PROCEEDINGS OF THE SECOND INTERNATIONAL AVIATION MANAGEMENT CONFERENCE, IAMC – 2014, DUBAI, UAE, 20 – 22 NOVEMBER 2014

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Editor

Ahmed H. Obaide

Dean – EAU Business School

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Message from the Conference Chairman

We are very pleased to host the second International Aviation Management Conference (IAMC) at Emirates Aviation University (EAU) in Dubai, United Arab Emirates, from the 20th to the 22nd of November 2014 under the theme of ***Future Challenges and Opportunities***. This was mainly derived by the success of the first IAMC, which was organized by EAU in 2012. We had received very positive feedback from keynote speakers, sponsors, authors, and other participants urging us to make the IAMC a recurring event.

The goal of the conference is to get together aviation management researchers, professionals, professors, and students to share their ideas and knowledge of case studies and best practices. Topics explored in the conference include (1) Commercial Challenges and Opportunities in Aviation Management, (2) Environmental Impacts on the Aviation Industry, (3) Legal/Aero-Political Issues, (4) Technological Advances and Impacts on Aviation, and (5) Aviation Safety and Security.

The invitation for papers attracted more than thirty papers from thirteen countries. The Technical Committee carried out a blind review and accepted twenty papers for oral presentation. We apologize to those who have missed the deadlines, and anticipate that more authors, from both the academia and the industry, will be encouraged to prepare their work for publication in the next IAMC. The steady growth in the various sectors of the aviation industry necessitates the need for more research on the key issues that impact this industry.

I take this opportunity to thank the keynote speakers for their vigorous and expert participation, and the authors of the research papers for their valuable presentations. My appreciation goes to the distinguished sponsors and strategic partners who supported this event as well as the members of the Technical Committee who devoted their time and expertise to ensure compliance with the highest quality standards.

A special note of appreciation to His Highness Sheikh Ahmed bin Saeed Al-Maktoum, Chairman and Chief Executive Emirates Airline & Group and Chancellor of Emirates Aviation University. We remain indebted to his leadership and continuous support.

On behalf of the IAMC – 2014 conference committees, it is my privilege and pleasure to welcome you to Dubai. I hope that you find this an excellent opportunity to share knowledge and meet colleagues from around of the world. To the readers of these proceedings, I hope that you find them insightful.

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Keynote Speakers

Keynote Speakers

Keynote Speaker	Title
Mr Adel Al Redha, EVP and Chief Operations Officer – Emirates Airline	Future Challenges and Opportunities in the Aviation Industry from an Airline Operation Perspective
Mr Hussein Dabbas, Regional VP – Africa & Middle East - IATA	Future Challenges and Opportunities in the Aviation Industry from the IATA Perspective
Dr. Norbert Lohl, Certification Director – European Aviation Safety Agency (EASA)	Managing the Future based on Experience

Proceedings of the 2nd *International Aviation Management Conference, IAMC –* 2014, *Dubai, UAE,* 20 – 22 *November* 2014

Future Challenges and Opportunities in the Aviation Industry from the IATA Perspective

Hussein Dabbas

Regional Vice President Africa & Middle East - IATA

This year marks the 100th anniversary of commercial scheduled air travel. A century ago a short trip between St. Petersburg to Tampa, Florida with a pilot and a single passenger performed the first commercial flight. The industry grew quickly. This year we will connect 3.3 billion passengers and 52 million tons of cargo over 50,000 routes with 100,000 flights a day.

The Middle East and North Africa region is one of the fastest growing regions for both passengers and freight. I am always passionate to reiterate the impressive growth that our region is going through and how the Middle East is changing the way the aviation sector conducts business and is revolutionizing connectivity throughout the world. But this expanding global presence brings challenges with it. We are all aware of the issues that stand in the way of fully reaping the benefits of this industry; safety, air traffic management, adoption of global standards, over-regulation, high cost of business, consumer protection, climate change, liberalization - just to name a few.

This region is uniquely placed—due to its rapid growth, ability for global connectivity and recognition of aviation as a pillar of economic growth—to benefit from a successful air transport sector. That will need further efforts and collaboration between industry players. I am confident that the region is able to play an even more crucial role in aviation's future.

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Managing the Future based on Experience

Norbert Lohl

Certification Director European Aviation Safety Agency (EASA),
Adjunct Professor Embry-Riddle Aeronautical University (ERAU)

There is huge experience existing from the last 50 years how technology innovations and safety challenges can be actually managed by the Aviation Safety System which has proven to be able to continuously feed-back lessons learnt and to permanently correct the system in accordance with the needs.

This systematic approach is called now the "data driven" Safety Management System (SMS) of which basic elements were in place already since many years and which has certainly to be refined and improved for the future. Examples in the past demonstrate how ongoing challenges were converted into great opportunities despite initial resistances of the system and the human beings involved.

The concept for the future of aviation must be based therefore on the experience in the past. New generations of engineers, administrators and pilots have to take the lessons learnt into account. The transfer of knowledge from the past into the future is the main challenge of the actual generation of aviation experts.

Very demanding additional challenges are Security and Meteorological Phenomena which have to be urgently addressed by fully integrating these elements into the Aviation Safety System by making use of the Total System Approach.

Delegates' Papers

Proceedings of the 2nd *International Aviation Management Conference*, *IAMC* – 2014, *Dubai*, *UAE*, 20 – 22 *November* 2014

Reflections on Developing a Pilot Scholarship of Teaching and Learning (SoTL) Project for Aviation with the Use of an Airline Simulation Activity

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Coventry University, United Kingdom

Abstract: This case study seeks to test the effectiveness of a new approach to develop and use Serious Games (SGs) specifically designed for second year aviation management undergraduate students. Previous studies have addressed only one of the key considerations, knowledge gain and student engagement, as part of the game development process without taking into consideration that the inclusion and assessment of learning outcomes is absolutely necessary in the academic environment. With the implementation of aviation led Scholarship of Teaching and Learning (SoTL) project previous deficiencies have been successfully managed.

Keywords: aviation, simulation, scholarship of teaching and learning, serious games, pedagogic research

1. Introduction

Simulation games have been widely used supporting case-based teaching within general management courses. Authors such as Faria and Nulsen (1996), Garris et al (2002), Wolfe and Luethge (2003), O'Neil, Wainess and Baker (2005). Evidence a positive correlation between the use of this type of games and improvements in the students' cognitive ability and the affective dimensions of learning. Nevertheless, Wouters, van de Spek, and van Ootendorp (2009) warn of the importance of aligning the scenario and the type of game to the actual learning outcomes. Ensuring that the level of competency and capability of the new graduates match up an increasingly competitive and globalised industry is a major challenge for Aviation Management courses at HE level; taking previous works into consideration this paper aims at summarizing a novel approach to use simulation games as a means to enhance cognitive skills and therefore employability in the specific industry while making sure that the students reach the expected academic requirements by engaging on the activities and mastering the expected learning outcomes.

1.1 Key Objectives

Three different but overlapping objectives build on the complexity of the design, running and management of the simulation process adopted as part of a second year airline marketing and management module:

- To develop stimulating simulation scenarios that are representative of the complexity of the global aviation system while taking into account the learning outcomes of the module and the skills of year 2 undergraduate students;
- To explore realistic challenges in the management field and initiating the first documented user test within the Serious Games (SGs,) theory;
- To encourage deep learning while enhancing student experience and meeting expected academic standards.

1.2 Justification

Organizations such as the Advisory Council for Aeronautics Research Europe, the Institution of Civil Engineers (ICE), CONSAVE and scholars such as Mason and Alamdari (2007), Franke and John (2011) and Linz (2012) have already taken on the challenge and adopted scenario planning based methodologies as the way for students and industry professionals to improve their long-term planning and support decisions-making skills. Higher Education supports high impact activities that promote generic employability skills (Yorke, 2006). Building theses competencies is a challenge that requires students developing cognitive skills, generic competencies, personal capabilities, technical abilities, industry awareness and critical evaluation of professional practice.

Nevertheless, it is important to notice that it is not sufficient to state that games facilitate the learning process but they also need to be tested to proof the learning within the expected academic standards. The lack of significant and extensive user tests is another area that requires further research and therefore collecting qualitative and quantitative feedback from already implemented system is a necessity largely highlighted in literature of SGs (Belloti et al., 2010: 32).

To address previous deficiencies, an aviation led Scholarship of Teaching and Learning (SoTL) project has been designed and implemented within the SGs theory focused on aviation concepts in an effort to establish the first documented user test. This represents a novel pedagogic approach for using serious games within this type of scenarios as it tackles previous deficiencies by planning the game taking into account the complexity of the industry and predefined learning outcomes as well as it tests the approach in an actual group of students collecting both quantitative and qualitative data (Figure 1).

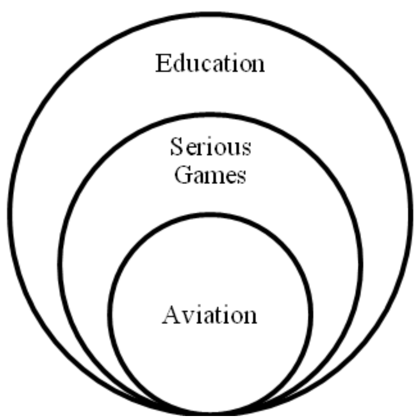

Figure 1: Key Areas of Theory Explored and Integrated

2. Methodology

A case-study method has been selected for this study taking into account the original research question, how student experience in understanding the aviation management system can be enhanced by using serious games and pedagogic best practices effectively, and previously identified deficiencies. Yin’s (2009:18) approach to Case Study Research embraces a comprehensive method that includes planning, design, data collection practices and data analysis techniques. The research questions guides the path towards selecting a SoTL approach as the theoretical framework in the design process; scholarly engagement, reflective practice and communication followed by dissemination are key components of good pedagogic practice and the SoTL process as described by Martin et al (Healey, 2014). SoTL is also ideal for another element of the case study research strategy that of connecting logically empirical data to the study's research (Yin 2009 :26) and for that purpose, an airline simulation game approach has been developed concentrated at level 2 (second year students) combining the pedagogic SoTL approach, aviation industry competitive fundamentals and Serious Games (SGs) concepts. Stimulating active and not passive learning as well as developing players capable of critical and creative thinking are the main drivers of this novel approach to teach following Boyer's (1990:23-4) suggestions.

2.1 A Theoretical Framework in Aviation based on Scholarship of Teaching and Learning Approach

For the purpose of this case study research, a modified version of the SoTL process has been created aligning the expected four elements used by the University of New South Wales (UNSW), planning, implementation, evaluation and reflection along a cyclic route in which inquire and communication are continuous activities along the process but then again specifically liking them to the aviation industry generating a 4-Route Methodology (Figure 2) as a new pedagogic approach to simulate the airline competitive environment within HEs' programs of study. A step by step procedure to the simulation activity is also included in the activity process involved in Route A (Figure 3). That route is critical to the success of the game as the drivers of the game have been developed and built on a logical sequence and according to level 2 standards. This is an area that could be modified in the future to match the requirements for different levels in HE, undergraduate or postgraduate. In this case, the key considerations of the structure included:

- the existing literature review in the Scholarship of Teaching, aviation industry and SGs;
- the learning outcomes of the module;
- observations on previous practiced and the limitation on the effectiveness of these experiences;
- building of a realistic competitive environments that promotes critical analysis and creative thinking;
- identifying tools and techniques that would allow testing users experience and performance and become significant inputs for possible external dissemination of the experience.

Theory and practice are brought together within the implementation stage, or in our case, Route B. This is the stage when the scenario is introduced and implemented with the use of simulation technology. While the idea that learning takes place in a well-constructed game is endorsed by many, this approach would suggest that three other considerations need to be also considered. First is the design of the different scenarios; second is the interaction between the game developer and the players and finally; the assessment and the option to align it to the simulation performance.

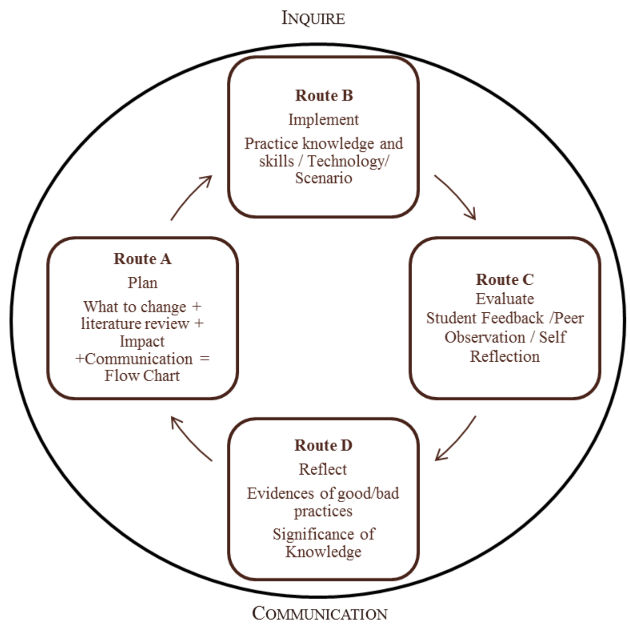

Figure 2: 4-Route Methodology based on Scholarship of Teaching and Learning process by the University of New South Wales (Healey, 2014)

Figure 3: Simulation Activity Flow Chart

If industry-specific skills are to be developed, specific industry knowledge is required; experience on the commercial environment within the aviation sector as well as an up-to-date understanding of key macro-economic events and regulatory bodies of the industry. The inclusion of sound cognitive learning and pedagogical principles encouraged by Greitzer et al (2007) within the design and structure of a web based game opens the opportunity for all students and encourages them to have an equal opportunity to the game process. It also allows including and addressing fundamental airline business models and regulatory constraints by allocating specific roles to all the participants making the scenario more realistic. The last consideration within the planning process is to consider the evaluation and measurement of the student performance. This is the data that could be used in later dissemination practices.

2.2 Data Collection Procedures

Three key principles followed the data collection process (Yin, 2009: 114) the use of multiple sources of evidences, the development of a case study database and the ability to record for the very first time results that contribute to further development of the simulation process. In the area of data collection, student actual simulation performance is monitored while personal experiences and observations are a significant part of the analysis. Ten are the categories predefined by the software as Key Performance Indicators (KPIs) in this game and therefore the basis of the competitive environment; forty airlines, from four key geographical regions, Europe, North America, Middle East and Asia Pacific, competed in a global liberalized economic arena for nine rounds. "Run your own Airline" is the problem presented and every participant is required to start an airline from a preselected airport to establish original nationality of the carrier. Once started airlines are encouraged to engage in competition and maintain profitability.

Competition is between scheduled carriers only and students have to choose to implement business models applied in the industry. According to the specific scenario, students have the adequate funding level to start their own airline in a dynamic environment and face different challenges in every round. The tutor acts as the administrator and also as the Module Aviation Authorities (MAA) and is responsible for managing the student experience and safeguarding smooth operation with consultations, approvals, and settlement of disputes based on International Civil Aviation Organization (ICAO) practices. Decisions involved key domains (Figure 4) and the data collected serves two objectives: first to evaluate the level of understanding of key aviation theories and practices and second to reflect on the process.

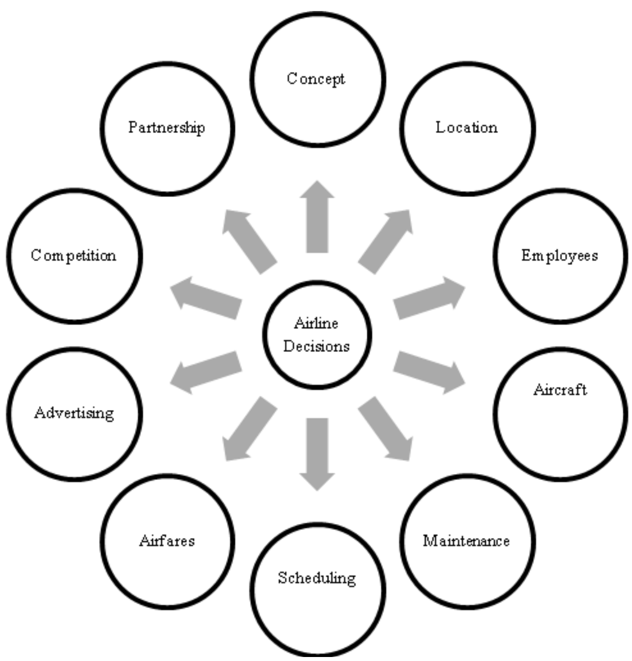

Figure 4: Key Areas of the Airline Management Decision Making Process

From early stages an evaluation strategy is adopted as suggested by Moore (2009). Evaluation and reflection, two key elements of Pedagogic Research (PedR) are used to measure student engagement and performance through route C and D respectively. Other used sources of evidence are, Survey questionnaires; direct observations; tutor's reflective diary; and role playing methods. Different methods served different purposes but the main aim is to evaluate how student learning changed. Reflection focused on content analysis though hypotheses and textual for improving the process.

3. Key Findings

Engaging successfully in the SoTL implies testing the hypothesis, in other words, measuring the effectiveness of the developed simulation game in the classroom among a specific aviation management group of students. Key findings presented below have been divided into four categories covering previous points and as a future reference to support the further development of the simulation activity.

3.1 Observations from the Classroom Experience and the Reflective Diary

The classroom profile has a significant international presence. This is what added value to the process as the majority of the students are familiar with key geographical regions not only from an academic perspective but also from personal experience. Within this diversity, managing the students' experience and expectations become a key challenge for the tutor who needs to emphasize that the actual learning experience and the sustainability of the overall environment are the drivers of the game instead of just pure competition among players. Once this is clear, the level of engagement and in-class participation of weaker students considerably improves even seeking additional advice during office hours. Higher achievers compete more aggressively, elevating competition and the environment results. Far from all running smoothly, there have been moments of high pressure but through an open door policy implemented by the tutor and continuous support escalation has been avoided. More findings from peer observation and the log have revealed that student expectations towards support are high especially during the crisis scenario period. As the process evolved students have also become more opened to cooperation with peers and pursued alliances and code share agreements following the industry trends.

Time constraints and software faults are areas that have caused significant problems during the simulation period. Flexibility is essential to copy with student frustration as software reliability is tested in every round. Deadlines had to be extended in three instances and even one round had been unanimously cancelled.

3.2 Simulation Results

The final results for the simulation environment involved nine rounds instead of ten as due to a technical fault and cancellation of the final round. However, the overall simulation environment is sustainable based on different Key Performance Indicators KPIs with average Load factors that reached 90% (Figure 5) while the crisis scenario and the Low Costs entrants affected negatively, as expected, the results of the legacy carriers. The results have showed continuous growth in traffic and to secure fair competition. The assignment process has been kept deliberately distant from student's actual simulation performance to guarantee deep learning and link it to predefined learning outcomes. The student surveys indicates that all students not only understood the assignment criteria but embrace it reaching a 92% pass rate on first attempt and high performance levels for those that engaged into deep learning.

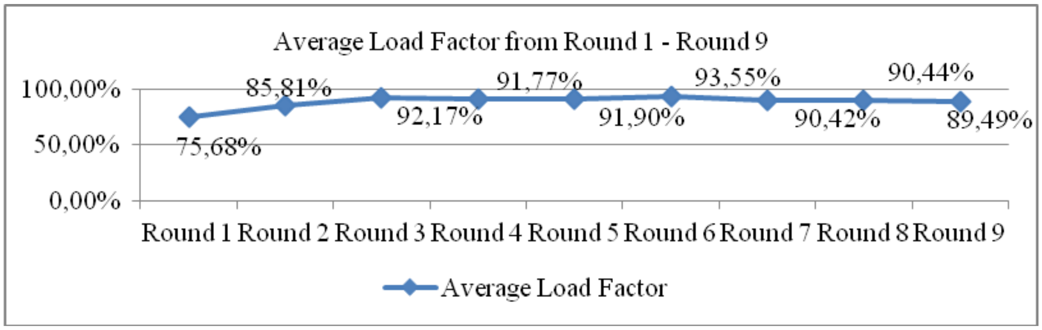

Figure 5: Average Load Factor per Round for the Simulation Environment

3.3 Survey Results

The entire framework has had positive effects on staff and student confidence producing high satisfaction rates not only for the activity but also for the entire module. The module survey (2014) confirms previous experiences using serious games with satisfaction rates for staff engagement and enthusiasm that reached 100 % while 97% of the students participating found that the module was intellectually stimulating and engaging. All comments about simulation have been positive while the activity is perceived as engaging, stimulating, interesting, industry based and aviation related.

Based on textual analysis of the student's view on the actual simulation environment (Table 1), the results indicate that the students require a trial period to familiarize both with the technical aspect software and human interaction. Students appreciate the competitive nature of the environment and have become particularly interested on how potential competitors behave, for many of the students this has translated into protectionist behavior as a means to protect or increase their profits. The students have also valued the weekly brief that has been used by the tutor to present financial and performance data. However, keen players have advised not to overanalyze results as this process would provide the competition with additional information. Finally, the vast majority of the students confirmed that the activity has helped them to develop a better understanding of the industry. Through peer discussion unhappy students have also clarified that it has been their overall performance and not the process that has really disappointed them and they have criticized software liabilities.

	Agree (%)
Trial period is important.	96.67%
I liked the Scenario because it allowed great flexibility.	73.33%
The analysis of the results was useful in supporting my decision making.	90.00%
Sufficient academic advice and support was available.	93.33%
Simulate experience developed a better understanding of the airline industry.	93.33%

Table 1: Highlights from the Student Survey Results

3.4 Student Engagement and Conceptual Learning

Biggs (2003:19) clearly states that "a learning outcome is determined by many factors, acting in interaction with each other" and uses a 3P model to describe a system that supported deep learning. Similarly, a system designed using the SoTL process follows the same three distinct stages described by Biggs as presage, process and product. For this particular cohort presage works in favor of the system identifying and integrating the participants' passion for aviation and enthusiasm as well as the objectives, assessment criteria and classroom ethos from the beginning. Student engagement has converted into high levels of commitment to the game both during the familiarization period and the actual simulation. The student have been keen even on increasing the level of difficulty of the game when twenty additional licenses were offered to them to operate Low Cost airlines despite the stress and extra workload involved. The competitiveness of the players has been clear from the beginning and despite using different business models committed students have been reluctant to discuss their airline strategy during the trial period and have preferred experimenting by testing the software abilities.

During learning, or in other words the process stage (Biggs, 2003), the students' attitude has changed and even strong players have been willing to act as partners in meaningful set of activities and the application of theory. Another key consideration as part of this pedagogic approach is to address supercomplexity (Mortimore, 1999) which develops not only core skills but also self-reliance, in this case study this is noticeable in the actual industry and corporate tactics and practices embraced by the majority of the participants; in some cases even too actively requiring the action of the regulatory body in the game after two official complaints for regulating actions and predatory pricing.

The outcome of learning is the last stage of the 3P model, the product. In this pilot case study, the product is measured and assessed taking into account not the actual result of the game but the learning outcomes of the module and the students' ability to master them; thirty six out of forty students passed the module on first attempt. Furthermore, the questions of the exam directly related to the activity have been attempted by all students and answered at good level. During the year it has become evident from students' emails and classroom discussions that this cohort is highly concerned with employability and consistently pursued job opportunities with the full endorsement of the aviation team which has translated into a large number of secured placements and Erasmus places. This could be the most realistic and therefore adequate measure to evaluate the effectiveness of the game from an HE organization perspective.

3.5 Limitations

Analyses have shown that there are two key limitations that need to be carefully addressed for developing an effective simulation activity within the aviation management courses. The first limitation relates to the software capabilities and constraints: unlike pilot and engineering training simulations, management simulations heavily depend on scenario based methods. Nevertheless according to Squire (2005), the characteristics of the scenarios developed and consequently the key pedagogic choices made a priory by the game developer would have a great influence on the actual effectiveness of the game and therefore in its educational potential.

The second limitation relates to the time constraints and how to effectively manage the activity within an existing curriculum as this is a time consuming process both for students and tutor.

Familiarization with the simulation requires an investment of time in technical knowledge while careful planning is required to avoid losing valuable teaching hours for student support (Douglas, 2008).

4. Conclusions

The aviation industry requires graduates with critical thinking and rational decision-making skills, specifically being able to react appropriately to continuously changing market conditions. Simulation games provide the ideal environment for active learning; nevertheless, active learning is only achieved when the pedagogical process is well designed and the assessments are aligned to the learning outcomes and industry specifications. Previous studies have addressed only one of the key considerations, knowledge gain and student engagement without taking into consideration that the inclusion and assessment of learning outcomes is absolutely necessary in the academic environment. This pilot case study combines the principles of a specific learning and teaching approach, SoTL, with the benefits of serious games simulating specific scenarios in the aviation and airline industry.

The findings of this pilot case study indicate that following an academic model when developing the scenarios within serious games has positive effects within the cognitive skills and engagement level of the students while making sure that the students reached the required academic level. The combination of these two outcomes produced a superior number of actual placements in the industry and Erasmus places. On the other hand, it is important to mention that for this approach to work it requires a person aware of the challenges faced by the aviation industry and following any market fluctuation that could change the competitive environment in the industry; this implies that those making the decision should have an awareness of the entire air transport value chain. The game also requires a time-consuming hands-on approach during the development and running stage. Future studies should seek to address longitudinal results of this study as well as the difference considerations that may be necessary at undergraduate and postgraduate level.

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Use of Synthetic Voice to Improve Communication between Air Traffic Controllers and Pilots

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Abstract: The paper proposes the idea of replacing natural voice communication between Air Traffic Controllers (ATC) and pilots with synthetic voice communication. ICAO has recognized pilot-controller miscommunication as a significant safety concern. Synthetic voices will relieve the extra mental effort required to comprehend a difficult accent, consequently reducing reaction times. A literature review on the adaptability of humans to synthetic voice and the technical feasibility of generation and transmission of synthetic voices was conducted. Using synthetic voice communication achieves the required speed of transmission but may suffer from accuracy problems. However, it is a feasible solution that manufacturers and operators should consider developing.

Keywords: air traffic controllers, pilots, synthetic voice, communication problems, aviation safety

1. Introduction

1.1 Objective of the Paper

The paper proposes a solution to the existing and well-known problem of miscommunication due to unfamiliar accents between air traffic controllers and pilots. The usage of synthetic speech on both sides shall mitigate the unfamiliarity and confusion associated with varying accents. It will also help in training, where pilots and ATC will have to focus on deciphering only one particular accent.

1.2 What is the Problem?

On April 30, 2014, Peach Airlines flight 252 dropped to 75m above the water carrying 59 passengers and crew, where the Ground Proximity Warning System alert came on (Peach Aviation Limited, 2014). The reason: The Argentinean pilots misunderstood the Japanese ATC's instructions (Japantoday, 2014). Increasing globalization and international flight operations means increasing interaction between native and non-native speakers of English in the pilot-ATC domain. As seen in Table 1, native speakers also find it difficult to comprehend non-native speakers of English. 54 % of pilots in a study stated that they face difficulty comprehending ATC instructions (Estival and Molesworth, 2009). Contrary to popular belief, difficulty in comprehension does decrease with time for non-native speakers of English but never reaches the level of native speakers. Adding to this problem are the factors of poor radio quality, cockpit noise, background noise in the ATC room and fast controller speech.

Speakers	Understanding frequency	Not understanding frequency
Local	490(98.6%)	7(8.9%)
English	474(33.4%)	24(30.4%)
Non-native	457(32.2%)	48(60.8%)

Table 1: The frequency and percentage of pilot 'understanding', (Fletcher, 2010)

The effects of unfamiliar accents and linguistic effects between ATC and pilots are as follows (Eurocontrol, 2006):

- Distinguishing similar call-signs
- Tuning into an incorrect frequency-almost 51 % of reported cases
- Non-standard phraseology- 50 % of reported cases
- Hesitation to talk when hearing angry or frustrated controllers/ pilots

These factors may be fatal during an emergency. The importance of standard phraseology is best known through the Avianca Flight 52 accident in which the fuel exhaustion was not properly communicated to the controllers. It was also a contributory factor in the deadliest aviation accident in history, the Tenerife runway incursion.

In order to improve the standards of English for controllers and pilots, ICAO advocated training courses for controllers to include mandatory English proficiency training for them to be able to recognize varieties of accents. ICAO has also developed the TRAINAIR programs to improve the standard of training. In spite of these developments, ICAO has identified English language proficiency as a significant safety concern, irrespective of the Level 4 English language requirements (Fletcher, 2010).

1.3 Why not Use Controller Pilot Data Link Communication (CPDLC)?

NextGen and Single European Sky ATM Research (SESAR) initiatives intend to mandate the use of CPDLC as seen in Figure 1. However the major disadvantage is that it cannot be used in a busy time constrained cockpit environment. Coupled with the fact that pilots face most communication issues during approach, climb and descent (Eurocontrol, 2006); the problem of miscommunication is not really solved. In a study conducted by the Federal Aviation Administration (Honeywell, 2006), pilots reported that CPDLC is fruitful during cruise, but they need voice communications during approach, climb, descent and taxiing.

Figure 1: CPDLC display (QF32, 2012)

In addition, CPDLC raises concerns about overburdening the visual channel of information, especially when combined with all the visually focused developments of NextGen and SESAR plans. Conditional clearances are easily misunderstood and an aural read-back allows for emphasis of the conditional part. Conferences such as DefCon have shown that Automatic

Dependent Surveillance-Broadcast offers security loopholes and a simple voice transmission can easily be tampered with.

2. Methodology

2.1 Research Approach

The paper is chiefly based on a literature review about pertinent topics such as the use of synthetic voices in the cockpit, the generation and transmission capabilities existing today for synthetic voices and further research in this area. Building upon the concepts learned, the primary research deals with the design of the proposed system and exploring its advantages and disadvantages.

2.2 Secondary Research

First, the problem of miscommunication between pilots and controllers was studied using the National Transportation Safety Board and Aviation Safety Network databases to find accidents in which miscommunication was a contributing factor. Popular cases such as the runway incursion at Tenerife 1977, fuel exhaustion of Avianca Flight 52 in 1990, mid-air collision at Charkhi Dadri in 1996 and mid-air collision of Gol Airlines Flight 1906 in 2006 were studied. After establishing that differing accents posed a risk to clear communication, the adaptability of humans to synthetic voices was studied using search keywords such as ‘trust synthetic vs human voice’, ‘persuasion synthetic vs human voice’, ‘response time synthetic vs human voice’. To understand the technical requirements of such a system, various documents like the ICAO Annex 6, ICAO document 9432 and Société Internationale de Télécommunications Aéronautiques (SITA) radiotelephony manual were studied. Informal interviews with engineers at Emerging Technologies Inc., were conducted to establish the current standard of synthetic voice generation.

2.3 Primary Research

Based on the findings of the secondary research, a design for a synthetic voice communication system was proposed in two possible layouts. The layout of the system was developed using the online draw.io software and the advantages and disadvantages of the system were analyzed.

3. Findings

3.1 Secondary Data Results

3.1.1 Use of Synthetic Voices in the Cockpit

The first study of pilot ability to understand natural and synthetic voices simultaneously was conducted by Grumman Aerospace Corporation in 1982, for incorporating synthetic voice warning systems in the F-14. Not only did pilots understand synthetic voices, but also they responded faster to instructions of a synthetic voice than of a human voice (Manaker, 1982). Going forward, there have been many studies comparing synthetic voices with human voices, showing that humans associate favorably towards human voices when coupled with a human face, but when they cannot see the person (as is the case of pilot-ATC communication), trust levels, amount of persuasion, perception and response time did not vary significantly between synthetic and human voices (Stern et al., 1999). Initially, synthetic voices may be harder to understand and may generate incorrect responses. However, with training, which will become uniform, simpler and cheaper; it is believed by the author that pilots and controllers will find it easier to work with.

Studies show that though it is possible to mix pre-recorded human and live synthetic speech, it is not advisable to do so (Gong, 2001). Future initiatives by NextGen also consider the use of synthetic speech as an auxiliary to CPDLC and found in test trials that, synthetic voices did not disturb pilots any more than natural voices and also advocate it in the view of multi-modal presentation of information on the flight deck (Lennertz et al., 2012). Knowing that voice is the most convenient mode of communication between humans and will remain so between ATC and pilots (Cushing, 1997), it is better to have clear synthetic voice during an emergency rather than hazy radio transmissions.

3.1.2 Generation and Transmission of Synthetic Voices

Generation of synthetic voices is best carried out using a text-to-speech mechanism (TTS), which can be implemented both as hardware and standalone software. Most smart-phones and computers today use this capability. Speech recognition software is relatively inexpensive at 200 USD. The cost of the overall unit will also be low as it is only a software patch. The maximum time for conversion from text to speech is one second today, presuming an available library of phonemes and moderate connection speed.

Speech recognition services that form the backbone of this TTS and speech-to-text systems are increasingly more accurate. The current accuracy rate for commercial speech recognition systems is between 90-96 %. However this rate is achieved under lab conditions and figures may vary due to the inherent noise in the cockpit. To increase this, it is recommended to use speaker-dependent systems which have accuracy rates of 95-98 % (Beeks, 2001). Speaker dependent systems are also restrictive in their nature, in terms of limited vocabulary and fast response time. A variation of speaker dependent systems is speaker adaptive systems, which adapt to the speaker's speech pattern. These systems have been tested in a cockpit environment, with accuracy rates of 97.27% in hangar conditions, 97.72 under 1g conditions, and 97.11% under 3g conditions; and have gained general acceptance among the pilots in the study (Beeks, 2001). Pilot-ATC vocabulary is already limited and has a specified grammar compared with full-scale commercial applications and with time, speaker adaptive systems can achieve higher accuracy rates than traditional systems. Specific grammar rules can be created in the system to eliminate garbage words that do not have any semantic value. For example, for the pilot utterance, "uhhhhhmm, select north up mode", the "uhhhhhmm" would be ignored as garbage (Beeks, 2001). This will mean improved clarity and efficiency in a busy ATC environment. Newer technologies like acoustic co-processors can halve the response time required (Hopperton, 2012). To increase the accuracy further, it is beneficial to use noise-cancelling high quality omnidirectional microphones, which are generally used in cockpits and ATC towers (Beeks, 2001).

The current standard for time taken for message delivery in CPDLC is to be under 60 seconds one way (ICAO, 2007). When interviewed on 20 January 2014, Ehab Hosny stated that the conversion from speech to text and subsequent TTS can be done within 4 seconds. Existing VHF Data Link-2 (VDL-2) data links in the aircraft that can transfer voice, data and even images can be used to conveniently transfer computer-generated voices to and from the aircraft (SITA, 2004). The minimum speed of VDL-2 when fully loaded is 100 bits/ second and the optimal speed is 31.5 kbps (Wavecom, 2012). The message data size for general pilot-ATC communications was observed to be under 660 bytes and message sizes exceeding 660 bytes were rarely observed (Kitaori, 2009). Hence, the author believes that the proposed system can be compliant with this requirement. Even in the case of last minute ATC instructions, the speed of transmission may not be affected as the typical time taken for the conversion mechanism is only in nanoseconds.VDL-3 AND VDL-4 provide higher speeds but are also more expensive.

3.2 Primary Data Results – Proposed Design

The system to generate and transmit synthetic voices between cockpits and ATC stations can be implemented in two general formats. Both layouts are customizable to the mode and level of operations at a particular station. Based on further research, it is also possible to incorporate a mechanism to identify non-standard phraseology that is used. Below are the visual representations of the formats.

3.2.1 Layout 1

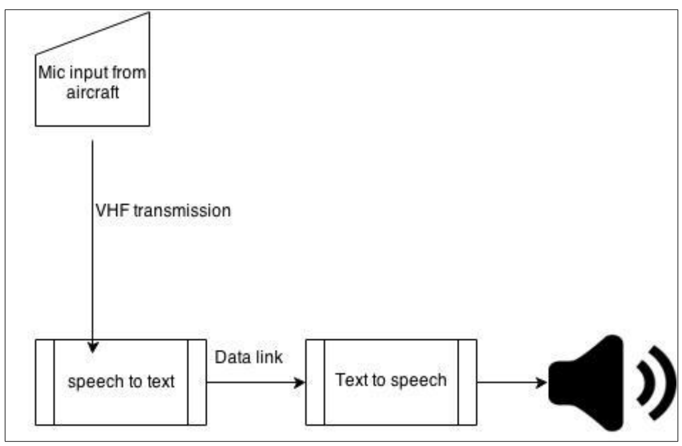

Figure 2: Layout 1 for the proposed system (Dhavala, 2014)

As seen in Figure 2, voice from the source is transferred through existing VHF bands or Voice over Internet Protocol. After conversion into text, the result can be transferred using a simple Integrated Circuit and stored into the input file of the TTS converter, at the ground ATC station. This layout allows the possibility of equipping only ATC stations with the speech conversion mechanism. Voice coming from all the aircraft can be converted and all aircraft within the FIR will hear the synthesized ATC voice. Also, in case of failures, controllers may be in a better position to revert to normal radio than pilots. In terms of cost, upgrading a ground facility may be less expensive than retrofitting aircraft. However, practically it will be possible to monitor the non-standard phraseology of only the controllers. Also, congestion of channels and subsequent time lag will not be improved until VoIP is used.

3.2.2 Layout 2

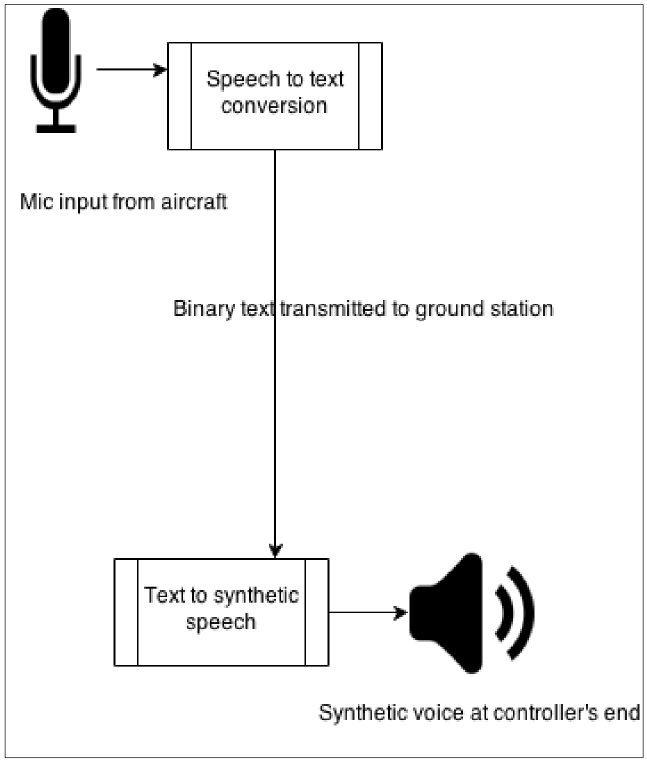

Figure 3: Layout 2 for the proposed system (Dhavala, 2014)

In this layout as seen in Figure 3, the pilot's speech is converted to text on-board the aircraft and then transmitted. The data link between air and ground can be provided by VDL 2, which is the standard data link for CPDLC. It could not be established whether all aircraft have VDL 2 capability, but from the available information, the following models from Boeing have it at present: B737 NG, B737, 747-400,757,767, all 777 variants, 747-8 and all 787 variants (Honeywell, 2006). This layout is disadvantageous in terms of cost and complexity, as it would require both ground stations and aircraft to be outfitted with the mechanism. The amendments to regulations required for this process may be tedious and time-consuming. However, this layout will improve time lag and free up channels for use because binary messages are faster to transmit than voice messages. This will be important as the air traffic increases. Also, this layout will allow both air operators and controller stations to monitor their use of non-standard phraseology.

3.2.3 Other Considerations

In terms of persuasion levels, male synthetic voices were found to be more persuasive than female synthetic voices. However, in terms of perceived authority, no difference was found (Mullennix et al., 2003). Initial human factors research in defense prompted them to use female synthetic voices for warning systems, affectionately known as Bitching Betty. However, later research by Arabitto (2009) showed that male synthetic voices were indeed better for use in cockpit warning systems. Due to statistically higher number of male controllers and pilots (The Guardian, 2009), the author proposes to use male synthetic voices in the system as it will contribute to a flatter gradient of change. The possibility of using female synthetic voices for warnings and urgent instructions, in order to provide a break from the monotony of a male voice, may be considered based on further research. The Received Pronunciation (RP) accent, also known as Standardized English is most easily understood (Jurcenko, 2012). Hence the author proposes to use the RP accent in the new system.

Developments are in place to recognize the underlying emotions in a person's voice automatically (Beyond Verbal, 2013). If intonation and stress levels are required elements of communication, it is possible to use this technology to alert the controllers of an underlying emergency. This will enable the controller station to be less complex but fully aware if there is an emergency.

The failsafe for this system would be inclusion of a redundant system and emergency revert to regular VHF radio. Based on further research, error correction mechanisms and auto-reverting to VHF radios during emergency can be incorporated.

4. Conclusions

It is widely known that removing even one link in an accident causal chain can stop many accidents in the future. The paper proposes a system design as a solution to the problem of difficulty in understanding regional accents of English, both of pilots and of controllers. As miscommunication between controllers and pilots is a contributing factor in many accidents, it is beneficial for the aviation community to use synthetic voice technology to reduce the acceptable level of risk further in this area. Though the current accuracy of speech recognition and text-to-speech services is not 100 % as we would require it to be for aviation implementation purposes, the author believes that manufacturers, operators and Air Navigation Service Providers should collectively work towards obtaining better versions of the technology and henceforth implementing it.

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Aviation Economic Impact on Tourist Destinations

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Abstract: Air transport is often the key driver for growth, especially for the attractive tourist destinations. This paper deals with the estimation of the air transport economic effects on regions heavily depended on tourism. By a systemic approach the key background on the subject, the economic effects assessment concept and the methodology are given, providing an essential tool for planners, economists, analysts and researchers. The numerical application deals with an attractive summer holiday tourist destination in southeast Mediterranean, providing key messages regarding the relationship of air transport and tourism industry on one hand; and aviation and regional development on the other.

Keywords: aviation, economic impact, tourism, regional development

1. Introduction

The essential contribution of tourism into an economy stimulates the interest for dedicated research on tourism business development. Davies et.al (2006) highlights that the key drivers of the tourism growth in a specific destination deal with the economic conditions of the origins and destinations, the logistic cost, the commercial regulations, the supply-chain capabilities and the performance of the air transport system. Tretheway & Mark (2006) provide evidence that for the summer holiday destinations the tourist demand related to aviation business environment, tourism and transport infrastructures and supply chain management.

It's noteworthy that the rapid expansion of leisure and holiday travel, from 1960s onwards, related to two essential changes, the booming in aviation business and the e-commerce, (Dwyer et al., 2000). The liberalized business environment of air transport led to significant changes in the aviation industry structure, management and innovation, (Gillen et al., 2001). While tourism demand is quite price elastic, and aviation liberalization reduce fares and increase capacity, thus increasing tourism overall, and often, altering tourism demand patterns. New remote tourist destinations may gain some market shares against traditional, but also they stimulate new demand providing new opportunities.

Institutions, associations, authorities and governmental bodies, widely, recognize the need for monitoring tourism demand and adopt strategies to achieve the economic benefits of tourism. World Tourism Organization (UNWTO, 2013) and Eurostat (2011) indicate that many regions draw a considerable part of their income from the tourism industry, which in turn, is heavily dependent on the aviation industry. Examples are the islands in the Mediterranean which their tourism business support the national economy. Therefore, especially for these economies, the relationship between aviation and tourism needs to be investigated not only to extrapolate the demand trends, but also to adopt policies, define strategies and support decisions towards tourism market growth.

The complexity of tourism and aviation business arising out of the behavioral aspects of demand, the business regulatory framework, the management abilities of the infrastructures, which are key elements for the strategic and business planning. The competitor environment of both industries increase the value of strategic planning towards effective fund allocation and prioritization of the investments in infrastructures. A key success factor is to define a clear, compact and coherent strategy available to support decisions and judgments based on the conceptualization of the necessary investments. Therefore, the quantification of the economic effects caused by aviation is an essential task to support decisions, policies and budgeting.

The key objective of this paper is to quantify the economic impact of air transports on regions heavily depended on outbound tourism. By a top-down analysis, the trends and characteristics of tourism and aviation are highlighted, providing the linkage between these two industries. According to a systemic approach the concept, the methodology and the results are analyzed, providing the framework for similar applications. The numerical application is Greece, which is a very attractive tourist destination on one hand; and suffers from economic stress on the other. Conventional wisdom is to provide an easy to handle tool appropriate for relevant applications; and highlight key messages to decision makers and stakeholders.

2. Methodology

Literature review shows that there is no unique concept to determine the interdependence of any industry and a regional or national economy, there are alternative approaches of measuring impacts components and different models depending on the scope of work and the use of the results. The concept of the key methodological approaches for the analysis of economic impact of air transport could be based on analysis of the: (a) income-expenditures, (b) costs-benefits and (c) spillovers.

Briefly, the Input-Output (I-O) approach and its variations normally provide results for three distinct group of economic effects: (1) direct, (2) indirect and (3) induced (Miller and Blair, 2009). The direct effect usually includes such aspects as employment within an industry and expenditures incurred directly by that industry. Furthermore, the indirect effect represents the economic activities deal with the linked third parties. The induced effects are the impacts induced by direct and indirect effects. The Cost-benefit method is used to quantify the benefits and costs for society and business induced by the industry, including time saved on travelling and commuting; costs of transportation (including maintenance costs); benefits became business stimulation, tourism inflows, as well as benefits (and costs) for local communities. The spillover analysis deals with the quantification and measurement, to what extent the industry stimulates activities, which it means for the air transports the effects in the supply-side of the local economy including impacts on investment, trade, etc.

The aviation industry has a substantial economic impact, both through its own activities and as an enabler of other industries (Lakshmanan and Chatterjee, 2005). There are two levels of economic effects: the first level ensues through the generation of employment, income, and capital investment “naturally” occurring in the process of producing air transport services and the second level of effects are the dynamic economic “catalytic” or “spin-off” benefits, in particular the direct/inward investment including tourism development stimulated by aviation. Transportation Research Board report (TRB, 2008), provide a concept to estimate the economic effects of air transport services, typically relying on the following approaches: input-output models (multipliers), the assessment of costs and benefits, and the analysis of catalytic effects. Applications of input-output models have traditionally centered on the national level, but modifications to the method of account for the increasing interest of the inclusion of specific local characteristics and regional economic development are popular, (Dimitriou et al., 2010).

In this paper, the analysis framework deals with the quantification of the direct, indirect, induced and catalytic economic effects generated by the aviation industry, to provide an estimation of how much activity and employment is supported by that industry. The methodology based on income-expenditures concept used to quantify the direct-indirect-induced effects of air transports and the spillover effects of air transports to tourism industry and, finally, to the local or national economy. The spillover economic effects involves identifying the key supply chain linkages in the transportation sector and the quantification of air transport in enabling tourism activity and inducing spending by foreign visitors in the domestic economy, referred as catalytic impact. Finally, the analyses provide results regarding the impact of aviation on key economic indicators and business sectors at a regional or national scale. The modeling approach based on the Input – Output (I-O) matrix algebra concept providing results of the air transports overall effects to an economy heavily dependent on tourism.

2.1 Direct Effect

The contribution of the aviation sector to the national economy is measured by the contribution to employment (jobs created) and the contribution to GDP (income generated). The direct contribution to employment is quantified as the total number of jobs created in the aviation sector because of the region air transports activity. The regional aviation activity deals with air carriers and airport operations, aircraft maintenance, air traffic control and activities directly serving air passengers, such as check-in, security services, baggage-handling, on-site retail and catering. These jobs represent the jobs in aviation primary firms that serving the region under examination.

2.2 Indirect Effect

The Indirect contribution to employment is quantified as the total number of jobs supported through the aviation sector's supply chain. The aviation sectors supply chain includes suppliers to air transport, for example, jobs linked to aviation fuel suppliers; construction companies that build additional facilities; the manufacture of goods sold in airport retail outlets, and a wide variety of activities in the business services sector (call centers, IT, accountancy, etc.).

2.3 Induced Effect

The Induced effect includes the expenditures made by the previous (Direct and Indirect) impacts in supporting new businesses and entities. Induced contribution captures the secondary impacts to the economy as direct/indirect sales, and payroll impacts are circulated to supporting industries through multiplier effects. The induced contribution on economy is estimated with the Input-Output (I-O) analysis. Input-output modeling based on Keynesian demand model on the grounds of market transaction tables, which are part of national accounting systems and are usually revised frequently. Transaction tables depict the supply demand linkages of the different economic sectors (Lynch, 2000). The first step in determining each type of impact is to identify the components of the aviation industry that define this type of impact as described analytically below. The combination of the four measured types equates into the aviation's total economic footprint or "benefit."

2.4 Catalytic effects

Catalytic effects capture the extent to which air transport contributes to a country or economy beyond any effects that are directly or indirectly associated with the air transport industry itself. There are a number of sources of economic spillover or economic catalytic impact from air transport. Some of these include the activity supported by the spending of international tourists that travel by air to the tourist region and the level of trade directly enabled by the transportation. The analyses focus on the catalytic impact on tourism for the purposes of this study the spillover effects caused by tourism spending.

3. Application and Key Findings

Greece have been selected for the application of the modeling mainly for two reasons, because, Greek economy is heavily dependent on the tourism sector and it is long term suffering by financial stress. The results are given in an essential manner flexible to compare and use in similar applications.

3.1 Greek Economy Profile

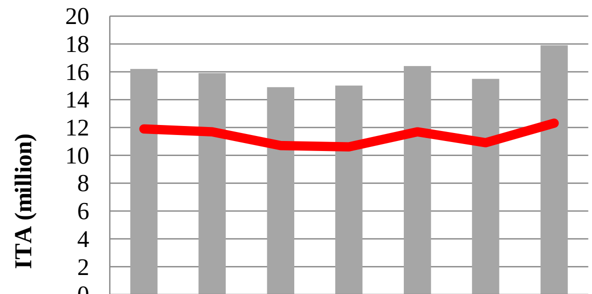
The Greek economy is heavily dependent on the tourism sector. It attracts a high number of tourists because of warm weather, 16.000-km of coast along the Mediterranean, the spatial allocation of Greek islands in Mediterranean and the high number of archaeological sites and cultural events. Greece is suffering financial stress and tourism development is a key driver towards national recovery. Therefore, the impacts effect of tourism is a critical element to support decision in field of economy recovery and investments.

The Greek economy, showed signs of recession in 2007, whereas from 2009 onwards the recession has been intensified considerably due to the country's fiscal imbalances. The need for consolidation has led the country to embark on a trilateral mechanism of financial support, comprising the EU, the IMF and the ECB (IMF, 2013). The restrictive income policy and drastic limitation of public expenses during the past few years had a negative impact on GDP which decreased by 7.1 % in 2011and 7% in 2012. This trend expected to continue in 2013, but at lower levels as the result of the expanded economy reform program applied from 2010, (IMF, 2013).

The growing unemployment is a major concern for Greek socio-economic life. According to OECD (2013) the unemployment rate achieved a level of 27.2 % in 2013, the highest rate in fourteen years. In the medium term, this decline is likely to reverse, as structural labor market reforms aimed at promoting business and job creation, decentralization of wage negotiations and flexible forms of employment deliver their full effect, and the economic recovery gains speed, (OECD 2013).

3.2 Tourism Indicators in Greece

In 2012, the contribution of tourism to Greek GDP amounted to 16.4%, while total employment in tourism (688,800 jobs) corresponded to 18.3% of the workforce. Compared to the rest of the world, Greek tourism has achieved a satisfactory performance. According to the most recent data published by the World Tourism Organization (WTO), in 2012 Greece was in 17th position as regards to the number of international tourist arrivals and 23rd as regards international tourism receipts. Moreover, according to the World Economic Forum (WEF), in 2013 Greece was in 32nd position out of 140 countries included in the Travel and Tourism Competitiveness Index, while Greece occupied the 96th position in the Global Competitiveness Index. This data proves that Greek tourism is one of the few sectors of the national economy that is competitive at a global level. Aviation is a key component for tourism in Greece. Since tourism destinations are a long distance from the tourist residences, (highest share Germany, France, Holland, UK) air transportation becomes very important. The aviation industry fulfils the task for over 70% of the ITA in Greece, as shown in Figure 1.



	2007	2008	2009	2010	2011	2012	2013
Total non residence arrivals in Greece	16.2	15.9	14.9	15	16.4	15.5	17.9
Non resident arrivals by air	11.9	11.7	10.7	10.6	11.7	10.9	12.3

Figure 1: ITA in Greece, (Bank of Greece, 2013)

3.3 Aviation in Greece

Airlines need ground-based infrastructure to operate. This infrastructure includes the facilities at Greek airports that directly serve passengers, such as baggage handling, ticketing, retail and catering outlets. The five largest airports in Greece – Athens, Heraklion, Thessaloniki, Rhodes and Chania - handle almost 28 million passengers in 2013, (Figure 2). In total 38 million passengers arrive or depart from Greek airports (year 2013).

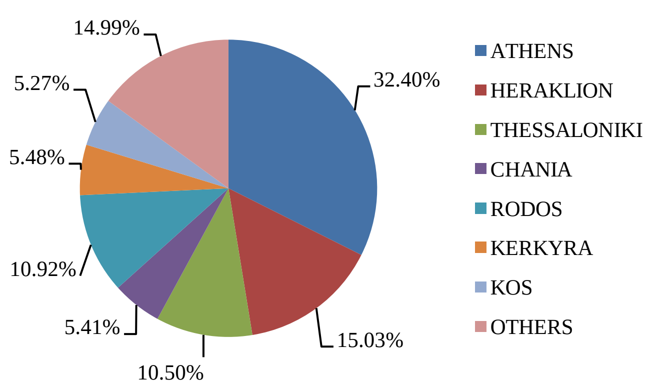


Figure 2: Passenger distribution by airport, (HCAA, 2014)

The most dynamic airlines registered in Greece (Aegean airlines and Olympic Air, merged in 2014) carried 4 million of international passengers to and from Greece (15% of total ITA, 2013). The nationality of the ITA fly to and from Greece is given in Figure 3.

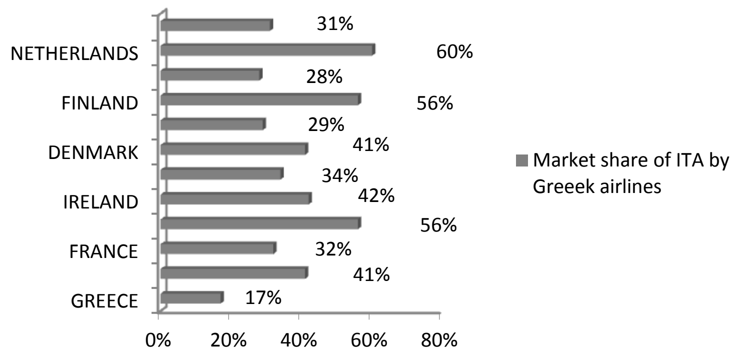


Figure 3: Market share of ITA by Greek Airlines (Aegean airlines, 2013)

3.4 Estimation of the Aviation Economic Impact in Greece

Airlines based in Greece directly employ 5,050 people locally (2013) and through the supply chain a further 1,500 jobs. Applying the input output method as above described 6,000 jobs are supported through spending by the employees of the aviation sector and its supply chain. These airlines directly contribute around €152 million to the Greek economy. The sector contributes indirectly another €45 million through the output of its supply chain. A further €180 million comes from the spending of employees of the airline and their supply chains

Aviation's ground-based infrastructure creates 17,000 jobs for Athens airport and 15,000 for other airports (AIA, 2013). These jobs, support through its supply chain a further 3500 jobs. These indirectly supported jobs include, for instance, construction workers building or maintaining facilities at airports, delivering aviation fuel; and jobs in the catering sector preparing the meals served on airlines as analyzed.

Applying the input output method as above described 32,500 jobs are supported through the spending by the employees of the aviation sector and its supply chain. The ground based infrastructure directly contributes around €960 million to the Greek economy. The sector contributes indirectly another €105 million through the output it supports through supply chain. A further €975 million comes from the spending of employees of the airports and their supply chains.

Aerospace manufacturer comprises firms that manufacture and maintain aircraft systems and engines. Aerospace employs 1,800 people. These jobs, support through its supply chain a further 500 jobs. Many of these indirectly supported jobs are in other manufacturing sectors for instance in firms that produce control equipment. Applying the input output method as above described 2,100 jobs are supported through the spending by the employees of the aviation sector and its supply chain. Aerospace directly contributes around €54 million to the Greek economy. The sector contributes indirectly another €15 million through the output it supports through supply chain. A further €63 million comes from the spending of employees of the airports and their supply chains.

Tourism, both for business and leisure purposes, makes a large contribution to the Greek economy, with foreign visitors spending over €10 billion in the Greek economy each year. Over 70% of these visitors arrive by air (Figure 1), so that passengers who arrive by air probably spend about €8.3 billion in Greece, according to Greek national statistics authority. Each component of the equation is estimated via secondary sources, through primary data collection, by means of a model, or through some combination of these methods.

The table below reports the economic contribution of the airlines, airports and aerospace for the three types of impact (direct, indirect, induced), as well as the catalytic spillover benefits in terms of tourism. Contributions are reported in terms of GDP and employment.

	Direct	Indirect	Induced	Catalytic	Total
Contribution to employment (jobs)					
Airlines	5,050	1,500	6,000		
Aerospace	1,800	500	2,100		
Airports	32,000	10,500	38,990		
Total	**38,850**	**12,500**	**47,100**	**280,000**	**378,350**
Contribution to GDP (Million Euros)					
Airlines	151	45	180		
Aerospace	54	15	60		
Airports	960	315	1,170		
Total	**1,165**	**375**	**1,410**	**8,300**	**11,250**

Table 2: Aviation contribution in terms of income and jobs to Greece

3.5 Key Findings

This paper provides evidence of the aviation essential contribution to regional/national economy. The key finding for an economy like Greece, which is a state with 11 million population accommodate 12.3 million air transport ITA. The key findings could be concluded:

- The aviation contribution multiplier to regional income is 0.91. This means that the 12.3 million air transport ITA contribute in around €11.25 million income or each one air transport ITA generates €914.6 income in the regional economy. This multiplier is essential for a mature tourist market like Greece and provides some best practice to other tourist regions.
- The income generated only by the aviation primary activities (direct, indirect and induced income) accounts around 26% of the overall income generated by the tourism and aviation activities. This means that while 2.9 billion generated by the aviation primary firms, an additional 8.3 billion is distributed in the regional economy caused by the ITA spending, which will not exist if not exist aviation business. The ITA spending is working as FDI in the national economy generates additional income related to tourism services, trade and consumption (accommodation, retail, etc).
- The aviation contribution multiplier to employment is 0.03 (in terms of jobs). This means that the 12.3 million air transport ITA support 378 thousand jobs or every 3 ITA

travelling by air support 1 job in the region. In other words, additional 1.22 million ITA or 10% ITA growth reflect to 1% less unemployment in national level. This issue is very critical not only for the economic recovery but also for the social stability.

4. Conclusion

In strategic level, the decisions about the fund allocation and investments have to be supported by relevant information and data. This paper provides the key methodological steps to estimate the effects of aviation in regional economy, providing essential tool to planners and decision makers. The numerical application provides the results for a very attractive tourist destination, providing essential results for completion to other places and applications.

The paper findings strongly suggest that the tourism sector must be seen as an important sector in the efforts of authorities to help recovery in economies based on tourism such as the Mediterranean countries. A very important factor that affects the growth of the sector is the accessibility, which is determined by the transport services provided, and is a fundamental condition for the development of any tourist destination. Moreover the transport industry can be a major beneficiary of tourism because of the additional passenger demand that may be generated.

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Aviation Liberalization as a Means of Promoting International Tourism: Comparing Morocco and Tunisia

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Abstract: The dynamics, in terms of air services and international leisure mobility (both of tourism and visits to friends and relatives [VFRs]), between the European Union (EU) and both Morocco and Tunisia, were compared. Indeed, the EU-Morocco market became liberalized after 2006. Significant dynamics then occurred on both the airline and travel sides. However, it is difficult to assess the extent to which aviation liberalization has been the cause of all of these changes. This suggests a comparison with the more regulated and more protected EU-Tunisia market. The results will be useful in light of negotiations to promote open-skies agreements.

Keywords: air transport liberalization, low-cost airlines, charter airlines, leisure travel

1. Introduction

1.1 Objectives

Operating air services were traditionally regulated according to protectionist views restricting access to the market, competition, capacities and fares. This regulation mode evolved following the aviation liberalization process related to different spaces, including the United States (US), United Kingdom (UK)-Ireland, European Union (EU), US-The Netherlands, Australia-New Zealand and the EU-Morocco markets. Within these spaces, registered airlines currently enjoy much more freedom than in the past; in some cases, they can enjoy full freedom in terms of access to the market (thus being network operated), capacity and fares. However, these new freedoms were accompanied by a ban *in principle* of state aid, theoretically forcing airlines to become financially profitable.

This new paradigm has had a major impact on the provision of air services and their geography. Dobruszkes (2008) highlighted the fact that aviation liberalization contains the seeds of two diverging trends: the decrease in air services (fewer routes and/or fewer services on remaining routes) because of the need for profitability and the potential expansion following the new freedoms offered. Many authors have analyzed the impacts of aviation liberalization within different spaces. These authors have found significant dynamics made up of an increased volume supplied, a launch of new routes being much more important than unoperated routes, a strong expansion of low-cost air services (with networks including niche routes and/or frontal competition on trunk routes), the traditional airlines being increasingly concentrated with a restricted number of hubs (if not only one), the charter airlines converting themselves into traditional airlines and trends of both enclosing vs. opening up, depending on the cases (Dobruszkes, 2008, 2014; Goetz and Sutton, 1997; Burghouwt, 2007; Goetz and Vowles, 2009).

The expansion of air services has induced, in some contexts, local or regional impacts in terms of tourism; these impacts are notwithstanding the fact that long-term impacts should be analyzed and that the expansion might occur in a zero-sum game with increases being counterbalanced by decreases elsewhere. Consequently, aviation liberalization has become a common leitmotiv to promote tourism expansion, as the EU-Morocco case illustrated (Dobruszkes and Mondou, 2013).

In this context, this paper is aimed at analyzing the extent to which liberalizing air transport induces positive impacts on the transport industry, considering two specific markets: Morocco and Tunisia.

1.2 Justification

The existing literature on the impact of aviation liberalization has expanded rapidly in recent decades, but it is still suffering from two primary gaps. First, nearly all published pieces of research have focused on so-called developed countries, despite several open-sky agreements involving developing or intermediate countries. Hence, the analysis of air transport dynamics is usually restricted to such a liberalized space. Second, all dynamics observed are put down to the liberalization process. However, part of the dynamics might be due to other factors, including international migrations and increasing incomes. In other words, it could be relevant to compare the dynamics observed in a liberalized space with the dynamics observed in a close/similar space that is not liberalized. This is the primary goal of this paper in comparing the dynamics related to the EU-Morocco market with the EU-Tunisia one. Indeed, Tunisia and Morocco show diverging policies.

Tunisia developed tourism as early as the 1970s, before Morocco, when mass tourism was expanding. Tunisia focused on coastal tourism related to the sea, sun and sand (Stock, 2003). This was initially geared towards European tourists with the strong support of the Tunisia Government (e.g. training, transport infrastructures and accommodations) and then by private investors (Miossec, 1996). Thus, Tunisia became the archetypal tourist spot (Gay, 2000) linked to all-inclusive packages sold by European tour operators. Despite this, Tunisia's international air market has not been liberalized.

By contrast, Morocco historically focused its tourist expansion and attractions on its imperial cities' heritage (mostly Marrakech and Fez), notwithstanding some other forms of tourism, including coastal (Agadir) and desert tourism. In the early 2000s, the adoption of the so-called Vision 2010 tourism master plan turned towards quantitative goals, with 10 million tourists in 2010 and new coastal resorts. This plan relied on national and international public and private operators. To contribute to these objectives, Vision 2010 explicitly planned to liberalize international air transport to obtain lower airfares and new routes (Moroccan Government and CGEM, 2001). Morocco then negotiated an open-sky agreement with the EU (EU27, at the time), which was signed in 2006, then progressively ratified by EU Member States. As a result, any EU or Moroccan airline was allowed to operate international flights freely between any EU airport and any Moroccan airport while the fifth air freedom is allowed under certain conditions (see Dobruszkes and Mondou, 2013). This agreement replaces all pre-existing bilateral agreements.

2. Methodology

Our research fundamentally relied on comparative analyses based on the figures observed ex-post. We gathered data from scattered sources that are usually not considered together. This made it possible to reach an integrated view about the dynamics between the two investigated markets. Econometrics was left for the next stage; forecasts were explicitly not considered because of the geopolitical uncertainties.

First, we aimed at comparing the degree of openness of the EU-Morocco and EU-Tunisia airline markets. To accomplish this, World Trade Organization (WTO) assessments of air service agreements (ASAs) were investigated. In short, the WTO built the so-called Air Liberalization Index (ALI), a composite index made up of marks related to regulations of traffic rights (5th, 7th and 9th air freedoms), capacity, tariffs, withholdings, designations, the exchange of statistics and cooperative arrangements (WTO, 2006a, 2006b). The ALI ranges up to 50; as such, the WTO could compute it for 2,200 ASAs, comprising 70% of the international scheduled traffic. The higher the ALI, the more the aviation market is liberalized.

Table 1 confirms the increase in aviation liberalization between selected EU countries and Morocco, while Tunisia remained at a level similar to that of Morocco prior to the EU-Morocco open-sky agreement.

The dynamics of regular air services is detailed in OAG Max, a series of datasets describing worldwide air services in a disaggregated manner (at the flight level); this data is nearly exhaustive. For each flight, they notably report the airline, frequency and number of seats supplied. Knowing the airline makes it possible to draw a line between conventional and low-cost airlines using fare-oriented methods and listings proposed by Dobruszkes (2014). However, data was only available for winter schedules. Hence, a search for annual data was conducted; however, annual data only provided the number of flights, not the number of seats. This was a problematic issue, given the range of planes' capacity. As a result, OAG data was relied upon. Since charter flight data was especially poorly known, this was problematic because flights in Tunisia were typically non-scheduled. Available data was used, when it was available. This data was primarily composed of aggregated statistics restricting potential interests.

	Morocco before liberalisation	**Morocco after liberalisation**	**Tunisia**
Austria	4	25 or 37 (a)	11
Belgium	10	25 or 37 (a)	
France	11	25 or 37 (a)	
Germany		25 or 37 (a)	10
Italy	6	25 or 37 (a)	1
Lithuania		25 or 37 (a)	4
Luxembourg	10	25 or 37 (a)	11
Malta		25 or 37 (a)	4
Poland	6	25 or 37 (a)	
Portugal	11	25 or 37 (a)	
Romania		25 or 37 (a)	10
The Netherlands	10	25 or 37 (a)	
UK	14	25 or 37 (a)	10

(a) 25 excluding 5th and 7th air freedom actually limited.
Sources: WTO (2006); Dobruszkes and Mondou (2013)

Table 1: Degree of liberalization for the EU-Morocco and EU-Tunisia airline markets.

Finally, dynamics related to international mobilities were analyzed through Moroccan and Tunisian statistics. Both countries published annual reports on tourism with extensive amounts of useful data. As for Morocco, data was available back to the early 2000s. Unfortunately, only more recent Tunisian reports were available. This restricted our initial ambitions. Furthermore, Moroccan figures made the distinction between 'Moroccans living abroad' (MLAs) and 'foreign tourists' in the context that a Moroccan cannot give up citizenship, even in the case of naturalization abroad (Belbah and Chattou, 2002). This allowed for the drawing of a line between MLAs who arguably visited friends and relatives and others who were expected to be 'authentic' tourists. Such a distinction did not exist on the Tunisian side and, again, restricted a potential comparison between the two countries.

3. Key Findings

3.1 Airline Dynamics

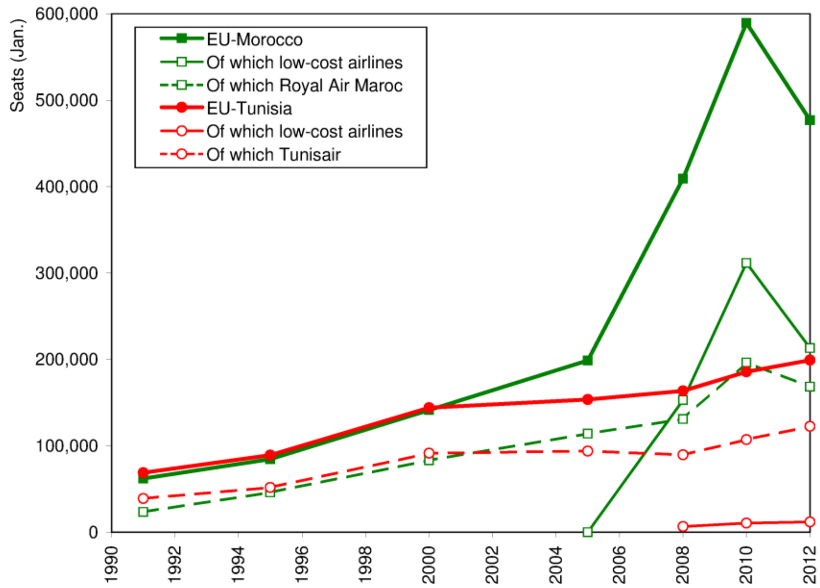

Figure 1: Comparing trends in terms of seats supplied on regular flights in January (Source: OAG; computations by the authors)

Figure 1 shows significant diverging trajectories between Morocco and Tunisia. Observations showed similar initial volumes in the early 1990s for all airlines and respective flag airlines (Royal Air Maroc and Tunisair) with a notable small gap during the early 2000s. After the EU-Morocco agreement, air services literally boomed, while EU-Tunisia increased in a much slower manner. The primary reason for these diverging trends was the penetration of low-cost airlines into EU-Morocco market on a much grander scale than on the EU-Tunisia market. In January 2012, low-cost airlines accounted for 45% of regular seats between the EU and Morocco; this consisted of a 77% increase for 2005-2012. Low-cost airlines were ranked 2nd, 3rd, 4th and 6th for this market (Dobruszkes and Mondou, 2013).

Despite some Moroccan low-cost airlines being launched, the two leading European low-cost airlines, Ryanair and Easyjet, best succeeded in penetrating the Moroccan market. Ryanair started new services from countries having significant relationships with Morocco, including France, Belgium and Spain. The airline focused on tourists, but also on Moroccans living in Europe. Evidence came from flights between Marseilles or Charleroi Brussels-South and Oujda, Nador and Tangiers, traditional areas of migration to Europe.

Ryanair set up two bases in Morocco, namely Fez and Marrakech. This involved more routes and more frequencies available from these two cities. Ryanair also appeared as a direct competitor of Royal Air Maroc. The latter could increase its provision of services (Figure 1). However, financial difficulties forced it to restructure the groups' activities, selling subsidiaries active in the hotel business and training; hence, the airline itself was reorganized.

Finally, impressive dynamics related to regular air services should be compared with charter services. Unfortunately, evidence was rather scarce, but some data was available. Figure 2 shows the initial huge gap between Morocco and Tunisia, the latter having relied on charter flights much more for a long time. This gap is coherent with initial tourist strategies followed by Morocco and Tunisia. Charter airlines reduced their services to Morocco following the open-sky agreement with the EU. Arguably, they could not face new competition from the low-cost airlines going along with travelers' building their own packages online. To Tunisia, the large decrease was likely due to the so-called Arabic revolutions and related political uncertainties.

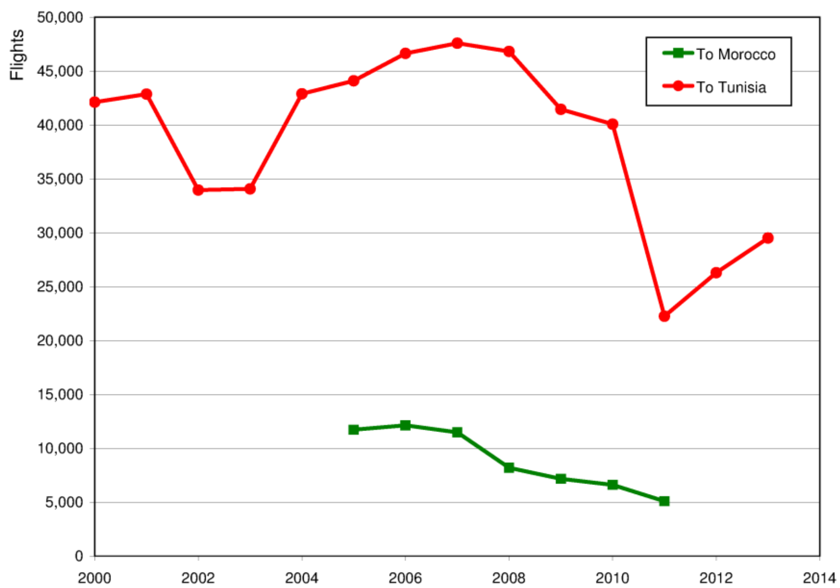

Figure 2: Trends in the number of charter flights towards Morocco and Tunisia (all origins). (Sources: Tunisian Civil Aviation and Moroccan Airport Authority)

As a result, it is relevant to also assess trends in the charter business through the number of tour operators' customers. Tour operators sell all-inclusive packages merging travel, accommodation, meals and local excursions. Figure 3 shows a significant decrease in the number of such packages sold between France (a traditional major source of tourists to Northern Africa) and Morocco and Tunisia. Many factors helped French tourists to skip the tour operators in travelling to these countries, including general (e.g. the advent of the Internet, empirical learning) and specific (e.g. same language, limited otherness) factors. By contrast, packages could be preferred in more 'difficult' destinations with different languages and higher otherness (Mondou and Volier, 2009). Figure 3 confirmed that Tunisia relied more than Morocco on all-inclusive tourists. The decrease had different causes, such as competition from the low-cost airlines to Morocco vs. political troubles in Tunisia.

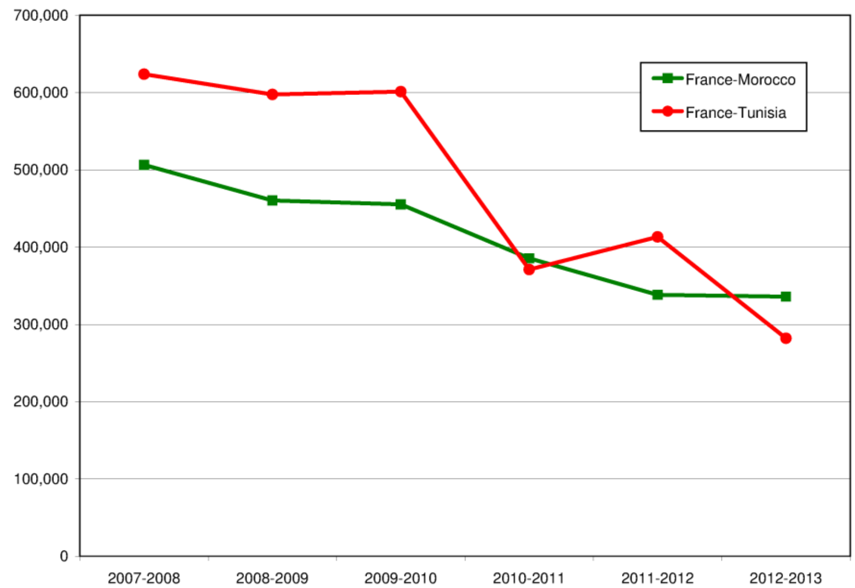

Figure 3: Trends in the number of all-inclusive customers from France (Source: CETO – French Tour Operators' Business Association).

3.2 International Leisure Mobilities

Figure 4 compares international leisure mobilities to both Morocco and Tunisia. To Morocco, the distinction between Moroccans living abroad (MLAs) and foreign tourists made it possible to estimate the share of visits to friends and relatives (VFR) and 'real' tourism, respectively. While the objective of 10 million tourist arrivals has apparently been achieved, several reservations must be highlighted. First, half of the so-called tourist arrivals related to the MLAs, who arguably mostly visited their relatives and friends. Their impact on the tourist business is thus expected to be much lower than foreign tourists, since their expenditures were likely to be less related to accommodation, restaurants and other tourist facilities. In addition, while the number of arrivals increased significantly (+104% or +99%, considering only foreign tourists), the increase in the length of the stay was much slower (+36%) and involved a decrease in the length of the stay. Indeed, the "long-weekend-to-Marrakech" spirit has expanded to the detriment of longer stays at coastal resorts or combining visits to several imperial cities.

Finally, figures related to foreign tourists only (not shown in this paper, because of space constraints), show that not all markets can be easily stimulated. Furthermore, countries with significant Moroccan immigration (France, Spain, Belgium and The Netherlands) experienced large increases in foreign tourist flows to Morocco. This may be due to the fact that the last generations can obtain citizenship by birth under certain conditions. They could then be classified as foreign tourists, rather than MLAs, but their visits to Morocco were likely matched with VFR travel. In other words, it could be that amongst the 10 million 'tourists' travelling to Morocco, there was more VFR travel than expected.

From 2006 onwards and the liberalization of the EU-Morocco market, the two markets have experienced diverging trajectories. Morocco has welcomed more and more tourists, while flows to Tunisia stagnated, even before the revolution (Figure 4). However, aviation liberalization cannot be concluded as enough to boost international flows; that policy could necessarily be successful in Tunisia. In addition, tourist arrivals' patterns diverged between Morocco and Tunisia. For example, arrivals from Europe accounted for 89% in Morocco, against 55% in Tunisia (according to the Tunisian Ministry of Tourism; both figures included immigrants visiting their home country). In Tunisia, the first source of arrival was Libya, with flows larger than from France. Liberalizing the EU-Tunisia market could thus affect only half of the flows.

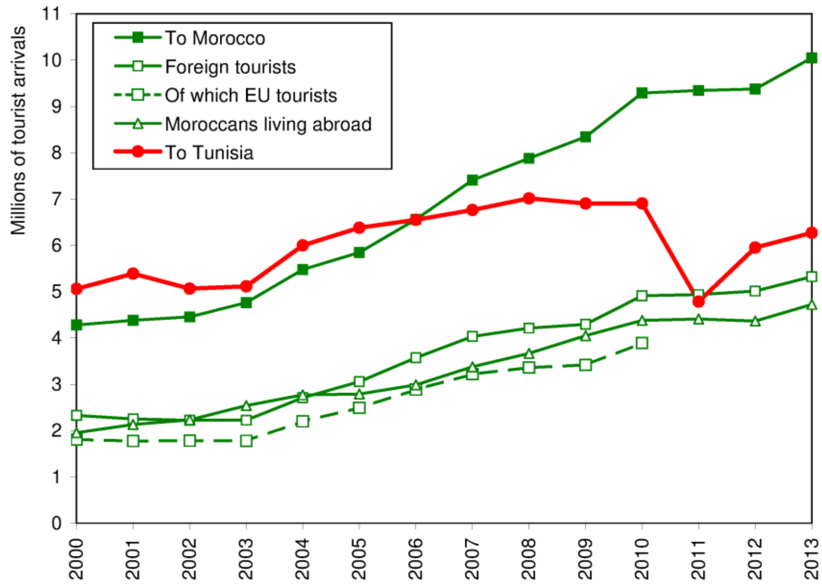

Figure 4: Trends in international mobilities
(Sources: Moroccan and Tunisian Ministries of Tourism, World Bank)

4. Conclusions

The Mediterranean basin is a primary tourist space for the world (both European and Northern Africa sides), with Europe being its primary source of tourists. For many countries, tourism has become a major economic engine (e.g. 7% of GDP and about 400,000 jobs in Tunisia in 2010). In this context, the efficiency and attractiveness of air services is a key element for such tourist destinations located a couple of hours away from Northern Europe.

Morocco and Tunisia have opted for diverging strategies. Morocco recently went to an open-sky policy, first applied with the EU. This induced significant dynamics introduced by this paper, although tourist statistics should be carefully considered.

The open-sky policy was followed by other Mediterranean countries, including Israel (agreement signed) and Tunisia (ongoing negotiations). Tunisia has had talks with the EU for a long time about open-air, but recent geopolitical events have slowed down the process. Hence, this country is considering more global changes in its tourist infrastructure to diversify its coastal product that is associated with a low-price, lower-quality image. A strategic study is ongoing. Furthermore, some other countries (Egypt and Turkey) have allowed European low-cost airlines to operate some international flights.

However, highlight should be placed on the EU-Moroccan case that has shown mixed evidence of success: more regular flights vs. less charter flights (highlighting, by the way, the need for studies taking into account non-scheduled air services), more tourist arrivals, but a large share of VFRs, and a drop in the length of stay. Furthermore, the success of any tourist policy should be analyzed in long retrospect to be sure that the effects are economically sustainable and not balanced by losses elsewhere. Finally, acknowledgement should be given to the apparent success of the EU-Morocco policy relying on air transport, and thus, on environmentally unfriendly travel, on low-cost airlines being less respectful of workers (Hunter, 2006; Curley and Royle, 2013) and on specificities making it easier to stimulate flows (e.g. large Moroccan immigration in Europe; no visa needed for EU citizens travelling to Morocco; rather short travel times). In summary, the results of this investigation should not be transferred as such to other markets.

Finally, it is worth noting that other Mediterranean countries are moving towards aviation liberalization, although to varying extents. Israel concluded an open-sky agreement with the European Union in 2013. Egypt and Turkey accepted some European low-cost airlines to serve them. All of these countries hope to take advantage of these airlines, the largest of which have become larger than many European incumbent airlines. Before the 2011 events, Tunisia also intended to liberalize its airline market; this policy has been put on the back burner. Thus, Tunisia is taking a risk in losing out on competition from countries that have engaged towards much more liberalization. However, the apparent success of Moroccan policies should be placed into perspective, as this study demonstrated.

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The Impact of Gulf Carrier Competition on U.S. Airlines

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Abstract: Gulf carriers such as Emirates, Etihad, and Qatar Airways have expanded aggressively and are creating an increasingly dense global network. Future growth prospects, however, hinge on these carriers' ability to gain access to lucrative markets in Europe and America, for example. Existing bilateral agreements stifle the Gulf carriers' ambitious expansion plans in some instances, and legacy carriers lobby to restrict further market access. The objective of this research is to empirically examine some of these arguments. Specifically, we analyze data provided by the U.S. Department of Transportation to examine how Gulf carrier competition has impacted U.S. carrier passenger traffic and fares. The empirical results collectively suggest that greater competition by Gulf carriers in U.S. markets has led to consumer welfare gains.

Keywords: Gulf carriers, competition, air fares, passenger traffic

1. Introduction

Following the deregulation of the U.S. domestic airline industry in the late 1970s, much academic research has investigated the effects of competition on air fares, passenger demand, airline profitability and social welfare (e.g., Borenstein, 1989; Brueckner et al., 1992; Fu et al., 2010), for example. Within this stream of research, a substantial number of studies examined how different types of carriers, namely legacy and low-cost carriers, differentially compete and impact market outcomes (e.g., Morrison, 2001; Hofer et al., 2008; Alves and Barbot, 2009; Ciliberto and Tamer, 2009; Borenstein, 2011; Murakami, 2011).

With low-cost carriers having evolved into major players controlling significant shares in most of the world's short-haul route markets (Binggeli et al., 2013), the "new force […] in the world of air travel [comes] in the form of three Gulf airlines" (The Economist, 2010). In fact, the Gulf trio, as Emirates, Etihad and Qatar Airways are often referred to, have significantly increased their capacity to the U.S. in recent years (Cameron, 2011). Meanwhile, U.S. airlines are fighting back, launching "a barrage of legal and political challenges to the Gulf carriers" (Carey and Michaels, 2013) in an effort to defend their stake in the lucrative international air passenger market.

While the rise of the Gulf carriers has received significant attention in the trade press, few academic studies have examined their effects on the air travel market. A notable exception is the work by Squalli (2014) who studied the relationship between the openness of air travel markets and the performance of Emirates Airline. Based on an analysis of 155 route markets originating in Dubai, Squalli (2014) concluded that further liberalization of the UAE market (and, by extension, other Gulf carriers' markets) leads to greater passenger volumes, lower fares and, ultimately, welfare gains. Hazledine (2010) studied trans-Tasman air markets and concluded that Emirates offered significantly lower fares but did not exert much pricing pressure on incumbent carriers Air New Zealand and Qantas.

The current study contributes to this nascent stream of research by examining how Gulf carrier competition affects traffic volumes and fare levels in international route markets. Specifically, we address the following question: How has Gulf carrier competition in U.S. markets impacted incumbent carrier passenger traffic and air fares in affected or adjacent route markets? Our work, thus, bears similarity to studies on the effects of low-cost carrier competition in the U.S. airline industry but differs in that the effect of Gulf carrier competition in international route markets is studied.

Drawing on data from the U.S. Department of Transportation (U.S. DoT), we conduct the empirical analysis in two parts: In the first analysis (Section 2), we explore how entry by Gulf carriers in various U.S. markets has affected aggregate passenger traffic between the Middle East and the respective U.S. regions. In the second analysis (Section 3), we examine how Gulf carrier competition—measured in terms of passenger volume—impacts U.S. carriers' fares and passenger numbers.

The current research contributes to the ongoing policy debate regarding the rise and perceived threat of the Gulf carries. That is, the results of our study help elicit the claims that Gulf carrier competition harms incumbent airlines and their home markets. Since such claims often result in calls for regulation (Carey and Michaels, 2013), our study should be of great interest to policy makers. Likewise, this research is managerially relevant since it presents insights into and quantifies the effects of Gulf carrier competition in terms of U.S. legacy carriers' fare and traffic data.

2. Effects of Gulf Carrier Entry on Aggregate Passenger Traffic between the U.S. and the Middle East

Emirates service between Dubai and New York (JFK) in 2004 marked the first foray of a Gulf carrier into the U.S. market. Since then, all three Gulf carriers have expanded their services into and from the U.S. and now serve numerous cities throughout the U.S. from their respective hubs in Dubai, Doha and Abu Dhabi. The purpose of our first analysis is to investigate whether and how Gulf carrier entry impacted aggregate passenger flows between the U.S. and the Middle East.

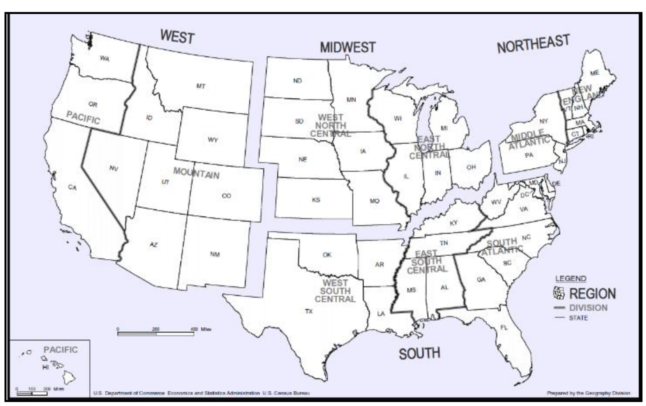

Figure 1: Census Regions and Divisions of the United States (U.S. Census Bureau)

The empirical analysis summarized in Figure 2 draws on data obtained from the U.S. DoT's T-100 database,[1] which provides route market-level passenger data for both U.S. domestic and foreign carriers. For the purpose of this analysis, we divide the U.S. into four different regions as shown in Figure 1 below and examine how aggregate passenger volumes to and from the Middle East changed upon initial entry by any of the Gulf carriers into these respective regions.

The graphs presented in Figure 2 were generated using STATA, a statistical software package, and plot aggregate quarterly passenger numbers for each airport-to-airport route market between the respective U.S. regions and the Middle East, and the initial entry by a Gulf carrier is marked by a vertical line. Regression lines were fitted to the data and model fit statistics (R^2) are reported in the labels of the respective plots. In nearly all instances, structural breaks in passenger flows are discernible. That is, with the arrival of Gulf carriers, a significant increase in passenger numbers was observed. In addition, accelerated market growth was evident subsequent to Gulf carrier entry into the U.S. West and U.S. Midwest markets. These findings suggest that the arrival of Gulf carriers stimulated substantial expansion of passenger traffic rather than simply shifting passenger volume away from legacy carriers to Gulf competitors.

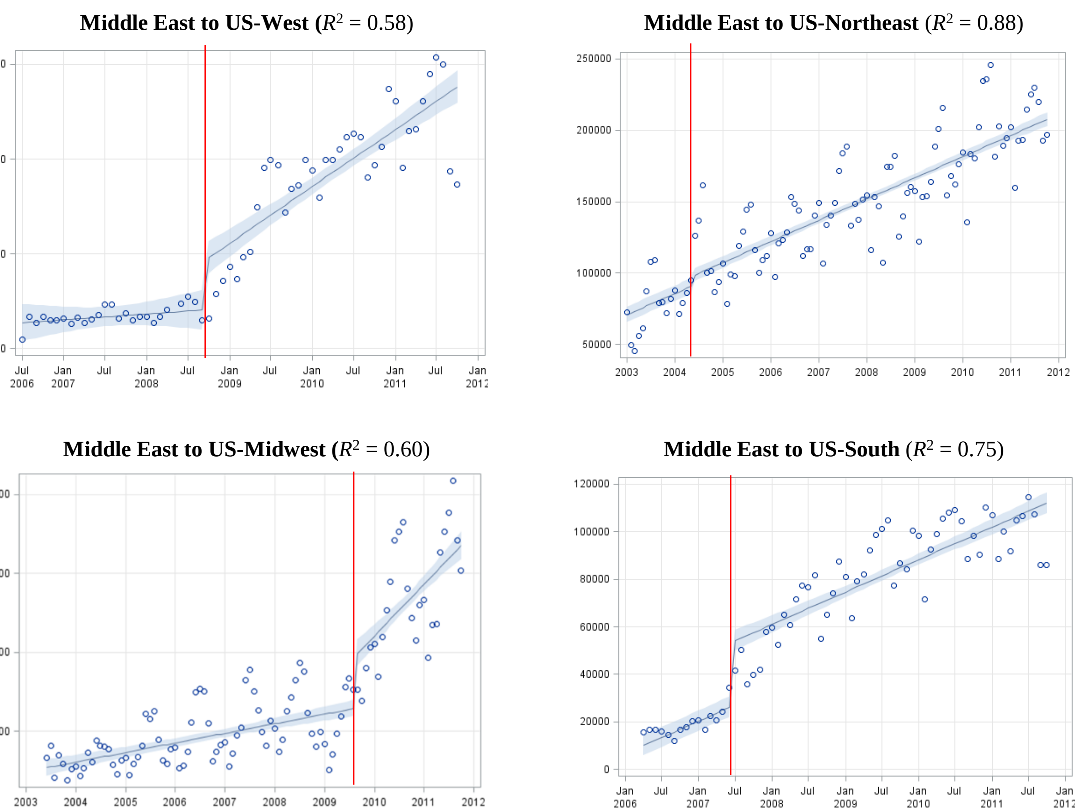

Figure 2: The Effect of Gulf Carrier Entry on Size and Growth of U.S.-Middle East Markets (v.v.)

While this analysis provides preliminary insights into the effects of Gulf carrier competition U.S.-Middle East route markets, it is incomplete for two primary reasons: First, the effect of Gulf carrier entry and competition on air fares is not considered due to the lack of fare data in the T-

[1] This data is publicly available through the DoT's TranStats website: http://www.transtats.bts.gov/homepage.asp.

100 database. Second, this descriptive analysis fails to consider secondary effects of Gulf carrier competition. Specifically, Gulf carriers not only compete in U.S.-Middle East markets. Rather, substantial numbers of passengers connect via these carriers' hubs on to destinations in, for example, the Middle East, Africa, Asia, and Oceania. Hence, we conduct a second analysis to obtain further insights into the effects of Gulf carrier competition on U.S. carriers.

3. Effects of Gulf Carrier Competition on U.S. Carriers' Fares and Passenger Volumes

As noted previously, the purpose of this analysis is to further explore how Gulf carrier competition, measured in terms of Gulf carrier passenger traffic between the U.S. and the Middle East, affects U.S. airlines' fares and passenger volumes in route markets between the U.S. and various regions of the world. The unit of analysis, thus, is a U.S. carrier's fares and passenger volumes in a given route market originating or terminating in the U.S. Further information on the data set and relevant variables is provided below, followed by sample descriptive statistics, a brief discussion of methodological issues, and the empirical results.

3.1 Data

The U.S. DoT's International DB1B database[2] provides a 10% sample of all international tickets sold by U.S. carriers, and for each ticket, specific itineraries and associated air fares are recorded. This data, obtained for the period from the first quarter of 2008 to the second quarter of 2013, was aggregated to identify average air fares and total passenger volumes transported by a given U.S. carrier between a U.S. airport and an international airport (or vice versa) in a given quarter. Route markets in which Gulf carriers potentially compete are of particular interest here such that observations pertaining to, for example, services between the U.S. and destinations in North America, Central America, the Caribbean, and South America were excluded from further consideration. The resulting data set contains 10,136 observations at the (U.S.) carrier-route-quarter level, where a route market is defined at the airport-to-airport level. To evaluate the effects of Gulf carrier competition on U.S. carriers, passenger data for non-U.S. carriers from the T-100 database were matched into this data set.

3.2 Variables and Measurement

There are two dependent variables of interest in this study: U.S. carriers' fares and passenger numbers. The *Price* variable represents a U.S. carriers' one-way fare, measured in U.S. dollars, based on round-trip ticket purchases. The *ODPax* variable, in turn, captures a U.S. carrier's total quarterly passenger volume between a route's origin and destination (*OD*) airports, with one of these airports being a U.S. airport.

The key independent variable is the total number of passengers carried by Gulf airlines in a given quarter between a given U.S. region, aggregated across all airports within that region and the Middle East (Dubai, Doha, Abu Dhabi). The aggregation of *TotalGulfPax* by U.S. region, allows us to capture the effects of indirect or adjacent competition. A Gulf carrier's entry into New York (JFK), for example, may have an effect on U.S. carriers operating out of Newark (EWR) or Philadelphia (PHL), for example. While Gulf carriers' onward connections beyond the Middle East are not identified in the T-100 database, it is reasonable to assume that the majority of

[2] This data is confidential and access is controlled by the U.S. DoT. Information on the database is available through the DoT's TranStats website: http://www.transtats.bts.gov/homepage.asp.

passengers connected to destinations throughout the Middle East, Africa, Asia, and Oceania. As such, the *TotalGulfPax* variable serves as a proxy for the degree of Gulf carrier competition in a broad array of international route markets originating or terminating in the respective U.S. regions.

Additional variables are expected to impact air fares or passenger numbers, respectively. Market concentration, for example, has been shown to impact air fares with higher concentration—indicative of lower levels of competition—associated with higher ticket prices (Cho et al., 2012). The *RegRegHHI* variable is the measure of market concentration in this study and is calculated as the Herfindahl-Hirschman Index (HHI), i.e. the sum of the squared aggregate market shares of all carriers operating between the origin and destination regions. U.S. regions were defined as shown in Figure 1, while international airports were assigned to specific geographic regions based on classifications published by the United Nations.[3] *Distance* is another variable expected to impact air fares (e.g., Hofer et al., 2005) and is measured as the nonstop mileage between a route market's origin and destination airports. Fuel costs, finally, are a key determinant of an airline's operating costs and, thus, ticket prices. Accordingly, we include *Fuel*, U.S. carriers' average cost per gallon of kerosene on international routes in a given quarter, as a control variable. The magnitude of trade flows between the U.S. and a given country, finally, may predict passenger demand for air travel between airports in the respective countries. As such, the *Trade* variable, measured as the sum of imports and exports between the countries, is included as an additional control variable.

3.3 Descriptive Statistics

Descriptive statistics and bivariate correlations for the data sample are reported in Table 1 and Table 2, respectively. All variables with the exception of *Fuel* were log-transformed prior to the empirical analysis to facilitate the interpretation of the resulting coefficient estimates.

Variable	Mean	Std. Dev.	Min	Max
Price ($)	854.6	352.0	195.1	3733
Distance (miles)	4927.8	1404.1	2593.0	10210
ODPax	15934.6	12437.0	2.0	101241
RegRegHHI	1519.1	1329.9	795.3	10000
TotalGulfPax	74605.1	30804.4	2229.0	132284
FuelCost ($/gallon)	2.7	0.6	1.7	3.8
Trade (billion $)	114	128	0.2	582

Table 1: Descriptive Statistics (n=10,136)

[3] The relevant world regions considered here include East Asia, Europe, Northeast Africa, Oceania, South Asia, Southeast Asia, Southwest Africa.

		1	2	3	4	5	6
1	lnPrice						
2	lnODPax	0.229					
3	lnDistance	0.562	-0.195				
4	lnRegRegHHI	0.448	-0.178	0.700			
5	lnTotalGulfPax	-0.199	0.012	-0.282	-0.310		
6	Fuel	0.282	0.030	-0.006	0.003	0.220	
7	lnTrade	0.273	0.130	0.216	-0.127	-0.189	0.082

Table 2: Pairwise Correlations (n=10,136)

3.4 Empirical Estimation Method

The empirical model consists of two equations with fares (*lnPrice*) and passengers (*lnODPax*) as dependent variables respectively. While the number of passengers is an important predictor of prices, prices are, at the same time, a key factor impacting passenger demand. This apparent endogeneity between *lnPrice* and *lnODPax* necessitates an instrumental variable approach. Specifically, *lnRegRegHHI*, *lnDistance* and *Fuel* are used as exogenous instruments in the price regression, while *lnTrade* is used as an instrumental variable in the passenger model. We account for the lack of independence of observations and potential concerns of serial correlation and heteroskedasticity in our panel data set by clustering the standard errors at the route-carrier level and by controlling for time effects.

The resulting estimation equations are specified as follows:

(1) $lnPrice = \alpha_0 + \alpha_1\ lnODPax + \alpha_2\ lnRegRegHHI + \alpha_3\ lnDistance + \alpha_4\ Fuel + \alpha_5\ lnTotalGulfPax + \Sigma\alpha_t\ Time + \varepsilon$

(2) $lnODPax = \beta_0 + \beta_1\ lnPrice + \beta_2\ lnTrade + \beta_3\ lnTotalGulfPax + \Sigma\beta_y\ Year + \Sigma\beta_t\ Time + \varepsilon$

3.5 Estimation Results

In line with prior research (e.g., Hofer and Eroglu, 2010), the simultaneous estimation of equations 1 and 2) was done using the three-stage least squares procedure in STATA, a popular statistical software package. The associated estimation results are shown in Table 3 below. The panel on the left shows the results with *lnPrice* as the dependent variable, while the panel on the right displays the estimation results for *lnODPax* as the dependent variable.

lnPrice	Coef.	Std. Err.		**lnODPax**	Coef.	Std. Err.	
Constant	-3.212	0.361	**	Constant	16.305	0.740	**
lnODPax	0.282	0.017	**	lnPrice	-1.485	0.078	**
lnRegRegHHI	0.119	0.009	**	lnTrade	0.210	0.012	**
lnDistance	0.825	0.020	**				
Fuel	0.052	0.042					
lnTotalGulfPax	-0.065	0.007	**	lnTotalGulfPax	-0.227	0.030	**
Number of obs.		10,136		Number of obs.		10,136	
χ^2		7,223	**	χ^2		580.46	**

** and * denote significance at p<.01 and p<.05, respectively. Time fixed effects are omitted due to space constraints.

Table 3: Empirical Results

Turning to the price regression first, we note that the model as a whole is highly significant and the coefficient estimates are largely in line with expectations. That is, greater passenger demand is associated with higher prices. Moreover, greater levels of market concentration and longer distances also imply higher air fares. The coefficient of the Distance variable, for example, indicates that a 10% increase in the mileage between origin and destination airports results in a 8.3% increase in prices. The result for the *Fuel* variable, while positive as expected, is statistically insignificant. With respect to the variable of primary interest, there is evidence that Gulf carrier competition (*lnTotalGulfPax*) leads to lower fares.

The results for the passenger model are also consistent with expectations. In line with basic economic theory, we find that the higher the ticket price, the lower the carrier's passenger numbers. Moreover, the estimates indicate that a 10% increase in Trade Flows between the origin and destination countries results in an increase in passenger demand of, on average, 2.1%. Finally, there is statistical evidence that greater Gulf carrier passenger volumes adversely affect U.S. carriers' passenger counts.

4. Discussion and Conclusion

The purpose of this study is to explore the effects of Gulf carrier competition on U.S. carriers. Drawing on U.S. DoT data, we first investigated how the size of international route markets, as measured in terms of total passenger volumes, changed as a result of Gulf carrier entry. The results indicate that passenger counts increased significantly following such entry events. In some instances, there is also evidence that Gulf carrier entry stimulated accelerated market growth.

In a second analysis, we further studied the effect of Gulf carrier competition on U.S. carriers' fares and passenger counts. Given the interdependence of passenger demand and fares, this effect is iterative: Greater Gulf carrier passenger volumes result in lower ticket prices which, in turn, stimulate passenger demand for U.S. carriers. Higher demand then leads to higher ticket prices. Based on our empirical results, we find that a 10% increase in Gulf carrier traffic between various U.S. regions and the Middle East results, on average, in U.S. carriers' fare decreases of 0.91%. Similarly, the 10% increase in Gulf carrier traffic equates to a 0.92% reduction in passenger numbers for U.S. carriers.

To ascertain that the empirical results and the associated estimates of the impact of Gulf carrier competition on U.S. carriers' fares and passenger demand are robust, we estimated the model via alternative statistical procedures. A panel two-stage least squares procedure produced results that are qualitatively identical and quantitatively very similar to the ones reported in Table 3.[4] Based on these 2SLS results, we conclude that a 10% increase in Gulf carrier traffic between the U.S. and the Middle East lowers U.S. carriers' fares and passenger numbers by 0.86% and 0.54%, respectively.

Collectively, these results support two key conclusions: First, Gulf carrier entry and competition leads to total market and revenue growth since the added passenger volume likely outpaces U.S. carriers' passenger losses in most cases. Second, the adverse effect of greater competition on air

[4] We do not report these results here due to space constraints. The results are available from the authors upon request.

fares contributes to gains in consumer welfare. These results based on analyses of U.S. data suggest that free market access and greater competition ultimately contribute to greater economic welfare, thus negating the often-cited calls for regulatory intervention. The insights offered by our work will hopefully contribute to the policy debate regarding Gulf carrier competition that is ongoing in Europe and parts of North America.

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Service Quality of Low Cost Carriers in the GCC –Passenger's Perception

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Abstract: Service quality is an integral part of a product offering provided to a customer, along with identifying expectations and perceptions/experiences of customers about service quality, it is therefore imperative for service providers like Low Cost Carriers (LCCs) to investigate whether service quality increases customer satisfaction and intention to buy or re-buy. Service quality is an abstract concept that has encouraged considerable interest in the research literature, primarily because it is intangible, variable, perishable and inseparable from service provided in nature. This study empirically evaluates a comprehensive service quality measurement scale (SERVQUAL) for its potential usefulness in measuring the service quality of LCCs. Qualitative research was utilized i.e. Interviews were conducted with passengers traveling with LCC in the Gulf Cooperation Council (GCC), to investigate their expectations and experiences while traveling with LCC.

Keywords: low cost carriers, service quality, expectations, perception, customer satisfaction

1. Introduction

The word "service" is widely used to denote an industrial sector that 'does' things for you. They don't make things" (Silvestro and Johnson, 1990, p. 206). "Service" also denotes organizations which meet the needs of society, such as health service, civil service, categorically termed as public service offered traditionally along with bureaucratic lines and are different than industrial service sector. According to Johns N. (1998), accountability of the service sector has increased due to their complex offerings and therefore, the quality of service offered by each organization is questionable. Johns further mentions that, the service sector concerns a wide range of intangible products, with certain key characteristics that distinguish services from manufacturing: **perishable**, which means that stocking to smooth demand is not possible; **simultaneous**, which means there is no time to correct any mistakes between creating the service and the customer receiving it; **heterogeneous**, since each service must be tailored to the particular customer; and, as mentioned earlier, **intangible**, where measurement of effectiveness is subjective. The result is that manufacturing quality methods, such as final inspection, have no value in the service industry since it is by then already too late to alter outcomes for customers. In addition, the variety and unpredictability of customer requirements mean that prescriptive procedures are less appropriate than in manufacturing, while the subjective nature of service makes reliable quality measurement difficult. Therefore, researchers of service quality developed a conceptual model called SERVQUAL (Parsuraman, Zeithaml and Berry, 1985-88) which has been successfully modified and tested in most service related fields.

The service industry, quality is neither absolute nor relative to contractual obligations; rather, it is judged relative to the performance believed to be available from competitors. These elements of service make it difficult for the service providers to remain casual in their approach since if they disappoint that customer they lose him forever. This means that improvements can be gained by managing the expectations of customers without any objective change in performance.

The world is becoming dominated by services, with many of the most advanced economies having more than 70% of their gross domestic product (GDP) generated by services (Ostrom A.L. et al., 2010). The service industry is also growing rapidly at the moment because of internationalization, which means that customers in the international market expect service quality to be of a good standard everywhere. It is therefore essential that the service industry should provide high quality service to its customers.

Low Cost Carriers (LCCs) are becoming an important part of the aviation industry in the world. They are significantly growing in the Middle East. LCCs are defined as airlines that operate on relatively short distances in a certain region without offering additional services. LCCs are designed to have a competitive advantage in terms of costs over Full Service Carriers (FSCs) however, service quality should still play an important role in the LCCs to gain customer confidence. In a research conducted by Li et al. (2010), found that even though LCCs are price conscious, service quality is high on the agenda and it was found that most LCCs have to devote themselves in improving service quality to attract leisure and business passengers.

1.1 Objectives

This paper focuses on investigating the service quality of LCCs in the GCC on the basis of passenger's perception. Since LCC is an emerging concept in the GCC aviation market, it is evident that there is a lot of room for improvement based on quality service as well as to understand the needs and wants of the customers. The study utilized 'SERVQUAL', the service quality model to develop the dimensions and variables suitable to measure the service quality levels of LCCs in the GCC.

2. Literature Review

2.1 Service Quality

Quality is an abstract, hard to define concept (Lagrosen, et al., 2004). According to Zeithaml (1988, p.3), service quality is 'the customer's judgment about a product's overall excellence or superiority'. Garvin (1983) considers service quality as a key constituent to effectively compete, remain profitable and survive in a competitive market. Furthermore, he suggests that, if performance is higher than expectations, then the perceived quality will be more than satisfactory, hence the customer will experience high satisfaction. Bitner and Hubbert (1994, p.77) define service quality as 'the consumer's overall impression of the relative inferiority/superiority of the organization and its services', thus, quality is conceptually based on perceived quality. Despite being considered as an elusive concept, the service quality process has produced considerable interest and debate in the research literature. Primarily, this debate developed due to the intangible, variable, perishable and inseparable nature of service provided to the customers (Parasuraman et al., 1985; 1988).

2.2 Service Quality Model "SERVQUAL"

Early studies during 1980s focused on defining what service quality meant to customers and developing strategies to meet customer expectations. The meaning of service quality had been defined by several researchers, such as Sasser, Olsen, and Wyckoff (1978), GrÖnroos (1982), and the study of Lehtinen and Lehtinen (1982) which inspired Parasuraman, Zeithaml, and Berry to undertake a comprehensive qualitative study to further define service quality in the form of the

SERVQUAL scale (Parsuraman, Zeithaml and Berry, 1985). SERVQUAL meets the challenge of reliably measuring perceptions in the service industry by proposing that Service Quality = Expectation - Perception. The SERVQUAL approach was modified (Parasuraman et al., 1998) in response to criticisms concerning conceptualization issues (Donnelly and Dalrymple, 1996), and has been successfully utilized to measure service quality. The scale was developed and tested across four service environments namely banking, credit card services, repair and maintenance, and long distance telephone services. In its final form, SERVQUAL contained 22 pairs of items; first part of these items were intended to measure (consumers) expected level of service for a particular industry (expectations). The other 22 matching items were intended to measure consumer perceptions of the present level of service provided by a particular organization (perceptions). Service quality was measured on the basis of the difference scores by subtracting expectation scores from the corresponding perception scores.

2.3 SERVQUAL Dimensions

TANGIBILITY

This dimension focuses on physical facilities, tools or equipment used to provide the service, appearance of personnel and other customers in the service facility in a related industry (Parsuraman et al., 1985). The dimension is completely applicable to the LCCs in the form of; physical facilities and materials related to an aviation service, such as on-board comfort, seating arrangement, leg room, quality of food, and co-passengers traveling on the flight are considered important indicators of the quality of an organization’s service. The tangibility dimension can be further divided into sub-dimensions or variables to identify exact gap in service quality.

RELIABILITY

The reliability dimension involves consistency of performance and dependability; meaning that the firm performs the service right the first time, it also means that the firm honors its promises made to the customers towards; accuracy in billing, keeping records correctly and performing the service at the designated time (Parsuraman et al., 1985). No matter which type of service is purchased, customer value service reliability. If the same is applied to the airline industry, the most important reliability variable would be the ability to perform accurately and dependably in terms of safety, most importantly through pilot navigation. The principle attraction of LCCs is on-time performance so customers will be loyal to an airline that gives importance to time management. In turn, passengers will perceive the service quality of such an airline as high. The organization will be considered reliable, if they attach considerable importance to factors like safe transactions, keeping promises and effective communication in times of need.

RESPONSIVENESS

Responsiveness is based on willingness or readiness of employees to provide service. It involves timelines of service pertaining to mailing a transaction receipt immediately, returning the call as soon as possible and providing prompt service such as fixing an appointment quickly (Parsuraman et al., 1985). Responsiveness plays a crucial role for travel and tourism related companies since it is all about good customer service. A research conducted by Prabaharan B. et al. (2008) proved that responsiveness dimension was imperative for sustainability tourism development in India. In the aviation industry, responsiveness means willingness to help passengers and provide prompt service, both by ground staff and flight crew. Every customer wants to be treated like an individual irrespective of the value he/she has paid for the service obtained. The customer expects that whenever he/she needs help it will be provided with care and attention, not just as a duty or obligation. For example, Zakaria Z. et al. (2010) found that transportation customers in Malaysia gave much more importance to responsiveness than to tangibility.

ASSURANCE

Customers always expect a safe and secure service since, once a service has been provided, it cannot be replaced as a defective product can. Thus, once the customer has had a negative experience, they will inevitably question the competence of the company's system and its security, credibility and courtesy. For example, nowadays, consumers use credit cards for most of their transactions, with most of these being done online due to technological advances, moreover customers always want their transactions to be safe and secure. LCCs generally intend to reduce cost, therefore, technology is used for online bookings since they are less costly, however, assuring the customers regarding the safe transactions through their website safety will develop confidence in the customers. Safe delivery of the customer baggage is deemed another important element for travelers especially on short trips for business or leisure.

EMPATHY

Empathy indicates providing individual attention and care to customers (Somwang C., 2008). The customers are delighted to deal with companies where the staff are approachable, the system is easy to access, and the organization is willing to understand customers' requirements and provide thoughtful services. In aviation services, legacy carriers utilize this dimension as a unique preposition to serve their passengers better. With LCCs this dimension can be applicable when the staff of the airline are found to be friendly and approachable, the passengers feel confident to travel in such an airline compared to the competitors.

SERVQUAL's five dimensions have been tested in different markets, with the results varying in each market. Lee et al. (2000) also argue that, the relative importance of all service quality dimensions for customer satisfaction vary according to industry. This paper utilized all the dimensions and adapted them to develop a scale for testing service quality in LCCs based on passengers' perception.

3. Methodology

To effectively investigate the proposed research framework, qualitative methodology was followed. Semi-structured interviews were conducted with 8 passengers who have traveled with LCCs in the GCC within one year of the interview conducted. These interviews were conducted at various locations depending on the comfortability of the interviewees as well as based on their readiness to answer. Research culture is very limited in the Middle East and therefore, not many passengers were ready to answer any questions fearing problems such as confidentially and impact on their job. The interview questions were designed based on the dimensions of SERVQUAL model; however, due to the convenience of the passengers some terms were modified. At times, probing and follow up method of questioning was used to extract appropriate answers required for the study.

All the interviews were then transcribed verbatim using word document and qualitative data analysis software NVivo 10 was utilized to complete the coding process. The software assists researchers to conduct word search, text search as well as design word trees, it also supports different document types like PDFs, word, images, audio as well as social media information like chats and tweets with the help of its new feature called NCapture. Welsh (2002, p.9) in her study of using manual and computer-based (NVivo) analysis techniques together, discussed that, " in order to achieve the best results it is important that researchers do not reify either electronic or manual methods and instead combine the best features of each". She believed that, if the data set is relatively small it would be possible to use only manual methods, although the researcher would risk human error in the searching for simple information on the whole data set. The implications of using this software like any other computerized data analysis software is that, it is complicated and at times time-consuming if the researcher has less technical knowledge.

4. Key Findings

The coding process identified key nodes that matched the dimensions discussed in the SERVQUAL model. Passengers of LCCs in the GCC did expect basic but good service quality even though they are relatively paying less than to travel with a full fare airline. The passengers also expressed their experiences and feelings about being satisfied or unsatisfied based on their past travel experience within GCC or other countries in the LCCs. It was identified that, the passengers considered price as a major influence while deciding to travel with a low cost however to most of them service quality also was as much important. The respondents expressed their thoughts regarding good service quality parallel with the SERVQUAL dimensions (Parsuraman et al., 1985). Most variables of the five dimensions have been repeatedly stated by respondents during the interview process, as shown in the sample quote of the transcribed data verbatim in Table 1.

SERVQUAL Dimensions (Parsuraman et al. 1988)	Variables related to LCC	Sample Quote
Tangibility	Reliable Aircraft	"With the aircraft I assume that the low cost carriers always use the old aircraft but I am not sure because the same happens in her country. I feel that the aircraft with low cost carriers are less modern than the full fare airlines". (Respondent Five, line no. 44-46)
	Comfortable Seats and Leg space	"My expectations are that there should be a certain level of comfortability in the seating arrangement; seats should be comfortable I do not mean too much leg space or a bigger seat but definitely appropriate spacing between the seats to rest and eat meals". (Respondent two, line no. 118 – 120)
	Noise level in the aircraft	"At times may there are a group of people traveling and they are having a go time haven't they? But they were loud, happy but it was really fine it didn't really bother us". (Respondent no. seven, line no. 117-118)
	Hygiene in the aircraft	"The Aircraft should be clean especially the toilet should be well maintained because, If anybody gets a back seat it is difficult to sit since the toilet stinks, the crew should spray some freshener in order to keep away from bad smell". (Respondent no. four, line no. 8-10)
	Food and Entertainment	"I would prefer the choice like buying my own sandwiches or food, I like to have the choice instead of given a Luke warm biryani especially when do not even eat during the short flight so there is so much of wastage". (Respondent three, line no. 17-19)

		"I suppose they can bring their own entertainment with kind today. Keeping in mind it is a low cost carrier, and again show me a child today who does not have their own entertainment". (Respondent no. seven, line 128-129)
Reliability	Keeping Promises	"The next day we went and they had given us a time we had to go at a particular time but when we went there was no response like the custom officers were not there and they said the reason was that the flight was delayed". (Respondent no. two, line 67-69)
	Safety and Security	"Safety and security is as important as any other airline, I don't think there should be any exceptions. (Respondent no. six, line no. 34-36)
	On-time Performance	"I was very much satisfied with the Airline in terms of reliability especially whenever I have flown with the airline the flight was always on-time while at arrival or departure". (Respondent no. one, line no. 28 -30)
	Task completed Correctly	"I felt even though they are budget carriers they should carry complaint and suggestion forms on board". (Respondent no. four, line no. 30-33)
	Website	I have visited the website only while booking the seats but I find it good source of information about flight timings availability and fares. I feel the transaction have been safe but few problems like could not copy the ticket details and print later. (Respondent no. two, line no. 127-129)
	Baggage	"I still feel that there should be baggage safety since at times people do carry perishable items and if the baggage do not reach on time things might be spoiled or damaged". (Respondent no. two, line no. 77-79)
Responsiveness	Effort in solving Problems	"I think it depends on the occasion like if it is for the kids; they are small so they cannot wait for a glass of water or if they have to be accompanied for the bathroom in this case yes I expect quick service" (Respondent no. five, line no. 73-74)
	Staff Knowledge and skills	"No, they were quick again I think that they actually don't have pressure of long meal service. It just goes through the cabin and it is pretty quick and rest is individual request from the customers and they respond it straight away. I didn't have to wait for anything". Respondent no. six, line no. 67-69)
	Special preference to (elderly, mums with infants)	"When you age or become older it does matter". (Respondent no. five, line no. 27)
	Value for money	"I find them really convenient, you get to see the world for a price that is nothing compared to national carriers and other carriers and if you don't mind basic service then why not". (Respondent no. six, line no. 1-3)
Assurance	Friendly and accessible Staff	"The crews on board were pleasant". (Respondent no. three, line no. 19-20)
	Inspire Confidence	"The staff takes more time to provide service which is ok with the passenger as long as the staff is ready with an answer to the question a solution to the problem". (Respondent no. four line no. 79-80)
Empathy	Communicate with Passengers	"We were not informed about it earlier which I think was not good". (Respondent no. two, line no. 34-35)
	Positive attitude towards customers	"I think at all times they have been helpful expect a guy who was very good at refunding the money but excuses that he came out with were a bit unacceptable to me". (Respondent no. seven, line no. 84-85)

Table 1: Key Attributes relating to the Dimensions of SERVQUAL

During the data coding process there were some other variables which were significant and had close relation to service quality of LCCs. One of the variables was 'culture of the passengers' in relation to their expectations, some of the respondents highlighted that expectations can be high or low depending on the culture of the passengers. Culture as defined by Geert **Hofstede**, "the collective programming of the mind which distinguishes the members of one group or category of people from another." (1991, p. 5). Many consumer behavior studies have discussed influence of culture on customer's expectation and perception while making a purchase decision. As some of the respondents expressed:

"once we become the citizen of the world your expectations also start to lessen or widen sometimes depending on our experience you live. As a person my habitual expectations comes from my culture and as a mother, a woman and as a high level citizen by means of education and everything I have expectation". (Respondent no. one line no. 117-120)

"Absolutely, I think culture influences what we expect a lot, I mean there are huge differences of people expect in terms of customer service because they are coming from different cultures". (Respondent no. six, line no. 118-119)

The next variable which was imperative for LCCs passengers relating to the improvement of LCCs service quality was identified as 'training of the staff' to improve their skill, knowledge and professionalism. The staff of any organization, especially, the front line staff is the face of that organization and if they do not represent the company very well, customers might be dissatisfied with the type of service received. Training the staff, improves their customer service skills as well as knowledge about the service provided and regarding the organization they work. Some of the expressions cited by the passengers as mentioned below:

"I think it is about three things; it's about training and personality. It definitely starts with recruitment, if you recruit people with right skills I think they can provide very good service and not everyone can". (Respondent no. six, line no. 54-55)

"It all goes back to training. I think that is the basic thing in fact at the most difficult times like today companies cut down on training that is what you really need to concentrate on and give yourself a competitive advantage over other airlines (Respondent no. seven, line no 77-79)

The LCCs in the GCC aviation market should identify the gaps between the perception of the passengers and the service provided, to gain competitive advantage not only over other LCCs entering into the market but also indirect competitors such as legacy carriers.

5. Conclusion

This paper focused on identifying the dimensions of SERVQUAL model which has been successfully utilized in various fields of service industry. Aviation Industry is an integral part of the service industry and LCCs have recently entered the GCC aviation market. It is important to identify the gap between passengers' expectations and experiences of level of service quality of a low cost carrier in the GCC. The five dimensions identified by Parsuraman et al. (1985-88) were applied using a semi structured interview with passengers traveling in LCCs in the GCC. The passengers strongly discussed that even though price is a major factor of consideration services matter as well. Services such as hygiene, comfortable seats, safety and security, on-time performance, courteous and friendly staff, solving customer problems and communicating with passengers in terms of problem situations such as delays were expected. The passengers discussed that they were satisfied with certain elements like friendly and courteous staff and satisfactory aircrafts; however, there could be improvements on time-management as well as communication with passengers in cases, when there are delays as well as policy changes. The passengers expect LCCs staff should be well trained to accommodate passenger queries as well as perform their duties correctly. Passengers also believed that culture is a driving force to have high or low expectations from LCCs and its staff. Further studies can focus on investigating the relationship between culture and customer satisfaction.

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Competing Governments' State Support for Strategic Industries: A Game-Theoretic Approach to the Commercial Aircraft Industry

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Abstract : Why have the European Union and the United States engaged in extensive support for their aerospace industries? Our analysis demonstrates that launch aid has a positive effect on economic welfare by promoting innovation and spillovers, but has a negative effect on welfare due to competition-distortion. All of these factors affect each government's incentives to provide launch aid. Overall, a level of launch aid is preferable to none, but whether welfare is maximized by both governments, or only one government, providing launch aid depends on the relative spillover and competition effects.

Keywords: launch aid, R&D spillovers, competition distortion, Airbus-Boeing dispute

1. Introduction

Over the last two decades, the United States and the European Communities have been engaged in an acrimonious trade dispute over government funding for the development of Large Civil Aircraft (LCA). The dispute between the two largest players in the aircraft market comes at a time when several other states, not least China, plan to enter the industry. Each of China and Russia has begun using launch aid in various guises to support its industry. This paper serves to inform the debate over the desirability of governmental launch aid, considering the competition and innovation effects of subsidies (Bagwell and Staiger, 2004; Leahy and Neary, 2007; Sykes, 2003). Particularly, we employ a game-theoretic approach to examine competing governments' incentives to provide launch aid to their respective aircraft industries, and the effects on economic welfare.

The model presented in this paper is close in spirit to that of Miller and Pazgal [MP] (2005). The analysis builds on MP's approach in several ways. First, it simplifies the approach by considering only 2 stages, with 2 sets of players (2 governments, and 2 firms). Secondly, it models product market competition in a reduced-form manner. A third difference is in the form of subsidy. In our model, the subsidy is in the form of the government offering 'cheap' equity to the firm. A fourth difference (compared to MP) is in the form of the government's and managers' incentives. In MP, the governments choose trade policy to maximize country welfare. In our model, the governments' have a richer 'political' objective function.). Furthermore, in MP, the managers act in the interests of the firm (given the level of competition) by strategically choosing quantity (in Cournot competition) or price (in Bertrand competition). In our model, managers are self-interested. They exert value-creating effort levels. Hence, we incorporate managerial moral hazard in the form of effort-shirking. Subsidies alleviate this moral hazard problem by providing a higher equity stake to managers.

Particularly, we model subsidized innovation as a type of real option-to-expand. That is, innovation is modeled as risky (it has a probability of success, but also may fail). If it succeeds, the firm may expand into full scale production. In our analysis, governments are far-sighted (incorporating the real option-to-expand into their assessment of the effects of launch aid). The stock market, on the other hand, is modeled as being myopic (that is, it does not consider the option-to-expand). This drives a wedge between the government's and the stock market's valuation of the project. In our analysis, this means that the firm is unable to obtain finance from the stock market, and must therefore approach the government for launch aid.

2. The Model

We consider a launch aid/project investment game consisting of two firms $i \in \{A, B\}$ (where A represents Airbus and B represents Boeing), and two governments $j \in \{A, B\}$. All agents are risk-neutral, and the risk-free rate is zero. Our game-theoretic focus is on the incentives of the competing governments to provide launch aid.

The timeline of the game is as follows. At date 0, each firm has existing operations-in-place with present value $V > 0$. Furthermore, each firm has a potential new project available (the Airbus A380 and the Boeing 747-8), requiring investment funds $I > 0$. The firms have insufficient internal funds to meet this requirement. Furthermore, they cannot obtain finance from the capital market. Each firm can, however, approach its own government for finance (we term government funding 'launch aid'). **The governments simultaneously decide whether to provide launch aid.**

If firm i receives launch aid, it invests in date 1 project development (R and D). With probability $q \in [0,1]$, firm $i's$ R and D succeeds, in which case full scale-production can go ahead at date 2. With complementary probability, firm $i's$ R and D fails, in which case, full scale production must be abandoned. Note that q, the probability of successful R and D, is identical for Airbus and Boeing. Furthermore, we assume that the companies' success probabilities are perfectly correlated (that is, they either both succeed together, or both fail together). This simplifies the analysis.

At date 1.5, if R and D has succeeded, such that full scale-production can commence, the government offers to the firm an equity stake $\alpha \in [0,1]$ in the project, with the government holding the balance of project equity $1-\alpha \in [0,1]$. Note that it is assumed that the government can only obtain an equity stake in the project, and not in the cash flows V from existing operations.

At the date 2 production stage, each firm's management exerts value-creating effort e. Effort is costly; that is, each management team faces a cost of effort $C(e) = \beta e^2$.

This managerial effort affects success probability, as follows. With probability $p = \gamma e$, the project provides date 3 income $g > 0,$ while with probability $1-p$, the project provides date 3 zero income. Note that γ represents managerial ability. We assume that managerial ability is identical across companies (this is similar to our assumption on the probability of successful R and D: see footnote 1). Therefore, the expected value of the project is $pg = \gamma eg$.

If only one firm invests in the new project, $g = 2G$. If both firms invest in the new project, $g = G + S - \delta$. This formulation captures the idea that if only one firm invests, it captures the whole market, while if both firms invest, they share the market equally. Furthermore, δ represents the loss in the value of each firm's project due to competition (such as Bertrand or Cournot competition). However, if both firms receive launch aid, and innovate, they both enjoy spillover effects, reflected by S.

At date 3, payoffs occur and the game ends.

We consider two effects resulting from the governments' simultaneous provision of launch aid. Firstly, a *competition-distorting effect*, whereby the provision of launch aid affects each firm's present value of existing operations as follows. If only one firm (say firm A) receives launch aid, $N_A = V + \Delta, N_B = V - \Delta$. If both firms receive, or if neither firm receives, launch aid, $N_A = N_B = V$.

The second effect is that launch aid allows innovation and growth (that is, investment in the new projects) that is not possible under market finance.

We solve the game by backward induction.

3.1: Date 2: Firms' Effort in the Growth Option.

We take as given that a firm has obtained finance $I > 0$ for the new project, that R and D has been successful, and that the government has offered to the firm an equity stake $\alpha \in [0,1]$ in the project. Solving for the firm's optimal effort level in the project is as follows.[5] The firm's expected payoff from the project is

$$\prod_i = \alpha \gamma e g - \beta e^2 \qquad (1)$$

Solving $\frac{\partial \prod_i}{\partial e} = 0$, we obtain the firm's optimal effort level as follows.

$$e* = \frac{\alpha \gamma g}{2\beta} \qquad (2)$$

Therefore, the expected value of the growth option is

$$V = \gamma e * g = \frac{\alpha \gamma^2 g^2}{2\beta} \qquad (3)$$

[5] At this stage, we do not consider whether one or both firms have received launch aid and been successful in R and D. We keep the situation general, by working with the expected value g, which is affected by whether only one firm, or both firms have successful R and D.

Thus, if only one government provides launch aid, $g = 2G$, and that firm's R and D efforts are high. If both governments provide launch aid, $g = G + S - \delta$, and both firms' R and D efforts are lower due to the competition effect, but higher due to the spillover effect. Hence, the net effect is ambiguous.

3.2: Date 1.5: The government's equity offer.

Given that R and D has been successful, the government makes its equity offer α to maximize its expected payoff;

$$\prod_G = (1-\alpha+\phi)\gamma e g = (1-\alpha+\phi)\frac{\alpha\gamma^2 g^2}{2\beta} \qquad (4)$$

where we have substituted for the firm's optimal effort level from (2).

The government chooses α to maximize equation (3). Solving $\frac{\partial \prod_G}{\partial \alpha} = 0$, we obtain the government's optimal equity offer as follows:

$$\alpha = \frac{1+\phi}{2} \qquad (5)$$

Note that the government's equity offer to the firm is increasing in the government's private benefits ϕ.

Substituting the optimal equity offer into equation (4), we obtain the government's indirect payoff from full scale-production;

$$\prod_G = \frac{(1-\phi^2+4\phi)\gamma^2 g^2}{8\beta} \qquad (6)$$

3.3: Date 0 Government's Launch aid decision.

Finally, we move back to date 0 to solve for the governments' launch aid decisions, employing a game-theoretic approach. Since we assume that these decisions are simultaneous, we can represent this as a normal form game (the implications of considering a sequential game are discussed later):

Govt A\B	No Launch aid	Launch aid
No Launch Aid	8, 9	10, 11
Launch Aid	12, 13	14, 15

These payoffs are as follows:

$$\prod_{GA} = \prod_{GB} = \phi V \tag{8, 9}$$

$$\prod_{GA} = \phi(V - \Delta) \tag{10}$$

$$\prod_{GB} = \phi(V + \Delta) + q\frac{(1-\phi^2+4\phi)\gamma^2.4G^2}{8\beta} - I \tag{11}$$

$$\prod_{GA} = \phi(V + \Delta) + q\frac{(1-\phi^2+4\phi)\gamma^2.4G^2}{8\beta} - I \tag{12}$$

$$\prod_{GB} = \phi(V - \Delta) \tag{13}$$

$$\prod_{GA} = \prod_{GB} = \phi V + q\frac{(1-\phi^2+4\phi)\gamma^2(G+S-\delta)^2}{8\beta} - I \tag{14, 15}$$

In order to solve for the governments' equilibrium launch aid decisions, we consider each government's best responses to the other's strategy. Furthermore, we analyze the effect of these launch aid decisions on economic welfare W. Economic welfare is represented as the summation of the firms' and the governments' payoffs: that is:

$$W = \prod_A + \prod_B + \prod_{GA} + \prod_{GB}$$

Note that, if neither firm receives launch aid, each firm's expected profit is V. If both firms receive launch aid, each firm's profit is

$$\prod_i = V + q\frac{\alpha^2\gamma^2(G+S-\delta)^2}{4\beta} = V + q\frac{(1+\phi)^2\gamma^2(G+S-\delta)^2}{16\beta}$$

If only one firm (say firm A) receives launch aid, the expected profits are

$$\prod_A = V + \Delta + q\frac{(1+\phi)^2\gamma^2.4G^2}{16\beta},\ \prod_B = V - \Delta$$

In order to focus the analysis, and restrict the number of cases examined, we assume the following:

A.1: $G > S - \delta <=> \phi\Delta + q\frac{(1-\phi^2+4\phi)\gamma^2.4G^2}{8\beta} > \phi\Delta + q\frac{(1-\phi^2+4\phi)\gamma^2(G+S-\delta)^2}{8\beta}$

The left-hand-side of assumption A.1 states that the value of the growth option in the case or R and D success (parameter G), when only one firm carries out R and D, exceeds the spillover effect minus the competition effect ($S-\delta$) when both firms engage in R and D. This assumption ensures that the incentives for one government to unilaterally provide launch aid are stronger than the incentives for both governments to simultaneously provide launch aid (reflected in the right-hand side of A.1).

Given A.1, proposition 1 demonstrates that the governments' simultaneous decisions to provide launch aid are affected by the level of investment required, compared with the competition and spillover effects:

Proposition 1:

a) If $\phi\Delta + q\dfrac{(1-\phi^2+4\phi)\gamma^2.4G^2}{8\beta} > \phi\Delta + q\dfrac{(1-\phi^2+4\phi)\gamma^2(G+S-\delta)^2}{8\beta} \geq I$, *both governments provide launch aid.*

Therefore, economic welfare is $W = 2(1+\phi)V + q\dfrac{(2+6\phi)\gamma^2(G+S-\delta)^2}{4\beta})$

b) If $\phi\Delta + q\dfrac{(1-\phi^2+4\phi)\gamma^2.4G^2}{8\beta} \geq I > \phi\Delta + q\dfrac{(1-\phi^2+4\phi)\gamma^2(G+S-\delta)^2}{8\beta}$ *multiple equilbria exist, whereby only one government provides launch aid {either Airbus provides launch aid and Boeing does not, or vice versa).*

Therefore, economic welfare is $W = 2(1+\phi)V + q\dfrac{(2+6\phi)\gamma^2G^2}{4\beta}$

c) If $I > \phi\Delta + q\dfrac{(1-\phi^2+4\phi)\gamma^2.4G^2}{8\beta} > \phi\Delta + q\dfrac{(1-\phi^2+4\phi)\gamma^2(G+S-\delta)^2}{8\beta}$ *no government provides launch aid.*

Therefore, $W = 2V$

In order to clarify our subsequent discussion of the implications of proposition 1, the results are presented graphically, as follows.

The diagram represents proposition 1, and demonstrates the combined effects of innovative spillovers (S), competition (δ), and required investment (I) on the governments' launch aid incentives and economic welfare.

Examining proposition 1, the top line in the diagram represents:

$$\phi\Delta + q\frac{(1-\phi^2+4\phi)\gamma^2.4G^2}{8\beta}$$

The lower (upward-sloping) line represents:

$$\phi\Delta + q\frac{(1-\phi^2+4\phi)\gamma^2(G+S-\delta)^2}{8\beta}$$

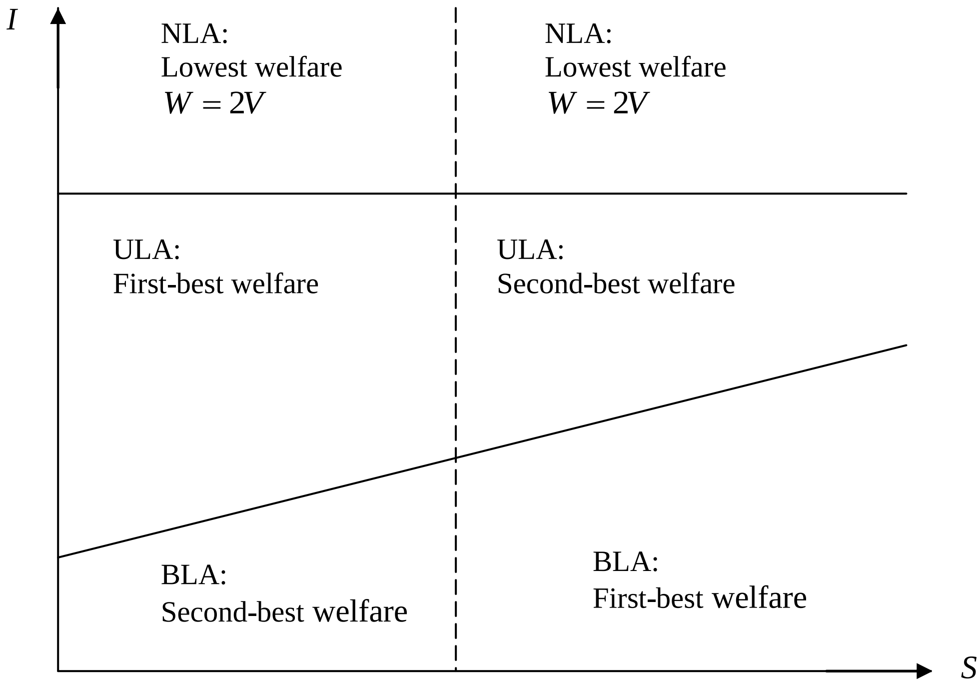

Diagram 1: The effect of innovative spillovers, product market competition, and required investment on governmental launch aid incentives and economic welfare

Hence, from proposition 1, these two lines partition the diagram into regions where no government provides launch aid (if investment is particularly high), one government provides launch aid (medium level of required investment: ULA = unilateral launch aid), or both governments provide launch aid (low level of required investment: BLA = bilateral launch aid).

The vertical line partitions the diagram into regions where unilateral launch aid provides first-best economic welfare (to the left of the vertical line, where, if both governments provided launch aid, the negative competition effects would exceed the positive spillover effects: $S < \delta$, compared with the case where bilateral launch aid provides first best welfare (to the right of the vertical line, where the positive spillover effects exceed the negative competition effects: $S > \delta$. Hence, different combinations of required investment I and spillovers S (with δ fixed) place us into different regions in the diagram, such that we can consider the effect on governmental launch aid incentives and economic welfare.

The argument can be summarized as follows. The governments' incentives to provide launch aid are driven by a) the market-capturing effect in relation to existing operations ($\phi\Delta$), the spillover effect minus the competition effect in relation to innovation ($S - \delta$), and the required investment I. Relevant to the launch aid dispute, proposition 1b) reveals that it may be rational for only one government to provide launch aid, particularly if a) the competition effect is high (so that the product market will only support one innovative firm), and b) the required level of investment is high.

In relation to economic welfare, the proposition demonstrates that a level of launch aid (either from one, or both governments) is preferable to no launch aid at all. The lowest level of economic welfare occurs in proposition c), where required launch aid investment is so high that neither government is prepared to provide launch aid. Furthermore, the case where both governments provide launch aid is first best (compared with the case where only one provides launch aid) if $S > \delta$, that is, if the spillover effect exceeds the competition effect.

Recall that it is assumed that both firms have identical R and D success probability, identical managerial ability, and both governments value project success equally. Another valuable insight from proposition 1b) is that, in spite of these equal factors, it may be optimal for only one government to provide launch aid, as the market may not support both governments doing so.

We may gain more insight by considering the sequential game in proposition 1b). Now, when the market only supports one firm receiving launch aid, there is a first-mover advantage. The government that 'gets in first' with its subsidy will deter the other government from providing such aid. Proposition 1 suggests that each government's decision to provide launch aid is driven by i) the private benefits it obtains from the development of its industry, ii) the government's assessment of the success probability of the project's innovation, and iii) the effect of competition.

3. Conclusion and Further Research

a) Launch aid has a negative aspect (competition distortion), and a positive aspect (innovation and R and D spillovers). However, since launch aid allows firms to invest in innovation, a level of launch aid is welfare-increasing.

b) Governmental incentives to provide launch aid are driven by the relative levels of the spillover effects and the competition effects, compared with the required level of innovative investment. Under certain levels of these parameters, the product market only supports one government providing launch aid.

c) Launch aid may be the only method of financing growth available, since governments are interested in helping the firm to innovate and grow, and furthermore, governments may be more far-sighted than myopic stock markets.

d) Even in the case where the stock-market provides finance, launch aid may enhance value-creating incentives, as governments give more equity to firms, due to the governments' private benefits from growth.

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German Air Passenger Duty

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Abstract: Legal issues concerning the taxation of international civil aviation are frequently the subject of aviation business and politics. The essential legal bases for taxation in aviation are laid down in the Chicago Convention. The Convention does not prohibit taxation in general, but sets in its articles 15 and 24 narrow limits. Comparing these limits and the German air passenger duty legislation the authors figured out an infringement of the Chicago Convention.

Keywords: taxation, Chicago Convention, air passenger duties

1. Introduction

The German "Luftverkehrsteuer" (air passenger duty) is subject of legal proceedings referring not only to German constitutional and European law but also according to questions of international air law (Finance Court of Berlin-Brandenburg (Finanzgericht Berlin-Brandenburg), judgment in the cases 1 K 1074/11 and 1 K 1075/11; other lawsuits still pending). The objective of this essay is to examine the German air passenger duty regarding its legality in the light of international air law and especially the Chicago Convention. This is an issue that was not raised yet. From this, the question has become apparent, what are the provisions of international air law for the taxation of international civil aviation? Answering this question may support the finding of justice in the abovementioned cases, which are important especially to third country airlines (non-EU-carrier).

The authors examined the legality of the German air passenger duty on the basis of a description of the legal framework of international aviation law, describing within which provision taxation of aviation is possible. An analysis of German legislation reviews, if these statutory provisions are observed.

2. Legal Framework Conditions

Basically, international aviation is a subject of global meaning and therefore subject of global standardization. This concerns not only technical but also legal and economic dimensions. In the first place Chicago Convention on International Civil Aviation defines the legal framework for international aviation. It lays down only the main provisions. All other significant substantive issues are the subject to the annexes.

The purpose of the Convention was to ease the air transport. According to the preamble of the Convention international air transport services' may be established on the basis of equality of opportunity and operated soundly and economically. This should not be read and understood only in the historical context, when the Chicago Convention was signed in 1944 to build up aviation in general. These objectives of the Convention still continue to apply. In that regard, the Convention has not changed, even if some new important issues have arisen, which were not anticipated – like environmental protection. This issue has not to be implemented necessarily into the Convention. Environmental protection is reflected by other means and also valid for aviation.

Against this background, the corresponding provisions of the Chicago Convention have to be understood. Concerning dues, charges and taxes the Convention contains two articles, article 15 and article 24.

Article 15 of the Convention refers to airport and similar charges, while article 24 refers to customs duty. Hence, article 15 governs charges concerning the aviation operation, while article 24 contains rules relating to the aircraft actually operating and the border crossing.

The Convention makes its rules rather starting from the principle of unlimited sovereignty of the contracting States. This position is found in article 1 of the Convention explicitly as follows: "The contracting States recognize that every State has complete and exclusive sovereignty over the airspace above its territory", which includes, of course, the recognition of the sovereignty over the territory itself with. This means for the present problem that each state has in principle also the revenue collection rights for all operations on its territory, provided that it is not limited by provisions of the Convention.

The scope of the Convention extends according to the preamble only to international flights. So domestic flights are subject to the state's sovereignty and rules of the Convention do not apply to them. This means at the same time that the tax offenses may only relate to operations in their respective territories. The national legislator may impose any tax or duty he considers desirable. But since the contracting States have voluntarily agreed to follow the rules determined in the Convention, they are bound for the adoption of provisions on charges for the international air transport. Consequently, all duties are allowed to the extent that they are not restricted or even prohibited by the provisions of the Convention. For a permitted levy this principle does not need to be repeated in the Convention. The provisions of the Convention can therefore only be understood either as regulation of certain duties or as their restriction or prohibition.

Still, even in international air transport there is one exemption possible. This occurs, when the contracting states agree on explicit contrary regulation in a bilateral or multilateral agreement. As a matter of fact, this is legally possible according the Vienna Convention on the Law of Treaties and customary international law. Especially within the European Union (EU) and its internal market, such deviations may occur. The consequence of the internal market in the airline industry is that the intra community flights are something comparable to regular domestic flights in "ordinary" countries.

3. Taxation Provisions for International Aviation

Under the Chicago Convention, certain rules for taxation of aviation are established – partially within the Convention itself, partly by other ICAO documents. These provisions are illustrated below.

3.1 Taxation Provisions under the Chicago Convention

According to article 15 paragraph 2 sentence 3 of the Chicago Convention the ICAO member states do not waive fees, dues or other charges on their territory solely of the right of the through-travel, entry or exit of an aircraft of a contracting State or persons or property on board. The content of this obligation is of course against the background of article 15 of the Convention.

To understand the concrete provisions under article 15, it is necessary to understand the conception of the used terminology within the Convention. The ICAO itself gives the explanation: In the ICAO policies there is a conceptual distinction between a charge and a tax, in that "a charge is a levy that is designed and applied specifically to recover the costs of providing facilities and services for civil aviation, and a tax is a levy that is designed to raise national or local government revenues which are generally not applied to civil aviation in their entirety or on a cost-specific basis" (ICAO's Policies on Taxation in the Field of International Air Transport, Doc 8632; and Resolutions adopted at the 35th session of the Assembly, Appendix I).

It is irrelevant that in the English text of the Convention the term "tax" is not used. Even after this distinction, the duties referred to in article 15 paragraph 2 of the Convention are no taxes but charges. This is for the charge pursuant to sentence 1 apparent, which is a levy that is designed and applied specifically to recover the costs of providing facilities, but also applies to the levy referred to in clause 3, as it is - as above already mentioned - in connection with the performance of the right of transit, entry and exit.

Thus, the levy mentioned in article 15 paragraph 2 sentence 3 of the Convention is in the understanding of the ICAO a "fee" or "charge", which is prohibited if the service exhausts "only" in the granting of these rights (i.e. when their aim is not the financing of air navigation facilities and services coming to the payer's benefit; compare Bielitz [2005], p. 65 et seqq.).

Against this background, therefore all levies are initially permitted to the extent this has not been restricted or even prohibited by the provisions of the Convention. For a permitted levy this principle does not need to be repeated in the Convention. The provisions of the Convention can therefore only be understood either as regulation of certain duties or as their restriction or prohibition. Article 15 paragraph 2 of the Convention distinguishes between lawful duties (those that are not explicitly stated) and are regulated or prohibited fees (which are the ones that are expressly mentioned there), as follows:

- Due to the (not explicitly mentioned in article 15 of the Convention) principle of state' sovereignty all taxes are initially permitted to the extent they are not specifically regulated or prohibited;

- Regulation of Article 15 paragraph 2 sentence 1 of the Convention: For fees referring to the use of airports or air navigation facilities, a prohibition of discrimination is established, in the manner that the fees for foreigners shall not be higher than for residents (under the specific conditions);

- Prohibition of Article 15 paragraph 2 sentence 3 of the Convention: As far as it concerns "solely" the "right of transit, entry or exit", the contracting States shall not impose "fees, dues or other charges". An additional prohibition of discrimination is not required here, as the contracting States have committed each other, just not to impose such charges. The provision therefore cannot be considered as prohibition of discrimination.

The prohibition in Article 15 paragraph 2 sentence 3 of the Convention, however, is only legally relevant if there is such a "right of passage, entry or exit". Only then it can be put it in a ratio of performance and counter performance. Despite the fact that Article 15 paragraph 2 sentence 3 of the Convention obviously presupposes the existence of such a right, the following should be considered:

Usually aircrafts are allowed to leave their particular national territory only with permissions, as well as foreign aircrafts only may fly in the sovereign airspace of another country only with its permission. This applies at least for the commercial aviation and complies with article 6 of the Convention (in Germany: § 2 para. 6 and 7 of the German Civil Aviation Law). These permits are usually issued on the basis of the principle of reciprocity, either multilateral (here the freedom of flight through the transit agreement – 1st freedom) or bilaterally, i.e. by “Air Services Agreements” (here the freedom of entry into and the trip for commercial purposes by the OSA - 3rd to 5th freedom). Against this background, the effect of article 15 paragraph 2 sentence 3 of the Convention that this reciprocal vested freedoms of transit over or entry into or exit a foreign territory should not be hampered by unilateral measures, at least not if they “solely” pursue this purpose. This applies regardless of whether a state is exercising the privileges granted in an air service agreement by himself or by a designated airline. Thus, it should be noted that the possibilities of transit, entry and exit of a foreign airspace belongs to one of the central pillars of the Chicago system.

Article 15 (in conjunction with article 24) is to be understood against the background of the ratio of the above-described principle (state sovereignty) and exception (prescribed as in the Convention). Therefore it does not covers the topic of “taxes” comprehensive, but only regulates limitations of the otherwise comprehensive state sovereignty.

However, on the face of it, it seems that article 15 paragraph 2 of the Convention deals with this matter not exhaustive, as the Convention addresses levies at a further point (in article 24), too. There it is settled in particular, that fuel, lubricants, spare parts, regular equipment and aircraft stores shall be exempt from customs duty, inspection fees or similar national or local duties and charges under the provisions of this article.

It should be noted that the initial situation, and thus the structure of the two articles in question is different. Whereas article 24 presumes the existence of general taxes (customs duties, etc.), it rules an exemption for aviation, while article 15 deals with levies specifically related to aviation. Article 24 is an exception rule, while article 15 paragraph 2 a regulation rule (sentence 1) or a prohibition rule (sentence 2). The provision therefore cannot be understood as an extension or addition to article 15. From this and from the fact that the Convention does not mention taxes elsewhere, it can be assumed that article 15 paragraph 2 of the Convention is an exhaustive regulation concerning taxation in international aviation compare (Bielitz [2005], p. 71 et seqq.).

3.2 Taxation Provisions under the ICAO Policy

Beyond the provisions for taxation of the Chicago Convention, the ICAO dealt with the issue taxation for years.

The ICAO has stated its “policy” in a Council decision (Doc. 8632 (2000), "ICAO's Policies on Taxation in the Field of International Air Transport"). This “Council Resolution” distinguishes between charges (charges) and taxes (taxes), and that - as described already above - in the way that fees are charges of covering the costs incurred for the use of facilities or for the use services are used, while controlling for the purpose of pure revenue generation are collected.

The resolution deals especially with the taxation of fuels and lubricants and with the taxation of the sale and the use of international air transport services. With regard to the first category it should be noted that this referred to article 24 (a) of the Convention. Fuels and lubricants are exempted from taxes, but only on the basis of reciprocity (the latter aspect is not mentioned in the Convention).

In terms of sale or use of international air transport services the resolution is, that each contracting State shall be obliged to reduce all forms of taxes as much as possible and to make plans for its abolition (“shall reduce ... and make plans to eliminate”). In addition, each contracting State shall inform the ICAO whether and what kind of taxes he collects so far and what countermeasures it will take.

Such appeal has not the same binding character as the Chicago Convention or its annexes. At least, they represent ICAO’s will to abolish levies to ensure best possible conditions for the ease of the international aviation.

On the last ICAO Assembly (end of 2013), the above-described “policies” were confirmed one more time: In its Decision A38-14 (consolidated statement of continuing ICAO policies in the air transport field, Appendix D), the General Assembly urged the Member States, in turn, to follow the Council's decision in Doc 8632, in order to avoid the imposition of discriminatory “taxes”. Furthermore, the Council was asked to ensure that the procedures and instructions in Doc 8632 is current in order to promote their use even more vigorously.

In the explanatory part of the Council Decision it is stated that such taxes are in contradiction to modern trends to liberalize trade and services and remove barriers (ICAO Doc 8632, commentary no. 13 on Council Resolution).

Beside the prohibition settled in article 15, there is this appeal to abolish the respective levies. Especially the contracting States which voted in favor of the resolution have a moral duty to respect and follow the provisions of the Chicago Convention and the ICAO policy.

4. The German “Luftverkehrsteuer” (Air Passenger Duty)

As evidenced by the supplement to ICAO Doc. 8632 (dated from 15th January 2013) a total of 19 of the 191 Member States of ICAO impose “Taxes on the Sale and Use of International Air Transport”. Probably, this list is incomplete. A quick research on the internet already reveals that other countries impose a sort of charge for air transport.

Of these 19 states 6 states use the income for aviation-related purposes, i.e. not contrary to article 15 paragraph 2 sentence 3 of the Convention. Six of the remaining 13 states have made no indication of the intended use, so that at least according to this list 7 out of 191 countries, including Germany, impose duties contrary to article 15 paragraph 2 sentence 3 of the Convention.

As stated above, the Member States did not submit sovereignty rights through the Convention to the ICAO. This means at the same time that the tax criterion may only relate to operations in their respective territories. § 1 para 1 of the German Air Passenger Duty Law describes the subject to tax as "legal process that ... entitles to the departure of a passenger from a domestic starting point". This legal process is usually a contract of carriage.

In cases where the contract of carriage has been concluded abroad, § 1 para 1 of the German Air Passenger Duty Law ties on a contract outside the German territory. Thus, this regulation is colliding with foreign sovereignty and is at least insofar unlawful, as he includes also those cases in German taxation.

The following should show that the German Air Passenger Duty Law independently from specific problems of its design is already unlawful for an infringement of article 15 of the Chicago Convention.

Article 15 paragraph 2 sentence 3 of the Convention prohibits the collection of "fees, taxes or other charges" in return "solely" for the exercise of the "right of transit, entry or exit". The German Air Passenger Duty violates this prohibition.

With its subject to tax of "legal process leading to a departure be entitled" it is ostensibly linked to a state power, but to a private law transaction (usually to a contract of carriage). Since the general government budget benefits from the raised revenue, it is considerable to assume them as a tax (assuming the contract of carriage has been concluded in Germany). This would be allowed according to the principle of national sovereignty and would not collide with the Convention.

The ICAO sees this obviously stricter. In the Doc 8632 ("ICAOs Policies on Taxation in the Field of International Air Transport"), the Council decided that Member States shall "reduce taxes on the sale and use of international air transport" ("to the fullest practicable extent") and make plans to eliminate these taxes, as soon as is practicable in the economic conditions.

Regardless of how to understand the different wordings in the English and German text of the Convention, the contract of carriage as the subject to tax is not dependent on state benefits, but is not conceivable without such power. Focus of the contract of carriage as a contract for work is the delivery of the passenger at the foreign destination. This process does not require any power of the German state, just as the departure. However, the German government has to permit the exit (see § 2 para. 6 and 7 of the German Civil Aviation Law and article 6 of the Convention). Thus, the fulfillment of the contract of carriage is unthinkable without the participation of two Member States: The involvement of the German government through the exit permit and participation of the target country in the way of the approach permit (and as the circumstances require the involvement of a third State by way of flying through permission).

§ 1 para. 1 of the German Air Passenger Duty Law bases only on the outgoing flight rather than the permission that follows from the contract of carriage. Hence, this is at least short-sighted. A connection with an event that is necessarily connected with the fulfillment of the contract of carriage does not alter the fact that the actual interests of air passenger who has purchased an international ticket, is directed to leave one country (exit) and to fly to another country (entry).

Regardless of whether this is mentioned in § 1 para. 1 of the German Air Passenger Duty Law, the legal process "international contract of carriage" entitles not only to the outgoing flight, but much more still to leave the country (as well as for the entry). An aviation company as the contracting party (paid for the carriage the agreed charge) is involved in this legal process as well as the German government by granting this possibility. The German Air Passenger Duty as an obligation to the government cannot be separated from this grant of rights.

The German Air Passenger Duty is also levied "solely" for the right of exit. The earnings are included in the general government budget, i.e. that no air navigation facilities or services are financed with the income from the German Air Passenger Duty. This makes the German Air Passenger Duty different from taxes which are raised in other states, in order to finance air navigation facilities or services.

The German Air Passenger Duty is illegal for this reason.

5. Infringements of International law

There are a variety of possibilities to violate the provisions and principles set out above. But there are just few methods to take countermeasures against such infringements.

Basically, there are two approaches imaginable, how to react to unjustified taxes. On the one hand it is possible to proceed against the legal basis itself (against the abstract legislative infringement), and on the other hand it is possible to file a suit against the national tax bill, to which the specific tax is payable (against the concrete administrative infringement).

The latter option is necessary anyway for airlines burdened with the tax. This is the only possibility for the tax debtor to avoid the payment of an unjustified tax. But this option does not apply to contracting States, who are infringed in executing their right of transit over or entry into or exit from a foreign territory (which at least is commissioned to a designated airline).

Only the first type of approach fights the infringements in general and is open to the action of a single State or the ICAO community.

The Chicago Convention provides a possibility for the settlement of disputes according to the Chapter XVIII, namely article 84 et seq. of the Convention within the Chicago system. Article 84 sets that if any disagreement between two or more contracting parties cannot be settled each ICAO member can invocate the ICAO Council, which has to decide about this disagreement. The concrete provisions are settled in the ICAO Rules for the Settlement of Differences (Doc 7782/2). Actually, it is doubtful, if the settlement of disputes under article 84 would be exerted. Until now, no Member State has shown any interest to do so.

Thus, it can be assumed that the political option within or outside the ICAO will be probably the most effective way to face infringements of international law.
Following the above, the tasks and powers of the ICAO on the one hand and on the obligations of Member States under the Chicago Convention on the other hand, it must be emphasized that the ICAO is not "master of the Convention" in such a way that they have the authority to interpret the understanding of his article. However, ICAO's view on individual issues should be

of particular weight, as the ICAO is called for by the Convention to fill it with life in the manner described above. This "interpretation weight" has no effect because of the character of the ICAO as a purely international organization without its own jurisdiction. Their findings on specific issues are not legally binding and they cannot be implemented with appropriate enforcement measures. The ICAO cannot “instruct” its members to refrain their violations against the Convention. There just remains the way of “naming and shaming” of Convention’s infringements. This more diplomatic / political lever is frequently used by the ICAO organs (for example, in the implementation of safety programs by audits of the Member States, as well as publishing the results on the official website of ICAO).

If the ICAO therefore only denounces or appeals to the Member States concerned referring to Convention’s infringements, this is the effect of the fact that it has no enforcement powers. So the Assembly cannot do more, than to

1. Urge Member States to follow the resolution of the Council as contained in Doc 8632, ICAO’s Policies on Taxation in the Field of International Air Transport so as to avoid imposing discriminatory taxes on international aviation;

2. Urge Member States to avoid double taxation in the field of air transport; and

3. Request the Council to ensure that the guidance and advice contained in Doc 8632 are current and responsive to the requirements of Member States and to continue to promote their application more vigorously;”

like the Assembly did in the last meeting (Resolution A38-14, Appendix D – Taxation, p. 50).

Ultimately, it will probably remain only in the admonitions, unless an infringement will occur, which has a similar scope and impact, such as the EU ETS. In this case, the international community achieved through political pressure - without a legal binding evaluation of the EU ETS - to suspend the EU's decision on the application of a supposedly unjustified levy (compare *Schwenk/Giemulla*, p. 794 et seqq.).

6. Conclusion

Taxation in international aviation is not strictly forbidden. Hence, the Chicago Convention sets some limits to the creativity of its Member States to generate revenue for the national budget. Levis in international air transport are allowed, if there is a purpose to reward a performance (according to the ratio of payment only at performance and counter performance).

Thus, the German air passenger duty infringes the provisions set by the Chicago Convention and the ICAO policies. Until now this issue was not considered in any ruling of a German court. The finance court Berlin-Brandenburg examined the air passenger duty in the light of national and European legislation only. Regarding the above mentioned findings and perceptions a different ruling seems to be possible – that the German air passenger duty will be found an infringement of international law and thereby unlawful.
Beyond the legal perspective of this issue, there has still to be considered the economic impact on international aviation by imposing taxes, duties and other charges. One main fact changed since the foundation of the ICAO and signing the Chicago Convention. When 1944 the contracting parties agreed on the principles of international civil aviation, this industry hardly

existed. In the meantime the world gained an enormous aviation industry. Insofar the aviation business may contribute to the tax revenue.

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All on Board for Environmental Analysis in Aviation?

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Abstract: Life Cycle Assessment (LCA) is a suitable tool for analyzing and assessing environmental impacts caused through production, use and disposal of products or product systems for specific applications. Depending on the goal and scope of a LCA study, LCA does not produce clear-cut straightforward assertions, but rather it gives diverse and complex results. It supports the process of decision-making by making complex issues transparent [1]. It is a useful technique for assessing the environmental aspects and potential impacts associated with a product by first compiling an inventory of relevant inputs and outputs of a product system; second to evaluating the potential environmental impacts associated with those inputs and outputs and third to interpret the results of the inventory analysis and impact assessment phases in relation to the objectives of the study. LCA studies, according to the ISO 14044 [2] analyzing the environmental aspects and potential impacts throughout the product's life (i.e. cradle to grave) from raw materials acquisition through production, use and disposal.

The presentation deals with the methodological basis, shows an overall life cycle of an aircraft and gives an example of an on-going EU project, how the approach is applied and environmental impacts in the aviation sector are quantified.

Keywords: eco-design, Life Cycle Assessment (LCA), carbon footprint, environmental assessment, green design, aviation supply chain management

1. General Introduction

1.1 Life Cycle Assessment (LCA) Methodology

The Life Cycle Assessment (LCA) is a suitable tool for analyzing and assessing environmental impacts caused through production, use and disposal of products or product systems for specific applications. Depending on the goal and scope of a LCA study, LCA does not produce clear-cut straightforward assertions, but rather it gives diverse and complex results. It supports the process of decision-making by making complex issues transparent. The standard ISO 14040 [1] defines a LCA as follows:

LCA is the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its entire life cycle.

The concept of a LCA is mainly related with the following basic aspects [1]:

- the observation of the whole life cycle of a product - from raw material extraction, processing and production to its use, recycling and disposal.
- the coverage of all those impacts associated with the life cycle on the environment, such as raw material and energy consumption, use of land, emissions to air, water and land, as well as waste.
- aggregation and assessment of these impacts in view of the possible effects on the environment with the aim of assisting environment-oriented decisions.

According to the ISO 14044 [2] the application of a LCA can assist in:

- identifying opportunities to improve the environmental aspects of products at various points in their life cycle;
- decision-making in industry, governmental or non-governmental organizations (e.g. strategic planning, priority setting, product or process design or redesign);
- selecting the relevant indicators of environmental performance, including measurement techniques, and in
- marketing (e.g. an environmental claim, eco-labeling scheme or environmental product declaration).

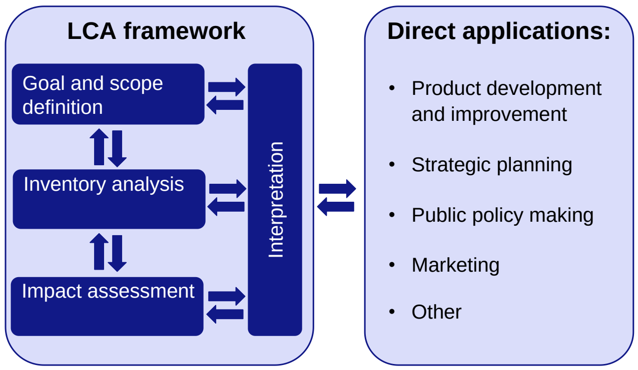

Figure 1: Phases of a LCA [1]

As shown in Figure 1, a LCA is standardized into the following phases - goal and scope definition, inventory analysis, impact assessment and interpretation [1]. The figure identifies the reciprocal influences of the individual phases and therefore shows the iterative character of a LCA. The application and the framework of the LCA have been purposely separated to show that an application or a decision is not automatically given through the results of a LCA study. The responsibility for an appropriate application of LCA data remains with the user; it cannot be taken on by the client or the practitioner of a LCA study. The single phases of a LCA are described in the following.

- The **Goal** of the study addresses two main aspects: the reasons and motivations for carrying out the study, and its intended applications and intended audience. The **Scope** defines the system boundary for the study, clearly stating what is included or excluded. It also states the functional unit of the study (e.g. 1kg of product) to which all results are related.
- **Life Cycle Inventory Analysis** is the phase of life cycle assessment involving the compilation and quantification of inputs and outputs, for a given product system throughout its life cycle.
- **Life Cycle Impact Assessment** aims at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system (ISO 14040).
- The final phase of the LCA is the **Interpretation**. Here the results are examined and summarized. This enables significant contributors to be identified and recommendations made to reduce the potential environmental impacts of the product. The interpretation of the results may lead to further investigation or redefinition of the goal and scope, and collection of more data in the LCI phase.

1.2 Life Cycle Assessment (LCA) Software Tools and Databases

In order to increase the efficiency in carrying out a LCA, electronic databases and software systems have been created that cover the individual requirements. Many of these databases provide LCI data from various sectors and calculation procedures for the results (e.g. various LCIA methods). Prominent examples of databases, which are embedded in modeling software tools, are such that as of GaBi software.

The professional LCA Software-System GaBi (www.gabi-software.com), which is one of the leading tools for LCA and LCE (Life Cycle Engineering) worldwide, is acknowledged for its intuitive software, database quality and volume; hence GaBi [3] is used by companies, industry associations, government institutions, researchers and consultants. It also contains the datasets provided by the European Commission on their platform (further information can be found: [4]).

1.3 The EU-Project NICETRIP

The NICETRIP project specifically addresses the acquisition of new knowledge and technology validation concerning the tilt-rotor and is fully relevant to the strategic objective 1.3.2.1: “Integration of technologies towards the future tilt-rotor aircraft”, of the work programs of call 3 “Thematic Priority Aeronautics and Space”. The main project objectives are:

- To validate the European civil tilt-rotor concept based on the ERICA architecture,
- To validate critical technologies and systems through the development, integration and testing of components of a tilt-rotor aircraft on full-scale dedicated rigs,
- To acquire new knowledge on tilt-rotor through the development and testing of several wind tunnel models, including a large-scale full-span powered model,
- To investigate and evaluate the introduction of tilt-rotors in the European Air Traffic Management System,
- To assess the sustainability of the tilt-rotor product with respect to environmental issues and to define the path towards a future tilt-rotor flying demonstrator.

The aims of the overall sustainability task are to provide a holistic picture and a reasonable environmental evaluation of the rotorcraft system that includes total life cycle considerations. The environmental profile will be determined, based on the environmental key parameters, e.g. emissions or energy consumption, to identify the environmental processes of relevance (“hot spots”) over the life cycle of the considered rotorcraft system [5].

2. Systematic Analysis of the Overall Life Cycle of an Aircraft

As explained in Section 1, the life cycle contains the 3 phases: production, operation and End-of-Life (EoL) of the air transport system, in this case the tilt-rotor system given by the EU project NICETRIP. The maintenance will be also taken into account.

Definition of the aircraft system

To assess the environmental impacts of the NICETRIP aircraft, all information on the three different life cycle phases (production, operation and EoL) have to be modeled. In the first step, data on materials, processes and technologies were gathered from companies participating in the project. In the second step, data on the operation of the aircraft were assumed, taking into account the simulation and design values given in the project, as it is not yet a flying demonstrator. To the operation phase, the maintenance was added, as during the lifetime various parts will be replaced. The third step included the possible way of recycling the aircraft, as also up to now no guidelines exist and therefore standard recycling routes were investigated. The information from these 3 steps was used to create a model in the GaBi LCA software. Based on this model, the environmental impacts of the production of the NICETRIP aircraft were evaluated.

The specifications and aircraft characteristic used for the design are summarized in Table 1. The design empty gross weight is given by 7070 kg [5]. The design values of the tilt-rotor aircraft are separated into the STOL (Short Take-off or Landing Aircraft) and VTOL performance values (Vertical Take-off or Landing Aircraft) (see Table 1).

Range	1200 km
Cruise altitude	7500 m
Empty gross weight	7070 kg
Gross weight-VTOL	10870 kg
Alternate gross weight STOL	11570 kg
Payload-VTOL	19 passengers with luggage
Payload-STOL	22 passengers with luggage
Cruise speed-VTOL mission	300 knots (around 556km/h)
Cruise speed-STOL mission	330 knots (around 610km/h)
Operative range-VTOL	650 Nautical Miles (NM)
Operative range-STOL	820 Nautical Miles (NM)

Table 1: Main design characteristics of the tilt-rotor aircraft [5]

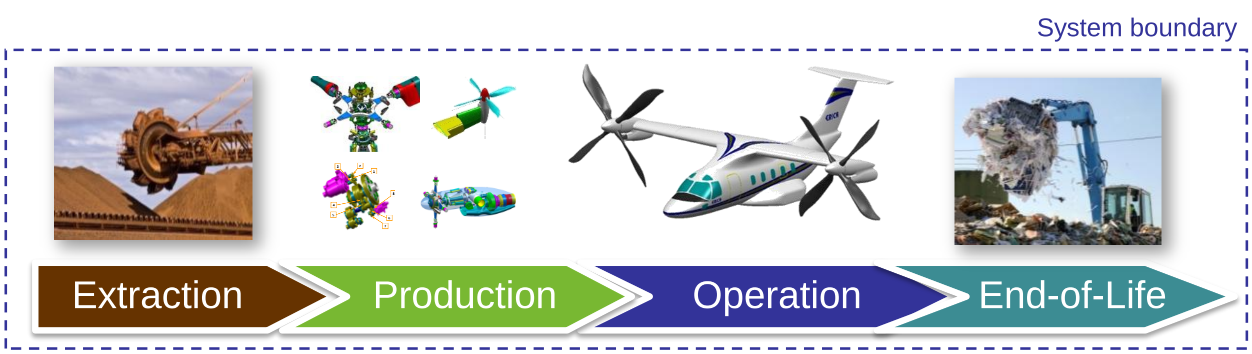

Figure 2: Life cycle of a tilt-rotor aircraft

3. Results and Discussion

The LCIA results will be based on the scientifically based impact categories Primary Energy demand (PE), Global Warming Potential (GWP), Acidification Potential (AP), Eutrophication Potential (EP) and Photochemical Ozone Creation Potential (POCP).

Due to the flexible and modular setup of the production phase of the tilt-rotor system in GaBi, it first offers the opportunity to analyze the specific components and modules of a tilt-rotor aircraft. Secondly, several parameters and modules within the tilt-rotor aircraft can be exchanged, for example by replacing individual components with different materials on weight or processing technologies to calculate scenarios or design alternatives.

The tilt-rotor aircraft in this study was mainly made of aluminum (about 30%), CFRP (about 21%), stainless steel (about 17%), titanium (about 8%) and other materials (about 24%, Copper, Rubber etc.). Standard processing technologies for the materials were used, for example casting, die-casting, machining and prepreg-autoclave molding. Since the data on the specific processing technologies of the materials in the aviation sector were not available, profound estimations were used and to some extent, standard processes from other industry sectors in the GaBi database were used.

Due to the complexity of the aircraft, it was subdivided into 3 main modules: "airframe", "power plant" and "auxiliary system". Summarizing the results for the tilt-rotor system with the production of the modules "airframe", "power plant" and "auxiliary system", it is obvious that the influence of the airframe and power plant dominates the environmental impacts on the overall production of the tilt-rotor aircraft. The most relevant processes of the module "airframe" are the production of the fuselage including the production and machining processes of aluminum and other metals as well as the production of the wing, which contains the manufacturing and prepreg-autoclave molding process of CFRP. A closer look on the production of the module "power plant" shows, that the production of the engines, the drive system, the rotating control and the rotor hub are the main contributors to the environmental impacts. The relevance is related to engines, which were made of various metals, predominantly titanium, tantalum and nickel based super-alloy. These metals are energy intensive to produce and associated with high emissions for their production. The production of the rotor hub requires a variety of materials, mainly stainless steel, aluminum and CFRP. The production and processing of aluminum is another important contributor to the overall environmental impacts. The rotating control is also mainly made of aluminum. Especially the production of the drive system, which requires a significant amount of stainless steel, contributes with a share of 65% to EP. The production of the module "auxiliary system" plays a minor role for the overall environmental impacts. The production of the flight control system dominates this module. The impacts of this production process are mainly related to the production of carbon fibers and the prepreg-autoclave molding of the CFRP.

The operation phase of the NICETRIP aircraft covers both the flight phase and maintenance processes. During the flight phase, kerosene is combusted in the engine, causing emissions on the ground and in the air. The production and provision of kerosene also causes environmental impacts. For maintenance, spare parts have to be constructed, which requires material and energy. Furthermore, the process of exchanging parts and disposing or recycling old parts has effects on the environment. All those aspects are covered in the assessment of the NICETRIP operation phase.

During the assessment, it was found that the operation phase of the NICETRIP aircraft is causing most of the total environmental impacts, contributing about 98 % of total life cycle impacts in each impact categories. It is therefore by far the most relevant phase during the life cycle. Within the operation phase, the flight phase causes the majority of impacts. This is due to the relatively long lifespan of the NICETIP aircraft (and aircrafts in general), combined with the long distances covered be aircrafts in general. Based on the underlying assumptions of this study, a total distance of 3,000,000 km is covered during the lifespan, thus resulting in a total fuel consumption of about 4.5 million kg of kerosene. This corresponds to a per-capita fuel consumption of 11.7 kg of kerosene per 100 Person Kilometers (PKM) (corresponding to 14.6 l of kerosene), assuming a seat load factor of 68.1 % and an average flight distance of 735 km. This results in emission of 42.2 kg of CO_2-equivalents, 0.16 kg of SO_2-equivalents, 0.02 kg of PO_4^{3-} -equivalents and 0.01 kg of C_2H_4-equivalents, as well as a Primary Energy demand of 596 MJ.

Against the background of a growing awareness for ecologic problems and limited availability of resources, EoL processing of materials and products is getting more and more important. It allows reusing materials for similar or other purposes and thereby reducing the demand of primary raw materials. Materials that cannot be recycled can be thermally recovered in order to benefit from the embodied energy, which again reduces the consumption of energetic resources.
As the level of knowledge in the aviation sector in general and for the newly developed NICETRIP aircraft is generally low, well-founded assumptions are taken to give estimates for EoL processes. Therefore, recycling quotas from other sectors are used, combined with standard EoL processes from other industries.

It was found, that environmental impacts can be reduced by recycling and recovering materials of the NICETRIP aircraft from 5-20 %, depending on each impact category. It can thereby drastically reduce the effects of production and maintenance processes. Furthermore, it was found that thermal recovery of materials with a high energy demand such as CFRP only offers a small energetic benefit, while the environmental impacts of its combustions are rather large.

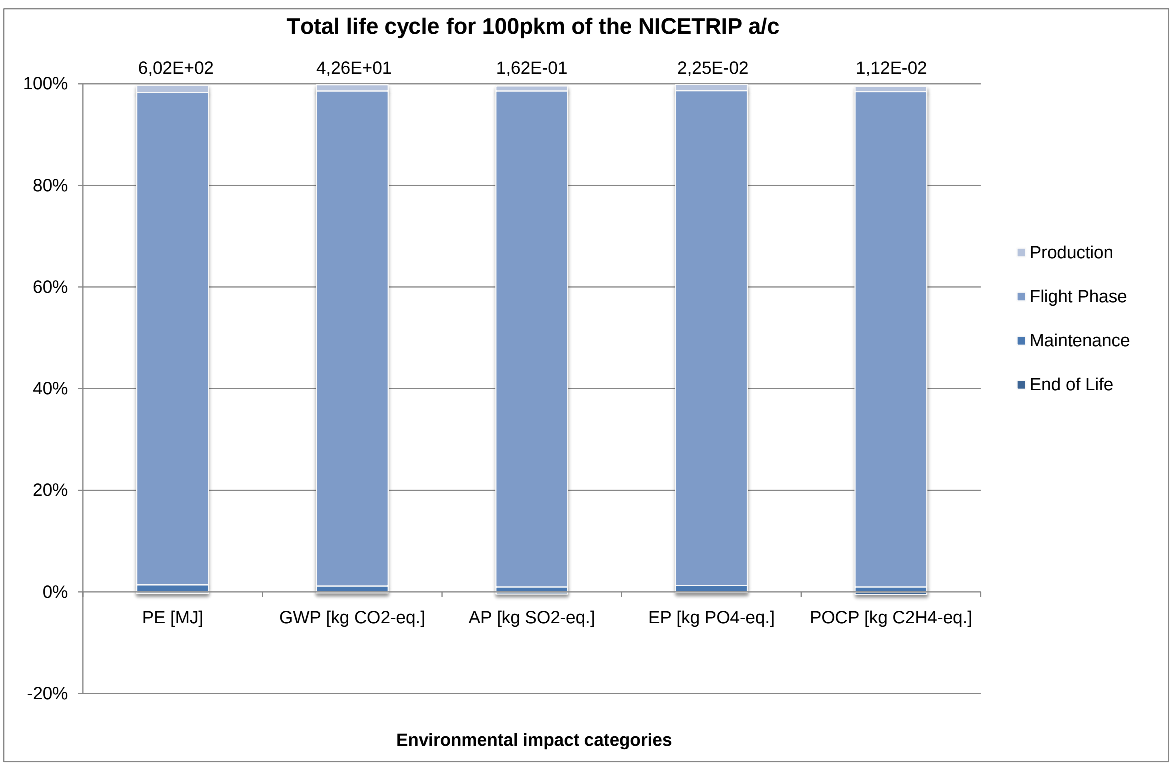

Figure 3: Environmental impact categories for the life cycle of the NICETRIP aircraft

It also has to be stated that information on environmental material and processing, respectively technological, data used in the aviation sector still have to be increased. This will lead to more accurate results and quantification of the aircrafts production phase. Further research should be undertaken by analyzing the final design and upscaling of the prototype aircraft.

4. Conclusion

Further research on the tilt-rotor aircraft production with detailed information should be improved in the future. Also, thinking about a possible future tilt-rotor aircraft, investigations and studies have to be conducted, which includes materials and processing technologies specifically addressing the aircraft sector. High alloyed materials and energy intensive compounds are used for the production of the tilt-rotor. Reducing the energy used for some processes, e.g. autoclave process could be used more efficiently (load of autoclave could be increased), could be an option. Also thinking about new production technologies could be used to reduce the energy intensive machining, e.g. new technologies like Quickstep (out-of-autoclave manufacturing) or Additive Layer Manufacturing" (ALM). On the contrary, more energy intensive and lightweight production processes could lead to less weight in the overall tilt-rotor production, leading to less emissions in the operation phase, therefore the production should not be regarded separately.

Due to the large impact of the operation phase, the use of biofuels could be an option. It can help in reducing greenhouse gas emissions and the primary energy demand. CO_2 is withdrawn from the atmosphere and embodied in the plants while they grow. Furthermore, the fuel gained from renewable resources reduces the amount of fossil energy carriers (in this case oil) required and thereby reduces the primary energy demand. This might be a way to reduce emissions of CO_2 in a very fast way. Furthermore, increasing the seat load factor is an efficient way to reduce per-capita impacts, as total impacts are divided among all passengers aboard and the number of total flights can be reduced. Finally, improving the operational performance should always be a goal. As it will be shown, maintenance (and production) only has a small environmental impact compared to the flight phase. Therefore, exchanging parts and components with newly-developed, lighter or higher performance part during maintenance or overhaul may not only reduce the environmental impacts over the life cycle but also generate economic benefits by reducing fuel consumption.

A goal for EoL processing should be to reduce scrap rates as well as material and energy consumption during production processes as much as possible in the first place, since EoL processes can never recover all energy or materials. Nevertheless, an approach to reduce the environmental impacts here can be to improve the efficiency of recovery processes. This could be done by establishing a system to retrieve as much material as possible, and by trying to raise the recycling quote.

Summing up, by conducting LCA a statement on the ecological benefit of lightweight concepts by the consideration of the entire life cycle can be assessed. By focusing the awareness of the designers for the environmental importance of individual materials, processing technologies and the correlations amongst production-, operation- and EoL phase of the tilt-rotor aircraft, a major contribution to the development of a sustainable tilt-rotor aircraft can be provided.

In general it is to say that due to the overwhelming environmental relevance of the operation phase, measures to improve the environmental performance should target this phase. From an environmental point of view, it seems justified to increase construction and maintenance efforts in order to reduce the operation phase impacts over the entire life cycle.

LCA captures environmental impacts across the entire life cycle, and thus is the ideal approach to have a quantified and sound basis to calculate environmental costs and implement effective solutions on a future path to a sustainable and green aviation.

5. Acknowledgement

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Assessment of Service Quality and Passenger Satisfaction of Air India

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Abstract: The principle objective of this research paper is to evaluate and assess the passenger satisfaction and expectation of Air India. To gain deeper understanding of what customers expect from airline's service quality as well as customers perception of Air India's service experienced, a service quality framework instrument was used known as SERVQUAL. A self completion questionnaire was developed to assess the discrepancy between the customers' expectation and perception on five key service quality dimensions. Through this SERVQUAL tool it was evaluated that passengers were not 100% satisfied with Air India's service quality. It achieved a satisfactory response on the product and service offerings but gained an unsatisfactory response on delivering these services due to unstable management approach. Over the completion of this research it was achieved that Air India lacks a competitive edge in comparison to its rivals resulting directly to low passenger satisfaction.

Keywords: service quality, SERVQUAL, Air India, expectation, perception

1. Introduction

Deregulation of the airline industry in 1978 and liberalization transformed the industry into a growing competitive market. Intense competition has shifted the focus of airlines towards a customer oriented service quality and quality management approach as opposed to a product oriented service (Chang & Yeh, 2002). Price is no longer the sole variable factor affecting consumer choice in the airline sector except for in the case of budget travel. Understanding just the perception of passengers of airlines service offerings is not only important but finding out what customers expect from the services also becomes a vital analysis for service providers (Chen & Chang, 2005). Service quality is created on each step of the travel process and thereby becomes a key to attract and sustain loyal customers (Liou & Tzang, 2007; Chang & Yeh, 2002).

Quality of service can be defined as a comparison between expectations and perceptions, in short how well a service is matched with the customers' expectations. Through providing travelers with superior quality of service airlines gain a competitive advantage over its rivals in terms of retention, market share, profitability and increased customer satisfaction (Morash & Ozment, 1994). According to (Tse & Wilton, 1988), customer satisfaction is the consumer's response to evaluation of the perceived discrepancy between prior expectation and actual performance of the product as perceived after its consumption. Understanding the importance of the same is paramount as customers are carriers' only assets (Carlzon, 1987) and a poor performance of service quality is often criticized publicly creating a bad image of the airline.

Airline industry being a multifaceted concept comprises of various factors that form a travelers flying experience and a critical distinction is that it is possible for customers to be highly satisfied but not loyal and the vice versa. Hence, the success of a carrier is directly affected by the satisfaction level of the service offerings. This research aims to evaluate the expectations and perception of India's state owned carrier Air India using a statistical tool called ServQual to assess its importance to a target group of customer chosen for the survey.

2. Methodology

2.1 Research Approach

A deductive approach has been adopted to carry out this research project. The content included in this research paper has been obtained from secondary as well as primary sources in order to achieve the objectives set out in this research paper. Secondary research has been presented in the literature review and primary research in the main findings. The information found in this research paper has been critically analyzed and evaluated using high order skills supported with evidence researched.

2.2 Secondary Research

Online sources and journal was used to gather relevant information related to Air India's product offerings and services in line with its business model. Various reports and articles were viewed to gather data regarding management practices.

Firstly, how the era of product oriented service changed into customer oriented service and changes in buying patterns and behavior in the aviation industry was viewed through various articles. The airlines timeline history was read upon. As well as various articles and expert opinions on the same aspect was viewed to get a clear picture. Air India's financial report was viewed to gather understanding in terms of their profitability and loss. Other researchers paper concerning this carrier as well as on significance of service quality was also touched upon. Lastly, travelers review Skytrax's was read to get a clear and an overall picture of passenger's perception.

2.3 Primary Research

A service quality framework tool known as SERVQUAL developed by Zeithaml, Parasuraman and Berry has been used to formulate questionnaire and measure passenger expectation of service quality and perceptions of the service they receive. This model has been adopted as researchers and managers believe that the best way to determine passenger satisfaction of a service provider is to understand the discrepancy between expectation of service quality and perception of service experienced. Using the SERVQUAL instrument a self completion questionnaire comprising of 22 statements was developed.

2.4 Respondents

Survey was handed out as well as placed online through social media and various channels to reach out to a wider section of people. Survey responses were obtained from passengers who have flown with Air India at least once. A total of 104 respondents were gathered out of which 54 were obtained through online and the remaining 50 were given out.

2.5 Limitations

- Acquiring unbiased and accurate response from the respondents.
- The quality of information may vary due to varying degree of time and brand awareness.
- Service quality dimensions were considered on a generic level and not on the basis of different cabin class.

3. Key Findings

3.1 Secondary Data Results

3.1.1 India's Airline Industry

Aviation has been a lifeguard for a country's economy in many parts of the world. The same holds true for the Indian Aviation sector as well. The liberalization in 2003 has unleashed a powerhouse for the Indian economy. But for over a decade critical uncertainty prevails the Indian aviation sector. Airlines in India face a challenging year due to weak financial performance, mainly of rising costs and regulatory uncertainty. Apart from the internal issues, rapidly changing and dynamic global environment pile pressures on poor performing airlines in the industry.

3.1.2 Business Model: Outcomes of Merger

Started by J.R.D Tata as Tata Airlines in 1932 and nationalized in 1953, Air India and Indian Airlines merged in April, 2007. This approach adopted by the government caused more challenges to the operations of Air India instead of the opposite. Expectations of being profitable through the merger were failed as both airlines continued to suffer losses and the outcomes posts the merger were multiplied more so ever. Due to a result, the management was not clear of their roles and functions, employees were against merger as they were worried about job security and labor unions were formed numerous times due to unequal pay. All of these factors affected the service delivery performance. This merger has witnessed to be a root problem of Air India affecting the service delivery and quality of airlines offering.

3.1.3 Internal and External Challenges

A significant improvement has been marked in the fiscal year of 2013 for Air India in its financial and operational performance. However, deep structural issues remain despite the improvements seen evident by the facts, which show that twelve routes operated by the carrier meet total costs of 189 routes served and international routes accounts for almost 80-90% of the losses (CAPA, 2013). From a total registered fleet of 127, a hundred are operational which also have a poor utilization rate when compared with the industry average. Overstaff of personnel is another challenge faced by the carrier since the integration of human resources management during the merger. Air India faces strong international competition from its rivals such as the Etihad –Jet Airways partnership as well as emerging market of low cost carries within the country and foreign carriers.

3.1.4 Service Quality

Despite of the improved financial and operational performance Air India has been mired in negative publicity for a long time now. A study conducted in 2009 by the Indian Market Research Bureau revealed that in the international market Air India was no longer preferred as it did not meet the required standards and was considered as a substitute airline choice of travel. Passengers complained that it was not oriented towards customer satisfaction and that more was demanded of the carrier than just mere basic facilities. But recent times show a progressive change in the management of Air India. The airline has modernized its services to improve travelling experience and comfort with the acquisition of B787 to its international routes retaining back its position of the Maharaja (implied as "the king). In spite of the challenges faced by Air India internally and externally the Indian airline made it to the top ten list ranking 9th position as best first class service. It was described as the ultimate in luxury by the richest website.

3.2 Primary Data Results

DIMENSION	STATEMENTS	AVG EXP SCORE	AVG PER SCORE	GAP SCORE
TANGIBLES	Appearance, attitude and uniform of employees	5.5	5.6	**0.1**
	Comfort and cleanliness of the seat	5.4	5.5	**0.1**
	Variety and selection of IFE programs	4.9	4.92	**0.02**
	Quality of in-flight meals	5.5	5.3	**-0.2**
	AVG DIMENSION SCORE	5.325	5.33	**0.005**
RELIABILITY	Performing accurate services at the first time	5.6	4.9	**-0.7**
	Consistent ground/in-flight services	5.6	4.8	**-0.8**
	Safety performance	6	6	**0**
	On-time departure and arrival	5.7	4.5	**-1.2**
	Transfer service and efficiency at departure airport	5.6	5.1	**-0.5**
	AVG DIMENSION SCORE	4.58	4.08	**-0.5**
RESPONSIVE	Employees' willingness to help	5.7	4.1	**-1.6**
	Prompt service and attention to passengers specific needs	5.7	4.7	**-1**
	Efficient check in/baggage handling services	5.8	4.7	**-1.1**
	Employees’ speed on handling request/complaints	5.6	4	**-1.6**
	AVG DIMENSION SCORE	5.7	4.375	**-1.325**
ASSURANCE	Employees are courteous	5.6	4.8	**-0.8**
	Employees instill confidence to passengers	5.2	4.3	**-0.9**
	Knowledge and skillful provision of services	5.6	5.3	**-0.3**
	Sincerity and patience in resolving passengers problems	5.7	3.9	**-1.8**
	AVG DIMENSION SCORE	5.525	4.575	**-0.95**
EMPATHY	Spontaneous care and concern for passengers	5.8	4.5	**-1.3**
	Employees behavior towards customer complaint	5.7	4.9	**-0.8**
	Convenient flight scheduling	5.61	5.62	**0.01**
	Loyalty program to recognize you as a frequent traveler	4.45	4.47	**0.02**
	Extent travel services (car rental, hotel etc)	4.9	4.9	**0**
	AVG DIMENSION SCORE	4.132	3.978	**-0.154**
	Average Unweighted score			**0.5848**

Table1: ServQual Calculation

3.2.1 Tangible

In the in-flight service process the first variable respondents were asked to assess was the appearance, attitude and uniform of the flight crew. Passengers are fairly satisfied with this variable as the perception exceeds expectations by a positive gap score of 0.1. Air India exceeds respondents' expectations by a gap score of +0.1 too in the area of seat comfort and cleanliness of the aircraft interior. Respondents' expectation of in-flight equipments and entertainment facilities of Air India is the least (4.9) when compared to other variables in the tangible dimension. This implies that IFE does not hold much importance to the passengers as oppose to other factors assessed in this dimension. Nevertheless respondents are fairly satisfied with the variety and selection of IFE programs as perception exceeds expectation. The last variable under this dimension is the quality of in-flight meals. Respondents are not satisfied with this factor as expectations exceed Air India's perception, evident by a negative gap score of -0.2. The average unweighted gap score for the tangibility dimension satisfaction is +0.005. This shows that the perceptions exceeds expectation of the tangible aspect and are in agreement that the Air India delivers their service in conjunction with passengers' expectation and best standards. Majority of the respondents agree that overall Air India has modern equipment and are visually appealing to the travelers.

3.2.2 Reliability

Starting with the first variable, which is performing services right the first time respondents were unhappy as expectations exceeded perception by a gap score of -0.7. Majority of the respondent were not satisfied with this factor as based on the result Air India failed to maintain an error free records. Next variable comprises providing consistent ground and in-flight service. Expectations were not met as it achieved a negative gap score of -0.8 implying that consistent service delivery was not offered i.e. same service provision every time. The same response was achieved with the criteria of transfer service and efficiency at departure airport. Another variable which achieved the highest negative gap score of -1.2 in this dimension is the on-time performance of flights. Expectations were not met by a huge margin due to poor on time performance records experienced by the respondents. The last variable under the reliability dimension constitutes the safety performance of the airline. Air India has accurately met respondents' expectation in this criteria with a gap score of 0 where Perception is equal to Expectation (P=E). The average unweighted gap score for the reliability dimension is -0.5. According to the results, Air India has fallen below expectations of the reliability aspects from a passenger's perspective.

3.2.3 Responsiveness

All four variables received a negative gap score implying that respondents were not satisfied in terms of responsiveness in the service delivery to the passengers. A negative gap score of -1.6 has been achieved in the area of employees' willingness to help which means that Air India's staffs according to the respondents do not show readiness to respond to customer request when the need arises. Respondents' expectations have not been met in the area of prompt delivery of services in catering to passengers individual and specific needs, evident with a negative gap score of -1. Efficient check in/baggage handling services is followed by with a gap score of -1.1. Lastly respondents were unhappy with the speed of staffs handling complaints and request achieving a gap score of -1. The average unweighted gap score for the responsiveness dimension is -1.325. Factors of efficiency in passenger guidance such as safety instructions, smooth seating, willingness to help with inquiries and prompt handling of request and complaints were evaluated by respondents and resulted in unsatisfactory response.

3.2.4 Assurance

When looking at each of the four factors forming the assurance dimension respondents' expectations exceeded Air India's perception. All four variables were not met with the required standards set by the respondents in the following factors; employees are courteous (gap score P-E = -0.8), employee behavior instills confidence (gap score P-E = -0.9), employees have the knowledge to answer questions (gap score P-E = -0.3) and sincerity and patience in carrying out transactions (gap score P-E = -1.8). The average unweighted gap score for the assurance dimension is -0.95. Air India failed to achieve a satisfactory level in the eyes of the respondents based on their past experience. Results show that respondents do not feel safe in the transaction carried out by the employees as they feel that some employees do not acquire the right knowledge when answering queries and instill a low confidence when called upon for assistance. Air India's competence and courtesy of employees and their ability to convey trust and credibility have proved to be unsatisfactory.

3.2.5 Empathy

When looked upon five variables forming this dimension, 3 factors perception of Air India exceeded respondents' expectations. All three achieved a positive gap score, these factors were airline having convenient flight scheduling, loyalty program and extent travel service. Air India performed fairly well in providing extent travel service to passengers as it achieved a gap score of 0 which implies that they have not exceeded but rightfully matched with the standards set. When it comes to frequent flyer programs respondents' expectation were not as high as other variables which states that loyalty program does not hold much importance to passengers. It is also shown that Air India offers convenient flight scheduling to passengers. The other two variables have received a negative score highest being spontaneous care and concern followed by employees' attitude and behavior towards customer complaints. The average unweighted gap score for the assurance dimension is -0.154. Overall based on the response it can be said that Air India are close to being empathic to the needs of the passengers. It has failed to reach a satisfactory level by a small margin. In terms of transaction of service provision such as convenient business operating hours for booking or making reservations/cancellations, baggage loss the airline has done fairly good. But the behavior and attitude in delivering this service has scored an unsatisfactory response.

3.3 Analysis

Based on the primary findings, it can be concluded that the respondents are not 100% satisfied with the service quality of Air India. The overall ServQual unweighted gap score achieved is a negative -0.5. This indicated that's in spite of the efforts made by Air India there are certain aspects of service quality that requires improvement from the management.

Based on the result of the respondents it can be said that when it comes to the tangibility aspect of Air India it has received a satisfactory response. This has been greatly achieved by Air India's operation of B787 Dreamliner on the Dubai-Delhi route which has wider seats and aisles providing more space and leg room, and innovating lighting. It is analyzed that Air India acquires and holds the right equipment of aircraft, product and service offerings needed to gain passenger satisfaction but it loses its mark when it comes to delivering the same provision of service.

When looked upon each service quality dimension in primary findings it can be analyzed that responsiveness and empathy dimension achieved the highest negative gap score. Among all the five dimensions these two hold a great importance in the eyes of the passengers. As the expectation scored among each of the variables falling under these two dimensions is high as oppose to other variables in the ServQual questionnaire. Passengers feel that employees are not able to understand and care for passengers' specific needs regards to experiencing the service.

Airline industry being a multifaceted concept comprises of various factor that make up a travelers flying experience. It does not just stop at providing the services, but in addition to that various other factors build passengers image and perception of the airline. Among few is proficiency of task and interpersonal skills like tolerance and patience in understanding passengers' problems, friendliness and courtesy. Air India scored an unsatisfactory response in these levels where front line employees have a major influence on customers' satisfaction.

Based on the secondary data and primary findings it can be concluded that Air India has a service quality gap. There arises discrepancy between what consumers expect of airline service quality and what consumer experiences of Air India's service quality. There lies a gap between expected service and experienced service. Multiple factors give rise to this gap. These factors can be traced to Air India's business model and management practice. The merger that took place in 2007 gave rise to management and personnel issues which still requires attention. This has directly and indirectly affected the service delivery of Air India and thus passenger satisfaction. A difference between consumer expectation and management perception lies with the flag carrier due to, too many layers between the front line personnel and the top level management.

Hence, there lies a gap between what customer expects and what customer consumed and experiences of Air India as overall expectations exceed passengers' perception. The state owned carrier has been successful in offering the standard products and service quality but it yet has to develop a product that would gain them a competitive advantage in comparison to its rivals.

4. Conclusion

The success of a carrier is directly influenced by passenger satisfaction of airlines product and service offerings. The purpose of this research was to investigate and assess whether Air India's service quality matches with the passengers expectation. Based on the survey carried out and evaluated in line with Air India's business model it can be concluded that the flag carrier require improvement in certain service quality dimensions. In this highly competitive market gaining a competitive edge becomes paramount to survive in the long run and remain profitable. Air India lacks in delivering its passengers' with high end quality of service despite of acquiring the necessary products and services. A comprehensive review of business model needs to be reworked to overcome weaknesses in key service domains. Service gaps can only be eliminated by clearly understanding what is it that customers' value and expect from an airline's service quality. A decisive action is therefore necessary to bring back the image of The Maharaja brand of India's state owned carrier.

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Fifth Freedom Airline Network Expansion: The Case of UK-US Services by Emirates

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Abstract: The paper provides an assessment of the business potential of direct UK-US routes offered by Emirates. It describes the regulatory framework for fifth freedom flights before turning to the relevant operational restrictions and commercial parameters for this kind of airline network development. The economic considerations are based on the "3 Cs" of airline network management (i.e., Costs, Consumers, and Competition). This practically oriented approach aims to identify possible candidates for fifth freedom airport pairs. The main result of the paper is that the number of such direct UK-US routes operated by Emirates will remain small even with open skies agreements allowing for fifth freedom flights.

Keywords: airline management, network management, fifth freedom traffic, Emirates

1. Introduction

Over the past decade, Emirates as the largest Gulf carrier has been building a passenger base by flying people from Europe to the Far East, India, Africa, and Australasia via its hub in Dubai (DXB). More recently, the carrier's network is expanding to fly people from China and India west beyond Europe to the Americas. In October 2013, Emirates entered the transatlantic market between the European Union (EU) and the United States (US) by launching a service from DXB via Milan-Malpensa (MXP) to New York-John F. Kennedy (JFK). The present paper examines the prospects of direct routes offered by Emirates between the United Kingdom (UK) and the US considering regulatory, operational, and commercial constraints. The primary objective is to provide an initial assessment of the business potential of direct UK-US routes offered by Emirates. In addition, the paper aims to indicate possible airport pairs for such fifth freedom services.

To the best of the author's knowledge there is no published academic research on the business potential of fifth freedom services by Gulf carriers on transatlantic routes. There is published work on the rise of the Gulf carriers during the last decade and the underlying business model (e.g., O'Connell, 2011). Reasons for comparative cost advantages of Gulf carriers have been addressed by de Wit (2014). Other researchers have dealt with the Gulf carriers' network development (Hooper et al., 2011) and the impact of new services via the hubs in Middle East on traffic flows between secondary airports in Germany and Asia (Grimme, 2011). Another stream of research relevant to this paper is the discussion of potential consumer benefits and the wider economic impact of granting traffic rights (e.g., Intervistas Consulting, 2009, Forsyth, 2014). CAPA, an aviation information consultancy, has published a report on Emirates' fifth freedom flights (CAPA, 2013) building on airline schedules data. According to this source, Emirates' fifth freedom services in the year 2013 were concentrated on flights to and from Australia.

The present paper analyzes network planning parameters based on the "3 Cs" of airline network management (i.e., Costs, Consumers, and Competition) which also reflect the nature of any airline's competitive strategy. This practically oriented approach provides context and meaning that is valuable for airline executives. The paper does not deal with the computational difficulties associated with the application of forecasting and operations research techniques to network planning and scheduling problems. A comprehensive overview of such techniques is provided by Jacobs et al. (2012). Obviously, the biggest limitation of any forecast of Emirates' future fifth freedom network is data availability beyond current flight schedules that in its entirety might only be known by Emirates' network planners. Hence, the following outsider's perspective includes educated guesses when developing predictions of why and how something will occur, that might turn out to be wrong but might be conducive to further research.

2. Regulatory Framework

The establishment of international air services depends on the permission to use the airspace above foreign states, i.e., existing traffic rights or freedoms of the air. As defined by ICAO (2004), air law distinguishes nine freedoms of the air. Fifth freedom is defined as the right to fly passengers, mail and cargo between two foreign states, as long as the origin or the final destination of such a chain of flights is in the registration state of the air carrier.

The problem of fifth freedom is that it must be granted by all states that would be part of such a chain of flights. As a precondition for Emirates' direct MXP-JFK services, Italy and the US had to grant fifth freedom to the United Arab Emirates. Italian regulators specially authorized it on an extra bilateral basis. The commercial impact of a non-existing fifth freedom right may be mitigated by combining third and fourth freedom. For example, Lufthansa German Airlines transports passengers between Italy and the US with a transfer in Germany; this contributes to Lufthansa's hub-and-spoke system (CAPA, 2014). A drawback of combining third and fourth freedom is longer overall travel times for passengers in comparison to non-stop flights. Because of Dubai's geographical location, Emirates is not able to bypass non-existing fifth freedom rights for EU-US routes this way.

Even if fifth freedom is granted in principle, conditions can be imposed as legal clauses in air services agreements on the exercise of this freedom that may hinder the freedom's commercial use. In this respect, the contents of air services agreements may include provisions on the designation of carriers, on frequencies and capacity, choice of aircraft, schedule and tariffs (ICAO, 2004). Further, fifth freedom rights might not encompass a whole country pair but only specific city or airport pairs. Since the 1980s, liberalized agreements or even open skies agreements have replaced restrictive bilateral air services agreements. Open skies agreements that grant fifth freedom rights exist between the EU and the US and between the US and the United Arab Emirates (UAE). However, neither the EU nor every single Member State of the EU has an open skies agreement with the UAE. The European Union consists of 28 Member States. The UK is by far the most important third and fourth freedom market of Emirates in Europe. The bilateral framework between the UK and the UAE signed in Abu Dhabi in June 2002 allows for specified fifth freedom rights, but not between the UK and North America. The present paper focuses on potential fifth freedoms for Emirates between the UK and the US, which builds on the implicit assumption that Emirates will be able to obtain the necessary fifth freedom rights to commence such services, for example, by a special route-specific permission from regulators in the UK.

3. Operational Restrictions

One of the most basic issues to consider when developing new intercontinental routes with wide body aircraft is sufficient airport infrastructure with regard to runway length but also with respect to other airport facilities. Emirates operates with Boeing 777-300ER on its fifth freedom routes that exceed a flight distance of 6,000 km such as the MXP-JFK route (CAPA, 2013). Even at airports situated at low altitudes, the long-haul operation of a Boeing 777-300ER with maximum take-off weight has a runway requirement exceeding 3,000 m.

All points served by Emirates in the EU and the US are shown in Figure 1. As of August 2014, Chicago (ORD) is Emirates' 9th US destination. Emirates' non-stop flights between DXB and Los Angeles (LAX) or San Francisco (SFO) have flight routings over Asia and not Europe, while the routings to Seattle (SEA) and the other US destinations are over Europe. For all depicted airports, the issue of sufficient airport infrastructure for long-haul operations with Boeing 777 in principal has already been positively resolved by the carrier. However, long-haul flights with Boeing 777 between more distant airports might encounter payload restrictions if the runway length is approximately 3,000 m.

Among the total of 28 cities served by Emirates within the EU with non-stop flights from its home base, 17 are in the five largest EU countries by population. Their share of the total frequencies is even higher. This is especially true for the UK. Emirates offers flights to five cities and six airports in the UK with seven daily frequencies between DXB and London-Heathrow (LHR) or London-Gatwick (LGW). All UK airports today served by Emirates have no night curfews which would facilitate efficient time coordination of the UK-DXB segment with a transatlantic segment.

Figure 1: EU and US cities served by Emirates in 2014 (Own figure based on Emirates, 2014)

In what follows it is assumed that commercially conceivable direct UK-US services by Emirates face no insurmountable operational restrictions on airport use such as slots or any other major problems with aircraft and crew rotation or maintenance requirements.

4. Commercial Parameters

Any extra landing and departure is costly. Intermediate stops lead to longer rotation of aircraft and crew. The inclusion of commercial stops on routes between DXB and the US increases absence time (i.e., the sum of block time and ground time) of aircraft and crew from the home base of Emirates. Additional stops also increase the risk of irregular operations and the need to plan for slack time to achieve a stable flight schedule. However, there are potential cost-savings for ultra-long non-stop flights of more than 15 hours, e.g., by avoiding an augmented flight crew. Ultra-long non-stop flights may also encounter payload penalties (i.e., empty economy seats, restrictions on cargo load) leading to higher operating unit costs. Hence, by splitting such non-stop operations into two flight segments, Emirates might lower unit costs. This would favor replacing some of Emirates' non-stop flights between DXB and LAX, SFO and SEA by two connecting flights with a stop in Europe. Setting-up a new station to manage airline operations at airports including customer service is costly. Cost savings are possible by concentrating traffic flows on a number of stations. Because of this reason, Emirates might prefer to establish new UK-US routes between two cities that are both already served by the carrier. What is more, the example of the MXP-JFK route indicates that the development of fifth freedom traffic might rely on existing third and fourth freedom traffic in Emirates' route network.

London metropolitan area is the leading European gateway for transatlantic passengers, followed with some distance by Frankfurt and Paris (see Table 1). When it comes to city pairs, New York routes are by far the busiest (see Table 2). London metropolitan area is ranked eight times among the ten busiest EU-US routes documenting traditionally close relations between the UK and the US. Similarly, London-Dubai is by far the busiest route between the EU and the UAE which indicates strong economic ties based on historical relations between the UK and the UAE.

Rank	Metropolitan area	Passengers
1	London	7,454,271
2	Frankfurt	3,099,317
3	Paris	3,038,558
4	Amsterdam	2,252,515
5	Munich	955,595
6	Rome	902,498
7	Madrid	898,080
8	Dublin	828,322
9	Manchester	609,138
10	Brussels	537,007

Table 1: Top 10 EU metropolitan areas in terms of (directional) passenger numbers to the US in 2013 (Own table based on data provided by Deutsches Zentrum für Luft- und Raumfahrt (DLR), 2014)

Rank	Route	Passengers
1	London (LHR) - New York (JFK)	1,435,621
2	London (LHR) - Los Angeles (LAX)	710,226
3	Paris (CDG) - New York (JFK)	650,289
4	London (LHR) - New York (EWR)	555,958
5	London (LHR) - Chicago (ORD)	544,715
6	London (LHR) - Miami (MIA)	464,382
7	London (LHR) - San Francisco (SFO)	457,736
8	London (LHR) -Washington (IAD)	447,122
9	London (LHR) - Boston (BOS)	417,642
10	Frankfurt (FRA) - New York (JFK)	354,082

Table 2: Top 10 busiest EU-US city pairs in terms of (directional) passenger numbers in 2013 (Own table based on data provided by Deutsches Zentrum für Luft- und Raumfahrt (DLR), 2014)

Tables 1 and 2 refer to flight legs, i.e., non-stop operations of aircraft, and not to passengers' origins and destinations. For example, passenger numbers between London, Paris or Frankfurt and New York include connecting passengers with other travel origins or destinations. Only on the busiest EU-US routes there is arguably enough local demand to sustain year-around non-stop services with more than one daily frequency on a stand-alone basis. This certainly holds for the New York route to the European megacities London and Paris with their large catchment areas and a significant share of premium travelers. There is also a difference between actual passenger numbers and air travel demand. It might be that strong air travel demand between some EU regions and the US is constrained by limited seat capacity or high ticket prices due to an insufficient offer of scheduled services. Such an expectation of existing but unsatisfied demand might have been the decisive reason for Emirates to start MXP-NYC fifth freedom flights in October 2013.

The inclusion of commercial stops in Europe may increase overall load factors of Emirates' flights compared to non-stop routings from DXB to the US. Clearly, the impact on the yield has to be considered as well. Any additional stop plus the associated detour compared to a direct flight lowers the willingness to pay of time-sensitive consumers. One-stop services tend to be less popular among passengers than non-stop services. However, some passengers might enjoy breaking up their journey on longer trips. The theoretical flight distance DXB-MXP-JFK is 11,120 km, while the non-stop flight DXB-JFK is 11,002 km. However, for passengers travel time matters more than flight time. In comparison to the non-stop flight DXB-JFK, the additional total trip duration of DXB-MXP-JFK is eastbound 3 hours (+24%) and westbound 4.5 hours (+32%). The potential for reducing the one-stop trip time is limited as a scheduled turnaround for long-haul aircraft of less than two hours makes it difficult to absorb any occurring irregularities in daily operations even at uncongested airports.

Both, the UK and the US are mature air transport markets. The competitive exposure for direct UK-US routes offered by Emirates would be especially high at Europe's largest airports LHR. In cooperation with its Oneworld alliance partners, British Airways would mobilize all available means to protect its North Atlantic market share from/to LHR against a market entry of Emirates. For this reason is highly unlikely that Emirates will choose to fly fifth freedom routes from/to LHR. The carrier might consider entering head-to-head competition with Virgin Atlantic on the route between Manchester (MAN) and Orlando (MCO) and with British Airways between LGW and MCO. However, it is reasonable to assume that Emirates prefers to avoid direct competition with a British carrier. Such head-to-head competition would lower chances to get fifth freedom rights enabled by UK authorities.

An additional network management issue regarding any potential direct UK-US services is how to provide connections at both ends of the transatlantic segment that match demand. Interline connections based on code sharing with other airlines can contribute to Emirates' success on UK-US routes as they foster access to regional markets, feeding and de-feeding travelers from regional airports in Europe and North America to the gateway airport of Emirates' intercontinental flights. Emirates and JetBlue Airways have established such a code sharing partnership in the US market (JetBlue Airways, 2013). Commercial agreements of Emirates with partner airlines might also include cooperation in frequent flyer programs, coordination of schedules, the sharing of airport facilities, and an investment in the partner airlines' shares. The search for suitable partner airlines in the UK might turn out to be difficult. Flybe could be a potential partner airline offering short-haul services throughout the UK as well as to other European countries but is already code sharing with Etihad.

5. Potential UK-US Routes

Based on the previous analysis, UK is arguably the most promising country for further EU-US services by Emirates, once the regulatory framework allows for such fifth freedom services. It is also easier for Emirates to set up a new service between two points across the North Atlantic which are already in its network. However, LHR is a rather unlikely airport candidate because of operational constraints (e.g., slot availability) and its key importance for British Airways. Besides LHR, LGW and MAN today are the UK airports with the most flight frequencies offered by Emirates. LGW is UK's second busiest airport in terms of passenger numbers, MAN ranks third. Fifth freedom rights for LGW will be more difficult to obtain from UK authorities than for services departing from Northern England or Scotland. Long-haul flights from MAN or Birmingham (BHX) to more distant US destinations like LAX or SFO might encounter payload restrictions due to an available runway length of approximately 3,000 m. The runway of Glasgow (GLA) is even shorter. Edinburgh (EDI) might be an alternative for GLA. However, Emirates has preferred GLA to EDI for services between Scotland and DXB.

Any demand forecast for new UK-US fifth freedom services by Emirates is difficult. The current and announced US airports (as of April 2014) served non-stop by the Gulf carriers provide a hint at routes in demand. Emirates, Etihad and Qatar Airways all fly to JFK from their home bases. Considering the latest route developments, all three carriers will also offer direct flights to Dallas (DFW) and ORD by the end of 2014 which makes it three US destinations in total that are served by all of the big three Gulf carriers. LAX, Washington-Dulles (IAD) and Houston (IAH) are served by two of the three carriers, Boston (BOS), SEA and SFO only by Emirates, Miami (MIA) and Philadelphia (PHL) only by Qatar Airways. Local demand for DFW and IAH routes comes from the oil and gas sector. However, Gulf carriers like Emirates cannot maintain long-haul routes to destinations such as DFW or IAH with local traffic from/to the Middle East alone, but also need connecting traffic via their hubs to the Far East, India, and Africa.

If only local traffic from an airport's catchment area were available to fill aircraft capacity, the first choice US destination would be New York as a year-around destination with a significant share of premium passengers. JFK and not Newark would be Emirates' airport choice because of the existing interline agreement with Jetblue Airways allowing regional connections for transfer traffic beyond JFK. BOS is also a focus city in Jetblue's US network. While all major US airlines fly to Boston, none of them has BOS as their primary and secondary hub making it a potential airport candidate for Emirates for fifth freedom flights from the UK. Savings in operational costs might be possible for ultra-long haul flights to LAX or SFO when flying via the UK instead of non-stop flights from DXB. Both, LAX and SFO are also large markets and the traffic composition on UK routes to LAX and SFO includes high yield traffic, making them potential US airports for fifth freedom routes.

Emirates does not fly to Florida. Presumably, the carrier's network planners consider demand not to be sufficient for non-stop services from DXB. This assessment may change with a possible route via the UK since Florida is a well-established destination from the UK. In addition, the non-stop flight distance between DXB and MIA is about 12,500 km with a 16 hours flight time. Cost savings might result from breaking up such an ultra-long-haul flight into two legs. Airport alternatives to MIA might be MCO and Fort Lauderdale (FLL). One issue with routes to Florida is that they tend to be highly leisure oriented which might not fit to Emirates' product (e.g., the offer of a first class cabin on US routes).

6. Conclusion

Future global network expansion of Emirates needs fifth freedom rights if its growing long-haul fleet does not meet enough demand in third and fourth freedom markets. Despite of the trend towards open skies, the air services agreement between the UK and the UAE does not allow for fifth freedom passenger services. However, if former flag carriers take cuts in their route network, national authorities might enable foreign carriers to fill the gaps. The recent granting of traffic rights to Emirates on the MXP-JFK route indicates that on a case-by-case basis such authorizations are possible. One line of reasoning to open up fifth freedom for Emirates is to improve regional connectivity to the world and to make better use of existing airport infrastructure. However, the Italian court ruling against Emirates in April 2014 to stop the MXP-JFK route it launched in October 2013 shows how complicated fifth freedom network expansion becomes if rival carriers from foreign states protest and industry associations as well as unions call on their government to limit traffic rights.

Because of regulatory constraints but also because of cost, consumer and competitive issues it is unlikely that Emirates will offer more than a handful of direct UK-US routes in the coming years. UK airport candidates for such routes are LGW, MAN, BHX and GLA, conceivable US airports comprise JFK, BOS, LAX, SFO and MIA. The success of UK-US routes offered by Emirates can be promoted by cooperation with other airlines to serve regional demand in Europe and North America beyond local airport catchment areas. Clearly, such network expansion by Emirates would pose a competitive challenge for the two UK carriers British Airways and Virgin Atlantic as both carriers rely on long-haul traffic.

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Quantifying the Environmental Potential of Lightweight Construction during Aircraft Operation through Life Cycle Assessment

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Abstract: Lightweight construction is being more and more applied in the aviation sector. Lighter aircrafts mean lower fuel consumption or higher payload, resulting in more revenues for aerospace carriers. While the economic aspects of lightweight construction and cost reduction are well known, environmental impacts are often neglected. Production of lightweight components often causes high environmental impacts, but reduces fuel consumption and thereby environmental impacts in the service life. This paper uses Life Cycle Assessment to show the environmental potential of lightweight construction, using the example of trolleys. It was found that the production impacts of lightweight trolleys are compensated through lower in-flight emissions after 78 flights for the system under assessment.

Keywords: Life Cycle Assessment, sustainability, lightweight construction, carbon footprint

1. Introduction

Over the last years, great progress has been made in lightweight construction in the aviation sector. Most prominent examples of this are large aircrafts like the Airbus A380, A350 or Boeing 787, which are substantially built with carbon fiber reinforced plastics (CFRP) and other high performance, lightweight materials (Airbus, 2007), (Airbus, 2010), (Boeing, 2008). In combination with advanced aerodynamics and efficient engines, this helps reducing the fuel consumption and thereby also reducing operating costs and environmental impacts. The trend towards lightweight construction also takes also place inside the cabin. This paper focuses on the environmental impacts of lightweight construction. Due to reduced weight, the fuel consumption during the flight will be reduced, thus subsequently reducing also the environmental impact of flight operations. However, lightweight construction comes at a price: when exchanging existing components with lightweight components there are both economic and environmental impacts: costs to purchase and install new equipment and environmental impacts from the production of replacement components.

This paper quantifies the reduction of environmental impacts due to lightweight construction. This will be done by using Life Cycle Assessment (LCA). The impacts of lightweight construction will be shown by using the example of replacing current trolleys with lightweight trolleys.

Thereby, this paper offers a broader view on the consequences of lightweight construction, not only from an economic, but also from an environmental point of view.

2. Methodology

In order to quantify environmental impacts of both production and operation phase of lightweight trolleys made of composite material, a Life Cycle Assessment (LCA) is carried out.

LCA is standardized in ISO 14040 (2006a) and ISO 14044 (2006b) and is established in both industry and academia for more than 20 years. When carrying out LCA, there are four major steps according to ISO 14040 (2006a):

- Definition of Goal and Scope
- Inventory Analysis
- Impact Assessment
- Interpretation

These steps are described in detail in the following.

2.1 Goal and Scope of the Analysis

This paper aims at quantifying the environmental impacts of aircraft operation in a standard configuration compared with the same aircraft but with lightweight trolleys instead of standard trolleys. The functional unit on which basis the assessment is being carried out is a single flight over a distance of 5,000 km in an Airbus A380. It is assumed that 31 full-size trolleys and 115 half-size trolleys are being used in the aircraft, which is derived from the number of trolleys used in a comparable aircraft. Airline service trolleys are being used for in-flight passenger service, transport and storage during a flight (Norduyn, 2014).

The system under assessment is limited to operation of the aircraft compared with operation of an aircraft with lightweight trolleys. For the lightweight trolleys, production is taking into account. End of life processes are not included in the assessment. This paper analyses the replacement of regular aluminum trolleys that are currently in use with composite based trolleys in order to assess whether a replacement of trolleys is reasonable from an environmental point of view. Therefore, the production of aluminum trolleys is not being assessed.

The reference flight under assessment is a long distance flight with a total distance of 5,000 km great circle distance. An overall fuel consumption with the reference aircraft in standard configuration of 68,221 kg of kerosene is assumed (Lissys, 2010). In the following, weight reductions in steps of 500 kg to a maximum weight reduction of 5,000 kg. The practical relevance of this approach is shown using the example of service trolleys.

Impact categories under assessment are

- Global Warming Potential, in kg CO_2-equivalent,
- Acidification Potential, in kg SO_2-equivalent,
- Eutrophication Potential, in kg Phosphate-equivalent,
- Photochemical Ozone Creation Potential (Summer Smog), in kg ethylene-equivalent.

Results of the assessment are scaled up, assuming an overall flight distance of 2,3 million km per year (Recaro, 2014). Operation of airports and maintenance processes of the aircraft are neglected.

It has to be noted that the reduction in fuel consumption through lightweight construction was only carried out for the reference aircraft; and only until an overall reduction of 5,000 kg. The analysis has to be modified when analyzing other aircrafts or further weight reductions.

The focus of this study is only on environmental aspects; economic aspects are excluded.

2.2 Life Cycle Inventory

Within the Life Cycle Inventory (LCI), a model with all input and output flows to the product system is created. This model is based on the mass and energy flows that go into and out of the system. In order to do so, and to include information on environmental impacts of materials and resources used, professional Life Cycle Assessment software, in this case the GaBi software and database (PE International, 2014) is used. As the functional unit was defined as a single flight over a given distance, environmental impacts are related to this reference flight. Fuel consumption for a reference aircraft equipped with standard aluminum trolleys and lightweight trolleys made of composite materials is calculated; providing information on the respective environmental impacts during the operation. A break-even analysis is carried out to analyze when the environmental impacts of the production are compensated by the reduced emissions during operation.

2.3 Life Cycle Impact Assessment

Within the Life Cycle Impact Assessment, environmental impacts are classified in impact categories, and translated in the respective reference unit of each impact category. This step is carried out since the LCI gives out a list of several hundred or thousand input and output flows. Due to the sheer amount of information, the LCI is very hard to interpret and to use as basis for decision making.

Impact categories sum up all input and output flows that contribute to the same environmental impact and expresses them in a common metric. For example, emissions of Carbon Dioxide (CO_2) contribute to Global Warming. However, other emissions such as Methane (CH_4) also contribute to Global Warming. Therefore, they – among others – are summarized in the impact category Global Warming Potential (GWP). However, the emission of 1 kg of CO_2 has a different contribution to GWP than the emission of 1 kg CH_4. Characterization factors help to express all contributing emissions in a reference unit. The reference unit for GWP is kg CO_2. Therefore, all emissions contributing to GWP are expressed in CO_2-equivalents, based on the intensity of their contribution. For the example of Methane, this characterization factor is 25; meaning that the emission of 1kg of Methane has the same contribution to Global Warming as the emission of 25 kg of CO_2 (PE International, 2014).

LCIA improves the usability of environmental assessment for decision making by reducing the complexity of results without neglecting details.

2.4 Interpretation

The interpretation is an ongoing process when carrying out results. It allows evaluating whether the functional unit is chosen reasonably, if system boundaries or assumptions are defined correctly and whether results are plausible. Furthermore, key drivers of environmental impacts are identified within this step. Finally, conclusions can be drawn and limitations of the study can be identified.

3. Key Findings

Based on the data collected, the models created and the assumptions taken, the environmental impacts of weight reduction in economy class were assessed. The results are shown in Figure 1. As it can be seen, the emission of CO_2-equivalents is decreasing almost linear.

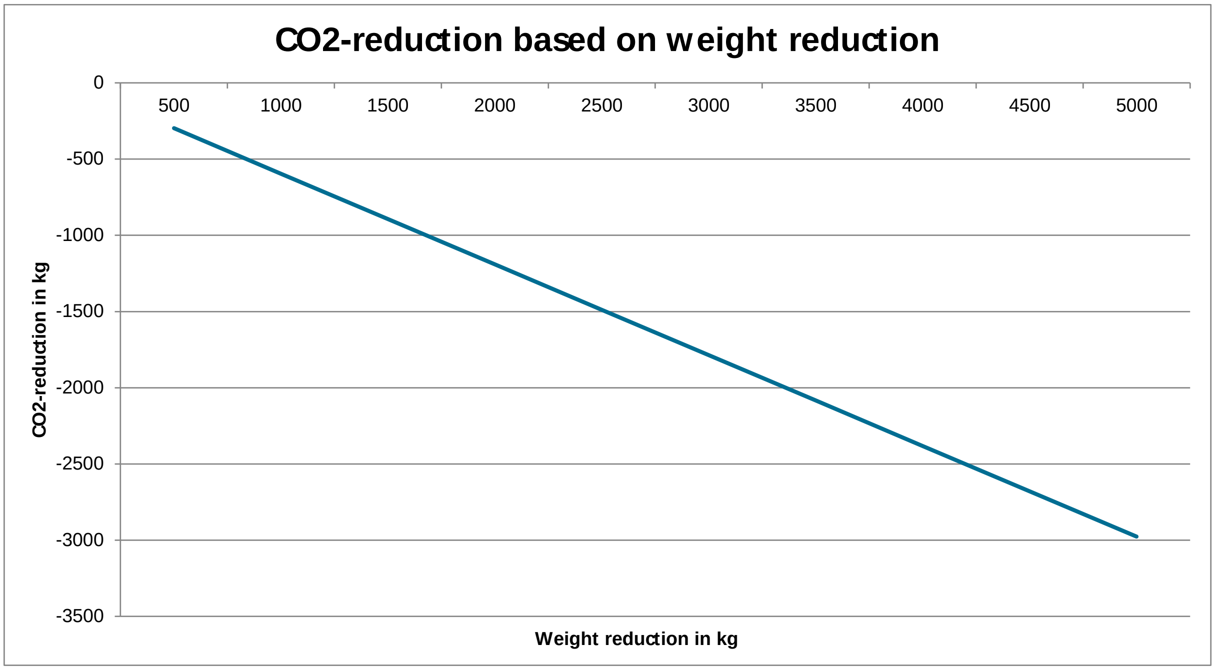

Figure 1: CO_2-savings during operation phase per kg weight reduction

With the underlying assumptions, a weight reduction of 500 kg reduces the CO_2-emissions per flight by around 275 kg. The reduction thereby is linear, with each 500 kg of weight reduction; emissions of CO_2-equivalents are reduced by 275 kg.

With an annual flight distance of 2,300,000 km, a weight reduction of 500 kg results in a reduction of about 127 tones of CO_2-equivalents.

The trend is similar for the other impact categories under assessment. Per 500 kg weight reduction, an average reduction of

- Acidification Potential by 6.2 kg of SO2-equivalents
- Eutrophication Potential by 1.2 kg of Phosphate-equivalents
- Photochemical Ozone Creation Potential by 0.6 kg of Ethene-equivalents

can be reached for each reference flight.

In order to give an example on how to analyze and interpret such results, the case of trolleys made of composite materials is examined. This allows constructing trolleys with a lower weight. It is assumed that in an A380, 31 full-size trolleys and 115 half-size trolleys are used. Furthermore, it is assumed that a full-size composite trolley has a 9.4 kg lower weight than a standard trolley and a half-size trolley is 7.2 kg lighter than a standard half-size trolley (Norduyn, 2014). This results in an overall weight reduction of 1119.4 kg. However, in order to use this potential, new trolleys have to be built. A screening LCA of the trolleys was carried out, only taking into account the environmental impacts of the material production. At this stage, production processes and end of life treatment has been neglected. Furthermore, maintenance is neglected, as the technical lifespan is even longer than that of aluminum trolleys (Norduyn, 2014).

A break-even analysis was carried out in order to analyze whether the use of lightweight trolleys is reasonable from an environmental point of view, and if so, when. The results are shown exemplarily for Global Warming Potential in Figure 2. The initial contribution to Global Warming Potential (GWP) from production adds up to 51,682 kg of CO_2-equivelant. However, due to lower fuel consumption, this environmental impact is compensated subsequently.

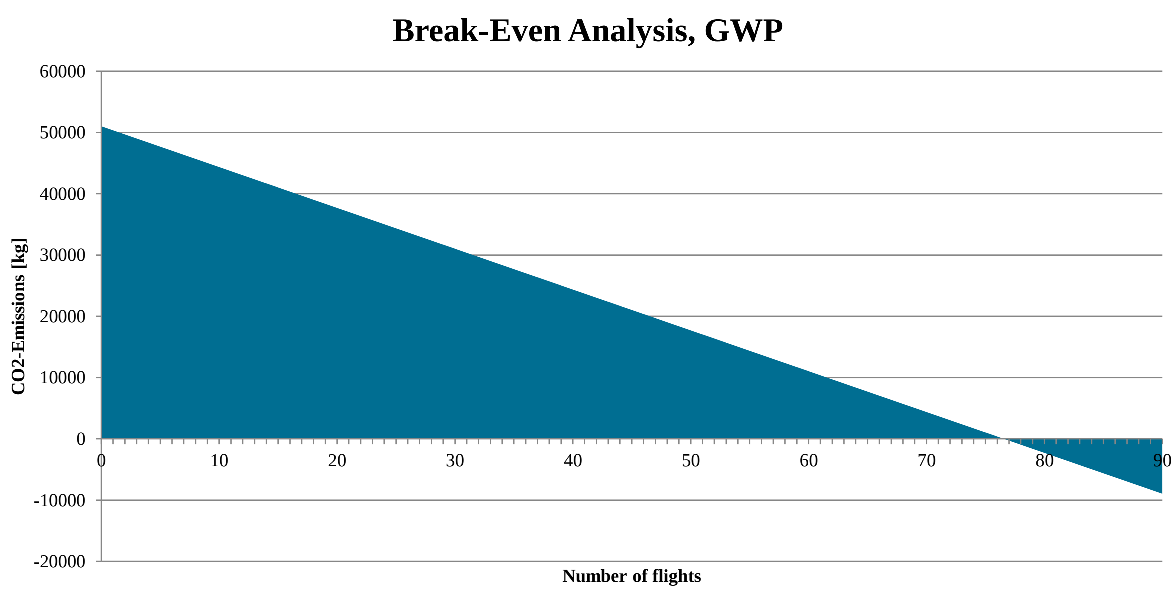

Figure 2: Break-Even Analysis of lightweight trolleys, GWP

It was found, that the production impact of the lightweight trolleys is compensated through the lower fuel consumption after the 78th flight. Therefore, the exchange of trolleys can be considered as a reasonable measure considering the contribution to global warming. Compared with aluminum trolleys, lightweight trolleys would subsequently reduce the emission of CO2-equivalents by about 306.000 kg every year per aircraft for the applied boundary conditions.

The same analysis was carried out for the other impact categories and is shown in Table 1.

As it can be seen, the break-even will be reached rather soon, taking between 7 and 78 flights, depending on the impact categories under assessment. The earlier an environmental break-even point is reached; the better a measure is to reduce environmental impacts. Assessing the environmental break-even point of different measures or design options offers therefore valuable support for decision making.

Impact Category	Break-Even (no. of flights)
Acidification Potential [kg SO2-Eq.]	15
Eutrophication Potential [kg Phosphate-Eq.]	7
Global Warming Potential [kg CO2-Eq.]	78
Photochemical Ozone Creation Potential [kg Ethene-Eq.]	12

Table 1: Environmental Break-Even of the exchange of trolleys

4. Conclusion

Lightweight construction allows reducing fuel consumption and subsequently environmental impacts during aircraft operation. However, lighter components have to be produced and substituted with current components. The production of lightweight materials like CFRP or highly alloyed aluminum often causes a rather high environmental impact. In order to reduce the overall environmental impact of both components production and aircraft operation, life cycle thinking has to be applied. LCA offers a solid methodological approach to do so. It allows quantifying environmental impacts of material provision, component production and aircraft operation in order to retrieve an excellent basis for decision making from an environmental point of view. Combined with existing economic approaches, this allows considering environmental and economic aspects in decision making.

As it was shown with the example of lightweight trolleys, the overall environmental impact of measures can be analyzed by taking into account not only benefits during operation but along the entire life cycle of a product. For the system under assessment in this paper, the replacement of existing aluminum trolleys with lightweight composite trolleys appears to be advantageous. The initial environmental impact from the production of lightweight trolleys will be compensated within the first months. Through the long technical life span of 10 years, exchange of the service trolleys will contribute to a significant reduction of environmental impact compared to the use of conventional aluminum trolleys.

LCA provides a powerful tool that allows to systematically including environmental impacts in decision making. It can also provide support when comparing different configurations or layout options. By integrating environmental impacts, it supports a holistic decision making process.

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Accident Investigations and Safety Data in Light of Criminal Prosecutions of Aviation Professionals

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Abstract: In recent years, following a number of high profile aviation accidents, parallel investigations have been conducted by technical investigators in accordance with Annex 13 and judicial investigators seeking to identify blameworthy party(s).

An examination of a number of aviation accident investigations as well as the subsequent civil and criminal proceedings illustrate that prosecutors often rely on the official Annex 13 accident investigation report as well as sensitive safety data obtained during the technical investigation as the basis for litigation. A recent decision by the UK Court of Appeal in Hoyle v Rogers & Anors, which will, in the opinion of the authors, have a significant impact on future civil and criminal proceedings subsequent to aviation accidents, will be discussed.

Keywords: aviation accidents, prosecution, safety data

1. Introduction

The recent decision of J Leggart in the UK Court of Appeal, in the case of Hoyle v Rogers & Anors, as well as an analysis of cases in which a number of courts in different jurisdictions accepted the accident investigation report as admissible evidence raises serious questions whether the philosophy of conducting an accident investigation is being undermined.

Aviation professionals should in no way be exempt from liability for serious legal transgressions, however in the interest of justice, the judicial authorities should strictly adhere to the correct procedures in their quest for upholding the law and making wrongdoers accountable for their blameworthy behavior. Of major concern to the aviation industry, in the light of the criminal prosecution of aviation professionals, is maintaining a balance between aviation safety and prosecutions based on the official accident investigation report and the use of confidential safety data and other information obtained during the investigation or information obtained through the confidential and other reporting systems which are in place.

Aviation accidents are investigated in accordance with ICAO Annex 13 and the national legislation of each country. In the European Union accident investigations were based on EU Directive 54/96 which was recently repealed by EU Regulation 996.

It is specifically stressed throughout each stratum of legislation, that the sole purpose of investigating an aviation accident or serious incident is not to determine or apportion blame or liability but to make safety recommendations to prevent future similar accidents.

The technical investigation is non-punitive in nature and the focus is on establishing the accident scenario by examining the events leading up to the accident in order to identify corrective measures and make safety recommendations to enhance aviation safety.

On the other hand, the judicial investigation seeks to determine the fault and liability of a party and to then apportion blame. The judicial investigators focus on determining the cause of the accident for the sole purpose of determining blameworthy parties and to gather evidence which can clearly establish their guilt in order for them to be held accountable in a court of law for their behavior.

Considering the different aims and objectives of each there is clearly a very divergent approach by the judicial authorities and the technical investigators, which often leads to conflict (Michaelides-Mateou & Mateou, 2010).

The investigation of aviation accidents are conducted by experienced aviation professionals who undergo specific training and who have a duty to implement the philosophy of Annex 13. The judicial investigators on the other hand are not experienced in the investigation of aviation accidents, do not have any technical expertise nor knowledge of the complex issues involved in such an investigation with regards to, inter alia, aircraft systems and the analysis and understanding of the data obtained from the accident site, particularly the sensitive data obtained from the Cockpit Voice Recorders (CVR) and Flight Data Recorders (FDR).

2. Results / Findings

Of great concern is the fact that, where judicial and technical investigations are conducted in parallel, inevitably, the judicial authorities rely on the findings of the technical investigation. An analysis of cases illustrate that subsequent civil and criminal proceedings illustrate that judicial authorities often rely on the official Annex 13 accident investigation report as well as sensitive safety data obtained during the technical investigation as the basis for litigation.

This is more often the case in countries that have a civil legal system as they give the judicial authorities greater powers than those afforded to the technical investigators. On the other hand, common law countries such as the United Kingdom, the USA and Australia give preference to the technical investigation, unless a crime, such as a terrorist attack, is suspected.

In countries having the civil legal system, such as Greece, Italy and France, the investigating magistrate has prevalent access over the wreckage, records and the sensitive data obtained from the flight recorders. Often, as a result of the laws that allow the judicial authorities to take the primary role in investigating the accident, vital evidence, particularly from the cockpit voice recorder and flight data recorders have been withheld from the technical investigators conducting the official accident investigation on accordance with ICAO Annex 13.

2.1 Testimony

Testimony obtained from those who are directly or indirectly involved in an accident, be it voluntarily or confidentially obtained through safety reporting systems or testimony obtained during an investigation provides valuable information to the investigators. However, there have been cases in which such information has been used against the provider in criminal proceedings. This may undoubtedly result in aviation professionals who will be reluctant and unwillingly to provide important safety information on the basis of their fear of incriminating themselves or their colleagues.

In the Helios accident which will be examined in more detail below, it worthy to note that the two mechanics that had vital Information pertinent to the investigation, only provided statements to the Greek Accident Investigation and Safety Board during the technical investigation and to the Greek judicial authorities, in the presence of their lawyer.

This clearly indicates that aviation safety may be affected as vital information may be withheld from the investigation for fear of prosecution.

2.2 CVR and FDR Data

Following the Concorde accident, the judicial authorities maintained control over the wreckage, records and documentation as well as the CVR and the FDR. In the final report the UK accredited representatives commented that, even though the French BEA co-operated with the UK AAIB, they made a note that French judicial authorities presented a major obstacle to the AAIB investigation and that they did not, inter alia, allow the AAIB full access to all relevant evidence and severely restricted their access to the accident site (BEA Final Report, 2004, p 182).

The ANSV official report of the Tunisair ATR-42 accident which occurred in August 2005, states in paragraph 1.18 that, in accordance with the relevant legislation, they filed the necessary application to the judicial authorities to be given access to the documentation which they had in their possession (ANSV Final Report, 2007). Some documentation was handed over within a short time while other documentation was released only after many repeated requests. The CVR and DFDR read-out were seized by the judicial authority, in accordance with Italian law and kept in their possession until it was ruled by the judicial authority on August 30, that they be taken to the ANSV headquarters, pending further orders from the judiciary. On the 10th September, in the presence of the judicial authorities, the data in the CVR an FDR were extracted at the ANSV laboratories. The judicial authorities then sequestrated the data and the tapes removed and ANSV was not given a copy of the CVR data. A copy of the FDR raw data was made available to the ANSC for further de-coding and analysis. A few days later, following a judicial authority decision, they were granted access to the CVR, but they were not permitted to supply the data from the CVR and FDR to the foreign accredited representatives who had a right to have access to that data. This also prevented the ANSV from conducting simulations pertinent to the technical investigation. Nearly a year later, the ANSV was still requesting that the judicial authority lift the restriction they imposed to allow the ANSV to provide the data to the accredited representatives. On 9 November 2006, the judicial authorities allowed the data to be used unconditionally by the ANSV for their investigation and to be given to the accredited representatives. The report also states that some of the accredited representatives rights afforded to them by ICAO Annex 13, particularly in relation to expedient access to pertinent information which is vital to accident prevention, were limited as a result of the powers given to the judicial authorities in accordance with Italian law.

The report also notes that in accordance with Italian criminal procedure the judicial authorities used the CVR and FDR data for punitive measures contrary to the provisions of ICAO Annex 13.A further point is made that the judicial authorities made the content of the CVR readout available to parties involved in the criminal investigation and on that same day, that the media had possession of it and made it public both in print and in the voice media. Part of the CVR conversation which was made public did not play any role in determining the sequence of the events leading up to the accident.

Another example is the Cessna 650 Citation III air ambulance accident which occurred South-West of Rome in February 2009. The Italian ANSV reported that they were unable to conduct a complete investigation into the accident without the CVR and FDR as the judicial authorities had taken control of them. The ANSV reported the conflicts between themselves and the judicial authorities and called for legislative amendment which resulted in the vital information then being given to them (Flight Safety Foundation, AeroSafety World, 2009, p 10).

In the Turkish Airlines B737-800 accident which occurred when the aircraft crashed short of landing at Schiphol Airport in Amsterdam in February 2009, the Dutch prosecutor attempted to gain access to the CVR and FDR which was under the control of the technical investigators, leading to a public confrontation between the public prosecutor and the Dutch Safety Board.

The cause(s) identified in the technical report outlining the most probable scenario leading to the accident have often become the basis for the judicial authorities to file criminal charges against aviation professionals whose acts or omissions have been pointed out as having had a role to play in the resulting accident.

Aviation professionals are becoming more wary of the legal ramifications they may face subsequent to an aviation accident, and as a result they may deal with the accident investigation process by primarily focusing on avoiding culpability. This can be illustrated by the engineer in the Helios accident who agreed to provide testimony to the accident investigators only in the presence of his lawyer as will be outlined below.

2.3 Helios Accident

After the Helios accident that occurred on 14 August 2005, the Air Accident Investigation and Aviation Safety Board (AAIASB) of the Hellenic Ministry of Transport & Communications investigated the accident following ICAO practices and in accordance with Annex 13, EU Directive 94/56 and Greek legislation. The final report was published in November 2006. The report did not outline the causes of the accident as the ‘probable cause(s)’ of the accident, but as the ‘direct and latent causes’.

On the same day of the accident judicial investigations into the accident were launched by the Greek and Cypriot judicial authorities. Statements were immediately taken from the two engineers who performed the non-scheduled maintenance of the aircraft prior to its departure. Two days later, their statement and personal details were revealed by the media, resulting in their hasty departure from Cyprus. During the technical and judicial investigation, further statements were made in the UK, in the presence of their lawyers.

Two parallel investigations were taking place, namely, the judicial and the technical investigations, but they were taking place in two countries, Greece and Cyprus.

Greek judicial authorities initiated their judicial investigation into the accident and appointed safety experts as sworn judicial investigators. The judicial investigating team was actively involved in the investigation as illustrated by the fact that when the technical investigators conducted a reconstruction flight on 19 December 2005, members of the Greek AAIASB and the Cyprus AAIIB as well as the Hellenic District Attorney in charge of the State Judiciary were on board the Olympic Airways B737-300 aircraft used for the re-construction. The presence of the Greek prosecutor in charge of the judicial authority on board the reconstruction flight clearly indicates the extent of the judicial involvement in air accident investigation and their determination to obtain undisputed evidence regarding the investigation as well as an intermingling of the two investigations (Michaelides-Mateou & Mateou, 2010).

2.4 Charges

In Cyprus, one hundred and nineteen counts of manslaughter in accordance with Article 205 (1)(2)(3) of the Cyprus Criminal Code, Cap 154, and Article 210, causing death through a reckless, careless and dangerous act were filed against the airline, Helios, as a legal entity, the Executive Chairman, the Managing Director, the Flight Operations Manager and the Chief Pilot on the basis that they were criminally negligent by permitting the flight crew to operate the aircraft when they knew or should have known that they were not sufficiently competent and did not work sufficiently well with each other.

The Nicosia criminal court found the defendants not guilty based on the ruling that there was no causal association between the defendants and the negligence they were charged with for the fatal accident. The defendants were acquitted but the Attorney General filed an appeal and in December 2012 the Cyprus Supreme Court, by a majority decision, upheld the appeal and ordered a retrial of the case.

Parallel criminal proceedings were filed in the Greek courts. It is the first case in which criminal trials in two jurisdictions were initiated against aviation professionals subsequent to an air accident.

In February 2010 the Greek judicial authorities, despite the fact that four individuals as well as the (now defunct) Helios airlines as a legal entity were already on trial at the Nicosia Criminal Court, proceeded with filing charges for negligent manslaughter in the Greek criminal courts against four defendants, the Managing Director, the Flight Operations Manager, the Chief Pilot as well as the ground engineer who signed the technical log prior to the fatal flight. The airline and the Executive Chairman were not charged.

As the criminal proceedings in the Cyprus courts were underway the Athens court suspended the trial in Greece, awaiting the decision of the first instance criminal court in Cyprus. Shortly after the court acquitted all 5 defendants of wrongdoing the trial in Greece commenced in December 2011.

The Greek court held that the accident investigation report was admissible as evidence. In April of 2012 the Greek court found all *four* defendants guilty of the charges of negligent manslaughter and they were sentenced to 10 years imprisonment. The defendants then lodged an appeal and on 7 February 2013, the Athens High Court confirmed the guilty verdict for *three* of the defendants, the Managing Director, the Flight Operations Manager and the Chief Pilot. The British engineer was found not guilty and was acquitted. The three guilty defendants were sentenced to 10 years imprisonment each. The court gave the defendants the option, which is available in Greek law, to 'buy off' their prison sentence, for an amount of 75 000 Euros each. An appeal has been lodged in the Areos Pagos Supreme Court of Greece against their conviction.

In the light of the verdict by the Athens court, the Attorney General of Cyprus lodged an application that the charges against the four natural defendants as well as the company, Helios, be dropped, based on the principle of double jeopardy and arguing that to continue criminal proceedings against the fourth defendant, the Executive Chairman, and the defunct airline would be too difficult without having the other three accused as co-defendants. The charges against all the defendants were therefore dropped.

2.5 Recent Developments

In a recent precedent setting case in the UK, that of Rogers & Rogers v Hoyle (EWHC/QB, 2013), the courts had to decide whether or not the official AAIB report was admissible. The claimants were dependants of a passenger who had died in an accident which occurred on 15 May 2011 when the deceased who was a passenger in a Tiger Moth bi-plane piloted by the defendant was killed when the aircraft crashed. The pilot was seriously injured but survived.

The claimants based their claim on part of the AAIB report which stated that a loop maneuver *"was carried out at too low a height for the pilot to be able to recover from the subsequent spin"* and, further, that as the pilot *"did not have sufficient knowledge or training on the Tiger Moth's correct spin recovery technique, it is probable that he would not have been able to recover from an unintentional spin, especially given the limited height available*" (AAIB Bulletin, 2011). They sought to attach the AAIB report in support of a number of their claims, inter alia, that he did not have sufficient knowledge or training in the correct spin recovery for that aircraft and that shortly before the accident, the aircraft was seen to pull up into a loop that during the maneuver it entered a spin from which it did not recover. The defendant pilot denied this and claimed that the rudder pedals jammed and that he was not able to prevent the aircraft from stalling and flipping over into a spin from which he could not recover as the pedals were jammed.

The defendant contested the admissibility of the report and initiated an application for (1) an order that those parts of the claimants' statements of case which refer to the AAIB Report be struck out, and (2) a declaration that the report is inadmissible in the current proceedings (EWHC/QB, 2013, para 21).

The High Court at first instance held that the AAIB report was admissible as evidence in civil proceedings, both as evidence of the facts stated in the report and as expert opinion evidence. Mr. Justice Legatt stated that the question regarding the evidential weight to be given to the report was a matter for the Court to decide and concluded that *'... the whole of the AAIB Report is admissible as evidence in these proceedings, with it being a matter for the trial judge to make such use of the report as he or she thinks fit. Even if I had concluded that the AAIB Report contains some inadmissible material, I would not have thought it sensible to engage in an exercise of editing out parts of the report. Even on that view, the whole report should be before the court, with the judge at trial taking into account what is admissible and ignoring the remainder' (Rogers & Rogers v Hoyle, 2013, para 118).*

The defendant appealed on three main grounds, namely:

1. The admission of the Report was contrary to the principle in *Hollington v Hewthorn [2943] KB 857* that factual findings made by judges in civil cases cannot be admitted as evidence of fact in later civil proceedings. The defendant argued that the as the AAIB report contained findings of fact based on an evaluation of evidence, it fell within the ambit of this rule;
2. Insofar as the report contained expert evidence it was inadmissible as it did not comply with the rules of court on expert evidence (CPR Part 35) and should thus be excluded; and
3. That if the Report was admissible it should be excluded, as a matter of discretion, under CPR 32 as the first instance court had failed to properly take into account policy considerations when failing to exercise its discretion to exclude the report from evidence, including the prejudice that might be caused to future air accident investigations as a result of the use of AAIB report's in civil proceedings.

The Department for Transport (DFT), representing the interests of the AAIB, as well as the International Air Transport Association (IATA) supported the third argument. Both intervened in the appeal proceedings and made representations that the courts should use its discretion to excluded the report from evidence as its admission would impede future accident investigations and aviation safety.

The Court of Appeal rejected the appeal on all grounds and held that the trial judge was correct to admit the report both as to the facts it contains and as expert opinion evidence. Clarke LJ giving judgment stated that '*The potential value of this material to anyone seeking to establish the cause of the accident (and any culpability therefore) is obvious. The inspectors are experienced and expert individuals fulfilling a public duty to investigate air accidents and incidents for the purposes of preventing further accidents or incidents in future. It is no part of their function to attribute blame or responsibility. …I agree with the judge when he said that a non-lawyer would be astonished that the report of the AAIB was not something to which a court could even have regard'* (Hoyle v Rogers & Anors, 2014 at para 29).

The fact that the testimony was unattributed and that it did not include the context of exact information, went, in the opinion of the Court, to the weight to be given to the evidence rather than admissibility. As the report included statements or reported statements of fact, it was *prima facie* admissible. Secondly, the court did not agree with the submission that the AAIB report fell within the ambit of the *Hollington v Hewthorn* rule. The Court stated that the report was a document containing expert statements of opinion by the accident investigators regarding statements of fact and as such, was not rendered inadmissible by the rule. In addition, the court held that CPR Part 35 regulated the evidence of experts who were *"instructed to give or prepare expert evidence for the purpose of proceedings"*, and Part 35 did not exclude the admissibility of other expert evidence, such as the AAIB report which was prepared for the purpose of preventing accidents. With regards to the third ground of appeal, the appeal court rejected the arguments that the admissibility of the report into evidence would have an adverse effect on future accident investigations and safety.

Clarke LJ submitted that, inter alia, there is no good reason why the admissibility of the report should impede or inhibit the inspectors in their work as they are professionals who are not focused on establishing liability; that the reports are available to litigants and can be used as a basis for a claim or defense, and this has not had any apparent adverse effect on the AAIB's work as he did not consider that the admissibility of the reports would likely significantly affect the willingness of people to give information and assistance to the accident investigators because they have a vested interest in aviation safety (Rogers & Rogers v Hoyle, 2013, paras 89-96). He concluded by stating 'I do not, however, regard the admissibility of AAIB reports as so likely to prejudice the interests which the AAIB is there to serve, that they should generally be excluded from consideration in court,' (Rogers & Rogers v Hoyle, 2013, para 88).

An examination of court proceedings in other jurisdictions demonstrates that there have been a number of cases where the accident investigation report was admissible as evidence in the civil and criminal proceedings against aviation professionals.

The final report of the JAL MD-11 accident of 1997 at Nagoya International Airport, in which a cabin crew died 20 months later, included a probable cause theory by referring to the actions of the captain, pointing to the captain as the person who probably caused the accident, thus identifying a blameworthy person. Based on the findings of the technical report, the captain was prosecuted for criminal negligence, found guilty but later acquitted by the High Court on 2002. Despite the argument by the defense that according to Annex 13, the final report should not be used for punitive measures, the court held that the report should be admissible as it provided the court with evidence that the captain was responsible for initiating the oscillations which had caused the crew member's fatal injury. In this case, not only the finding of the report, but the entire report was admitted into court.

During the criminal proceedings following the Yak-42 accident in Thessaloniki in 1997, the court accepted both the official technical report as well as the report compiled by the aviation accident review board. The judgment finding both the air traffic controllers guilty of manslaughter and sentencing them to five years imprisonment, continually refers to parts of these reports. An appeal court in 2002 confirmed their conviction.

During the criminal trial against the pilots and eight Olympic Airways engineers following the Presidential Falcon 900B accident in Romania in 1999, the accident investigation report found its way into the court room via the back door. Even though the Greek court did not officially accept the accident investigation report conducted by the Romanian accident investigation branch, the court accepted as admissible the investigation report conducted on behalf of the Greek judicial authority which was based on the Romanian accident Investigation report.

Subsequent to the Concord accident in June 2000 and the Tuninter accident in August 2005 off the coast of Italy, French and Italian courts also accepted the accident investigation report as admissible in court.

3. Conclusion

Clearly the decision of Rogers & Rogers v Hoyle will have far reaching implications. However, it is of paramount importance that the initiatives by ICAO to provide tangible material to states in order to amend relevant laws and regulations to protect safety information, which includes the air accident investigation report, must be concluded as soon as possible otherwise world-wide judicial developments may render such protection ineffective.

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Assessing "Drones for Good"—Public UASs in the Middle East

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Abstract: The future challenges and opportunities in aviation are encapsulated by the projected billion dollar unmanned aerial system ("UAS") or "drone" industry. While public perception is predominated by a militarized narrative of UAS applications, the United Arab Emirates ("UAE") is showcasing the technology's versatility and welfare-enhancing and humanitarian uses through its "Vision 2021" initiative. This paper evaluates existing UAS aviation laws and regulatory regimes abroad to conclude that issues of airspace management, safety, and security must be managed if the UAE's proposed model for civil UAS functionality is to be exportable to the private sector globally, whatever its success achieved domestically.

Keywords: unmanned aerial vehicles, commercial drones, airspace rights, autonomous aviation

1. Introduction

Unmanned Aerial Vehicles ("UAVs") range from pocket-sized nano-devices to fixed-wing aircraft weighing more than a thousand kilograms and capable of remaining aloft for hours and days at a time (*e.g.*, high-altitude or medium-altitude long-endurance ("HALEs" and "MALEs")). Importantly, the term "UAV" refers only to the airplane or flying component of a digitally connected network that includes pilots on the ground, a control station, on-board computers, data links, and other ancillary operational assets. Consequently, the abbreviation "UAS"—unmanned aerial system—more aptly describes what is commonly referred to as a "drone."

The advantages of UASs over traditional manned aviation platforms explain the tremendous global investment in the technology by private investors and emerging market entrepreneurs. Through its "Connectivity Lab," for example, Facebook recognizes an opportunity to deliver (and profit from) basic Internet service to everybody in the world through HALE UAVs. Meanwhile, under "Project Loon," Google is experimenting with an unmanned network of stratospheric balloons that would serve as a floating Internet connection drifting with the wind at 20,000 meters above the ground. Small UASs ("sUASs")—*e.g.*, UAVs weighing less than 25 kilograms—are particularly promising. They are more agile than traditional aircraft and can be built cheaply, launched quickly, operated in most weather conditions, and then recovered, repaired, and reused. sUASs perform maneuvers too dangerous for piloted aircraft to attempt. Moreover, they may be controlled by a transmitter that fits in a backpack and they do not require a dedicated infrastructure such an airstrip or airport. Notwithstanding these comparative performance advantages, UASs receive substantial bad publicity given their operational ancestry in combat missions.

Extricating pejorative warfare connotations from the concept of automated or autonomous aviation is difficult given that the history of drones (Janot, 2013) is tightly connected with the formative wars of the modern era, dating back to torpedoes and remotely controlled airplanes of the early 1900s. Presently, the term "drone," standing alone, triggers thoughts of "Predators" and "Reapers" and hunter-killer robots with incomparable intelligence, reconnaissance, and surveillance ("ISR") capabilities. Negative views and militarized conceptions of UASs are particularly acute in parts of Northern Africa and the Middle East, including Iraq and Afghanistan, where the "war on terror" has been carried out, in substantial part, by remote control weaponized drones.

The popular narrative told by media outlets worldwide of combat UAVs (*e.g.*, "UCAVs") aside, unmanned or optionally manned aviation technology presents significant private and public opportunities. These include weather forecasting, firefighting, oil pipeline monitoring, search and rescue, law enforcement surveillance, and even document delivery. Existing efforts by the UAE government to exploit and promote these and other commercially and socially advantageous uses are promising. Less certain is whether the laudable work of the UAE in promoting public UAS functionality can be reproduced in other aviation business environments with a decidedly less favorable regulatory regime governing UAS operations.

1.1 Objective

Under the rubric of "Vision 2021," the UAE has set out to become the first government to use UASs to deliver government services (Carrington, 2014). If successful, the UAE will establish a fresh and momentous example of how to integrate and manage the latest aviation technologies with traditional governmental obligations and powers in the civilian arena. As of mid-2014, however, essentially all civil UAS operations were strictly unlawful (absent special limited exceptions) in traffic rich airspaces such as the United States. In fact, in the United States, aviation regulators prohibit all commercial UAS operations. This effective ban on commercial UAS activity has been defended on a policy putatively grounded in terms of safety and personal privacy (Ravich, 2009). This reality brings into question the reach of UAE UAS initiatives, including whether activities in the UAE would translate well or hold precedential value for other jurisdictions and airspaces with UAV operators.

This paper compares emerging UAS laws in the United States, as developed and enforced by the Federal Aviation Administration ("FAA"), with related rules of the UAE General Civil Aviation Authority ("GCAA"). The aim of this comparative analysis is to test a hypothesis that the American regulatory approach to non-military UAS operations is overly reactionary and prohibitive to new and disruptive automated aviation technologies while the UAE plan offers a better path forward. Correlatively, however, this paper explores whether the UAE model for public UAS operation is jurisdictionally limited and unworkable abroad given the absence of a dedicated regulatory regime for airspace management, safety, and security with respect to UAS operations such as those existent and emerging in the United States.

1.2 Justification

The United States government has estimated that spending around the globe in the unmanned aviation sector will exceed US$89.5 billion by 2024 (Federal Aviation Administration 2014). In Europe, the ASTRAEA consortium in the United Kingdom is working to enable the routine use of UAVs. And, the Middle East market for UAVs is projected around US$260 million annually and US$38 billion over the next decade, with the Middle East accounting for about eight percent of the global UAV market (Feuilherade, 2014, p.35). Given these extraordinary economic forecasts, the announcement in February 2014 by Sheikh Hamdan Bin Mohammad Bin Rashid Al Maktoum of a plan to deliver government services by 2021 by drone is as innovative as it is logical.

The intention of Middle Eastern companies including the UAE's Adcom Systems to establish a footprint in the UAV military market space particularly is unmistakable (Cauchi, 2013). However, at the same time, the UAE has set out to stimulate ideas for incorporating drones into routine government and civilian services as part of its Smart City and Smart Government objective (Masudi, 2014). To further this objective, the UAE has sought to incentivize local and international engineers with the "Drones for Good Award." The initiative contemplates a two-part competition. First, local UAE residents could win US$27,000 for the generation and presentation of ideas for the deployment of UAVs to facilitate the efficient and effortless delivery of various government services; second, US$1,000,000 is offered for international submissions designed to make the world a better place via small autonomous aviation platforms (Carrington, 2014).

Among the services and civilian applications envisioned by the UAE are disaster and emergency management; assessing the effects of floods and drought; weather forecasting; monitoring power lines, pipelines and oil spills; search and rescue missions; and policing and traffic surveillance (Feuilherade, 2014, p.35). For example, at the Dubai International Convention and Exhibition Centre in January 2014, Dubai Civil Defense teams announced their anticipated use of "quad-copters" as "first responders" in fire detection and firefighting dousing operations as well as outfitting policing and traffic surveillance drones with digital systems that can match one person's face out of five million faces in mere seconds (Masudi, 2004.) Additionally, the General Directorate of Residency and Foreigners Affairs in Dubai joined a global drone trend for document delivery, *e.g.*, IDs, driver's licenses, and medication (Barakat, 2014; Carrington, 2014).

"In a first of its kind initiative, the government aims to compete with the private sector in terms of the caliber of service it provides," the Crown Prince of Dubai said, adding that "it's now time to use our skills and expertise to show what this government can offer, not just to Dubai, but also to the world." (Dubai Crown Prince, 2014.) This paper arises from and appraises this extraordinary goal.

2. Methodology

This research was primarily grounded in the review and textual analysis of American judicial opinions over a seventy year period, enacted and proposed legislative enactments of the modern era, executive announcements and initiatives, and administrative directives and policy statements where applicable in the United States or the UAE. Key findings were developed from an item-by-item comparison and evaluation of current aviation regulations in both jurisdictions. Secondarily, this project was informed by global and local media coverage and reports, together with consideration of law journals focused on integration of unmanned aerial system technology into domestic and international airspaces.

3. Key Findings

Evaluation of the laws and aviation regulations in a globally dominant UAV market such as the United States juxtaposed with relevant UAV rules and policy guidance in the UAE evidences: (1) aviation regulators in the UAE control more airspace than their American counterparts and, therefore, may be better positioned to allow a greater range of public UAV operations; (2) the UAE airspace is unique such that drone operations in that environment may not be possible in other aviation environments; (3) regardless of whether the UAV operational and regulatory environment in the UAE can be duplicated elsewhere, the UAE commands a tremendous opportunity to demonstrate that UAVs can be deployed regularly and safely, thereby setting a precedent to loosen restrictive UAV regimes elsewhere; and (4) if undertaken with an outstanding safety record, the UAE government's UAV initiatives could hasten commercial UAV operations worldwide by exposing incremental approaches to integrating UAVs into national airspaces as over-cautious and based on artificial distinctions among types of aircraft and flying machines.

3.1 Civil Drone Functionality Necessarily Relates to Legal Conceptions of Air and Property Rights

The legal controversy surrounding UASs concerns air rights more than technical know-how. UAVs do not enjoy the safety record of other aviation platforms (McGarry, 2013), but they generally work within an otherwise acceptable range of tolerance for accidents or incidents. They work sufficiently well enough, in fact, that Amazon broadcast on the *60 Minutes* its ability to deliver more than 80 percent of its entire inventory via fully automated GPS-guided UAVs.

Where UAVs are permitted to fly is the critical issue and generally is a matter of domestic and international law. In the United States, for example, the federal government controls the use of airspace pursuant to the Supremacy Clause of the Constitution as effected through aviation laws and regulations that preempt state and private property laws. The origins of this legal regime go back to Roman law.

For centuries, ownership of land extended to the periphery of the universe as expressed in the ancient doctrine *cujus est solum ejus usque ad coelom*— "whoever owns the soil, it is theirs up to Heaven." This doctrine was a part of the American common law until it was abandoned in the case of *United States v. Causby* in the 1940s. There, a farmer in the state of North Carolina sued the United States federal government under the principle of inverse condemnation. American Army and Navy aircraft, including four-motored heavy bombers, transports, and fighter airplanes repeatedly flew at low altitudes and landed along a "path of glide" that was a mere 25 meters above the farmer's land, 19 meters above his barn, and 5 meters above the highest tree. He claimed that light and noise from the airplanes not only terrified his family but caused his chickens to kill themselves from fright, resulting in the destruction of the use of his property as a commercial chicken farm.

Pursuant to the Air Commerce Act of 1926, the United States has "complete and exclusive national sovereignty in the air space" over the United States while its citizens enjoy "a public right of freedom of transit in air commerce through the navigable air space of the United States." In this context, "navigable air space" includes "airspace above the minimum safe altitudes of flight prescribed by the [Federal Aviation Administration]." As such, the government argued in *Causby* that its flights were merely an exercise of the right of travel through the airspace within the minimum safe altitudes for flight. Because the flights occurred within the navigable airspace without any physical invasion of the farmer's property, the government argued, the flights did not effect a taking, but at most caused only incidental damage as a consequence of authorized air navigation.

On appeal, the Supreme Court of the United States agreed that the government had essentially taken or deprived the land owner of a particular use of his property through the overflight of its airplanes. However, the court's opinion recognized that society would have to accept airplane operations within the navigable airspace generally, stating that "[t]he airplane is part of the modern environment of life" where ancient doctrines of airspace ownership such as *ad coelom* "have no place in the modern world. The air is a public highway … Were that not true, every transcontinental flight would subject the operator to countless trespass suits."

The *Causby* decision thus involved the balancing of traditional private property rights in the United States with an emergent public need for unobstructed national airways. Today, under *Causby*, the taking of an aviation easement in modern American business law turns on whether an airplane flies directly over private land, the altitude and frequency of the flights, and whether the flights directly and immediately interfered with the enjoyment and use of the land. This legal analysis has since been applied by other courts in disputes involving airspace use and private property rights. Indeed, airspace management is essential as a practical matter in modern commercial, general, and military aviation—even in outer space. Today, numerous laws and regulations exist to manage aviation traffic, including rules for terrain clearance, minimum en route altitudes, ground and airborne navigation aids, air traffic density, and air traffic control procedures.

The reason why integrating UAVs into the nation's airspace is difficult for safety-conscience aviation regulators is simple to explain, therefore: the airspace was originally designed for manned assets. With the number of UASs projected to be 15,000 by 2020 (Federal Aviation Administration, 2014), the prospect of accidents and mid-air collisions is not strictly hypothetical; recent events have aggravated the concern regulators have about UAS integration. In November, 2013, a malfunctioning UAV crashed into a United States Navy ship off the coast of Southern California, injuring two sailors. A remote controlled aircraft reportedly almost struck a US Airways flight about five miles from Tallahassee Regional Airport in Florida at an altitude of 2,300 feet a few months later (Frizell, 2014). In 2014, the United Kingdom's Civil Aviation Authority prosecuted a man who flew his UAV in restricted airspace over a nuclear submarine facility, collecting an £800 fine and recouping £3,500 in legal costs. In Australia, a chartered aircraft preparing to land at Perth Airport missed an unmanned flying aircraft by 20 meters after taking evasive action. Three days later, a rescue helicopter with a crew of five nearly collided with a UAV hovering above a soccer stadium. Measured against these events, the fervor to allow commercial UAS operations in the United States is rightly tempered by aviation regulators.

Given that a robust set of aviation laws exists in the UAE to encourage safe aeronautical operations, and given that the UAE is unconstrained by many of the constitutional concerns that present in the United States, aviation regulators in the UAE command more control over more airspace than their American counterparts and, therefore, may be better positioned to allow a greater range of public UAV operations of the type encompassed by the "Vision 2021" project.

3.2 Air Rights, and thus Drone Operations, are Unique in the UAE

UAE aviation regulations exhibit many of the standard operating provisions found in aviation rules around the world. For example, applicable regulations, under the heading "general regulations"— address the topic of "minimum heights," stating

Except when necessary for take-off or landing, or except by permission from the GCAA, aircraft shall not be flown over a congested area of cities, towns, or settlements or over an open-air assembly or persons, unless at such a height as will permit, in the event of an emergency arising, a landing to be made without undue hazard to persons or property on the surface. (United Arab Emirates General Civil Aviation Authority, 2005 Chapter 2, Section 2.3).

UAE air regulations also make a special provision for restricting flight near public figures, including "over or in the vicinity of any area to be visited or travelled by the President, Sheiks, or other public figures." (United Arab Emirates General Civil Aviation Authority, 2005 Chapter 2, Sections 2.13, 2.16). And, like federal aviation regulations promulgated by the Federal Aviation Administration, the UAE aviation regulators provide for right of way rules and restrict aircraft from operating in such proximity to other aircraft so "as to create a collision hazard." (United Arab Emirates General Civil Aviation Authority, 2005 Chapter 2, Sections 2.15, 2.16). In this regard, the aviation legal landscape in the UAE appears to account for safety in a manner consistent with accepted international practices while customizing drone operations to UAE's protocols and culture, *e.g.*, concerning the dignity of public figures.

But, the GCAA also enjoys powers that may facilitate the public use of drones in ways not possible elsewhere. In comparison to American aviation laws and regulations governing UAS activities, for example, the GCAA Civil Aviation Regulations ("CARs") define navigable airspace as "airspace above the minimum flight altitudes prescribed by or under Civil Aviation Rules, including all legitimate low level operations but not including prohibited, restricted and danger areas." (United Arab Emirates General Civil Aviation Authority, 2005 Pt. I ("Definitions") No. 743). Interestingly, the idea of "minimum *flight* altitudes" differs from the American conception of "minimum *safe* altitudes," the consequence of which may be a regulatory tolerance for low level airplane operations in the UAE that does not (and perhaps cannot) exist in the United States.

In any case, while Part VII, Subpart 3 of the CARs goes on to provide specific guidance with respect to navigable airspace, including its designation and classification and control of objects and activities affecting it, the phrase "legitimate low level operations" is nowhere defined. Presumably a determination of the legitimacy of such operations would rest exclusively with the GCAA, just as the interpretation of federal aviation regulations ("FARs") in the United States are drafted and interpreted by the FAA with limited judicial review and oversight. But, at a minimum, it would seem the UAE government enjoys broader discretion to control the operations of civil, public, non-military UAVs than currently exists in the United States.

Meanwhile, to the extent the CARs speak to the issue of "airspace infringement," they clearly disallow "any manmade object to infringe above a height of 200 feet above ground level within 8 km of an airport, or 300 feet above ground level elsewhere within the UAE [Flight Information Region], unless approved by the appropriate Emirate Department of Civil Aviation." (United Arab Emirates General Civil Aviation Authority, 2005 Chapter 7, Section 7.1). Notably, Chapter 7, Subpart 7.1(c) of the CARs specifically extends this provision to "model aircraft or drones" though neither of those terms is defined by rule. (The CARs provide a definition for "unmanned free balloon" (United Arab Emirates General Civil Aviation Authority, 2005 Part I, No. 1157) but do not define "drones" or "UAV" or "UAS" separately or as within the generalized definition of "aircraft" (United Arab Emirates General Civil Aviation Authority, Part I, Nos. 69 and 70), *i.e.*, "any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface" and "airframes with aircraft engines installed thereon or helicopters.")

In the final analysis, the GCAA's airspace rules are more restrictive than the 400 feet discussed in the aforementioned *Causby* decision and current aviation regulations in America establishing the floor of the national airspace system ("NAS") at 500 feet for most category of aircraft (but not rotorcraft, including helicopters). In effect, the UAE government commands greater air rights relative to its citizens than is true in the United States, a fact that encourages the initiative to use drones for government purposes.

The unique aspects of UAE aviation regulation presented here may not be transferrable to other jurisdictions with respect to UAV operations. The relationship between governments and citizens differs around the world, after all, and what may be workable in one place may be unworkable in another place. However, the UAE will establish an important precedent for UAV operability globally if it safely, reliably, regularly, and successfully demonstrates the use of UAVs for routine public functions in *any* airspace. Such operations would empower a private firm currently disallowed from deploying a drone for remuneration to point to safe and productive UAV operations in the UAE in order to loosen existing restrictions to which it must comply.

3.3 UAE UAS Policies are Decisive and Predictable without Apparently Disregarding Safety

In contrast to the executive decision in the UAE to incorporate drone capabilities into government service, aviation lawmakers in the United States, together with private stakeholders, have been evaluating potential UAV rules for nearly a decade.

Most recently, in 2012, the United States Congress enacted legislation designed to promote safety and commerce for UAS assets. Under the "FAA Modernization and Reform Act of 2012" ("FMRA"), Congress directed the FAA to produce comprehensive UAS regulations to "safely accelerate the integration of civil unmanned aircraft systems into the national airspace system." The FMRA specifically requires the FAA to implement a plan to integrate UASs into the NAS "not later than" September 30, 2015. The FMRA also directs the FAA to prepare recommendations and projections on the rulemaking that will define the acceptable standards for operation and certification of civil UASs, ensure that any civil UAS has sense and avoid capability, and establish standards and requirements necessary to achieve the safe and routine operation of civil UASs in the NAS. The FMRA allows for a "phased-in" approach for civil UAS integration, but also establishes target dates or ranges, *i.e.*, August 2014 for the publication of a final rule governing operations for sUASs.

In the interim, while private UAV operators await formal regulatory guidance, no person may operate a commercial UAS in the NAS without first obtaining specific authority from the FAA in one of two ways. First, a Certificate of Authorization or Waiver ("COA") must be obtained from the FAA to operate a UAS as a public entity, *e.g.*, agencies receiving funding from the federal government, including police, fire rescue services, and public universities. Otherwise, all other operators must apply for a Special Airworthiness Certificate - Experimental Category under federal regulation 14 C.F.R. § 21.191 for limited purposes, including research and development, market surveying, and crew training. With only 545 COAs active as of December 4, 2013, civil UAS operations are exceedingly rare.

Against this backdrop, if the UAE can implement its plan to incorporate drones into regular government processes and achieve an outstanding safety record, then the prospect for civil and commercial UAV operations elsewhere would be improved markedly and serve as a striking counterpoint to the extended, almost interminable UAV law making process ongoing in the United States. Conversely, a high incident of UAV accidents or adverse events in the UAE would be a substantial setback for firms interested in civil and commercial UAV applications and validate the deliberative pace of United States UAV rulemaking.

3.4 Distinguishing Model Aircraft from Commercial Drones is Artificial, but Matters

In the United States, no approval is required from the FAA to fly a "model aircraft" for recreation. The FAA has recognized that modelers are generally concerned about safety and exercise good judgment. Nevertheless, in 1981, the FAA published Advisory Circular 91-57, entitled "Model Aircraft Operating Standards," for the purpose of providing "guidance to persons interested in flying model aircraft as a hobby or for recreational use." AC 91-57 focuses on site selection and recommends model airplane operations occur below 400 feet, three miles from an airport, and away from populated areas. In a direct attempt to prevent companies like Amazon from using drones, the FAA has fashioned a hobby-versus-drone distinction to eliminate commercial UAV operations as evidenced in Table 1, below (Department of Transportation, 2014).

Mission Type	Hobby or Recreation	*Not* Hobby or Recreation
Leisure v. Business	Flying a model aircraft at the local model aircraft club.	Receiving money for demonstrating aerobatics with a model aircraft
Personal Use v. Commercial Gain	Taking photographs with a model aircraft for personal use.	A realtor using a model aircraft to photograph property that he is trying to sell and using the photos in the property's real estate listing.
Compensation	Using a model aircraft to move a box from point to point without any kind of compensation.	Delivering packages to people for a fee.
Scope of Operations	Viewing a field to determine whether crops need water when they are grown for personal enjoyment.	Determining whether crops need to be watered that are grown as part of commercial farming operations.

Table 1: U.S. Regulatory Guidance Differentiating Hobby or Recreational Flights from Disallowed Operations

The FAA's distinction between hobby or recreational airplanes, on the one hand, and commercial drones, on the other hand, is as arbitrary as it is consequential. Flight is allowed in one scenario and completely disallowed in the other—the only distinction apparently being the exchange of money. In this context, too, remarkably, the UAE government has an outstanding opportunity to outpace private enterprise by demonstrating the reliability of drone technology whilst American aviation regulators draw distinctions between model aircraft and UAVs that frustrate and deepen a pent-up demand for commercial drone operations.

4. Conclusion

The potential for a government—any government—to make drone deliveries before a private company such as Amazon is jolting and strikingly ironic for free market thinkers and advocates (Wohlsen, 2014). Whereas the United States is working at an almost glacial pace through a rulemaking process that could last a decade before private firms deploy commercial drones, the UAE is evidencing a willing embrace of the subject technology. In the final analysis, safety may be a deciding factor as to whether the Federal Aviation Administration's lethargy or the UAE's energy is a better way. If the UAE can establish a system of routinely safe UAV operations along a broad range of activities, aviation regulators in the United States will be hard pressed not to loosen commercial restrictions and apply best practices demonstrated by the UAE. On the other hand, if the UAE is not able to fly UAVs predictably safely, the entire emerging industry could be dealt a serious setback. Such is the essence of risk-taking and entrepreneurialism, which in the context of UAVs, is a bright hope in a region of the world where drones have earned a decidedly negative reputation.

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Airfares Global Distribution Strategy for Higher Incremental Revenues in Non-Core and Distant Markets

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Abstract: This paper elaborates an often ignored commercial potential of non-core and distant countries. It is shown that airlines can seek incremental revenues in off-line markets utilizing their current distribution channels at minimum investment. Yet the airlines often miss these opportunities by not having set their fares accordingly. The study, supported by sound literature review, analyzes these points of issue, proposes an airfare global distribution strategy for higher incremental revenues from non-core and distant countries and provides recommendations for implementing this strategy.

Keywords: non-core and distant markets (NCDM), distribution, fares, e-ticketing, interline partner airlines

1. Introduction

Profitability has been a major issue in the aviation industry for a few decades even though, according to IATA (2014), airlines are expected to achieve a collective global profit of USD 18 billion this year. Tony Tyler, Managing Director and CEO of IATA, comments (IATA, 2014): "… That sounds impressive. But the brutal economic reality is that on revenues of USD 746 billion we will earn an average net margin of just 2.4%. … Every day is still a struggle to keep revenues ahead of costs. … The average return on invested capital today is 5.4%—up from 1.4% in 2008. But we are still far from earning the 7-8% cost of capital that investors would expect."

There are numerous approaches and methods how to support revenue generation and decrease costs. Airlines usually focus on better yield management, revenue accounting, more economical aircrafts and looking for any kind of cost savings. These projects ordinarily require time and substantial resources and also imply certain significant financial investments (for example, renewing fleet), or unwillingly reducing or giving up a part of services (for instance, canceling a route or removing the first class from the cabin).

This paper proposes an unconventional method, which can notably increase airlines' revenues at practically negligible additional cost by implementing an efficient airfares distribution strategy, which enables airlines to exploit sales opportunities not only their on-line and core markets, that is, where airlines actively fly and sell e-tickets, but also in their non-core and distant markets [6] with existing distribution tools in existing distribution channels. Before elaborating this topic, let us first briefly examine the airline distribution environment, focusing only on GDS travel agencies as the most important distribution channel.

[6] Non-core and distant markets (abbreviated as NCDM) were coined by Riha (2014) as the countries, where a particular airline 1) does not operate any flights, 2) does not offer any marketing code share flights, 3) does not have any own sales office or any general sales agent (GSA) and 4) did not make its tickets available to local travel agencies through entering a local IATA Billing and Settlement plan (BSP).

Passenger airlines established the cornerstones of the computerized distribution in the 1960s in order to make their seats available for sale internationally in an automated way. These systems, usually called "GDS" (Global Distribution Systems), have been spreading throughout the world and developing very profoundly in the past four-plus decades.

Today, there are three major GDS companies in the world – Amadeus, Sabre and Travelport. According to PhoCusWright (2009), altogether they power the critical reservations and technology infrastructure employed at over 83% worldwide travel agents, executing over 75% of all airlines' bookings. They generated more than $9.6 billion in revenue and more than $1.1 billion transactions in 2008.

In order to benefit from the power of the GDS distribution, airlines have to be able to control the entire sales process from publishing their flights over loading and setting their fares to e-ticket issuance. The first step is relatively simple; the airline signs a distribution agreement with a selected GDS company and connects its airline reservation system. As a result, travel agents can see the airline's flights and book its seats.

The final step to issue the e-ticket is also relatively straight-forward; the airline runs its e-ticketing database and is also a member of IATA BSP (Billing and Settlement Plan) in its key active markets to enable agents e-ticket issuance and settlement of the respective due amounts collected by travel agencies.

In other markets, airlines usually rely on the e-ticketing of their partner airlines, so-called interline partners, to issue e-tickets, so that the revenues are properly collected and forwarded.

In this respect, airlines can also benefit from cooperating with Hahn Air, a premium German business jet carrier specializing in global distribution. Hahn Air has established a network comprising of over 260 airlines, 190 markets and 91,000 travel agencies. Thus, travel agents anywhere in the world can book desired flights marketed by Hahn Air's partner airlines in any GDS and issue Hahn Air e-tickets to accomplish their sales transactions. Hahn Air then takes care of all revenue collection, revenue accounting and reporting with respective airlines, typically including the revenue settlement via ICH (IATA Clearing House).

At this point, a key question is, whether a particular travel agent actually chooses to sell an airline's booked flight he or she found in GDS. This can depend on various factors. However, the price (fare) is one of the most important, for it intensely drives the demand, as confirmed by Holloway (2008, p.131).

Now, what if a distant agent in a non-core and distant country can sell only high fares on a desired flight making the flight significantly less competitive or less affordable, whereas, at the same time, other agents in on-line countries can sell the same flight for more convenient fares? What if a distant agent can't find any applicable fare, for the respective carrier did not set any fare relevant for the travel agent's market neglecting it for being non-core and distant? Typically, travel agents remove such a flight from the booking and search for other more competitive options or they stop and tell their customers bad news. As a result, the respective carrier loses a sales opportunity without noticing.

Regarding airfares distribution, airlines tend to believe that their offerings are available in all travel agencies all over the world exactly in the way they wish, since their yield management teams steer their capacities, booking classes and thus yields centrally and globally. In order to make airfares available worldwide, airlines usually use ATPCO (Airline Tariff Publishing Company) for filing their fares. ATPCO automatically and regularly redistributes all fares to all distribution systems. ATPCO works with 444 passenger airlines storing 140 million fare records from all around the world, of which 60 million records are public, that is, intended for overall travel agency distribution. (Purzer, 2013) However, as the reality shows, this may be true for airlines' core markets (countries), but it needn't always be true for their non-core and distant markets, which usually stay out of the horizon from the head-office.

The fact is that airlines often occur to impose so-called "document restrictions" on their fares to let them sell only on their own e-tickets to save on distribution cost and to limit possible revenue delusion. This works fine for airlines' on-line and core markets, but it negatively impacts non-core and distant markets, where the airline may sell over other airline' e-tickets. By saving a few dollars, airlines give up all or significant portions of potential distant sales.

Exploiting incremental sales in non-core and distant markets can considerably help airlines to improve their financial health. For example, to show significance of the NCDM sales potential, if Air Malta were selling extra one or two million Euros per annum in ticket revenues outside of Europe, which is realistic, in the markets, where Air Malta does not fly, does not have any sales offices nor conduct any particular sales activities, Air Malta could reduce its 2012 annual loss by between 4-8% from EUR 25 million down to EUR 23-24 million Euros.

At this step, let us briefly consult literature to set viable foundations for airfare distribution.

2. Literature Review

Holloway (2008) provides a practical overview and useful insights into airfares and its distribution serving as the basis and theoretical foundations for this work. The following paragraphs exempt the key facts, principles and recommendations.

Holloway deems pricing as extraordinarily important, because it is airlines' fare and cargo rate structures that drive the system yield. Yield factor is a key element in the principle commercial equation lying at the heart of the entire airline business:
TRAFFIC x YIELD < > OUTPUT x UNIT COST = OPERATING PERFORMANCE (i.e., PROFIT or LOSS)

Moreover, price has been becoming an ever more sensitive element in the industry's marketing mix in most parts of the world.

Holloway sets the fundamental objective of the pricing function as to design a tariff structure for each market that maximizes revenue earned from price-inelastic segments of demand, stimulates demand from price-elastic segments to fill space that would otherwise fly empty, and imposes conditions sufficient to limit revenue dilution arising from the diversion of demand from high-yield fare or rate bases targeted at price-inelastic segments to lower fares or rates targeted at price-elastic segments.

In light of the above objective, he suggests that on the level of the passenger fares, it can be helpful to treat the fully flexible, refundable, unrestricted fare applied for travel in a particular cabin (economy/coach, business, or first class) in a given market as the strategic 'price platform' for the service concept of which the cabin concerned is a part; this fare is usually called 'full fare' or 'unrestricted fare'. A series of lower fares can be developed from any price platform to tap into the price elasticities of different segments of demand identified by reference to their willingness to pay to travel in the cabin concerned, in the market concerned, at particular times.

Holloway points out that demand does not just exist; it exists at a price, thus being one of the most important determinants of demand. And since different prices and conditions address different parts (segments) of the demand, airlines shall have more sets of fares that address these different demand curves. In other words, airlines shall create their 'fare structures'.

Holloway explains that 'fare structure' is a term encompassing the many different passenger fares that may be offered in a market at any point in time. Fares, together with the specific rules applied to each comprise 'tariff structures'. Tariff structures should be clear and straightforward enough to be easily understood, particularly by travel agents and others in external distribution channels, and yet also sufficiently layered to tap into the various level of willingness to pay that exist in different segments.

Holloway identifies four principal pressures shaping passenger tariff structures. Two pressures in particular have contributed to increasingly complex tariff structures and price volatility:

1) Liberalization and deregulation
2) The use of revenue management systems (RMSs) to micromanage seat availability at different prices

Conversely, two pressures have more recently contributed to a simplification of tariff structures, most notably in short-haul markets:

1) The growing market reach of low-fare airlines
2) The penetration of the Internet, particularly in North America and Europe, enabling almost instantaneous price comparisons to customers

Lastly, Holloway stresses out the major phenomenon influencing the tariff structures, fare levels and tariff conditions. From 2000 onwards, first in the US and Western Europe, gradually everywhere in the world, it became clear that the price-inelasticity taken for granted in the business traveler segment was unraveling. Revenue models built around exploiting the price-inelasticity of business travelers, and the willingness of others to accept restrictions in return for discounts, have been undermined by:

- Corporate customers' reassessment of business travel budgets and practices
- The inexorable growth of low-fare airlines
- Much greater price transparency resulting from the shift to Internet distribution.

3. Methodology for Analysis of Fare Structures in NCDM

Key findings from Holloway (2008) speak clearly. Fares must be set for all markets, which also logically embrace non-core and distant countries. Fares must be competitive and minimally restricted to successfully compete in today's global market place. This chapter explains how to analyze airlines' fare structures whether they meet Holloway's requirements in respect to successful distant distribution.

First, it is practical to select a sample of routes representing the carrier's network not to have to analyze all the city pairs, which can be extensive. According to Riha (2014), the following template provides a good picture at rational effort:

- One major domestic route (if a carrier does not fly domestically, a characteristic local/regional route to be chosen instead)
- Two typical local/regional routes (short-haul)
- Two major middle-haul or long-haul depending on the carrier (international, beyond the region)

When choosing the routes for the sample, it is to consider a number of weekly seats or flight frequencies (the higher the number, the more important role the route is in the network) and a geographical factor (for example, one route to Europe, another to Asia).

Next, using a GDS terminal, it is possible to display a Fare Quote Display for a respective route showing all published fares of the analyzed airline. By checking each fare for its 'fare rules', conditions for sale can be read out whether the fare is 'document restricted' or not. If the fare is document restricted, it can be sold only on the airline's own e-ticket. As a result, such a fare is unsalable in all non-core and distant countries, where the airline's own e-tickets are unavailable. Depending on a portion of unsalable fares in the fare structure, Riha (2014) defined the following categorization to easily interpret and evaluate salability of airlines' flights in NCDM.

NCDM Restriction Extent	Description	Conclusion
Open	Basically all published fares are available for sales in NCDM countries.	Positive
Slightly Restrictive	Only a few lowest fares are not available for NCDM sales.	
Very Restrictive	Most fares are NCDM restricted. Only high-priced economy, business and first class fares are open.	Negative
Extremely Restrictive	Virtually no published fares suitable for NCDM distribution were discovered.	

Table 1: Categorization of the Extent of NCDM Restrictions

The following section will show the above analytical method in action using an example of a real analysis of a carrier's fare structure and will derive recommendations and a strategy for airfares global distribution to generate higher incremental revenues in non-core and distant markets.

4. Analysis and Results

Air Austral was chosen as a typical case. Air Austral is an airline based in Réunion, a French territory located in the Indian Ocean.

The airline used to offer a highly ambitious set of scheduled and charter services to destinations in Africa, Europe, the Indian Ocean, Asia, and Australasia until 2012. Air Austral announced in 2009 an order for two 840-seat Airbus A380s, to operate on its high-density route between Réunion and Paris, with talk also of services to the Asia Pacific region, including Australia, where it then operated with the 777 equipment. After suffering substantial losses and a partial bailout by the government, a major restructuring program was initiated in 2012, involving reduction of network and fleet and reportedly cancelling the A380 orders. Air Austral currently operates 8 aircrafts to 13 destinations. (CAPA, 2014)

```
**  RULES DISPLAY  **                       TAX MAY APPLY
                                            OB FEES INCLUDED
                                            SURCHG MAY APPLY-CK RULE
21JUL14**21JUL14/UU RUNPAR/NSP;EH/TPM  5818/MPM  7066
LN FARE BASIS     OW   EUR  RT   B PEN  DATES/DAYS   AP MIN MAX R
02 JRPOW        [redacted]          J -       -      -   + -  -   -  R
FCL: JRPOW     TRF: 849 RULE: ABLC BK:  J
PTC: CCM-CARD CARRYING MEMB FTC: BU -BUSINESS UNRESTRICTED
FR.FARE BY RULE
FARE BY RULE CONDITIONS APPLY
BASE FARE:  FCL: JOW       TRF:  23 CARRIER: UU RULE: 06UU
PTC: ADT  FTC: BU

[redacted].RULE APPLICATION
FARE BY RULE
FOR BUSINESS UNRESTRICTED FARES
AIR AUSTRAL CLUB AUSTRAL SUBSCRIBER FARES
 APPLICATION
   CLASS OF SERVICE
     THESE FARES APPLY FOR BUSINESS CLASS SERVICE.

SR.SALES RESTRICT
FARE BY RULE

  TICKETS MUST BE ISSUED ON UU .
  EXTENSION OF TICKET VALIDITY IS NOT PERMITTED.

AP.ADVANCE RES/TKT
  NONE UNLESS OTHERWISE SPECIFIED
```

Figure 1: An Example of Air Austral's Document Restriction in a Fare Rule

Route Category	Routing	Number of Published Fares	Number of Inspected Fares	Number of NCDM Restricted Fares	% Restricted Fares	NCDM Restriction Extent
Long Haul	RUN-PAR	86	86	58	68%	very restrictive
Regional	MRU-RUN	21	21	18	85%	very restrictive
	RUN-DZA	31	31	14	45%	very restrictive
	RUN-TNR	21	21	14	66%	very restrictive
	RUN-JNB	19	19	12	63%	very restrictive
NCDM Restriction Extent	extremely restrictive	very restrictive	slightly restrictive	open		
Result	0%	100%	0%	0%		**negative**

Table 2: Air Austral NCDM Fare Accessibility Analysis

Table 2 shows the results of Air Austral's fare structures. The analysis discloses that its fare structures are very restrictive across its network (an example of the specific document restriction is shown in the Figure 1, the setting marked in red). This makes Air Austral considerably uncompetitive in the global market place, reflecting the fact that Air Austral offers its tickets only in 22 countries (Source: Amadeus GDS). In all other countries, where Air Austral could have been sold on other partner airlines' tickets, Air Austral blocks most of its fares for any sale in non-core and distant markets. Thus, the airline has been sacrificing incremental revenues, which could have been generated in distant countries. These revenues could have possibly supported its on-going restructuring program and improve financial health of this carrier.

Riha (2014) analyzed a sample of 10 airlines based on the statistical data of 270 scheduled passenger airlines, which were selected for suspicion of the probable deficiency of their fare structures for sales in NCDM. The analysis showed the following findings:

- Airlines sell in average 0.65% tickets in NCDM measured by arithmetic mean and 0.26% measured by median.
- Thus, selling less than 0.65% or 0.26% indicates tendency to underperform in NCDM sales. Selling less than 0.1% tickets is sure underperformance (25th percentile).
- 60% of fare structures were adverse for sales in non-core and distant markets. 60% is significant. It can be deemed as a pattern, not as a coincidence. Thus, restrictive fare structures certainly have a negative impact on NCDM sales.
- However, there are other "soft" factors contributing to underperformance, too (rest 40%). It can be, for instance, brand awareness, expected service quality, safety reputation, attractiveness of the hub for distant sales, etc.)
- Based on Riha's findings, the following strategy for higher incremental revenues in non-core and distant markets can be proposed:
- Bearing in mind the airline's overall strategy and competitive environment in mind, airlines shall efficiently tap incremental revenues by making their common airfare structures fully (or partially with intentionally selected airfares) available for sales in non-core and distant markets, so that all or desired fare bases can be normally sold on e-tickets of selected interline partner airlines present in particular non-core and distant countries.
- Further on, the following recommendations can be given for implementing this strategy:
- Airlines should analyze revenue delusion and distribution cost taking into account NCDM distribution. Their possible revenues in NCDM cannot be diluted from own tickets to other airlines' tickets, since the own tickets are not offered there. Their distribution cost cannot be too high in NCDM, when thinking in terms of marginal cost and contribution and carefully analysed using cost-benefit analysis.
- Airlines should verify:
  - whether their airfare accessibility is in accord with their overall strategic goals, in particular, when they aim to improve sales and make their business profitable
  - whether their airfare accessibility supports their growth, expansion and market penetration strategies, especially when facing intense competition
  - whether their regional offices, if they set airfares, do not omit NCDM

In the end, it is simple: No tickets in NCDM, no sales in NCDM, no contribution from NCDM. No incremental revenues in NCDM result in less profit or in higher financial loss.

5. Conclusion

This paper points out the hidden sales potential of so-called non-core and distant markets, which can be quickly exploited through minimum investment to improve airlines' financial results at the age of the difficult economic reality.

In spite of the fact that airlines ordinarily use distribution tools for global distribution, in particular, GDS, ATPCO, IATA BSP and ICH, they tend to reserve their airfares for sales only on their own e-tickets. This results in losing sales opportunities in the countries, where they do not make their e-tickets available to travel agencies.

On the contrary, literature proposes that airfares be set for all the markets, which logically mean also including non-core and distant countries, and be competitive and minimally restricted to successfully compete in today's global marketplace.

Next, this paper presents a methodology how to analyze airlines' fare structures in this respect. Using an example of Air Austral, it is demonstrated how airlines give up on the NCDM sales potential. Previous analyses of 10 other carriers from a data set comprising of 270 airlines prove the same conclusion.

Finally, this work proposes a strategy for successful airfare distribution in non-core and distant markets and offers supporting recommendations how to tap the sales potential there.

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Improving the Speed and Impact of New Technology Adoption in Aviation

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Abstract: This study investigates the reasons for the gap between technological advances and the technological adoption rate within aviation. Research suggests that the impact of technological advancement on aviation is below the expectations considering the growth and influence of new technologies. Current technological trends in aviation have been presented at a high level, but this research work primarily focuses on passenger IT trends in e-commerce and m-commerce. Technology cost and impact analysis has been applied to provide an estimation of the timeline and factors needed for airlines and airports to achieve true "paperless travel and seamless integration" across the industry.

Keywords: e-services business case, passenger services alignment, operational efficiencies, technology adoption

1. Introduction

Global passenger airline traffic is expected to increase steadily over the next 20 years by an average of about 5% per annum (Airline Data ICAO, 2014). The main reasons for the predicted growth are increases in GDP, increased globalization, and population growth. To accommodate this growth trend aircraft manufacturers and airline solution providers are implementing new technologies into aircrafts, focusing on increased safety, increased capacity, increased range, reduced emissions, reduced noise, enhanced payload, higher flight speed, better overall management of the aircraft, lower operating and maintenance costs, and integration of e-services to serve passengers better.

Introducing improvements in such a diverse areas at once has been made possible by emerging technologies, which create radically new materials and devices with a vast range of applications in engineering, electronics, oil, energy and, by extension, aviation. Examples of these emerging technologies include nanotechnology and carbon fiber construction, new computer processor lithographic techniques and reducing die sizes, and the increasing development and interoperability of global computational networks (IEEE, 1997).

The objective of this paper is to identify and understand the technological advances and the significant gap between wider IT Trends and the rate of technological adoption within the scope of e-commerce and passenger services in aviation. The paper later suggests how to bridge this gap and thus improve the passenger's overall travel experience.

1.1 Current Technological Advancements within Aviation

An overview of some of the recent technological advancements in aviation can be found below (Aircraft IT, 2014):

- Next Gen Aircrafts - New generation aircrafts are designed with the extensive use of nanotechnology and carbon fiber. Resulting in reduced weight, increased fuel efficiency and simpler airframe design.
- Usage of 'big data' - Airbus and IBM utilize 'big data' to bring to the market new, innovative and integrated IT-solutions. Sagem and Snecma have released a joint fuel efficiency service known as SFCO2, which helps airlines set up and maintain a fuel conservation program by reducing fuel consumption and carbon dioxide.
- Maintenance & Engineering systems in 'The Cloud' - Outsourced or insourced distributed and scalable computing, often referred to as 'The Cloud', has allowed airlines and maintenance, repair and overhaul (MRO) organizations to access their Software-as-a-Service (SaaS) from any location with an internet connection.
- Use of Radio-frequency identification (RFID) - RFID has been used to improve baggage tracking and enhance the baggage service offering to passengers.
- Tablet Electronic Flight Book - easyJet and flydubai are amongst the airlines replacing traditional paper charts and aircraft documentation with tablet-based electronic flight books.
- E-commerce and M-commerce - The industry is currently in the peak period of deploying e-commerce and m-commerce technologies, such as e-tickets, bar-coded boarding passes, e-freight, e-services to sell seats, manage booking, baggage, insurance, and Electronic Miscellaneous Documents (EMDs).

1.2 The Challenges of Technology Adoption within Aviation

Air transport markets and the airline industry have been transformed beyond recognition over the past 40 years. Passenger and cargo volumes have grown immensely, in spite of threats of financial instability, health epidemics, sabotage and terrorism. Especially over the last decade, the industry has been hit by a series of successive crises and shocks, including volcanic eruptions, global economic upheavals, 9/11, and an unprecedented rise in fuel cost, which currently accounts for the single biggest component of operating costs for most airlines. The industry posted a combined net loss of $30 billion between 2000 and 2010 (IATA, 2009). IATA's Vision 2050 report (IATA, 2011) predicts that by 2050, carriers will fly 16 billion passengers and 400 million tons of cargo annually. The industry is already planning measures to address the resultant capacity issues this growth will bring through the development of sustainable technologies and efficient infrastructures.

Due to a range of industry-specific considerations including the overarching priority of safety in flight operations, the aviation industry has not historically embraced new technologies as fast as some other industries. A good example of this is in the development of e-tickets, which took over 10 years to implement in a cohesive manner despite being technically straightforward.

Over the past 15 years, as the internet has become increasingly used for business and commerce, IATA has espoused the merits of e-technology and stated their intent to move towards an e-service enabled industry. IATA's e-Services Project (2005-2014) outlines IATA's roadmap for EMD usage, in which a future of integrated, paperless e-travel is defined in three phases: phase 1

- e-ticketing, phase 2 - e-boarding and phase 3 - automation of other paper documents. The IATA Board's target was first target for EMD usage and seamless integration was June 2010. This was later revised to October 2013 and further extended to June 2014. To date, this has still not been achieved. IATA's vision is for a future where it will be easy for customers to choose products/services and airlines have the ability to customize their offering through all buying channels (SITA, 2013). In IATA's concept of the 2020 airport, passenger experience will be seamless and airport processes will be swift by maximizing use of self-service options such as boarding pass generation, self-check-in, common bag drop and automated border control. Combined, these minimize traveler inconvenience.

Passenger services alignment and baggage handling issues continue to remain prominent areas of focus. Many governing bodies are involved in the search for a solution, conducting conferences and seminars designed to address the challenge of how to synchronize across borders and utilize the latest technological trends. However, until recently, there has been little progress, and the industry is now trying to understand the underlying resistance to technological uptake.

Technology adoption happens when costs of the change are outweighed by the potential benefits of the change. Both the costs and benefits are often uncertain and cannot be truly understood until well after the project has finished. It is the rate of technological adoption within aviation, rather than technological advancement itself, that ultimately determines the rate of technological improvement in the aviation industry. The ultimate decision on adoption is made by the airline but the benefits and costs can be influenced by decisions made by suppliers of the new technology. The most important point about this kind of decision is that at any point in time the choice being made is not a choice between adopting and not adopting, but a choice between adopting now or deferring the decision until later. Airlines err on the side of caution.

To summarize, the challenges facing faster technology adoption within airlines include:

- Uncertain growth in passenger numbers and thus revenue
- The fast pace of change outside the direct control of the industry, especially the recent financial instability in the sector
- The overarching focus on safety within the industry and the necessary limitations this places on new technology adoption
- Culture of resistance to change from within the industry itself

2. Methodology

2.1 Approach

In this paper, the research approach has been categorized as: Qualitative and Quantitative. The qualitative research establishes the factors restricting the technology adoption rate, while the quantitative research method gauges the intensity of the underlying technology adoption challenges.

The research consisted of analysis of in-house flydubai business plans to understand senior executive concerns with technology projects, and workshops (conducted via emails and telephone) with the following airlines: Blue Panorama, Egyptair, Peach, flydubai, Petra Airlines, Star flyer Airlines and Emirates. The study also included statistical research on use of online and check-in kiosks by flydubai customers at Dubai International Airport Terminal 2 and an analysis of customer feedback surveys based upon review of existing analytics report from SITA and IATA.

2.2 Qualitative Research

2.2.1 Business Cases for flydubai Technology Projects

As part of the research for this paper, a range of technology projects business cases for flydubai were inspected. The business cases are concerned with two primary questions:

- What are the financial imperatives pertaining to the project, including cost, ROI and payback period?
- How else will the organization benefit tangibly or intangibly from the technology project?

Considering the commercial and sensitive nature of the business cases reviewed, the results are not published in full, but below is an example of the methodology and questions which are considered when the decision to adopt is made. Following the review of a range of 12 e-commerce and m-commerce projects in the business, observations were made relating to the most common reasons for “Go”, “No Go” or “delay” decisions. Tables 1 and 2 contain sample data related to business cases for technology projects within flydubai:

Project title:		**Pre Sell Meals**				
Department:		**Ancillary Revenue**				
Payback	**Five years**	**NPV 5%**	**AED131,07**			
	year 0 (AED)	year 1 (AED)	year 2 (AED)	year 3 (AED)	year 4 (AED)	year 5 (AED)
Cumulative Benefits	0	720,00	1,476,00	2,269,80	3,103,29	3,978,45
Cumulative costs	2,209,08	3,074,75	3,261,93	3,399,12	3,586,30	3,723,48
Cumulative Benefits / (Loss)	- 2,209,08	- 2,354,75	- 1,785,93	- 1,129,32	- 483,01	254,96

Table 1: Calculation of Payback Period and Cumulative Benefits/Loss
Source: Sample business Case for Technology Project (Pre Sell Meals)

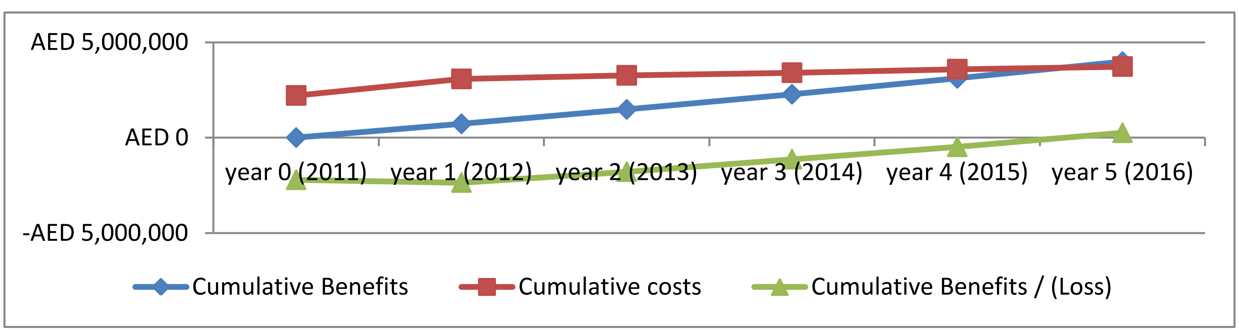

Figure 1: Calculation of Payback Period and Cumulative Benefits/Loss
Source: Sample business Case for Technology Project (Pre Sell Meals)

Project title:		**CRM**				
Department:		**Customer Experience**				
Payback	**Uncertain**	**NPV 5%**	**-AED 8,601,3**			
	year 0(AED)	year 1(AED)	year 2(AED)	year 3(AED)	year 4(AED)	year 5(AED)
Cumulative Benefits	0	3,709,1	7,944,2	12,788,6	18,340,6	24,715,5
Cumulative costs	6,760,0	10,424,8	14,859,4	20,144,8	26,469,3	33,860,4
Cumulative Benefits / (Loss)	-6,760,0	-6,715,6	-6,915,1	-7,356,1	- 8,128,6	-9,144,9

Table 2: Calculation of Payback Period and Cumulative Benefits/Loss
Source: Sample business Case for Technology Project (CRM)

2.2.2 Workshops with Aviation Experts and Airline Representatives

A representative cross-sample of twenty low cost, hybrid, legacy and cargo carriers was contacted to discuss the technology adoption challenges. These twenty airlines were selected based on their client rating with leading IT solution providers to the industry, namely Mercator, Sabre, Navitaire and IBS. Research was conducted through workshops, reference client site visit and online meetings. The focus was to understand the following specifically with respect to low cost and hybrid carriers:

1. Technological Challenges
2. Cost impact
3. Implementation and Support challenges

Whilst the specific responses are confidential to flydubai, three points were repeatedly mentioned when discussing the airlines willingness or unwillingness to invest in new technologies:

- ROI and breakeven uncertainties
- The potential impact on brand reputation
- The risk of implementing untested technology and the potential for increases in operational costs

Another theme emerging from the workshops with airlines and their suppliers was that too many airlines were focused on volume and yield, rather than on margin. They compete on size and network breadth, rather than on the differentiation created from customer services or technological advancement. These challenges result resistance to switch to technologies which have a minimal ROI and longer duration to achieve breakeven. Airlines avoid capacity left unused, increase short-term profitability, and create first mover advantages, but on aggregate they contribute to a market environment that leads to complicated travel services and difficulty in passenger alignment and baggage services. The main focus of airlines still remains on short term revenue generation rather than technological adoption and subsequent investment.

Whilst brand reputation and better customer service remain areas which can be drastically improved through technological developments, the view of many in the industry is that these can also be achieved by alternatives, at lesser cost than by investing in expensive or untested technologies. The aircraft and business financial model remains the primary concern for the majority of airlines. Going ahead with non-aircraft related technology projects are secondary to this.

2.3 Quantitative Research

2.3.1 Customer Survey: IT Trends

The SITA IT Trends Customer Survey (SITA, 2013) and SITA Airline IT Trends Survey (SITA, 2014) white papers were reviewed to investigate passengers' point of view regarding technology adoption.

The SITA customer survey report (SITA, 2013) states 'the sample is representative of the demographic and airline mix of each airport. Overall combined results are calculated as a weighted average, taking into account the relative passenger traffic of each airport, for a total of over 299 million passengers traveling annually through the six airports. The weighted average does not represent a worldwide weighted average. Results do not reflect the services offered by any individual airport or any specific airline, as close to 40% of interviewed passengers were in transit.'

The survey was conducted at 6 airports, and on 2489 passengers from 70 countries. A higher percentage of business travelers were encountered at all locations, and hence a higher percentage of frequent flyers.

The six airports are:

- Abu Dhabi International Airport
- Hartsfield-Jackson Atlanta International Airport
- Beijing Capital International Airport
- Frankfurt Airport
- Chhatrapati Shivaji International Airport, Mumbai
- GRU Airport

60% of airlines have invested in e-commerce; however 78% of passengers cite usability concerns and limitations of devices as the reason for not using mobile devices for a particular aspect of travel. The survey emphasized that to persuade people to change their travel habits, mobile services need to deliver additional value over alternative options.

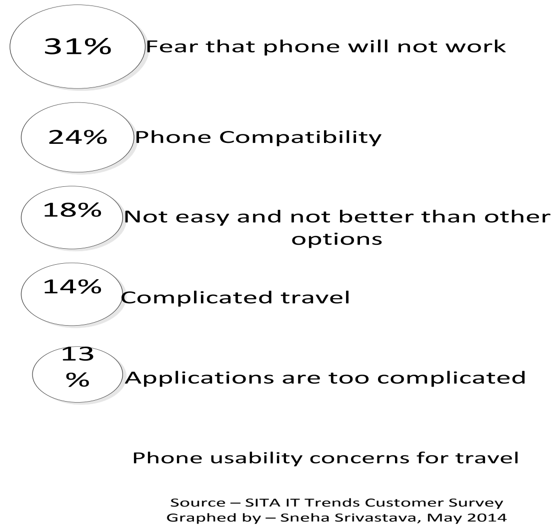

Figure 2: Phone Usability Concerns for Travel
(SITA IT Trends Customer Survey, 2013)

2.3.2 flydubai Statistical Data on Online Check in Service and Self-Service Kiosk Facility

Statistical research on utilization of online check-in and kiosk facilities offered to flydubai customers was analyzed to identify reasons for resistance to new check in technologies.

The figures in the table below show the utilization of a recently launched service to provide online check-in. Data was collected from one of the busiest sectors of the 65 'activated' online check-in destinations. The selected sector accounts for 6% of all online check-in-enabled flights.

Flight Date	**OLCI to Joiners %**
22-Jun-14	6 -8%
23-Jun-14	4-6%
24-Jun-14	4-6%
25-Jun-14	4-6%
26-Jun-14	6 -8%
27-Jun-14	3-5%
28-Jun-14	4-6%
Total	3-8%
Average Range	**4% - 7%**

Table 3: Overall summary for Utilization of Online Check In facility
Source – flydubai internal data analytics report

As can be seen, take-up was between ranges of 4% to 7% on average. Similarly, referring another flydubai internal analytics report, period 22nd Jun- 28th Jun 2014, on self-service kiosk facility, the utilization showed up to 4 to 6% only. Feedback analyzed suggests that the take up can mostly be apportioned to the fact that customers prefer the information 'pushed' to them through SMS or mobile alerts rather than having to 'pull' it themselves.

The result indicates that economies of scale exist on the demand side, which means, it is easier to generate user demand with a strong brand, a wide distribution presence, and a large network of connections. There are also benefits from established operations in generating route density and route profitability to allow larger aircraft (lower costs) and higher frequency (higher price). Supply-side economies of scale are limited especially if airlines grow beyond a level of approximately 45 aircraft. This creates some disadvantages for new airlines but not for existing ones looking to expand into new market segments.

3. Key Findings

The research gives a strong indication that IT investment decisions mirror the trend in the industry's economic performance. This is because of uncertain growth in passengers and cargo volumes and end users concerns with utilization of new technology. The key findings of the research are summarized below.

3.1 Airlines Resist Investing in Technology

The analysis of business cases indicates that one key challenge to adoption is that shareholders of airlines over the recent technology evolution period (2004 to 2014) have seen little to no return to compensate them for their risk taking in investing in new technologies. Dixit, A. and Pindyck, R. (1994) stated the prime reasons for investment decisions being rejected are:

- Uncertainty over future profit streams
- Irreversibility that creates at least some sunk costs
- The opportunity to delay (procrastination)

This is also reflected in the IATA economics briefing "N4, Value chain profitability analysis report" by Smyth M. and Pearce B. (2006) which shows that airlines have the lowest average return amongst all stakeholders as airlines remains at the lowest level of value chain to make profits. Over the past 40 years, the net post-tax profit of the airline industry worldwide has averaged only 0.1% of revenues, regardless of the technology used and deployed by industry. Very few airlines in all regions around the world actually consistently generate a return on capital that exceeds their costs. Those airlines that have managed this, have tended to balance passenger growth and operations, mostly by reducing operating cost and improving efficiencies through the introduction of a smaller range of selected new technologies.

3.2 Passengers Response on IT Trends

Currently, around 70% of passengers and cargo customers are smart phone users (SITA, 2013). As a result, use of mobile phones to store boarding passes, perform check-in and receive flight or cargo status updates can improve dramatically. Despite this, mobile booking is not fully-fledged yet, as passengers consider ticket purchasing via their mobile a useful option, but not their first choice. From the passenger's point of view, major concerns are that phones might not work during travel, payment security/fraud, concern over phone compatibility issues, and fear of complicated applications or services displaying error messages.

Customers expect the next self-service wave will focus on the deeper integration of mobile devices into travel. However, passengers accept that the adoption will be gradual. For now, going online using a desktop PC remains the preferred choice for completing travel tasks. In a SITA customer survey report, 69% of respondents booked their travel through a website and only 20% used a kiosk for check-in on the day of travel (SITA, 2013).

3.3 Applied Push Pull Strategy

In business theory, there is a gap between the willingness of aviation IT suppliers to push new technologies to airlines and the airlines willingness to adopt these new technologies. A 'push' means that a new product or invention is pushed through R&D and production functions onto the user without proper consideration of whether or not it satisfies a user demand. In contrast, an innovation based upon user demand 'pull' has been developed or produced by the R&D function in response to an identified user need.

Applying the Push/Pull model onto the results of the airlines and customers view, research suggests that the technologies 'push' is much stronger than the market 'pull' for passenger services. This is because safety, security, environmental, legal and political factor have higher priority than technology adoption. This means major investment decisions are directed towards these requirements rather than on technology.

3.4 Analytics Results on Technology Cost and Impact: Graphical Representation

There is a strong outlook among airline executives that regions like US and Europe will perform comparatively better and thus remain technological market leaders (Technology roadmap, 2013). However, the rate of technology adoption in aviation can be seen as directly correlated to the growth of passenger volume, cargo volume, and Gross World Product; and inversely proportional to the cost of technology. This phenomenon is demonstrated graphically in Figure 3 derived from Pivot chart analysis.

As the graph, in Figure 3, shows, the industry is moving at a slow pace of technology adoption, due to high cost and long implementation timelines of new technology projects. From the airline perspective, capital investment remains a challenge as the upfront costs of new technologies are typically high, and the payment schedules offered by IT providers normally require significant investment in year 1. Further, the technical challenges of deploying the latest IT trends with legacy systems are also complex, and thus more cost and time is required to implement new technology than to maintain the status quo. This further compounds the problem as legacy technology, such as mainframes and old messaging architecture which are less and less common outside of aviation, remain in-situ in the aviation industry because they difficult and expensive to replace. The longer they are left in place, they more expensive and difficult it gets to replace them and airlines become stuck in a self-perpetuating cycle of obsolete technology maintenance and resistance to change. This further lowers the rate of new technology adoption.

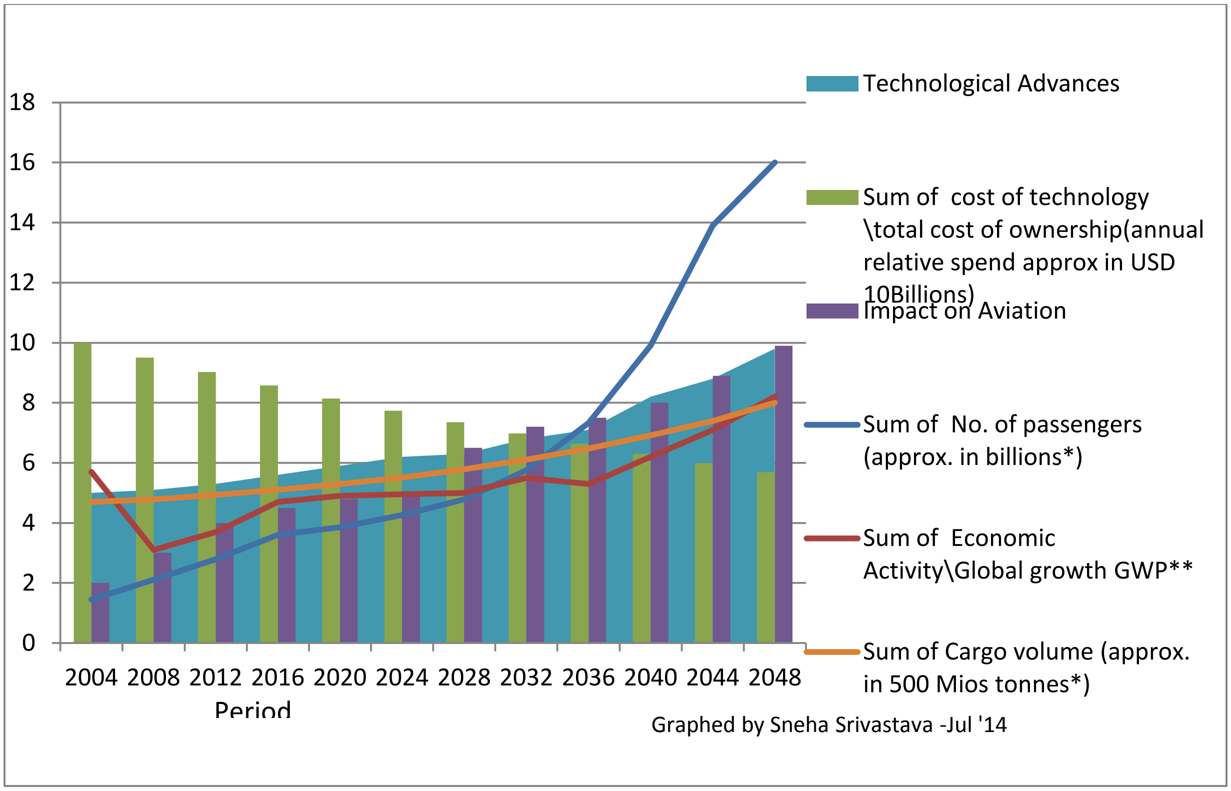

Figure 3: Technology Cost & Impact Analysis in Aviation
*Source – Centreforaviation.com/analysis and IATA Vision 2050 (2011)
** Source - http://www.indexmundi.com/g/

Another inference that can be drawn is that, following the current trends, the industry will continue to struggle until the late 2020s to achieve a significant pace of adoption to synchronize with technological advancements and passenger's expectations. However, after this time the considerable growth in passengers and cargo volumes will lead to increased revenue, liquidity and stability for airlines, and thus help drive faster technology adoption within aviation. Put simply, the aviation industry as a whole cannot afford to embark on a major technology renewal cycle until the passenger and cargo volumes, and associated revenue, grows enough to support this.

4. Conclusion

The major reasons for the low adoption rate of new technologies in aviation are:

- Proliferation of legacy technologies throughout the aviation industry acts a barrier to new technology adoption
- Razor thin profit margins leading to lack of discretionary funds for new and untested technologies
- Inbuilt conservatism, and restrictive regulatory environment especially in the flight operations space

IT solution providers such as Sabre, SITA, Mercator, HP and Amadeus should offer a business proposal which will fit the airlines financial model, where the capital expenditure is expected to be low and the remainder of the cost can be taken over a period of time, by classifying it as operational expenditure. Simplifying the technical challenges faced during the product and solution implementation, to reduce cost and schedule, will further help improve the adoption speed.

A stable and secure customer base is an important factor for technology adoption within aviation. Airlines need to be assured that there will be income in the future to pay for the investment which will be a way of reducing risk inherent in the adoption decision. Growing number of passengers, cargo volumes, Gross World Product and the reducing cost of technology over time will ultimately bring a faster technology adoption rate to the industry. The next 5-10 years of technological change also offer the opportunity of significant benefits to those airlines that embrace the opportunities ahead of the curve by investing in technology. This will create first mover advantages and increasing brand reputation and passenger adoption for those airlines brave enough to move first.

The governing bodies need to drive a realistic technological roadmap to help the airline industry adopt technological trends and thus streamline passenger services. The roadmap should consider the implications on aviation security arising from technological advances and include remediation planning, thereby providing proper guidance to the airlines on mitigating strategies. Industry bodies should also work with the various governments to develop shared guidelines which can be applied across borders to reduce rework for airlines on compliance projects such as APP/APIS.

Competitive pressures from low-cost carriers, problems with the reliability and operating performance of the air transportation systems, and volatile fuel prices all suggest that the industry has not fully recovered after the global financial crisis. However, airline owner's strategic decision making and risk appetite will remain the major driver of technology adoption rates. For an airline, the willingness to invest in technology will increase with the following factors:

- The existence of sound technology business cases with quantifiable ROI within a lower payback periods, as it is proven that the longer the payback period, the higher perceived risk to the airline and the lower the rate of adoption
- Improved profitability from their operations due to increased passenger and cargo volumes
- Improved and consistent operational efficiency to serve passengers effectively and reduce the operational cost per passenger

Strong collaboration between all the stakeholders (owners, vendors, regulatory bodies, industry bodies) will bring a significant positive change towards technological adoption rate within aviation.

5. Acknowledgements

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The Factors of Air Passenger Choice of an Indirect Itinerary: A Study of Asia to Europe Traffic Transiting in the Gulf

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Abstract: Taking the Asia-Europe air transport market, we test for the factors of choice of indirect itineraries via Gulf airports over direct itineraries between Asia and Europe, a growing trend among air travelers seeking lower fares, increased comfort and frequencies. On the other hand, such itineraries increase time of travel.

Using a sample of passenger choices for direct and indirect flights, we show that lower price, increased comfort and frequency are significant factors, but that increased time reduces the market share of indirect itineraries.

Most interestingly, the type of travelers most sensitive to the lower fares are business travelers, not economy class travelers, as we had hypothesized. This is a significant conclusion, contributing to the awareness of business passenger elasticity to price on the Asia-Europe market via the Gulf hubs.

Key Words: Gulf hubs, connection, itinerary, demand, elasticity

1. Introduction – Statement of Purpose

One of the most remarkable current trends in air transport is the dynamism of air traffic between Asia and other regions of the world. Air routes between Asia and Europe are among the fastest growing routes in the world, with growth rates above 3 % per annum, a figure double that of the Europe to North-America traffic growth rate of 1.5 % (IATA, 2011). Routes between the major cities of South-East Asia, India and China, such as Shanghai, Singapore, Kuala-Lumpur or Bombay on the one hand and major European cities such as Paris or London on the other, enjoy the densest traffic levels and highest growth rates (Table 1).

	2005	2006	2007	2008	2009	2010	2011	**Annual average growth rate**
Shanghai				475,780	464,896	512,045	520,505	**3.0%**
Singapore	407,120	429,315	397,798	460,156	458,262	470,468	483,780	**2.9%**
Delhi	201,540	210,807	206,916	222,124	237,328	240,611	248,900	**3.6%**
Kuala-Lumpur	144,815	125,615	158,936	145,077	123,828	132,901	163,073	**2.0%**

Table 1: Passenger Traffic between five Asian cities and Paris (France)-2005-2011
Source: French Civil Aviation Authority

A second major evolution over the last decade in the world air transport scenery is the emergence of Gulf country airport hubs (Dubai, Abu-Dhabi and Doha mainly) as transit points between Europe and Asia. The unique geographic position of these cities makes them extremely attractive to go from an origin in Asia to a destination in Europe. So far, most of the research has focused on explaining the attractiveness of transits in the Gulf over transits in the origin (Asia) or destination market (Europe), when a transit is unavoidable to get from origin to destination because there is no direct flight.

However, a new phenomenon has emerged: a growing share of passengers choose to fly via a transit point in the Gulf, **even when a direct flight is offered between origin and destination**.

For instance, a passenger in Singapore going to Paris may choose to fly direct (two daily flights), or fly with a transit in Dubai, Doha or Abu-Dhabi, with five daily possible combinations. This phenomenon is gaining momentum: As displayed in Figure 1, on routes such as Kuala-Lumpur to Paris, Delhi to Paris or Singapore to Paris, the share of passengers choosing indirect itineraries has increased by respectively 28, 10 and 6 points over the last 6 years, a fact that airlines competing against Gulf airlines may have to worry about.

Yet, this phenomenon has received little attention of researchers. This is the point of focus of this paper.

Therefore, the purpose of this research is to explain the factors of choice of an indirect itinerary over a direct itinerary when the passenger has the choice. Why would passengers choose a “via trip”? Is it simply to save on travel costs? Is it the reputation for comfort of the Gulf carriers (Emirates, Qatar, Etihad) that attract those passengers? Is it the fact more frequencies, overall, are offered when you fly via then when you fly direct (one or two daily long-haul flights at the most against 4 to 6 daily combinations via the Gulf). How about trip time (and the hassle of a stop time), is that a deterrent?

Using data of direct and indirect itinerary bookings, on a number of key routes between Asia and Europe, we test for those factors.

The literature review gives us insight on the possible key factors we have to consider to explain and predict passenger flows.

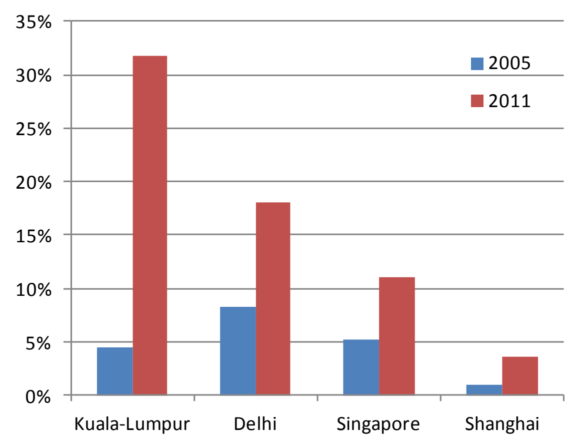


Figure 1: Share of economy class passengers flying on an indirect itinerary via the Gulf rather than a direct trip, over total passengers, between 4 Asian cities and Paris Charles-de-Gaulle airport (2005-2011)
Source: courtesy of Sabre MIDT flight bookings

2. Methodology

2.1 Factors of Air Transport Demand

Theory recognizes that passenger choice is a factor of price (elasticity or sensitivity to price, total journey time (elasticity or sensitivity to total journey time), schedule (the possibility of leaving or arriving at the desired time), frequencies (the flexibility to change departure on a given day), routing (direct flights are favored to connections), airline (brand and reputation) and belonging to a Frequent Flyer Program (Doganis, 2010; Shaw, 2011). A meta-analysis of price elasticities of demand for passenger air travel (Brons et al., 2002) concludes that the willingness to substitute monetary for time advantages are lower for economy class passengers than business passengers. The relative gain (or loss) in trip time or fare will impact the choice of airline, and hence itinerary.

Another aspect which may impact the choice of the passenger is the current quality of the service he or she is receiving. Park (2007) argues that service quality perception by the passenger is an "overall impression", representing the non-monetary value associated with the use of a service. When making an actual choice, quality will be taken into account in a holistic way, with a global impression deriving from a variety of attributes, and an average appreciation depending very much on the personal values of the passenger and his or her total trip time. The longer the flight, the more a passenger will logically attribute importance to comfort (Pavaux, 1984) Doganis (2010) as well as non-academic sources (Skytrax, 2012) have researched this aspect and ranked airlines according to perceived quality of service by passengers. The three major Gulf carriers, which carry the majority of passengers via the Gulf, are ranked among the best of the world. Among European airlines, only Lufthansa and Swiss rank among the twenty best airlines. Among South-East Asian airlines, only Singapore airlines compares with Gulf carriers in terms of perceived quality. We therefore argue that the perceived quality difference may be a factor explaining indirect itinerary, alongside fare, time and frequency.

2.2 Hypothesis

H1: The higher the saving on fare paid by the passenger flying on the indirect itinerary, relative to the direct itinerary, the higher the probability of choosing the indirect (via Gulf) itinerary.

H2: The lower the total trip difference, relative to the direct trip time, the higher the probability of choosing the indirect (via Gulf) itinerary. Here, total trip time includes either the direct flight duration, or the two legs flown via the Gulf + transit time.

H3: The highest the perceived relative quality of the trip via the Gulf over the direct flight, the highest the probability of choosing the indirect itinerary via the Gulf.

H4: Moderating effect of purpose of travel. We hypothesize that business travelers will be less inclined to travel indirect rather than direct, as they are much more time elastic than price elastic and the difference in quality standards is much reduced in higher classes of travel (Boyd & Hutchens, 2009). Therefore, a test will also be carried-out with a "purpose of travel" binary variable. 1=flying economy class; 0=flying business, where we expect to see little relation between price gain and choice, but a major negative impact of total trip time.

We hypothesize an inter-action between fare and class of travel: At the opposite of hypothesis H3a, our hypothesis is that the choice of itinerary (direct over via) will be highly a factor of time as far as business class is concerned. We hypothesize that business travelers will not be sensitive to price.

H5: The highest the relative number of flight combinations available via the Gulf over the number of direct flights, the highest the probability of choosing the indirect itinerary via the Gulf. Here, a flight combination is, for instance, the possibility to fly five times per day between Singapore and Paris via the Gulf for instance, and only twice daily direct.

These effects are presented in the conceptual map; Section 2.5.

2.3 Sample

Data was provided to us by a flight booking company made available to us for 12 Asia to Europe routes, for both passengers flying on a direct itinerary and an indirect itinerary via the Gulf, over a seven year period. Data is aggregated per route, year and class of travel (economy and business class). The data made available includes, for each direct and indirect trips: number of passengers, in one direction (Europe to Asia), number of available flights, flight duration of flights and transit (if any) duration. All together, 168 Ys were thus provided, but it appeared that in the initial years, no via Gulf flights were offered on some routes, therefore the data sample was reduced to 108.

Flight quality was estimated using the ranking of each airline and by weighting this rank with number of passengers flying each airline, direct or via the Gulf, per year, on each route. Flights via the Gulf always get five, as Skytrax has awarded a five star mark to all the Gulf carriers concerned. When a passenger is flying business, the mark is 5 for Gulf and 4 for other airlines, whatever airline, as the gain in comfort is marginal when travelling in business class with Gulf carriers.

An extract of the sample is displayed in Table 2.

Year	Origin	Destination	Class	Direct Flights					Flights Via Gulf					
				No of Passengers Direct	Avg Fare Direct	Flights per Week Direct	Flight Quality Direct	Trip Time Direct (minute)	No of Passengers Via	Avg Fare Via	Flights per Week Via	Flight Quality Via	Trip Time Via (Minute)	Transit Time (Minute)
2005	CDG	BKK	Eco	68148	598.39	14.44	3.12	703.66	17780	499.56	17.00	5.00	756.60	135.18
2005	CDG	BOM	Eco	26723	400.27	21.90	2.55	547.81	2980	435.28	17.00	5.00	580.00	204.23
2005	CDG	DEL	Eco	28542	405.86	7.30	2.08	515.00	2551	492.93	17.00	5.00	588.40	180.01
2005	CDG	KUL	Eco	15595	1340.89	5.22	3.12	744.17	734	539.60	17.00	5.00	820.00	224.94
2005	CDG	PVG	Eco	73290	826.30	17.34	3.75	707.53	710	355.95	17.00	5.00	866.60	210.34

Table 2: Sample data type (one way trips
Source: Sabre MIDT

2.4 Variables

Dependent variables:

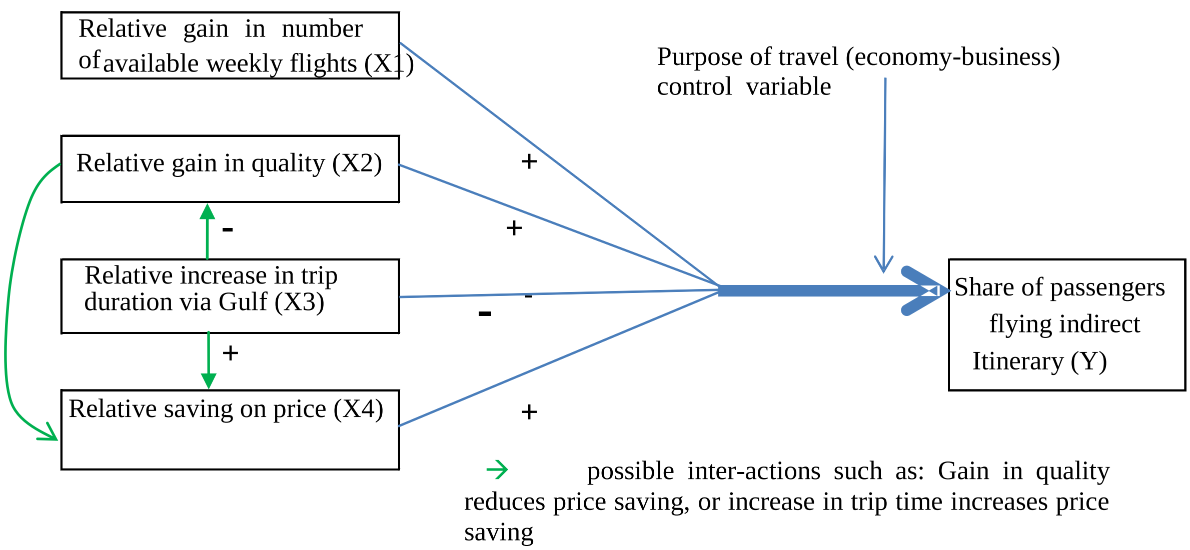
Y(*)=Ratio of traffic flying on an indirect itinerary via the Gulf / traffic flying on the direct itinerary.
As we will show in this research, after an initial phase of tests, that we will explain, the LN of Y is chosen as we are dealing with a probability value, and this is a recognized transformation of Y. Therefore Y= LN (indirect traffic / direct traffic), after initial linear regression test

Independent variables:

X1= relative frequency difference = (frequency of via flights per week – frequency of direct flights per week)/frequency of direct flights

X2= relative quality difference = (quality of via flight- quality of direct flight)/ quality of direct flight
X3= relative time difference = (total time of via flight including transit- total time of direct flight)/ total time direct
X4= relative fare difference = (average fare via flight- average fare direct)/average fare direct

2.5 Conceptual Framework and Hypothesized Effects



3. Results and Findings

A logit linear regression (probability) with all variables was carried-out and enabled us to make a first assessment of the validity of the constructs we have used. We noticed limited co-linearity, with some effects shared by variables, correct directionality of the effect, and time, quality, frequency as significant** in the model.

However, the significance of fare on the aggregate sample of both business and leisure traffic was problematic (0.093 t-sig). Therefore, in a second stage, we controlled for purpose of travel and interactions between fare and time.

The linearity assumptions were confirmed through ZRES Regression of Standardized Residuals. The Breusch-Pagan test showed constant variance. The normality assumptions were verified using a Kolmogorov-Smirnov and Shapiro-Wilk.
After exclusion of outliers:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 - \beta_3 X_3 + \beta_4 X_4$$
$$Y = -0.86 + .54\ X_1 + 2.12\ X_2 - 8.93\ X_3 + 0.85\ X_4$$

With

Y= LN (indirect traffic / direct traffic)

X1= relative frequency difference = (frequency of via flights per week – frequency of direct flights per week)/frequency of direct flights
X2= relative quality difference = (quality of via flight- quality of direct flight)/ quality of direct flight
X3= relative time difference = (total time of via flight including transit- total time of direct flight)/ total time of direct flight
X4= relative fare difference = (average fare via flight- average fare direct)/average fare direct

Correlations

		Cheaper fare via	Gain in Quality via	Loss of Time via	Gain in Frequency (more flights via)
Cheaper fare via	Correlation	1.000	-.631	-.313	.025
	Significance (1-tailed)	.	.000	.000	.397
	df	0	106	106	106
Gain in Quality via	Correlation	-.631	1.000	.221	.073
	Significance (1-tailed)	.000	.	.011	.227
	df	106	0	106	106
Loss of Time via	Correlation	-.313	.221	1.000	.084
	Significance (1-tailed)	.000	.011	.	.195
	df	106	106	0	106

Frequency correlation not significant. Coefficient of determination shows that some variability is shared between variables.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-.859	.522		-1.647	.103		
	fare	.847	.500	.146	1.695	.093	.483	**2.070**
	freq	.540	.109	.298	4.957	.000	.986	1.014
	qual	2.119	.307	.574	6.902	.000	.515	**1.941**
	time	-8.935	.981	-.572	-9.113	.000	.906	1.104

a. Dependent Variable: share

VIF Below 5, but above 1; acceptable but some degree of collinearity. Fare remains an issue. Significance must be tested with a moderator: trip purpose. Inter-actions must be tested.

Table 3: Correlations

The tests show that the <u>most significant coefficient for business class travelers is fare gain</u>, with higher elasticity to fare gain than time gain: the motive which pushes the low percentage of business travelers that do decide to fly via the Gulf (between 5 to 10 % in our sample, against 5 to 35 % for economy class) is fare.

However, relative quality gain for all business class data is 0.25. So this variable does not enter regression models. So, it is difficult however to compare this model with the original model with 4 variables (with data for both classes).

4. Conclusion

The outcomes of our tests are therefore the following:
H1: The higher the saving on fare paid by the passenger flying on the indirect itinerary, relative to the direct itinerary, the higher the probability of choosing the indirect (via Gulf) itinerary <u>is verified, but not significant when taking the whole sample</u>.

However, it is significant for business class passengers, because of the inter-action between class of travel choice and price choice and class of travel choice and time choice (see H4A and H4B).

H2: The lower the total trip difference, relative to the direct trip time, the higher the probability of choosing the indirect (via Gulf) itinerary. This hypothesis is verified with significant effect.

H3: The highest the perceived relative quality of the trip via the Gulf over the direct flight, the highest the probability of choosing the indirect itinerary via the Gulf. This hypothesis is verified with significant effect.

H4: The inter-action between fare difference and class of travel and time loss and class of travel is verified, with high significance.

H5: The highest the relative number of flight combinations available via the Gulf over the number of direct flights, the highest the probability of choosing the indirect itinerary via the Gulf. This hypothesis is also verified, but with less effect than time and quality choice factors.

The results overall therefore confirm the sensitivity of travelers flying indirect routes to a gain in fare, increased in quality and frequency, but only if the time loss is limited. Any increase in travel time will cancel the effects of price and quality gain, all things being equal.

The most significant outcome is that controlling for purpose of travel, the highest sensitivity in choice to fare is for business passengers, not economy. This is confirmed by the evidence of our sample that airlines operating direct flights have, in economy class, fares quite close to that of Gulf carriers. Mean fare difference between direct and via flights in economy class. Whereas mean fare difference for business class ($\text{MeanFare}_{\text{Direct, Business}}$ – $\text{MeanFare}_{\text{Via, Business}}$) is $765.46, or about 30% of the average fare paid on the direct flights in the whole business class sub-sample.

5. Limits and Suggestions for Future Research

A broader sample of routes may have given more significant results. Data available restricted our study to two destinations in Europe, and five origins in Asia. Because of the weight of Britain in traffic to the Indian sub-continent and of Germany on traffic to Thailand, Cambodia and China, a German and UK destination should have been chosen. Also, we did not include data to Indonesia, when here again Amsterdam produces major traffic flows transiting via the Gulf. Generality of our results require more research.

Seasonality factors should also be examined: during holiday seasons, or periods of the year when family unite, the attractiveness of cheaper indirect flights may be greater.

Also, we did not have data on belonging to frequent flyer programs. These constitute strong retention tools for major airlines. However, Gulf carriers are also offering frequent flyer programs to passenger's whose habit s now to transit via the Gulf when travelling between Asia and Europe
With more detailed data for each specific route, a more specific analysis could have done. However, the advantage of our aggregated sample is that it provides variance along different combinations of flight time, transit times, quality, fares and class of travel, and therefore these factors may explain some of the significant results we believe we identified in this study.

Interviews should be carried-out, both possibly to scale the quality perception indicator and test the utility of passengers as regards fares, time, frequency and quality when it comes to choosing a via a Gulf hub option..

Finally, the variable "quality" is the only one in our model that we estimated, form a mark attributed by an airline quality benchmark agency. It is a very generic mark, and although significant, the scale used may impact the results. In a more comprehensive study, we would need to test this parameter with a scale built creating a pool of items regarded as favorable and unfavorable regarding the proposed constructs.

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Aircraft Operational Fuel Efficiency

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Abstract: In addition to the primary concern of reducing its fuel-related costs, airlines industry has been provided with further incentive to reduce its emissions with recently implemented or future market-based mechanisms (MBM). Moreover the general public's interest in climate change issues gives airlines an additional impetus to showcase their fuel-saving efforts. Given that context, developing a capability to increase airline fuel efficiency has become critical. This paper aims at demonstrating that airlines' fuel efficiency measure can be shown in different forms, depending on its purpose. In particular, it introduces an operational concept able to reflect the daily factors impacting airlines' operations.

Keywords: aviation; aircraft operations; fuel efficiency; metrics.

1. Introduction

1.1 Context and Objectives

In addition to the primary concern of reducing its fuel-related costs, the airline industry has been provided with further incentive to reduce its emissions with environmental policies in place, such as the European Union emissions trading system (EU ETS), or the development and future implementation of the International Civil Aviation Organization (ICAO) global market-based measure (MBM). Moreover the rising concern about climate change issues has prompted the general public's interest in travelling in a more efficient and environmentally friendly way, which gives most of the airlines worldwide an additional impetus to showcase their fuel-saving efforts. Given that context, developing the capability to assess and increase airline fuel efficiency has become critical.

This paper aims at demonstrating that airlines' fuel efficiency can be represented in different forms, each of them having a specific purpose. First, it revisits the definition of 'being fuel efficient'. It then identifies the existing ways of addressing the concept of fuel efficiency and their purpose. Finally, it introduces and presents the Operational Fuel Efficiency Factor (OFEF), a concept that enables to measure fuel efficiency for addressing the daily factors that impact airline's operations. Comparison of this new approach against the commonly used RTK metrics is presented for long-haul commercial jet aircraft.

1.2 What is '*Being fuel efficient*'?

In 2009, the High-level Meeting on International Aviation and Climate Change (HLM-ENV/09) endorsed the Program of Action on International Aviation and Climate Change. This included a global aspirational goal of 2 per cent annual improvement in fuel efficiency until the year 2050 (ICAO, 2009). One year later, the 37th ICAO Assembly (ICAO, 2011) committed to achieve more ambitious goals:

i) a global annual average fuel efficiency improvement of 2 per cent until 2020 and an aspirational global fuel efficiency improvement rate of 2 per cent per annum from 2021 to 2050; and

ii) a medium term global aspirational goal of keeping the global net carbon emissions from international aviation from 2020 at the same level (carbon neutral growth from 2020 at 2020 levels).

The above targets raise a concern on how to measure and track the fuel efficiency trends at a global level and go back to the question: what is '*being fuel efficient*'?

The fuel efficiency is basically a measure of the capability to optimize the quantity of fuel necessary to get a mass (in our case an aircraft) to move a given distance. It should demonstrate how much and how far we can transport using as less fuel as possible. The notional concept of fuel efficiency is therefore a combination of three parameters that can be expressed as the following generic ratio:

$$\text{Notional metric} = \frac{\text{Mass} \times \text{Distance}}{\text{Fuel used}} \qquad (Eq.1)$$

The product [mass] multiplied by [distance] is called transportation unit. Increasing fuel efficiency is therefore a combination of increasing the transportation unit and/or decreasing the total fuel used. Depending on how these three parameters are defined, fuel efficiency can be reflected in many different ways and therefore be used to serve different purposes.

2. Methodology

2.1 Different Metrics for Different Purposes

Commonly used fuel efficiency metrics across aviation are built based on Eq.1 or one of its variants, where each of the three components of Eq.1 can be defined differently. They usually take the form of a ratio of [fuel quantity used] (either in mass or in volume unit) over the product [payload] multiplied by [distance flown] which can be actual, planned or theoretical distance. ICAO and IATA define *payload* as the weight of the people and items that are being transported, including passengers, their luggage, and cargo *Revenue payload* is the payload for whose transportation the aircraft operator receives financial remuneration.

These metrics include input-based metrics, such as available seat kilometers (ASK) or available ton kilometers (ATK); and output-based metrics, such as revenue passenger kilometers (RPK) or revenue ton kilometers (RTK). While the input-based metrics measure what is produced, RPK and RTK capture what is actually used (Zou, 2012). Output-based metrics are more commonly used by airlines to express and publish their fuel efficiency.

a) ICAO Metrics: Global Environmental Trends

In 2010, the ICAO Committee of Aviation and Environmental Protection (CAEP) recommended the use of the Commercial Aircraft System Fuel Efficiency (CASFE) metric as the metric for assessing the ICAO environmental goals for global civil aviation through its modeling activities (ICAO, 2010). The metric generic formula is described as follows:

$$\text{CASFE} = \frac{\text{m}_F}{\text{Payload} \times \text{GCD}} \qquad (Eq.2)$$

where:

- m_F is the total mass of fuel used; and
- GCD (Great Circle Distance) is the shortest distance between the published Aerodrome Reference Points (ARP) of the origin and destination airports.

This metric's expression serves as the sole purpose of establishing environmental trends. Further, CAEP recommended that work should be continued on defining other appropriate metrics for operational and technology goals and Standards.

In 2009, the ICAO Council's Group on International Aviation and Climate Change (GIACC) presented a generic formula that considers the need for a metric to take into account carbon intensity, to enable determination of efficiency improvements achieved through sustainable alternative fuels for aviation or market-based measures. In this formula, the basic fuel efficiency component, expressed as Volume/RTK, is expanded into a larger formula including a fuel density factor, a carbon factor and a carbon reduction from market-based measures factor (GIACC, 2009):

$$\text{"Net CO}_2\text{ Intensity Metric"} = \overbrace{\left(\frac{Vol_{\text{fuel}}}{RTK}\right)}^{\substack{\text{Fuel Efficiency}\\ \text{Metric}}} \cdot \overbrace{\left(\frac{Mass_{\text{fuel}}}{Vol_{\text{fuel}}}\right)}^{\substack{\text{Fuel}\\ \text{Density}}} \cdot \overbrace{\left(\frac{Mass_{CO_2}}{Mass_{\text{fuel}}}\right)}^{\substack{CO_2\\ \text{Factor}}} - \overbrace{\left(\frac{\text{MBM Reductions}}{RTK}\right)}^{\substack{\text{Market-Based}\\ \text{Measures}}} \qquad (Eq.\ 3)$$

In the meantime, ICAO has put a plan to work further and enhance the fuel efficiency metrics form to be derived from the formulas in Eq.2 and Eq.3 (ICAO, 2013).

b) IATA Metric: Aviation Industry Fuel Efficiency Improvements Reporting

In support to the airlines industry's fuel efficiency and the global environmental objectives, IATA provided guidance to airlines to enable participation in IATA fuel consumption data collection efforts. The following metric is proposed to be used by airlines in their reporting exercise (IATA, 2014):

$$\text{metric}_{IATA} = \frac{\text{Fuel consumption}}{(\text{revenue load} + \text{non revenue passenger load}) \times \text{GCD}} \qquad (Eq. 4)$$

2.2 Aircraft Operator Perspective

From an aeronautical engineering viewpoint, the efficiency of an aircraft can be improved through three different areas: propulsion, aerodynamics and weight (materials/design/systems). From an operator perspective, aircraft and/or engines are not easily changeable due to the high costs involved. As a result, being efficient is mostly left to best operational practices. Each airline may have its own method of measuring each particular fuel saving practice that may be unique to the airline.
The RTK-based metrics are mainly driven by the commercial aspects – through load factor. Thus, all the operations involving positioning flights (cargo flights, leased business aircraft flights, maintenance flights), commercially empty flights (deliveries, demonstration flights,

training flights), as well as low load factor flights that scheduled carriers have to operate, may be seen as not efficient. However, the aircraft itself and the way to fly it might be fuel efficient.

These metrics do not seem to be a tool that allows the operators to closely monitor their fleet's fuel efficiency behavior and proactively adjust it. The efforts in implementing fuel savings procedures or in renewing the fleet would be hidden behind the commercial aspects. Conversely, any inefficient operations are not highlighted and, subsequently, potential improvements might be avoided.

Furthermore, the RTK-based metrics are not suitable for operators mixing different types of aviation business. An operational improvement impacting all the aircraft, whatever configuration and mission, would not be visible at the fleet level which could prevent the operator from correctly indicating good results or progress.

2.3 Operational Fuel Efficiency Factor (OFEF)

In order to move away from the commercial aspects inherent to an RTK-based formula, it is proposed to present the Operational Fuel Efficiency Factor (OFEF) for operational fuel savings monitoring purpose:

$$\mathrm{OFEF} = \frac{\mathrm{ZFW} \times \mathrm{GCD}}{\mathrm{BF}} \qquad (Eq. 5)$$

where:

- ZFW (Zero Fuel Weight) is the total weight of the aircraft (including the aircraft, the crew members, the passengers and the cargo) without the fuel;
- BF (Block Fuel) is the fuel burnt during the flight, from gate to gate.

The overall metric unit is expressed in tonnes-kilometres/litres. The selection of the metric parameters is described below:

- Mass. As stated in section 2.1, it is frequently represented by the payload. However, this representation does not take into account the distinctions between the three travel classes (Economy, Business, First) that an operator might have to accommodate. These distinctions encompass varying baggage allowances, aircraft infrastructure (galleys, lavatories, monuments) and passenger comfort level (seats, screens). Furthermore, a scheduled carrier will have to cope with low load factor situations. In an extreme case, if payload approaches zero, which would make the whole fuel efficiency irrelevant. Consequently, the operator cannot rely on this tool anymore to measure the impact of using the most fuel efficient aircraft and operational practices. By using ZFW, the commercial aspect is eliminated and all fuel saving practices can be accounted for in the final result.
- Distance. Amongst the different distances that characterize a flight, the actual distances flown by the aircraft are subject to a great variability. Ground distances vary depending on the routes chosen for the day while the weather conditions will affect air distances. Using GCD is simple and still gives an incentive to the operator to optimize the selection

of the route by using the shortest air distance possible and taking advantage of higher level altitudes, winds and temperatures.

- Fuel. The fuel factor should consist of only the fuel burnt during the flight and should not include the fuel reserves or alternate diversion fuel. These elements have an impact on the gross weight of the aircraft and are therefore taken into account by the formula to incentivize fuel optimization.

3. Key Findings

3.1 Case Study: Passenger Flights

Figure 1 shows the evolution of an RTK-based metric (in blue) and the OFEF metric (in red) every month over two years for a mixed fleet of 1 Airbus A319, 23 Airbus A330, 15 Airbus A340, 47 Airbus A380 and 124 Boeing B777.

The RTK metric has been calculated using the following formula:

$$\mathrm{RTK}_{PAX} = \frac{\text{Fuel consumed to carry only the passengers}}{\text{100 revenue passengers} \times \text{air distance flown}} \qquad (Eq.6)$$

The parameters in the OFEF metric formula are as described in Eq.5.

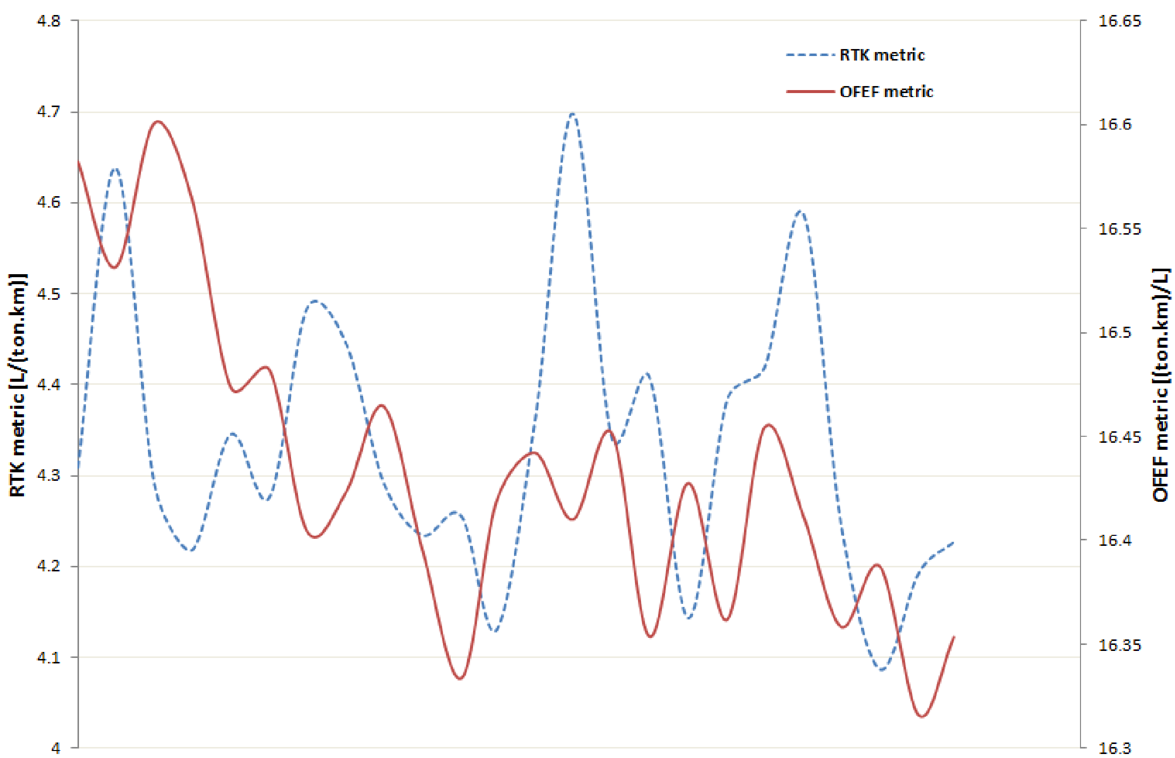

Figure1: Evolution of an RTK-based metric (in blue) and the OFEF metric (in red) every month over two years for a fleet of long-haul commercial passenger jet aircraft.

3.2 Case Study: Cargo Flights

Figure 2 shows the evolution of an RTK-based metric (in blue) and the OFEF metric (in red) every month over two years for a mixed fleet of 10 Boeing B777 freighter and 2 Boeing B747 freighter.

The RTK metric has been calculated using the following formula:

$$\mathrm{RTK}_{CARGO} = \frac{\text{Fuel consumed to carry only the cargo}}{\text{revenue payload} \times \text{air distance flown}} \qquad (Eq.7)$$

The parameters in the OFEF metric formula are as described in Eq.5.

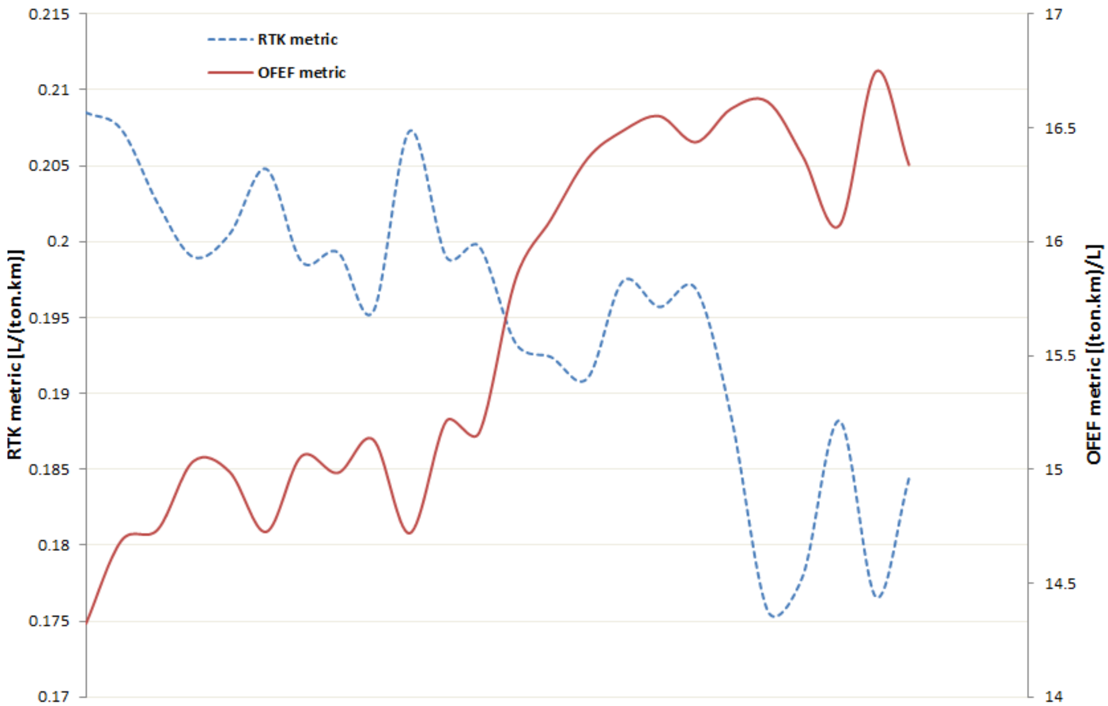

Figure 2: Evolution of an RTK-based metric (in red) and the OFEF metric (in blue) every month over two years for a fleet of long-haul commercial cargo jet aircraft.

3.3 Qualitative Analysis

Before starting the analysis, it is worth mentioning that, due to the RTK metric definition itself, the lower the number the better the fuel efficiency. Conversely, in the OFEF metric definition, the higher the number, the better the fuel efficiency. In other words, when the RTK metric trend goes up, it means that the efficiency is getting worse. When the OFEF metric trend goes up, it means that the efficiency is improving.

Regarding both study cases, it has to be noted that the two metrics vary in the same direction, i.e. improvement and deterioration happen at the same time for both metrics, which reflects an overall consistency in the proposed measurement methods.

For passenger flights (Figure 1) the OFEF fuel efficiency shows smaller absolute variations than the RTK fuel efficiency. This reflects that the parameters influencing the OFEF metric inter-compensate each other while the RTK metric is mainly driven by the load factor.

For cargo flights (Figure 2), it can be seen that the fuel efficiency absolute values given by OFEF are pretty similar to the passenger flights values (around 15 (ton.km)/L for both passenger and cargo flights). Conversely, the fuel efficiency absolute values given by the RTK metric show very different orders of magnitude for passenger and cargo flights (around 4 L/(ton.km) for passenger flights and around 0.2 L/(ton.km) for cargo flights, which represents a factor 20). It means that OFEF offers a more universal measure of the operational fuel efficiency compared to RTK when attempting to track the impact of fuel savings initiatives.

4. Conclusion

Following a constant growth curve, international aviation is certainly at the heart of global environmental considerations on the path towards sustainability. A significant number of measures have been undertaken by most of the ICAO member States, either individually or under the umbrella of broader entities or schemes, including aircraft-related technology development, improved air traffic management and infrastructure use, more efficient operations, economic/market-based measures, and regulatory measures.

Ambitious aspirational goals for fuel efficiency have been set by ICAO and the member States, which aviation industry is committed to achieve, have raised discussions about the measurement of the aviation fuel efficiency.

The best fuel efficiency metric to be adopted by the international authorities goes well beyond the purpose and scope of this paper. However, the paper reminds that, depending on the expected achievements of the fuel efficiency measure, different formulas can be used and serve different purposes.

As recommendation, the OFEF metrics form, which is simpler in formula and yet able to show a universal operational fuel efficiency for both passenger and cargo aircrafts, may easily be adopted by airlines for their operational fuel efficiency measure, as alternative comparison to the well know RTK metrics measure from IATA / ICAO.

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Financial and Environmental Impacts of Fuel Tankering in a Potential Alternative Fuels Market

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Abstract: Within the current context of the development of a global market-based measure (MBM) by the International Civil Aviation Organization (ICAO), carbon offset programs are more than ever at the heart of the aviation industry's environmental issues. The use of alternative fuels is considered as one of the potential ways to compensate for its emissions. This paper shows that, although the net carbon dioxide (CO_2) emissions would be reduced by using alternative fuels, the financial impact would not necessarily give aircraft operators enough incentive to avoid tankering conventional jet fuel.

Keywords: aviation, aircraft operations, alternative fuels, fuel price, emissions offset

1. Introduction

1.1 Political Context

The European Union Emission Trading System (EU ETS) originally applied to industries and utilities, and took effect for airlines on 1 January 2012. The system initially imposed a cap on carbon dioxide emissions for all planes arriving or departing from EU airports, while allowing airlines to buy and sell "pollution credits" on the bloc's carbon market to reward low carbon-emitting aviation. Initial inclusion of foreign airlines operating in European airspace under the ETS triggered an international controversy which has prompted ICAO to develop a global MBM. Within this context, it is anticipated that the use of alternative fuels would be included in the global scheme as one of the ways to offset international aviation emissions.

1.2 Alternative Fuels: Different Perspectives

From a pure greenhouse gas emissions perspective, the alternative fuels are considered as one of the main steps towards carbon neutral growth. The ones approved to date, Fischer-Tropsch (F-T) fuels and Hydroprocessed Renewable Jet (HRJ) fuel, could provide aviation with 10% to 50% reduction in emissions that contribute to global climate change (Stratton et al., 2010). It still has to be noted that in order to fairly capture the overall benefits of using alternative fuels, it is necessary to perform their life-cycle analysis (LCA) which requires to account for the emissions produced during the overall production/transport 'field-to-tank' process (Prieur et al., 2011). However all these considerations still belong to the scientific research area.

On the other hand, aircraft operators may have a completely different perspective when it comes to actually buying a new type of fuel available on the market. The paramount criterion that airlines have to consider remains the price. Predictions of alternative fuel prices show that they are more expensive than conventional jet fuel (Hileman et al., 2009), so one might consider tankering conventional fuel to avoid purchasing potentially available alternative fuels.

1.3 Purpose and Objectives of the Study

Tankering fuel is a long-time practice amongst airlines, especially those having a well-developed short range network. Commonly used flight planning tools and methodologies also account for the fuel tankering issue (Strout et al., 1992; Lido/Flight, 1995).

This paper studies the financial and environmental impacts of fuel tankering in a potential alternative fuels market. It demonstrates that, depending on the range flown and the quantity of fuel that can be tankered, although the net CO2 emissions would be reduced, the financial impact of purchasing alternative fuel would not necessarily give aircraft operators enough incentive to avoid tankering conventional jet fuel. Based on publically available information on realistic alternative fuel price ranges, the study presented here tries to identify thresholds in range and fuel costs from which buying alternative fuels can be envisaged.

2. Methodology

2.1 Fuel Types and Costs Assumptions

In this paper, the following assumptions in terms of fuel types and fuel price ranges have been made (Hileman et al., 2009):

Fuel type	Conventional jet fuel	UltraLow Sulfur (ULS) fuel	Jet fuel from oil sands	Gas-To-Liquid (GTL)-based fuel	F-T fuels from coal	F-T fuels from biomass and coal
Price range (USD/USG)	1.40-2.10	1.45-2.15	1.19-1.55	1.40-2.50	1.60-1.92	6.00
Average difference to conventional jet fuel (%)	0	+3	-20	+10	+5	+200

It has to be noted that the production of jet fuel from oil sands results in roughly 10 to 25% higher life-cycle greenhouse gas (GHG) emissions over conventional Jet A, depending on extraction technique. Approaches are available to reduce these emissions to levels close to conventional petroleum, but their application might increase production costs beyond the range shown in the above table.

In summary, there is currently no evidence that any of the alternative fuels for aviation likely to be available in the next decade could be produced/distributed at a lower or even equal price than the conventional Jet A fuel while serving the purpose of reducing GHG emissions. This paper and the modeling scenario described in the next section are based on that assumption.

2.2 Description of the Modeling Scenario

The following assumptions have been used for the modeling:

- Aircraft type: two wide-body jet aircraft types, one being 13% more fuel efficient than the other.
- Flight length range: 200NM-3000NM, which reflects the actual range of distances where tankering is likely to occur. This range was split into two categories of three destinations

each: three short-haul destinations (SHD1, SHD2, SHD3) and three medium-haul destinations (MHD1, MHD2, MHD3).
- Fuel cost range: conventional jet fuel × b where b=1.01; 1.05; 1.10; 2.
- Flight schedule: 18 flights, the more fuel efficient aircraft operating to each destination twice, the less fuel efficient aircraft operating to each destination once.

The Lufthansa Systems' flight planning system (Lido/Flight, 1995) has been used to obtain the fuel consumptions as well as optimizing extra fuel uplift.

The below table (Table 1) summarizes the modeling assumptions along with codified names that will be used in the analysis in later sections:

	Description	**Codified names**	**Remarks**
Aircraft type	2 wide-body jet aircraft types	A1, A2	A1 is 13% more fuel efficient than A2.
Flight range	3 short-haul destinations	SHD1, SHD2, SHD3	SHD1=188NM SHD2=207NM SHD3=1638NM
	3 medium-haul destinations	MHD1, MHD2, MHD3	MHD1=2972NM MHD2=3157NM MHD3=3450NM
Fuel types and cost range	4 alternative fuel types whose cost is defined by [conventional jet fuel × b]	AF1, AF5, AF10, AF200	b=1.01; 1.05; 1.10; 2 AF1 costs 1% more than the conventional jet fuel. AF5 costs 5% more than conventional jet fuel, etc…
Flight schedule	18 flights		A1 operates each of the 6 destinations twice. A2 operates each of the 6 destinations once.

Table 1: Summary of the modeling scenario.

2.3 Description of the Calculation Methodology

The calculation methodology is as follows:

$$cost_{Conventional\ \ Jet\ Fuel} = (Q + \delta) \times price_{Conventional\ \ Jet\ Fuel} \qquad (Eq. 1)$$

$$cost_{AF1} = Q \times price_{AF1} \qquad (Eq. 2)$$

$$cost_{AF5} = Q \times price_{AF5} \qquad (Eq. 3)$$

$$cost_{AF10} = Q \times price_{AF10} \qquad (Eq. 4)$$

$$cost_{AF200} = Q \times price_{AF200} \qquad (Eq. 5)$$

where:
- Q is the quantity of fuel that represents:
  - tankered conventional jet fuel (in Eq.1) or
  - purchased alternative fuel (in Eq.2, Eq.3, Eq.4, Eq.5);
- δ is the extra fuel burn due to tankering the quantity of fuel Q.

3. Key Findings

3.1 Financial Impact

Figure 1 shows the financial impact of purchasing and tankering conventional jet fuel versus purchasing the same amount of alternative fuel. The variable $cost_{\,Conventional\ Jet\ Fuel}$ (Eq.1) is taken as the reference (thus, is equal to 1 in the graph) and the four other variables $cost_{\,AF1}$ (Eq.2), $cost_{\,AF2}$ (Eq.3), $cost_{\,AF3}$ (Eq.4) and $cost_{\,AF4}$ (Eq.5), are normalized to this reference. Therefore, the vertical axis values have no unit.

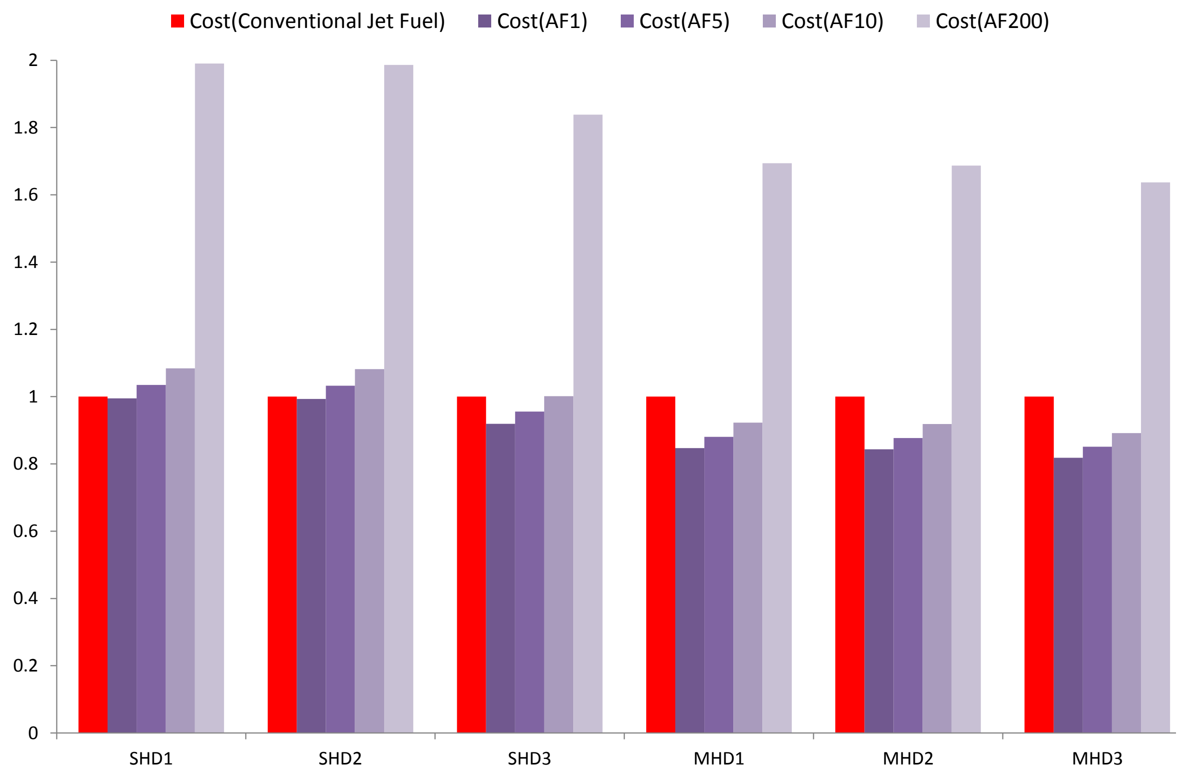

Figure 1: Financial impact of purchasing and tankering conventional jet fuel versus purchasing alternative fuel.

From Figure 1, it is interesting to note that any alternative fuel costing twice the price of conventional jet fuel will unlikely be purchased.

In case of very short routes (SHD1 and SHD2), the cost of purchasing and tankering conventional jet fuel versus purchasing an alternative fuel that is 1% more expensive (AF1) is almost similar. If alternative fuels price is 5%, or more, more expensive than the conventional jet fuel, then tankering conventional fuel has a relatively reduced financial impact on the aircraft operator. In case of medium-range routes (MHD1, MHD2, MHD3), it is worth buying available alternative fuel. In case of 'in between' range (SHD3), it starts being worth purchasing alternative fuel instead of tankering conventional fuel.

From Figure 1 and the ranges described in Table 1, it is assumed that the range from which buying alternative fuel could be envisaged is around 1000NM.

3.2 Environmental Impact

Figure 2 shows, for each of the six destinations, the ratio of the trip fuel necessary to fly the distance without tankering fuel over the quantity of fuel tankered. It reflects that the further the distance, the less fuel one would tanker.

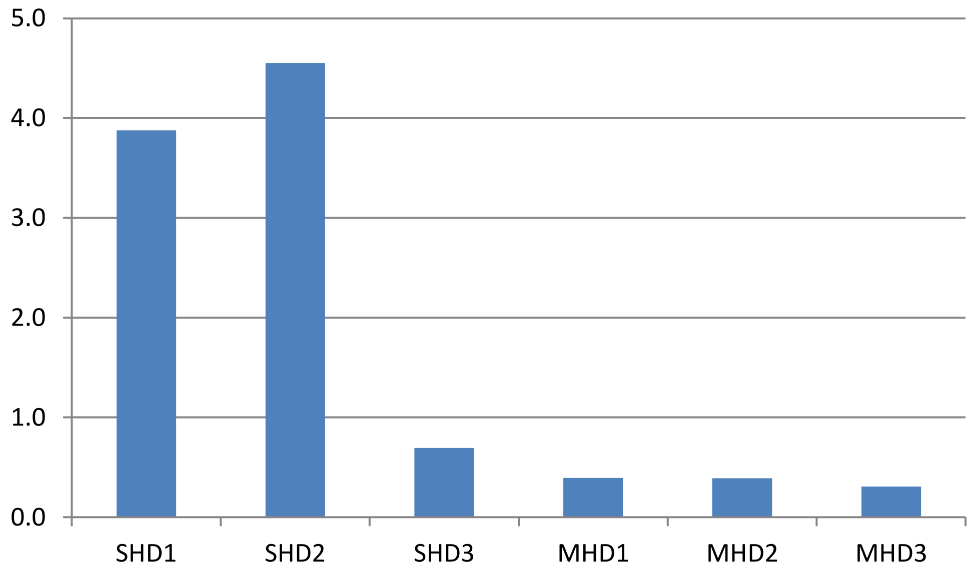

Figure 2: Ratio of the trip fuel necessary to fly the distance without tankering fuel over the quantity of fuel tankered.

Figure 3 shows, for each of the six destinations, the increase in CO2 emissions due to the fuel consumed to carry the fuel tankered.

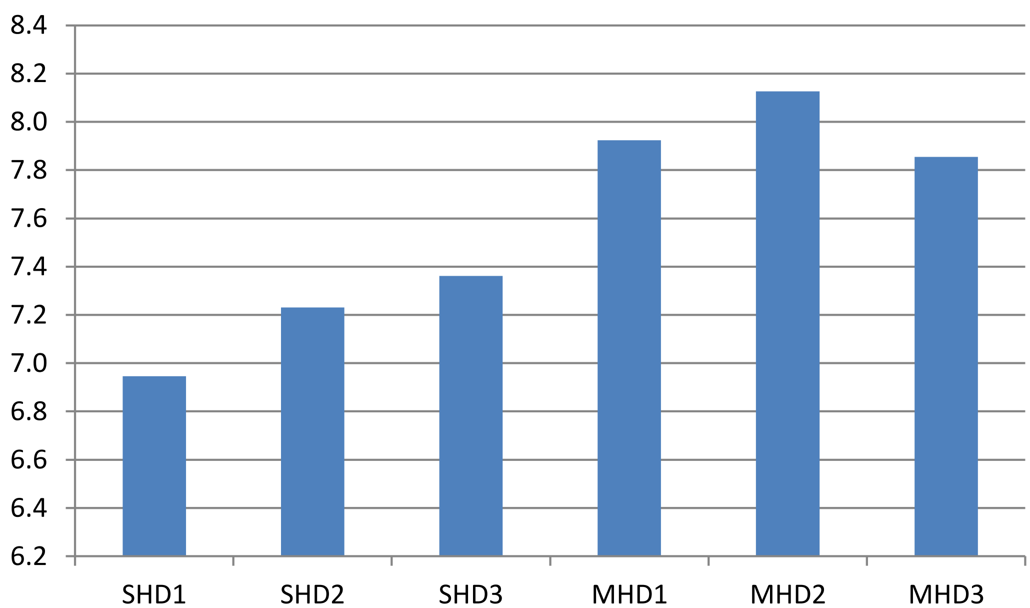

Figure 3: Increase (in percent) in CO2 emissions due to the fuel consumed to carry the fuel tankered.

From Figure 3, it is assumed that for all ranges from 200NM to 3500NM, the extra fuel burn, and therefore the increase in CO_2 emissions, due to fuel tankering is around 7.5%. It has to be reminded from Figure 2 analysis that the further the distance, the less fuel one can tanker. That is the reason why the extra fuel consumed while tankering does not evolve proportionally to the distance.

Based on the findings contained in Section 3.1, fuel tankering will likely continue to occur at least for the shortest routes to avoid buying more expensive available alternative fuels. In this case, an increase in CO_2 emissions is anticipated. Whether or not this increase will have a significant impact at the global level goes beyond the scope of this paper.

4. Discussion

Findings on financial impacts show that the range from which buying alternative fuel could be envisaged is around 1000NM which is typically the distance between Dubai and Mumbai, Amman, Islamabad or Jeddah. This result could be applied to the recent Indonesian mandate on alternative fuels[7]. The mandate is to commence in 2016 at a 2% blend and will be further increased to 5% in 2025. If similar initiatives start arising at other important international airports, airlines industry would have to establish a broader internal fuel tankering policy.

Findings on environmental impacts show that for the range 200-3500NM, the extra fuel burn, and therefore the increase in CO_2 emissions, due to fuel tankering is around 7.5%. In the current and future development and implementation of emissions reporting systems, aircraft operators will have to either pay more to buy alternative fuels, or buy more carbon credits. The relevance of using alternative fuels in order to reduce global greenhouse gas emissions might be jeopardized unless airlines industry is provided with an incentive to do so.

5. Conclusion

In the current context of the development of new environmental policies driven by market-based mechanisms, it is anticipated that the use of alternative fuels would be included in the future global – or regional – schemes as one of the ways to offset international aviation emissions.

The alternative fuel distribution prices are strongly driven by the compatibility with existing aircraft fuel systems, the maturity of the production process technology and the global scale production potential. The availability of alternative fuels whose combination of these paramount criteria can be envisaged in the next decade, but it is unlikely that within that timeframe, the prices will be lower or even equal to the conventional jet fuel current price.

This paper studies the financial and environmental impacts of fuel tankering in a potential alternative fuels market and has identified thresholds in range and fuel costs from which buying alternative fuels can be envisaged. Within the conditions and assumptions used to build the case study presented in this paper, tankering fuel remains a better option from the financial perspective for routes shorter than 1000NM provided the production cost of the available

[7] http://www.iata.org/pressroom/facts_figures/fact_sheets/pages/alt-fuels.aspx and http://www.icao.int/environmental-protection/GFAAF/Lists/SAAFA/SAAFA.aspx

alternative fuels is less than 10% of the conventional jet fuel. The paper also shows that regardless of the range, the increase in CO_2 emissions due to tankering is around 7.5%.

However, in the context of civil aviation emissions offset programs, governments or environmental entities might give airlines an incentive to buy alternative fuels. For example through State subsidies, or through an offset factor that would mitigate the overall actual emissions. This incentive is yet to be determined. This study has been based on the sole price criterion. Future research on the topic will have to be performed by taking into account this incentive, whatever form it takes, and modify the methodology described paragraph 2.3 accordingly.

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