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A Classification and Assessment of Research Streams on Low Cost Modeling in Civil Aviation Transportation Industry

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Abstract

This article attempts to identify key research streams in Civil Aviation Transportation Industry during the past decade and highlights the evolution of the literature. Progress in six established research thrusts and a new research stream is discussed. Using content analysis, the existing research is also examined from a methodological point of view. The review provides evidence for an increasingly sophisticated and rich body of knowledge in global Civil Aviation Transportation Industry.

Keywords: Civil Aviation Transportation Industry (CATI), Low Cost Strategies (LCS), Low Cost Carriers (LCCs), Classification, Assessment.

1. Introduction

Aviation Industry is the fastest means of transportation for goods, services and people, and as per the most recent estimates it carries about 2.2 billion passengers annually (IATA 2010, Bureau of Transportation Statistics, 2010). Aviation sector has brought globalization to the every corner of earth. The goods transported by air accounts for about 35% of all international trade. Now-a-days, Aviation Industry is one of the most competitive markets, where the Low Cost Carriers (LCCs) are quite popular and accessible in national and global scenario. To develop competitive advantage, LCCs are coming up with variety of strategies and one of them is Low Cost Strategy (LCS). Broadly speaking, LCCs are nothing else but only those airlines which follow LCS. The LCS is not limited to specific region and country. In fact, the LCS based model was introduced by South-west airlines in US in 1971, adopted by Ryanair in Europe in early 90's and makes a good success even in the Australian, Asian and other continent's markets.

The LCS model is the by-product of deregulation policies adopted by the governments, and results into lowering fares with higher market shares (D. E. Pitfield, 2008), and even lower fares on other routes (Martin Dresner et. al., 1996). The LCS model is observed as more successful in developing countries where population density is high and economic developments are being made (Xavier Fageda et. al., 2009). Aviation research indicate that the research growth in this area is not limited to technology development only, but is extended to management issues like marketing programs, flights and route scheduling and the LCS. And this strategy results in competition among the airlines (James R. Atwood, 1980; Mark J. Lijesen et. al, 2002; David Gillen and Morrison, 2003; Markus Franke, 2004), which yields economic development of regions and nation as a whole. Increased competition creates downward pressures on output prices and led to improved productivity and efficiency. The purpose of this article is threefold:

(a) Delineate and classify various research streams in Civil Aviation Transportation Industry,
(b) Assess the progress that has been achieved within each research stream, and,
(c) Evaluate research methodologies that have been employed in these research streams.

The review is restricted to the period 2000-2011. The article is organized in the following way. First, the challenges in Civil Aviation Transportation Industry (CATI) are addressed. Second, the research methodology is explained. Third, development of each research stream is assessed and discussed. Next, research methodologies utilized by these streams are evaluated. This article concludes with a broad characterization of the advances in the literature.

2. Challenges in Civil Aviation Transportation Industry

To grow and survive in the competition, LCCs have to cope with many challenges like, **high fuel price**, **safety** that includes air navigation, aircraft operations, airworthiness, air-traffic control, airport and aircraft design, s**ecurity** and a decline in yield. Literature advocates that researchers have been addressing these challenges since years, and are summed up in **Table 1** with some references that provide some insight for the researchers to work in the related field.

Safety is a prime aspect of Aviation Industry and is an economic attribute of any transport service as is highly valued by the customers yet is costly to provide. Majority of accidents occur during take-off and landing of the aircraft, so Aircraft and Airport safety are the prime issues with their customer's safety. With parallel technological improvements shown by both by the aircraft manufactures and the airport management, an improvement in the maintenance techniques is witnessed with improved airport infrastructure, safety is enhanced. Second prime challenge for Aviation is the Security aspect. Security in Aviation is to deal with the criminal activity that certainly occurs on the airports and the aircrafts. Criminal violence in US air in mid 50's and the growing hijackings in the Cuban air during 60's utters the urgent demand for the baggage-inspection devices. Federal Aviation Administration (FAA) in 1973 made emergent rule for inspecting baggage and scanning of all passengers. Earlier, Hauge Convention (1970) for the Suppression of Unlawful Seizure of Aircraft characterizes hijacking as Criminal rather than Political Act. Montreal Convention (1971) strengthened the Hauge convention. Despite of the security measures for baggage inspection, passenger scanning and the implementation of laws against criminal activities; the 9/11 terrorist attack happens. Security is hence a prime issue for the airlines from their start-up to till date. Paul Dempsey (2003) briefs all multilateral Conventions held for Aviation Security from 1944 to 2001 that reflects the domestic responses to Aerial Terrorism. Ken Dunlop (2011) describes security as a checkpoint for future and argues for the flight delay. IATA surveys show an additional 45 seconds per passenger at a checkpoint could lead to a two to five-hour delay.

Aviation Emission is yet another challenge for the Aviation Industry and is the pollution and the noise that aircrafts produces during its operation. Technology has been successful in reducing atmospheric and ground level emissions at airports, both from aircraft and surface vehicles. Earlier turbojets were used; they are replaced by 1st Generation turbofans followed by 2nd Generation turbofans to reduce noise level. Progress in aircraft noise reduction is shown by John P. Clarke (2003) with the revolutionary change in the engine design. But, the technological returns are diminishing and being offset by aviation's long term growth. Paul Upham et al. (2004) discussed about the concept of environmental capacity of an airport that describes the capacity of receiving environment to tolerate the impacts of airport activities. Emissions can further be reduced by encouraging development of biofuels and updating air traffic systems. The biggest reason for switching to biofuels is the high price of aviation fuel. Airlines' pricing more or less depends upon the fuel price; if prices fluctuate, it put a serious note on the pricing strategies of the airlines. Improving the fuel efficiency directly improves direct operating cost for an airline, and is a major area of technological research. Technological improvements include aerodynamic changes, weight reductions, more fuel efficient engines and increased operational efficiency. Raffi Babikian et al. (2002) focused on the impact of regional aircraft on aviation system and examine the technological, operational and cost characteristics of turboprop and regional jets. Airlines sometimes hedge fuel when there is a chance of further increase in price of jet fuel. Moreover, advanced research is in progress for the alternate fuel selection. Sehra and Woodrow (2004) reviewed Hydrogen as future power for 21st century aviation.

In the competitive market, Low cost modeling is a prime task for the airlines to grow and survive in order to gain higher traffic volumes. This reflects their ability to compete through Low Cost focus. Many studies analyzed low-cost business (Fariba and Fagan, 2005; Cristina Barbot, 2006) and depicts the profitability and pricing behaviors of these low-cost airlines. With the development of LCS, a number of LCCs grow. Their growth leads to congestion in Airspace and congestion at Airports. Flight schedule is another aspect of planning to avoid congestion. Nicolas et al. (2006) considered the planning problem of determining the aircraft types assigned to a flight for a flight schedule. A. H Ahmed, Poojari (2008) developed and investigate a prototype fleet assignment model to avoid congestion from airspace. Congestion can lead to serious fatal accidents, and hence, airspace and airport congestion challenge is quite governing when the safety parameter is kept in mind.

3. Method

When conducting an investigation of the state of knowledge in a field, three basic approaches have been used. One approach is Delphi method, second approach is meta-analysis and the third approach, the one used in this study is the content analysis – a research technique for systematic, qualitative and quantitative description of the manifest content of literature in an area.

The first step in conducting a content analysis is to define categories which permit classification of the articles under review and allow measurement of the intensity and frequency of the occurrence of these categories. This step is implemented in the next section in which categories of research streams are classified. The second step is to determine the type and number of journals that will be investigated. The following guidelines were established for selection of the journals. Only scholarly journals are included since the subject matter is the investigation of research streams in CATI, and therefore, transport periodicals are excluded. Second, the journals selected are those that are reasonably accessible to both academicians and practitioners. Moreover, only those journals are selected which are having impact factor greater than one. This procedure yields a total of 20 journals included in the study and are identified in **Table 2** with a total of 311 research articles.

4. Classification of Research streams in Civil Aviation Transportation Industry (CATI)

Based on a series of literature reviews and the current study, research streams in CATI can be delineated into six broad categories. These research streams are:

Safety and Security, a stream of literature investigating safety and security as an integral part of CATI.
Aviation Emissions, a stream involving research on aviation emissions i.e. noise and harmful gases and deals with transportation noise and emission reduction, the laws associated to aviation emissions.
Capacity Management, a stream focusing on managerial issues of capacity, fleet assignment and proper scheduling of fleet and the crew.
Aviation Fuel, a stream exploring the fuel pricing, fuel consumption and the use of alternate fuels for further research. Aviation fuel governs overall aviation cost and is a much broader area of research.
Cost based modeling and Competition, a research stream examining the cost based modeling for aviation industry and the competition hence associated with this cost based modeling.
Congestion, delays and scheduling, a research stream examining the congestion at airports and airspace, the delays associated to congestion, scheduling in order to improve airport efficiency and hence reduce the delay costs.

These categories of research streams in Aviation Industry possess a number of significant characteristics. First, each research stream focuses on the challenges for Aviation and is the dimensions within which most aviation issues can be addressed and analyzed. **Table 1** illustrates these dimensions and the associated aviation thoughts. These research streams did not necessarily flourish simultaneously over time. **Figure 1** illustrates the evolution of these research streams. Finally as a group, these research streams form an integrated body of aviation industry phenomena. A frequency distribution of the literature by the research stream is provided in **Table 3 and 4**.

5. Development of the Research Streams

In these streams of literature research, what had been established before the 2000s? What has been achieved afterwards? Which authors and major works are associated with these streams? The total 311 articles related to the identified research streams are shown distributed among these research streams in **Table 4**. The following discussion highlights key contributions of each research stream.

5.1. *Aviation safety and security*

Aviation safety and security were the prime challenges for aviation industry before 2000 and still are the prime challenges for any airline, as the accident rates for aircraft operations has not changed. Aviation safety and security are reaching beyond borders (Vahid & Roger 2004). Earlier studies have examined the link between financial performance and air carrier safety following deregulation, using accident rates as a measure of safety. These studies have relied on limited post-deregulation data. Sunder & Rhodes (2005) re-examines these trends with extended post-deregulation data and found the accident rates since 1978 have been increasing, raising concerns that the growth in the industry is dominating safety improvements. George J. Siomkos (2000) formulates the role of consumer safety perceptions in managing the airline disasters. Yu-Hern & Chung Yeh (2004) developed a new airline safety index that helps the airlines to understand their relative safety strengths and weakness in terms of manageable safety attributes and identical functional areas for safety improvement. Aviation accident risk factors are quantified by D.K.Y Wong et. al (2006). Moreover, Fedja & Milan (2008) reviewed the risk and safety modeling in civil aviation. Wen-Kuei Lee (2006) developed a quantitative model for assessing aviation safety risk factors. In case of heavy rainstorms, airplanes can skid on the runways. A. Benedetto (2002) proposed decision support system for the safety of runways. A systematic approach for runway safety is provided by B. M. Horowitz & Santos (2009) and can be helpful for implementing ultra-safe options. Moreover, airlines cut expenditure of advertisement in reaction to major accidents; Jay Squalli (2009) depicts that airline sector follow restorative advertising.

Safety of an airline can be linked directly to in-time maintenance of the aircraft and the security aspects adopted by the airports. It is essential that airlines efficiently perform aircraft maintenance in order to ensure aviation safety and schedule punctuality. Konstantina Gkritza (2006) provides an exploratory assessment for airport security screening. Kelly Leone, Rongfang (2005, 2011) proposed the design parameters for baggage screening at airports and shows improvement in airport screening can be achieved by paced system designs. Alexender G. Nikolaev et. al (2007) discusses the stochastic security system for aviation. Sun Olapiriyakal, Sanchoy (2007) designed two-stage security screening and analyzed the system. These inspections result in significant operational costs and they can further lead to delays. Wen-Chin et. al. (2008) developed an analytical framework to investigate the role of human errors in the aviation accidents. Moreover, pilots are expected for safe and successful management of the flight. Brett Molesworth et. al. (2006) concluded the development of risk assessment skills among pilots in the low-flying operations. Alcohol appears to play an important role in aviation crashes. Guohua Li et. al. (2005) concluded distinctive epidemiological patterns were exhibited in alcohol related aviation crashes.

5.2. *Aviation Emissions*

It includes noise and air pollution, which an airplane emits into the environment. Due to the increasing demand for passenger travel, aircraft emissions that contribute to local and global air pollution are of rising concern. Deborah Black et. al. (2007) concludes stress and hypertension among the residents due to exposure to aircraft noise. US Federal Aviation system, in 2001 developed a System for assessing Aviation's Global Emissions (SAGE), that develop global inventories of aircraft fuel burn and the emissions of pollutants into the environment. Their results indicate that global fuel burn and nitrogen oxide (NO_x) emissions decreased by over 6% from 2000 to 2001 (fuel burn and NO_x), and then steadily increased to over 12% (fuel burn) and 15.5% (NO_x) above 2000 levels in 2005 (Brian Y. Kim et. al 2007). Moreover, SAGE may be used to resolve small differences in fleet emission performance. Jooseng Lee et. al. (2007) shows the capabilities of SAGE to distinguish uncertainties in flight-by-flight NO_x predictions. The statistical assessment of results from earlier studies is done by Kenneth Button (2003) and showed meta-analysis, value transfer and economic valuation as a part of airport environmental appraisal.

Abigil and Wardman (2006) innovatively derived values of aircraft noise by time of day and by day of week, which further may lead to policy decisions. C. Miyosi & mason (2009) calculates carbon emissions for some airlines, with differ aircraft types in different geographic markets. Their results show differences in airlines' strategies such as aircraft type used, load factors, seat configurations. Antony and Andreas (2011) simulates airline strategic decision makings and its impact on aircraft emissions. Increased competition directly increases the flight frequency to meet out the demand which somehow increases the aviation emissions, irrespective of the technological advancements.

Noise and emission charges have been imposed to mitigate aviation emissions. Moreover, they encourage sustainable development in CATI. Chang and Lin (2005) investigated airline network design considering noise charges, and analyze the performance of airport noise policies. Airlines have to adjust types of aircraft, flight frequencies, and adopt an optimal air route. Hence, the overall effect of imposing aviation charges can be seen on passenger costs, airport revenues and the aircraft schedules. Cherie Lu & Morell (2001, 2006) also discussed the evaluation of environmental charges and by hedonic pricing evaluate the implication of these charges in terms of airline costs, airfares and passenger demand. They also proposed the application at different costs for different sized airports. Fredrik Carlson (2002) derives optimal environmental charges for different types of airline markets i.e. monopolistic and duopolistic markets. Moshe and Rietveld (2010) showed that increasing aircraft size and adjusting the service frequency to offer similar seating capacity will increase local pollution but decrease climate change impact and noise pollution. When local pollution and climate change impacts are monetized and aggregated the analysis showed that environmental benefits will result from increasing aircraft size. Peter Morell (2009) also suggests using larger aircraft for reducing CO_2 from the European skies. Mark Lijesen et. al. (2010) used hedonic pricing for predicting the benefits of noise reduction and developed a bottom-up cost function to analyze the cost of reducing noise for airlines. Christina Hofer et. al. (2010) concludes that potential increase in air-traffic and related emissions may substantially reduce the environmental benefits of air travel carbon emission taxes. The continuous and sustainable growth of air travel can be achieved through the awareness among air travelers, but Clauss Lessen (2010) shows other rationalities might affect travel behavior more strongly than environmental attitude, and there is a possibility for focused link between travel behavior and environmental attitude.

More charges were introduced at some German airports that aimed at reducing local emission charges of NO_x and hydrocarbons (Janina D. 2010). The charges are further aimed to foster eco-friendly engine technologies. The role of advanced air traffic management is vital in reducing the impact of aircraft noise and hence enabling the aviation growth. John Clarke (2003) concluded that the primary obstacle is the inability of air traffic controllers in high traffic density, to maintain the precise sequencing and spacing required for maximum take-off and landing rates.

5.3. *Capacity Management, Crew & Fleet Scheduling, Crew & Fleet Assignment*

Cheng-Lung and Caves (2002) reviewed the air traffic management and found the demand for air transport grew more quickly than the capacity management. Their review concluded with the establishment of efficient airport information system so as to use the airport capacity better and an improvement in flight scheduling. The capacity analysis model of R. Koray & Karasahin (2008) formulated a management strategy to be developed to prevent queues. The capacity of an airport has to be changed with increased demand for air travel, and can be done by increasing number of runways and the runway length. Senay Solak et. al. (2009) emphasis on their study for airport terminal capacity planning.

Diego Klabjan et. al. (2001) develops a model for airline crew scheduling which minimizes cost and maximizes the regularity of itineraries. The demand for air travel is uncertain and as a result, many departed flights have empty seats,

whereas some flights lack in number of seats to accommodate the travelers. Hai Jaing & Cynthia (2009) developed a dynamic scheduling approach that re-optimses the elements of flight schedule during the booking process itself. Airline schedule design involves determining when and where to offer flights, so as to maximize the profit, and fleet assignment which includes assigning aircraft types to flights to maximize revenue and minimize the operating costs. Fleet assignment is an art used by the airlines in order to assign aircrafts to the flights in a schedule. Further, fleet assignment lead to profit maximizations and affect the marketing and operational processes of an airline. Brian Rexin et. al. (2000) earlier made a generalized fleet assignment model with time windows for simultaneously assigning aircraft types to the flights and schedules the flight departures with significant lower costs. Barry Smith & Johnson (2006) developed fleet assignment solutions that increase planning flexibility and reduce cost by imposing station purity, limiting the number of fleet types allowed to serve each airport in the schedule.

5.4. *Cost based Modeling, Competition among Airlines and Airports*

After deregulation in the US in 1978, air carriers were focused around a small number of hubs. Southwest Airlines began its operations in early 1970s and has been copied by airlines of US, EU and of the rest of world; in terms of its network organisation, management, service and operating characteristics. D.E. Pitfield (2008) did a time-series analysis of Southwest effect in terms of US airline's impact on pricing, competition and traffic volumes. David Gillen and Morrison (2005) reviewed the growth of hub-and-spoke networks after deregulation which is focused on the evaluation of business strategies and network structures with an emergence for value-based airlines. The emergence of a new wave of low-cost entrants has been a significant component for recent development of air transport industry. The LCCs tended to follow a differentiation strategy as opposed to cost leadership on which the original low cost model was based (Fariba & Fagan 2005). Competition provided by the LCCs to full-service carriers (FSCs) has become a relevant issue of airline industry. Carlos & Cristina (2010) found that LCCs organize their boards differently from full service carriers to achieve lower costs and a faster decision-making process is required for their business model. Alessandro (2008) concludes profitability is dependent of the relevance of market size and the presence of rivals on the route; and for profitability, LCCs mainly focus on short-haul and high-density markets. The expansion of LCCs for tourism is also significant and has positive direct and indirect effects that led to tourism growth. Aisling (2001) examined US 'low-cost' operators in terms of their traffic distribution and demonstrated that the LCCs have a lower level of concentration on average than the full-service carriers. Moreover, LCCs focus their traffic flows around a limited number of key nodes. David Gillen and Morrison (2003) employs locational approach for product differentiation, which provide an insight for LCCs competition to FSCs. Alexander and Levin (2010) investigate the positive effect of fleet commonality on operating performance of LCCs. Results also shows that fleet size positively affects this relationship, whereas route length variations do not.

Airlines tried to gain competitive advantage over their rivals, in order to capture the market shares. Airlines outsource resources and functions to gain competitive advantage. But, this strategy is not always successful. Chieh-Hua & Chen (2011) using cluster analysis identifies group of airlines that compete on a particular services. To achieve competitive positions, airlines have to simultaneously adopt strategies to maintain and enhance its current strengths and to strengthen attributes in which it is lacking. Carlos & Cristina (2010) developed a model of quantity and price competition for LCCs. The model is based on announcements of new routes and their impacts on announcer and the rivals. Profitability depends on launching costs for the announcer, and on whether market expansion or market substitution is dominant for the rival. Derek Clark et. al. (2011) analyses equilibrium fares that arise from Collusion, Cournot, Stackelberg, Bertrand and Sequential Price Competition when two profit maximizing transport firms produce symmetrically differentiable services and have identical costs. Moreover, Mark Lijesen et. al. (2002) proposed measures for competition, where several indicators are available, as number of competitors, the C4 index and the Herfindahl Index.

Airports are the locations for an airline to immense its operations and a place to compete. Airports provide a geographic location for travel market and can generate both air and ground revenues. David Smith & Potter (2005) concluded that the demand for low-cost services along with aeronautical charges is the important factors for LCCs to choose an airport for its operations. But, the LCC revolution led airlines to compete on price, and the airports too feel some sort of direct competition. The low-cost model motivates airlines to negotiate contracts that significantly reduce aeronautical revenues, leaving airports to compensate by seeking commercial revenues from the increase in passengers (Graham Francis et. al. 2003). Cristina Barbot (2009) develops a model of airport and airline for a three-stage game, and analyzes vertical collusion between an airport and an airline that compete with another airport and another airline, by means of static and dynamic games. The incentives for collusion exist when airports and airlines have different market sizes and when secondary airports and LCCs compete with main airports and FSCs. Cristina Barbot (2006) builds a vertical differentiation model to analyze the effects of subsidies, or lower aeronautical charges, for secondary airports on competition between LCCs and FSCs. Subsidized airport charges benefit consumers and negatively affect incumbent airlines. However, they may be more affected

by competition than by the subsidy. Moreover, airline sets lower fares when flights depart from or arrive at dominated airports.

5.5. *Congestion at Airports & Airspace, Delays associated to the Congestion*

Airport congestion is of major concern for airlines and is a relevant policy issue as it may lead to flight delays, cancellations affecting both travelers and the airlines. Ricardo (2010) addressed the interplay between flight frequency and aircraft size in a congestion-pricing model, finding that airlines schedule too many flights using small aircraft, which constitutes a major contributor to congestion. Georgina Santos and Robin (2010) found four significant variables; market concentration, slot coordination, hub airports and hub airlines in explaining delays at European airports. Congestion tolls are to be calculated, which account for the congestion imposed on other carriers and the congestion imposed on all passengers. Some airports increase the airport charges to generate healthy revenue and to protect passengers from excessive congestion. The response of air transportation system to avoid airports with high delays could significantly impact passenger demand and air traffic for the dependent airports. And to manage the airport capacity, airlines form strategic alliances. Competition effects are associated with flight frequencies at high levels, preventing a significant shift toward larger aircraft, which would otherwise reduce the impact of the capacity constraints. Anming and Yimin (2010) found that a profit-maximization airport would over-invest in capacity and is driven by the interaction between airports and the carriers with market power.

Erik Verhoef (2010) studied the regulation of an airline duopoly for a congested airport. Congestion and overpricing due to market power are to be regulated. Baggage scheduling is also an important aspect at congested airports, as improper scheduling may lead to further passenger and aircraft delays. Cheng-Lung and Caves (2002) developed a cost minimization model to optimize the scheduling of aircraft rotation and is designed to control flight punctuality and delay costs.

6. Review of Research Methodology in Civil Aviation Transportation Industry

The previous section provides the assessment of six research streams in CATI. The current section deals with investigating the status of research methodology adopted in the study of these research streams. Specifically, we intend into

(1) Present a classification scheme for research methodology
(2) Determine the number of studies associated with each type of methodology, and
(3) Evaluate the data collection techniques and sample sizes used in these studies.

The classification we have adopted for investigating the methodology is divided into conceptual and the empirical studies. For conceptual dichotomy, we consider the non-data studies that concentrate on formulation of ideas, concepts, theories and the models. For Empirical dichotomy, the data-based studies that focus on the validation of the concepts, hypothesis and theories through data analysis are considered. We further divide the empirical research into two subcategories: statistical and non-statistical. Statistical are meant for quantitative analytic technique used to test statistical significance, whereas, Non-statistical refers to qualitative study based on in-depth analysis of some cases and the observation of facts.

7. Conclusion and Future Research Directions

This review traced the evolution of six established research streams in Civil Aviation Transportation Industry (CATI). Each research stream has a distinct focus in aviation industry, and can be characterized by major works and key contributors. The existence of the research streams provides a general framework for the researchers pursuing a specific broad area in CATI and they are encouraged to relate their study area to the broader research thrust. The classification schemes further uncover and explore the important issues in each research area and unaddressed issues to be resolved. The above review of the literature in CATI provides an evidence for the growing literature for:

(1) Cost based modeling,
(2) Competition among Airlines and Airports, and
(3) Capacity Management, Crew and Fleet Assignment, Crew and Fleet Scheduling

Study shows competition prevails as cost based modeling is adopted by low-cost carriers and the effects can be seen among the airports too. This led to further plan the capacity and the schedule and crew and fleet assignments for easily establishment of their plans.

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AUTHOR'S PROFILE

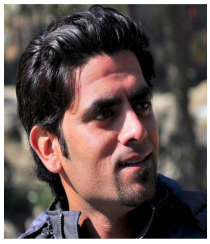

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Table 1: Challenges addressed by various Authors and Associated Schools of Thought

Challenge	School of Thought	Authors
Safety	Passenger Safety Aircraft Safety Airport Safety	Ivor Thomas (1949); Suzanne C. Pinkerton (1978); Golbe D. L (1986); Leon Moses, Ian Savage (1990); Rose (1992); Ford (1997); Marc Wilson (1997);Pooley (1999); McDonal (2000); Marifran Mattson, Young (2001); A. Benedetto (2002); Yu-Hen Chang, Chung (2004); ICAO/DGCA (Montreal Conference 2006); Yu-Hern Chang, Liao (2009)
Security	Aircraft Security Airport Security	Manoj Patankar, Holscher (2000); Paul Stephen Dempsey (2003); Paul Evans (2005); Bruce George, Natalie Whatford (2007); Mark B Salter (2008); M S Fayez et al. (2008); Kenneth Button (2009); Ken Dunlap (IATA 2011)
Aviation Emissions	Environment (Noise and Emissions)	Nero, Black (1980); Pennington et al. (1990); Uyeno et al. (1993); Steven E. Morrissette (1996); Feitelson (1996); Joosung J. Lee et al. (2001); Fredrik, Henrik (2002); Paul Uphan et. al. (2003); Janina, Wolfgang (2007); Karen Mayor, Richard S.J. Tol (2009); David S. Lee et al. (2009)
Capacity Management	Overcapacity Reservation Control	H.R. Thompson (1961), Hemant Kumar (1996); Tae Hoom Oum et al. (2000); Doganis R (2002); Marianne Raffarin (2004)
Fuel Consumption & Pricing	Fuel Pricing Advanced Fuels for Future Fuel Hedging	Hemant Kumar (1996); Rao V. K (1999); Joosung J. Lee et al. (2001); Danish A. Hashim (2004); Peter Morrell, William Swan (2006); Vladimir Karamychev, Reeven (2009)
Cost based modelling and competition	Low Cost Modelling	Graham Francis, Ian Humphreys, Alessandro Fidato (2003); Alamdari, Fagan (2005); Barbot C (2005); Volodymyr Bilotkach (2007)
Congestion & delays at Airports	Proper Scheduling Advance Air Transport Air Traffic management	Ruwantissa (2000); Bruckner (2002); Marianne Raffarin (2004); Nicholas et. al. (2006), A H Ahmed, Poojari (2008); Leonardo, Zhang (2008); Jan K. Brueckner (2010),

Table 2: Journals included in the study

Transport Journals included in the study	
Transportation Research Part A (Policy and Practice)	Transportation Research Part B (Methodological)
Transportation Research Part D (Transport and Environment)	Transportation Science
Journal of Air Transport Worldwide	Transport Reviews
Transportation Journal	Journal of Air Transport Management
Other Journals included in the study are	
Accident Analysis and Prevention	European Journal of Operational Research

Energy Conversion & Management	International Journal of Hydrogen Energy
Few Articles are from the following journals (represents [M] in Table 3)	
Sustainable development, Review of Policy research, Financial Management, The Journal of Industrial Economics, Canadian Journal of Economics, Strategic Innovators, OPEC Energy Reviews, International Journal of Tourism Research, Pacific Economic Review	

Figure 1: Research Streams in Aviation Industry

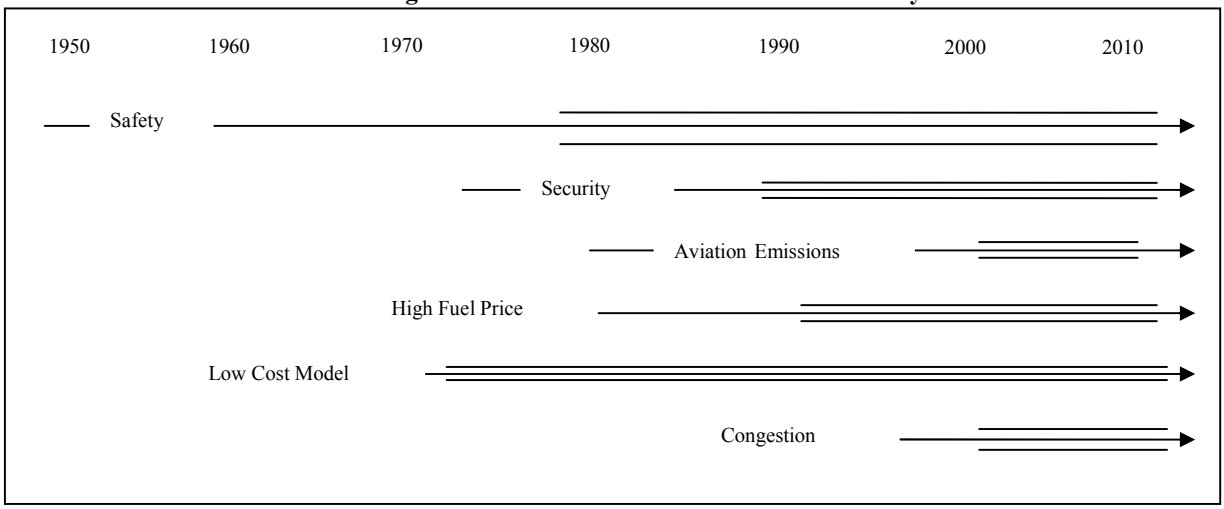

Table 3: Distribution of Studies by Literature Streams

Dimensions	Historical Journey	Research papers 2000 - 2011	Journals Cited (Impact factor, 2011)
Aviation safety and security	1937 – Aviation safety holds focus of attention 1950's – Criminal violence in US air 1960's – Hijackings in Cuban air 1970 – Hauge Convention 1971- Montreal Convention	A. 05 B. 22 C. 03 D. 01 E. 02 F. 00 G. 02 H. 04 I. 06 M. 01	A. Transportation Science (2.821) B. Journal of Air Transport Management (1.312) C. Transportation Research Part A (1.601) D. Transportation Research Part B (2.091) E. Journal of Air Transport Worldwide F. Transport Reviews (1.722) G. Transportation Research Part D (1.589) H. European Journal of Operational Research

Aviation Emission	1975 - Establishment of Aviation Environment Federation (AEF) Introduction of Less polluting Turbofan & Turbojet Engines in Aviation 2003 – Silent aircraft initiative 2004-06 baseline for aviation emission 2007 – ICAO's open emission trading to meet CO_2 reduction objectives	A. 00 B. 27 C. 00 D. 02 E. 00 F. 03 G. 20 H. 01 I. 01 J. 02 K. 02	(2.158) I. Accident Analysis and Prevention (2.350) J. Energy Conversion and Management (2.417) K. International Journal of Hydrogen Energy (4.407) L. Fuel (3.618) M. Other Journals
Capacity Management, Crew, Crew & Fleet Scheduling	1970 – yield/revenue management and optimization started in Western countries. Internet brings boom for yield management Fleet assignment & scheduling are further used to cut costs and facilitate with generating health revenues	A. 17 B. 05 C. 04 D. 04 E. 02 F. 01 G. 00 H. 11 I. 00	

Fuel consumption & pricing, Alternate fuels	1981,1990 – Gulf crisis, and the prices of fuel rises dramatically 2008 – tests for using Bio-fuel as aviation fuel 2011 – Aviation jet fuel crisis (India)	A. 00 B. 02 C. 00 D. 00 E. 01 F. 01 G. 06 H. 00 I. 00 J. 01 K. 02 L. 10 M. 05	
Cost based modeling, Competition among Airlines	1938 – Civil Aeronautics Act 1978 – Airline Deregulation Act Toward the end of century, no frills products were offered by low cost airlines. And Now-a-days, airline profitability is under-pressure due to high competition, overcapacity and lower yields	A. 01 B. 58 C. 08 D. 07 E. 03 F. 02 G. 01 H. 05 I. 00 M 06	

Congestion &, Delays at airports	After 2000, there is steady growth in passenger numbers on the airports. It is followed by congestion on & delays at airports. Airlines look for Secondary airports to commence uncongested and cheap operations	A. 02 B. 22 C. 03 D. 10 E. 02 F. 00 G. 01 H. 02 I. 00 M 02	

Table 4: Frequency Distribution of Studies by Literature Streams

Research Streams	Number of Studies	Percentage of Studies
Aviation Safety and Security	46	14.79
Aviation Emissions	58	18.65
Capacity Management, Crew & Fleet Scheduling, Crew & Fleet Assignment	44	14.15
Fuel Consumption & Pricing, Alternative Fuels	28	09.00
Cost based Modeling, Competition among Airlines	91	29.26
Congestion & delays at Airports	44	14.15

Table 5: Frequency Distribution of Studies based upon the methodology adopted

Types of Methodology	Number of Studies	Percentage of Studies
Conceptual	216	69.45
Empirical	95	30.55
Total	311	100

Table 6: Distribution of Research Methodologies by Research Streams

Research Streams	Conceptual		Empirical	
	No.	% age	No.	% age
Aviation Safety and Security	33	15.28	13	13.68
Aviation Emissions	41	18.98	17	17.89
Capacity Management, Crew & Fleet Scheduling, Crew & Fleet Assignment	26	12.04	18	18.95
Fuel Consumption & Pricing, Alternative Fuels	13	06.02	15	15.79
Cost based Modeling, Competition among Airlines	74	34.26	17	17.89
Congestion & delays at Airports	29	13.43	15	15.79

Table 7: Distribution of Statistical and Non-Statistical Methods in Empirical Studies

Methods	Number of Studies	Percentage of Studies
Statistical	31	32.63
Non-Statistical	64	67.37
Total	95	100

*** **NOTE**

Readers can contact the Authors for the complete list of the References

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