Figure 2: Benchmarking results "Quality of physical platform"

Figure 3 addresses the high-level parameter "journey time and costs" and includes the key performance indicators:

- Price of different alternatives considered in the analysis
- Travel time along the journey
- Interchange time between journeys.

The total costs consist of the actual price, i.e. the flight price and costs for public transportation, and travel time. Travel time is made up of the actual time in a vehicle as well as the time allocated for the interchange and waiting times between different transport

modes. In order to obtain values in the same measuring unit, the travel time values are monetized using the general value of travel time for passengers, published by Eurocontrol (2013), with an average of EUR 27 for both leisure and business travellers. These travel time related costs are added to the ticket price for each journey (Figure 3). The actual ticket price has been extracted for a specific short-haul connection from each of the airports, i.e. the cheapest ticket on a specific day (November 10, 2014) has been selected.
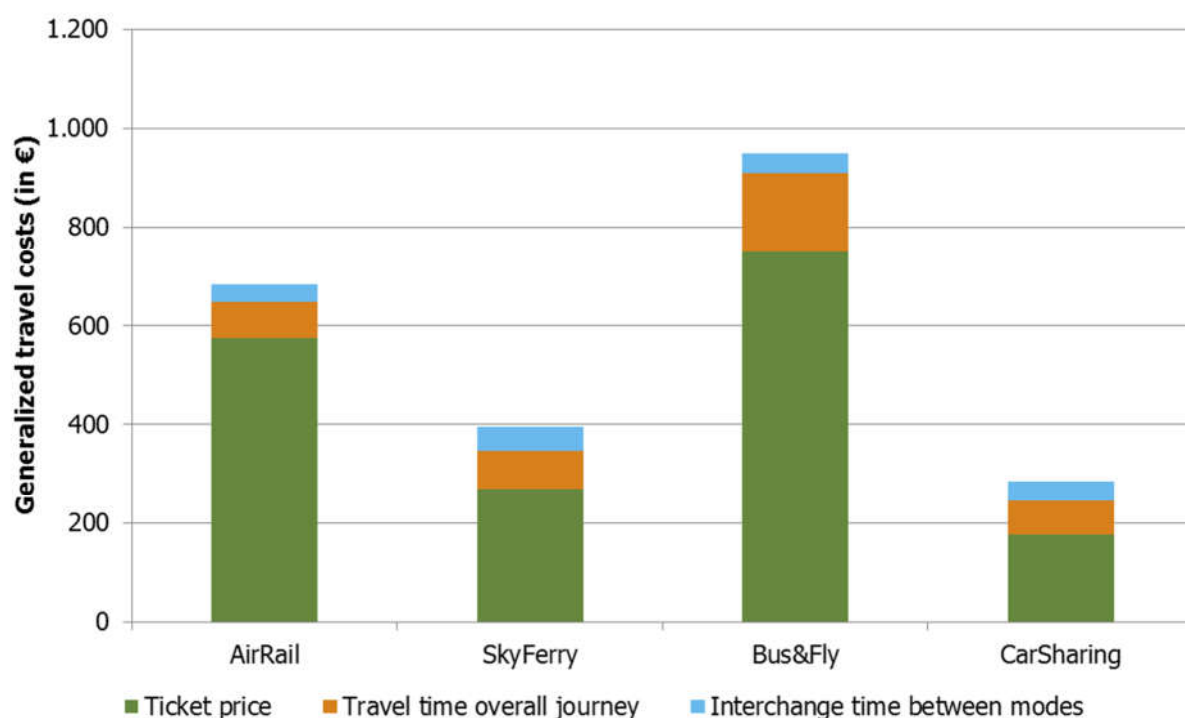
Figure 3: Generalized travel costs for intermodal approaches (short-haul)
(reference day: Nov 10, 2014)

For the European intermodal approaches, London Heathrow (LHR) has been selected as short-haul destination, resulting in the routes Madrid Airport (MAD) – LHR (Bus&Fly), Frankfurt Airport (FRA) – LHR (AIRail) and Munich Airport (MUC) – LHR (CarSharing). For Hong Kong Airport, Manila has been selected as short-haul destination since it provides an equivalent to the short-haul routes in Europe. Taking the average generalized travel costs for each approach, the CarSharing approach performs best in this category, and the Bus&Fly offer is the most expensive one, both in regard to ticket price (one-way) and to overall travel time.

5. CONCLUSION AND FUTURE WORK

The paper introduced a quantitative assessment approach including key performance indicators with respective metrics to measure the intermodal performance of four different

intermodal concepts currently in place. The AIRail concept yields the best performance, followed by the Bus&Fly and SkyFerry concepts. The CarSharing approach revealed most drawbacks in regard to intermodal performance and, therefore, ranks last. This assessment approach and results yield a feasible guidance for decision makers in regard to identifying intermodal improvement potential as well as enablers that contribute to the realization of a four hour door-to-door journey for passengers.

These include the establishment of a common platform for data transfer and exchange which requires the involvement of stakeholders from other industries than the transport sector, e.g. providers of data exchange platforms that deliver respective capabilities across all involved transport modes. Data exchange is a necessary prerequisite for passenger comfort, e.g. real-time information provision and ability to react to schedule changes during the journey, as well as for an improved communication among different transport mode operators. Incentives have to be designed for stakeholders, both from the transport industry and other sectors contributing additional expertise, to engage in new approaches. This includes a detailed analysis of the cost and revenue allocation scheme as well as liability aspects across interest groups. If responsibilities and benefits are not clearly defined certain stakeholders will not engage in intermodal solutions. Therefore, it is recommended to conduct a detailed analysis of different stakeholder business models, the regional focus and market segment addressed by their operation, and the passenger groups which are targeted at. A regional train company, for example, might not be interested in investing in infrastructure, technological services and facilities to ensure smooth and hassle-free interchanges between rail and air since its business focus is on a particular region and the respective origin and destination transport. A detailed market analysis also facilitates the establishment of harmonized intermodal framework conditions and a feasible incentive structure for different providers. Other important areas are the improvement of the quality of interchange between transport modes for passengers. This includes the provision of real-time and accurate information along the entire journey, optimization of schedules to reduce passenger waiting times including suggestions for schedule alignment in case of delays as well as the provision of a physical connection platform.

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A COST BENEFIT ANALYSIS OF DELHI AIRPORT PPP PROJECT

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ABSTRACT

One of the central tenets of the cost benefit analysis (CBA) literature is the divergence between a project's financial returns and social evaluation of what is desirable from the larger economic priorities and social goals of development. This article focuses on building a base of CBA for Delhi International Airport Limited (DIAL) as a case for Brownfield PPP Airport Project in India. The process of evaluation of the relative merits of the project in terms of the accrued benefits and costs, serves as a template for future frame of reference in similar PPP airport projects.

KEYWORDS

Cost Benefit Analysis (CBA); Externalities; Shadow Pricing; Public Private Partnership.

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1. INTRODUCTION

Airports in India play a vital role in the development of the aviation industry in India. According to the Center for Monitoring Indian Economy (CMIE), the growth in air passenger traffic in India is estimated to have fast-tracked to 12.6 per cent in 2014-15 from the 6 per cent growth recorded in 2013 – 14. New airlines like Tata Airlines and Singapore Airlines JV called Vistaara and Air Asia taking off in Indian skies in 2014, coupled with a strong rise in domestic passenger traffic due to hefty discounts on fares by domestic carriers like Spice Jet, Indigo, Go Airways and Jet Airways in the past one year boosted this growth. Domestic passenger traffic accounts for 70-75 per cent of the total air passenger traffic in India.

During 2015-16, Indian airports are expected to handle 207.2 million passengers, 8.9 per cent higher as compared to 2014-15. Majority of this traffic would be concentrated in Delhi, Mumbai, Hyderabad and Bengaluru. A total of 151.8 million domestic passengers are likely to travel from the Indian airports as compared to 139.1 million estimated for 2014-15. This translates to a rise of 9.2 per cent (CMIE, 2015). The air traffic canvas is however much broader. India has a population of 1.2 billion. On a daily basis only 0.01% (1 in 10,000) of the population uses an aircraft (MOCA, 2011). International visitors excluded the ratio would be even lower. This illustrates the enormous potential for air travel in a large and diverse country like India. The development in India is still at a comparatively early stage. While significant investments have been made and public private partnerships are proving successful, further investment is required in response to quickly rising demand for air travel and corresponding infrastructure on the ground and in the air. The modernized airports in Delhi and Mumbai only provide sufficient capacity for the next few years before further expansion or even a new airport is required. Greenfield airports hold enough capacity for the medium term future; however, the modernization of 35 smaller airports plus plans for more Greenfield airports will further stimulate air traffic growth quickly filling excess capacity at these airports.

While ACI predicts global air traffic to double within 15 to 20 years, traffic volumes will at least triple in India during the same period. The current plans for further modernization and expansion of the airport network in India are estimated at USD 10 billion. A similar or higher amount will be required to accommodate growth beyond 2015 (ACI, 2011). To secure financing and world class know-how, a first step was made by establishing public private partnerships for four Delhi, Mumbai, Hyderabad and Bangalore. However, to ensure the viability of the airport sector in the future more private sector involvement is essential. This article aims to primarily focus on the economic and social costs and benefits of PPP airport

infrastructure project in India, where the special case of Delhi Airport Brownfield project is discussed in the light of Cost Benefit Analysis.

2. REVIEW OF LITERATURE

a. Role of Infrastructure in Economic Growth

Infrastructure services can be described as being of 'strategic importance' (Kay, 1993). Infrastructure plays like pillar for an economy to be sustainable. Sound infrastructure drives national competitiveness. An infrastructure project can usually be classified as a form of public good, because it has both non – rivalry and non – excludability properties. Non – rivalry means the good can be used by another person at no additional or marginal cost; while non – excludability means it is not possible to exclude people from using the good even if they don't pay for it (Stiglitz, 2000). Recent trends in commercialization of infrastructure will be a shift from this model of non – rivalry and non – excludability. Infrastructure has some inherent characteristics like it entails a huge investment, large sunk cost and a long gestation period. So it is not possible for the government alone to bear the entire huge investment requirement for the infrastructure sector. The solution lies in privatization or the private participation in public infrastructure projects which is popularly termed as PPP.

The World Bank (1994) found evidence that the role of infrastructure in growth is substantial, and frequently greater than that of investment in other forms of capital. Spillovers arising from an infrastructure project are of a much larger order of magnitude than for many other activities (Threadgold, 1996). Aschauer (2001) pointed out that investment in public infrastructure has positive spillover effects on an economy's productivity and thus on economic growth. Also, Milbourne et al. (2001) found a positive effect on economic growth from public investment with particular evidence of gains from investment in transportation, communication and education. Recent studies confirm a statistically significant positive relationship between productivity and infrastructure and suggest that infrastructure may be a key determinant of comparative advantage between countries (Yeaple and Golub, 2002).

Infrastructure projects typically exhibit economies of scale, possibly leading to natural monopolies; they may be socially desirable but not privately profitable. To correct these failures governments may regulate private service providers or provide the services

themselves. These government failures may actually exceed the market failures, favoring private provision as argued by Winston (2006).

Infrastructure services, in general, are becoming more commercially oriented (Grimsey and Lewis, 2002). There has been the perception that a move from 'tax payer pays' to 'user pays' (i.e. from ability to pay to the benefit principle) is likely to be associated with a better economic use of the services (Musgrave, 1959).

Infrastructure is also expected to play a more important role in the catching-up process of developing and transition countries, both of which are supposedly facing underinvestment. (Estache et al., 2002; Hirschhausen, 2002).

b. Airport Infrastructure

Over the past decade, across much of the world, there has been extensive reform of airports. In several cases, airports have been fully or partly privatized, and in other cases, they have been restructured as corporations. Ownership structure has been changed with a view to making airports more commercially oriented. Airport privatization has been and still is, on the agenda of national air transport policies of many countries throughout the world. Privatization may take many different avenues, ranging from a minor divestiture of airport companies by public shareholders (for example in Germany) to a complete sell-off of (former) public airports to private investors (for example in Australia). Privatization can be restricted to the operation of public infrastructure facilities by a private firm (for example in Bolivia), or it can also involve privatizing the airport's infrastructure (for example in the UK). (Wolf, 2008)

c. Concepts of PPP

The term "public-private-partnership" was probably originated in the USA initially referring to joint public private sector funding for educational programmes. The scope of PPP was broadened in the 1950s to include funding for utilities, but came into wider use in the 1960s to refer to public-private joint ventures for urban renewal. In the provision of infrastructure, PPPs can be conceptualized as "project-based" or "contract-based" arrangement, which gained importance in the early nineties (Yescombe, 2007). Ministry of Finance, Government of India defines PPP as: "A partnership between a public sector entity (sponsoring authority) and a private sector (a legal entity in which 51% or more of equity is with the private partner/s) for the creation and/or management of infrastructure for public purpose for a specified period of time (concession period) on commercial terms and in which the private

partner has been procured through a transparent and open procurement system. (Department of Economic Affairs, Ministry of Finance, Government of India, 2007)"

d. Cost Benefit Analysis of Infrastructure Projects

Cost benefit analysis is concerned with the theory and application of criteria for appraising the desirability of investment decisions in the public sector, in terms of national objectives (Chawla, 1987). The fundamental economic problem facing most nations is the optimal allocation of scarce resources in competing projects. This involves making a rational choice between various alternative projects and selecting the best possible one according to the criterion of maximization of net societal benefit. Social Cost Benefit Analysis (SCBA) of projects should aim to establish two national objectives, increasing the total national income (growth objective) and improving the income distribution so as to make it more egalitarian (equity objective). The other objectives of SCBA are ensuring that a selected project subscribes to employment generation, self-reliance, balanced regional development, protection and improvement of environment.

Projects are to be evaluated by the extent to which they contribute to (benefits) or detracts from (costs) from the national objectives. If benefits exceed costs, the project is acceptable. The benefits are defined in terms of their national objectives, whereas the costs are opportunity cost, which is the benefit foregone by not using these resources in the next best investment decision available. The benefits foregone can be re-defined in terms of their impact on national objectives. In an ideal condition, where every information pertaining to competing alternative projects are available, the investments are usually made to the best possible projects.

3. DATA SET

For the purpose of the present study, DIAL has been chosen to represent CBA. DIAL has completed a large part of the capital expenditure earmarked for its first phase of airport expansion. Terminal T3 with annual passenger handling capacity of more than 30 million is already operational.

The present work is based on secondary data collected from Centre for Monitoring Indian Economy (CMIE), Airports Authority of India (AAI), Airports Economic Regulatory Authority

(AERA) and National Council for Applied Economic Research (NCAER). The dataset for analysis is collected for the period 2006 – 2012

4. COST BENEFIT ANALYSIS OF DELHI AIRPORT PPP PROJECT

The article focuses on building a base of CBA for Delhi International Airport Limited (DIAL) as a case for Brownfield PPP Airport Project in India. It may be worthwhile to mention that according to OECD Manual (Little Mirrlees Approach, 1968), UNIDO Guidelines (1972), World Bank's Guide to Practical Project Appraisal (1978), European Commission's Guide to Cost Benefit Analysis (2008) and similar such works on project evaluation discussed in the literature review observed that CBA is primarily meant for ex-ante appraisal of projects. However, it is argued that the use of the approach may be encouraged equally for ex-post evaluation of projects like Delhi Airport, to analyze why a particular project succeeded or failed.

a. Schematic Representation of CBA

A schematic representation of Delhi Airport is shown below

Figure 1: The Six Steps of Cost Benefit Analysis for DIAL
(Source: Adapted from Guide to CBA, EU, 2008; NCR stands for National Capital Region, India)
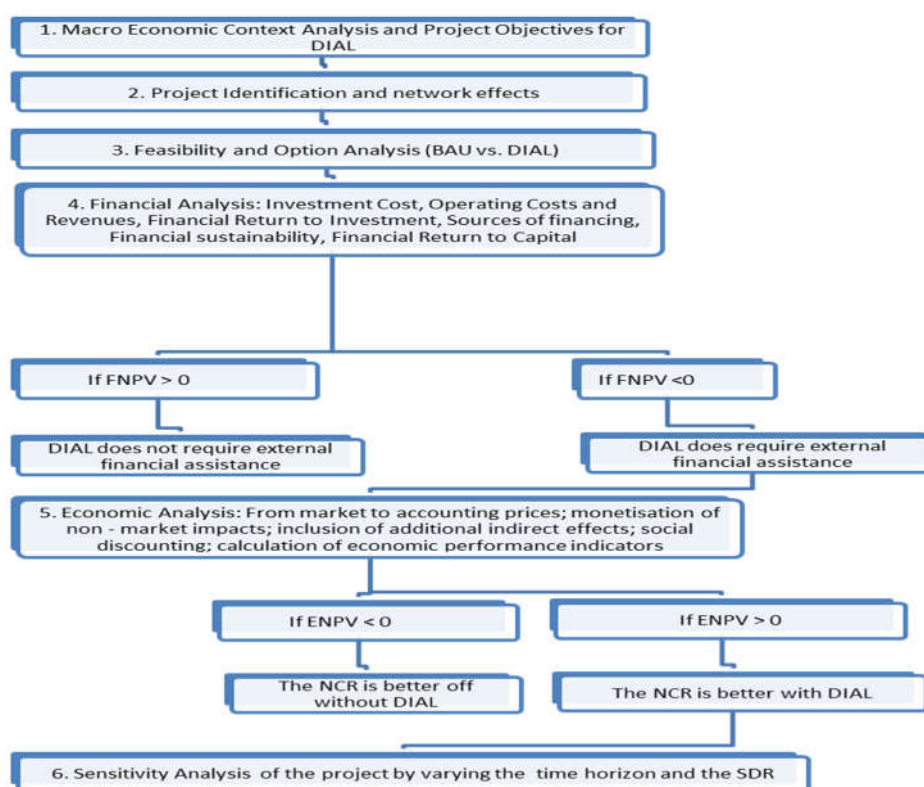
b. Macro-economic context analysis and the project objectives

The ascent of the 21 Century witnessed unprecedented growth in the quantum of trade in India, which were associated with heightened business activities and passenger movement for domestic as well as International traffic. As the national capital, Delhi naturally became the first port of call for many India inbound passengers. The growth in air travel was further escalated by the arrival of many low cost airlines, which touched base with Delhi either as hub port or as a routing station. These lead to a spurt of aviation growth focused on the national capital region and with the passage of time, aircraft, passenger and cargo movements took an incline that prompted Ministry of Civil Aviation to draft a blue print for expansion of the terminal building, runways, apron space and other aeronautical facilities at the Airport. At the same time, investment in CNS, ATM and related technological backbone for airborne and ground surveillance of the aircrafts were also planned. This called for a planned investment in Delhi Airport and the government embarked upon a journey of public private partnership as a procurement mechanism to augment Delhi's airport infrastructure.

c. Project Objectives

The key objective of Delhi Airport in general and Terminal 3 in particular was to build a world class International airport and provide a gateway for passengers coming to India via Delhi. In particular, there are four specific objectives, associated with Delhi Airport project. They are:

Institutional objectives: reduction of congestion by eliminating capacity constraints through balancing airside and landside demand and capacity.

Air passenger objectives: the infrastructure augmentation creates travel time savings and travel cost savings for passengers which results in efficiency whereas the decongested DIAL air space promotes the LCCs, enabling the common man to become airborne, thus fulfilling the equity objective of the airport.

Social objectives: as an economic asset, DIAL strengthens the social welfare of the national capital region by generating positive spillover effects in the community.

Economic objectives: are associated with ensuring the economic gains of the Government in leasing the airport to a private operator and re-investing the revenue earned from DIAL by building airports in the economically unfavorable locations or modernization of existing AAI managed airports.

d. Identification of the project

The identification of an infrastructure project implies that the functions of the project should be clearly stated and it should be coherent with the objectives of the investment. Delhi International Airport Private Ltd. (DIAL) was formed with the objectives of operating, maintaining, developing, designing, constructing, upgrading, modernizing, financing and managing the Indira Gandhi International Airport, New Delhi. DIAL, the Integrated Brownfield Airport Project is comprised of three separate terminals - 1A (for domestic flights of state owned Air India, MDLR and Go Air), 1B (was used by other domestic airlines, now closed and demolished), the Domestic Arrival Terminal (1C) and the newly-constructed 1D (now used by all remaining domestic airlines). There is also a separate Technical Area for VVIP passengers. Additionally there is a separate terminal for Haj flights. Delhi Airport has two parallel runways and a near-parallel runway.

e. Feasibility and Option Analysis

The basis of any investment appraisal is to make a comparison between "with and without" the project. The core of benefit cost analysis is based upon the "with and without" approach and this in turn is grounded on the concept of opportunity cost. The best possible alternative solution on the basis of technical, regulatory and managerial constraints and demand opportunities, is the "do-something" alternative. This is the option which has been taken for the major brownfield project – DIAL.

f. Financial Analysis

The financial analysis is carried out through subsequent, interlinked accounts, referred to as the Integrated Documentation System (IDS) in the UNIDO Guide to Practical Project Appraisal, which is depicted in the figure in the following page.

In the financial analysis, it has been observed that though the net cash flow is still negative at 2012, but the rate of inflows has grown in leaps from 7% in 2010 – 2011 to 30% in 2011-2012. The greatly increasing returns trades off the negative imbalance in net cash flows. This is a strong indication that the project is financially viable; with the prospect of earning increasing returns on investment as the project matures. This satisfies the first test of the success of a project, i.e., financial sustainability.

The financial performance indicators are:

- Financial Net Present Value (investment) FNPV (C): **INR (15016.35) CRORES, OR,**

-**2252452500.00 USD**

- Financial Net Present value (capital) FNPV (K): **INR 1941.42 CRORES OR**

291213000.00 USD

Figure 2: Structure of Financial Analysis (Source: EC Guide to CBA, 2008)
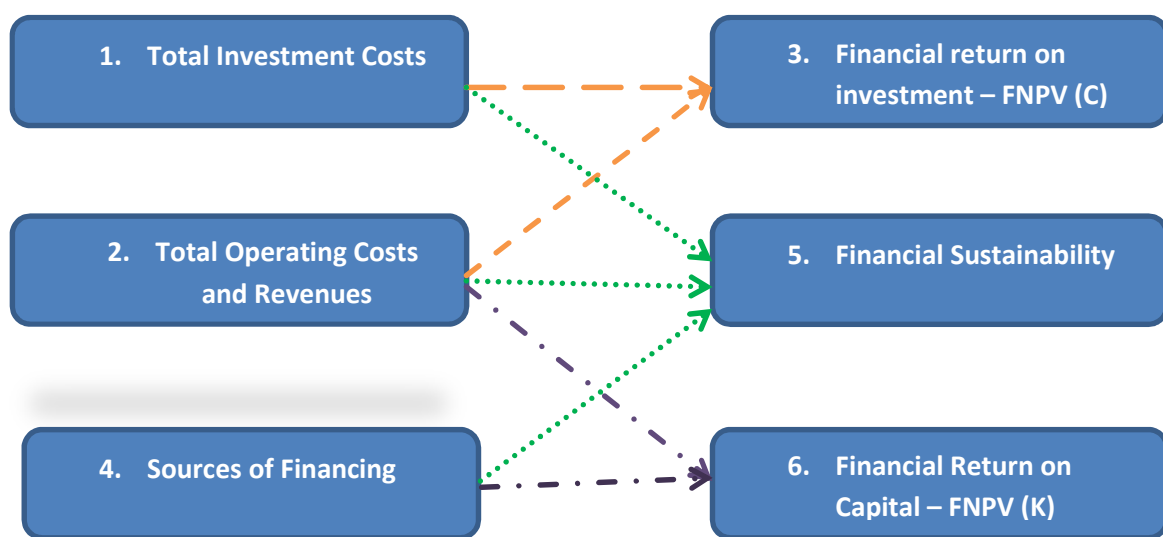
g. Economic Analysis

In the cost benefit appraisal of DIAL, the financial analysis of the project is followed by economic analysis. The analysis draws its merit from the concepts of consumers' surplus and rents, the distinction between benefits and transfer payments, the concept of shadow pricing, external economies and diseconomies, the choice of investment criteria and the problems of uncertainty are adequately covered in the succeeding sections.

The economic analysis is distinctly different from the financial analysis with respect to benefits accrued as a result of the project. Whereas the latter is merely concerned with the owners or promoters of the project, economic analysis attempts to identify the project's impact on the society at large. The fundamental premise on which the economic analysis is grounded, is based on the use of accounting prices (shadow prices), centered on the social opportunity cost, instead of observed distorted prices. This happens because observed

prices of a project's inputs and outputs may not truly reflect the social opportunity cost (social value) like in case of imperfectly competitive markets. Financial data, though useful for project budgeting and financial control, may not be a good judge of welfare indicators of an economy.

To make a reasonably good Economic Analysis, it is equally important to consider the externalities that are not accounted for in the converted financial inputs and outputs. The sum total of the spillover effects as a result of the Delhi Airport megaproject is considered based on the direct, indirect and induced impact generated by airport construction and operational activities of DIAL. The qualitative aspects of these spillage effects have been attempted to capture under the umbrella of quantitative analysis.

Consumer Surplus

According to Alfred Marshall (1925), the consumer's surplus is the maximum sum of money the consumer would be willing to pay for a given amount of the good, less the amount he actually pays.

The consumers of an airport project are the airlines and the passengers. In these, airlines are the direct consumers in the sense that they interface with the operators on a daily basis in their transactions. The passengers are indirect consumers of airports; they patronize airlines flying in multitude directions and routes. The Consumer's Surplus of the DIAL project may be categorized in the following areas:

(a) Consumer Surplus (airlines) due to save in travel time, thus opening up new routes apart from existing schedules
(b) Consumer Surplus arising out of savings in Aircraft Operating Cost (AOC) in fuel expenses as a result of de-congested skies (less "go around" before receiving permission from ATNC to touch down)
(c) Consumer Surplus (Air Passengers) as a result of more flights, increased frequency of departures between Delhi and other metros and lower airfare stemming from competitive airlines market.
(d) Consumer Surplus (Air Passengers) as a result of saving in travel time.
(e) Consumer Surplus (passengers) in time savings as a result of intermodal switching (road/rail to air) in short haul routes like Delhi-Jaipur, Delhi-Chandigarh, Delhi-

Gwalior, etc. Also, for the existing passengers in the same modes and routes, the road/rail corridor is now de-congested, so there is a lowering of the Vehicle Operating Cost (VOC) and savings in travel time too.

(f) It may be mentioned here that the VOC of the passengers travelling to T3, DIAL may slightly increase due to increased distance travelled to access and egress the new link to T3, however, this cost is offset by the reduction in travel time, as a result of Delhi Metro Railway Corporation and Delhi Metro Airport Express (Reliance Metro Airport Express Line) where the normal 60-80 minutes off peak hours drive has been reduced to 18 minutes for INR 80=00 for a distance of 22 kilometers compared to normal taxi fare of INR 500=00 for the same distance at a much lesser comfort and convenience.

Producer Surplus

New International airlines are now arriving and departing IGI Airport as a result of capacity expansion and modernization of New Delhi Airport. They are also adding new routes connecting India to other places on the global map. This increases the net aeronautical revenue for DIAL and generates producer's surplus on three counts. New airlines or increased routes increase the revenue model for DIAL. Due to expansion of capacity, marked by opening of the new routes and new entrees, there is considerably more passenger traffic, which greatly augments the Passenger Service Fee (PSF) and the User Development Fee (UDF) collected from the passengers. Thirdly, the growth in International (as well as domestic) passengers fuels the retail and miscellaneous sales of passenger facilities at the airport, thus boosting the non-aeronautical revenue stream for the airport developers and operators. This is the aggregate Producer's Surplus generated from the operation of DIAL.

Government Surplus

Government's surplus from this Brownfield infrastructure initiative comes from multiple avenues. Having a share of 44%, as DIAL's revenue arises automatically Government's revenue also gets boost up. With the new terminal T3, additional flights and routes have opened at Delhi, bringing in additional passengers, thus having more tax revenues per passenger as well as from each airliner.

Figure 3: Consumer Surplus as a result of reduced Generalized Cost
(Adapted from Mishan, 1976)
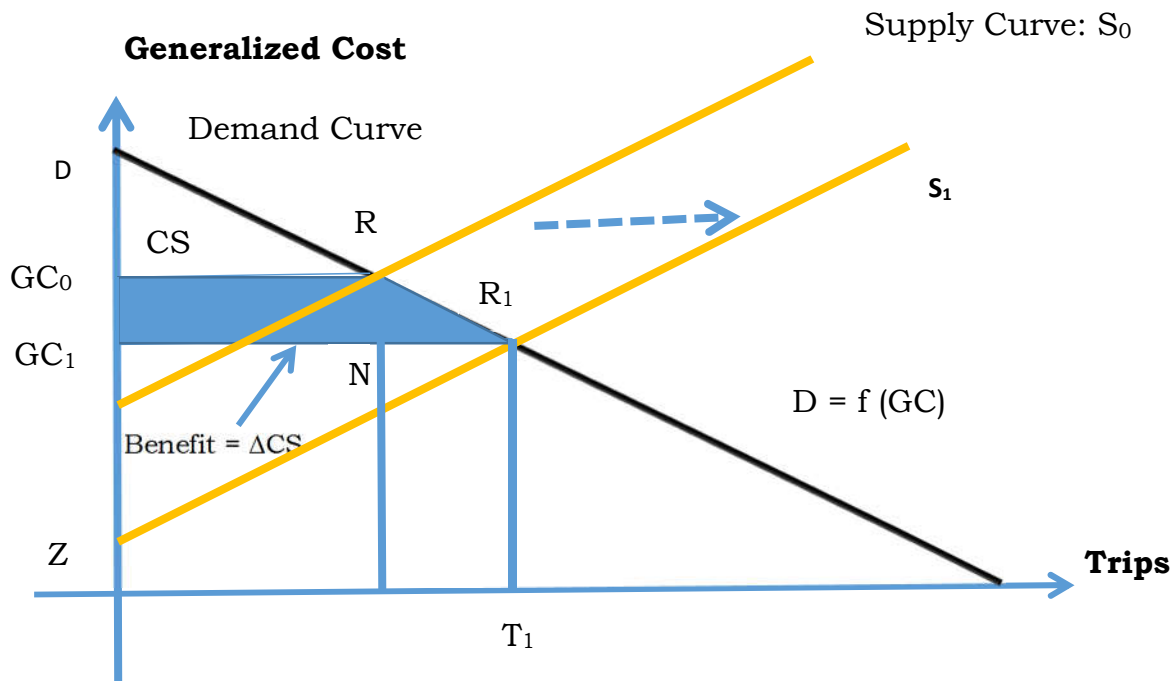
The above figure clearly explains the concept of Consumer Surplus in the specific case of DIAL. As a result of development of Delhi Airport as a Brownfield Project, there occur considerable scale efficiencies, thus lowering of prices from OGC_0 to OGC_1. The rectangle GC_0RNGC_1 is the resultant savings achieved by the existing airlines and its customers from the development of Delhi Airport, namely T3. Now let us consider the triangle RNR_1. This part of the savings is brought about by the additional flights touching down and departing T3. These additional flights on new and existing routes and opening up new sectors for air travel further increases the competitiveness of airlines as compared to other modes of transportation like railways or roadways, thus substantially lowering down the price paid by the passengers toward the cost of air passage.   This combined effect of cost saving (Consumer Surplus = Area of rectangle GC_0RNGC_1 + Area of triangle RNR_1 = Area of enclosed figure $GC_0RR_1NGC_1$) achieved by the airlines and passengers is expressed in the Generalized Cost Function.

Generalized Cost Function (GCF) is conveyed as the combination of the monetized and non-monetized cost associated with a particular journey. Algebraically, GCF is expressed as:

$$GCF = \grave{a}T + \beta L \ldots (1)$$

Where $\grave{a}$ = value of time

T = average travel time

β = Vehicle Operating Cost (VOC)

L = travel distance

The triangle $DRGC_0$ represents the consumer surplus (CS_0, which is beneath the demand curve and above the generalized equilibrium cost) before the commencement of the project. The DR_1GC_1 is the new area (larger than the earlier one) for consumer surplus, brought about by implementation of the airport project. Therefore, the User Benefit = $CS_1 - CS_0$. We assume that with introduction of additional flights and new sectors and routes because of the new airport project, the supply curve will shift more toward the right (from S_0 to S_1) and hence the triangle GC_1R_1Z becomes the new producer surplus.

h. Results of CBA for DIAL

The Economic Performance Indicators of DIAL is given below.

- Economic Net Present Value (ENPV): INR 121,737.90 Crores (2006 – 2012)

- Economic Net Present Value (ENPV): INR 232800 Crores (2013 – 2017)

- B/C Ratio (Project Evaluation Phase: 2006 – 2012): 3.78

- B/C Ratio (Using discounted cash flow technique; 2013 – 2017): 8.15

The PPP of DIAL with the competition induced efficiency of the GMR led private partnership and the Government's effective monitoring and control has led to a synergy of relationships that ultimately gets reflected in the project evaluation and appraisal with regard to both the financial indicators and economic indicators. The performance indicators point to the fact that the project has been viable, both in the short-term as well as the future horizon of the lease period of 30 years till 2037. This work is a unique endeavor by itself, namely, the construction of finite elemental cost benefit analysis of an airport megaproject in India, which by all counts has been investigated for the first time in the area of airport infrastructure projects in India.

5. CONCLUSION

The article presents a comprehensive analysis of the benefits and costs associated with the construction of Terminal 3 at Delhi Airport project (DIAL). The benefits include not only the financial gains of the stakeholders in the system, but also the economic gains to the National Capital Region (NCR) as a result of the increase in social welfare created by the DIAL T3.

Asian Development Bank (2007) observed that "countries differ in economic structure, capital scarcity, stage of financial development, efficiency of financial intermediation, impediments faced in accessing the international capital market, and social time preference." These differences result in varying SDRs and BCRs for airport infrastructure projects around the world. It may be worthwhile to examine the choice of social discount rates and the corresponding BCR for airport infrastructure projects across developed and developing economies to affirm the soundness of the results obtained in the CBA for Delhi Airport project.

The choice of the Social Discount Rate has significant impact on the outcome of BCR and Economic Net Present Value (ENPV). Economists across countries have applied a wide range of methodologies to get the SDR for a given infrastructure project. Prior to 1991, Australia used 8% SDR, and in recent times it follows the annually reviewed Social Opportunity Cost (SOC) Approach, which is less than 8%. As against this Canada uses a SDR of 7%, whereas in France it is 4% based on the Social Rate of Time Preference (SRTP) Approach. In the case of Italy it is 5% and Spain 6% based on SRTP Approach. Coming to Norway and UK it is still lower at 3.5% based on rate of government borrowing and the SRTP Approach. Compared to these US Office of Management and Budget follows a SDR of 7%. In the developing economies like Pakistan follows a 12% SDR based on SOC Approach, Philippines 15% based on SOC Approach, China 8% for Short and Medium Term Projects and less than 8% for Long Term Projects. In the present analysis, we have used a SDR of 10.81% using the SRTP Approach. There are significant variations in SDR policies in practice around the world based on the nature and the duration of the project, with developed countries applying lower rates (3–7%) than the developing countries surveyed (8–15%) and therefore our estimated value of 10.81% using SRTP Approach for a large scale and long term strategic infrastructure project like Delhi Airport that acts as major gateway, appears reasonable for a rapidly emerging economy like India.

The SDR affects the outcome of the project like changes in Benefit Cost Ratios (BCR) as economic performance indicators of Delhi Airport project. A variation in the discount rate can considerably change the BCR as observed in the sensitivity analysis for Delhi Airport project's economic performance. An examination of the project BCRs of the airport infrastructure sectors across countries reveals an interesting observation. The East West Gateway Council of Government estimated a BCR of 10.90 for St. Louis Regional Airport, USA, which is primarily used for air freights. Florida Department of Transportation (2009), estimated a BCR of 7.3 for South West Florida International Airport using NPV for a 20-year design life and a 7% discount rate. Graham (2013) of Imperial College, London mentions a BCR of about 5.6 for airports. A CBA was done for Rock County Airport in Southern Wisconsin by Wisconsin DOT to receive federal aviation funds from FAA for the airport expansion project. Technically it was a project appraisal which considered case of a runway expansion. The estimation of benefits and costs was undertaken using the Airport Benefit-Cost (ABC) software, developed for Wisconsin DOT by Economic Development Research Group with Cambridge Systematics; using the state of Wisconsin's officially accepted 7% discount rate. The sensitivity analysis of BCR varied between 3.23 – 5.27 when compared and contrasted against the set of alternatives for Rock County Airport. PricewaterhouseCoopers (PwC) estimated the project BCR for Sunshine Coast Airport (SCA), Australia to vary in the range of 3.52 – 6.24. Management Research Centre University of Waikato Management School (2008) obtained a BCR in the range of 2.15 – 3.85 for Waikato Regional Airport. The underlying observation for these variances reveal that for air freight focused airports, the BCR often assumes a double digit value and for passenger airports the BCR lies in the range of 2 – 5.6, which is specific to the macroeconomic context of the country, with due weightage to the nature of the project and its duration. These observations validate our BCR estimation of 3.78 for Delhi Airport and confirm the soundness of the estimate.

The financial and economic benefits have therefore been well justified in the results and highlights the worth of PPP in airport infrastructure projects in India.

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A HIGH-FIDELITY ARTIFICIAL AIRPORT ENVIRONMENT FOR SESAR APOC VALIDATION EXPERIMENTS

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ABSTRACT

Europe's SESAR Program develops a wide range of solutions to increase the performance of the Air Traffic System. At airport level, the Airport Operations Center (APOC) is expected to provide the most benefit in adverse weather conditions, being the ultimate communication platform to pursue the Total Airport Management (TAM) Collaborative Decision Making Process. It will increase mutual and common situation awareness and allows the joint definition and implementation of the operational strategy.

The assessment of APOC benefits in a live airport environment is rather limited and requires implementation and "right" weather and traffic situations. This work argues for validation trials in high fidelity artificial airport environments as a more reliable and less costly alternative which allows comparison between operations before and after implementation of new solutions. Based on requirements provided by SESAR concept documentation and from live operations this work presents an approach for such a high fidelity artificial environment.

KEYWORDS

TAM; APOC; Validation; Human-in-the-Loop; Simulation Environment; SESAR

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1. INTRODUCTION

The SESAR (Single European Sky ATM Research) program is one of the most ambitious research and development projects ever launched by the European Community. The program is the technological and operational dimension of the Single European Sky (SES) initiative to meet future capacity and safety needs (European Commission, 2004, 2013; European Parliament & European Council, 2004), in compatibility to the US initiative NextGen (Brooker, 2008; Federal Aviation Authority & SESAR Joint Undertaking, 2014) and Japan's CARATS (Study Group for the Future Air Traffic Systems, 2010).

To coordinate and concentrate all relevant research and development efforts in the Community, the SESAR Joint Undertaking was founded by the European Commission and EUROCONTROL (European Council, 2007, 2008). Corresponding to the size and scale of the SESAR Program, a number of priority business needs (cf. SESAR Joint Undertaking, 2013, page 2) encompassing all of the ATM partners have been identified, referred to as 'SESAR Solutions'. These solutions are structured in a way as to ensure that their deployment will lead to benefits for all of the stakeholders across the ATM domain.

The validation of the different elements comprising each solution is structured around the so-called 'SESAR Release' process. Each Release comprises a number of validation exercises designed to prove the maturity of the individual building blocks of the overall SESAR concept and, as a result, their readiness for deployment.

Within the 'Airport Integration and Throughput' priority business area, a major work thread (Operational Focus Area – OFA 05.01.01) is focusing on the issue of Airport Operations Management (AOM) and among its research scope the development and validation of an Airport Operations Plan (AOP) and Airport Operations Center (APOC) for managing airport operations in nominal, adverse and/or exceptional operating conditions is addressed.

The SESAR AOM Concept (Bogers et al., 2015a, 2015b) builds upon the European Airport Collaborative Decision Making (A-CDM) concept (EUROCONTROL, 2013a). The concept will be scalable in order to permit its implementation across the broadest possible spectrum of Airport environments present in Europe and it is articulated around four services (Marsden, 2014). The are the *Steer Airport Performance*, *Monitor Airport Performance*, *Manage Airport Performance* and the *Perform Post-Operations Analysis* service.

The validation of these four services associated to the Airport Operations Management concept is being performed by the SESAR partners with a focus on so-called maturity levels V1 through to V3, following the standardized European Operational Concept Validation Methodology (E-OCVM; EUROCONTROL, 2010). The work to date has comprised the iterative

elaboration of the SESAR AOM concept by the definition of operational requirements captured in the form of an Operational Services and Environment Description (OSED; Bogers et al., 2015a, 2015b) and integrating specific operational processes such as the management of demand and capacity imbalances. This realization was subjected to V1 and V2 validation activities and the results have been used to further refine the OSED.

What still is missing is a benefit assessment of the concept and the associated prototypes within a dynamic and realistic environment.

2. LITERATURE REVIEW

Validation is employed in a wide range of disciplines, e.g. in statistics, medical products, car manufacturing industry and in air traffic management research (e.g. Carstengerdes, Jipp, Piekert, Reinholz, & Suikat, 2012). All validation endeavours have the common goal to provide a fit for purpose identification of differing complexity for the proposed aspect under consideration. In SESAR it is important to use validation as a means of quantifying the benefits or demonstration that the anticipated benefits have been achieved by the concept and prototypical implementation.

E-OCVM foresees eight phases, starting from V0 to V7. Whereas phase V0 and V1 of the E-OCVM Concept Lifecycle Model define the air traffic management needs, the scope of the concept under test and the possible operational and technical solutions, phase V2 addresses feasibility, acceptance and operability issues. The major advantage of the E-OCVM methodology lies in the opportunity of assessments and quick reactions to potential show-stoppers at early concept stages. With each phase the validation scope and the realism of the validation activities are evolving. The more mature a concept is, the more ecologically valid (Brewer, 2000) the validation activity has to become regarding the operational context.

The term "lifecycle" indicates that concept development and validation are tightly coupled in view of the fact that validation activities are supporting the refinement of the concept which – in turn – will be validated again until the transition criteria to the next validation phase are achieved. In the next phase, this process is starting again.

Coming from the V2 questions dealing with feasibility aspects, V3 is concerned with the pre-industrial development and integration. Validation activities in this phase are therefore related to the assessment of operational benefits of the concept under test. The concept and supporting enablers like prototypes, roles, procedures and responsibilities, and associated

human performance aspects are evaluated together in order to clearly identify costs and benefits associated with the proposed solution to the identified ATM need.

Finally, concepts should be stable after this phase and ready for a transition into an operational environment (V4: industrialization), followed by deployment (V5), operations (V6), and decommissioning (V7).

It should be clear from this description that every phase (V1 to V3) has its own set of appropriate validation techniques, tools and methods, starting with literature studies, model- and data based approaches, gaming or fast-time simulations and ending with real-time simulations, shadow-mode and even live trials.

The most straight-forward approach to assess the benefit of new procedures and technologies is the comparison of situations, where the application or implementation of these innovations has not yet occurred, with situations where the new procedures are applied or the technologies have been operationally implemented. Depending on the individual enhancement each procedure or technology is expected to provide, the induced effect may vary greatly and may even vary from situation to situation.

Regular operations, without external disturbances, appear to be well manageable and most probably can still benefit from innovations. But most of the potential of some innovative solutions in airport management was designed to manifest in situations that forces limitations onto the well-established operational processes. A major proportion of these bottleneck situations are caused by weather phenomena (EUROCONTROL, 2013b; Lau, Forster, Tafferner, Dzikus, & Gollnick, 2011; United States Department of Transportation / Bureau of Transportation Statistics, 2015), affecting various operating areas. Generally assumed, the intensity of the bottleneck situation is dependent on the severity of the weather phenomenon.

V3 validation can be supported by a wide range of techniques, with live trials being considered the culmination. The above indicated ideal solution environment apparently is an airport in live operations where, over an extended period of time, qualifying metrics have been measured prior and after APOC implementation and adjustment of procedures was completed. But considering the intended target situation, the crux is the availability of these situations when required. It appears unreasonable to start the implementation of innovations into a live environment and then wait for these situations to occur only to conduct benefit assessments as a decision support whether to implement these systems or not. Additionally, in cases where the implementation costs are high or have significant risks associated to them, the implementation in the live environment may be pursued only as a second step. In

those cases, applicable to the innovations addressed in this work, the first step is the benefit assessment in a live-like, but artificial environment that allows controlling of all parameters.

Consequently, the environment that qualifies for a V3 APOC validation has to offer a dynamic representation of the world typically encountered at an airport and the possibility of hosting the innovative prototype systems supporting the concept and operators.

These aspects can be expressed as requirements. The validation environment that consists of the artificial airport environment, including the baseline support systems, and the novel support systems that support the new AOM concept elements, need to cope with this set of requirements. Concerning the airport environment, the requirements in most cases are a reflection of the live operational environment transcribed into specific IT terms. The AOM concept covers requirements concerning its new conceptual functions and procedures. It does not directly provide requirements for validation environments, as the concept itself was created for a live operational environment. A thorough analysis of the concept's requirements has to be performed and the appropriate requirements have to be transferred into the individual exercises' validation plans (e.g. Carstengerdes et al., 2015). For example, such requirements can be grouped into requirements concerning the validation environment, operational procedures and functional aspects for the support systems. Examples are provided below.

Type	Example
Environment	"It is assumed that the airport simulated in the validation exercises is at least a primary node, i.e. a medium sized airport with a limited hub function and intercontinental P2P connections (e.g. Lyon Saint-Exupéry, Nice, Budapest, Warsaw, Athens etc.)" (Carstengerdes et al., 2015, p. 34).
Procedure	"It is assumed that the airport simulated in the reference scenario has implemented the A-CDM Information Sharing element of the A-CDM concept. In particular, it is assumed that this airport is equipped with an A-CDM Information Sharing Platform and similarly that the A-CDM concept elements of variable taxi-time and milestone monitoring are all implemented" (Carstengerdes et al., 2015, p. 31).
Procedure	"The APOC supervisor or responsible stakeholder (depending on the severity level A, B, C, D) shall update the overall impact message in the system (AOP)" (Bogers et al., 2015a, p. 235).
Functional	"Each warning / alert from airport performance monitoring shall lead to the instantiation of an overall impact message. This OIM will be indicated to the responsible stakeholder determined in advance" (Bogers et al., 2015a, p. 234).

Table 1: Examples for different types of requirements

Theoretically, every air transportation network and airport process and procedure can be modelled and then simulated with highest level of detail and degree of realism. Highly sophisticated models may, however, not always be required, or the real world data is not available in sufficient quality or quantity. A taxonomy of simulations and application of various modelling types and detail levels is provided in Haßa (2016) and further examples

are given in Odoni et al. (1997) and De Prins, Ledesma, Mulder, and van Paassen (2008). It is therefore evident, that an appropriate scaling of the process simulation that adheres to the requirements of V3 assessments has to occur.

Additionally, as explained above, exercises require specific weather information to unlock the potential of these innovations. This information has to be provided not only to the human operators (who will act as stakeholder representatives), but as well to the driving simulators and the APOC support systems. All will use this weather information in their area of work. The simulators will have to dynamically provide model driven reactions in the process chains and the APOC support systems will assist the operators in assessing the severity of the impact. The human operators who additionally judge by their experience what is presented to them will identify the implied consequences on airport operations. This approach will allow control of the most important experimental parameters. These focus around the timely distribution of weather or other disruptive events which are affecting the airport processes, and the air traffic demand and its density distribution (e.g. arrival and departure ratios).

In the remaining sections the above argumentation will be exemplified by an approach for conducting a V3 real-time Human-in-the-Loop (HitL) validation exercise (identified as SESAR EXE-06.03.01-VP-757). In this exercise it was necessary to not only identify the already documented requirements, but additionally to construct the necessary simulation requirements.

3. THEORETICAL CONTRIBUTION

The requirements build a framework of needs that has to be fulfilled by four pillars of this exercise. These are a) the industrial prototypes that provide the new functionality and procedure support, b) the physical environment where operators will be working jointly, c) the simulators that simulate reality and d) user interfaces as the means of interaction between operators and the support systems. These four pillars will be explained in more detail in the following sub sections.

4. THE INDUSTRIAL PROTOTYPES

INDRA is the industrial partner in this validation exercise and has developed the Systems Under Test (SUT) prototypes. Due to INDRA's business needs and intended target customers, their prototypes are designed to connect to operational airport systems or to

systems of the local air navigation service provider (ANSP). Therefore, the simulation environment has to provide similar interfaces and data of comparable quality. The SESAR Airport Operations Management concept (OFA 05.01.01 OSED; Bogers et al., 2015a, 2015b) envisages that with the deployment of APOC processes at an airport, A-CDM processes become established automatically, as these present the foundation of this collaborative airport management approach. Further, when the APOC concept and its support tools are deployed, it is assumed that airport data sharing will be conducted via System Wide Information Management (SWIM; Petrovsky et al., 2012).

The AINS prototype (developed within SESAR Work Package (WP) 12.06.09 – "Integration of CDM into SWIM") is a SWIM gateway system, feeding the Airport Operations Plan (AOP) with local A-CDM information and providing information back into the SWIM. The ASDI prototype (SESAR WP 12.06.07 – "AMAN, SMAN and DMAN fully integrated into CDM processes") presents the bridge to the local ANSP, thus providing ANSP related planning information to the AOP. The AOP prototype (SESAR WP 12.06.02) is implementing the Airport Operations Plan and adequate mechanisms and procedures to manage all aspects relevant for the concept. The majority of airport related data will be directly provided by the Airport Operational Data Base (AODB), which is a part of the A-CDM simulator, to the AOP, which acts as the data core of the APOC processes. The interfaces between the simulation environment and the prototypes are implemented following state-of-the-art techniques (e.g. web service mechanisms). Together with the APAMS prototype (SESAR WP 12.07.03 – "Airport Performance Assessment Monitoring System"), the AOP implements the *Steer Airport Performance, Monitor Airport Performance* and *Manage Airport Performance services* as outlined by the conceptual approach (Bogers et al., 2015a, 2015b).

5. THE AIRPORT CONTROL CENTER SIMULATOR

The ACCES (Spies et al., 2008; Suikat, Kaltenhäuser, Hampe, Timmermann, & Weber, 2010) is an infrastructure component of DLR's Air Traffic Validation Center (Kaltenhäuser, 2015). It consists of a server room housing the computers running the simulation as well as the industrial prototypes and a large multi-purpose room that can accommodate operators for human-in-the-loop exercises, the validation supervisor, the simulation control team and exercise observer teams. An additional room to host operational level operator working positions is also provided adjacent. The main operator room provides flexibility for different validation setups, operator working positions can be freely rearranged on ground level as exercises require, e.g. to support research on the optimal seating arrangement to optimize

stakeholder communication. The simulation control team and the validation supervisor are located on an elevated platform hosting the simulation control system interfaces, opposite to an optional large video projection screen. The current arrangement of operator working and control team positions is depicted in the photograph below (figure 1), which includes a schematic 2D diagram of the overall arrangement. Currently, there are six operator working positions installed, in a hexagon arrangement. For positioning two operators in front of a single working position another chair can be added, the tables and available spacing provide enough room. Observers to exercises can be positioned either next to or behind the working positions, or on the simulation control team's platform.
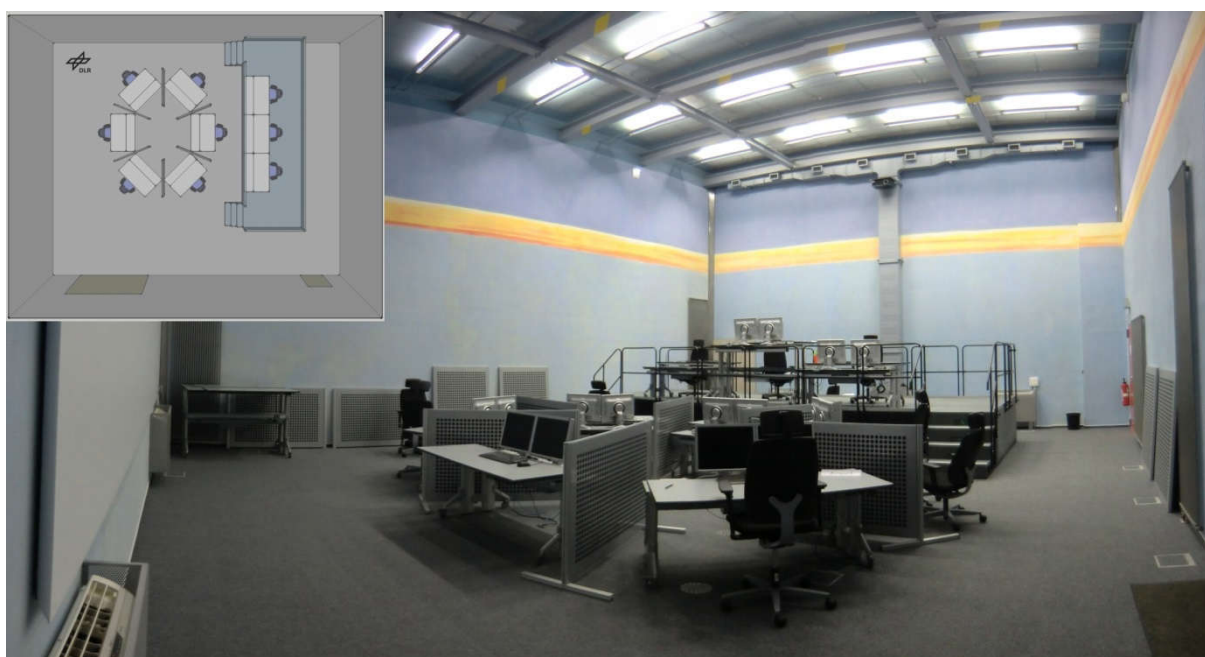
Figure 1: ACCES Control Room Layout (long shot and 2D layout, operator positions in front)

6. THE SIMULATION ENVIRONMENT

The technical simulation system is based on a combination of simulators described by Spies et al. (2008), refined in Suikat and Deutschmann (2008) and further elaborated in Suikat (2012). The approach taken for this V3 assessment does not require all of those combined specialized simulators with their full functionality.

The central components to be used is an Airport Collaborative Decision Making (A-CDM) simulation (Schier, Timmermann, & Pett, 2016). This simulation models a flights' progress over time and sets the necessary event milestones required for the airport management. As for some phases of the flights a simple process model is not detailed enough, additional

simulation models were added to conduct a joint simulation and cover all aspects with sufficient detail level.

TAMODES (Kügler & Reichmuth, 2012), which features a complete turnaround process simulation, was redeveloped and its core turnaround simulator engine was integrated into the A-CDM simulation engine. The most important passenger process milestones (A-CDM milestone #11 "Boarding starts" and A-CDM Milestone #12 "Aircraft Ready") are thus provided by functionality within the A-CDM simulator, while a full passenger/landside simulation is not required.

The air traffic simulator NARSIM (developed by NLR; NARSIM, 2013) simulates aircraft movements in final approach, on runways, taxiways and the apron. Based on the total energy model and the base of aircraft data (Nuic, 2014) these phases are calculated in high accuracy and can therefore give a more realistic impression than the calculations of the A-CDM milestone simulation.

Support vehicles that are required for the turnaround processes are not addressed in detail in this exercise. The A-CDM simulator will use appropriate turnaround times matching to the simulated scenario airport.

The validation does not require a direct connection to the Network Manager (exchange of information with the Network Operations Plan, NOP); nevertheless there exists the need to obtain information from the NOP (e.g. A-CDM milestone #3 "Take off from outstation" or A-CDM milestone #4 "Local radar update", which can be understood as a Flight Update Message (FUM) and Slot Assignments). All of these will be created by the simulator, while Departure Planning Information (DPI) and Slot Requests will be submitted by the tools. DPIs are not relevant for the assessment. Further, it is assumed that the Network Manager will actively support solution implementation in bottleneck situations. This implies that the simulation will accept the requested slots as they are. Although this is a deviation from reality to some degree, the overall assessment does not suffer from this as this approach will be the same for both, the so-called reference and solution runs (which are described below in section 8).
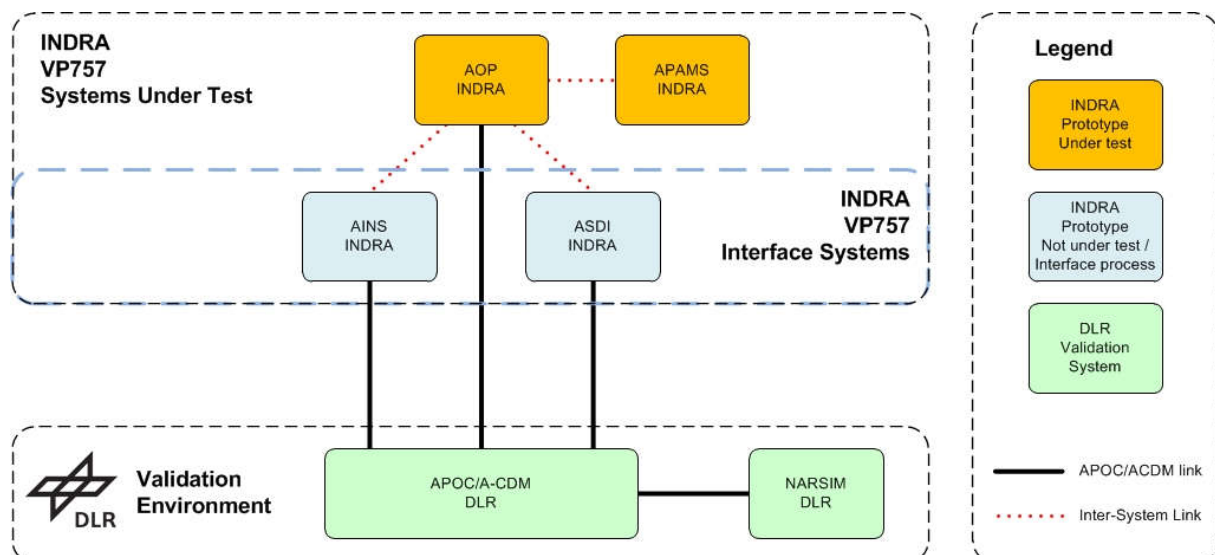
Figure 2: EXE-6.3.1-VP-757 Solution Situation Technical Setup of Prototypes and Simulators

Figure 2 depicts the technical system setup of EXE-6.3.1-VP-757. It shows various systems, DLR's validation environment featuring the combined simulators, INDRA's prototypes that represent the Systems Under Test and auxiliary support systems acting as interface systems. The solid lines depict the uni- and bi-directional connections between the simulators and INDRA's industrial prototypes used in the validation exercises, implementing the APOC/A-CDM link between the systems. The dotted lines represent the inter-prototype connection of INDRA's systems.

7. OPERATOR USER INTERFACES

AOP, APAMS and the A-CDM simulation provide Human Machine Interfaces (HMI) to the exercise operators. While the industrial solutions offer sophisticated functionality, the A-CDM HMI supplies the basic functionality that is required for these V3 exercises (Schier, Pett, Mohr, & Yeo, 2016). Assuming that the implementation of operational decisions is conducted on the operational level (e.g. via the airline Flight Operations or Hub Control Centre), the A-CDM HMI is used for these implementations (e.g. setting of the runway capacities by the local ANSP, adjustment of a TOBT (Target Off-Block Time), cancellation of a flight or a slot request) and for the actions of the airport actors.

The industrial HMIs are used to interact with the three above mentioned APOC services. When the stakeholders involved in the exercise agree on process planning aspects, these are stored in the AOP. Due to the bi-directional link between the AOP and the simulation environment, these new parameters are presented to the simulation. These then are used by

the simulation models to derive the implementation result, dynamically altering the future development of the traffic, metrics and the course of the exercise.

The simulation additionally provides a set of control HMIs to the technical supervisor and simulation control staff.

8. THE APPROACH TO APOC VALIDATION

The aforementioned APOC solution will be evaluated using the human-in-the-loop real time simulation technique in the above mentioned environment. The purpose of the proposed validation activity is to demonstrate that the developed SESAR APOC concept (including prototypes supporting the operators in performance monitoring, assessment and management as described above) leads to improved situation awareness and – owing to the collaborative approach to decision making – to a quicker recovery to normal operations and an improved overall airport performance (relating to different key performance indicators like departure and arrival delay, punctuality, usage of available apron and runway capacity). Especially, this should hold true for situations with adverse conditions where a highly collaborative environment will facilitate an improved decision making. Furthermore, the validation will assess if the APOC concept and environment provides an enriched data availability to generate post-operation analysis reports which can be used for the generation of solution support for the APOC operators in future adverse conditions.

Therefore, the key elements of the APOC concept for validation are:
- Situational Awareness of current and predicted airport performance through the AOP data content and alert messages,
- Overall Airport Performance Monitoring and Alerting,
- Deviation Impact Assessment,
- Collaborative Decision Making for performance optimization, and
- Enriched data availability for post-operations analyses.

9. APOC AVAILABILITY

The impact of the presence of an APOC (so-called "solution scenario") will be validated against airport operations without APOC and support tools (so-called "reference scenario"). As explained above, A-CDM is considered as the current standard and state-of-the-art for airport management, and therefore considered as reference. Accordingly, the management

functionalities provided in the two scenarios differ from each other. In the reference scenario the operators will only be provided with their individual "local systems" which deliver input to and allow interaction with the A-CDM platform and consequently the AODB. The APOC and its associated support tools are not provided, consequently not allowing tool supported performance monitoring and no provision of performance alerts to all stakeholders at the same time and no facilitation of the collaborative decision making process.

Three different exercises with different impact severity levels and key drivers like the possibility to anticipate the constrained situation or the location of the disruption (airside or landside) have been chosen based on actual operational constraints, which are typical of airport operations. These scenarios have been successfully used in former OFA 05.01.01 validation trials (Goni Modrego et al., 2015; Marsden et al., 2014) and will be adapted regarding severity and possible course of action to fit to the validation questions at hand. As a result, six runs (three different exercises, each executed twice, once as reference and once as solution scenario) will be performed with operational experts.

To be more specific regarding the content of the three exercises, in validation exercise #1 an airport faces a constrained situation whereby an external disruption coupled with the execution of planned works on the apron will lead to significant ground congestion. Validation exercise #2 deals with a situation where the airport is faced with a heavy thunderstorm whilst a light thunderstorm was forecasted. This adverse condition affects the operation of all airport stakeholders. In validation exercise #3, a disruption in passenger processes will take place due to an incident at the security control. These three situations have to be resolved with (solution) and without (reference) the APOC and its industrial support tools.

Using this approach, the benefit of the APOC concept will be shown in different performance degraded situations with different impact on each stakeholder and with different management options to mitigate the situation. This and in conjunction with the realistic APOC simulation environment will result in a more accurate assessment of the overall benefit of the APOC as a platform to pursue and enable the Total Airport Management (TAM) CDM (Günther et al., 2006; Spies et al., 2008).

10.THE REFERENCE SETUP

Figure 2 and figure 3 depict the logical setup of stakeholders and operating work places for the reference and solution scenario approaches. In the reference setup, as figure 2 shows,

there are three airlines (Airspace User - AU) present, addressing different AU business models/mode of operations; hub and low cost operator and the third represents all others including cargo operations. Two representatives from the operation level share a work place for each AU, representing e.g. the functions of a "Strategic and CDM Manager" and "Slot Manager" (the function denominators may vary from AU to AU in reality). Together they decide and implement operational decisions on aircraft movements and problem solution strategies. These two are representatives of a typically larger operational group usually involved in the AUs' processes. The local ANSP has a single representative, combining the Airport Tower Supervisor role and incorporating the Clearance Delivery Controller operational level role in these exercises. No direct communication to controllers is required as this is simulated by the simulation environment and no additional back office support is required for the exercise. The Airport Operator again has two representatives; the Airport Operator and the Stand and Gate planning role. They are locally grouped with their two working positions. All stakeholder companies have access to the local A-CDM system (HMI) only, an HMI that they share between their representatives. The airport Stand Planner additionally has access to a Stand and Gate Management system (powered by the simulation environment). The two stakeholder representatives can directly communicate face to face. The inter-stakeholder communication is limited to the use of a messaging system or phone only. No direct face to face communication is foreseen, to reflect the reality at most airports nowadays (with the exception of airports already using a centralized multi-stakeholder facility).
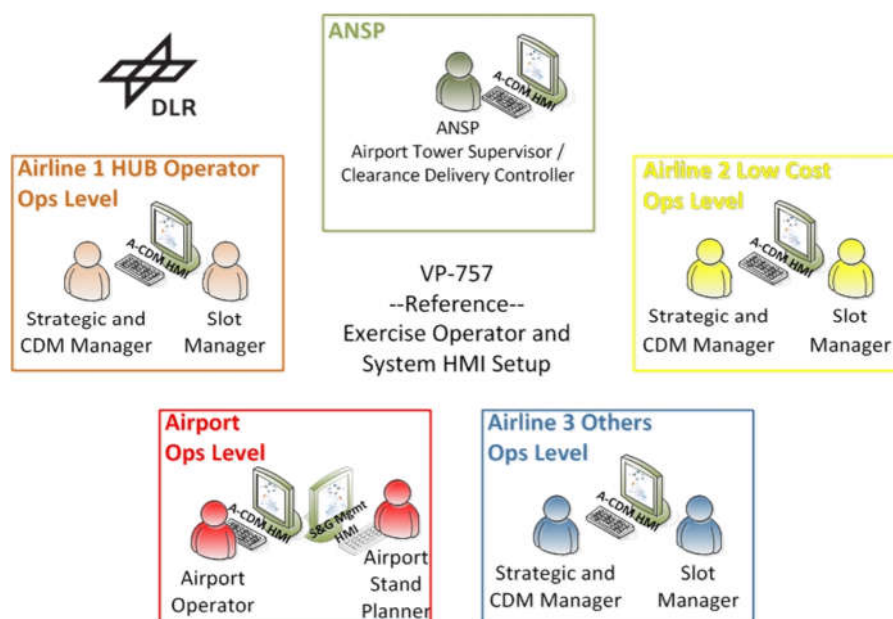
Figure 3: EXE-6.3.1-VP-757 Reference Situation Operators and HMIs

Due to the non-necessity of a direct link to the Network Manager (European Commission, 2004, 2005, 2010, 2011a, 2011b)/NOP, there is no Network Manager Representative (in reality this stakeholder may be represented by the Flow Manager Role at an airport) and no corresponding working position in either scenario setup. Since the three airspace user companies represent 100% of all traffic and aircraft handling decisions, the presence of a ground handler representative is omitted similarly.

11. THE SOLUTION SETUP

In contrast to the reference setup is the solution setup, which is depicted in figure 3. All management level representatives will be situated in a central APOC, the operational level representatives will be located outside the APOC, providing a degree of realism since the stakeholders' operation centres are not part of the APOC. The three Airspace Users each have a single management level representative and an associated working position in the APOC and another operational level representative in a back office environment (representing e.g. the Flight Dispatch or Hub Control Centre). Again, the operational level representatives will be responsible for the operational implementation of decisions for the airline. The local Air Navigation Service Provider (ANSP) will have the same representative as in the reference setup in the APOC, maybe not replacing the Tower Supervisor, but with an entirely new role defined. Again, there is no back office support for the local ANSP in this exercise setup. The Airport Operator will act as the APOC supervisor, being authorized to decide in decision making stalls and representing the goals of the airport. The supervisor is supported by an operational level representative outside the APOC, including the role of the Stand Planner as before.
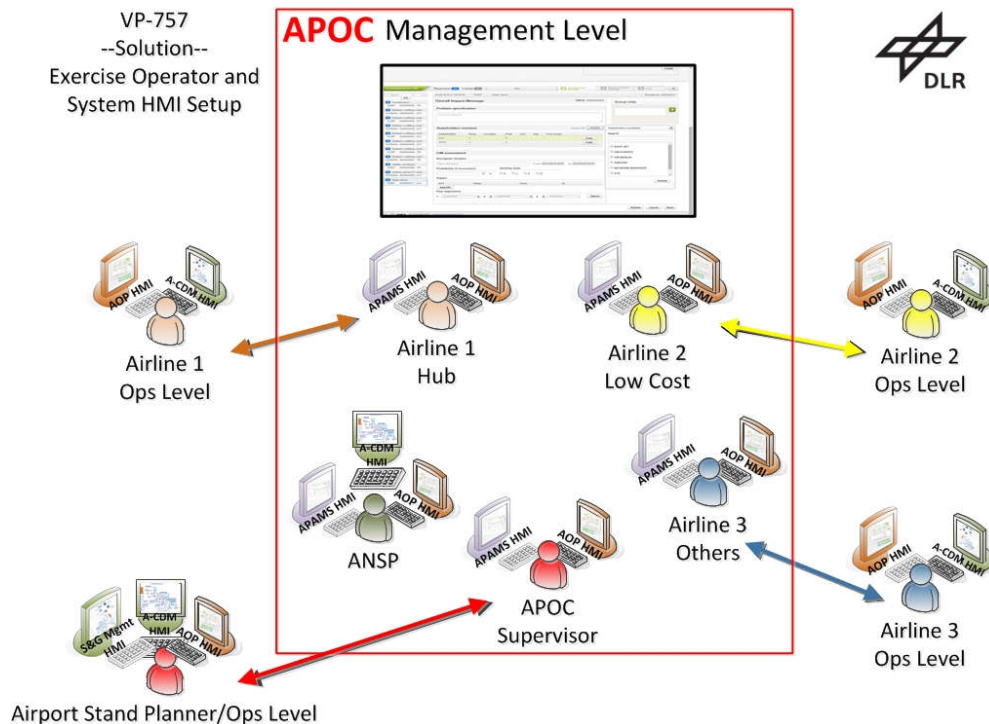
Figure 4: EXE-6.3.1-VP-757 Solution Situation Operators and HMIs

The APOC will provide a centralized video wall installation, where the APOC supervisor's APAMS HMI will be displayed. This video wall is expected to increase the situational awareness of the stakeholders' representatives and supports the efficiency of the decision making processes. The representatives in the APOC have access to HMIs of APAMS and the AOP, the local ANSP representative additionally has access to the local A-CDM HMI (since he still needs to implement his operational decisions for ease of simulation setup). The back office representatives have access to the AOP and A-CDM HMIs. The airlines' views are filtered though, to allow access to their own flights only while the airport back office sees the full picture for all flights. Additionally, the Stand and Gate Management System access lies with the airport back office representative. All operational level decisions and implementations are conducted by these representatives outside the APOC, while the management decisions are taken by the agents in the APOC. The agents can communicate with their back offices via phone or the messaging system. Inside the APOC all representatives have a direct face to face inter-stakeholder communication and may use the phone and the messaging system.

By implementing this setup it now is possible to conduct a V3 APOC assessment for the first time, providing a suitable dynamic environment for systems and operators, and fulfilling external and ecological validity criteria.

12. SUMMARY AND CONCLUSIONS

The next steps that will be taken on the way to the conclusion of this important validation goal include a variety of technical and support actions.

The industrial prototypes need to be integrated into the airport simulation environment after their development has concluded and the simulators have been enhanced to satisfy the interface requirements. Following this technical milestone, a thorough verification phase will be conducted, ensuring the reliability, consistency and interoperability of all technical components. This includes the execution of test runs with operators (not necessarily operational experts) to assess the correct operation of the system HMIs. These experiments will additionally be used to adjust prototype parameters where necessary and help to scope the specific scenario configuration that will then be used for the validation exercise runs.

Parallel to the technical actions, the preparation of the scenarios will be started, including the adaptation and definition of use cases based on the OSED that define the work flow of the operators in the APOC. The scenarios include definitions of events and the time of their occurrence, forming the storybook that will be used by the simulation control team to trigger those events as these would happen unforeseen on a real day of operations.

The test runs will be planned carefully, together with the real exercise schedule. Additional training test sessions with the operational expert personal will be conducted as part of the verification phase. This phase will be completed with the system acceptance test. The solution bundle referred to in this work is a part of the SESAR Release 5 cycle. Therefore, once the verification and preparatory actions have concluded, the "ready for validation" will be awarded through the SESAR System Engineering #2 (SE#2) Review.

Once the SE#2 is passed, the previously invited subject matter experts conduct the previously scheduled set of validation exercises, which are expected to be completed within a week's duration, running multiple exercises per day. During the execution of the exercises the relevant data from the systems, the simulators and the human interactions are captured and adequately processed. This data then will be analysed by the validation team responsible for the validation exercise. Under the consultation of the industrial and the operational SESAR partners, the data will be evaluated and assessed against the pre-defined validation

goals and corresponding success criteria, using the pre-defined metrics. A comprehensive validation report will finally conclude the validation.

With the successful completion of this validation activity, the SESAR APOC validation activities will be completed. The identified lessons learned and potential modifications derived from the assessment then will be used to provide input to a new edition 4 of the OSED and additionally may be included in the work program for SESAR 2020 (SESAR Joint Undertaking, 2014) which is expected to be launched at the end of 2016. By implementing the above mentioned requirements, the realistic and dynamic high-fidelity validation environment as described in this work offers the capabilities that are needed for this final SESAR APOC validation assessment. Furthermore, it closes the gap between pure laboratory experiments and live trials by offering flexibility concerning the required degree of fidelity and sophistication in order to deliver meaningful operational benefit assessments. The studies can be conducted in a scenario based approach using experimental designs, allowing control of confounding variables. The environment is ready to be used or can easily be adapted for future SESAR 2020 and Performance Based Airport Management (PBAM) APOC innovative research and validation assessments.

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SUPPORTING AIR TRANSPORT POLICIES USING BIG DATA ANALYTICS: A DESCRIPTIVE APPROACH BASED EMERGING TREND ANALYSIS

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ABSTRACT

Qualitative research methods based on literature review or expert judgement have been used to find core issues, analyze emerging trends and discover promising areas for the future. Deriving results from large amounts of information under this approach is both costly and time consuming. Besides, there is a risk that the results may be influenced by the subjective opinion of experts. In order to make up for such weaknesses, the analysis paradigm for choosing future emerging trend is undergoing a shift toward implementing qualitative research methods along with quantitative research methods like text mining in a mutually complementary manner. The change used to implement recent studies is being witnessed in various areas such as the steel industry, the information and communications technology industry, the construction industry in architectural engineering and so on. This study focused on retrieving aviation-related core issues and the promising areas for the future from research papers pertaining to overall aviation areas through text mining method, which is one of the big data analysis techniques. This study has limitations in that its analysis for retrieving the aviation-related core issues and promising fields was restricted to research papers containing the keyword "aviation." However, it has significance in that it prepared a quantitative analysis model for continuously monitoring the derived core issues and emerging trends regarding the promising areas for the future in the aviation industry through the application of a big data-based descriptive approach.

KEYWORDS

Aviation; Big Data Analytics; Text Mining; Topic Analysis; Trend Analysis; Descriptive Approach

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1. INTRODUCTION

Recently, there has been a surge of interest in finding core issues and analyzing emerging trends for the future. This represents efforts to devise national strategies and policies based on the selection of promising areas that can create economic and social added value. The existing studies, including those dedicated to the discovery of future promising fields, have mostly been dependent on qualitative research methods such as literature review, expert judgement and the Delphi method. This approach involves the gaining and processing large amounts of information and the analyzing and reasoning results from them. Therefore, it takes a lot of time and effort to implement as a research methods for emerging trend analysis. Besides, there is a risk that the subjective opinions of experts might affect the results.

Efforts have been made to make up for the weaknesses of the conventional qualitative analysis approach designed to select key promising areas through discovery of future core issues and emerging trend analysis in various areas of academic research: the information and communications technology industry (Chung and Lee, 2012), the construction industry (Jeong and Kim, 2012; Korea Institute of science and technology Evaluation and Planning, 2010), the steel industry (Min et al., 2014), the public sector (Korea Agency for Infrastructure Technology Advancement, 2013; Korea Institute of S&T Evaluation and Planning, 2014). There needs to be a paradigm shift in toward implementing qualitative research methods along with quantitative research methods like text mining in a mutually complementary manner. The change is to ensure objective and practical emerging trend analysis results based on large amounts of data. However, even such studies have had shortcoming related to their dependence on simple keywords for analysis, which makes it difficult to derive meaning from data. Besides, no study has been carried out so far to develop core issues and analyze emerging trends in special domains like the aviation industry. Based on the issues, it identified aviation-related research trends and selected the promising areas for the future.

In this study, unstructured text data are quantitatively analyzed through text mining, which is a big data analytics technique. In this manner, the promising future areas for the air transport industry are selected based on objective data from aviation-related research papers. In order to compensate for the difficulties in grasping the meaning of single words in emerging trend analysis at keyword levels, this study will adopt topic analysis, which is a technique used to find out general themes latent in text document sets. The analysis will

lead to the extraction of topics, which represent keyword sets, thereby discovering core issues and conducting emerging trend analysis.

Research on core issue retrieval and emerging trend analysis for the aviation industry based on big data analysis is still in its incipient stages. So, the analysis targets for this study are restricted to data from aviation-related research papers. In the future, the scope is slated to expand to cover relevant domestic or international news articles and bidding information as well, thus increasing the reliability of analysis results.

On the basis of the topic analysis results, core issues for the aviation industry will be determined. Then, emerging trend analysis for the issues will be implemented by year in order to identify the changes they undergo in time series. Through these procedures, this study aims to prepare a system for developing key promising areas for the future aviation industry as well as for ensuring rapid response. Additionally, the promising areas selected based on the aforementioned results and the analysis of pertinent policy research reports will be compared with the areas in which the actual government investments are made. The results from this comparative analysis are expected to make useful reference materials for future policy development and budget establishment.

2. APPROACHES FOR EMERGING TREND ANALYSIS

The trend analysis is to understand the current phenomenon and further prospect and forecast the future emerging trends. Emerging trend is defined as "a topic area that is growing in interest and utility over time," (Kontostathis et al., 2004). Landford (1972) categorized three approaches for forecasting emerging technologies as intuitive approach, exploratory approach, and normative approach. Intuitive approach is to utilize expert's knowledge for forecasting the future about specific technologies. Experts prospect the future technologies based on specialized knowledge of expert or information previously provided to experts. This approach includes Delphi method, brain storming, cross-impact analysis, analogy, gap analysis, and monitoring. Exploratory approach is a technique for forecasting continual shifts in the future through trends represented during the period from the past to the present in the condition that is not directed to specific social demand. This approach assumes properties of technology or multiple determinants affecting technology development is changed by the time-series pattern, and analyzed using techniques such as trend extrapolation, growth curve, substitution curve, correlation, regression, and technometrics. Normative approach is to regulate the future technology shifts or the

demand for technology development, and then suggest optimal technological plan to satisfy the future demand. This approach contains relevance tree, scenario, morphology, mission-flow diagram, and simulations.

The existing studies have generally adopted qualitative research methods such as literature review, expert judgment such as the Delphi method among the various research methods for the selection of emerging issues based on trend analysis. This approach is contained to intuitive approach according to Landford (1972)'s study. Deriving results from large amounts of information under this approach is both time-consuming and costly, and it has weakness that may reflect subjective judgment. In this paper, we propose descriptive approach for analyzing changes of core issues and prospecting the promising areas in the future through trends analysis during the period from the past to the present. This approach mainly uses text mining techniques as an automatic data-driven approach. There has been no study that analyzes general trends using quantitative research methods such as text mining technique for the purpose of identifying core issues and prospecting the future promising areas of the aviation industry. This study is the first attempt to apply descriptive approach in the trend analysis for the aviation industry. The proposed approach extracts the latent themes of the aviation industry within document sets by using topic analysis, and analyzes changes of topics by year.

3. TEXT MINING

Text mining refers to a technique designed to obtain meaningful knowledge by deriving hidden patterns or relations from a large amount of unstructured text data comprised of natural language. This technique is based on the NLP (Natural Language Processing) technology that can understand languages spoken by humans. Text mining is considered as a part of the partial area of data mining, it differs from general data mining. Even though text mining is to search for meaning within unstructured text data, data mining is to a technique designed to discover patterns in structured data. While most of studies on knowledge discovery in data have focused on structure data, it is required for analyzing unstructured text data in that most of the available data is text data from various data sources according to the rapid of growth in the data available on the web (Feldman and Dagan, 1995). Text mining is used to extract meaningful information from vast amounts of text data, identify the association with other information such as structured data, and find out the categories corresponding to the text. It outperforms a simple information retrieval in terms of the scope of results that can be generated. The stages of performing text mining in

this study are illustrated in Figure 1.

Figure 1: Stages of Text Mining

Text data collection	Morphological analysis	Feature generation & selection	Pattern Analysis

• Reviewing and defining research data (papers, patents, news, etc.)
• Determining the data retrieval period
	• Separation of morphemes
	• Part-of-speech tagging
	• Retrieval of appropriate part-of-speech
		• Removal of low-frequency term within documents
		• Term weighting (TF-IDF)
		• Removal of stopword
		• Stemming
			• Topic analysis
			• Trend analysis
			  - Top-down approach
			  - Bottom-up approach

3.1 Text Data Collection

The first stage is the process of collecting research data after selecting the sources. It is dedicated to collecting vast amounts of text data from a variety of sources such as office documents, email, news, blogs, and postings on social media. Data fit for analysis purpose should be selected.

3.2 Morphological Analysis

Morphological analysis is a stage when contents corresponding to terms, phrases and clauses are transformed into data forms suitable for language analysis processing. It is implemented through morpheme separation and part-of-speech tagging. Part-of-speech fit for research purpose should be extracted.

3.3 Feature Generation and Selection

After implementing morphological analysis, meaningful terms should be selected in order to make it possible to discover patterns hidden in text and analyze their trends. Term filtering involves the following procedures: removing low-frequency terms within documents, handling of stopwords, stemming, and assigning weights by term. First of all, terms are removed in case the number of documents containing them falls short of the minimum n. There are no established rules concerning this, so the minimum number should be determined through experiments. Terms difficult to understand, such as the definite article, as well as terms not used in the domain are processed as stopwords. In addition, terms with the same stem are processed as a single term in order to enhance the efficiency of text processing.

In order to store the processed text data as semantic information, term-specific weights are calculated by considering TF-IDF (Term Frequency-Inverse Document Frequency) which is widely used in the field of information retrieval, rather than just using term frequency (Salton & McGill, 1983). TF-IDF represents a value that can help determine the importance of a particular term in various document sets. TF is a value that reflects how often a particular term appears within a document. In general, the value increases proportionally to the importance of a term in a document. However, the frequent use of the term in a set of documents indicates that it is common. For this reason, not only term frequency but IDF (Inverse Document Frequency), which represents the reciprocal of DF (Document Frequency), is taken into consideration. IDF reflects how commonly a specific term appears within a set of documents. It is calculated by dividing the total number of documents by the number of documents containing the term, and then taking the logarithm of that quotient. The TF-IDF value is gained by multiplying the TF and IDF values, as shown in the following formula:

$$TF\text{-}IDF = TF \times log(N/DF)$$

Where

TF = Frequency of a terms within a document

N = Total number of documents

DF = Number of documents containing the term

IDF = Reciprocal of DF

Through the task of text preprocessing such as morphological analysis and feature generation and selection, an unstructured document collection is converted into a structured term-document matrix.

3.4 Pattern Analysis

In the last stage, information is reproduced through document classification or clustering based on the finally selected semantic information. Once a set of unstructured text documents is transformed into a structured, analyzable form, documents are clustered. Clustering is carried out through text clustering or topic analysis, grouping documents in accordance with similar characteristics. Text clustering and topic analysis are techniques used to discover clusters or topics hidden in a text document set. They involve clustering of documents in accordance with similarity based on the association of terms. Association

between terms is calculated by co-occurrence frequency within a set of documents. Text clustering is conducted by using such schemes as the EM (Expectation-Maximization) algorithm and the HAC (Hierarchical Agglomerative Clustering) method. Topic analysis was first based on a technique called LSA (Latent Semantic Analysis) suggested by Deerwester et al. (1990). Later, Hofmann (1999) proposed PLSA (Probabilistic Latent Semantic Analysis) by introducing a probabilistic concept into LSA. Lately, LDA (Latent Dirichlet Allocation), a technique proposed by Blei et al. (2003), is being used widely in various areas.

Conventional text clustering is based on the assumption that individual documents correspond to one theme. Thus, it has limitation that it is difficult to derive overall themes from large amounts of text documents. In contrast, topic analysis is based on the assumption that an individual document can contain complex themes dealing with various topics. A cluster or topic is represented as a set of multiple keywords. The task on naming of each cluster or topic should be determined directly by the researcher.

4. MODEL DEVELOPMENT

4.1 Research Data

Various information sources that can be used for generating core issues and analyzing emerging trends for the aviation industry include academic papers, policy research reports, patents and news articles. This study focuses on collecting aviation-related data from the academic research papers in Korea. For the trend analysis in this study, a total of 4,104 academic papers and policy research reports containing the keyword "aviation" were selected from among those published in Korea since 2000. Analysis focused on the period from 2000 and to September 2014, during which the nation laid the groundwork for take-off of its aviation industry beginning with the opening of the Incheon International Airport. Also taken into consideration was the fact that domestic aviation research started in a full-fledged manner in 2000. Detailed contents of the target data are presented in Table 1.

Table 1: Research Data

Source	Retrieval period	Frequency
NDSL academic papers	2000.1 ~ 2014.9	2,780
KISS academic papers		1,214
PRISM research reports		110
Total		4,104

NDSL (National Digital Science Library) is a database that provides data on academic papers, patents, reports, trends, and factual information. As NDSL is focused on the science and technology fields, this study additionally used KISS (Korean Studies Information Service System), which is oriented toward social sciences. PRISM (Policy Research Information Service & Management) is a system designed to effectively manage the policy research tasks implemented by the central government agencies and share the policy research reports.

NDSL search led to the retrieval of 2,780 aviation-related papers, which had been published in 415 journals over a period of about 10 years. Large portions of the papers were found from the following journals: Journal of The Korean Society for Aeronautical & Space Sciences, Journal of the Korean Society for Aeronautical and Flight Operation, Journal of Surveying Geodesy Photogrammetry and Cartography, Aerospace Engineering and Technology, and The Korean Journal of Air & Space Law and Policy. Through KISS, 1,214 papers were discovered from 195 journals, which included prominent ones such as The Journal of the Korea Navigation Institute, Journal of the Aviation Management Society of Korea, Tourism Research, Journal of Tourism Management Research, Korean Journal of Hotel Administration, and International Journal of Tourism and Hospitality Research. Because NDSL and KISS databases were found to have the same document, only one of them was taken in order to avoid duplication. From PRISM, a total of 110 research reports were found in relation to aviation policies.

4.2 Experimental Design

Research on core issue generation and emerging trend analysis for the aviation industry is still in its early stages. Pilot experiment is conducted to build a framework based on descriptive approach for emerging trend analysis and examine the feasibility for the aviation domain application. Topic analysis, one of the text mining techniques, is employed as a way to retrieve the key issues affecting the aviation industry from academic research paper. The proposed research model and the analysis scope of this study are shown in Figure 2. Data-based model development based on descriptive approach for emerging trend analysis in the aviation industry is implemented through main two steps: text document collection and text mining based trend analysis.

Figure 2: Text Mining Based Trend Analysis
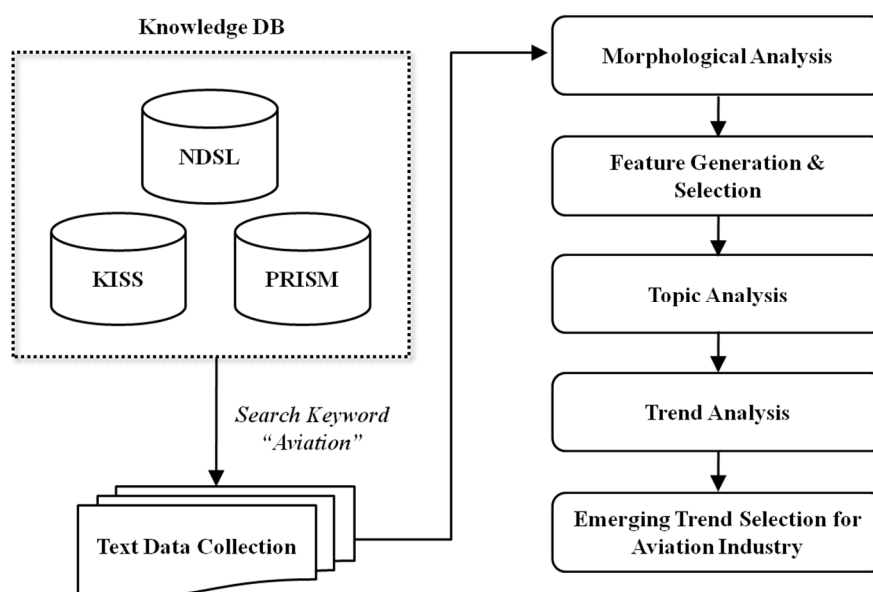
Text Data Collection

Various information sources that can be used for generating core issues and analyzing emerging trends for the aviation industry include academic papers, policy research reports, patents news articles, and bidding information. However, this study uses academic research papers and policy research reports. News articles data have copyright issue, and there also exist restrictions stemming from the difficulty of standardizing data crawled from a diversity of sources on the Web. Academic research paper data are relatively applicable to collect and analyze because they are composed of structured formats and items such as author, year of publication, abstract and keywords. In the case of policy research reports, data collection efforts faced limitations because of some organizations' practice of not disclosing the texts and due to the use of different items for mutually related information. In some cases, titles provided in summarized information by theme were used for data collection.

Research papers containing the term "aviation" in text data collection steps are retrieved through search of titles, abstracts and keywords. In general, the search keyword is selected from words specifically used in the pertinent domain, or chosen by experts. The keyword should be picked based on the relevance between research data and the purpose of the emerging trend analysis. This study is aimed at analyzing the overall aspects of emerging trends in the aviation sector, so the general term "aviation" was chosen as the search keyword. It will be necessary to prepare more sophisticated keywords when conducting

emerging trend analysis in the future targeting detailed areas within the aviation sector. Additionally, policy research reports are collected in order to compare the major issues dealt with in academic papers and policy research projects. The research reports are also analyzed to check whether proper investment is made in the core areas for the aviation industry.

Next is the process of clearly defining the scope of research data among a total of 4,104 academic papers and policy reports containing the keyword "aviation" selected for the emerging trend analysis in this study. Retrieved from search of NDSL, KISS, and PRISM databases are systematically organized and classified by year of publication, author, title, and organization in charge.

Text Mining-Based Trend Analysis

Based on the retrieved data, text mining, which is one of the big data analysis technique used to analyze the data in text form, is implemented through analyzing and processing technologies for the unstructured text data. Analysis targets are the theme of aviation-related academic papers and policy research reports. First of all, text preprocessing work, including morpheme analysis and feature selection, is implemented. This is followed by topic analysis to discover themes hidden in text document sets as well as trend analysis designed for time series review of the discovered topics. In topic analysis, documents are divided into groups based on similarity of themes. The similarity is determined by words' co-occurrence frequency within a document set. A topic is described as a set of one or more keywords, and topic analysis is based on the assumption that individual documents can handle not only single but multiple themes. Thus, topic analysis can be a useful tool for extracting general themes from large quantities of documents.

A topic extracted from a research paper can be understood as a set of keywords. The frequency of a particular topic's appearance within a document set reflects the level of interest in the concept the topic represents. Estimating the level of such interest makes it possible to analyze the trends regarding a particular concept. Eventually, it makes it possible to generate the core promising areas in the future for the aviation industry.

There are two approaches that can be used for trend analysis designed for time series review of the discovered topics. The first one is the top-down approach. In this method, the final topic is picked first, being followed by analysis of trends by year. After extracting a

topic from the entire data, frequency-based analysis is conducted by year based on the same topic. It can determine whether a topic is on the increase or decrease in terms of frequency. The second method is the bottom-up approach, which is to derive topics by era and analyze the trends. It makes it easy to grasp the topics that can be differentiated by era. However, it is difficult to examine the trends of topics taking place from the past up to the present. For this reason, this study adopts the top-down approach. By using this method, it implements trend analysis for the aviation industry, focusing on the identification of trends by year regarding the same topics.

This paper analyzes each topic's trends by using time series graphs showing yearly changes in the retrieved keywords and the discovered topics. The core issues and areas are generated through reflection of experts' opinions in addition to the keywords and the topics derived through topic analysis. This process is followed by the mapping of topics for each area. Finally, the topic trends are illustrated by using time series graphs by area. Through this process, topics showing growth trends are picked as the core promising areas for the aviation industry.

5. RESULTS AND ANALYSIS

A total of 261 keywords were retrieved as semantic information to be used for topic analysis from a total of 3,994 aviation-related academic research papers published between 2000 and 2014. The frequency and TF-IDF values of the retrieved keywords are exemplified in Table 2. We used TF-IDF values to weight terms for semantic information retrieval in the topic analysis.

Table 2: Frequency and TF-IDF of Derived Keyword Examples

No.	Keyword	Frequency	TF-IDF
1	Hub	76	7.534
2	Threat	82	7.317
3	Lidar	134	7.260
4	Job satisfaction	126	7.260
5	Disaster	86	7.260
6	Aviation safety	87	7.179
7	Airline service	74	7.179
8	Prevention	75	7.153
9	Cell	179	6.983
10	Low cost airline	160	6.960

On the basis of topic analysis results as well as experts' opinions in the aviation domain, the emerging topics were broadly classified into the following issue categories: aviation policy/air transport industry, airport, safety/security, and environment/technology. The topics and keywords corresponding to the core issue categories are presented in Table 3. Topic analysis led to the development of 23 topics, each of which was represented as a set of five keywords.

Table 3: Emerging Topics Derived for the Aviation Industry

Issue Categories	Topics	Keywords
1. Aviation policy/ Air transport industry	1.1 Aviation safety policy	Aviation, Safety, Accident, Aviation safety, Operation
	1.2 Airfare (low-cost carriers)	Carrier, Cost, Low cost airline, Operation, Value
	1.3 Distribution channels	Travel, Agency, Airline, Distribution, Channel
	1.4 Job satisfaction	Job, Satisfaction, Job satisfaction, Employee, Commitment
	1.5 Aviation agreements (baggage liability, etc.)	Law, Liability, Convention, State, Damage
	1.6 Flight attendant training/management	Flight, Attendant, Flight attendant, Commitment, Training
2. Airport	2.1 Airport service appraisal	Service, Quality, Passenger, Service quality, Satisfaction
	2.2 Aviation logistics	Airport, Cargo, Passenger, Facility, Logistics
	2.3 Airport hub strategy	Airport, Facility, Passenger, Security, Hub
	2.4 Noise control measures	Noise, Level, Airport, Measurement, Vibration
3. Safety/ Security	3.1 Air traffic control (collision prevention)	Control, Traffic, Controller, Response, Demand
	3.2 Air accident prevention	Accident, Passenger, Damage, Risk, Liability
4. Environment/ Technology	4.1 Eco-friendly high-efficiency fuel	Fuel, Cell, Power, Energy, Density
	4.2 Aircraft wing/shape design optimization	Aircraft, Operation, Wing, Landing, Stability
	4.3 Radar	Radar, Vehicle, Antenna, Traffic, Performance
	4.4 Sensor (error prevention)	Sensor, Error, Accuracy, Camera, Measurement
	4.5 Spatial resolution enhancement	Image, Camera, Resolution, Feature, Photo
	4.6 Unmanned aircraft	Vehicle, Path, Unmanned aerial vehicle,

		Aerial, Flight
	4.7 Lidar	Building, Lidar data, Lidar, Surface, Height
	4.8 Engine	Engine, Flow, Fuel, Performance, Temperature
	4.9 Composite materials	Material, Property, Composite, Temperature, Strength
	4.10 Digital map	Map, Digital map, Accuracy, Photo, Road
	4.11 Aerial photo	Land, Photo, Aerial photograph, Management, Construction

The derived topics, which can be understood as keyword sets, were mapped onto the four core issue areas. There are six topics in the aviation/air transport industry category, four in the airport category, two in the safety/security category, and 11 in the environment/technology category. Among the derived topics, the following 10 were selected as the highest ranked ones in terms of frequency: aircraft wing/shape design optimization, air traffic control (collision prevention), radar, flight attendant training and management, sensor (error prevention), airport service appraisal, spatial resolution enhancement (geographical features), aviation logistics, aviation safety policy, air accident prevention, unmanned aircraft, radar, engine, composite materials, and airfare (low-cost carriers). These can be considered to be the core issues being studied in the aviation sector. The selected topics and frequency of each core issue category are summarized in Table 4.

Table 4: Core Emerging Topics of the Aviation Industry

Rank	Categories	Topics	Frequency
1	Environment/ Technology	Aircraft wing/shape design optimization	614
2	Safety/Security	Air traffic control (collision prevention)	466
3	Environment/ Technology	Radar	441
4	Aviation policy/ Air transport industry	Flight attendant training/management	436
5	Environment/ Technology	Sensor (error prevention)	425
6	Airport	Airport service appraisal	423
7	Environment/ Technology	Spatial resolution enhancement (geographic features)	389

8	Airport	Aviation logistics	388
9	Aviation policy/ Air transport industry	Aviation safety policy	387
10	Safety/Security	Air accident prevention	370

We additionally retrieved the keywords and core issue categories to discover the investment areas from the aviation-related policy research reports. Then, they were compared with the areas in which the actual government investments were being made. The 10 keywords derived from the policy research reports are safety management, noise control measures, space, small craft, aviation accidents, aviation demand, aircraft certification, service appraisal, air traffic control, and unmanned aircraft. The level of correspondence was 60% between the academic research areas and government investment fields as shown in Table 5. It is determined that the non-matched areas such as small aircraft, aviation demand, and aircraft certification will be studied in the academic field for the future. The results from this comparative analysis are also expected to make useful reference materials for future policy development and budget establishment.

Table 5: Correspondence between Core Emerging Topics and Issues in Aviation Policy Research

Rank	Categories	Keywords	Frequency	Correspondence
1	Safety/Security	Safety management	13	○
2	Airport	Noise control measures	6	○
3	Aviation policy/ Air transport industry	Space	5	
4	Environment/ Technology	Small aircraft	4	
5	Safety/Security	Aviation accidents	4	○
6	Aviation policy/ Air transport industry	Aviation demand	4	
7	Safety/Security	Aircraft certification	3	

8	Airport	Service appraisal	3	○
9	Safety/Security	Air traffic control	3	○
10	Environment/ Technology	Unmanned aircraft	3	○

Trend analysis was conducted to identify the changes by era in the degree of interest in the finally chosen topics as well as to determine the promising fields for the future aviation industry. The data for 2014 were excluded from the trend analysis because they were available only for the first nine months. Finally, the topics corresponding to the core issues were analyzed through the top-down approach. First of all, topics are extracted from the entire data. Then, analysis is conducted to find out yearly changes in the degree of interest for the same topics. It represents a scheme to determine topics on the increase or decrease in terms of the level of interest. Frequency of a particular topic within a document set reflects the degree of interest in the concept represented by the topic. The annual degree of interest for an individual topic is calculated in the following manner:

Degree of interest = Frequency of a pertinent topic / Total number of documents

For trend analysis, the period from 2000 through 2013 was divided into three phases by reflecting relevant changes in the aviation industry. Then, time series patterns were analyzed for each topic. Phase 1 (2000~2003) was named the "period of stable growth and preparation for take-off," while Phase 2 (2004~2007) was called the "period of take-off and rapid change." Phase 3 (2008~present) was referred to as the "period of stability and second take-off."

Phase 1 saw the acceleration of the signing of aviation agreements as well as the introduction of international standards for aviation policies. In addition, efforts to secure aviation safety were intensified through the implementation of the confidential aviation incident reporting system, the aviation safety inspector system, the air operator certificate system, and the maintenance organization approval system. Following the 2001 opening of the Incheon International Airport, various standards were established, thus laying the groundwork for take-off the Korean aviation industry.

Phase 2 was a period when the hub strategy for Incheon International Airport was

implemented along with its second-phase construction project. An aviation safety management system was established to enhance the level of safety. In particular, low-cost carriers began to appear amid efforts to provide air services suitable for domestic situations. Their market participation was related to decreases in air demand caused by an economic slowdown and progress in the development of alternative modes of transport. Korea's first low-cost carrier was Hansung Airlines (presently T'way Air), which launched its flight services in August 2005. During the period of Phase 3, the 3rd-phase construction of Incheon International Airport began in a move to strengthen its competitiveness. The project is to be completed by the end of 2017. At present, two full-service carriers - Korean Air and Asiana Airlines - and five low-cost carriers are in operation in Korea. Other major developments included the preparation of autonomous air safety reporting regulations and the further easing of market entry restrictions for air transport operators. This was a period when the nation secured a basis for diversifying air transport businesses such as the operation of small aircraft.

The topics found to be on upward trends were picked as the core promising areas for the aviation industry. As demonstrated in Figures 3 to 6, researches pertaining to aviation were shown to be actively implemented during Phase 3, which were referred to as the stability period and the take-off period, respectively. The number in the following bar graphs was matched by the selected emerging topic in Table 3.

Figure 3: Trend Analysis for the Issue of Aviation Policy/Air Transport Industry
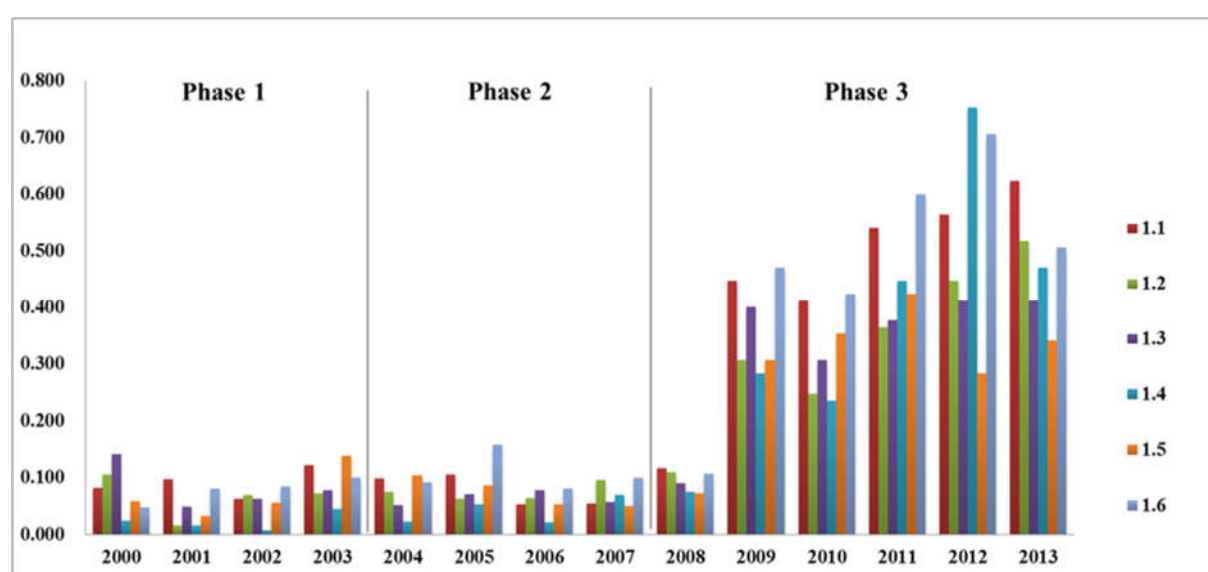
Figure 4: Trend Analysis for the Issue of Airport
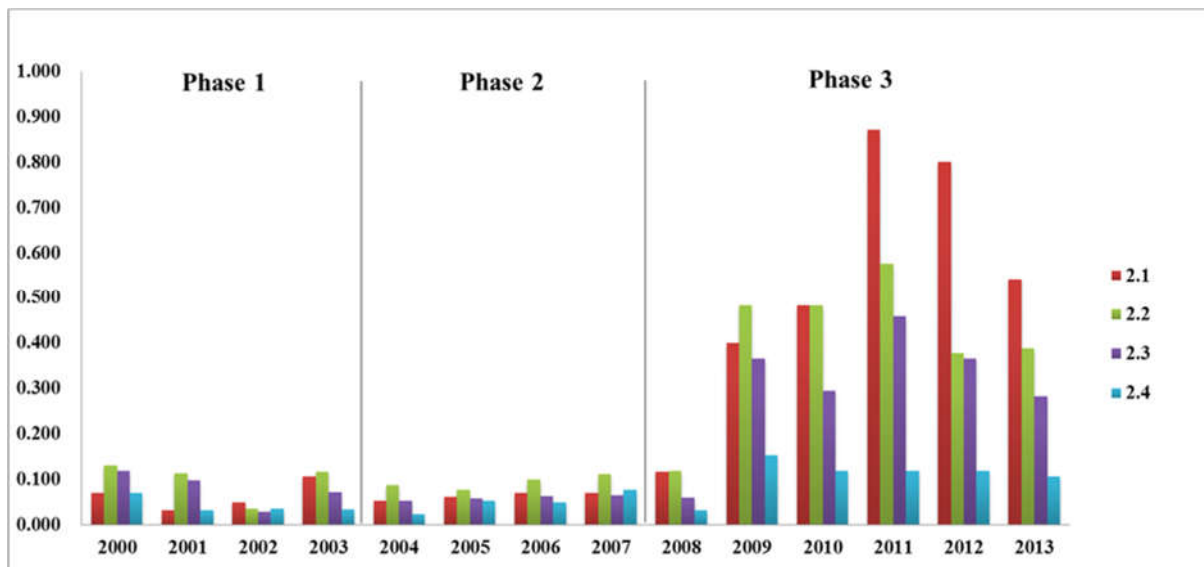
Figure 5: Trend Analysis for the Issue of Safety/Security
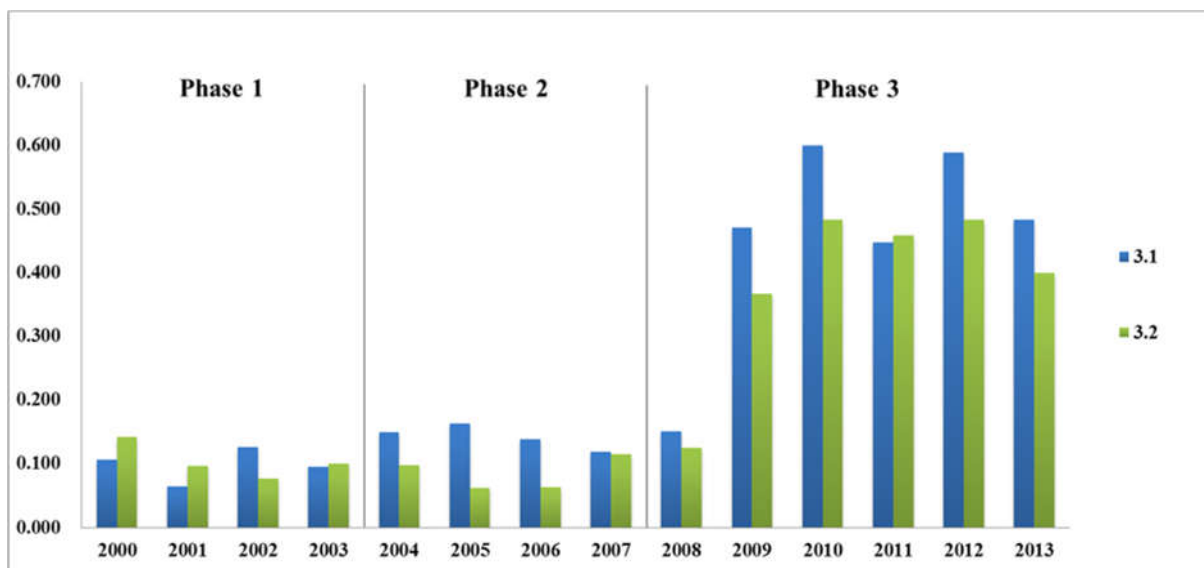
We categorized topics as three types through time-series pattern analysis: upward trends, downward trends, and types without upward or downward trends on the degree of interest for a topic. Types without specific patterns indicated that that it was consistently considered as important topics without trends or downward trends on the degree of interest for a topic. Topics with high degree of interest were selected as the future promising areas in the aviation industry by reflecting the number of three or more consecutive upward trends during the entire research period and the number of upward trends during phase 3,

considering that aviation-related studies were shown to be actively conducted in recent years.

Figure 6: Trend Analysis for the Issue of Environment/Technology
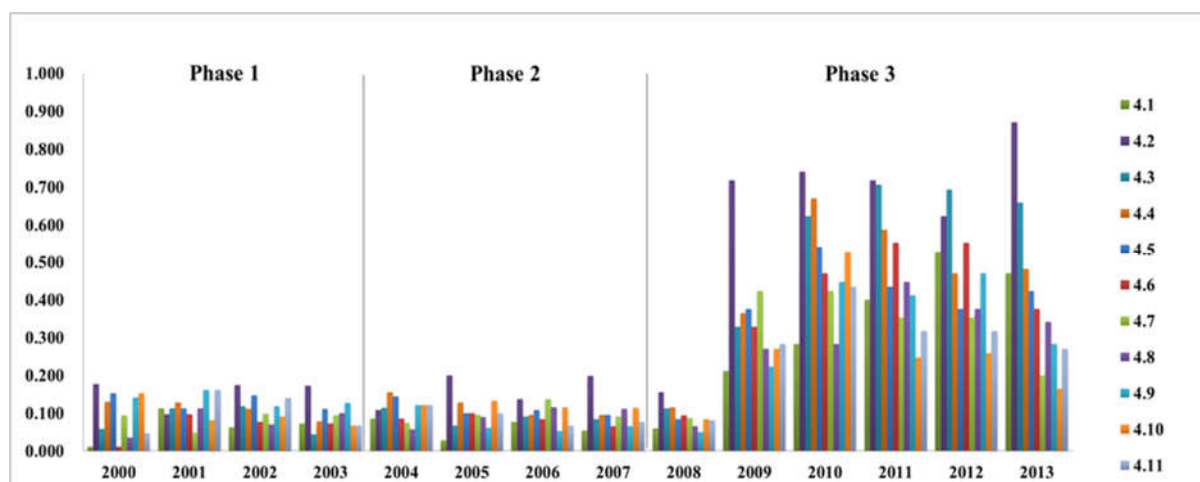
Topics such as aviation safety policy, airfare (low cost carriers), and eco-friendly high-efficiently fuel were found to be on upward trends. First, aviation safety policy, a topic that belongs to the issue category titled aviation policy/air transport industry, has drawn an increasing level of attention since the nation's aviation industry entered a period of stability and second take-off, as manifested in Figure 7. This was a period when international standards on aviation safety policy were introduced into the nation. In May 2008, Korea underwent a safety audit administered by the International Civil Aviation Organization (ICAO). Through the audit, Korea was certified to have implemented 98.89% of the relevant international aviation safety standards. Aviation accidents occur at lower frequency than those of other modes of transport such as trains, buses and ships. Once they occur, however, they cause large numbers of human casualties and serious damage to aircraft. Besides, aviation users become distrustful of the airlines involved. For these reasons, aviation safety policy is expected to keep attracting a high level of attention. There is a need to continuously improve the aviation safety system and to prevent accidents, flight delays and cancellations.

Second, airfare is a topic that belongs to the issue category of aviation policy/air transport industry. Particularly with regard to low-cost carriers, the airfare issue kept attracting a high level of interest beginning in 2009, as demonstrated in <Figure 8>. Low-cost carriers entered the aviation market as the nation was seeking a new air service system suitable for domestic conditions, following a drop in aviation demand caused by an economic slowdown and the development of alternative modes of transport. In August 2005, Hansung Airlines

(predecessor of T'way Air) began operations as the nation's first low-cost carrier. Four more budget carriers launched their commercial flights over the next several years: Jeju Air in June 2006, Jin Air in July 2008, Air Busan in October 2008, and Eastar Jet in January 2009. According to statistics compiled by the Ministry of Land, Infrastructure and Transport, the airline domestic market shares in the first quarter of 2014 reached 29.4% for Korean Air and 23.1% for Asiana Airlines. The share for low-cost carriers were 13.2% for Jeju Air, 11.9% for Air Busan, 7.9% for Eastar Jet, 7.3% for T'way Air, and 7.2% for Jin Air. Domestic low-cost carriers increased their flights and opened new routes. These activities led to a rise in the number of people using the budget airlines. As a result, the market shares of Korean Air and Asiana Airlines went down. The low-cost and full-service carriers are expected to compete fiercely over the market shares. Amid such a competitive atmosphere, the airfare issue will likely continue to attract a high level of attention.

Figure 7: Trend Analysis for Aviation Safety Policy
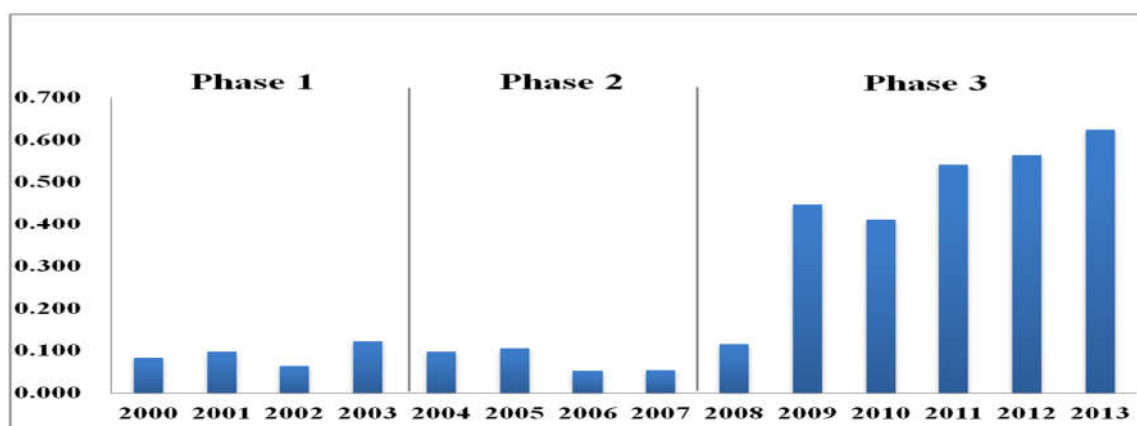
Figure 8: Trend Analysis for Airfare (Low-Cost Carriers)
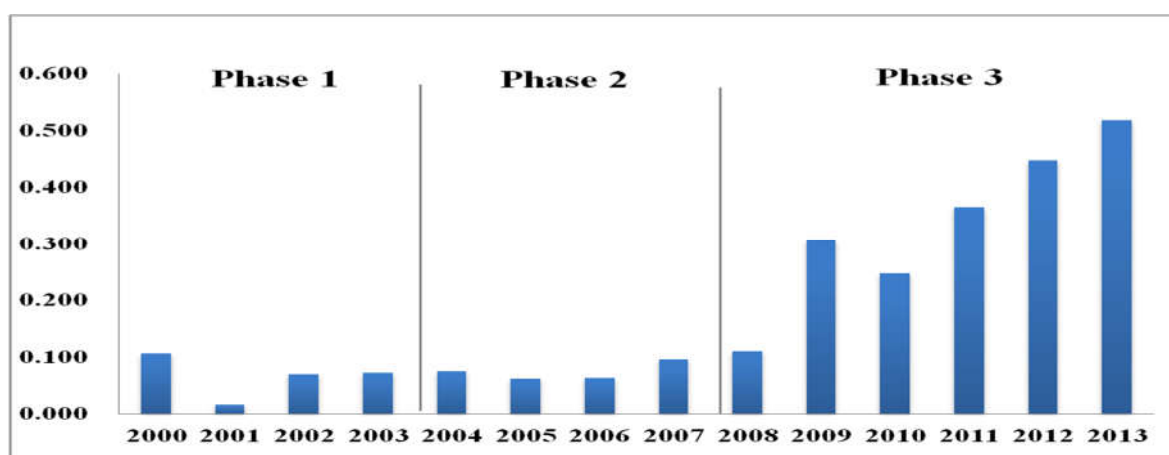
Third, eco-friendly high-efficiency fuel is a topic that belongs to the environment/technology issue category. As shown in Figure 9, the level of interest in the topic has steadily increased since 2009, although it slightly went down in 2013. In relation to efforts to reduce greenhouse gas emissions from aircraft, the level of interest is particularly high for environment-friendly and high-efficiency fuels like hydrogen fuel cells, secondary batteries, and biofuels. In addition, a growing level of attention will likely be focused on matters related to greenization of the aviation industry, such as the use of composite materials, the use of fuel-efficient engines, and fuel conservation through shape design optimization.

Figure 9: Trend Analysis for Eco-Friendly High-Efficiency Fuel
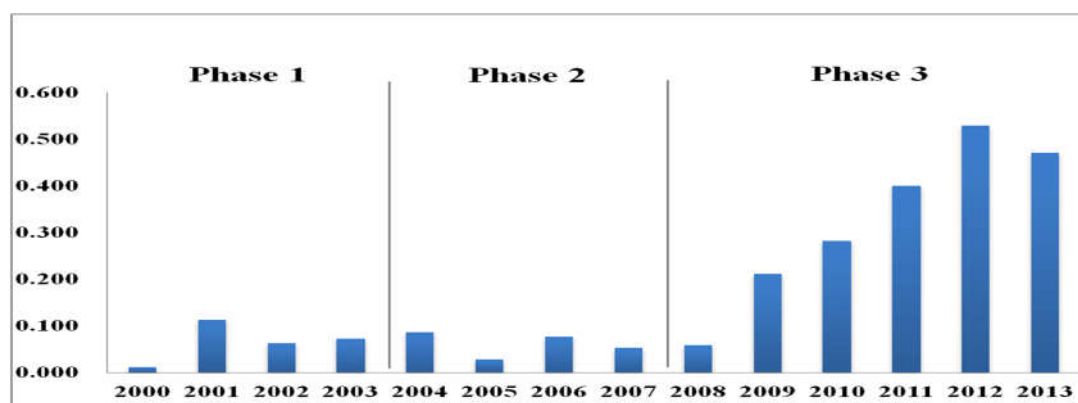
Topics such as airport hub strategy, noise control measures, lidar, and aerial photos were found to be on downward trends. In contrast, the following are steadily regarded as important topics without specific patterns: circulation channel, job satisfaction, aviation agreement (baggage liability, carry-on baggage restrictions), flight attendant training and management, airport service appraisal, aviation logistics, air traffic control (collision prevention), air accident prevention, aircraft wing/shape design optimization, lidar, sensor (error prevention), spatial resolution enhancement (geographic features), unmanned aircraft, engine, composite materials, and digital map.

6. CONCLUSIONS

This study focused on deriving core issues for the air transport industry from aviation-related academic research papers by using a text mining method, a big data analysis technique, with a view to identifying the relevant trends and making predictions on promising areas for the aviation industry. It has limitations as its research for discovering the core issues and promising areas was restricted to academic research papers containing

the keyword "aviation." However, it has significance in that it has helped establish a quantitative research method for generating and steadily monitoring aviation-related core issues as well as for presenting directions of core promising areas in the future.

Research on extracting core issues and conducting emerging trend analysis for the aviation industry through the application of a big data-based descriptive approach is in its early stages. However, given the rapidly rising number of research papers, news and patents, it seems essential to prepare measures to cope with changes in relevant technologies and environments. In the future researches, efforts will be made to enhance the reliability of analysis results by selecting more detailed search keywords and expanding the scope of research sources to cover news articles, patents, and bidding information as well.

To increase the accuracy of the text mining based trend analysis results, in-depth studies will have to be carried out continuously on ensuring research data coding standardization and defining the pertinent standards as well as establishing an automation scheme for text representation. Such studies will help develop more objective analysis methods for discovering the core issues and promising areas pertaining to aviation, laying the groundwork for establishing mid- and long-term policies aimed at securing the competitiveness of the aviation industry. In addition, reflecting the opinion of domain experts will additionally considered for capturing the correct meaning of topics through a set of keywords.

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INFLUENCE OF THE THREE LINKS AGREEMENT ON THE BEHAVIOR OF TAIWAN AIRPORTS: A TWO-STAGE DEA ANALYSIS

Lu Yang[1]

ABSTRACT

Taiwan is a small island with a relatively large number of airports. These airports show great disparity in terms of passenger volume and cargo tonnage. This paper in the first part evaluates the efficiency and productivity of Taiwanese airports using a panel data set, to verify the ones with lower efficiency performances. DEA (Data Envelopment Analysis) and Malmquist index methods are applied. In the second stage the changes of these scores are analyzed in different regression methods to test the influence of the Three Link agreement between China and Taiwan. It reveals that airports in Taiwan with routes to China have lower efficiency scores but their productivity grows faster than that of the other airports. This paper also confirmed that airports on offshore islands have higher efficiency scores and productivity.

KEYWORDS
DEA; Malmquist index; Airport benchmarking

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1. INTRODUCTION

Taiwan is an island off the southeast coast of mainland China, facing the Pacific in the other side, consisting of a main Taiwan Island and several offshore islands. Taiwan has a natural advantage in international aeronautic transportation in the Asia-Pacific region: it is only 90 minutes away from Hong Kong and even less time to Shanghai by air. The flight time it costs from Taipei to Seoul and Tokyo are 140 minutes and 180 minutes respectively. Within 3 to 4 hours, one can reach Bangkok and Singapore from Taipei easily, enough for a one-day business trip. In its economic development history, there used to be a huge aviation demand that came along with the Taiwanese economic taking off during the 1970s, when more than one third of the civil aviation airports in Taiwan were built. Partly because of this convenient location between East Asia and Southeast Asia, also because of a great aviation demand in its economic development history, Taiwan has quite an extraordinarily high level of airport density. In Figure 1 we list the airport density of major countries/regions around the world. The information of commercial airports is collected from the official websites of each country's Civil Aviation Authority or the Department of Transportation. We can see that Taiwan ranks top in these selected countries/regions.

Figure 1: Worldwide Airport Density
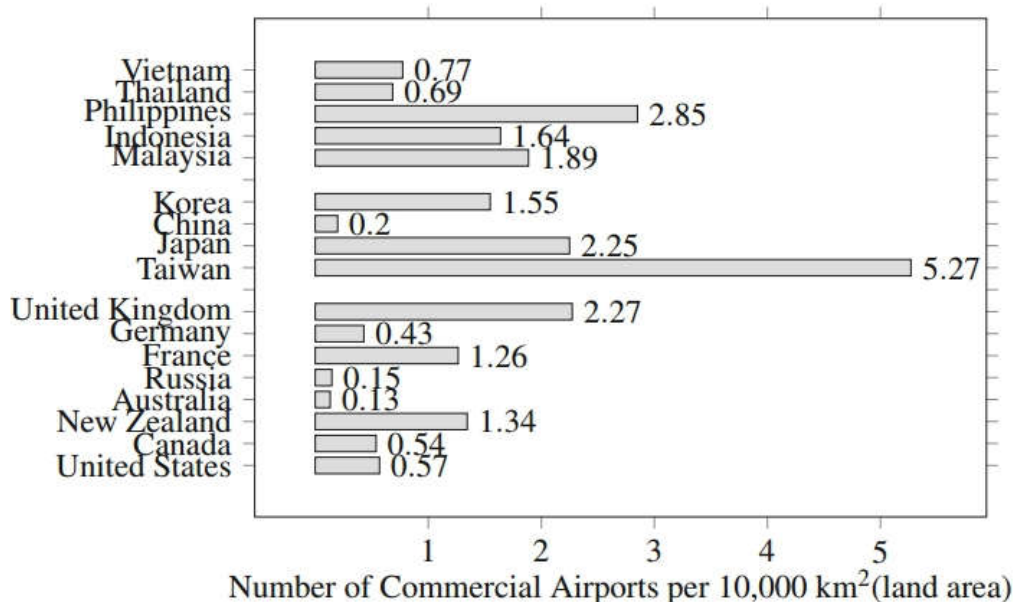
However, the total aviation passenger number as well as cargo tonnage have been on the decline since the year 1997 (with some exception years), along with the decelerated economic growth. The trend of Taiwanese aviation demand in recent forty

years is shown in Figure 2. This decline continued in domestic flights when THSR[2] opened for service in 2007. However, as we can see in Figure 2, despite the fact that the domestic aviation demand decreased rapidly after around 1996, the international aviation passengers number kept growing.

More importantly, Taiwanese airports experienced a big change last decade, when the "Three Links" agreement was signed between mainland China and Taiwan. "Three Links" stands for direct postal service, direct transportation and direct trade between mainland China and Taiwan, which put an end to the history of no traffic relations between PRC China and ROC Taiwan since the end of the Chinese Civil War in 1949. The first chartered flight between mainland China and Taiwan appeared in 2003, when the flights had to make a transit in Hong Kong or Macau, and the airplane could only make one-way flight during traditional Chinese festival periods. After the huge earthquake in Sichuan, China in May 2008, humanity chartered flights were permitted for Taiwanese relief supplies[3] and rescue teams[4] to be sent directly to the disaster area. Two months later on July 4th 2008, first weekend regular chartered cross-strait flight made its debut without stopping by Hong Kong[5], although a symbolic passing through the Hong Kong FIR (Flight Information Region) was still necessary. Finally, at the end of 2008, the regular daily flights across Taiwan Strait without detouring over Hong Kong came into reality[6].

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[2] Taiwan High Speed Rail. Currently runs from Taipei to Zuoying (Kaohsiung).

[3] Chinese Airlines chartered cargo plane will make a direct flight to Sichuan in the afternoon to deliver relief supplies (in Chinese). RTHK. May 15, 2008.
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http://www.chinapost.com.tw/taiwan/china-taiwan-relations/2008/06/13/160749/Taipei-Beijing.htm

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http://www.chinapost.com.tw/taiwan/china-taiwan-relations/2008/12/15/187643/p2/Direct-cross-strait.htm

Figure 2: Taiwan's Aviation Passenger[7]
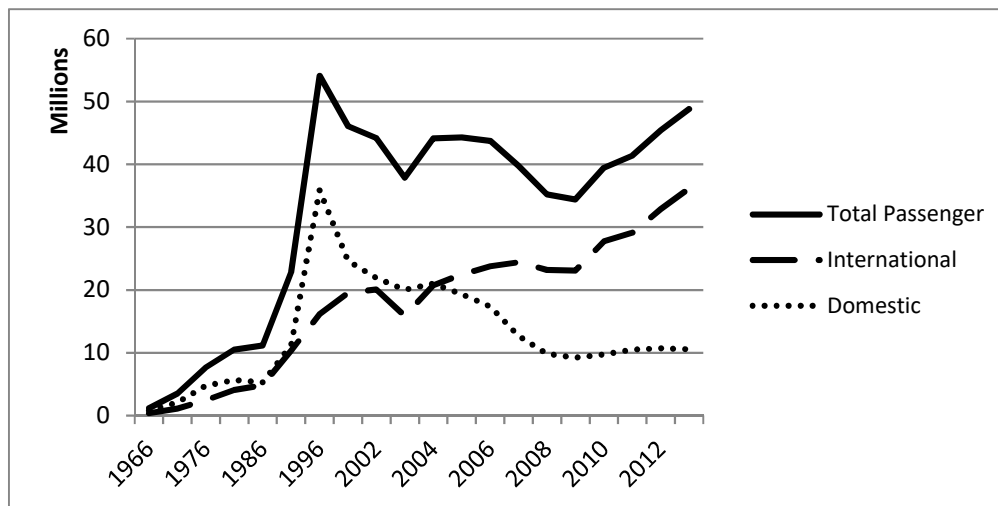
It would be interesting to see how the policy change by the Three Links Agreements affects the efficiency and productivity of airports from both China and Taiwan. We focus on the behavior of Taiwanese airports in this paper. From Figure 2 the year 2009 appears to be a watershed: the growth of international aviation demand sped up and the domestic aviation demand stopped decreasing and increased slightly in recent years. As a whole the total aviation demand of Taiwan finished its 10 years decrease and returned to a strong increase ever since. Despite of the influence of the financial crisis of 2007-2008 and the bankrupt of Lehman Brothers, which pulled down the growth rate of Taiwan's GDP to around -5%[8], along with the opening of THSR, both domestic and international passenger volume have better performance since 2009 than before. Our hypothesis in this paper is that the opening of direct China air route plays an important role. To evaluate the efficiency difference, we define efficiency by the DEA efficiency scores and productivity change by Malmquist index. DEA scores measure the relative ratio of (weighted) output to input of a specific DMU (Decision Making Unit) while Malmquist index evaluates the productivity change of one DMU between two time periods. The detail will be discussed in section 2.2, where the overall efficiency and productivity will be compared before and after the Three Link agreement. As it is widely discussed within Taiwan about whether small local airports should be open to direct China routes, our interest also lies in the possible gap between big airports like Taoyuan airport and small airports like Hengchun airports, after the Three Link agreement.

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[7] Data source: Traffic of Civil Aviation by Airports:
http://www.caa.gov.tw/en/content/index.asp?sno=362
[8] Taiwan GDP Growth Rate. http://www.tradingeconomics.com/taiwan/gdp-growth.
Trading Economics

The remainder of this paper unfolds as follows. In the next section, we will introduce the development of DEA in airport benchmarking. In section 2, I will introduce the methodology applied in this study. In section 3 we are trying to measure (1) the efficiency of Taiwan airports; (2) the technical efficiency change (TEC) and the frontier shift (FS) of Taiwan airports over the years 2004 to 2011. Furthermore, we are going to analyze the impact of this policy change not only on the efficiency (DEA score) but also on the productivity change (Malmquist Index) of airports. A second stage panel data regression will be adopted to check the impact of endogenous factors of the airports, especially the effect of the Three Links Agreement between China and Taiwan. The results and conclusion, as well as policy suggestions, will constitute the last section.

2. LITERATURE REVIEW

The efficiency of airports has long been measured and evaluated in a wide variety of contexts. Among those methods DEA is one of the most widely used ones. In fact, in the appendices of Liebert and Niemeier's survey of empirical studies on the productivity and efficiency of airports (Liebert & Niemeier, 2013), only 4 studies employ price-based index approaches, 20 papers applied parametric approaches (SFA: Stochastic frontier analysis, is the main approach), while 37 papers use non-parametric approaches. Among those non-parametric papers 30 apply DEA purely and 6 compare DEA results to those of other methods. DEA method is chosen in many empirical studies because of its advantage in dealing with the naturally complex relation among multiple inputs and outputs of the DMUs, which is difficult to deal with other methodologies. In DEA models there is no assumption on a functional form for the DMUs and the production process is seen as being operated in a black box. For example, when measuring Taiwan's domestic airport efficiency, Yu (2004) applied DEA analysis with one undesirable output (airplane noise) and population of the prefecture where the airport locates is introduced as an environmental variable. The economical cost of the airplane noise or the mechanism it affects airports' operation is not necessary in DEA and the weight for each input or output is decided individually.

In the field of airport benchmarking, there is a significant amount of studies done by various researchers. Yoshida and Fujimoto (2004) calculated both the CRS and VRS efficiency scores of Japanese airports in year 2000. In the second stage they conducted a Tobit regression to test the connection between the efficiency scores and

two factors indicating the characteristics of each airport. Abbott and Wu (2002) analyzed both the total factor productivity (Malmquist Index) for twelve Australian airports and technical efficiency (DEA efficiency score) for Australian and international airports. Malmquist Index is decomposed into technical efficiency change and technological change, technical efficiency change is further decomposed into pure technical efficiency and scale efficiency. A second stage regression is also applied.

For the efficiency of Taiwan airports, the previous studies are quite limited. Some research compared the efficiency of global airports and TPE (Taoyuan International Airport) is included as one of the research objects. For example, Oum and Yu (2004) measured and compared the Variable Factor Productivities (VFP) of 76 major airports including TPE, utilizing the data from the 2003 ATRS global airport benchmarking report. VFP is chosen in this study because of the lack of information on the capital input of each airport and the distortion caused by government subsidy on airport capital expansion projects. TPE is also included in Yang's research (2010) on twelve international airports of the Asia-Pacific area from 1998 to 2006. DEA and SFA are both used in his study and the relations between the results of the two methods are discussed. Lin and Hong (2006) calculated the DEA efficiency score for twenty airports around the world by both CCR and BCC model. Besides the undesirable output study (Yu, 2004), Yu, Hsu, Chang, and Lee (2008) applied Malmquist-Luenberger productivity index and window approach to a panel data of four domestic airports of Taiwan, for a period from 1995 to 1999. Yu (2010) also conducted a cross section research on the fifteen domestic airports of Taiwan in the year 2006, using a slacks-based measure network DEA (SBM-NDEA) model.

In the Taiwan airport case, we not only want to obtain the efficiency scores for each airport, but also more importantly we are eager to identify the possible influence brought to the efficiency and productivity of Taiwanese airport by the Three Link agreement. At first, we would like to distinguish the performance of Taiwanese airports before and after the specific year when a China route was opened. If we want to know how the efficiency and productivity of DMUs changes during a specific time period, the Malmquist Index is a proper indicator which is calculated based on DEA efficiency scores of each year. Two stage Malmquist Index analyses are rarely seen in airport benchmarking. Fung, Wan, Hui, and Law (2008) evaluated the efficiency scores and Malmquist productivity for twenty-five Chinese airports during year 1995-2004. In the

second stage, however, they did not use a regression but only showed the ODF[9] by groups to explain the relation between the airports' productivity and other factors such as the location or ownership of the airports. In this paper SBM DEA and Malmquist index model are applied for all the Taiwanese airports for a time span across the signing of Three Link agreement, also a second stage regression is run to verify the effect on efficiency and productivity of airports by China air routes or other characteristic factors.

3. DATA AND MODELS

Data

We collect the data of eighteen airports used in this study from the website of Civil Aeronautics Administration, Republic of China[10]. The biggest Taoyuan International Airport is operated by a state-owned cooperation. All the rest seventeen airports are administrated by the Civil Aeronautics Administration. It is a balanced panel data from year 2004 to year 2011. This is the longest time period given data availability and the fact that Hengchun Airport started its operation in the new terminal since Dec. 2003 and that Pingdong Airport finished its run in the year 2012. We have three variables each for input and output. The annual volume of Passenger, Cargo and Taking-off and landings are output variables. Terminal area, runway area and apron areas are input variables. Labor input is not included in this study because of data availability. This is not a big issue as we only focus on the capital input productivity.

There is a giant gap in the inputs and outputs among Taiwanese airports, while the changes along the eight years in each airport are not so significant. If we look at the input variables in the year 2011, we can find that the terminal area of Taoyuan International Airport accounts for nearly 80% of the total terminal area of the nineteen airports. Correspondingly, its apron area accounts for more than half of the total apron area. For runway area it is not so extreme but still Taoyuan runway accounts for 20% of the sum. The situation, as expected, is similar in the output section, where 42%, 60%, and 94% of the taking-off and landing, passenger volume and cargo volume are delivered by Taoyuan International Airport.

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[9] Output Distance Functions, the terminology they adapt for DEA efficiency score.
[10] http://www.caa.gov.tw/big5/content/index.asp?sno=186

Taking a deeper glance at the output data, we could also find some interesting trends for different airports. For example, the passenger number of Taoyuan International Airport increases steadily until 2008, possibly due to the opening of THSR and the global recession resulted from the bankruptcy of Lehman Brothers. Both passenger volume and cargo volume recovered in 2010 though, when Taiwan economy expanded remarkably at a 23-year high of 10.8%[11].

For the second biggest Songshan Airport located within Taipei city which mainly operates domestic flights, the recovery in 2010 is not so strong as the previous one. The passenger number fluctuates around 4 million per year, no bigger than 2008 level. Kaohsiung Airport is the second biggest international airport in Taiwan, which has a decreasing passenger volume even before the crisis. However, the recovery since 2010 seems to be strong comparing to other airports. Passenger volume of Taichung Airport and Kinmen Airport grows rapidly despite of the crisis in 2008, passenger volume in Magong Airport recovers immediately since 2009. The four airports in main Taiwan island, namely Tainan, Taitung, Chiayi and Hualien, are examples of a rapidly decreasing passenger volume, the recoveries are slow and seem to be difficult for them. The trends of passenger volume for these typical airports are listed in Figure 3 and Figure 4.

Models

Assuming variable return to scales, which is realistic for the airport case, we chose an input-oriented model because our research focus is on the necessary infrastructure of airport in accordance with demand level. In other words, aviation demand is regarded as an exogenous variable here. We are trying to find out the most efficient allocation for the airport capital investment inputs, in order to give a reference to policy makers in making the right decisions.

The original input oriented model is a radial DEA model, where a proportional change of inputs and/or outputs is dealt with. There is another *non-radial* DEA model too. According to Cooper, Seiford, and Tone (2007), a non-radial input-oriented slacks-based model (SBM) deals better with input slacks (excesses). In the case of this paper, all the inputs for Taiwanese airports do not change in the same scale. For example, there exists a minimum requirement for the length and width of the airstrip even in an

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[11] National Statistics, Republic of China (Taiwan)

airport with small passenger volume. On the other hand, we could increase the efficiency score by reducing the size of the terminal building. This kind of input slack would not affect the ordinary CCR efficiency score, though. So the Slack-Based Model (Tone, 2011) is applied to take into account all input slacks in DEA calculation.

Figure 3: Passenger Volume Trend for the Three Biggest Airports in Taiwan
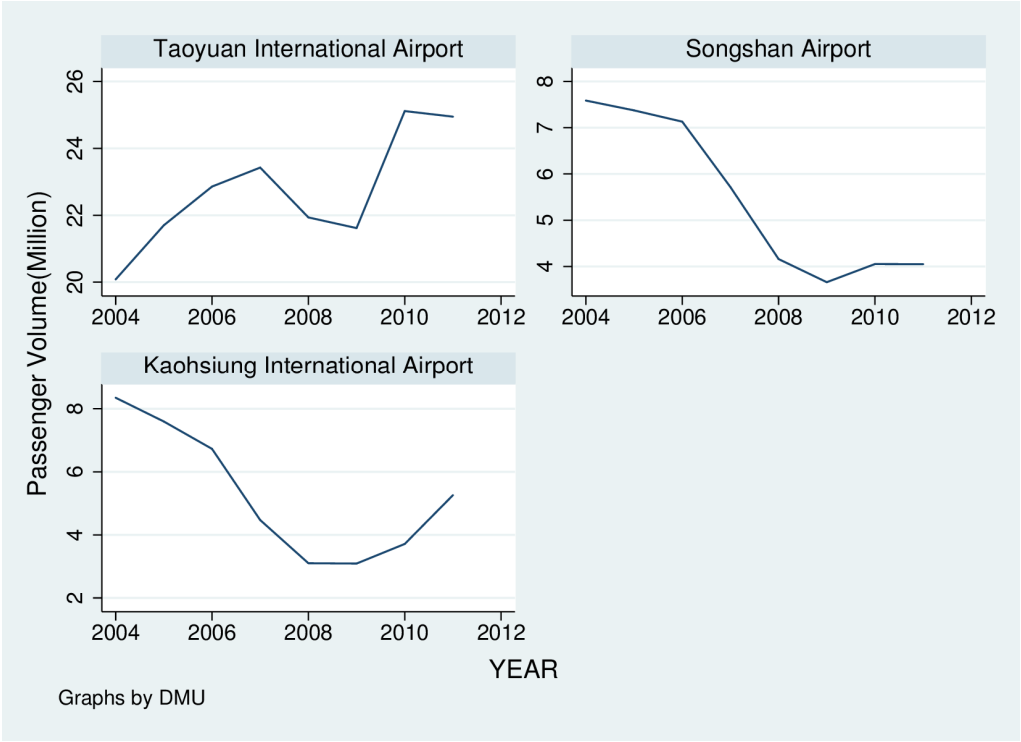
Figure 4: Passenger Volume Trend for some Typical Airports in Taiwan
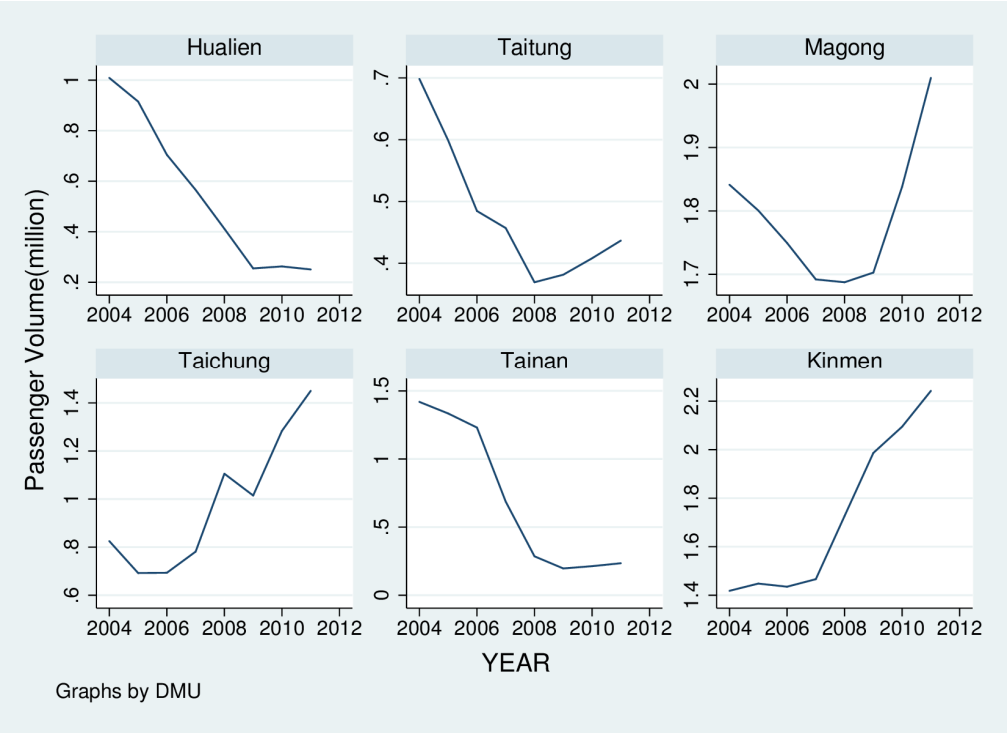
Suppose there are *n* DMUs for which the efficiency score is calculated. For each DMU there are *m* inputs and *s* outputs. For a specific year, **X** and **Y** are the input and output matrices respectively. s_i^- is the slack of input *i* for DMU *o* and **λ** is a non-negative vector $\lambda = (\lambda_1, \ldots, \lambda_n)^T$. The efficiency value θ_o^t for DMU *o* at time *t* is obtained by solving the following problem:

$$\theta_o^t = \min_{\lambda, s^-} (1 - \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{io})$$

(1)

Subject to

$$X_o = \mathbf{X}\lambda + s^-$$

$$y_o \leq \mathbf{Y}\lambda$$

$$e\lambda = 1$$

$$\lambda \geq 0, s^- \geq 0$$

As we are eager to know the historical trend of Taiwanese airports' performance and how it is affected by the China factor and other characteristic variables, we apply Malmquist index calculation afterward for the productivity measurement, based on the efficiency score result of non-radial input-oriented SBM model above. Malmquist input index is developed into a productivity measurement by Fare, Grosskopf, and Lovell (1994) from the original idea of Malmquist (1953).

$$M_o = \left[\frac{\theta_o^t(x_o^{t+1}, y_o^{t+1})}{\theta_o^t(x_o^t, y_o^t)} * \frac{\theta_o^{t+1}(x_o^{t+1}, y_o^{t+1})}{\theta_o^{t+1}(x_o^t, y_o^t)} \right]^{\frac{1}{2}}$$

(2)

Here $\theta_o^t(x_o^t, y_o^t)$ calculates the above input-oriented VRS model (1), comparing the production of DMU *o* at time *t* to the productivity frontier at time *t*. $\theta_o^t(x_o^{t+1}, y_o^{t+1})$ calculates the input-oriented VRS envelopment model, comparing the production of DMU *o* at time *t+1* to the productivity frontier at time *t*, respectively.

Additionally, Malmquist Index can be decomposed into two parts: catch-up and frontier-shift. Catch-up effect indicates the change in relative efficiency of a specific DMU from period t to period t+1; Frontier-shift effect indicates the change in the frontier technology around a specific DMU from period t to period t+1.

$$M_o = CU * FS$$

(3)

$$CU = \frac{\theta^{t+1}(x_o^{t+1},\ y_o^{t+1})}{\theta^t(x_o^t,\ y_o^t)} \tag{4}$$

$$FS = \sqrt{\frac{\theta^t(x_o^t, y_o^t)}{\theta^{t+1}(x_o^t, y_o^t)} * \frac{\theta^t(x_o^{t+1}, y_o^{t+1})}{\theta^{t+1}(x_o^{t+1}, y_o^{t+1})}} \tag{5}$$

where CU stands for catch-up effect and FS stands for frontier-shift effect.

4. RESULTS

We use DEA-Solver (Version 10.0) to calculate the DEA efficiency score and Malmquist index. The results are listed in section 3.1 to 3.3. The second-stage regression results and test results in section 3.4 are obtained via Stata.

Input Oriented VRS SBM

Results of input-oriented VRS model are shown in Table 2. Those with full efficiency are shown with white cells and shaded cells indicate low efficiency.

Table 2: SBM-I-V Efficiency Score

DMU	2004	2005	2006	2007	2008	2009	2010	2011
Taoyuan	1	1	1	1	1	1	1	1
Kaohsiung	0.769353	0.804921	0.763018	0.875124	1	0.753767	0.714564	0.623997
Songshan	1	1	1	1	1	1	1	1
Hualien	0.58435	0.555488	0.479275	0.385938	0.283289	0.19006	0.189618	0.182221
Taitung	0.694452	0.714841	0.697383	0.540035	0.44977	0.534609	0.539313	0.535436
Magong	1	1	1	1	1	1	1	1
Taichung	1	0.73207	0.732061	0.634835	0.610309	0.560486	0.639007	0.691158
Tainan	0.799096	0.781894	0.730039	0.447778	0.247333	0.16782	0.163063	0.170801
Chiayi	1	1	1	1	0.389674	0.425881	0.398026	0.398361
Qimei	1	1	1	1	1	1	1	1
Wang'an	1	1	1	1	1	1	1	1
Lanyu	0.819752	0.988219	1	1	1	1	1	1
Lyudao	0.653847	0.671599	0.653019	0.677558	0.682305	0.651903	0.629085	0.676846
Kinmen	1	1	1	1	1	1	1	1
Beigan	1	1	1	0.584962	0.599952	0.642481	0.649289	0.663155
Pingtung	1	0.173222	0.151087	0.135798	0.124331	0.120765	0.122052	0.122052

Taoyuan, Songshan, Magong, Qimei, Wang'an and Kinmen are the 6 airports with full efficiency for the entire period. Except for the two capital airports (Taoyuan and Songshan Airports), the rest are all off-shore island airports. Kaohsiung, the second

biggest airport enjoys a full efficiency in year 2008 but faces decreasing efficiency behave since 2009. Hualien, Taitung, Tainan and Chiayi are the 4 airports confronted with a decreasing in efficiency since 2008. They are all small airports on the main Taiwan island. For the rest, there are no obvious shifts in efficiency. (Turning points for Beigan and Pingtung are due to a big construction and the following increase in input.)

Malmquist Indices

In Table 3 we see more light area (increasing productivity) on the right-hand side of year 2008 and more dark area (decreasing productivity) on the left-hand side. It shows more clearly that after 2009 almost every airport in Taiwan enjoys an increase in productivity, especially Kaohsiung, Songshan, Magong and Taichung airports, which all have direct flights to China.

Table 3: I-V Malmquist Index

Malmquist	04=>05	05=>06	06=>07	07=>08	08=>09	09=>10	10=>11
Taoyuan	0.970455	1	1	0.89846	1.020901	1.063923	1
Kaohsiung	0.966457	0.809812	0.799871	0.698511	0.740948	1.2323	0.996388
Songshan	0.552371	0.603279	0.490991	0.466601	0.835447	1.238678	1.361529
Hualien	0.8858	0.825454	0.804369	0.799473	0.701664	1.029555	0.960294
Taitung	0.949908	0.962843	0.787122	0.872472	1.136283	1.040366	1.02285
Magong	0.950492	1.010626	0.97148	0.979018	0.902955	1.274775	1.152318
Taichung	0.690981	0.960663	0.884156	1.043512	0.885757	1.220758	1.114377
Tainan	0.896155	0.909021	0.622626	0.572991	0.716769	1.00805	1.051322
Chiayi	0.865841	0.91396	0.5734	0.391761	1.06138	0.946415	1.019584
Qimei	1.073039	1.006904	0.994883	1.008695	1.014983	0.978614	0.99857
Wang'an	1.000527	1.044849	0.994917	1.000017	1.030529	0.97055	0.998791
Lanyu	1.101359	1.110826	0.997029	0.934062	1.243842	1.144537	1.000018
Lyudao	0.975225	1.019262	1.049688	0.997696	1.020449	0.948005	1.07085
Kinmen	1.071665	0.990474	1.148917	1.292277	1.0934	1.064796	1.048295
Beigan	0.730759	0.950789	0.477362	1.036779	1.062957	1.028248	1.016207
Pingtung	0.15486	0.887884	0.891436	0.92334	0.977228	0.999884	1
Nangan	0.845858	0.867175	0.921815	1.077861	0.984109	0.920374	1.098163
Hengchun	0.988481	0.997418	0.994539	0.998913	0.997499	1.000126	0.999767
Average	0.870568	0.937291	0.855811	0.888469	0.968172	1.061664	1.050518

Among these airports, a special example is Songshan Airport. Being the first airport in Taiwan and the only airport within Taipei city, Songshan Airport used to be the sky gateway into Taiwan until 1979 when Taoyuan International Airport[12] started operation as one of the "Ten Major Construction Projects" in Taiwan and at the same time

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[12] Was named as Chiang Kai-shek International Airport from 1979 to 2006.

replaces Songshan Airport as the only international airport of Taipei. However, thanks to the "Three Link" agreement, Songshan Airport opened its international routes again to Hongqiao Airport of Shanghai in 2010. As part of Taiwanese President Ma Yin-jeou's "Golden Aviation Circle in Northeast Asia" campaign[13], the flight services between Songshan Airport and Haneda Airport of Tokyo resumed operation in the same year. Moreover, in 2011 the flight service between Songshan Airport and Gimpo Airport of Seoul also started operation. As a result of the newly opened China routes and other northeastern Asian routes, Songshan Airport's decreasing trend due to the declining demand for domestic flights abated in 2009 and since 2010 Songshan Airport embraces strong increase ever since.

Decomposition of Malmquist index

Figure 5 illustrates the Catch-up Effect, Frontier-shift Effect as well as the Malmquist index of all the airports in the specific period. In the original Malmquist index graph, it looks more like chaos where the increasing trend is not so clear, although we can still tell that more values before the year 2008-2009 is below one while more values afterward is above one.

In the Frontier-shift Effect graph, we could understand this radical change more clearly: almost every DMU has a Frontier-shift Effect value less than one while most of them enjoy a value above one after 2008-2009 period. By contrast, the graph of Catch-up Effect shows a different trend. The values are dispersing before the year 2008-2009, where the smallest value is around 0.2 and the biggest value exceeds 1.2. After the year 2008-2009, however, the values are congregated with a distance around 0.2 between the biggest value and the smallest ones.

Second-Stage Regression

At this stage, we use regression models to verify the impact of several characteristic factors. At first, we run the following fixed effect, random effect to test the factors affecting airports' DEA efficiency scores:

$$DEA_{it} = X_{it}\beta + \alpha_i + U_{it} \tag{6}$$

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[13] Direct flights from Taipei's Songshan Airport to Seoul's Gimpo Airport to begin in March. Taiwan's president continues to carry out his "golden routes". CNN Travel 15 November 2011 http://travel.cnn.com/seoul/visit/direct-flights-taipeis-songshan-airport-seouls-gimpo-airport-begin-march-487057

The $\mathbf{X}_{it}$ here include the following dummy variables: CN indicates whether the airport operates a direct China route or not. OFF indicates whether the airport locates on an offshore island (1) or on the main Taiwan Island (0). INT shows at least one international route is connected to this airport and ML suggests whether the military force also uses this airport. The Mega and Mini variables are used to measure the passenger size of the airport.

Figure 5a: Progression of catch-up effect
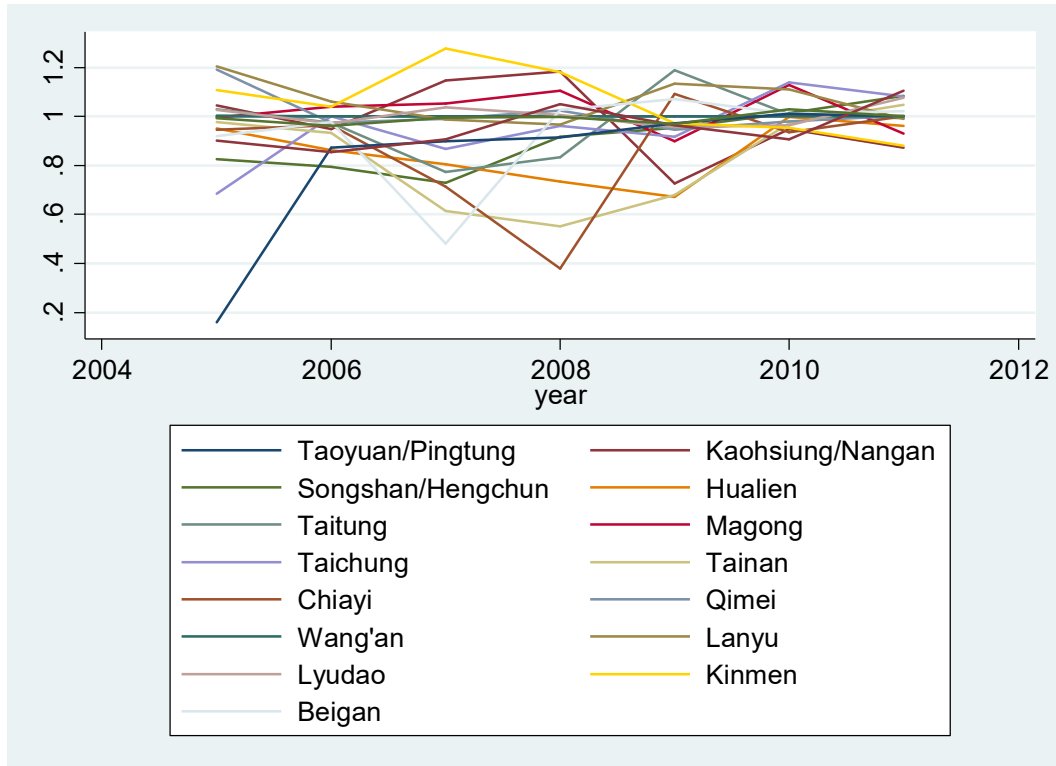
Figure 5b: Progression of frontier-shift effect
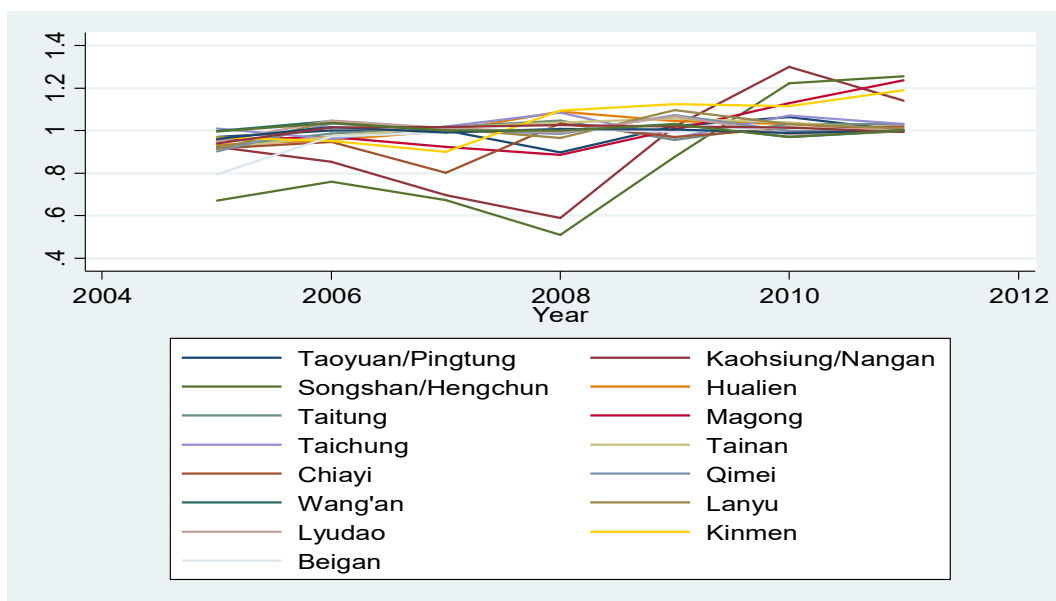
An airport is classified as "Mega" airport if the passenger volume exceeds 10 million and "Mini" airport if its passenger volume is less than one million. In a fixed effects model OFF, ML and Mega are excluded from $\mathbf{X}_{it}$ because these variables are time-invariant. Relatively, in a random effects model we could include all these variables with the assumption that α_i is not correlated with $\mathbf{X}_{it}$. In the Hausman and Taylor model, however, the restriction of no correlation between α_i and $\mathbf{X}_{it}$ could be relaxed without losing those time-invariant regressors. Hausman Test is applied to verified which regressor is correlated with the individual effect α_i.

$$W = \frac{\left[\widehat{\beta_{\{FE,k\}}} - \widehat{\beta_{\{RE,k\}}}\right]}{\left[se\left(\widehat{\beta_{\{FE,k\}}}\right)^2 - se\left(\widehat{\beta_{\{RE,k\}}}\right)^2\right]^{\frac{1}{2}}} \tag{7}$$

The test results for CN, INT and Mini variables are 0.443, -1.175 and 1.529, which all have a p-value larger than 0.05. The Hausman Test for the overall model shows consistent result of a chi-squared value at 2.52 and a p value at 0.47. As a result, random effects model is preferred. We list both results in Table 4, with a pooled Simar & Wilson efficiency analysis model as a reference. In Table 4, we find negative relationship between the DEA efficiency score and the dummy variable CN. This might be an unexpected outcome before further exploring. Table 5 shows us the regression result for Malmquist index. At a significance level of 5%, the dummy variable CN has positive impact on the improving of productivity of Taiwanese airports. International route also brings positive effect to Malmquist index, with a larger coefficient and a bit higher significance. On the other side, in pooled OLS and random effect model off-shore island airports show a strong positive gap with the airports on the main Taiwan island.

From the regression result of Malmquist index, the airports with a direct China route do increase faster than their counterparts. Why is the CN variable negatively related with the DEA score then? An overview of the data structure gives us a possible answer. Eight Taiwanese airports were opened from 2009 to Chinese routes. Taoyuan and Kaohsiung are permitted for regular flights while Songshan, Hualien, Taitung, Taichung, Kinmen and Magong are for chartered flights. Although capital airports Taoyuan and Songshan, along with offshore island airports Kinmen and Magong show full efficiency along this period, we should notice that smaller airports in Taiwan island like Hualien, Taitung and Taichung are also appointed to Chinese routes. Although they do show a

progress in their efficiency, as we observed in the Malmquist index, their absolute values of DEA efficiency scores are lower than their counterparts. In addition, Kaohsiung airport does not seem to be successful even after the agreement. As a result, we see the negative sigh in the regression result of DEA efficiency score.

Table 4: Regression Results for DEA Efficiency Scores

	Pooled Simar & Wilson	Fixed Effect	Random Effect
CN	-0.1505**	-0.0992*	-0.101*
	(0.054)	(0.016)	(0.012)
OFF	0.3065***	0	0.320**
	(0.000)	(.)	(0.002)
INT	0.1827***	0.00644	0.0334
	(0.051)	(0.920)	(0.575)
ML	-0.0099	0	0.0349
	(0.046)	(.)	(0.737)
Mega	0	0	0.300
	(.)	(.)	(0.171)
Mini	-0.2891***	-0.117	-0.193**
	(0.059)	(0.175)	(0.006)
Constant	0.6593***	0.840***	0.710***
	(0.000)	(0.000)	(0.000)
Observations	126	126	126
Adjusted R^2	0.467	-0.114	
rho		0.709	0.585

p-values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Regression Results for Malmquist Index

	Pooled	Fixed Effect	Random Effect
CN	0.141***	0.142***	0.143***
	(0.001)	(0.001)	(0.000)
OFF	0.195***	0	0.201***
	(0.000)	(.)	(0.000)
INT	0.0959*	0.200**	0.112*

	(0.040)	(0.002)	(0.025)
ML	0.0259	0	0.0219
	(0.487)	(.)	(0.635)
Mega	0.0716	0	0.0495
	(0.349)	(.)	(0.607)
Mini	0.0411	-0.143	0.0277
	(0.302)	(0.102)	(0.549)
Constant	0.765***	0.965***	0.770***
	(0.000)	(0.000)	(0.000)
Observations	126	126	126
Adjusted R^2	0.227	0.080	
rho		0.585	0.0966

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5. CONCLUSIONS AND FOLLOWING WORK

According to the results of DEA efficiency scores and Malmquist index, along with the regression result for both of them, we try to shed a light on the effect of direct China routes on the efficiency of Taiwanese airports. As discussed in the previous chapter, China route variable is negatively related to DEA efficiency scores due to the selection of appointed airports. It is likely that economic benefit is not the only reason to open a specific airport. Otherwise, the best strategy would be opening only Taoyuan International Airport in order to support its target to become a hub airport in the Asia-Pacific region. The cross-strait relation, as well as the election and politics in Taiwan also played an important role here. On the other hand, the China route variable shows positive effect on Malmquist index. Those assigned airports may be less efficient in the beginning but they are growing faster than others are. After the Three Links agreement, the overall productivity of Taiwanese airports increases but the gap between big airports and small airports in the sense of efficiency also increases.

How to keep the growth of big international airports in the competition with other Asian airports, as well as how to deal with the inefficient small airports without prejudice against local residents are the two important topics facing Taiwan civil aviation authorities. Possible future research would be on: (1) Figure out the reason behind the negative relationship between Chinese routes and Taiwan airports efficiency. (2) Construct an applicable methodology of adopting Assurance Region model in calculating the Malmquist Index.

As a final remark, we point out that traditionally, Tobit regression was used due to the interval of the DEA scores being between zero and one. However, John McDonald argues that since DEA efficiency score is a fractional data instead of being generated by a censored process, Tobit model may not be appropriate. An ordinary least square is consistent in this situation (McDonald, 2009). Additionally, others argue that a fractional regression model is the best fit for analyzing DEA scores in the second stage (Ramalho, Ramalho, & Henriques, 2010). Verifying the result of this paper by using fractional regression model would also be a possible following work.

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PAKISTAN'S NATIONAL AVIATION POLICY (2015)
FLIGHT PATH, CROSS WINDS & OFF-COURSE

Wali Mughni[1]

ABSTRACT

Pakistan is an emerging economy where the aviation policy, promulgated in April 2015, was designed to dramatically boost aviation activities, which in turn was expected to enhance the country's economy. Ownership and market access liberalization, stringent adherence to international standards, subsidies, taxes and duty exemptions/reduction, emphasis on education, investor friendly environment, greater safety and security assurance, and above all, travel and business friendly culture was the strategic direction that Pakistan's forward looking National Aviation Policy anticipated to achieve. Well after a year of promulgation, poor internal and external stakeholder buy-in of the policy continues to mar expectations of the industry's stability, growth and prosperity. This paper critically looks at stakeholder apprehensions and suggests possible remedial measures that may be adopted for a course correction.

KEYWORDS

Aviation policy; Pakistan; liberalization; stakeholder buy-in.

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1. INTRODUCTION

Pakistan's National Aviation Policy 2015 (NAP-2015), was formulated after 15 years. The policy marked an important milestone in Pakistan's aviation history, where Pakistan's Government along with all stakeholders, representing various segments of the aviation industry, collectively developed a comprehensive and forward looking document. The policy outline and key strategic aspects were also deliberated at length by industry experts and internationally acclaimed aviation policy consultants. While the key objective set forth for aviation division was to develop a safe, secure and efficient air transportation structure, the policy also extended its realm to create an environment to foster economic activity through dynamic and innovative strategic measures. This paper scrutinizes and analyzes overt as well as subtle responses of internal and external stakeholders with regards to policy buy-in. Notwithstanding extensive involvement of stakeholders prior to the formulation of the policy document, the policy once promulgated created dissents amongst many stakeholders. This resulted in widespread criticism of the policy; and the prevalent psyche of operators as well as regulators has de facto formed a barrier for new-entrants and induced greater hindrances for the incumbent operators. The desired cultural change in the existing environment did not come about as the policy failed to effectively bring in the expected values (by incorporating dynamic and bold strategic measures) that the policy hoped to inculcate. With known bugs and anomalies in the previous policy of year 2000, the 2015 policy aimed to rectify and debug weak-links in the system. The Nation Aviation Policy 2015 formulation was initiated with the realization that a non-user-friendly environment existed and that it was pervasively hampering growth and prosperity.

The paper scrutinizes and analyzes the policy's key features and the proposed changes that it aimed to bring about. The study recognizes the positive aspects and then reviews the extent of effective implementation, the degree of stakeholder buy-in and new operational glitches that emerged as a consequence of the new policy. Analyzing the ambiguities and areas that were not readily accepted (and not implemented or half-heartedly implemented), the study further evaluates possible reasons of resistance to change, ingrained cultural inertia and reconciliation with status quo as the preferred option. Concurrently, it was observed that amongst operators in particular there is widespread criticism about the policy that continues to foster an undesirable operational environment that is adversely impacting growth prognosis.

It was also observed that incumbent aviation businesses are eager to grow and expand as the market demand for aviation continues to grow at a fast pace. It is evident that there is a widening gap between supply and demand of various services within the aviation industry. Therefore, while many

entrepreneurs are enthused to expand their businesses, many are lined up to avail the business opportunities that exists within the aviation space. Notwithstanding the fact that the policy intended to bridge this gap, it unwittingly failed to achieve its major objective of facilitating growth. De facto, many aspects of the policy, the attitude of a number of regulators, and the socio-political environment, are an apparent deterrence to prosperity and growth and subtly but surely the overall milieu is perceived by many as a show-stopper. Such cognitive dissonance to invest or hold (wait and see) continues to bother both incumbent operators and prospective new businesses (market entrants) into the aviation domain.

2. METHODOLOGY

To better grasp the on-ground reality and deeper understanding of stakeholder issues, perceptions, popular understanding and common viewpoints about the policy, subjective data and relevant information was gathered through aviation industry grapevine. Prominent aspects were then identified, which were followed by surveys, targeting a diversified sample of stakeholders. Interviews were also conducted, with discussions and deliberations on applicable identified topics, and finally, detailed analysis was done using Q-methodology and factor analysis where applicable.

3. STUDY OBJECTIVE

Having realized the prevalent situation and understanding that the intent of the policy formulators was to achieve certain goals through policy implementation; and recognizing the evident diagnosis that the ensuing post policy results have fallen short of the expectations, this paper ventures to recommend and suggest a few remedial measures or corrective actions. To draw an analogy (in the aviation lingo), it may be described as 'a policy that did not fly the expected route', while the cross-winds (criticism and inadequate buy-in by the operators and regulators) continues to drift the industry towards the proverbial uncharted territory of possible downdrafts and wind shears ahead. Finally, moving forward, the paper recommends a course correction to regain the desired track, that the policy originally intended to fly (attain).

4. IMPLEMENTATION / POLICY BUY-IN: ON-COURSE & OFF-COURSE

Hitherto, the service provider function and regulatory function of both Pakistan Civil Aviation Authority (PCAA) and Airports Security Force (ASF) were under their own domains, and this conflict of interest resulted in obvious inefficiencies and latent irregularities. In other words, both ASF and PCAA were service providers and supposedly, regulators/auditors of themselves. Therefore, in order to ensure effectiveness and oversight of aviation safety and

security in particular, regulatory and service provider functions were made independent of each other with independent functions. According to the policy, Pakistan Civil Aviation Authority shall be the regulator and the Airports Security Force is mandated to be the service provider. Therefore, the inherent conflict of interest is resolved.

Similarly, Safety Investigation Board (SIB), which was under Director General PCAA, is now made independent and now reports to the Minister of Aviation to ensure that findings and safety recommendations of an investigation remain unbiased.

While the above two policy changes were accepted and implemented with zero or negligible resistance, few other aspects that may be considered as continuing bone of contention where reluctance to implementation in true letter and spirit has been observed to be evident. These are discussed in the succeeding paragraphs.

Over the years, protectionism and restrictive market access policy has suppressed the growth potential of the aviation sector in Pakistan. Therefore, transition to more liberal Air Service Agreements (ASAs), was stated in the policy, and it was expected that this would accord greater business freedom, higher levels of customer satisfaction and greater micro and macro-economic growth of the aviation domain (Dawna Rhoades, et al, 2015). As per policy, following the norms and conventions, Pakistan is expected to pursue bilateral open skies policy towards other countries based on the principle of reciprocity.

The proponents of the dissent of this aspect of policy (i.e. liberalization with regards to ASAs) was propagated from executive and managerial level individuals who hailed from the national air careers. Their point of view was projected in a manner that indicated a strong culture of protectionism, and propagating an argument that such a liberal approach was anti-patriotic and that national airline's interest would be compromised. Therefore, a large majority of individuals who subscribe to restrictive market access vehemently opposed the policy in favour of the protectionist approach in the larger interest of the national careers. To ascertain this approach a survey was carried out. The survey results on a Likert scale of 5 indicated a mean of 4.7 with all 20 sample subjects (heterogeneous aviation/airline professionals) specifying their opinion between 4 and 5 (out of 5) in favor of dissent to this aspect of policy.

Those policy changes, as stated in the NAP 2015, that appear to be attractive incentives but have not yielded any significant results, except a few half-hearted prospective investors, are discussed below:

Global trend in participative and cooperative business structures has given credence to the concept of Public-Private Partnership (PPP) models for operation and management of airports. While the private sector specializing in airport management enhances passengers' travel experience by investing in modernization of facilities; the Government is, as per policy, required to focus on the oversight of the operations and ensure accountability of the services, while the private party is expected to run the operations and provide services. PCAA shall (according to the policy guidelines) work with global airport management companies to find suitable PPP models to be followed for the operations and management of landside and terminal facilities of airports. Accordingly, this policy shall also be implemented for small, medium and large airports, with a view to exploit their commercial and tourism potential.

As per the policy, airport infrastructure was to be modernized to meet future needs of aircraft, passenger and cargo traffic. It included refurbishment of airport buildings and rehabilitation of airside infrastructure. Air cargo import and export would further strengthen the business community and help in promoting Pakistani products globally. According to the policy, two state-of-the-art cargo villages are to be established, one in the North and one in the South.

In spite of the incentives offered in the PPP model, companies have not yet come forth to avail the opportunity. It appears that either the policy (and the opportunity) has not been advertised, or not advertised enough, or the incentive package needs to be re-evaluated. In either case, more research needs to be done to identify the cause of poor response.

Aspects of the policy which are grossly misinterpreted are discussed below:

Another impediment in the growth of air travel and cargo was unjustified taxes and duties, which was hampering investment and not yielding any significant revenue for the Government. Rationalization of duties and taxes in the aviation sector shall now (according the stated policy) help attract more businesses, thus resulting in the growth of the industry and ensuing benefits to the end-users. In accordance with the policy, the taxes were supposed to have been restructured and simplified in line with the best international practices. Higher taxes and duties on aviation businesses negatively impact transportation activity in the country, which in turn, adversely impact Gross Domestic Product (GDP) and employment. Therefore, the policy strongly advocates that there should be no taxes and duties on investment in aviation sector.

The objective and the intent of this policy regarding tax breaks and exemption of CAA charges was to facilitate incumbent operators and to attract investors in various sectors of aviation business, including establishment of quality Maintenance, Repair & Overhaul (MRO) organizations.

Notwithstanding the above, the statement of the policy (para 4.8 [b]) guideline that "Import or lease (wet/damp/dry) of any General Aviation (GA) aircraft shall be tax and duty free", was misinterpreted and the commercial aircraft category selected was any aircraft that weighed above 15,000 kg was put under Pakistan Customs Tax Free regime. Those aircraft that were below this weight limit were not mentioned, and therefore, not included. Pakistan Customs allots Pakistan Customs Tariff codes (called PCT codes) and publishes all leviable duties and taxes against them. The PCT code allotted for exemption of duties and taxes is 8802.4000, which is for all categories of aircraft weighing above 15,000 kg. It is also worth noting that that EASA (European Aviation Safety Agency) refers to the Convention on International Civil Aviation, and quotes its Annex 8 (for Airworthiness of Aircraft), that specifies standards that fixed wing aircraft with maximum takeoff weight of greater than 5,700 kg must comply with. Furthermore, most General Aviation (GA) aircraft are below 5,700 kg MTOW (Maximum Takeoff Weight) category. Therefore, this misinterpretation appears to be arbitrary and not based on any weight category that could be confused or misinterpreted with. The only place where 15,000 kg (MTOW) category of aircraft appears is airport landing and parking fee structure of various airports across the globe. It can thus be assumed that 15,000 kg limit is not based upon any precedence or relevant logic.

Similarly, the policy envisaged reduction and/or removal of taxes and duties on GA aircraft, aircraft spares and material for maintenance of GA aircraft are also required to be given the same status. The policy did not get implemented in letter and spirit; additionally, it also introduced more complications in the process of import which should have been made simpler and user friendly. Thus, cumbersome and time consuming processes are negating the intent and purpose of the policy. Procedural complexities and misinterpretation in this area of operation is hurting the GA operations in particular and the aviation industry in general. This information was given by few senior GA operators and the case was further investigated and found to be absolutely true and valid.

The policy guideline to address the 100 LL (Low Lead) supply and distribution monopoly has also proven ineffective. No change to monopolistic fuel supplier for aviation fuel for GA operations i.e. 100 LL continues to plague GA operations, particularly the flight training

operation. Albeit it is very clearly and categorically mentioned in the policy that the monopoly of supplier and distributor of 100 LL aviation fuel shall be addressed so that cost of fuel is reduced (due fair competition), nothing concrete is visible to break the monopolistic powers of the supplier. It is known that fuel cost can be as high as 75% of the Variable Cost of GA operations. Therefore, to contain costs and offer flying training at an affordable price, it is incumbent on the Government to reduce the price of fuel. It can be done by incentivizing new entrants (suppliers of 100 LL) and breaking the monopolistic approach of a single supplier. Alternatively, a cost cap was also not enforced, that could have kept the cap (upper limit) to preclude exorbitant prices. Resultantly the GA operation continues to suffer, and the end result is that the training of pilots has become cost prohibitive to many prospects who can ill-afford the fees that the flight training schools are charging to sustain their operations.

Recent air crashes and incidents have highlighted the need for stringent checks and procedures. In accordance with the new policy, PCAA is now reviewing such procedures and regulations for greater safety and efficiency of air transportation services. The policy also encourages induction and operation of more efficient aircraft by Pakistani operators. Such modern aircraft are safer and more fuel efficient. As a measure to ensure that only sound investors/operators venture in the aviation business, the paid-up capital requirement to obtain relevant licenses has been enhanced and the chronological age of aircraft for initial induction has been capped at 12 years.

The chronological age limitation to induct aircraft less than 12 years was introduced for the following reasons and logical assumptions:

a) Twelve-year period was primarily based on two 'D' checks which are required to be completed on aircraft (which are generally approximated at 6 years' chronological age interval).

b) Most newer aircraft (≤ 12 years' chronological age) are relatively more fuel efficient than their older counterparts.

c) Most newer aircraft (≤ 12 years' chronological age) are relatively greener than older aircraft.

d) Most newer aircraft (≤ 12 years' chronological age) have better navigation and safety equipment installed as compared with their older versions.

e) The maintenance cost of newer aircraft (≤ 12 years' chronological age) is generally less than older counterparts.

f) This also indicates that the aviation business entity that is buying or leasing the aircraft are financially stronger than those who look for relatively older and cheaper aircraft.

g) While there are research studies that have indicated that there is no significant correlation between age of aircraft and fatal accidents up to 26 years of chronological age (Hansman 2012), there are a few studies that suggest that there is a positive correlation (Vasigh and Herrera, 2009) in their comprehensive study on "A Basic Analysis of Aging Aircraft, Region of The World, And Accidents." Interestingly, the rate of accidents and the probability of incidents, occurrences and accidents drop significantly just after 6 years (i.e. after 'D' Check, see Figure 1 below). The study was conducted on a global database of 549 aircraft accidents analyzed between 2000 and 2007.

Figure 1: Number of Accidents
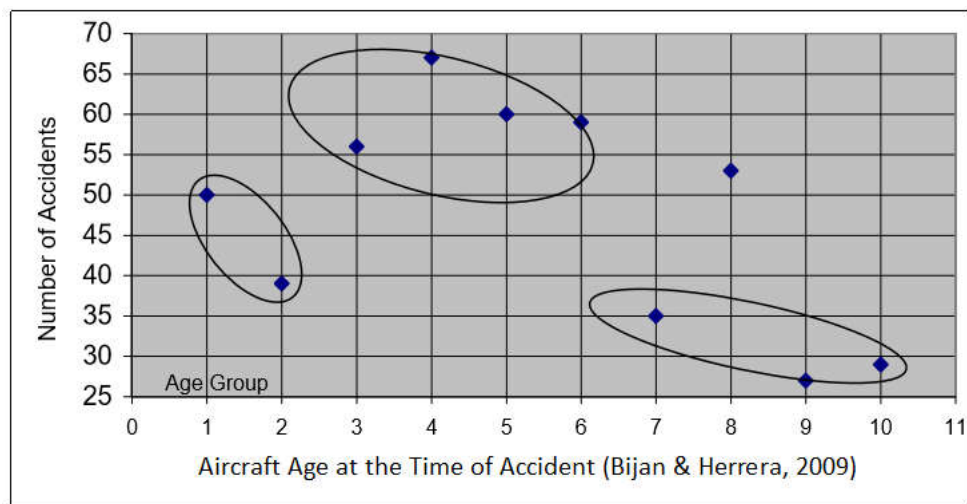
h) With reference to the study stated above, it appears that statistically and historically, the safest period in the life of an aircraft is just after 'D' Check. Thus, when the policy states less than 12 years it is assumed that businesses desirous of inducting aircraft for RPT (Regular Public Transport) operations would like to induct aircraft just after the first 'D' Check. Induction of such aircraft would have the highest probability of safety (least accident probability).

Table 1: Aircraft Accidents by Region

Aircraft Accidents by Region		
	Accidents	Probability
North America (NA)	121	25.42%
Latin America (LA)	60	12.61%
Europe (EU)	99	20.80%
Africa/Middle East (AF)	69	14.50%
Asia/Asia Pacific (AP)	127	26.68%
Total	476	100.00%
Source: Vasigh & Herrera 2009		

i) Another study (Vasigh & Herrera 2009, see Table 1 above) also clearly indicates that Pakistan falls in a region where the probability of accidents is one of the highest in world. Therefore, to mitigate other factors and reduce the probability of occurrence, all possible measures must be undertaken for ensuring greater safety. Therefore, it can be concluded that 12-year chronological age limitation for induction of aircraft is a positive step and must be taken in the right spirit.

Another concern sounded by most individuals is an objection to the enhanced paid-up capital limit. For domestic charter operations, the new policy requires that a company applying for the domestic charter license would be required to show a paid-up capital of Rs. 25 million. Although this seems like an excessive hike in the required amount (from previously 2 million to the new limit that is 12.5 times higher); it may be noted that the amount approximates only $250,000. A company that desires to enter the aviation business offering charter services must at least be able to bear the monthly lease charges, maintenance charges and insurance charges and that may add up and exceed the paid-up capital stated in the policy. In the larger interest of the public that a new entrant wants to serve the market, it must have enough financial strength to sustain initial operations and bear losses as may be expected during the initial period after commencing operations.

Wet lease cost will be no less for aircraft typically deployed in an RPT operation. The required paid-up capital for RPT license is only $5,000,000 (approx.) which for an operation with at least 3 aircraft (another policy requirement) would not be enough to cushion losses before break-even level is attained. Since the public is involved (as customers and clientele who may plan their business and travel requirements with the growth of the aviation services in the region, may be adversely affected if an airline closes down, bankrupts or simply performs inefficiently or compromises safety. It may be noted that there is a recent history of failures of new entrants because of lack of adequate financial strength, wherein the concerned entrepreneurs suffered losses while the general public was deprived of the services promised to them. Due to such repeated failures due to insufficient funding capability of the RPT operators, the aviation business environment has suffered in terms of consumer confidence, reputation and safety record. Therefore, it may be argued that it is reasonable to expect better performance by a more serious and financially sound new entrant in the aviation business. Thus the policy justifies the economic oversight as required by ICAO.

Scheduled routes to politically and socially deprived locations are now ear-marked to be served for those entrepreneurial business entities who want to avail the opportunity. According to

the policy, the operators are offered attractive incentives such as waived-off fees and other allied charges while operating to and from these locations. For such operations a new term was coined -- 'socio-political' routes. These routes are planned because political integration and social welfare was the primary objective of this operation and economic considerations were secondary.

Notwithstanding the incentives, there has been little or no response from the entrepreneurs to avail this business opportunity. The reason for such a lackluster response could be as follows:

a) Lack of awareness about the opportunity, particularly for those who are capable of undertaking this venture.
b) Not enough conducive environment for the entrepreneurs to venture in to such business.
c) Non-business friendly attitude of the PCAA (Pakistan Civil Aviation Authority). This aspect is based on a few random interviews with entrepreneurs considering market entry in the aviation domain. A survey is underway to ascertain reasons with a greater degree of confidence.
d) Perceived insecure environment (security concerns) in the remote areas where the identified airfields are located on the specified 'socio-political' routes.

The policy puts strong emphasis on up-gradation of air navigation infrastructure and effective utilization of satellite based technology to improve safety standards and future capacity needs of air traffic. However, except a few positive changes, not much improvement in the facilities is visible and it appears that the priorities are moving away from what was expected from the policy.

In order to capitalize the true potential of General Aviation (GA), apart from routine training of aviation personnel, other GA areas like aero-sports, tourism, agricultural pesticide and seeding sprays, cloud seeding, etc. would be encouraged and facilitated wherever considered possible and appropriate. Befitting incentives were to be offered for the growth of this sector. This seems to be an unattended and unaddressed area of the stipulated GA growth plans indicated in the policy.

Keeping in view the rapidly changing technology in the aviation industry, training and skill development of aviation personnel has also been given due importance in this policy, but no effort by the authorities to promote training and education is visible. This is a perception

shared by most incumbent aviation training and education institutes. This too is a survey based conclusion.

5. IMPEDIMENTS TO SUSTAINED GROWTH (DRAG)

Issues that are perceived as road blocks to good governance, development and sustained growth of the industry were identified and are summarized below:

There has been inadequate human resource development. The regulators as well as the service providers lack adequate formal training on international standards. The operators too short handed on qualified human resource with desired training, certifications and educational qualifications. Training and education in all segments of aviation industry must be given serious attention and priority. Formal training of technicians, education in aviation management for managers, international certifications for air traffic controllers, air transport & economic regulators, airspace and aerodrome safety regulators, airworthiness and flight standard inspectors are few of the areas that deserve attention. Emphasis on human resource development in finance and information technology is also lacking. Additionally, there seems to be a perpetual shortage of regulators, particularly flight standards and airworthiness regulators. This shortage adversely affects ramp inspections which the industry needs for efficient approvals and certification processes.

The policy emphasizes that there is a cultural change required in being customer-centric, safety and security-conscious and being positive in our attitude with high moral values and good work ethics for all PCAA personnel in particular and the aviation industry in general. This is a known weakness and concerted efforts need to be initiated to bring about a constructive change. Changing culture takes time and results will not be immediate, but we must initiate the efforts to make the desired change today. The future of Pakistan's aviation system depends on this change.

There is slow and inadequate infrastructure development (aerodrome facilities and navigation facilities on the airside). This aspect has been neglected in the past and is supposed to be addressed on priority. There are also huge gaps in communication and surveillance coverage in the western and northern part of Pakistan airspace due to limitations of conventional transmitters and sensors in hilly terrain. This could have been resolved long ago by application of satellite technology like CPDLC (Controller Pilot Data Link Communication), and ADS(C) [Automatic Dependent Surveillance (Contract)]. These technologies are ideally suited not only for the hilly terrain but are also cheaper alternates to conventional tools of

communication and surveillance necessary for air traffic control at long distances. Hence, action to aggressively address this issue is required as it relates to safety of air traffic transiting through Pakistan airspace.

The "procedures and regulations" are not user-friendly and act as a barrier to entry for new entrants in the industry. This aspect also needs to be addressed as soon as possible.

There is inadequate technology awareness, adoption and usage in all segments of the industry.

There is insufficient commercialization of non-aeronautical areas at the airports (e.g., real estate, car parking, food & beverages, retail stores, hotels, commercial plazas, etc.)

In the past, National Aviation Policy was also not implemented effectively. Therefore, National Aviation Policy-2015 implementation plan forms an integral component of the policy and timely implementation and follow up are structured in the system. Progress audit and remedial measures for non-performance is to be enforced. Steps to ensure implementation, stakeholder buy-in, and continual evaluation and assessment to see if the industry is moving on-track and on-schedule is important and critical to success.

6. RECOMMENDATIONS & CONCLUSION (COURSE CORRECTION CHECK-LIST)

It is conclusively determined that the buy-in of policy is equally important for successful implementation of the policy. In retrospect, it is agreed by most policy contributors (consultants, regulators and operators) that before the next policy is formally approved it is recommended that the policy's various aspects may be circulated and formal and informal feedback must be taken and evaluated in a timely manner, and more seriously and comprehensively than it was done before. Furthermore, road shows, seminars and conferences may be conducted so as to inform and educate the stakeholders. Once the policy is formulated and approved, it must be implemented effectively. Periodically and in a systematic manner, the achievements must be measured, and time-lines considered, while never losing sight of the desired objectives of the policy.

The results of the policy must favorably impact local, regional and global business entities and passengers travelling within, as well as to-and-from Pakistan.

Incentivized involvement of foreign investors is a key component of the policy and incentive packages may be re-evaluated and tweaked (wherever necessary) to get better results. The

involvement of international reputable organizations and institutions is certainly expected to bring about greater collaboration, a favorable cultural mix and much needed enhanced confidence amongst all national and international participants. Economic well-being for all industry participants and stakeholders is a collateral advantage of the measures envisioned in the policy.

Periodic evaluations, change management and buy-in efforts through print, electronic and social media must also be exploited.

Reasons of resistance to change also need to be studied and evaluated. Deliberated corrective measures will have to be continually implemented and monitored to bring about a positive cultural change.

Table 2		
Strategy to Cater for Resistance to Change		
Approach	Situation	Advantages
Education + Communication	Where there is lack of information or inaccurate information and analysis	Once persuaded, people will often help with the implementation of the change
Participation + Involvement	When a change in design is necessitated and there is considerable power to resist	People who participate will be committed to implement change and relevant inforamtion will be integrated in the change plan
Source: Harvard Business Review July-Aug 2008, Kotter & Schlesinger		

"It must be considered that there is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things." Niccolò Machiavelli, The Prince.

As shown in Table 2 above, the strategy to cater for the resistance to change is primarily through apt education and effective communication. This strategy as elaborated and discussed by Kotter & Schlesinger's article published in Harvard Business Review magazine (July 2008) is considered most suitable where there is a general lack of complete knowledge or inaccurate information about the subject at hand. Inaccurate analysis leads to false beliefs, and commonly accepted norms are difficult to change.

As aptly quoted by Kotter & Schlesinger: "It follows that an acceleration in the rate of change will result in an increasing need for reorganization. Reorganization is usually feared, because it means disturbance of the status quo, a threat to people's vested interests in their

jobs, and an upset to established ways of doing things. For these reasons, needed reorganization is often deferred, with a resulting loss in effectiveness and an increase in costs."

When a policy demands macro level change, macro level change management must follow. It is also pertinent to note the fact that an amenable relationship between the initiators and the people is mission critical for success. Equally important is a sincere effort, logical approach and a few dedicated professionals who may be taken on-board to make a team that disseminates and propagates the concepts that form the essential drivers to instill a change that is pervasive and progressive.

To get back to the desired track, all the above shall have to be considered. Albeit, time is of essence and it takes time to change, the effort must commence today to expect a positive change in the days and months to come.

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AN EVALUATION OF AIRPORT WAYFINDING AND SIGNAGE ON SENIOR DRIVER BEHAVIOUR AND SAFETY OF AIRPORT ROAD ACCESS DESIGN

Nur Khairiel Anuar, Romano Pagliari; Richard Moxon[1]

ABSTRACT

The purpose of this study was to investigate the impact of different wayfinding provision on senior driving behaviour and road safety. A car driving simulator was used to model scenarios of differing wayfinding complexity and road design. Three scenario types were designed consisting of 3.8 miles of airport road. Wayfinding complexity varied due to differing levels of road-side furniture. Experienced car drivers were asked to drive simulated routes. Forty drivers in the age ranges: 50 to 54, 55 to 59 and those aged over 60 were selected to perform the study. Participants drove for approximately 20 minutes to complete the simulated driving. The driver performance was compared between age groups. Results were analysed by Mean, Standard Deviation and ANOVA Test, and discussed with reference to the use of the driving simulator. The ANOVA confirmed that age group has a correlation between road design complexity, driving behaviour and driving errors.

KEYWORDS

Airport; Senior driver; Driving behaviour; Road safety; Simulation

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1. INTRODUCTION

The importance, functions and design criteria of wayfinding and traffic signs are essential in designing a complete airport road access. Poor wayfinding provision discourages drivers and is not directed towards understanding the concepts or practice (Burns, 1998; Darken & Sibert, 1996; Montello & Sas, 2006) in airport areas. Previous literatures (Beijer, Smiley, & Eizenman, 2004; Burns, 1998; Charles & Haddad, 2007; Darken & Sibert, 1996; Findlay & Southwell, 2004; Fuller, 2002; J. R. Harding et al., 2011; J. Harding, 2012; Raubal & Egenhofer, 1998; Raubal & Worboys, 1999; Raubal, 2001; Smiley, Houghton, & Philp, 2004) discussed wayfinding and signage as a supporting role of the urban landscape and architecture. The design of signage, wayfinding, roads and the facilities provided for airport building is very important to all travellers, as airports contribute to high growth economies and affect the environment and quality of life.

The debate concerning visual effects caused by the proliferation of signs and wayfinding along roads has led to considerable discussion by transport planners. This is a major problem which threatens to become greater as more and more elements are added to roadside landscapes; much of the road furniture is not there to help with road safety and it is understandable and right that transport authorities consider this one of their main priorities (Transport Scotland, 2006). Ineffective signage around airport areas distracts from wayfinding. Harding (2012) stated that many airports have not established the concept of 'simple, functional and less is more' for airport signage systems. He suggests a simple wayfinding and sign message could help reduce the overall cost of poor signage systems which make them less attractive and competitive than neighbourhood airports (Alhussein, 2011; J. R. Harding et al., 2011). In many cases, drivers experience most difficulty in understanding the complete wayfinding process, resulting in distraction while driving (Bhise & Rockwell, 1973; May, Ross, & Bayer, 2005) in airport areas. This distraction (e.g. too much advertising signage) increases drivers' confusion and road accidents (Mitchell, 2010; Wener & Kaminoff, 1983) in airport road access.

Senior drivers and airport road access design has been discussed in section 2 and 3. The methodology of this paper was explained in section 4, followed by results in section 5 and discussion in section 6. Conclusion, limitation and future research of this study has been described in section 7, 8 and 9, respectively.

2. SENIOR DRIVERS AND AIRPORT ROAD ACCESS

There are challenges in defining when an individual becomes an elderly or senior citizen. Most developed countries set the age of senior citizen at 65 years old, but in other regions such as Africa, the "senior" threshold is much lower at 50 years (WHO, 2016). Orimo et al. (2006) stated that with recent technology in the medical and health science industry, the average lifespan has increased rapidly, thus, such a definition of elderly to simply include all persons over 65 years might be no longer appropriate for this era with a life expectancy of 80 years. WHO (2016) agreed that a definition of senior is arbitrary and introduces additional problems of data comparability across nations. For example, the MDS Project[2] collaborators agreed at the 200 Harare MDS Workshop to use the chronological age of 60 years as a guide for the working definition of "old"; however, this definition was revisited (i.e. "older" was set at the age of 50 years) due to it not taking into account the real situation of older persons in developing countries. In addition, British Senior Insurance[3], the minimum age range of senior citizen has been set to 50 years old in order to have the Lifetime Payment Guarantee policy.

WHO (2011) reported that the number of people aged 65 and over is projected to grow from an estimated 524 million in 2010 to nearly 1.5 billion in 2050, with most of the increase in developing countries. Driving represents the most significant mode of transportation for senior drivers in terms of mode share and distance travelled (O'Hern & Oxley, 2015). With an increasing ageing population throughout much of the developed world combined with increasing life expectancies, it is necessary to understand travel behaviour, mobility and safety implications of active transport used (i.e. the private car) on airport road access (Budd, Ison, & Ryley, 2011; Chang, 2013; Tam, Lam, & Lo, 2008) by senior drivers. Understanding senior drivers' mobility and accessibility needs was crucial to ensure that a specific requirement of road access systems is fully provided (Alsnih & Hensher, 2003). The output of this research could be significantly beneficial to airport management, road sign design professionals and airport users, including senior drivers, in the future.

Senior drivers are a large and increasing proportion of the population (National Institute on Aging et al., 2011; RoSPA, 2010). In 2014, 21,490 casualties were reported as being senior drivers in the UK (Department for Transport, 2015a, 2015c). Senior drivers are commonly

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[2] The workshop was convened on behalf of the World Health Organization's Minimum Data Set (MDS) Project on Ageing and Older Adults in sub-Saharan Africa, by South African MDS Project collaborators Monica Ferreira (Institute of Ageing in Africa, University of Cape Town) and Craig Schwabe (Geographic Information Systems Centre (GIS), Human Sciences Research Council).

[3] https://www.britishseniors.co.uk/over-50-insurance/

involved in road accidents often because of misjudged speed or distance of other vehicles or failing to see a hazard (Department for Transport, 2015b; RoSPA, 2010).

Senior drivers are likely to drive to the airport due to carrying extra luggage and preferring more time spent in the vehicle (Ashford, Mumayiz, & Wright, 2011; Chang, 2013). DfT (2015d) reported that private car is the preferred transportation mode to reach the airport; i.e. Manchester Airport (57 per cent), London Luton Airport (54 per cent), and Gatwick Airport (43 per cent). Public transport is the second preferred transportation mode at Stansted Airport (39 per cent) and London Heathrow International Airport (29 per cent). With a current ageing population throughout much of the developed world, there is an imminent need to understand the current transportation requirements (Alsnih & Hensher, 2003; O'Hern & Oxley, 2015) of senior drivers, and to ensure sustained safe mobility and comfort on airport road access (Chang, 2013; Chebli & Mahmassani, 2002; O'Hern & Oxley, 2015). The results confirmed that the wayfinding has importance for the promotion of road safety.

The research focuses on the senior drivers as this segment of the travel market is becoming increasingly important in many countries. Many airports report that the proportion of elderly passengers using their facilities has increased and is predicted to rise further in the years ahead. An improvement on airport road access wayfinding, road safety and comfort for senior drivers should be considered by airport management, road sign design professionals and road authorities.

3. DRIVING BEHAVIOUR AND ROAD SAFETY OF SENIOR DRIVERS

Underlying health conditions, and some types of medication taken to treat those problems, are common factors in accidents involving senior drivers. Indeed, a proportion of senior driver fatalities occur when a senior driver dies of natural causes while driving, and so their vehicle immediately crashes. Senior drivers are commonly involved in collisions at junctions, because of misjudging the speed or distance of other vehicles or failing to see a hazard (Devlin & McGillivray, 2016). They are likely to drive slowly and in some circumstances they probably stop driving completely, particularly when approaching junctions. Although this may appear to be safe behavioural adaptation, their speed reduction can occur without consideration of traffic regulations. However, not all senior drivers do this, and there is little guidance for drivers about it. A major deterrent to self-regulation or stopping driving is the lack, or perceived lack, of viable alternatives to the car.

Elander et al. (1993) stated that the relationship between drivers' skills, behaviour and accident involvement is complex. Safe driving is clearly a complex skill in which various cognitive processes such as perception, attention and motor control are involved (Jamson & Merat, 2005). Elander, Jamson and Merat found that the association between drivers' skills and crash involvement were related through the changes in the way drivers are trained and tested.

Senior drivers' behaviour and safety are connected to the driving abilities and willingness to take risks on the road. The contrast between the safety performances expected of road transport and the management of all other risks is stark, not least when compared with other transport modes (e.g. rail and sea) in terms of fatality and the total of all casualty categories (Department for Transport, 2015c; Evans, 2003; Gayle, 2014). Senior drivers felt that their driving experience skills and driving abilities may not be as good as they once were, which in turn, means that they started to have difficulties in assessing complex problems or high-speed traffic situations and required additional information process time to make a decision (Hassan, King, & Watt, 2015; IAM, 2010). Driving behaviour that led to risk of road accidents (i.e. failing to look properly, poor turn manoeuvre, speeding, aggressive driving, overtaking and tailgating the car in front, failing to stop for traffic lights, and unable to process information on signs) has appeared as a critical factor of distinguishing crashes involving senior drivers (Department for Transport, 2015c; Elander et al., 1993; Godley, Triggs, & Fildes, 2004; Mårdh, 2016; Oltedal & Rundmo, 2006; RoSPA, 2010), which are caused by poor wayfinding on current road designs.

Reported statistics indicate that the risk of an accident increases after the age of 60 up to 70, and they are no more likely to cause a crash than to be the victim of another road user's mistake. However, drivers over 70 are more likely to be at fault when they crash. CrashMap (2015) reported the high road accidents rate on airport road access; i.e. London Heathrow Airport (LHR) had the highest reported casualties (129 casualties), followed by Gatwick Airport (43 casualties), Edinburgh Airport (39 casualties), Glasgow Airport (26 casualties), Manchester Airport (19 casualties) and London Luton Airport (15 casualties) in 2014.

Road safety plays a fundamental role by decreasing the risk of being involved in an accident. Engineering measures such as a road design can prevent accidents and injuries to senior road users (RoSPA, 2010). RoSPA suggested that due to a higher number of accidents at junctions were involving senior drivers, road planners should redesign areas in which high crash rates are reported. An important aspect of senior drivers' safety is being able to

accurately identify which drivers are significantly more likely to be involved in crashes, and ultimately to help them give up driving and adapt to life without a car.

4. METHODOLOGY

Driving scenarios were scripted within a general-purpose "world" provided by a simulator that included a dual carriageway, with buildings, static objects, pedestrian walk-ways and vegetation. Driving simulation is field experimentation using a model building technique to determine the effects of changes and computer-based simulations (Sekaran, 2003). It was developed to test drivers' performance on a virtual environment of airport road access wayfinding design. Drivers and architectural clues (e.g. signs, maps and buildings) were included in the driving wayfinding simulation (Raubal, 2001). A causal and effect analysis was performed with the control of the researcher in the experimental simulation (Beins & McCarthy, 2012; Sekaran, 2003) which validated selected research variables of the intended study. As stated by Raubal and Egenhofer (1998), the combination of drivers' choice (decision) and clues (i.e. sign message) in a real world can be measured through virtual simulation.

This research set the minimum age of 50 years as a "senior", and selected 40 senior drivers aged 50 years and above as a sample of the population. The definition of "senior" being aged 50 years and above was set to allow an accepted minimum "older" age (i.e. based on the MDS Workshop case) globally (Kowal, Rao, & Mathers, 2003). This research, hopefully, could be extended to be applied to other countries for airport road access wayfinding improvements.

a. Scenario Specifics

The simulated driving was scripted using a Scenario Definition Language (SDL) provided by the STISIM Drive Software Version 2. The authoring software was used to add the necessary objects (e.g. direction and advertisement signs, bollards and pedestrians) and auditory cues which provided the driver with instructions (e.g. "That is the end of the simulation"). Scenarios were scripted within a general purpose of the simulator that was a mixture of dual carriageway, buildings, static objects, pedestrian pavement and vegetation.

Three scenario types were designed to provide a variety of driving scenarios and complexity of the road designs to the airport. The complexity of wayfinding varied to assess the safe driving behaviour on alternative airport road access design. Drivers' decisions and judgement are extremely important while driving especially when they have to make a rapid

decision or whilst making decisions under pressure at decision points (Casutt, Martin, Keller, & Jäncke, 2014; Hassan et al., 2015). Drivers need to demonstrate visual scanning of the driving environment. They also must be able to make a quick scan of the signage information. Drivers often will face degrees of pressure and anxiety on journeys to airports in order to ensure that flights are not missed.

Table 1 shows the total number of signs and road furniture in the driving simulation scenarios. We established three scenarios representing different degrees of airport road design complexity.

Table 1: Total number of signs and road furniture in the driving simulation scenarios

Road furniture type	Simulation 1 (S1)	Simulation 2 (S2)	Simulation 3 (S3)	Total
Directional sign	129	145	160	434
Regulatory sign	8	8	8	24
Warning sign	36	36	36	108
Advert	8	21	28	57
Bollard	68	68	68	204
Traffic light	2	2	2	6
Pelican beacon	2	2	2	6
Street light	45	45	45	135
Pedestrian	218	326	513	1057
Intersection	11	11	11	33
Building	90	101	111	302
Vehicle	199	199	199	597
Roundabout	3	3	3	9
Bus stop	2	2	2	6
Total	821	969	1188	2978

Scenario 1 or 'Less Complex' scenario was designed to be as less busy as possible to test the effect of road design on drivers' wayfinding to the airport. Drivers' behaviour and safety during navigation were also tested. The signage placement and road furniture were included to assess drivers' adaption to the actual airport road design with accurate wayfinding (including signage) provided. Scenario 2 or 'Complex' scenario was designed as a busy road and more complex in terms of road access design and wayfinding (including signage). Curved roads and warning signage were included in order to measure the impact of airport

road design on drivers' safety and driving behaviour. Multiple signage types (e.g. diamond and rectangle signs) in the simulation design were considered. Scenario 3 or 'More Complex' scenario was designed as a busiest airport road with different types of direction and warning signs (e.g. diamond and rectangle signs), advertisement signs and complexity of airport road design provided with accurate wayfinding systems (including signage).

b. Procedure

The simulation participants were selected based on convenient sampling and participation in this study was completely voluntary. Convenience sampling is a non-random (nonprobability) sampling technique that involves using whatever participants can conveniently be studied. It is most often used during experiment-based research and is the best way of obtaining basic information in the most efficient way (Sekaran, 2003). Thus, convenient sampling is the most appropriate sampling design for this paper because the collection of information is collated from the population of participants who are conveniently available to provide it.

40 experienced car drivers holding a valid driving license volunteered to take part in the study. The age of drivers ranged from 50 to over 60 with a sample mean age of 59 years. Complete instructions were given before the simulation started. Drivers were instructed to drive to the airport with the aid of wayfinding and signage in the driving scenario. The simulation test was 3.8 miles long for each scenario and took approximately 20 - 30 minutes to complete all three simulations. Participants decided which route to use based on the provided signage and wayfinding systems. The scenario was tested randomly.

c. Data Analysis

The mean and standard deviation were used in this research as they are the most common descriptive statistics, and a very useful tool of statistical rules, in normal distribution (Beins & McCarthy, 2012; Robson & McCartan, 2016; Sekaran, 2003). Beins and McCarthy (2012) stated that ANOVA compares group means to assess the reliability of different means. In this research, ANOVA was used to measure the most prevalent importance of driving behaviour, road safety and the complexity of road design. The ANOVA test measures the differences of the independent variable (e.g. drivers' age group) and the dependent variables (e.g. risk of collision and centreline crossings). The level of significance ($p < 0.05$) was set in this study while 95% confidence level was selected as a conventionally accepted level (Sekaran, 2003).

5. RESULTS

a. Hypotheses

Table 2 shows the mapping of research hypotheses, research variables and analysis techniques in the airport road access wayfinding research.

Table 2: Research Hypotheses, Research Variables and Analysis Technique

Hypotheses	Study Variables	Analysis Techniques
H_0: Low adverse impact of airport road access complexity design on driving behaviour and road safety.	Factors that contribute to safe driving behaviour and road safety (IV)	Frequency analysis (Mean and standard deviation)
H_1: High adverse impact of airport road access complexity design on driving behaviour and road safety.	Airport road access wayfinding (DV)	ANOVA Test

b. Drivers' Age and Gender

There were a total of 40 respondents who volunteered to participate in this research as a convenience sampling design was applied. Table 3 shows the age group of senior drivers who volunteered as participants in this research.

Table 3: Range of drivers' ages

	Minimum	Maximum	Mean	Standard Deviation
Age	50	71	58.60	5.31

The minimum and maximum age of the senior drivers are 50 and 71 years old, respectively. Mean and standard deviation of age range was computed as 58.60 and 5.31, respectively. The mean and SD results revealed that most of the participants were aged in the range of 53 to 63 years. In total, 24 male drivers (60 per cent) and 16 female drivers (40 per cent) successfully completed the driving simulation test. The selection of senior drivers' gender was based on convenience sampling and volunteered feedback during invitation timeframe (e.g. 6 months).

c. *Key Factors Influence Senior Driving Behaviour*

Figures 1, 2 and 3 show mean and standard deviation computed for senior drives' age mistakes based on 'Less Complex', 'Complex' and 'More Complex' road design, respectively. The results show that there is a low impact between road design complexity and driving errors. The results also revealed that the road edge excursions was the most mistakes and 'disobeyed' red traffic lights was the lowest mistakes made by senior drivers in all simulated driving scenarios. Senior drivers preferred to drive near to the road edges (or road shoulders), 'too carefully' at the junctions and roundabouts and surprisingly drove too fast in sections of the road that had lower speed limits. This pattern showed that senior drivers are less safe and are exposed to incidents on the road. In the 'Less Complex' wayfinding design (Figure 1), senior drivers were likely to cross the road edge (mean=3.90, SD=2.32), be exposed to the risk of collisions due to driving too close to a vehicle in front (mean=1.43, SD=0.81), exceeding the speed limit (mean=0.33, SD=0.57), cross the centreline (mean=0.10, SD=0.30) and were less aware of red traffic lights (mean=0.05, SD=0.22).

Figure 1: Mean and SD of drivers' age based on 'Less Complex' Scenario

	Risk to collisions	Speed exceedances	Traffic light tickets	Centreline crossing	Road edge excursions
Mean	1.43	0.33	0.05	0.10	3.90
Std. Deviation	0.81	0.57	0.22	0.30	2.32
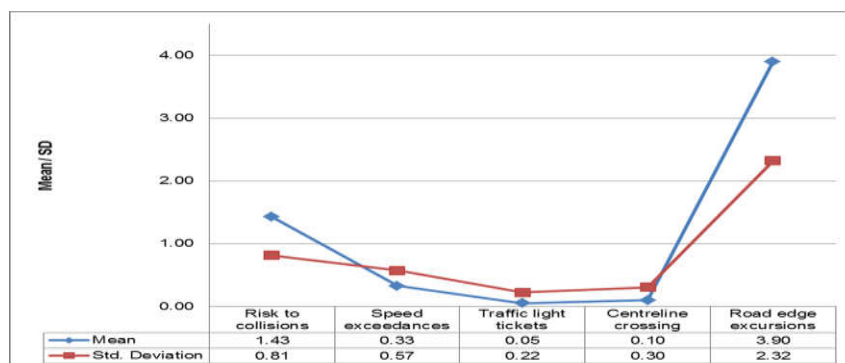
Senior drivers' mistakes during the driving simulation test were recorded. In the 'Complex' wayfinding design (Figure 2), senior drivers were likely to speed and exceed the standard speed limit (mean=0.43, SD=0.84). They preferred to drive close to the kerb, which resulted in road edge excursions (mean=4.20, SD=4.44).

However, they were likely to cross the centreline of the road lane (mean=0.15, SD=0.43) when attempting to turn at the next junctions. Tailgating as one of the major contributors to the road accidents could raise the risk of collision (mean=1.48, SD=0.91). Traffic light ticket (mean=0.03, SD=0.16) rates were low in the 'Complex' scenario, perhaps because of their experience from the previous simulated driving test.

Figure 2: Mean and SD of drivers' age based on 'Complex' Scenario
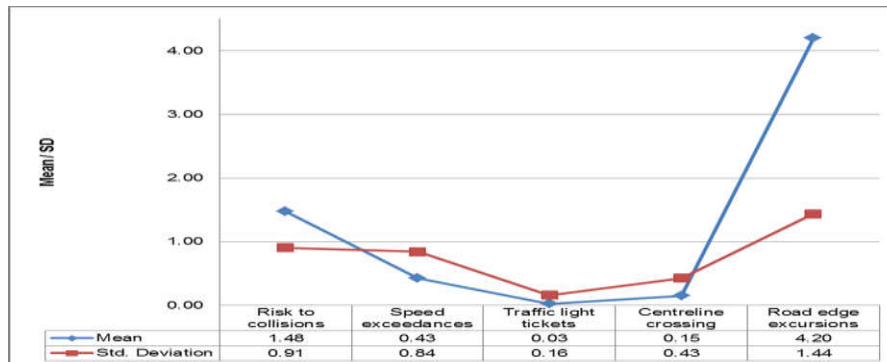
Drivers made more errors in the 'More Complex' wayfinding design (Figure 3); road edge excursions (mean=4.85, SD=1.12), risk to collisions (mean=1.63, SD=0.70), speeding (mean=0.60, SD=1.08), crossing the centreline (mean=0.35, SD=1.48), and less aware of red traffic lights (mean=0.13, SD=0.33) while performing navigation in this scenario. These five mistakes are the major factors influencing senior driving behaviour and safety on airport road access wayfinding design.

Figure 3: Mean and SD of drivers' age based on 'More Complex' Scenario
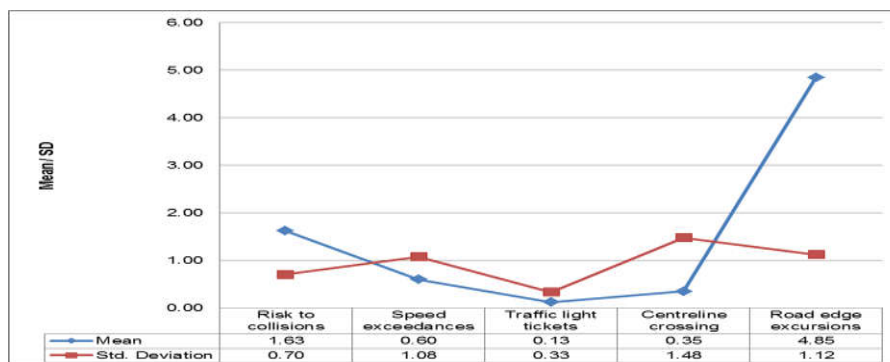
d. The Impact of Airport Road Access Complexity on Driving Behaviour and Road Safety

Table 4 shows the ANOVA test results of the research parameters.

Table 4. Summary of Senior Drivers' Mistakes in Simulated Driving

Driver's Mistake	Simulation 1		Simulation 2		Simulation 3	
	F	p-value	F	p-value	F	p-value
Risk to collisions	0.928	0.405	0.727	0.490	0.158	0.855
Speed exceedances	0.216	0.807	0.523	0.597	1.725	0.192
Traffic light tickets	0.849	0.436	1.177	0.319	0.720	0.493
Centreline crossings	0.742	0.483	0.146	0.865	0.826	0.446
Road edge excursions	0.564	0.574	1.262	0.295	1.228	0.305

i. Risk of collisions

The ANOVA result of risk to collisions shows that there was low statistically significant difference between risk of collisions and senior drivers' age group. It shows that senior drivers had no difficulties to reach the airport in Simulation 1 (F=0.93, p=0.41), Simulation 2 (F=0.73, p=0.49) and Simulation 3 (F=0.16, p=0.86). Therefore, there is low statistical impact to airport road access wayfinding designs on road safety. Based on Table 4, the highest possibility of senior drivers being exposed to a road accident was in the 'More Complex' (mean=1.63, SD= 0.70), followed by 'Complex' (mean=1.48, SD=0.91) and 'Less Complex' (mean=1.43, SD=0.81) scenarios. Senior drivers were observed to drive near to the road edges (especially at the roundabouts), had difficulties in making a fast decision at the decision point (e.g. junctions and approaching signs), and failed to respond to speed limit signs at low speed limit roads. These factors were contributory factors that lead to road collisions.

ii. Speed exceedances

The ANOVA result shows low significant impact between speed exceedances and age group of senior drivers; Simulation 1 (F=0.22, p=0.81), Simulation 2 (F=0.52, p=0.60), and Simulation 3 (F=1.73, p=0.19). The results in Table 4 revealed that airport road access wayfinding design has low link to senior driving behaviour and safety. Drivers preferred to speed in the 'More Complex' (mean=0.60, SD=1.08) airport road access wayfinding design compared to the other scenarios. Variable speed limit signs were considered in the "More Complex" scenario; however, the results confirmed that the complexity of the airport road access wayfinding design less affect senior drivers' behaviour. Surprisingly, research results revealed that the speeding was controllable in the 'Less Complex' scenario (mean=0.33, SD=0.57). The 'less busy' and 'cosy' environment led senior drivers to the comfort driving

without thinking of other tasks. Observation confirmed that senior drivers felt it to be comfortable and easy to navigate to the airport. DfT (2015c) and Oxley et al. (2006) reported that exceeding the speed limit and driving too fast are contributory factors to the accidents and casualties statistics. Exceeding the speed limit was reported in around 16 per cent of fatal accidents in 2014, whereas 8 per cent of fatal accidents were caused by driving too fast. A similar pattern was seen for reported road fatalities where exceeding the speed limit contributed to 17 per cent of fatalities and driving too fast contributed to 8 per cent of fatalities. The road statistics also revealed that 7 per cent of serious accidents and seriously injured casualties were allocated to the categories of exceeding the speed limit and travelling too fast.

iii. Traffic light tickets

The ANOVA result shows the airport road access wayfinding design has low significant impact on driving behaviour and road safety in terms of traffic light awareness. Senior drivers were less aware of red traffic lights in all scenarios; Simulation 1 (F=0.85, p=0.44), Simulation 2 (F=1.18, p=0.32) and Simulation 3 (F=0.72, p=0.49). Statistical results revealed that senior drivers are more likely to fail to stop at red traffic lights in the 'More Complex' scenario (mean=0.13, SD=0.33) compared to the 'Complex' (mean=0.03, SD=0.16) and 'Less Complex' (mean=0.05, SD=0.22) scenarios.

iv. Centreline crossings

The ANOVA result shows the senior drivers' age had low impact on road centreline crossing in all scenarios. Drivers are likely to cross the centreline more often in the 'More Complex' road design (F=0.83, p=0.45) compared to the 'Less Complex' and 'Complex' roads designs (F=0.74, p=0.48; F=0.15, p=0.87), respectively. The ANOVA results revealed that the complexity of road design affected senior driving behaviour. The complexity of the 'More Complex' scenario led senior drivers to cross road centrelines more often (mean=0.35, SD=1.48) compared to the 'Less Complex' (mean=0.10, SD=0.30) and 'Complex' (mean=0.15, SD=0.43) ones. Poor turn manoeuvre at roundabouts and junctions were main factors of unsafe driving behaviour. DfT (2015b) confirmed that poor turn manoeuvre led drivers to road accidents.

v. Road edge excursions

Table 4 shows there is a low significant impact between the senior drivers' age group and road edge excursions; Simulation 1 (F=0.56, p=0.57), Simulation 2 (F=1.26, p=0.30), and

Simulation 3 (F=1.23, p=0.31). The ANOVA test revealed that senior drivers crossed the road edge more frequently in the 'More Complex' scenario (mean=4.85, SD=1.12) compared with the 'Less Complex' (mean=3.90, SD=2.32) and 'Complex' (mean=4.20, SD=1.44) scenarios. As similar to centreline crossings, poor turn manoeuvre affected senior drivers' safety which could lead to the risk of collisions. Senior drivers being likely to drive close to the kerb (e.g. to get a close view of traffic signs' information) was the reason for the highest mean value. Based on Table 4, the alternative hypothesis has been rejected and at the same time the null hypothesis was accepted at a significant alpha of 0.05. The hypothesis states that there is a low impact between driving behaviour, and road safety on airport road access wayfinding design.

6. DISCUSSION

The paper suggests that driving simulation is useful for testing drivers' wayfinding ability in a virtual environment. The study investigated the impact of different wayfinding and signage provisions on driving behaviour in three groups aged 50 and over. ANOVA results showed that drivers' particular age group had a low impact between driving behaviour and road safety on airport road access wayfinding design. There are several contributory factors that may influence safe driving behaviour. To emphasize the driving simulation results, the preferred key factors leading to road accidents have been considered as shown in Table 5.

DfT (2015c) reported that road accidents involving fatalities of senior drivers have only fallen by 15 per cent from the years 2005 to 2009. However, road accidents that involved serious injuries rose 10 per cent over the same period. DfT reported that in the year 2000, people aged 60 or over accounted for about 20.8 per cent of Great Britain's population. By 2013, this had risen to 23 per cent, just over a 10 per cent increase. As the number of people in the senior age group increases, a higher number of road accidents involving senior drivers would be expected. In addition, as people get older their health condition becomes more infirm (Cuenen et al., 2016; National Institute on Aging et al., 2011). Thus, it could lead to problems such as poorer depth perception and an increase in mistakes in both cognitive and physical behaviour (Department for Transport, 2015c; Marin-Lamellet & Haustein, 2015; National Institute on Aging et al., 2011; Oxley et al., 2006; RoSPA, 2010). These factors affected senior drivers' ability to focus on the road while driving to the airport.

Table 5: Mapping of contributory factors influence safe driving behaviour

Contributory Factors	Risk to collisions	Speed exceedances	Traffic light tickets	Centreline crossings	Road edge excursions
Failed to look properly	X	X	X	X	X
Poor turn or manoeuvre	X			X	X
Failed to judge other drivers' path or speed	X	X			
Following too close	X				
Disobeyed 'Give Way' or 'Stop' sign or markings	X	X	X	X	X
Loss of control	X			X	X
Travelling too fast	X	X	X	X	X
Swerved	X			X	X
Exceeding speed limit	X	X	X		
Aggressive driving	X	X	X	X	X

There are three major of driving simulation that affects the ease of driving orientation and wayfinding designs to the airport. Firstly, the sign design of driving scenario's should be distinctive and different (J. R. Harding et al., 2011). Airport 'directional arrow' sign should be bigger, bold text, different colour and symbol than other signs. The airport landside signs should be identical in term of size, colour and style to be compared with current motorway signs. The senior drivers could differentiate and signifies the airport signs while they are performing wayfinding. Therefore, it is very important that airport signs adhere to copy, styles and sizes, consistent terminology and symbols and uniform colours of basic guiding principles standard functions (AASHTO, 2010; J. R. Harding et al., 2011; Smiley et al., 2004). Message content should be easily understood by airport travellers. For instance, first time travellers require different information rather than frequent flyers. Secondly, some attributes in driving simulation can be seen from various viewpoints. For example, the 'Less Complex' scenario was developed with 'comfort' driving environment which allows drivers to view the routes and landmarks more easily and distinctively compared than other scenarios. Adding more to that, in some attributes of simulated driving such as 'More Complex' scenario, senior drivers require sign direction to be displayed as far as possible to the airport (AASHTO, 2010). Thirdly, as age increases, it is certain that general health and fitness will begin to deteriorate which leads to road accident risks. The senior drivers felt that their

driving experience skills and driving abilities may not be as good as they once were (RoSPA, 2010). As a result, senior driver control their driving experience and develop a more defensive and cautious driving behaviour as they grow older. The senior drivers are commonly involved in collisions often because they misjudge the speed or distance of other vehicles or fail to see a hazard (Chevalier et al., 2016; Cuenen et al., 2016; Devlin & McGillivray, 2016; National Institute on Aging et al., 2011). From the driving simulation results, it shows that the 'more complex' of road design makes wayfinding more difficult. For instance, the senior drivers made more errors in the 'more complex' scenario which led to risk of collisions, exceeding the speed limit, centreline crossings, and road edge excursions. Senior drivers are more likely to have more driving errors which leads to road accidents.

7. CONCLUSION

In conclusion, the study revealed that senior drivers' attention and ability to process signage and wayfinding information is limited. These limitations can create difficulties because driving requires the division of attention between control tasks, guidance tasks and navigational tasks. Drivers' attention can be switched rapidly from one wayfinding information source to another. This means that drivers only attend well to one source at a time. For instance, while driving to the airport, drivers can only extract a small proportion of the available information from the road scene (i.e. airport directional signs). Thus, to interpret a limited information processing capacity while driving, drivers can only determine acceptable information loads that they can manage (Mårdh, 2016). When drivers' acceptable incoming information load is exceeded, they tend to neglect other information based on level of importance (i.e. if driver was looking for the word 'airport' on the sign, they tend to neglect the speed limit signs). As with decision making of any sort, error is possible during this process (Casutt et al., 2014). Drivers were less focused on information that turns out to be important, while less important information was retained. In addition to information processing limitations, drivers' attention is not fully within their conscious control. For drivers with some degree of experience, driving is a highly-automated task. Driving can be performed while the driver is engaged in thinking about other matters. Most drivers, especially a frequent traveller to the airport or one familiar with the airport route, have experienced the phenomenon of becoming aware that they have not been paying attention during the last few miles of driving (e.g. airport staff). The less demanding the driving task, the more likely it is that the drivers' attention to the airport wayfinding and signage will wander, either through internal preoccupation or through engaging in non-driving tasks. Factors such as complexity of road design and environment or increased traffic congestion

could also contribute to distracted driver's ability to keep track of wayfinding. Inattention may result in unintentional movements out of the lane, exceeding the speed limit (Chevalier et al., 2016) and failure to detect a vehicle on a conflicting path at an intersection (Dukic & Broberg, 2012; Mårdh, 2016; Oxley et al., 2006) that exposed drivers to the risk of collisions and reduced road safety.

8. LIMITATION

Driving simulators have a few disadvantages. For instance, simulator sickness (a type of motion sickness) is experienced by senior drivers whilst "driving" in the simulator room; it may include dizziness, headache, nausea and vomiting (Mourant & Thattacherry, 2000). Apparently, a senior driver would be compromised when experiencing these symptoms and it may not be appropriate for all drivers to be involved in a simulated driving experience. Gruening et al. (1998) claimed that the information gained through driving simulations may be misleading if the simulator does not provide an appropriate analogue to the simulated scenario, and that high reliability driving simulations are sometimes far more expensive than vehicle testing.

9. FUTURE RESEARCH

This research addressed the gaps in the literature on the airport road access wayfinding and the relationship between senior driving behaviour and road safety on airport road access wayfinding design. A driving simulator has been used as a tool to measure the relationship between these variables. In this section, further directions for future research are suggested. Firstly, Satellite Navigation (Sat Nav) was suggested to assess its impact on senior driving behaviour towards airport road access wayfinding. However, the Sat Nav was not built-in in the STISIM driving simulator Version 2. The idea of the insertion of Sat Nav as a tool to aid senior drivers to perform airport wayfinding hopefully would extend the current research, with additional variables on the impact of airport road access design using a simulated driving scenario. Secondly, senior drivers aged 50 years and over were chosen to participate in this research. Results from the simulated driving test were analysed and findings were measured only focusing on senior drivers attributes. It is suggested that this research could be extended to the younger drivers and with a consideration of gender to assess any effects on driving behaviour and road safety on the complexity of road design.

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THE CUSTOMERS' EXPECTATIONS AS A GUIDE TO SERVICE INNOVATION IN THE AIRLINE INDUSTRY

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ABSTRACT

According to the strategic innovation paradigm, service companies have their innovative efforts guided by market needs, so customer demand is crucial to successful innovation. However, the service literature about air transportation has been focusing on the evaluation of service quality delivered instead of the identification of market demands. This study applied the Hierarchical Model of air transportation service quality evaluation adapted to identify customer' expectations in a Brazilian domestic airport. The results indicate that customers have higher expectations regarding airline employees' conduct and expertise, which suggests areas where investments should be prioritized in order to optimize efforts on service innovation.

KEYWORDS

customers' expectation; innovation; service quality; air transport; airlines; services.

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1. INTRODUCTION

Providing high quality services is crucial for airline companies to increase profitability and market share (Wu & Cheng, 2013). In spite of that, some reports such as the Air Travel Consumer Report e JD Power Airline Satisfaction Study show that customers are not completely satisfied with the service provided by airlines (Waguespack & Rhoades, 2014). According to the authors, the disquality rates are calculated with data from the percentage of late flights, total number of customer complaints, total number of involuntary denied boardings, total number of mishandled baggage reports and cancellations.

Attempting to offer better services to customers and increase profitability, airlines innovate in services. Some examples of air transport service innovation developed in the past years that are becoming mass services are: on line check-in, self-check-in kiosks, web-booking with up sell offer, one-way ticket pricing, limousine service, empty middle seat, mobile phone usage onboard, live TV/radio, onboard bar and lie-flat seat (Rothkopf & Wald, 2011). Those innovations are incremental and create ancillary revenues (O'Connel & Warnock-Smith, 2013). However, the fees for these services, which apparently increase profits, are one of the main complaints of airline customers (Waguespack& Rhoades, 2014).

Therefore, airlines must understand their customers' expectations to improve service superiority and market performance, creating value (Carbonell, 2009). In that sense, customer interaction can provide a more accurate understanding of customer's wants and needs and prevent against the development of bad and undesired services that will not be accepted in the market (Alam & Perry, 2002).

The strategic innovation paradigm states that innovations are market-driven, meaning that the market situation is an important factor for determining the innovation's success (Sundbo, 1997). Market orientation requires learning about customers' needs, competition, environmental forces and customer involvement aims to facilitate the process of sensing the market (Matthing, Sanden & Edvardsson, 2004). Additionally, the literature on airline services has prioritized service quality issues in spite of customers' expectations.

This paper aims to identify customers' expectations, answering what clients want from air transport innovation and indicating innovation priorities for the companies. For that matter, the Hierarchical Model of air transportation was adapted and applied, because it is a multi-dimensional instrument with four primary dimensions and eleven sub-dimensions, which help elaborate management strategies and tactics and improving performance (Wu & Cheng,

2013). The adaptation process included using the techniques from Analytic Hierarchy Process (AHP) to provide decisions that are more objective from customers (Saaty, 2008) and understand the true level of importance of each dimensions.

2. AIRLINE SERVICE QUALITY

Quality is a manifold concept and is related to satisfying the needs of the stakeholders of the organization, including customers, owners and staff (Edvardsson & Olsson, 1996). It is usually defined as a form of evaluation of a product or service, a condition of global judgment, while satisfaction is related to a specific transaction. As satisfaction episodes accumulate over time, the customer develops a perception of service quality (Parasuraman, Zeithaml & Berry, 1988).

Service quality is the most important matter in obtaining service sector competitive advantage and financial success (Parasuraman, Zeithaml & Berry, 1988). Customers are the final evaluators of service quality and if they are unhappy, they will share their dissatisfaction with people they know (Cheung & To, 2011). Therefore, many studies have tried to investigate the service quality attributes in the airline industry.

The quality dimensions studied are usually tangibles, responsiveness, reliability, empathy, safety (Pakdil & Aydin, 2007; Chou et al, 2011; Mitra, 2014), cabin service (Liou et al., 2011; Wong& Chung, 2007), flight patterns, image, availability (Pakdil & Aydin, 2007), and communications (Hussain et al., 2014). Table 1 summarizes service quality research and its main results.

Table 1: Service Quality Research

Source	Method	Respondents	Main results
Basfirinci and Mitra (2014)	SERVQUAL and Kano Model	238 respondents (126 from Turkey and 112 from USA).	For US airlines and Turkish airlines, quality delivered is bellow customers' expectations; cultural differences influence customers' expectations and perceptions of service quality affecting satisfaction.
Chou et al. (2011)	Fuzzy weighed SERVQUAL	329 passengers from an international airline that flies from International Airport of Kaohsiung in Taiwan.	Passengers consider reliability and assurance dimension and safety-related services items as top priorities.
Hussain et al. (2014)	SERVQUAL	253 respondents from Dubai International Airport.	Superior service quality, perceived value and corporate image create passenger satisfaction and lead to brand loyalty.
Laming and Mason (2014)	Survey (Airs@t survey)	18.567 passengers from 15 airlines (five based in Asia, seven in Europe and three in the Middle East).	Satisfaction is derived specially from cabin features, crew and pilot performance, and in-flight food and drink and these items crate customer loyalty.
Liou et al. (2011)	Modified VIKOR	5598 passengers from UNI Air, TransAsia Airways, Mandarin Airlines and Daily Air.	Cabin services are considered the most important dimension of service quality; the services with higher satisfaction levels are reservation, ticketing, check-in and boarding processes. The lower satisfaction levels refer to baggage claim and handling delays.
Pakdil and Aydin (2007)	Weighed SERVQUAL	320 passengers from an airline in Istanbul Ataturk International Airport.	Passengers' past experience is the most important reason in choosing an airline; passengers' education levels affect their expectations and perceptions; the "responsiveness" dimension is the most important and "availability" is the least.
Wong and Chung (2007)	SERVQUAL and C5.0 decision tree	812 passengers from a Taiwanese Airline.	Passengers like responsive, reliable and assured air transport service.

The Hierarchical Model proposes that service quality consists of four primary dimensions composed by sub-dimensions. The first dimension is interaction quality. It refers to the personal interface between service providers and customers during service delivery and its sub-dimensions are conduct, expertise and problem solving. The second dimension is physical environment quality, referring to the physical characteristics of the service production process and its sub-dimensions are cleanliness, comfort and tangibles. The third dimension, outcome quality, focuses on what customers obtain from the service and its sub-dimensions are valence and waiting time. The fourth dimension, access quality, refers to the ease and speed with which people reach the desired location and its sub-dimensions are information and convenience (Wu & Cheng, 2013).

The dimensions should be considered when developing management strategies, while the sub-dimensions can be analyzed when formulating daily management tactics. The combinations of those areas compose the general perception of airline service quality (Wu & Cheng, 2013).

3. SERVICE INNOVATION AND CUSTOMER' EXPECTATIONS

Many quality problems are caused by drawbacks in the development of new services. When developing a new service, the right quality must be built from the beginning, planning the development of services which customers see as appealing (Edvardsson & Olsson, 1996). The new service development process comprises four stages: idea generation, idea transformation, development and implementation. When developing a new service it is crucial to learn from and with customers, because they are a "potential goldmine" and help create value (Edvardsson et al., 2012). To deeply understand clients' needs and wants it is necessary to involve them in the new service developing process (Gustafsson, Ekdahl & Edvardsson, 1999).

Customers might get involved with the service depending on how important and meaningful that service is for them. The more involved a customer is with a service, the more customers' expectations will influence the evaluation of service performance. Therefore, companies should stimulate and try to increase customer involvement in order to obtain better ideas for new service development and achieve higher satisfaction levels (Cheung & To, 2011).

When developing new air transport services, involving customers helps tailoring the service and create unique experiences that enhance loyalty. The higher the degree of co-creation, the higher the financial (profits) and non-financial (loyalty and satisfaction) levels of the company. The value is created not only in the delivery of the service itself, but also in the development process, because the customer feels special and useful for the company (Grissemann & Stokburger-Sauer, 2012).

The idea generation phase is the most important stage in the development of new services, because it helps develop services that match customer's needs, especially if clients are involved in the process. In this phase, clients can contribute as they state needs, problems and solutions, criticize existing services, help identify gaps in the market and can provide a wish list of the services wanted (Alam & Perry, 2002). In the idea generation phase, companies should identify customers' expectations and design services that serve them (Edvardsson & Olsson, 1996).

As quality is a comparison of how the customers feel the service and how should be the perception of the service offered, as more companies know about customers' expectations, more quality it can provide by trying to achieve that expectation (Parasuraman, Zeithaml & Berry, 1988).

The customer' expectations are what clients want or wish for, what they think the company should provide them and not only what the company would provide (Parasuraman, Zeithaml & Berry, 1988; Zeithml, 1993; Edvardsson & Olsson, 1996). They are previous beliefs that are used as standards or references to judge the service that is provided, determining customers' satisfaction and service performance. Two clients can have different expectations about the same service. That is why organizations in the same business can have completely different service levels and still maintain customers satisfied (Zeithml, 1993).

Expectation construct is fundamental in determining the quality evaluations. Perceived service quality is the difference between customers' perceptions and desires. The desired service is the one the client hopes to get, that will attend all of his needs and surprise him. It mixes what services can be and should be. As customers know that it is not always possible, they can have a lower level of expectation that is still acceptable, called the adequate service level which customers will accept (Parasuraman; Zeithaml; Berry, 1988).

Expectations can be influenced by the company's image and reputation, the clients' previous experience with the company, marketing campaigns (Edvardsson; Olsson, 1996), personal needs, situational factors, past experience, word of mouth communication, advertising, personal selling, perceived alternative services and service promises (Parasuraman; Zeithaml; Berry, 1988).

4. METHODOLOGY

The research was conducted in a Brazilian domestic airport located in São Paulo (CGH) in January, 2015. This airport was chosen because it is one of the most important and busy airports in the country, with more than 200 thousand landings and takeoffs per year and around 20 million passengers in 2015, being behind in Brazil only of the Guarulhos Airport (GRU), with approximately 300 thousand annual landings and takeoffs and more than 38 million passengers in the same year (DECEA, 2016; INFRAERO, 2016).   The convenience sampling technique was used for data collection. One hundred and twenty-two passengers that were waiting to board their flights answered the questionnaire in the airport lounge. Twenty-two of these questionnaires were incomplete and thus excluded from data analysis, resulting one hundred valid questionnaires. It is believed that this amount of interviewees, even if small, can be used as an initial reference for the study of the subject in this paper.

The Hierarchical Model for air transportation was adapted in order to measure expectations instead of service quality. The dimensions conduct, expertise, problem-solving, cleanliness, comfort, tangibles, safety & security, valence, waiting time, information and convenience of the Hierarchical Model were compared against each other in pairs, using the Analytic Hierarchy Process method (AHP) to provide more objective assessments from customers (Saaty, 2008) and understand each true level of importance of dimensions regarding customers' expectations. An example of this method is shown in Table 2.

Table 2: Some of the questions applied using the AHP method

In your opinion, this item below is...	More important	Equally important	Less important	...than this item?
Employees' conduct ...	☐	☐	☐	Employees' expertise
	☐	☐	☐	Employees' ability to solve problems
	☐	☐	☐	Aircraft' cleanliness...

The AHP method used with passengers by the Table 2 was applied by means of a questionnaire. The questionnaire was constructed with questions designed to assess customers' expectations through AHP, through the comparative analysis of the level of importance between the variables by the passengers, and questions that aimed to define passengers' demographic characteristics.

The questions that sought to assess customers' expectations compared two dimensions at a time in order to determine whether the respondent held higher expectations for a certain dimension or if he/she had equal expectations for both. If certain dimension was considered more important than the other one it was being compared to, the more important dimension should score 3 points and the less important dimension should score 1 point in the data analysis. If the importance weights were the same, both should score 2 points. Since eleven dimensions were analyzed in pairs, it was needed fifty-five comparisons in order to evaluate all of the possible relationships between pairs of variables.

5. RESULTS

The passengers' demographic characteristics answered are summarized in Table 3. As shown in Table 3, out of the one hundred respondents, 67% were males and 33% were females. Regarding respondents' ages, 61% are from 21 to 40 years old, and 88% of respondents have at least higher education and the majority of passengers - 63% of them were on a business trip. 40% of respondents use air transportation from 3 to 6 times a year, while the second biggest group uses it 11 times or more per year (30%).

Table 3: Sample Characteristics

Measure	Option	Frequency	%
Gender	Male	67	67%
	Female	33	33%
Age	20 years old or younger	11	11%
	21-30	34	34%
	31-40	27	27%
	41-50	17	17%
	51-60	8	8%
	60 years old or older	3	3%

| Measure	Option	Frequency	%
Education	Elementary school or below	0	0%
	High school	12	12%
	Higher education	53	53%
	Post graduate	35	35%
Trip purpose	Leisure/Tourism	31	31%
	Business	63	63%
	Others	6	6%
Annual frequency of air travel in the last 12 months	2 or less	16	16%
	3-6	40	40%
	7-10	14	14%
	11 or more	30	30%

To classify the dimensions analyzed according to customers' expectations, it is used a total score for each variable. The total scores are composed by the sum of all individual scores a dimension received by respondents in the questionnaire. Table 4 presents the AHP matrix as well as the total scores each dimension received, in which the higher the total score a dimension received, the higher customers have high expectations for this dimension. Fig. 1 orderly classifies the dimensions importance in terms of customers' expectations by using the percentage of the sum of all total scores a dimension has.

Thereby, Figure 1 shows that, among all dimensions of service quality inherent to the Hierarchical Model of air transportation service quality, customers have higher expectations regarding airline's conduct and expertise.

Table 4: AHP matrix

Dimensions	Conduct	Expertise	Problem-solving	Cleanliness	Comfort	Tangibles	Safety & security	Valence	Waiting time	Information	Convenience	Total scores
Conduct	-	223	229	237	218	227	220	220	211	218	213	2216
Expertise	177	-	236	225	222	223	227	220	223	213	220	2186
Problem-solving	171	164	-	239	232	210	225	222	223	228	218	2132
Cleanliness	163	175	161	-	204	203	184	203	186	193	199	1871
Comfort	182	178	168	196	-	203	190	223	209	209	212	1970
Tangibles	173	177	190	197	197	-	212	219	208	216	207	1996
Safety & security	180	173	175	216	210	188	-	262	250	255	248	2157
Valence	180	180	178	197	177	181	138	-	217	214	217	1879
Waiting time	189	177	177	214	191	192	150	183	-	221	219	1913
Information	182	187	172	207	191	184	145	186	179	-	226	1859
Convenience	187	180	182	201	188	193	152	183	181	174	-	1821

Figure 1: Customers' expectations classification
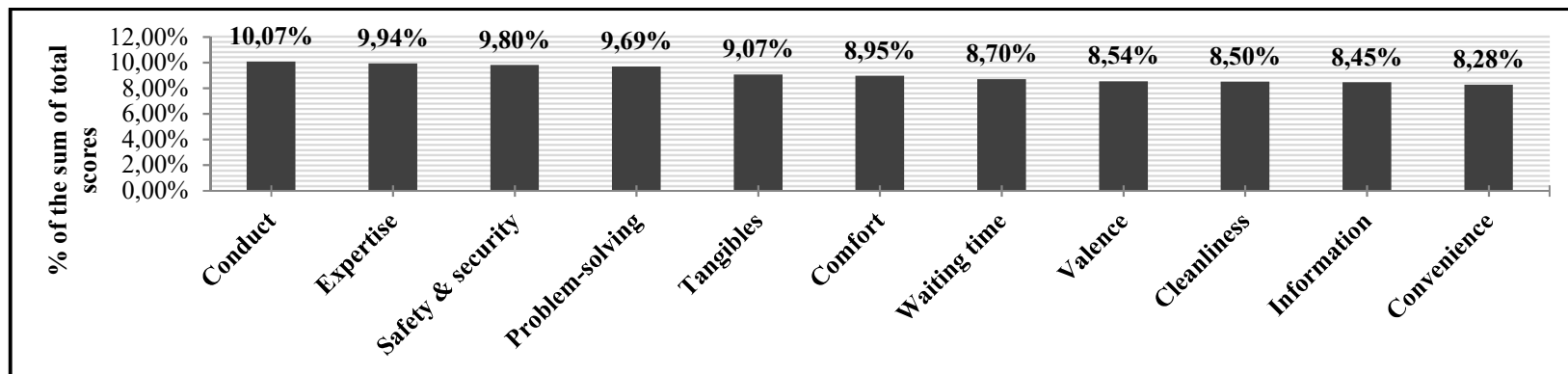
The conduct dimension in the Hierarchical Model of air transportation service quality comprises the airline employees' willingness to help customers, the airline employees' friendly behavior and their understanding of customer needs, the sense of trust passed on by their behavior and the quality of service provided by them, the sense that customers can rely on airline employees to take actions in order to satisfy customers' needs.

Regarding the items that form the conduct dimension, all of them are related to airline employees' behavior, thus indicating an area of extreme importance for airlines to have good performance and also to seek ways of generating innovation in order to increase the level of service offered, since this is the dimension customers have higher expectations about.

The second dimension to which customers have more expectations about is the expertise dimension, which is formed by three items: the conscience of employees that customers depend on their professional knowledge to have their needs satisfied, the confidence that customers can count on the airline employees knowing their jobs and responsibilities and, finally, the airline employees' competence. Similarly to the conduct dimension, the expertise dimension also is completely related to the airlines' employees, reinforcing the critical importance of the airlines' employees to the quality of service received by customers in the airline industry.

6. CONCLUSIONS

The purpose of creating new services is to enhance profitability as the company retain clients and obtain new ones as they became loyal and satisfied (Gustafsson; Ekdahl; Edvardsson, 1999). This paper aimed to answer the question: what do clients want? Considering the customers' high expectations related to conduct and expertise, companies should innovate primarily in those two dimensions in order to meet customers' expectations, thus delivering a higher quality of service, and optimize efforts on service innovation.

This findings of this research should assist airlines' managers as it highlights the importance of human resources in the airline industry, thus indicating that managerial actions regarding human resources management, such as having good recruiting and selection processes, as well as offering adequate training in order to raise employees' expertise concerning their functions, could help airline companies to elevate their quality of service delivered and consequently strengthen their position against competitors.

As limitations of the study, we point the convenience sample, as the research was conducted in a Brazilian airport and the sample size was relatively small (one hundred valid answers). Even so, the research has important implications for both theory and practice as little effort has been made to understand what customers want regarding airline services. Future research should continue on this path, in order to help increase customers' satisfaction and airlines' profitability.

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