Journal of Air Transportation World Wide

Volume 4, Number 2 – 1999

Editorial Board

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The Editors

Brent D. Bowen

Dr. Brent Bowen is Director and Professor, Aviation Institute, Department of Public Administration, University of Nebraska at Omaha. Bowen attained his doctorate in Higher Education and Aviation from Oklahoma State University and a Master of Business Administration degree from Oklahoma City University. His Federal Aviation Administration certifications include Airline Transport Pilot, Certified Flight Instructor (Gold Seal), Advanced Instrument Ground Instructor, Aviation Safety Counselor, and Aerospace Education Counselor. Dr. Bowen's research on the development of the national Airline Quality Rating is regularly featured in numerous national and international media, as well as refereed academic publications. Dr. Bowen has in excess of 200 publications, papers, and program appearances to his credit. His research interests focus on aviation applications of public productivity enhancement and marketing in the areas of service quality evaluation, forecasting, and student recruitment/retention in collegiate aviation programs. He is also well published in areas related to effective teaching and has pioneered new pedagogical techniques. Dr. Bowen has been recognized with awards of achievement and commendation from the American Marketing Association, American Institute of Aeronautics and Astronautics, Federal Aviation Administration, Embry-Riddle Aeronautical University, W. Frank Barton School of Business, Travel and Transportation Research Association, World Aerospace Education Association, and others.

Igor Kabashkin

Dr. Igor Kabashkin is Vice Rector of Riga Aviation University, Latvia and a Professor in the Aviation Maintenance Department. Kabashkin received his Doctor Degree in Aviation from Moscow Civil Engineering Institute, a High Doctor Degree in Aviation from Moscow Aviation Institute, a Doctor Habilitus Degree in Engineering from Riga Aviation University and Latvian Academy of Science. His research interests include analysis and modeling of complex technical systems, information technology applications, reliability of technical systems, radio and telecommunication systems, and information and quality control systems. Dr. Kabashkin has published over 217 scientific papers, 19 scientific and teaching books, and holds 67 patents and certificates of invention.

Frederick Hansen

Frederick Hansen is a doctoral student in Public Administration at the University of Nebraska at Omaha. He received his Master of Public Administration degree from the University of Nebraska at Omaha and a Bachelor of Science degree in Aerospace Engineering from Iowa State University. He retired from the United States Navy after twenty-four years as a Naval aviator. Fred's interests include aviation safety, airport security, intermodal transportation planning, and research methodologies.

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The *Journal of Air Transportation World Wide's (JATWW)* mission is to provide the global community immediate key resource information in all areas of air transportation. The goal of the Journal is to be recognized as the preeminent scholarly journal in the aeronautical aspects of transportation. As an international and interdisciplinary journal, the *JATWW* will provide a forum for peer-reviewed articles in all areas of aviation and space transportation research, policy, theory, case study, practice, and issues. While maintaining a broad scope, a focal point of the journal will be in the area of aviation administration and policy.

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The *JATWW* was conceptualized to fulfill an international void of scholarly publications in this area as identified by the primary organizers. It is envisioned that aviation leaders will utilize the *JATWW* as a key decision-making tool. Scholarly rigor and standard will be uncompromised with regular evaluation by the Editorial Board and Panel of Reviewers.

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Reviewers are appointed by the Editor to represent all elements of aviation and space transportation scholarship and practice. An appointment to the Panel of Reviewers recognizes professional and academic achievement. For membership consideration, submit a curriculum vita or statement of interest to Dr. Brent Bowen, Editor.

Panel of Reviewers

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Journal of Air Transportation World Wide Vol. 4, No. 2 - 1999

DETERMINING USABILITY VERSUS COST AND YIELDS OF A REGIONAL TRANSPORT

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21P

Slobodan Gvozdenovic
University of Belgrade

NOMENCLATURE

α,β , g and d - represent statistical coefficients for one particular aircraft type determined by using Performance Manual

a, b, c and d - coefficients depend upon the type of cruise (HSC or LSC) and flight altitude

DOC - direct operating costs

DOC_{AT} - direct operating cost per aircraft trip

e, f, e_1 and f_1 - coefficients which are determined for each aircraft type and configuration, reserve fuel and flight regime

F_p - fuel price

g, h and i - coefficients known for each aircraft type and supposed economic assumption

t_g - ground time

HSC- High Speed Cruise

I_{AT} - income per flight

IOC - indirect operating cost

IOC_{AT} - indirect operating cost per aircraft trip

l_p - cabin load factor

j, k, m and n - coefficients known for each particular aircraft type and for established network serviced by this aircraft type

k_p- trip fuel correction factor

k_t - trip time correction factor

l_F - freight load factor

LRC - Long Range Cruise

P_{AT} - number of passengers per flight

PF - passengers fare

PR - profitability ratio

R - trip distance

R_A - maximum range to which maximum payload can be transported

$R_{av.}$ - average trip distance

RB - maximum range which can be attained by full fuel tanks

RC - maximum range which can be attained by operating aircraft with full fuel tanks but with zero payload

R_l - left limit of the usability range

R_r - right limit of the usability range

S_a - number of available seats

t_b - block time

TC_{AT} - total costs per each flight

t_f - trip time or flight time

t_g - time for taxing

t_{to} - flight time required when carrying full payload

UR - usability range

W_E - Operating Empty Weight

W_{Fb} - block fuel

W_{Ff0} - required trip fuel for max. payload

W_{Fg} - fuel used for taxing

W_{Ft} - trip fuel

W_g - mass of the aircraft with zero payload

W_p - actual payload

W_{p0} - maximum payload

W_{pF} - maximum mass that could be transported in freight compartments after passengers have been loaded

INTRODUCTION

Regional transports are designed to operate on air networks having the basic characteristics of short trip distances and low density passengers/cargo, i.e. small numbers of passengers per flight. Regional transports passenger capacity is from 10 to 100 seats and operate on routes from 350 to 1000 nautical miles (nm).

An air network operated by regional transports has the following characteristics (Kanafani & Ghobrail, 1982; MIT, 1973):

- connecting regional centers;
- operating on low density passengers/cargo flow services with minimum two frequencies per day;
- operating on high density passengers/cargo flow with more than two frequencies per day; and
- operating supplemental services whenever market demands in order to help bigger capacity aircraft already operating the same routes (Kanafani & Ghobrial, 1982; MIT, 1973).

Airlines owning regional transports have to find out what are the trip distances (R) and what are cabin load factors (I_p) that make particular aircraft operation efficient. Efficient operation of an airliner, in this paper, is defined by results that achieve a maximum yield/cost ratio.

Passengers, being the sole air transportation consumers, need to be transported to their destinations with low cost and with convenient time tables without any delays.

In order to meet passenger requirements providing low fares and high or required number of frequencies, airlines must constantly monitor operational costs and keep them low. It is obvious that costs of operating aircraft must be lower than yield obtained by transporting passengers and cargo. The requirement to achieve favorable yield/cost ratio must provide the answer to the question of which aircraft will best meet a specific air network (Simspon, 1972). An air network is defined by the number of services, the trip distance of each service, and the number of flights (frequencies) per day and week.

DETERMINATION OF OPERATING COSTS PER FLIGHT

Operating a commercial flight on a trip distance (R) an airline would experience block time (t_b) and block fuel (W_{Fb}). Block time is a sum of the time required for taxing (tg) and trip time or flight time (t_f)

$$t_b = t_g + t_f \tag{1}$$

whereas block fuel (W_{Fb}) is a sum of fuel used for taxing (W_{Fg})(kg) and trip fuel (W_{Fl})(kg),

$$W_{Fb} = W_{Fg} + W_{Ff} \tag{2}$$

Both flight time and trip fuel represent time and fuel required for take-off, climb, cruise, descent and landing. For one particular aircraft type both flight time and trip fuel are directly proportional to the trip distance (R) and may be expressed in equation form,

$$t_f = a + b \cdot R \tag{3}$$

$$W_{Ff} = c + d \cdot R \tag{4}$$

where coefficients a (Fh), b (Fh/NM), c (kg) and d (kg/NM) depend upon the type of cruise (HSC or LRC) and flight altitude (H). Table 1, among other data, gives coefficients a, b, c and d for ISA conditions and High Speed Cruise for 15 aircraft types.

Commercial flights, in air transportation, are considered such flights in which payload (passengers and cargo) is transported to a distance-R. The PAYLOAD-RANGE diagram shown on Figure 1 is defined for each aircraft type.

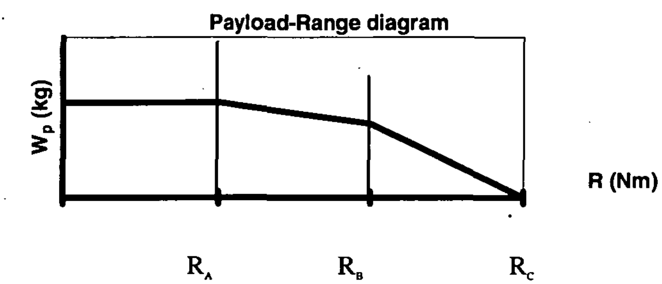

Figure 1. Payload-range diagram

One can easily note three characteristic ranges.

- Range R_A is the maximum range to which maximum payload can be transported;
- Range R_B is the maximum range which can be attained by full fuel tanks;
- Range R_C is the maximum range which can be attained by operating aircraft with full fuel tanks but without any payload.

Functional relation of the mass of payload (W_P) versus range (R) can be expressed in analytical forms as given below

$$W_p = W_{po} \quad \text{for} \quad 0 < R \le R_A \tag{5a}$$

$$W_p = e - f \cdot R \quad \text{for} \quad R_A < R \le R_B \tag{5b}$$

$$W_p = e_1 - f_1 \cdot R \qquad \text{for} \qquad R_B < R \leq R_C \tag{5c}$$

where R (NM) represents range, W_{po} (kg) represents maximum payload, e (kg), f (kg/NM), e_1 (kg) i f_1 (kg/Nm) are coefficients which can be determined for each aircraft type and configuration, reserve fuel and flight regime. In Table 1, coefficients e, f, e_1 and f_1 are determined for the concerned aircraft on the basic of data given by manufacturers. See Table 3 for a list of the specific manuals researched.

In transporting the mass of payload W_p to the given or required distance R, the aircraft consumes fuel and flight time which both influence transportion costs. Airlines consider such cost as operational costs. The aim of each airline is to control and administer their traffic on the given air network and so try to accomplish minimum total costs per each flight (TC_{AT}). Total cost per aircraft trip in air transport industry is usually split into:

- direct operating cost per aircraft trip - DOC_{AT} and
- indirect operating cost per aircraft trip - IOC_{AT}

Direct operating costs *DOC* that depend on the trip include:

- flight crew,
- fuel,
- maintenance,
- hull insurance,
- depreciation, and
- finance. (Boeing Airplane Economic Group, 1994)

Indirect operating cost-*IOC* are, by rule, independent on the trip distance or flight time and can be split into:

- airline related,
- passenger related, and
- cargo related. (Boeing Airplane Economic Group, 1994)

Indirect operating cost are estimated on the basis of aircraft capacity (seats and cargo), average trip distance for the network flown, type of traffic (domestic, international), expected passenger cabin and cargo compartments load factors, ticket sales commission, etc. (Boeing Airplane Economic Group, 1994).

Total cost per flight (TC_{AT}) are obtained by adding direct operating costs (DOC_{AT}) and indirect operating cost IOC_{AT}

$$TC_{AT} = DOC_{AT} + IOC_{AT} \tag{6}$$

Direct operating cost per flight DOC_{AT} is linear function of the trip distance [3] and may be defined as:

$$DOC_{AT} = c_1 + c_2 \cdot R \tag{7}$$

where DOC_{AT} is given in U.S. dollars, c_1 in U.S. dollars (USD) and c_2 in U.S. dollars per nautical mile(USD/NM) and both c_1 and c_2 are known coefficients for one particular aircraft type and market environment data. Indirect operating costs - IOC_{AT} are determined for each aircraft type on the basis of average passenger cabin load factor - l_p, average trip distance R_{av}. as explained in by Simpson (1972) or they could be estimated as a percent of direct operating cost per aircraft trip DOC_{AT} (AEA, 1990).

To determine direct operating costs for a particular aircraft type it is necessary to define required block time - t_b and block fuel - W_{Fb} for the anticipated trip distance - R, whereas for the estimation of indirect operating costs it is necessary to judge or to know passengers and average weight of cargo per flight as well as average trip distance on the network. Equations 1 through 4 for determination of the block time and block fuel are written for the case when transporting maximum payload. However, since the number of passengers and cargo weight are both, as a rule, less than maximum payload, it is necessary to perform a correction of the required flight time and fuel when the actual payload W_p is less than the maximum W_{p0} i.e. $W_p < W_{p0}$. It is known that a lighter aircraft consumes less fuel and, when flying HSC techniques, the flight time is less for the same trip distance. For corrections of required flight time t_f and trip fuel W_{FT} for selected trip distance by using reduced mass of payload W_p, the following correction parameters are introduced: k_t is the correction factor for flight time and k_p the correction factor for trip fuel. The correction factor of the flight time k_t, represents the ratio between time required - t_f when carrying a reduced mass of payload W_p and the time tt0 required when carrying a full payload W_{p0} for the same trip distance R or

$$k_t = \frac{t_f}{t_{f0}} \tag{8}$$

$$t_f = k_t \cdot t_{fo} \tag{8a}$$

The trip fuel coefficient correction kf is the ratio between required trip fuel - WFf to transport a reduced mass of payload - W_p and the required trip fuel W_{Ff0} to transport a full payload W_{p0} over the same trip distance.

$$k_F = \frac{W_{Ff}}{W_{Ff0}} \tag{9}$$

$$W_{Ff} = k_F \cdot W_{Ffo} \tag{9a}$$

Correction coefficients (k_t and k_f) are both nondimensional units. Values for (t_{t0} and W_{Ff0}) are determined by equations 3 and 4. Numerical values of the coefficients (k_t and k_f) for one particular aircraft type are determined by using statistical methods for determining trip fuel and time, and for the number of different masses of payload (from $lp = 0.1$ to $l_p = 1.0$) for selected trip distances based upon the Performance Manual and they have the following form.

$$k_t = \alpha \cdot (W_E + l_p \cdot S_a \cdot 91 + l_F \cdot W_{pF})^{\beta} \qquad (10)$$

$$k_F = \gamma \cdot (W_E + l_p \cdot S_a \cdot 91 + l_F \cdot W_{pF})^{\delta} \qquad (11)$$

where α, β, g and d represent statistically determined coefficients for one particular aircraft type using Performance Manual. W_E (kg) is Operating Empty Weight, l_p is passenger cabin load factor, S_a number of available seats, l_F freight load factor, W_{pF} (kg) is maximum mass that could be transported in freight compartments after passengers have been loaded. It is assumed that one passenger mass together with baggage is 91 kg. So this gives

$$W_{pF} = W_{p0} - S_a \cdot 91 \qquad (12)$$

Numerical values of coefficients α, β, g and d for ISA condition and HS cruise are given in Table 5 for 15 different aircraft types. Figures 2a and 2b are graphic representations of $t_f(R)$ and $W_{Ff}(R)$ for passenger cabin load factors $l_{p1} < l_{p2} < l_{p3}$.

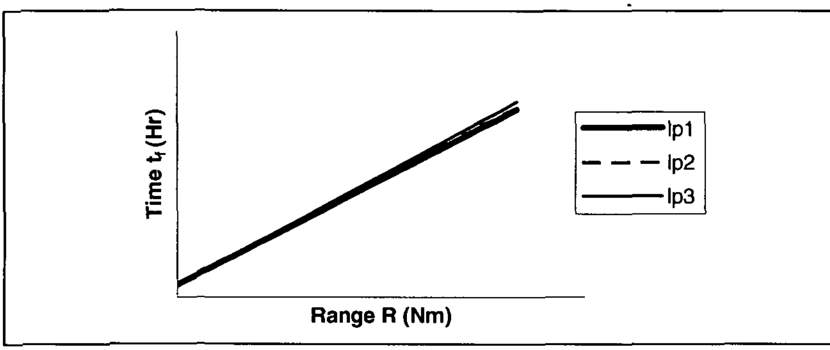

Figure 2a. Representation of trip time for different passenger load factors

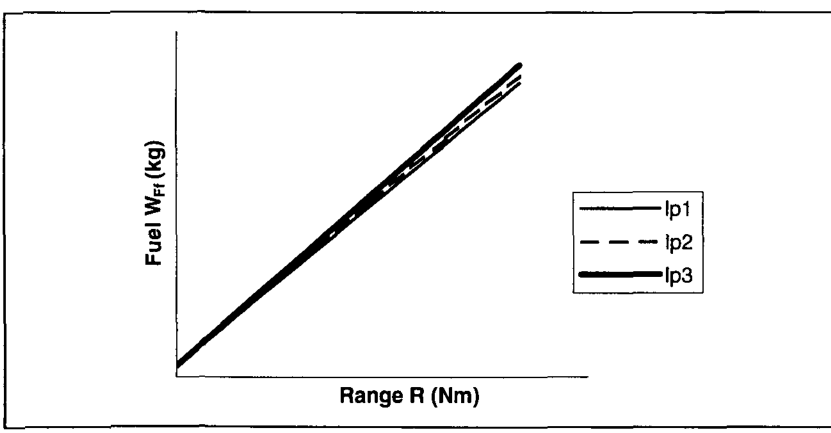

Figure 2b. Representation of trip fuel for different passenger load factors

Diagrams as shown on Figures 2a and 2b clearly indicate that both trip time and trip fuel determined by equations 8 and 9 are linear functions of trip distance and that the higher the mass of payload W_p and hence higher the mass of the aircraft W_g, more time and more fuel is required to fly selected distance. Using equations (8) and (9) an assembly of straight lines are obtained which are used to determine required trip time - t_f and trip fuel - W_{Ft} not only as function of trip distance R but also as functions of payload mass which are pondered by using correction coefficients k_T and k_F more exactly by coefficients of passenger cabin load factor - l_p and freight compartment load factor l_F.

Using methods to estimate the total costs per flight TC_{AT} adapted for both turbo jet and turboprop aircraft, as well as equations 8 through 11 to determine required trip time and fuel with newly introduced correction coefficients k_t and k_F for selected trip distance - R it is possible to determine total costs per flight TCAT versus trip distance-R versus mass of payload - W_p. So now we have the equation

$$TC_{AT} = \Phi\ (R,\ W_p) \tag{13}$$

Direct operating costs per flight DOCAT, are depending on trip time and fuel but also on trip distance R and payload mass W_p.

$$DOC_{AT} = \Phi_1\ (R,\ W_p) \tag{14}$$

This can be written in the form of following equation

$$DOC_{AT} = g + h \cdot t_g + i \cdot t_f + F_p \cdot W_{Fg} + F_p \cdot W_{Ff}) \tag{14a}$$

$$DOC_{AT} = g + h \cdot t_g + i \cdot k_t .\, t_{fo} + F_p \cdot W_{Fg} + F_p \cdot k_F \cdot W_{Ff0}) \tag{14b}$$

where DOC_{AT} (USD) represent direct operating cost per flight, g (USD), h (USD/Hr) and i (USD/Hr) are coefficients known for each aircraft type and economic assumption (Table 1), t_g (Hr) ground time, t_f flight time (Hr), F_p (USD/kg) fuel price, W_{Fg} (kg) ground fuel and W_{Ff} (kg) flight fuel.

Coefficients given in equations (14a) and (14b) depend on aircraft characteristics and economic assumptions under which the traffic is being executed and they are determined by modified methods (AEA, 1990; Simpson, 1972). The following conditions should be noted,

1. coefficient g depends on the number of aircraft of the same type in the fleet, value of spare parts (aircraft and engine), of the power plant parameters, aircraft operating empty mass, maintenance labor rate for aircraft structure and power plant and upon burden.

2. coefficient h depends on total investment per aircraft, annual utilization, depreciation period for aircraft and equipment (number of years and depreciation rate), interest rate and time to pay off the credit, insurance rate and aircraft take-off mass.

Table 1
Entry Economic Assumptions That Influence Traffic

Economic Assumptions	
Number of aircraft	5
Deprecation period (years)	10
Residual value (%)	15
Financial period (years)	5
Interest rate (%)	6,75
Insurance (%)	0,75
Labor rate (USD/Mh)	50
Burden (%)	200
Crew utilization (Bh/Month)	65
Fuel price (USD/kg)	0,215
Average distance (NM)	250

3. coefficient i depends from one side from total investment per aircraft, annual utilization, depreciation period (number of years and depreciation rate), interest rate and time to pay off the credit, insurance rate and aircraft take-off mass, and from the other side, from number of aircraft in the fleet, aircraft operating empty mass, power plant parameters, labor rate for maintenance of aircraft and power plant and finally burden.

Indirect operating cost per flight IOC_{AT} for established network having average trip distance R_{av}. depends on the payload mass W_p, and for an aircraft type could be written as:

$$IOC_{AT} = \Phi_2 (W_p) \qquad (15)$$

$$IOC_{AT} = \Phi_2 (W_p) \qquad (15a)$$

where IOC_{AT} (USD) represent indirect operating cost per flight, and j (USD), k (USD), m (USD) and n (USD) are coefficients which are known for each particular aircraft type and for established network serviced by this aircraft type. These are presented in Table 2.

Coefficients in equation 15 are determined by using modified methods and the following conditions should be noted.

1. Coefficient j depends on aircraft empty mass and mass of maximum payload.

2. Coefficients k and m depend on number of passenger seats, and maximum mass of freight that can be loaded in freight compartments, average trip distance on the network flown by the same aircraft type, maximum take-off mass, sales commission for selling transport capacity (passenger seats and cargo).

3. Coefficient n represents cost for tanking fuel at departure airport.

To estimate total cost per flight TC_{AT} by equations 13, 14, and 15 one must define entry economic assumptions which influence traffic, as shown in Table 1. This information is required in addition to knowledge of specific aircraft as presented in Table 3.

Table 6 contains coefficients (g, h, i, j, k, m and n) required for estimation of total cost per flight for fifteen regional transports. Since both trip time t_f and trip fuel W_{Ff} are linear function of the trip distance R as shown by equations 8 and 9 and by figures 2a and 2b, it means that total cost per flight is also linear function of trip distance R but depends upon payload mass - W_p as shown in the equation below,

$$TC_{AT} = \Phi_1 (R, W_p) + \Phi_2 (W_p) \tag{16}$$

Figure 3 shows total cost per flight TC_{AT} versus trip distance - R for different values of payload mass - W_p expressed by passenger cabin load factor coefficient - l_p where $l_{p1} < l_{p2} < l_{p3}$ as shown here.

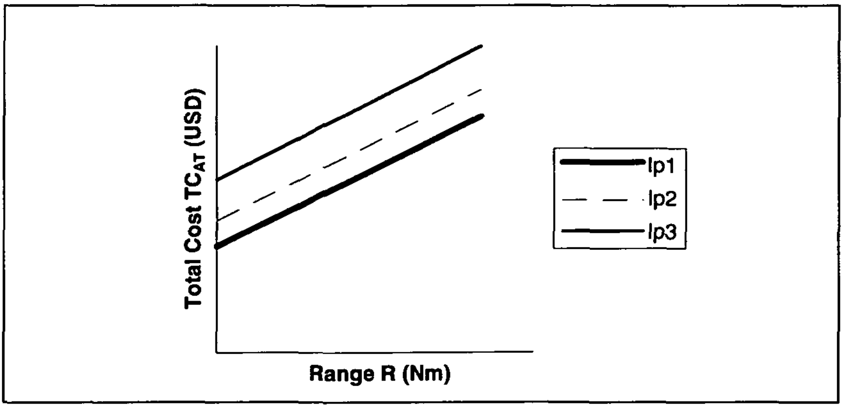

Figure 3. Total cost per flight for different passenger load factors

The difference between standard estimation of operating cost and method described above lies in introduction of correction coefficients k_t and k_F which both depend on payload mass - W_p. By doing so we have, instead of a single straight line representing total cost TC_{AT} versus trip distance R, an assembly of straight lines (figure 3) representing a nomogram for cost estimation. This renders possible more precise estimation of operating cost. So, for instance, a turboprop aircraft having a 50 passenger seat capacity ($S_a = 50$) over a trip distance ($R = 250$ *NM*), and if the coefficient of passenger load factor is $l_p = 0.7$ or $PA_{AT} = 35$, then the planned total cost per flight can be estimated to be USD 3423 which is for USD 321 or 9.38 percent less in comparison with an estimation using the standard method (based upon transportation of full payload all the time).

For efficient planing, it is necessary to know, besides total cost per flight TC_{AT}, value of unit cost- t.c. Unit cost is defined as total cost per flight TC_{AT} divided by unit of transportation work (payload range) or

$$t.c. = \frac{TC_{AT}}{W_p \cdot R} \tag{17}$$

or

$$t.c. = \frac{g + h \cdot t_g + i \cdot t_f + F_p \cdot W_{Fg} + F_p \cdot W_{Ff} + j + k + m + n}{W_p \cdot R} \tag{17a}$$

$$t.c. = \frac{g + h \cdot t_g + i \cdot k_t \cdot t_{f0} + F_p \cdot W_{Fg} + F_p \cdot k_F \cdot W_{Ff} + j + k + m + n}{W_p \cdot R} \tag{17b}$$

where $t.c.$ (USD/kg/NM) represent operational cost per seat equivalent freight per NM; TC_{AT} (USD)- total cost per flight determined by use of equations 14 and 15; $W_p = l_p \cdot S_a \cdot 91 + l_F \cdot W_{pF}$ is the mass of the payload (kg) determined by Figure 6 and/or by equation 5. R (NM) is the trip distance. Dependence of change in unit cost - t_c versus trip distance R is shown in Figure 4.

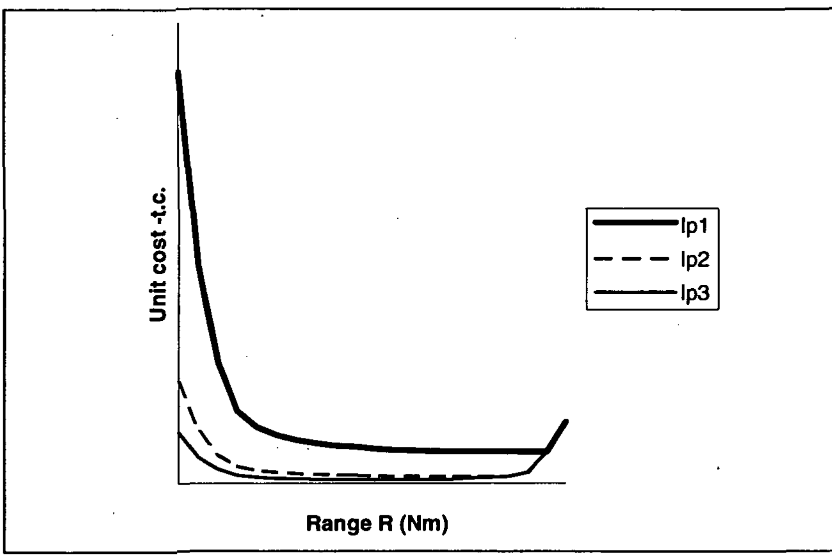

Figure 4. Dependence of change in unit cost for different passenger load factors

Unit cost $t.c.$ (same as total cost per flight TC_{AT}) depends not only on the trip distance R but also on the mass of payload W_p so, as a consequence, instead of one single line we have assembly of lines each for one particular value of payload mass. Knowing unit costs values it is possible to compare two or more different aircraft types to be used on established air network. By using this advantage it is possible to define tariff policy, etc.

DETERMINATION OF REGIONAL TRANSPORT USABILITY INTERVAL

For airlines it is important to know what are total cost per flight but besides this they should be able to predict what are trip distances R that their airlines can economically operate if passengers and cargo flows are known (expressed by coefficients l_p and l_F). Rational operation then can be defined as range interval ΔR in which airplanes can economically operate by transporting known or anticipated passengers and cargo flows. Such interval can be defined as useful range (UR).

$$UR = (R_l, R_r) \tag{18}$$

Left side limits represent minimum range and right side limits represent maximum range. Intervals within such limits are usually defined as the useful range in which it is possible to operate economically.

Criteria used to determine useful range interval - UR in this paper are the minimum operational costs or the maximum profit-ratio of income per flight- I_{AT} over costs per flight- TC_{AT}.

In the second criteria above, total costs per flight (TC_{AT}) have been defined by using equations 14, 15 and 16. The results are shown in figure 3. Since total costs per flight are represented as an assembly of straight lines versus trip distance ® it means that it is not possible to determine trip distance for the minimum cost except when the trip distance equal to zero. This solution is of course not usable.

Unit operational costs determined by equation 17 and shown in Figure 4 for a unit mass of payload W_p are decreased by increasing range until the point R_A (range to which maximum mass of payload can be transported). At the range R_A unit costs have the minimum value and after further increases in range, the unit costs start to raise again. This is logical due to the reduced mass of payload being transported as shown by equation 5 and presented in Figure 1. This means that a criteria of minimum unit costs can not be used to determine useful range, because interval is reduced to one single point R_A. It is known from practical operation that transport category aircraft and especially regional transports operate on ranges considerably less than R_A, or:

$$\min(t.c) \rightarrow R = R_A \tag{19}$$

The aim of operating an airline is to create income from transported passengers and/or cargo. Income per flight is obtained by the number of passengers carried (P_{AT}) and airfares applied (PF).

The number of passengers per flight P_{AT} is represented by the equation

$$P_{AT} = l_p \cdot S_a \tag{20}$$

Passengers fares (PF) basically depends upon the trip distance- R (NM) and could be represented as

$$PF = o \cdot R^{p} \tag{21}$$

where *PF* (USD) represents the passenger fare on the trip distance *R* (NM) and *o* (USD) and *p* are statistically determined coefficients which depend upon the type of operation (domestic or international), and the quality of transportation (first class, tourist class, reduced fares). In this paper coefficients have been determined using AIR INTER GROUP AIR FRANCE fares in 1996 for Y class so that their values are $o = 2.492$ (USD), $p = 0.752$ and correlation coefficient $r = 0.706$. Knowing all this, the income per aircraft trip I_{AT} can be expressed as the following equations.

$$I_{AT} = P_{AT} \cdot PF \tag{22}$$

$$I_{AT} = l_p \cdot S_a \cdot o \cdot R^{p} \tag{22a}$$

where I_{AT} (USD) represent income per aircraft trip, I_p (percent) passenger cabin load factor, S_a number of passenger seats in the aircraft, *R* (NM) trip distance, *o* (USD) and p statistical coefficients depending upon airline fare policy and type of fare. Therefore income per aircraft trip depends upon number of passengers P_{AT} or mass of payload carried $W_p = I_p \cdot S_a \cdot 91$. The number 91 represents the mass of a single passenger with baggage and *R* trip distance. So it can be written as follows,

$$I_{AT} = \Phi_3\,(W_p \cdot R) \tag{23}$$

Each airline works hard to have more income than operating costs, or at least to equalize both $(TC_{AT}\ \ I_{AT})$. To estimate whether the operation is economical, the ratio between income per aircraft trip I_{AT} and total operating cost per aircraft trip TC_{AT} may be used. This ratio is named the profitability ratio (*PR*) and can be determined by equations 13, 15 and 16.

$$PR = \frac{I_{AT}}{TC_{AT}} = \frac{\Phi_3(W_p,R)}{\Phi_1(W_p,\ R)+\Phi_2(W_p)} = \Phi_4(W_p,R) \tag{24}$$

or

$$PR = \frac{l_p \cdot S_a \cdot o \cdot R^{p}}{g+h \cdot t_g + i \cdot t_f + F_p \cdot W_{Fg} + F_p \cdot W_{Ff} + j+k+m+n} \tag{25}$$

$$PR = \frac{l_p \cdot S_a \cdot o \cdot R^{p}}{g+h \cdot t_g + i \cdot k_t \cdot t_{fo} + F_p \cdot W_{Fg} + F_p \cdot k_{Ff}\ W_{Ff0} + j+k+m+n} \tag{25a}$$

Diagram of profitability ratio *PR* versus trip distance *R* and number of passengers per flight P_{AT} or passenger cabin load factor is shown in Figure 5.

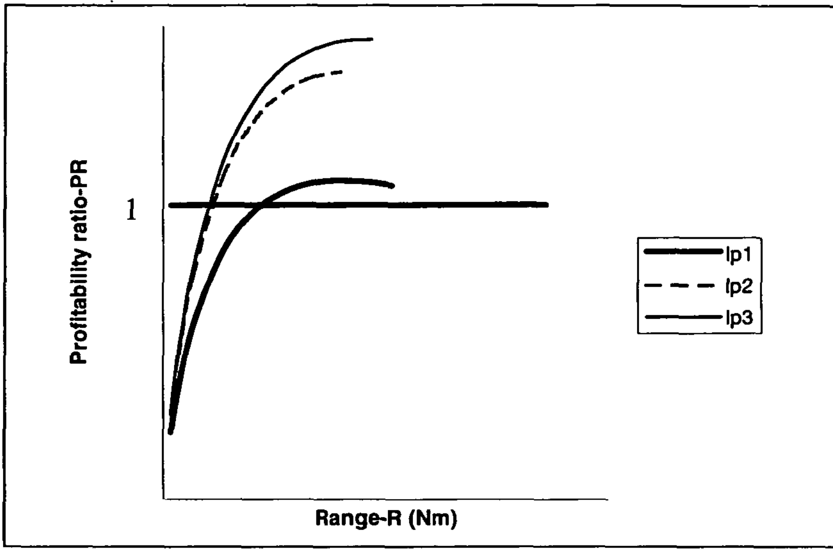

Figure 5. Profitability ration versus trip distance for different passenger load factors

Both Figure 5 and equation 25 show that increasing trip distance R and/or the mass of the payload (number of passengers) per flight increases the profitability ratio.

If we accept criteria $PR > 1$ it is then possible to determine the interval of useful range UR (i.e. left R_l and right R_r) and limits of the range. Left and right limits of the useful range are determined as follows. The interval of useful range is determined for a value of payload mass $W_p = const.$ or $l_p = const.$ and for the predetermined economic assumptions as listed in Table 1. The left limit of the useful range interval R_l is determined from equation 25 by setting the profitability ratio equal to one.

$$PR = 1.0 \rightarrow R_l(Nm) \tag{26}$$

The right limit of the useful range interval R_r is determined from the condition that constant mass of payload $W_p = const.$ is transported to such a distance to achieve max. PR. For one particular value of the mass of payload W_p, the maximum value of PR is determined from equation 25. The maximum possible distance to which payload W_p can be transported is R, as defined by equations 5b and 5c i.e.

$$\max.PR \rightarrow R_r = \frac{e - l_p \cdot S_a \cdot 91}{f} \tag{27a}$$

or

$$\max.PR \rightarrow R_r = \frac{e_l - l_p \cdot S_a \cdot 91}{f_l} \tag{27b}$$

where e (kg), f (kg/NM), e_l (kg) and f_l (kg/NM) are coefficients determined for each aircraft type based upon payload range diagram (Figure 1) as shown in Table 3. Using equations 26 and 27, the useful range UR or interval of rational range from the economical point of view can be determined by:

$$UR = \Delta R = R_r - R_l \qquad (28)$$

The interval of useful ranges (UR) for passenger cabin load factors of $l_p = 0.5$ and $l_p = 0.7$ and high speed flight conditions is given for 15 regional transports in Table 2 by using equations 26, 27 and 28.

Table 2
Intervals of Useful Ranges for Aircraft at Two Values of Cabin Load Factors

	Sa	lp=0,5			lp=0,7		
		Rl (NM)	Rr (NM)	UR (NM)	Rl (NM)	Rr (NM)	UR (NM)
Do 228	19	236	1090	854	128	867	739
1900D	19	327	1227	900	154	980	826
SD 330	30	250	626	376	122	616	494
Do 328	30	193	1552	1359	115	1327	1212
SF 340	34	188	1370	1182	110	1346	1236
ATR 42	46	141	2456	2315	88	2430	2342
F 50	50	134	1508	1374	85	1465	1380
Saab 2000	50	159	1240	1081	100	1221	1121
ATR 72	66	109	2282	2173	72	2243	2171
Dash8-400A	70	119	1331	1212	79	1318	1239
CRJ	50	166	1303	1137	104	1256	1152
CRJ-700	70	164	2569	2404	104	2391	2287
F 70	79	132	1748	1616	87	1656	1569
F 100	105	102	1672	1570	70	1550	1480
A 319	124	133	3231	3098	88	2720	2632

Results given in Table 2 may be used as a base to determine the trip distances to be operated by different aircraft. Figures given take into consideration aircraft capacities and performances and are presented for two values of cabin load factors. By increasing the mass of payload W_p or passenger cabin load factor l_p, the left limit of the usability range moves towards shorter ranges which means that the aircraft could be used economically on shorter trip distances.

For airlines, it is significant to define the minimum trip distance operation which is economically justifiable. This minimum trip distance is the left limit of the trip distance interval (R) obtained from the condition when $PR=1.0$. As already stated, limits of the interval are not fixed values but they do depend on the mass of the payload for the defined economic assumptions (Table 1).

Left limits of the usability range versus passenger cabin load factor l_p is shown on Figure 6 for two aircraft of the same capacity (70 passengers seats). One airplane is the propjet Dash 8-400A while the other is the turbojet CRJ-700.

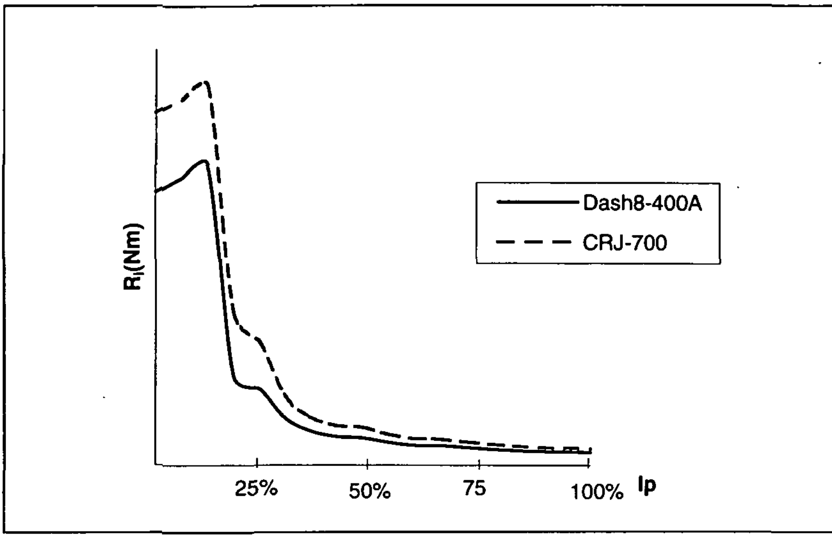

Figure 6. Left limits of usability range for Dash 8-400A and the CRJ-700

Results shown in Figure 6 confirm the known supposition that, for the same capacity, turboprop aircraft are more economical on short trip distances than pure turbo jet aircraft. Both in table T3a and T3b give left limit of the usability range R_l versus number of passengers per flight P_{AT} (or mass of payload W_p) for 15 aircraft types considered in this paper. They were examined for High Speed flight and condition that $PR=1$

The following conclusions can be drawn from Table 3:

1. for one type and capacity of aircraft, an increase in the number of passengers per flight P_{AT} reduces the range of economically operated $(PR>1.0)$ trip distances.

2. for a predetermined number of passengers per flight (data typical for a network serviced by the operator) $P_{AT} = const.$ it can be shown that the more seats that exist in the aircraft, the longer the trip distance is required to operate economically with $PR=1.0$. So for an aircraft with 30 passenger seats (Do328), the minimum range for economical operation is $R_l=75$ *NM* whereas for an aircraft with 50 passenger seats (Saab 2000) $R_l=122$ *NM* and for an aircraft with 70 passenger seats $R_l=149$ *NM.*

3. turbojet powered aircraft, by the rule for the same economical assumption for $PR>1.0$, require longer ranges to operate economically as compared with turbo prop powered aircraft.

Table 3
Left Limits of Usability Range for Aircraft by Number of Passengers

P_{AT}	*Do228*	*1900D*	*SD 330*	*Do 328*	*SF 340*	*ATR 42*	*F 50*	*Saab 2000*	*ATR 72*	*Dash8-400A*	*CRJ*	*CRJ-700*	*F 70*	*F 100*	*A 319*
5	1065,1	1004,9	729,2	1236,5	1021,8	962,3	1130,6	1240,3	989,6	1181,7	1145,4	1524,1	1348,5	1325,4	1451,5
10	209,4	281,2	796,3	581,5	1099,6	1030,3	1199,6	1311,8	1048,2	1243	1206,4	1583,8	1404,3	1375,5	1493,8
15	107,2	126,7	250,5	193,6	245,1	375,4	494,3	530,3	1107,3	1303,2	1267	1642,6	1460,8	1426,6	1532,1
19	80	91,7	145	132,4	154	200,1	246,3	264,8	305,7	386,5	345,8	659,6	719,6	1466,9	1562,8
20			132	123	141,8	180,5	221	237,5	266,6	330,5	300,9	534,2	557,5	1027,3	1570,4
25			94	92,5	102,8	124,4	148,7	159,3	166,8	202,2	187,6	296,9	291,4	363,5	1609,6
30			74,7	75,4	82,3	96,7	114,1	121,8	124,6	148,8	139,3	210,3	202,4	239,1	597,7
34					71,7	83	97,1	103,5	104,5	123,5	116,4	171,1	164,9	190,3	398,5
35						80,2	93,7	99,8	100,6	118,8	111,9	163,9	157,5	181,7	369,4
40						69,4	80,3	85,3	85,3	100	94,5	135,6	129,9	147,2	273,3
45						61,6	70,8	75	74,6	86,8	82,4	116	111	124,9	217,3
46						60,3	69,3	73,3	72,9	84,7	80,5	112,9	108,1	121	209,4
50							63,8	67,4	66,9	77,3	73,6	102	97,6	108,7	182,4
55									60,9	69,9		91,3	87,4	96,6	157,6
60									56,2	64,2		83	79,5	87,5	138,8
65									52,3	59,6		76,4	73,1	80,1	124,6
66									51,7	58,7		75,2	72	78,8	122,1
70										55,7		70,9	67,9	74	113,3
75													63,6	69,1	103,9
79													60,6	65,7	97,7
80														64,9	96,3
85														61,3	89,9
90														58,2	84,3
95														55,5	79,6
100														53,2	75,5
105														51	71,8
110															68,6
115															65,8
120															63,2
125															61,3

Note: Examined for high speed flight where the profitability ration = 1.0

CONCLUSION

The level of operational costs depends on economic assumptions but it also depends on trip time and trip fuel. In this paper trip time k_t and trip fuel k_F correction coefficients are introduced by estimating the influence of payload mass Wp and W_{Fl} on costs per flight TC_{AT}. So it is now possible to predict costs per flight more precisely and therefore predict them not only depending on the trip distance R, but also on the payload mass W_p through the use of coefficients I_p and I_l.

Introduction of usability range *UR* interval in which it is economical to fly if the condition $PR > 1.0$ is suggested. Usability range, therefore, for defined economic assumptions, depend only on the payload mass i.e. number of passengers per flight P_{AT}. Proposed methods to estimate usability interval and especially its left limit R_l (tables 2 and 3) may be used to anticipate aircraft capacity.

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Table 4
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Flight Planning and Operating Data Shorts 330", Crew Manual Sept. 1977
Dornier 328 Standard Specification, ref.AVS 001A, Feb.1990, Issue2
Saab 340 Performance Planning Guide, ref.SOO2.201 , August 1988
Performance Data for ATR 42 ref. A/DC/ET No. 732, May 1985 Issue 1
Fokker 50 Performance Information Based on:PDI-83-31, Issue3 , May 1985
Saab 2000 Performance Engineers Handbook Reg.No. 73ADS0394 Nov1995
Performance Data for ATR 72 ref. A/DC/ET No. 757 Nov.1985 Issue2
Dash 8Q Series 400 Program Overview ref. ASC072.A, March 1997
Performance Data CRJ Memo No: MAA-601R107F, Feb, 1993 Issue:F
Canadair Regional Jet Series 700, Program Overview ref. ASC074.AA May 1997
Fokker 100 Performance Information Based on:PDI-83-25, Issue2, Nov. 1983
Performance Manual A320 ref. P2210 Issue2 Nov. 1991

Table 5
Specification for Aircraft Studied

	Do 228 100/HS	*1900D 200/HS*	*SD 3-30 100/HS*	*Do 328 250/HS*	*SF 340 200/HS*	*ATR 42 200/HS*	*F 50 250/HS*
Price (MUSD)	3.900.000	5.950.000	8.050.000	10.100.000	11.850.000	13.200.000	14.250.000
W_o (kg)	6400	7688	10387	12500	12925	15750	20820
W_e (kg)	3739	4815	6805	8175	8034	9973	12474
S_a	19	19	30	30	34	46	50
W_{pF} (kg)	83	260	65	474	663	341	1120
W_{po} (kg)	1812	1989	2795	3204	3757	4527	5670
t_g/W_{Fg} (Hr/kg)	0,167/15	0,167/41	0,167/41	0,167/56	0,167/44	0,167/57	0,167/74
R_A (NM)	480	350	87	420	420	400	830
R_B (NM)	1260	1225	610	1340	1340	2480	1415
a (Hr)	0,048	0,0033	0,074	0,084	0,084	0,085	0,134
b (Hr/NM)	0,00427	0,0038	0,00546	0,00360	0,00360	0,00378	0,00347
c (kg)	24.711	55.330	4.780	38.526	38.526	45.443	109.124
d (kg/NM)	1.375	1.333	2.223	1.643	1.643	1.897	1.865
e (kg)	2.557.846	2421,8	2888,155	4415,304	4415,304	5147,577	7684,701
f (kg/NM)	-1.554	-1.236	-1.071	-1.567	-1.567	-1.551	-2.427
e1 (kg)	19500,000	28683,875	36318,750	36782,778	36782,778	81900,000	34318,750
f1 (kg/Nm)	-15.000	-22.675	-55.875	-25.722	-25.722	-32.500	-21.250
α	-	0,439	0,409	0,195	0,195	0,352	0,363
β	-	0,1030	0,0980	0,1743	0,17430	0,109	0,103
χ	0,75710	0,27100	0,33372	0,20660	0,20660	0,25246	0,08945
δ	0,032	0,142	0,120	0,168	0,168	0,143	0,246

Table 5 – continued
Specification for Aircraft Studied

	Saab 2000 250/HS	*ATR 72 200/HS*	*Dash 8Q-400A 250/HS*	*Canadair RJ-100 310/HS*	*CRJ-Series 700 310/HS*	*F 70 310/HS*	*F 100 310/HS*	*A319 310/HS*
Price (MUSD)	16.300.000	16.900.000	19.500.000	20.900.000	25.050.000	23.800.000	27.200.000	43.650.000
W_o (kg)	22800	21500	27329	21523	32885	39915	44450	64000
W_e (kg)	13800	12200	16537	13653	19595	22673	26119	40100
S_a	50	66	70	50	70	79	105	124
W_{pF} (kg)	1350	1494	1474	939	2157	2113	1066	5616
W_{po} (kg)	5900	7500	7844	5489	8527	9302	10621	16900
t_g/W_{Fg} (Hr/kg)	0,167/124	0,167/95	0,167/137	0,167/141	0,167/141	0,167/251	0,167/251	0,167/131
R_A (NM)	770	560	523	510	960	1206	900	685
R_B (NM)	1190	2240	1307	1230	2483	1450	1450	3400
a (Hr)	0,096	0,082	0,108	0,107	0,26000	0,080	0,0810	0,193
b (Hr/NM)	0,00271	0,00364	0,00292	0,00213	0,00214	0,00230	0,00230	0,00218
c (kg)	52.070	55.757	127.333	104.440	136.200	391.700	346.460	581.160
d (kg/NM)	2.771	2.162	2.983	2.916	3.276	4.714	4.943	5.485
e (kg)	8283,333	8566,667	9392,320	6714,342	11255,720	14497,545	14497,545	19929,138
f (kg/NM)	-3.095	-1.905	-2.960	-2,451	-2.842	-4.307	-4.307	-4.422
e1 (kg)	59340,000	73100,000	132164,421	27652,631	33477,871	30915,500	30915,500	81574,184
f1 (kg/Nm)	-46.000	-30.714	-96.895	-19,474	-11.792	-15.630	-15.630	-22.553
α	0,470	0,388	0,463	0,427	0,421	0,675	0,675	0,852
β	0,0076	0,095	0,077	0,086	0,087	0,038	0,038	0,014
χ	0,16260	0,29911	0,16499	0,17409	0,17665	0,02995	0,02995	0,01357
δ	0,184	0,122	0,182	0,177	0,175	0,336	0,336	0,392

Table 6
Specifications for Aircraft Studied

	Do 228 100/HS	*1900D 200/HS*	*SD 3-30 100/HS*	*Do 328 250/HS*	*SF 340 200/HS*
g (USD)	69.239	79.793	79.927	93.417	89.984
h (USD/Fh)	57,504+549705/U	63,257+838652,5/U	73,970+1134647/U	81,447+1423595/U	82,876+1670257/U
i (USD/Fh)	247,432+549705/U	263,401+838652,5/U	295,986+1134647/U	332,261+1423595/U	331,555+1670257/U
j (USD)	100.737	120.770	165.468	193.909	200.489
k (USD)	395,919*l_p+8,775* l_F	395,922*l_p+27,489*l_F	625,140*l_p+6,872* l_F	625,140*l_p+50,114*l_F	708,492*l_p+70,097*l_F
m (USD)	453.016	482.201	561.235	599.586	616.119
n (USD)	1,946+0,067*R	4,720+0,065*R	2,243+0,109*R	5,949+0,071*R	4,044+0,080*R
	ATR 42 200/HS	*F 50 250/HS*	*Saab 2000 250/HS*	*ATR 72 200/HS*	*Dash 8Q-400A 250/HS*
g (USD)	99.951	101.666	173.140	110.211	141.237
h (USD/Fh)	91,848+1860540/U	106,192+2008537/U	111,329+2297485/U	107,982+2382055/U	122,329+2748525/U
i (USD/Fh)	367,509+1860540/U	411,142+2008537/U	484,039+2297485/U	419,673+2382055/U	453,295+2748525/U
j (USD)	243.796	302.049	326.927	326.903	401.750
k (USD)	958,548*l_p+36,053*l_F	1041,9*l_p+118,414*l_F	1041,9*l_p+142,731*l_F	1375,308*l_p+157,956*l_F	1458,660*l_p+155,841*l_F
m (USD)	683.022	763.651	789.549	802.392	878.753
n (USD)	5,020+0,093*R	8,973+0,091*R	11,756+0,118*R	7,387+0,106*R	12,952+0,146*R
	Canadair RJ-100 310/HS	*CRJ-Series 700 310/HS*	*F 70 310/HS*	*F 100 310/HS*	*A319 310/HS*
g (USD)	190.003	225.203	227.954	238.276	324.918
h (USD/Fh)	108,042+2945855/U	134,686+3530797/U	148,962+3354610/U	157,535+3833840/U	190,413+6152467/U
i (USD/Fh)	497,243+2945855/U	673,662+3530797/U	658,921+3354610/U	677,393+3833840/U	831,047+6152467/U
j (USD)	318.010	461.560	523.160	599.336	923.212
k (USD)	1041,9*l_p+99,278*l_F	1458,660*l_p+228,053*l_F	1646,202*l_p+223,401*l_F	2187,990*l_p+112,705*l_F	2583,912*l_p+593,763*l_F
m (USD)	771.928	941.302	1024,928	1102,628	1306,814
n (USD)	12,026+0,143*R	13,583+0,160*R	31,492+0,231*R	29,275+0,242*R	34,896+0,269*R

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OUTSOURCING AS AN AIRLINE STRATEGY

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Stephen M. Rutner
and
John H. Brown
Georgia Southern University

ABSTRACT

Since the deregulation of the airline industry, carriers have searched for any method to improve their competitive position. At the same time, there has been a growth in the use of Third Party Logistics throughout corporate America. This paper presents an overview of the Third Party Logistics system of outsourcing and insourcing within the airline industry. This discussion generated a number of propositions, possible future scenarios and opportunities for empirical testing.

INTRODUCTION

Today's competitive business environment has forced companies to identify methods to improve efficiency. A common solution is to outsource certain non-strategic business functions. The company thus removes distractions and focuses managerial attention on operations within the scope of its core competencies.

The airline industry is a prime example of the stiffened competition as a result of deregulation.[1] Many airlines have used outsourcing as a method to control costs, improve efficiencies, and hopefully increase profitability.[2] While airlines continue to outsource, it is unclear what are the appropriate levels of outsourcing, or which functions should be maintained by the airline.

This article briefly reviews the benefits and costs of the outsourcing decision. Furthermore, it examines some of the areas that various airlines commonly outsource. Also, it presents possible scenarios of future outsourcing. Finally, the article discusses the relationship between airline characteristics and outsourcing.

LITERATURE REVIEW

This section builds a foundation for the discussion by defining outsourcing and briefly discussing its benefits and weaknesses. It also identifies which of the various airline operations and services are outsourced and which are performed by the airline or insourced.

Outsourcing Terminology and Strategies

Most business professionals are familiar with the concept of outsourcing. Leenders and Nollett define outsourcing as "the decision to buy goods and services from external sources rather than producing them in-house when internal provision is not justified in light of existing or anticipated business conditions."[3] An airline industry definition of outsourcing mirrors the general definition by stating that outsourcing is "shedding non-core functions or spinning them off into semi-autonomous subsidiaries or profit centers."[4]

McDonald's provides an excellent example of outsourcing as a non-airline business practice. By employing Third Party Logistics (3PL) companies, McDonald's focuses on its core competencies in providing fast-food services. Third Party Logistics companies support McDonald's by performing the various non-core logistics functions.[5]

A common function outsourced by airlines is maintenance. By 1989, United States carriers outsourced 25 percent of their maintenance functions or approximately $218 million to third party firms.[6] Maintenance provides a good example since it is a non-core activity. Non-core activities are items that may provide critical functions to the running of the business, but are "not a unique ingredient of the product."[7] Maintenance is a necessity, but it should not be a unique product ingredient. Every airline must continuously maintain aircraft to provide safe operations, but maintenance is rarely seen as a unique part of the airline service.

By removing the non-core activities, the company should theoretically be able to focus on its five to six core competencies.[8] However, the implementation of this theory in actual business situations may be problematical. At least one recent study identified an increase in the use of outsourcing of activities that apparently included areas of competitive advantage or strategic significance.[9]

An overall goal of the outsourcing strategy is to form strong relationships between companies. Outsourcing can help to create strategic alliances between the two firms creating a stronger relationship base and increasing value throughout an entire supply chain.[10] The goal of this relationship is to create a source of competitive advantage for the company that outsources a service or part.[11]

Given these benefits, it would appear that outsourcing strategies ought to dominate the airline industry. While it is true there are many examples of outsourcing, there are examples of the opposite behavior as well. The practice of insourcing is gaining popularity in the airline industry. Insourcing is the process of providing non-core services or parts for other companies, often competitors, to increase revenue, minimize labor idle time and offset high domestic labor costs.[12] Insourcing permits airlines that practice it to achieve economies of scale; i.e. they are able to produce at a lower cost per unit. This allows both the insourcing firm and the buyers to benefit. An additional benefit of insourcing is the gains in goodwill with employees.[13]

There are a number of current examples in the airline industry of companies that are marketing their services to other carriers. Lufthansa,[14] American,[15] and

Delta[16] all insource various maintenance operations. American also provides 3PL services by maintaining a spare part inventory for its customers.[17]

Airline Operations and Services Typically Outsourced

While there is a broad range of functions that are outsourced, the literature identifies various operations and services that are very likely to be outsourced. Various authors have compiled large amounts of anecdotal evidence to create groupings of various operations and services subject to outsourcing. The following table categorizes functions by the likelihood of an airline choosing outsourcing.

Table 1
Functions Likely to be Outsourced by Airlines

Very Likely
Ticket Sales and Distribution[18]
Aircraft Leasing[19]
Airport Gates[20]
Complimentary Limousine Pick-Up[21]
Food Services[22]
Ticketing[23]
Baggage Handlers[24]
Aircraft Interior Cleaning[25]
Likely
Engine Overhaul or Rework[26]
Maintenance Training[27]
Information Systems and Technology[28]
Pilot Training[29]
Advertising[30]
Moderate
Counter personnel[31]
Airframe Maintenance[32]
Spare Parts Inventory[33]
Feeder Operations[34]
Gate Personnel[35]
C and D Level Maintenance Checks[36]
Unlikely
Cargo Handling and Operations[37]
Marketing[38]
Human Resources Management and Recruitment[39]
Very Unlikely
Pilots[40]
Strategic Management[41]
Flight Attendants[42]
Accounting[43]
Routine Hanger Maintenance[44]

An additional grouping of services are the items that are likely to be insourced by the airline. While this list is not as extensive as that of items outsourced, there are a number of areas that are consistently insourced by the companies.

The most common of these included highly intensive maintenance operations,[45] leasing of aircraft,[46] cargo operations,[47] and baggage handling.[48] The literature reviewed highlights the wide variety of operations and services that airlines are currently outsourcing. Furthermore, it shows that every major airline was outsourcing some areas. It does not categorize airlines as high or low users of outsourcing. Finally, it identified some exceptions to the general outsourcing trend by noting some functions that companies are insourcing.

DISCUSSION

Given the vast array of services and operations that are outsourced, a number of important questions arise. The obvious question is "What factors cause an airline to choose outsourcing?" There are numerous forces both internal and external to the airline influencing this decision.

One factor that was universal to the outsourcing decision was cost. Every company considering outsourcing identified the idea of cost reduction as significant in their decision-making. All carriers are looking for any method to reduce costs in order to respond to competitive pressures. However, the idea of cost reduction as the sole driving force of outsourcing is too broad and simplistic. There are a number of additional factors that impact the outsourcing decision.

The literature and observation leads the authors to identify six primary factors that drove the outsourcing decision. In no particular order, these are 1) the level of unionization of the carrier, 2) the current state of the economy, 3) the ownership composition of the company, 4) the availability of and types of financing for the carrier, 5) the age of the company, and 6) the complexity of the service considered for outsourcing. These six factors determine the likelihood of outsourcing a given task.

A goal of this work is to develop a working model that helps to clarify some of these factors, and their impacts upon the outsourcing decision. Figure 1 provides a visual depiction of these six factors and how they influence the outsourcing/insourcing decision.

The age of the airline provides a good example. The start-up airlines appeared much more likely to outsource functions that established carriers either keep in-house or insourced. This appears logical given the established carrier may have developed skills or expertise in a specific area. For example, American Airlines insources complex maintenance tasks.[49] A two or three year old airline may not be able to achieve sufficient volume of these complex maintenance tasks to achieve economies of scale. Cost control will also be an important benefit of outsourcing for start-up airlines since their usual strategies involve offering budget fares. A particular benefit of outsourcing from the point of view of individual firms is that it reduces the fixed costs of the firm relative to its variable costs, which reduces breakeven level of output for the start-up.

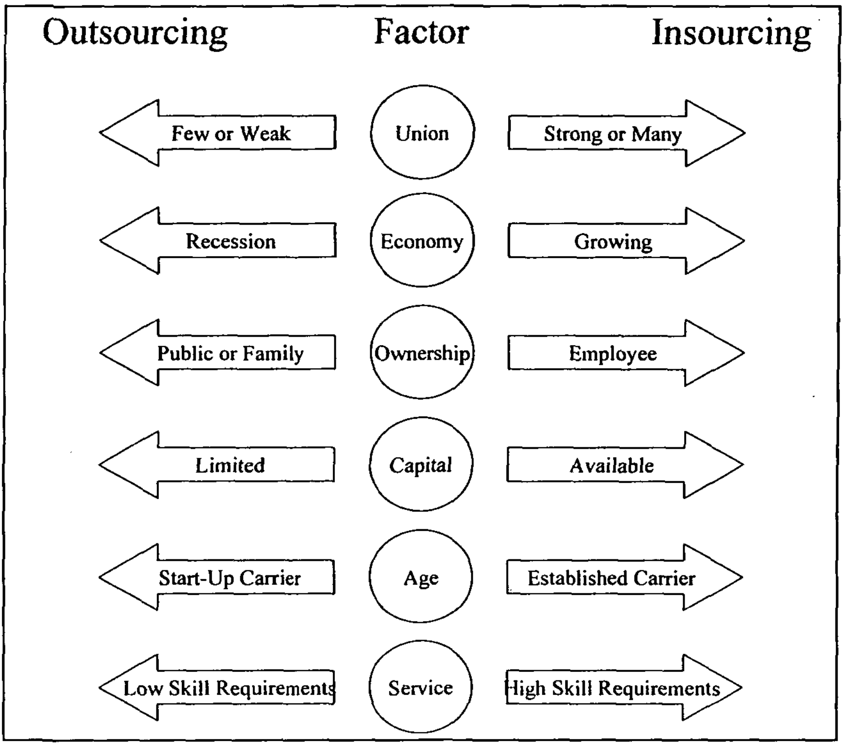

Figure 1. Impact of factors on outsourcing

The ownership of the airline and its level of unionization are also important. The unions tend to reject the idea of outsourcing and prefer that the airline offer job security for their members.[50] Job security is also likely to be a strong motive for avoiding outsourcing if the company is employee owned. On the other hand, if management is strong with few or weak unions, it is very likely to use large levels of outsourcing to reduce costs.

Another critical factor is the complexity of the service or operation considered for outsourcing. The more complex the item, the less likely it is to be outsourced. This is true because as service become more complex, the contracts necessary to secure them also become more complex and difficult to negotiate and enforce. These high transaction costs mean that complex functions can be completed cheaper internally. For instance, pilots' skill sets are very complex. They are also specific to particular types of aircraft, so that there must be a good match between an airline's fleet and the skills of its pilots. While the training of the pilots is outsourced frequently,[51] there are very few examples of pilots being outsourced. Normally, the pilot is considered an integral part of the company and a core component to its success.

Other important considerations include the condition of the economy and the availability of capital. Airlines have always been very sensitive to the economic cycle.[52] As noted above it the discussion of start-ups, an advantage of outsourcing is that it permits airlines to reduce the burden of fixed costs and thus the level of output at which the will breakeven. This is desirable in recessionary conditions when demand it depressed. Most of the literature identified that during the Gulf War and the 1992-1993 Recession, airlines had capital shortages and increased the number of aircraft they leased.[53] It may be that theses two points are highly correlated, but only empirical testing can determine their relationship.

Finally, the age of the airline appears to have a direct impact on the likelihood to outsource. The established carriers appear more likely to insource some operations and outsource the most basic services. The start-up airlines tend to outsource more functions including more complex operations. While age was chosen to represent this factor, that may be an oversimplification. It is more likely a combination of factors that occur over time as an airline grows, formalizes process, changes management, etc. However, the relationship between age and outsourcing appears sound.

CONCLUSIONS

The first conclusion is that the level of outsourcing has increased throughout the airline industry since deregulation. However, the growth of outsourcing has been erratic. During poor economic periods, outsourcing has grown rapidly. However, the opposite has not been true. During good economic periods, there has not been a dramatic shift towards insourcing.

Given this trend, it appears likely that over the next twenty years, the level of outsourcing will continue to grow in the airline industry. This has dramatic implications for both management and labor. Each must decide which functions remain core competencies that must be maintained by the firm. Areas that were considered integral to the airline ten years ago are now being outsourced (i.e., pilot training and maintenance). Much of the future relationship between management and labor will be based on the levels of outsourcing and which operations are chosen for outsourcing.

Another intriguing possibility is that the concept of a virtual airline may be becoming a realistic possibility in the industry. While a number of authors have hinted at this idea of the virtual airline[54,55] each increase in the use of outsourcing makes it seem more likely to occur. There may come a time when the only thing an airline truly owns is its brand name. A possible future scenario is an airline that leases aircraft, contracts crews (pilots and attendants), outsources maintenance, rents gates, relies on third-party reservation systems and electronic tickets, employs outside advertising and marketing firms, rents hanger and office spaces, as well as outsourcing all the typical operations of today (maintenance, baggage, food services, aircraft cleaning, etc.) This future firm would have little or no asset base and only a few managerial employees.

This mirrors the nature of a growing number of non-asset based 3PL companies. If this system works well in the cargo industry, it may be the next evolutionary step in the passenger airline industry. It appears that some airlines already outsource a large percentage of their total operations without any negative impact on customer service.[56,57] The virtual airline is the next logical step.

This implies a drastically different process of operating an airline. The implications for labor under this system are dramatic. Most workers would see this as a negative. The history of outsourcing has been one of replacing high cost labor with low cost labor. This need not be true under a virtual airline. The key is how labor unions, such as Airline Pilots Association (ALPA) react. ALPA could use the creation of virtual companies to provide a body of well-trained pilots for all the virtual airlines. This would have the effect of equalizing salaries across airlines and increasing security. No longer would a captain at one airline lose his seniority if that airline folds. Now, the ALPA seniority would remain as they worked for each carrier. The typical ALPA virtual pilot might bid on airlines as well as routes each month.

Regardless of which choices companies and labor make, there are tremendous opportunities as well as pitfalls with outsourcing. It is clear that outsourcing has become an accepted method of conducting business in the airline industry.

Limitations of the Current Research and Opportunities for Future Research

Given the conceptual nature of this article, there are obvious shortcomings. First and foremost, is the use of large amounts of anecdotal evidence to develop the analytical framework. An obvious extension is to determine through empirical testing if the six factors do effect the outsourcing decision. One of the goals of the authors is to use this piece as a springboard to future research. An equally import opportunity is to invigorate discussion on the possibilities of outsourcing within the industry. There is an opportunity to identify other views and possibilities of this area. There are many benefits and costs to any change. However, change is inevitable. Perhaps this discussion can benefit those who must make and those who must live with outsourcing decisions.

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STOCHASTIC MODELING OF AIRLINES' SCHEDULED SERVICES REVENUE

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M. M. Hamed
Jordan University of Science and Technology
Irbid, Jordan

ABSTRACT

Airlines' revenue generated from scheduled services account for the major share in the total revenue. As such, predicting airlines' total scheduled services revenue is of great importance both to the governments (in case of national airlines) and private airlines. This importance stems from the need to formulate future airline strategic management policies, determine government subsidy levels, and formulate governmental air transportation policies. The prediction of the airlines' total scheduled services revenue is dealt with in this paper. Four key components of airline's scheduled services are considered. These include revenues generated from passenger, cargo, mail, and excess baggage. By addressing the revenue generated from each schedule service separately, air transportation planners and designers are able to enhance their ability to formulate specific strategies for each component. Estimation results clearly indicate that the four stochastic processes (scheduled services components) are represented by different Box-Jenkins ARIMA models. The results demonstrate the appropriateness of the developed models and their ability to provide air transportation planners with future information vital to the planning and design processes.

INTRODUCTION

Airlines are under tremendous pressure to generate more revenues to lessen government provided subsidies (in case of national airlines). An airline's total revenue basically consists of two major segments. The first segment comprises revenue generated from scheduled services such as passenger, cargo, mail, and excess baggage. The second segment comprises revenue generated from chartering and other non-scheduled services and activities. The revenue generated from scheduled services accounts for the major bulk of the total airline revenue.

The basic difference between the two segments is that the first segment consists of services that are scheduled. As such, revenue generated from these services can be studied over a period of time and for the most part are predictable. The revenue generated from the second segment however can be categorized as being uncertain (fluctuates widely over time). The importance of future scheduled services revenue stems from the need to formulate future strategic management policies, determine government subsidy levels, and formulate governmental transportation policies.

By far, air passenger revenue constitutes the major bulk of the total revenue. Because of fierce competition, airlines are on the move to capture more passengers partly by means of opening new efficient routes and by improving their quality of service. It is therefore not surprising to see air passenger demand forecasting evoking the attention of many researchers.

Different techniques have been applied in the literature to predict future airline passenger traffic demand. Waheed, McCullough, and Crawford (1985) implemented the Box-Jenkins methodology to forecast airline passenger demand and assess future airport needs. An aggregate oriented data set was used for that purpose. Ashford and Benchemam on the other hand, developed an airport choice model on the basis of a disaggregate data set (1987). The estimated model highlighted the major factors that influence airline passenger decisions to choose a particular airport. Although the developed model was not intended to forecast airline passenger traffic demand, it nevertheless has the ability to predict air traffic demand. Recently, Rengaraju and Arasan developed a city-pair model to estimate domestic air travel demand. The specified model was calibrated with a cross-sectional aggregate data taken from 40 city pairs (1992). Other studies in this area include the work by Moore and Soliman (1981), Skinner (1976), Ozoka and Ashford (1988), and Harvey (1987).

Nearly most of the previous work done in this area was geared toward the prediction of air passenger traffic. Recognizing air passenger revenue as being the major contributor to the total airline revenue, it is also equally important to consider other sources of revenues in proper future strategic planning. Since each revenue component is affected by different external factors it is expected that each component will have its own characteristics and structure. Furthermore, addressing each component separately enhances air transportation planners, designers, as well as airlines to formulate specific strategies for each component.

To this end, no attempts were made to model the revenue generated from the airlines' scheduled services. This paper will explicitly address the total revenue generated from scheduled services, namely passenger, cargo, mail, and excess baggage. These stochastic processes will be represented by time-series models. The specified models will be estimated with the use of data obtained from the Royal Jordanian Airlines (RJA).

MODEL DEVELOPMENT

A number of mathematical techniques can be used to model the airline's total scheduled services revenue. These include multiple regression, econometric, and time-series analysis. Both multiple regression (special case of econometric models) and econometric models require variations in a number of economic factors to forecast the revenue generated from each airline's scheduled services. Time series models on the other hand require only the time-lagged values of each scheduled service revenue (past behavior of each revenue). Furthermore, utilizing time series models would explicitly account for patterns in the past variations of the scheduled services revenues, thus making them more widely used particularly in circumstances where information on variations in economic factors is lacking or unavailable.

Let Yi(t) represent the yearly generated revenue from the ith scheduled airline service (passenger, cargo, mail, or excess baggage). Since the collection of activities in each service is ordered in time, the process is called a stochastic process. A number of stochastic processes can be used to model the revenue generated from the aforementioned services. These processes include; Autoregressive Integrated Moving Average (ARIMA), pure Autoregressive (AR), pure Moving Average (MA), and random walk. When the mean, variance, and the covariance of the process is time invariant, then this process is considered as a stationary stochastic process. This implies that the fluctuation of revenue is stable over time. However, most encountered time series are nonstationary in nature, particularly those that deal with a passenger's choice of an airline and demand for air travel. Hence techniques are sought to overcome the nonstationarity. Of particular interest is the Box-Jenkins (1976) ARIMA models.

The success of this method can be attributed to the fact that this methodology is capable of dealing with different forms of time series (stationary, nonstationary, with or without seasonal elements). Furthermore, many computer packages available on the market have full documentation of this method.

The general polynomial representation of the Box-Jenkins Integrated model for nonstationary scheduled service revenue time series with seasonality ARIMA (p,d,q) x (P,D,Q)s can be written as,

$$\phi_P(B)\theta_p(B)(1-B)^d(1-B^s)^D Y_{i(t)} = \rho_q(B)\chi_Q(B)\tau_t + \delta$$

where $\theta p(B)$ and $\rho q(B)$ are polynomials representing regular autoregressive and moving average of order p and q respectively. $\phi P(B)$ and $\chi Q(B)$ are polynomials representing seasonal autoregressive and moving average of order P and Q respectively, τt is the random error component, and δ is the trend parameter. The trend parameter should be included in the model if the differenced series has a significantly large mean value. The Box-Jenkins methodology is used to convert the nonstationary time series into a stationary one. This conversion can be achieved partly by differencing the time series. The order of differencing is determined by studying the Autocorrelation Function (ACF) and the Partial Autocorrelation Function (PACF) of the original and of each of the differenced time series derived from it. In some cases however, a power transformation might be needed to stationarize a time series. Once stationarity has been achieved, identification of the stationary time series is sought. This is done by studying the ACF and PACF of the converted series.

In terms of the original time series which represent the revenue generated from scheduled services, the models below are called integrated models; ARI (p,d,0), IMA (0,d,q), ARIMA (p,d,q) respectively,

$$W_{i(t)} = \phi_1 W_{i(t-1)} + \phi_2 W_{i(t-2)} + \ldots + \phi_p W_{i(t-P)} = \tau_{i(t)}$$

$$W_{i(t)} = \theta_1 \tau_{i(t-1)} + \theta_2 \tau_{i(t-2)} - \ldots - \theta_q \tau_{i(t-q)} = \tau_{i(t)}$$

$$W_{i(t)} = (\phi_1 W_{i(t-1)} + \phi_2 W_{i(t-2)} + \ldots + \phi_p W_{i(t-P)}) - (\theta_1 \tau_{i(t-1)} + \theta_2 \tau_{i(t-2)} + \ldots + \theta_q \tau_{i(t-q)} = \tau_{i(t-q)})$$

where

$$W_{i(t)} = Y_{i(t)} - Y_{i(t-1)} \qquad \text{for } t = 2,3,\ldots,N$$

where $\phi 1, \ldots, \phi p$ denote autoregressive coefficients, $\theta 1, \ldots, \theta q$ denote moving average coefficients, and τt is the disturbance term.

The idea then is to specify and estimate all univariate time-series model for revenue generated by each of the four scheduled services.

DATA DESCRIPTION

Royal Jordanian Airlines (RJA) is the only national carrier in Jordan. Established in 1963, then under the name of Alia, RJA made great strides over the years. The airline started with three aircraft and made scheduled flights to three destinations Beirut, Kuwait, and Cairo. Now RJA has a fleet consisting of 19 aircraft (mainly Airbus and Boeing), with 39 destinations in total, and around 117 flights per week. Furthermore, RJA's route network has expanded rapidly over the years. Although, the RJA provide domestic air services (Amman-Aqaba route), international services dominate the RJA operations. Figure 1 shows the RJA route map. The total RJA revenue has registered a somewhat continuous growth.

The data set was obtained from the Royal Jordanian Airlines. The data consists of four stochastic processes. The data set represents the components of the scheduled services revenue, namely passenger revenue, cargo revenue, mail revenue, and excess baggage revenue. The data set represents the time period from 1964 until 1993 inclusive.

Figure 2 shows the evolution of RJA total scheduled services revenue over time. Figure 3 on the other hand shows the contribution of each component of the schedule services to RJA's total revenue. The figure clearly shows that on the average passenger revenue constitutes over 70 percent of the total revenue. Both mail and excess baggage revenues seem to be relatively uniform over time. The availability of air cargo aircraft that were capable of handling various types of products have positively influenced the revenue generated from cargo traffic.

Figure 4 shows the contribution of both chartering and other non-scheduled services to the RJA's total revenue. Unlike the scheduled services revenue, both revenues have pronounced peaking and fluctuate widely over time. For example, in 1990 revenue generated from both chartered services and other non-scheduled services amounted to 16.3 percent and 21 percent from the total RJA's total revenue respectively. However, such contributions fell to 5.6 percent and 7.2 percent respectively in 1992. This specific fluctuation can be attributed to

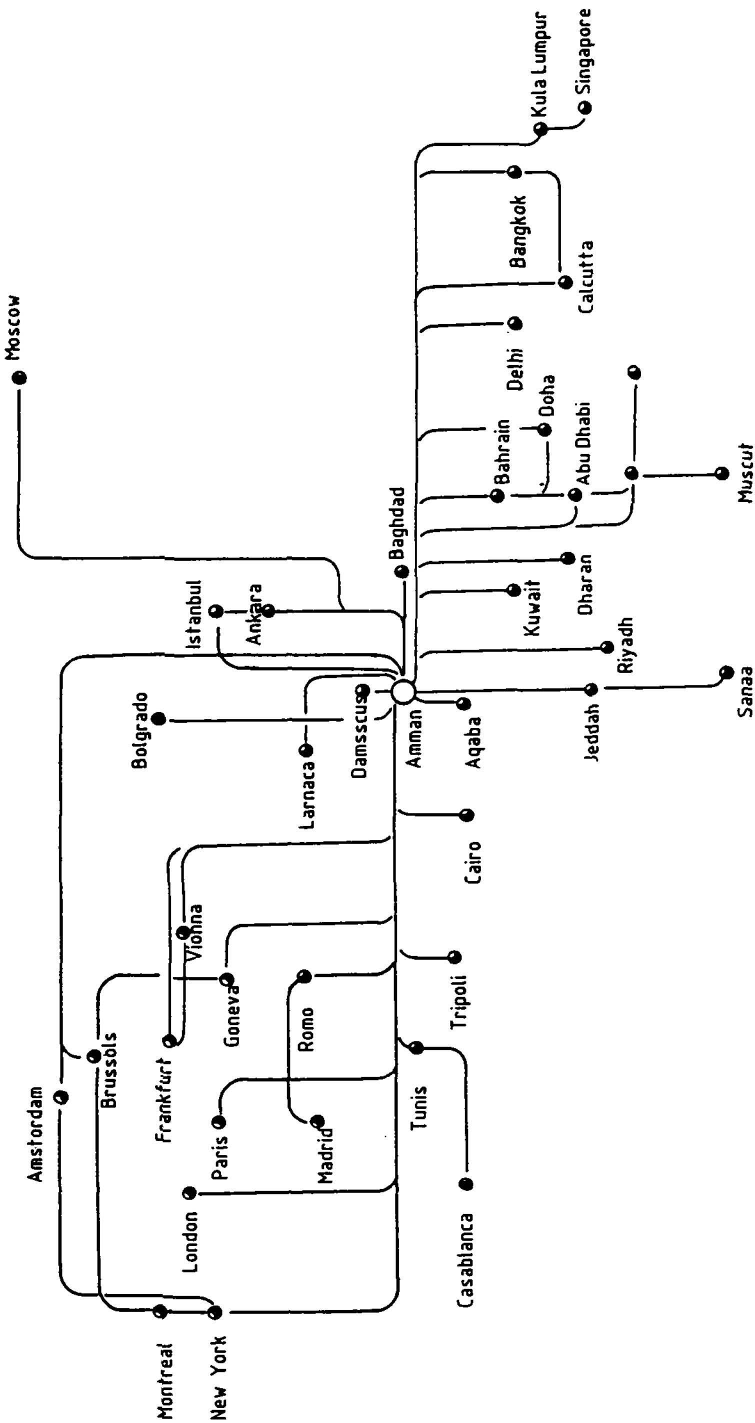

Figure 1. RJA route network, 1993

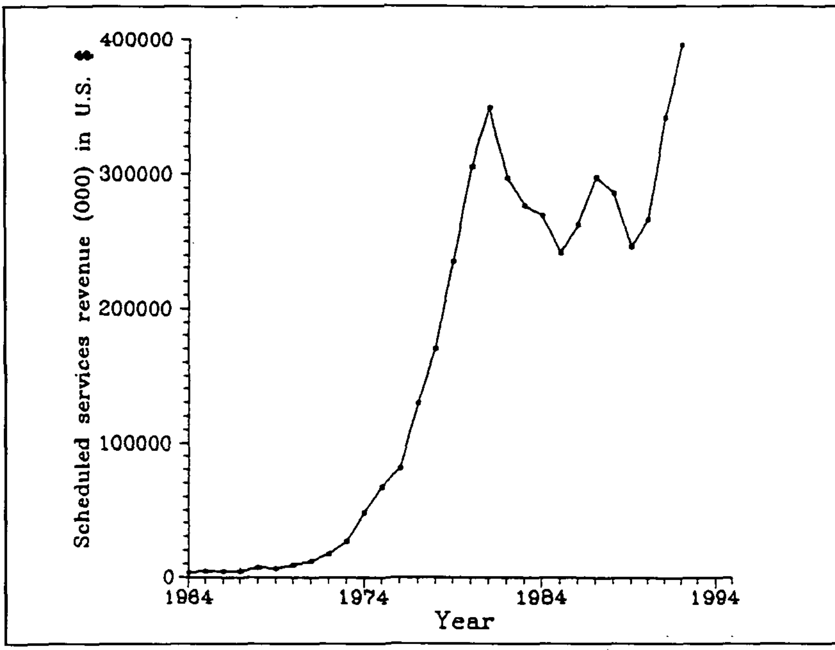

Figure 2. Total scheduled services revenue of RJA, 1964-1993

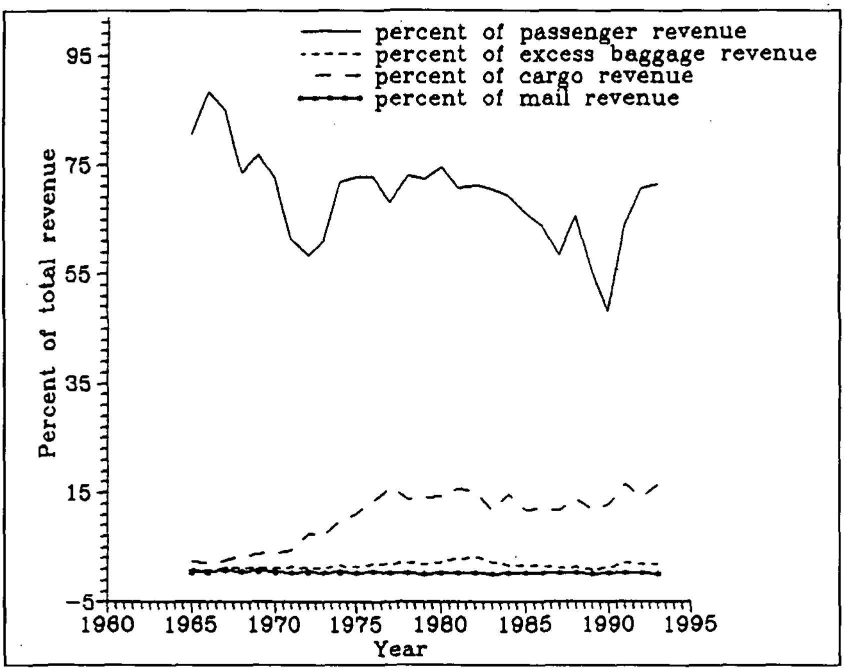

Figure 3. Scheduled services revenue components of RJA, 1964-1993

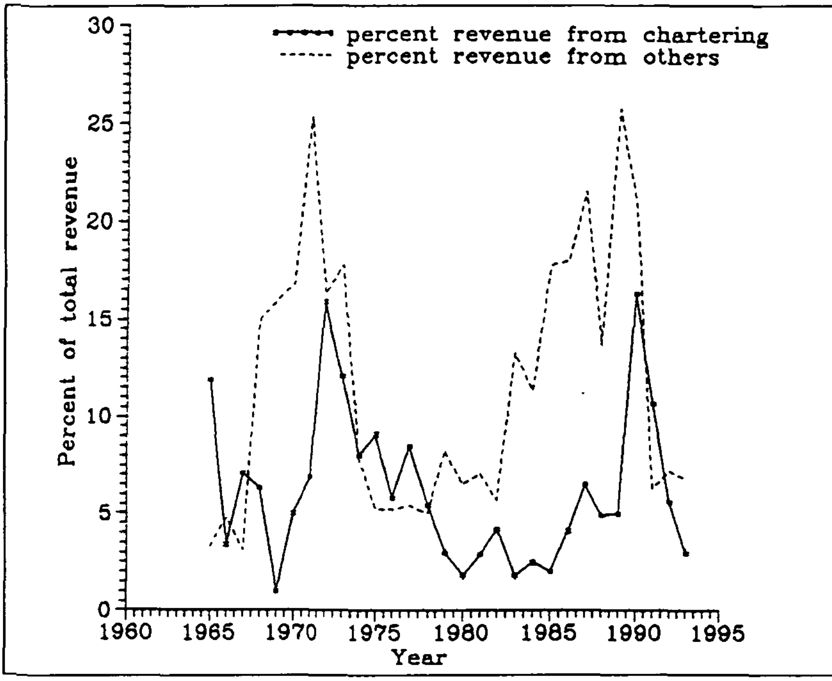

Figure 4. Yearly revenue from chartering and other non-scheduled services for RJA, 1964-1993

the Gulf Crisis where RJA had to compensate for the dramatic fall in passenger revenue through chartering and other activities. Even prior to 1990, Figure 4 clearly shows significant fluctuations in these two revenues.

EMPIRICAL RESULTS

The ACF and PACF for each schedule services revenue are shown in Figures 5 through 8. Without exception, all ACFs of the original series show slowly declining sinusoidal (slow damping off) with a large spike at lag 1. In fact, Figure 5 shows a large spike approaching unity at lag 1. The PACF plots for all time series show a similar pattern. In that a large spike approaching unity in some cases is present at lag 1. The ACF and PACF patterns clearly indicate all time series are nonstationary in the mean. A number of regular differencing of the original series has been carried out. It was found that for all time series, one regular differencing (d = 1) was enough to produce a stationary time series. Figures 5-8 show time-series plots for each of the above measures. All plots show strong evidence of nonstationarity in the mean. Generally, time series representing all the four schedule services revenue appear to have an upward trend. The decline in revenue in some years (e.g. 1967, 1970, and 1988) can be attributed to regional instability as a whole, the unprecedented low growth of Jordan's economy and the Gulf Crisis.

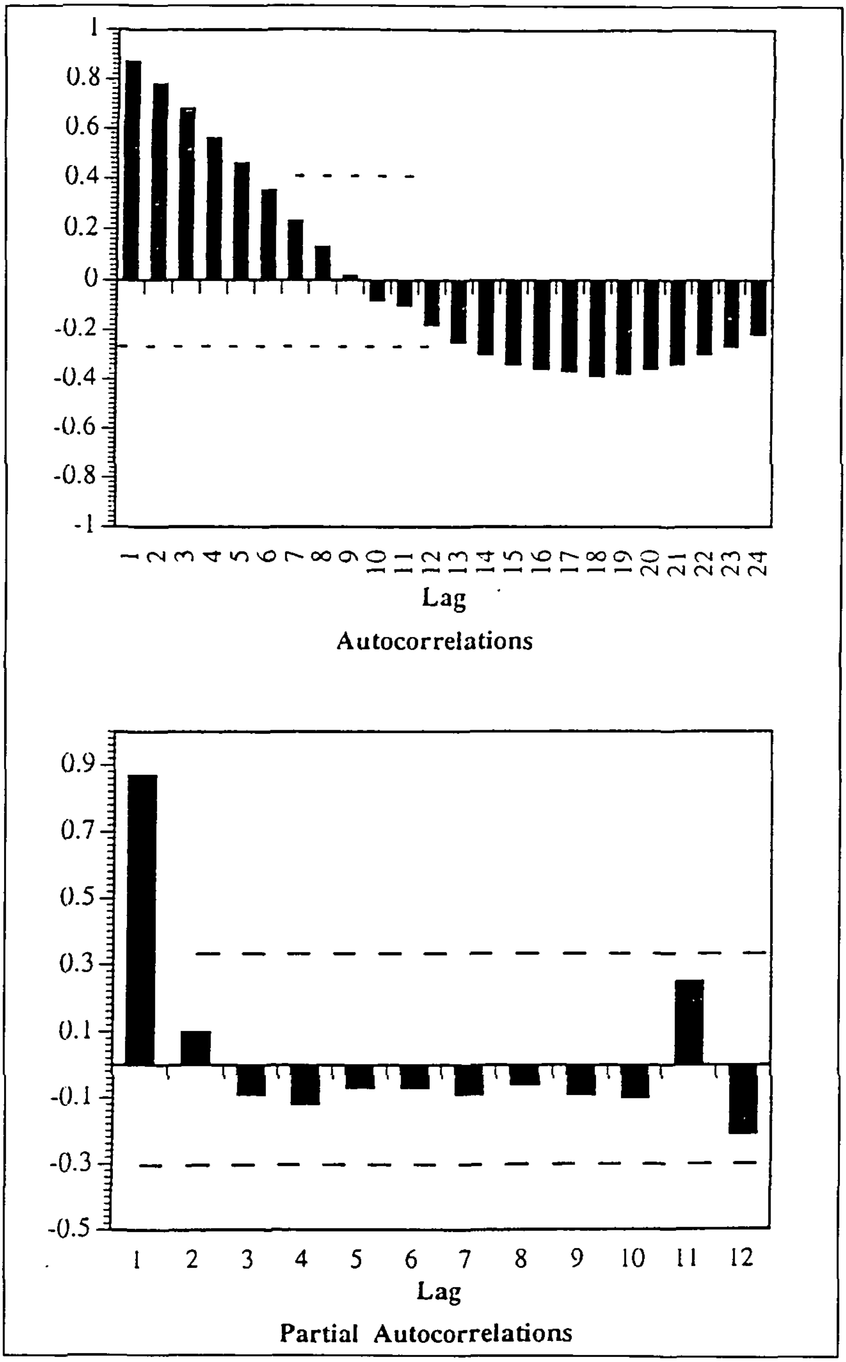

Figure 5. Estimated autocorrelations and partial autocorrelations of original passenger revenue time-series of RJA, 1964-1993

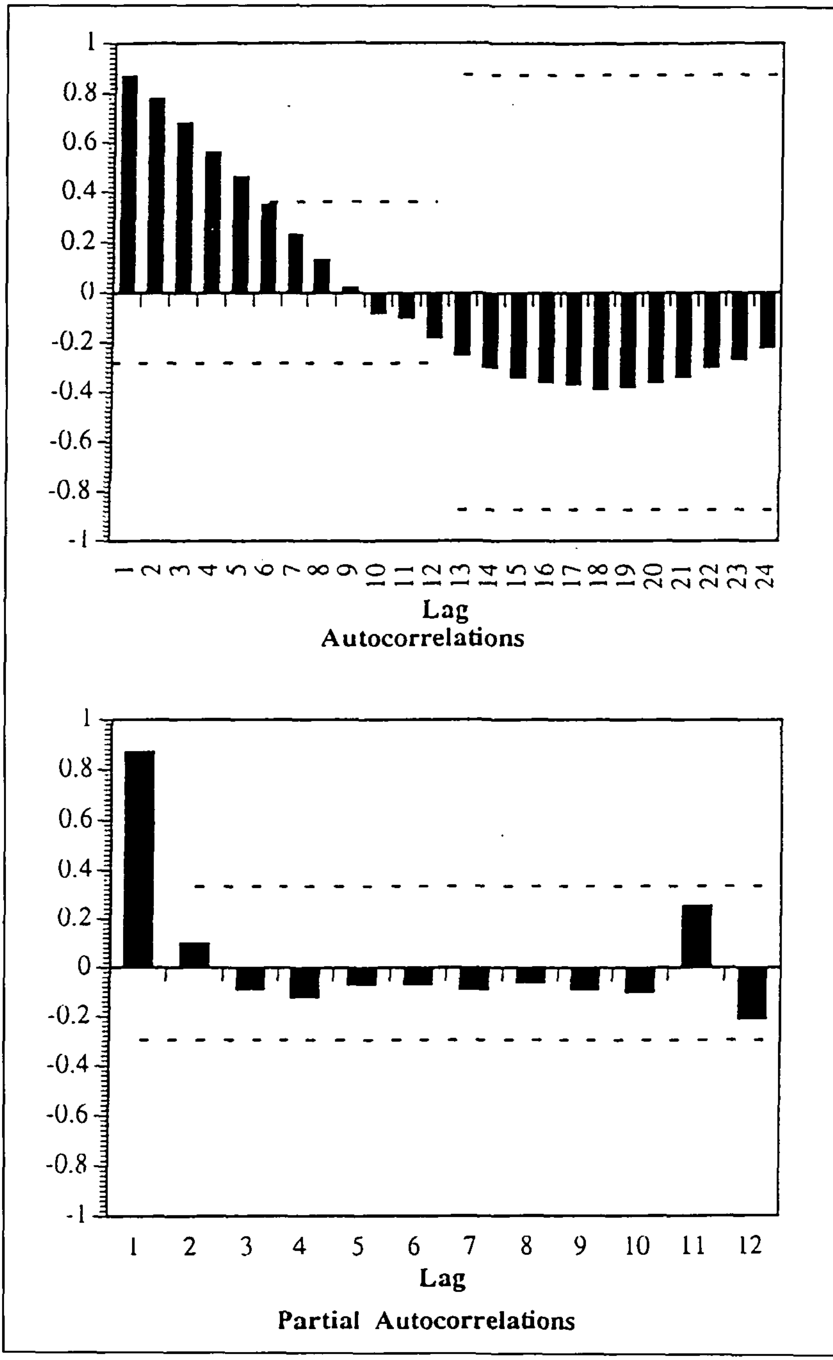

Figure 6. Estimated autocorrelations and partial autocorrelations of original cargo revenue time-series of RJA, 1964-1993

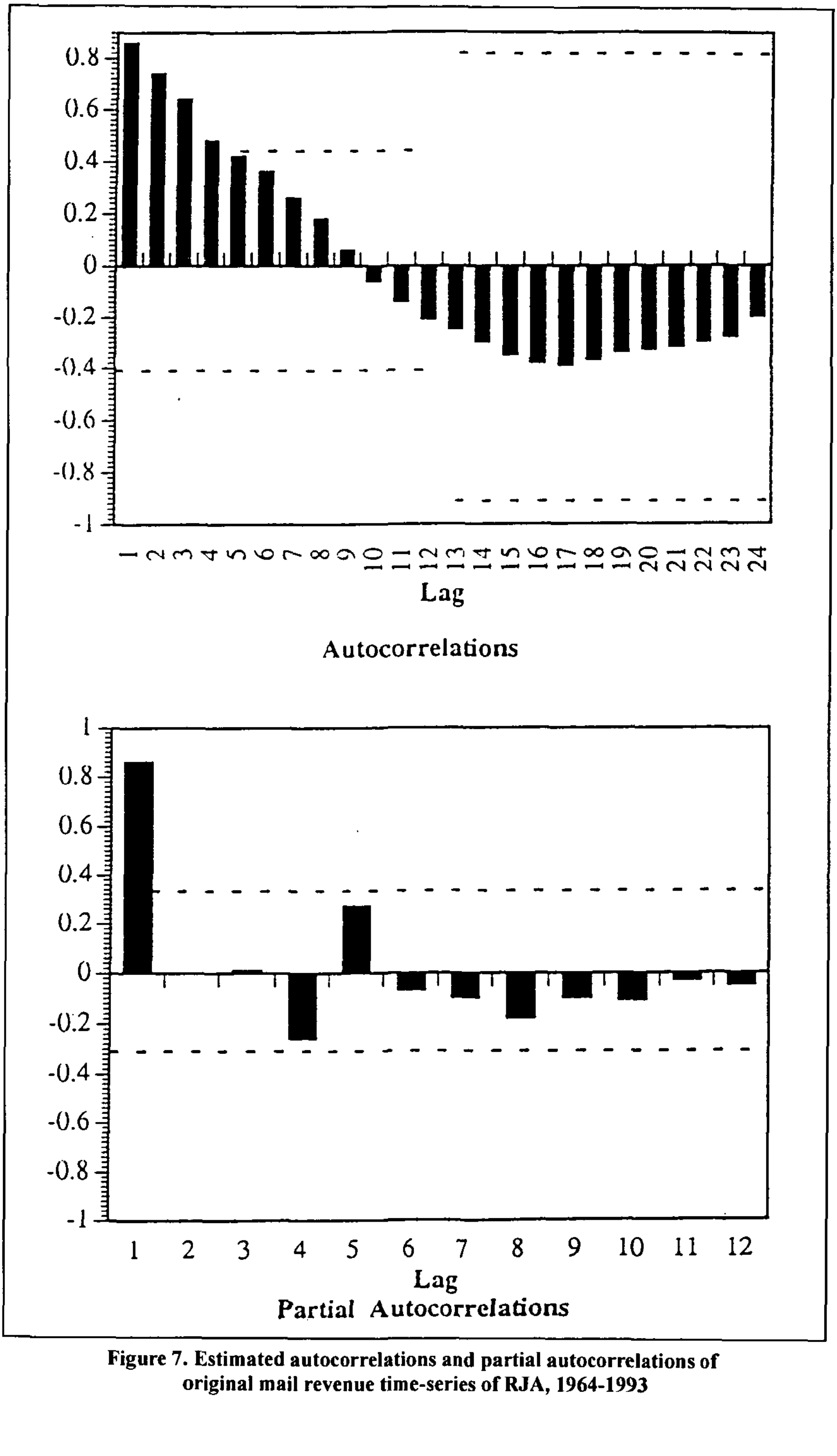

Figure 7. Estimated autocorrelations and partial autocorrelations of original mail revenue time-series of RJA, 1964-1993

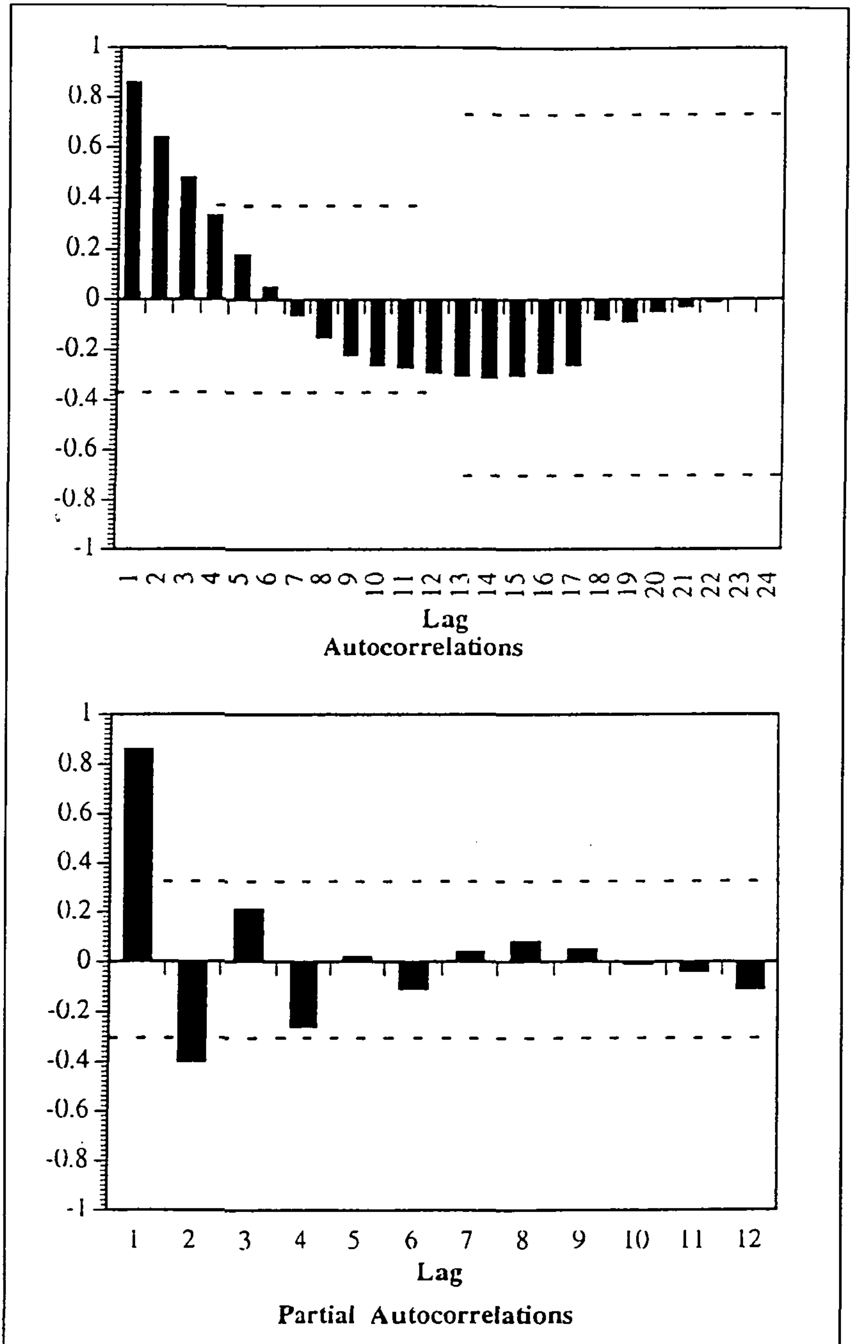

Figure 8. Estimated autocorrelations and partial autocorrelations of original excess baggage revenue time-series of RJA, 1964-1993

The initial model selection for each series was based on the inspection of the ACF and PACF patterns. A number of models were considered for each time-series in an attempt to avoid overfitting or underfitting. The selected model estimation results are shown in Table 1. The Akaike Information Criterion (AIC), which is a measure of the precision of the estimate and the degree of parsimony in the parameterization of the stochastic model, was used to determine the best coefficient values. After considering several models, the model that provided the lowest AIC value was chosen (see Table 2).

Table 1
Scheduled Services Revenue Models Estimation Results, t-statistics in Parentheses

Scheduled Services Revenue Component	*Model Structure*	*Best Coefficient Value*
1. Passenger revenue	IMA (0,1,1)	0.713 (5.279)
2. Cargo revenue	ARI (1,1,0)	0.270 (1.294)
3. Mail revenue	ARIMA (1,1,1)	
	AR(1)	0.517 (2.832)
	MA(1)	0.923 (18.490)
	trend constant(δ)	21.208 (2.175)
4. Excess baggage revenue	ARI (1,1,0)	0.338 (1.834)

Estimation results clearly show the stochastic process generating each schedule service revenue is different in its structure. For example, passenger revenue turned out to be best represented by the ARIMA model (0,1,1) with no trend, cargo revenue by the ARIMA model (1,1,0) with no trend, mail revenue by the ARIMA model (1,1,1) with a trend, and the excess baggage revenue by the model (1,1,0) with no trend.

With the exception of the mail revenue time series, the remaining time series did not incorporate a constant trend. The trend constant in the mail revenue series turned out to be significantly different from zero at the 5 percent level. Furthermore, the t-statistics show that all parameter estimates are statistically significant at the five percent level. The difference in model structure and best coefficient values support our claim that each revenue component has its own characteristics and patterns.

Below is a formal representation of the ARIMA models (0,1,1) with no trend constant (model 1), (1,1,0) with no trend constant (model2), (1,1,1) with a trend constant (δ) (model 3), and (1,1,0) with no trend constant (model 4); respectively. These models represent the passenger, cargo, mail, and excess baggage revenues respectively.

$$Y_{1(t)} = Y_{1(t-1)} + \tau_{1(t)} - 0.713\tau_{1(t-1)}$$

$$Y_{2(t)} = 1.271Y_{2(t-1)} - 0.271Y_{2(t-2)} + \tau_{2(t)}$$

$$Y_{3(t)} = 1.517Y_{3(t-1)} - 0.517Y_{3(t-2)} + \tau_{3(t)} + 0.923\tau_{3(t-1)} + 21.208$$

$$Y_4 = 1.338Y_{4(t-1)} - 0.338Y_{4(t-2)} + \tau_{4(t)}$$

Figures 9 through 12 show the actual and fitted airline scheduled services revenue.

The residual analysis was based on the assumption stated earlier that the residuals of the best model are approximately white noise. The estimated residual autocorrelations and partial autocorrelations were not significant.[1] This clearly support the hypothesis that the residuals came from a population whose mean is zero and whose values are random.

[1]The significance of the residuals autocorrelations were checked by comparing with approximate two standard error bounds $\pm 2/\sqrt{N} = (\pm 0.371)$ where N is the number of observation used in computing the estimate (N=29 in our case)

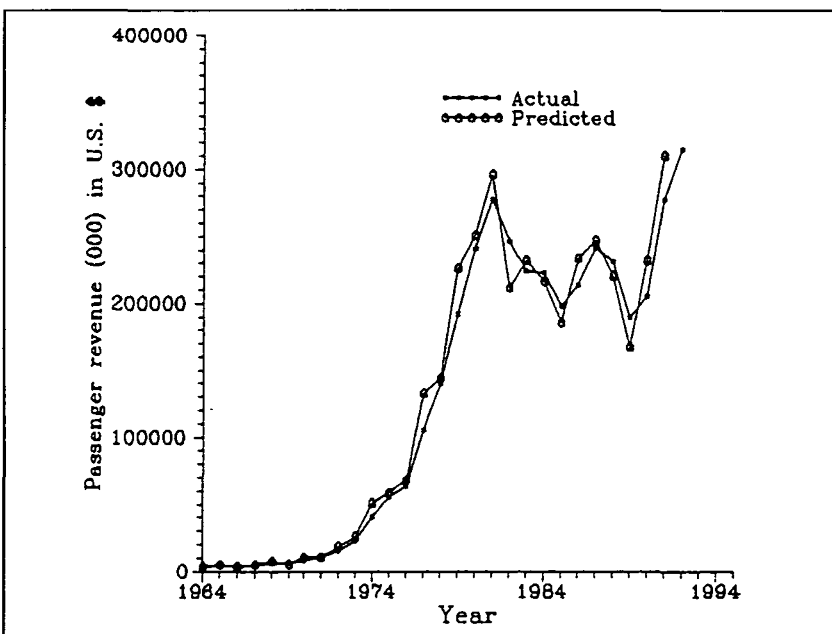

Figure 9. Actual and fitted yearly passenger revenue for RJA, 1964-1993

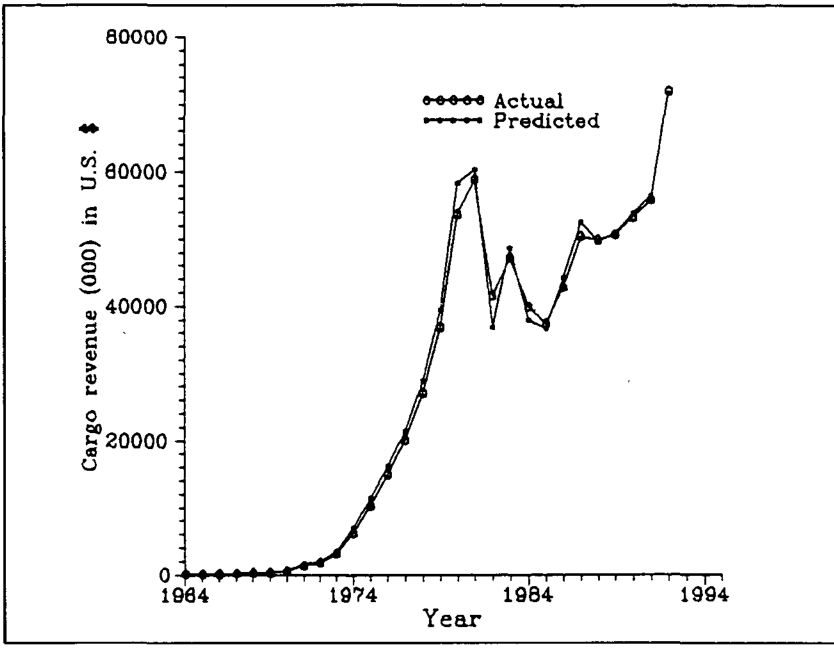

Figure 10. Actual and fitted yearly cargo revenue for RJA, 1964-1993

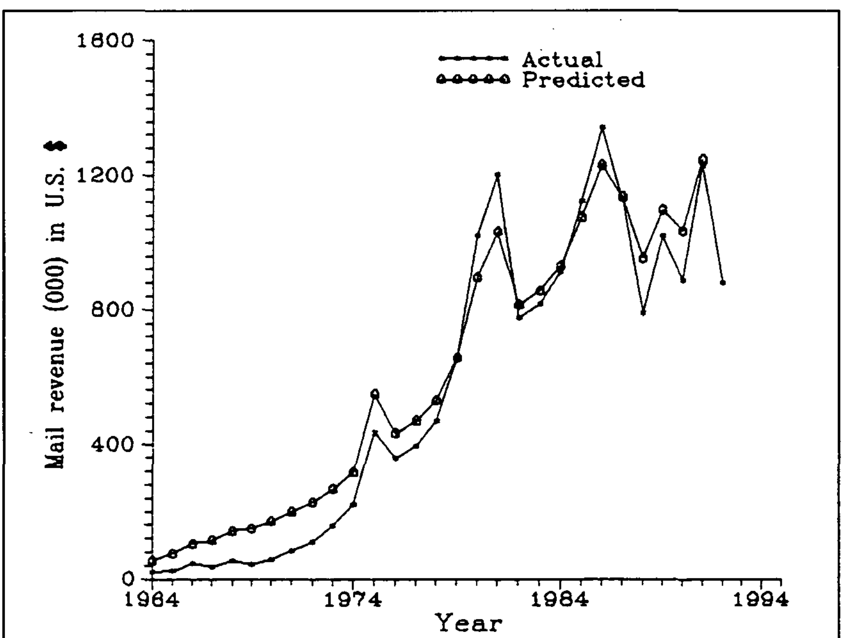

Figure 11. Actual and fitted yearly mail revenue for RJA, 1964-1993

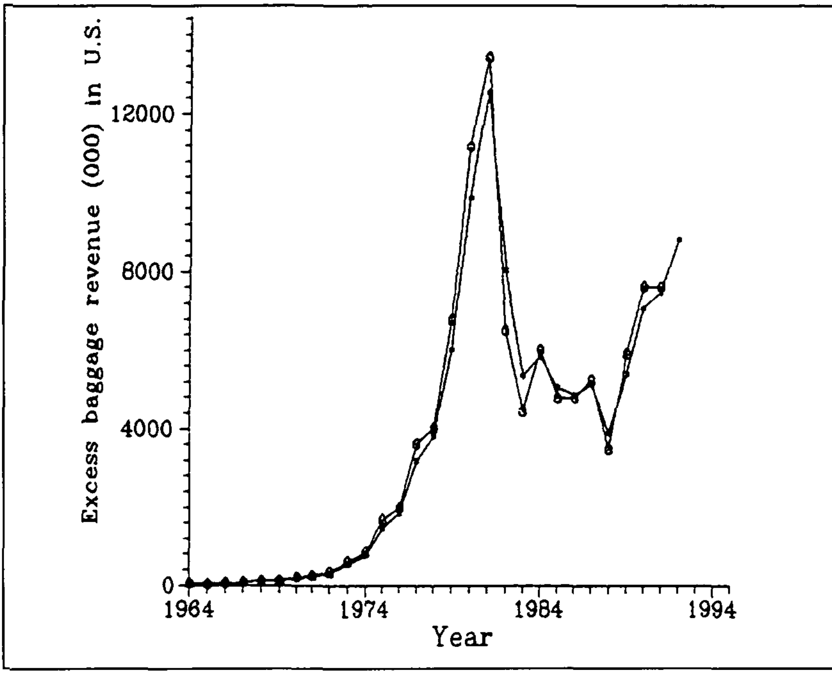

Figure 12: Actual and fitted yearly excess baggage revenue for RJA, 1964-1993

Table 2 shows summary statistics computed after the best coefficient values have been estimated. The Box-Pierce test statistics for all estimated models show no existence of serial correlation pattern in the residuals. The Q value for each revenue model is well below the critical 95 percent level (chi-squared critical value). Hence the selected models are appropriate for the purpose of forecasting.

The yearly fitted revenue from each schedule services time series model were added up to generate the total predicted scheduled services revenue. Figure 13 shows that the total yearly scheduled services revenue conforms very well to the

Table 2
Scheduled Services Time-series Models' Summary Statistics

Revenue Component Model	*AIC**	*Box-Pierce Statistics***
1. Passenger revenue	20.24	9.20
2. Cargo revenue	17.70	9.80
3. Mail revenue	10.65	16.50
4. Excess baggage revenue	14.68	8.50

*AIC: Akaike information criterion
** Q values for k=24 lags

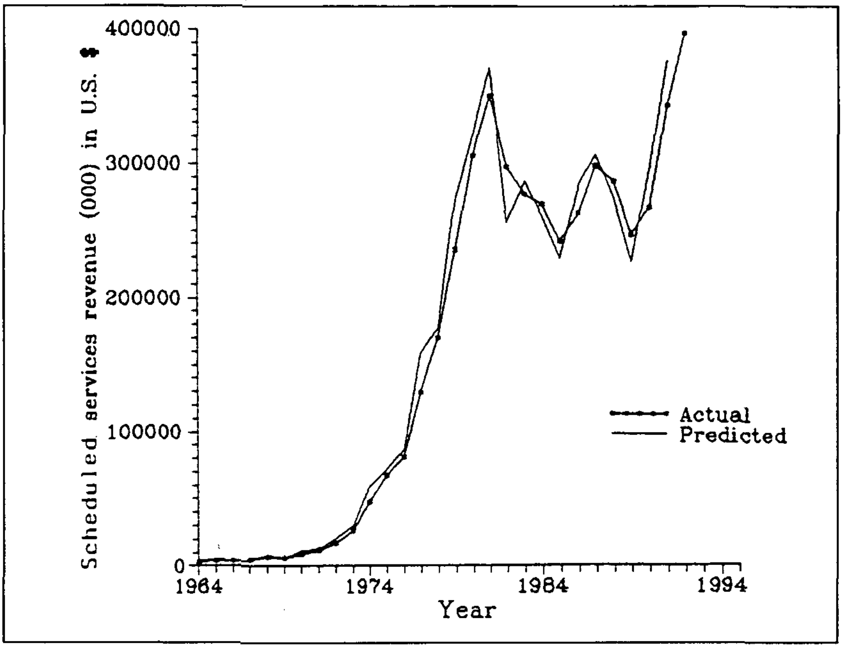

Figure 13. Actual and fitted total scheduled services revenue for RJA, 1964-1993

total actual scheduled services revenue. Both the direction and magnitude of forecasting values are correct.

CONCLUDING REMARKS

A set of stochastic ARIMA models were specified and calibrated in this paper to forecast the airlines' total scheduled services revenue. Four key components of the airlines' schedule services were considered. These are passenger revenue, cargo revenue, mail revenue, and excess baggage revenue.

Results showed that the four stochastic processes are represented by different Box-Jenkins ARIMA models. This clearly suggests that each component has its own characteristics and structure and as such should be considered separately. The yearly forecasts from each scheduled services revenue component were added up to produce the airline's total scheduled services revenue. The generated forecasts turned out to be reasonable and efficient in terms of both the magnitude and direction of forecasts. With the use of such forecasts, airlines can plan their operations and expenditure according to the expected scheduled services revenue. Furthermore, since forecasts are available for each service, air transportation planners and designers can enhance their skills to evaluate future capacity expansions, predict changes in airline's equipment, and formulate future strategies concerning each service.

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PLANNING FOR NEW PRIMARY AIRPORTS IN THE UNITED STATES: A SURVEY OF METROPOLITAN PLANNING ORGANIZATIONS

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David A. NewMyer
Southern Illinois University, Carbondale
Carbondale, IL

ABSTRACT

Airport congestion at primary airports in major metropolitan areas was analyzed in a report prepared by the Transportation Research Board (TRB) in 1990. Taking the top twenty-three most congested airports from this study, a questionnaire was prepared and sent to the metropolitan planning organizations (MPOs) for twenty of the twenty-three metropolitan areas represented in the TRB study. The questionnaire focused on the role of the MPOs in planning for new primary airports in the United States, including questions about the status of the most recent MPO airport system plan, whether or not the latest plan recommends a new primary airport, and whether or not any other entities in the MPO areas are recommending new primary airports. The results indicated that 44.4 percent of the eighteen respondent MPOs have airport system plans that are five years old or older. Also, only two of the respondent MPOs have recommended a new primary airport in their latest regional airport system plan and only one of these two is a common recommendation in the Federal Aviation Administration's National Plan of Integrated Airport System.

INTRODUCTION

Airport capacity problems and solutions have been debated for decades in the United States. Former Administrator of the Federal Aviation Administration (FAA) David R. Hinson made one of the strongest descriptive statements made in recent years:

> Within the next twenty years, we predict that our U.S. air traffic control system, our airlines and our airports will have to accommodate one billion passengers a year - twice as many as today. Providing for this surge of new travelers is a challenge we are going to be hard-pressed to meet. Not because of a shortage of seats in our carriers. Not because the sky is so clogged with planes that our air traffic control system begins to falter under the workload. The most serious potential problem in meeting the demands on aviation in the coming years will be inadequate capacity of our major airports, and the great

> difficulties we face in trying to enlarge this capacity (Hinson, 1994, p.1).

But what is the nature of the difficulties in meeting this demand for airport capacity, particularly when building all-new primary airports? The Transportation Research Board describes the difficulties this way:

> This approach [building new primary airports] has been explored in most major cities but with little success. Only two new major airports (Dallas-Ft. Worth and Southwest Florida Regional in Fort Myers, Florida) have been opened in the past twenty years. The principal barriers to a second (or third or fourth) airport to serve major metropolitan areas are lack of a suitable site, conflict with other potential uses of land, introduction of noise into sensitive areas, the difficulties of providing adequate landside access, traffic pattern conflicts and congestion in terminal-area airspace, opposition by incumbent airlines at the existing airport(s), and the large investment required to build a new facility in an already developed area. It is the past failure to achieve community acceptance and support for such projects that has contributed significantly to the lack of adequate airport capacity in our largest cities today (Transportation Research Board, 1990, p. 37).

So who is responsible for building this community consensus to construct new primary airports in major cities? Certainly, the FAA has a goal to expand the airport infrastructure, but as it can be seen, it is general in nature and does not apply just to metropolitan area airport planning:

> The FAA's policy for capacity and access is that the FAA will vigorously pursue optimization of the airspace and airport systems within the context of the overall transportation system. The FAA will adopt the following strategies:
>
> - Implement effective capital investment programs for expanding airspace airport capacity to accommodate growth and provide flexibility for future innovation.
> - Preserve and enhance the capacity of and access to existing airspace and airports, using effective management techniques and advanced technology.
> - Provide leadership to ensure coordinated airport system development among Federal, State, and local governments (Federal Aviation Administration, 1990, p. 27).

However, where does the airport system planning in metropolitan areas - which frequently span multiple county and even state lines and include hundreds or thousands of local government units - fit into the above statement? The answer is in the MPO or Metropolitan Planning Organizations. Federal law and regulations require that:

> A Metropolitan Planning Organization (MPO) be designated for each urbanized area and that the metropolitan area has a continuing, cooperative, and comprehensive transportation planning process that results in plans and programs that consider all transportation modes, and supports metropolitan community development and social goals. These plans and programs shall lead to the development and operation of an integrated, intermodal transportation system that facilitates the efficient, economic movement of people and goods (Code of Federal Regulations, 23CFR #450.300).

This metropolitan transportation plan is required to include the policy inputs of all affected local governmental agencies and is normally approved by some sort of representative policy committee of these agencies before being sent to the respective state and federal departments of transportation for their approval. The approved MPO-prepared transportation plan then becomes the basis for investing federal transportation funds in a metropolitan area. No plan? No Funds!

The purpose of this research article is to report on a survey of the MPO's in metropolitan areas that were reported to have the busiest major airports in the nation. This survey was designed to provide a status report on new primary airport planning in those MPO areas, as well as to describe the overall problems faced by MPO's in planning new primary airports.

ADDITIONAL DEFINITIONS

Before proceeding with the bulk of the article, several definitions must be provided:

1. **Primary Airport:** A primary airport is defined by the FAA as a commercial service airport with 10,000 or more annual enplaned passengers (FAA, 1995).

2. **Metropolitan Area:** The United States Office of Management and Budget (OMB) defines metropolitan areas according to published standard that are applied to the U.S. Census Bureau data. A metropolitan area must include at least one city with 50,000 or more inhabitants, or a Census Bureau-defined urbanized area (of at least 50,000 inhabitants) and a total metropolitan population of at least 100,000 (75,000 in New England) (U.S. Census Bureau, 1998).

3. **Airport System Plan:** This is a plan for a system or group of airports in a given area (such as a metropolitan area, a state, national, etc). This is different from an airport master plan, which is a plan for a single airport.

LITERATURE REVIEW

This literature review describes the demand for airport capacity, difficulties in solving the airport capacity problem and the role of the MPO in airport system planning. In 1990, the Committee for the Study of Long-Term Airport Capacity Needs of the Transportation Research Board issued a report entitled Airport System Capacity: Strategic Choices (Transportation Research Board, 1990). In that report, the TRB stated the airport system capacity problem this way:

> Air travel is growing at a rate that outstrips the capacity of the airport and air traffic control system, resulting in mounting congestion and delay. The consequences for the air transport industry and the traveling public are higher costs, greater inconvenience, declining quality of service and possibly diminished safety. Development of airport and airway infrastructure to accommodate growing demand is seriously lagging - mired in funding problems, local opposition to airport expansion, lack of direction, inertia, and predisposition to make do with infrastructure that has not been increased substantially in twenty years or longer (Transportation Research Board, 1990, p. 1).

The TRB went on to list 23 of the most congested airports in the U.S. at the time of their study (See Figure 1).

Four years later then-Administrator of the Federal Aviation Administration, David R. Hinson, gave a speech to the Wings Club of New York entitled "No Place to Land: The Coming Capacity Crunch at U.S. Airports." In the speech Mr. Hinson noted the following problem.

> The magnitude to the airport capacity problem has been clearly understood for at least a decade. In 1990, the Transportation Research Board published a report that provided a comprehensive, impartial analysis of the issue, and then laid out seven different strategies for expanding airport system capacity. The study was completed during the euphoria if the 1980's, when no one could foresee that civil aviation was about to enter one of the worst economic slumps in the history of the industry. But with this unforeseen event, a new chapter was opened. A page was turned. Once again, history has changed the subject, and congested airports were no longer an issue. Well, as I've said, we've about to come full circle. Airport capacity, not excess seat capacity, is about to become our most important future concern. It's time to renew all those old proposals that have been shelved for the past five years. Hinson, 1994, pp. 4-5).

One of the key proposals of the TRB, Mr. Hinson and others who deal with the problem of airport capacity is that the development of new airports is an

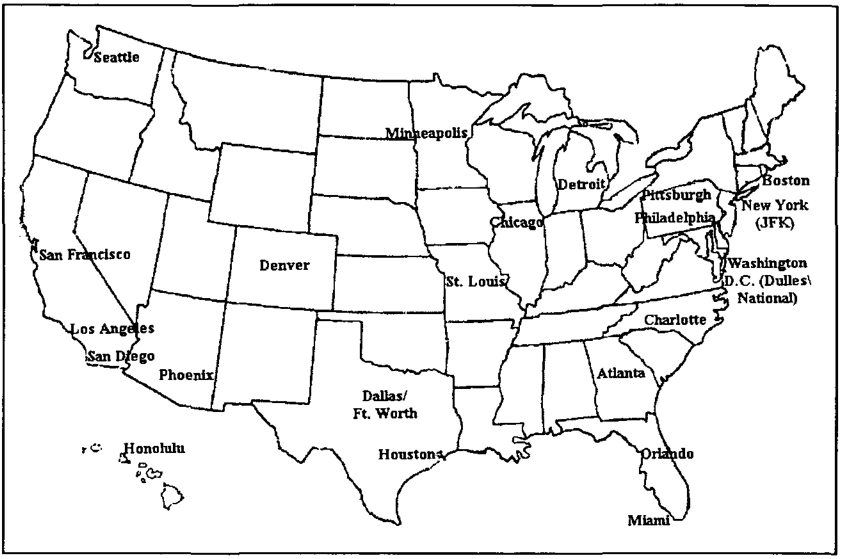

Figure 1. Transportation Research Board (TRB) 1990 list of 23 most congested primary airports

important strategy for solving the airport capacity problem. For example, the FAA stated in 1990, "Expanding capacity and access by encouraging new or expanded airports, runways, and roads, and preserving existing capacity through increased efficiency and productivity are preferred policy" (FAA, 1990, p.28).

Also, the Federal Aviation Administration notes in the 1997 Airport Capacity Enhancement Plan, "The largest NAS [National Aviation System] capacity gains result from the construction of new airports." (FAA, December 1997, p. 45).

This study goes on to describe why this is a difficult strategy to implement.

> However, given the high cost of airport construction (e.g. more than $4 billion for the new Denver International Airport, which opened in 1995) building a new airport is not a common capacity enhancement technique. Currently, no new airports with the potential to significantly impact NAS capacity are being constructed, with the exception of construction required to convert Bergstrom Air Force Base [Austin, TX] into a civilian airport (FAA, December 1997, p. 45).

Another federal government report further defines some of the problems facing the planners of airports in major metropolitan areas.

> One study suggests that beyond the year 2000 new airports will be required to maintain the quality of service available today. As iden-

> tified in several studies, the principal barriers to building new airports include aircraft noise, opposition from incumbent airlines at existing nearby airports, and the large investment needed to build in an already developed area. Our work on the new Denver airport confirmed that establishing new airports usually requires overcoming significant political and community opposition and having strong support from the anticipated user airlines (General Accounting Office, Feb 5, 1992, p.4).

In spite of all the problems in developing new primary airports, the TRB did identify ten metropolitan area locations (See Figure 2) with potential for adding operational capacity from new airports. They were: Chicago, Atlanta, Los Angeles Basin, Dallas - Ft. Worth, Denver, New York, San Francisco Bay Area, Miami, Phoenix - Tucson, and Boston (TRB, 1990, p. 39). Since that time, the new Denver International Airport has opened.

So what is the Federal response in the area of new primary airport planning? The Federal Aviation Administration has the responsibility for issuing the National Plan of Integrated Airport Systems (NPIAS) as a report to Congress pursuant to Section 47103 of Title 49 of the United States Code. As noted in this plan, "The NPIAS estimates the costs associated with establishing a system of airports adequate to meet the needs of civil aviation and to support the Department of Defense and the Postal Service" (FAA, 1995, p.17). In the most recent NPIAS, dated April 1995, the FAA lists five new, already built new primary airports (See Figure 3), and another six that still need to be built (See Figure 4).

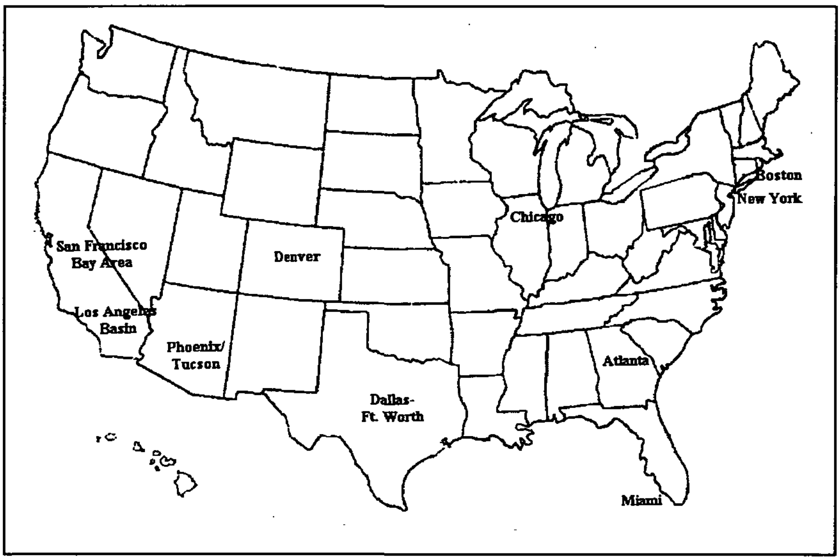

Figure 2. Ten metropolitan areas identified by TRB with potential for adding new primary airport (1990)

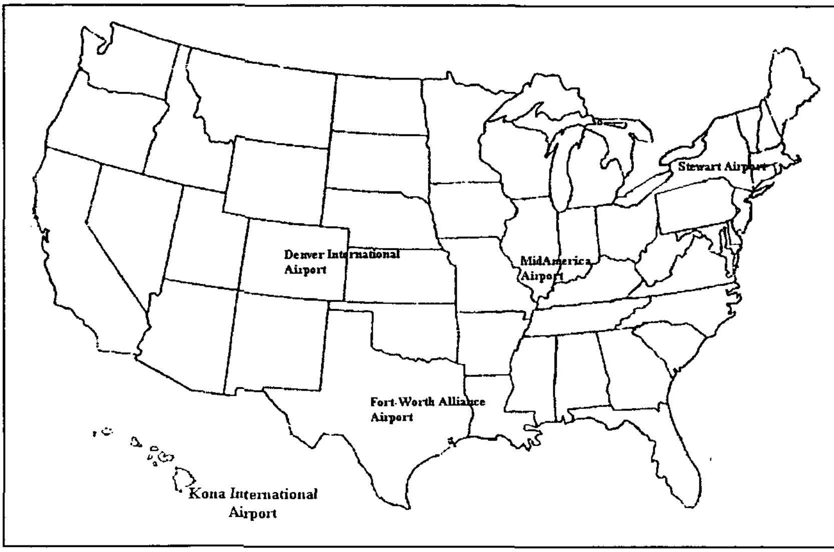

Figure 3. New primary airports opened in the past ten years (from NPIAS)

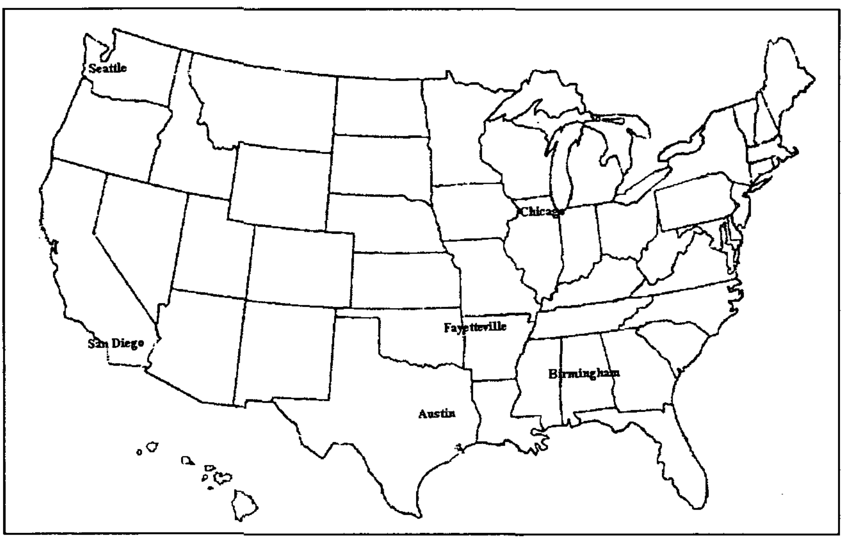

Figure 4. Proposed new primary airports in the current National Plan of Integrated Airport Systems

The Federal Aviation Administration also developed guidelines for the development of Metropolitan airport system plans in 1970, when they produced a joint publication with Airport Operators Council International entitled *Planning the Metropolitan Airport System* (May 1970). The purpose of that document was stated as follows.

> This document, then, is in recognition of the need for guidance in airport planning for the Nation's large metropolitan areas. A large metropolitan area is defined as one which has more than one publicly owned airport and can be expected to have at least 500,000 population or which generates annually over 250,000 scheduled airline enplaned passengers within the planning time frame. It is these large urban areas that are most significant in the national air transportation system. The principles set forth in this document can also be used, in part, for correcting immediate problems and identifying priority development requirements. (p.7)

This document also noted how important it was to coordinate metropolitan airport system planning with metropolitan-wide comprehensive land use and urban (ground) transportation planning.

> The airport system must be recognized as a key element in metropolitan planning and development, by virtue of its nature as a major consumer of urban land, a principal environmental influence, an important stimulant to intensive urban development, and a significant consumer of ground transportation services.
>
> All large metropolitan areas have some type of metropolitan planning agency carrying on a continuing comprehensive planning effort which aims to construct the framework for metropolitan development. Also, all large metropolitan areas have a specific urban transportation planning process dealing with ground transportation. The relationship between these two planning efforts varies from virtual separation to, in a few cases, complete merging.
>
> Since an airport is one of the most important public facilities in a metropolitan area, there is a need to mesh airport system planning with these other planning efforts. This merging or other lesser coordination of planning programs should take place during that organization phase of the airport system planning endeavor and should continue throughout the several stages of initial plan preparation, adoption, implementation, and continuing planning. (p. 4)

The general requirements for metropolitan planning are clear in their inclusion of multi-modal transportation planning:

> Process of development. The process for developing the plans and programs shall provide for consideration of all modes of transportation and shall be continuing, cooperative, and comprehensive to the degree appropriate, based on the complexity of the transportation problems to be addressed (23 USC Part134, paragraph a.4).

This MPO planning process may get to be even more specifically coordinated with airport operators according to a 1997 United States Department of Transportation policy proposal which states, in part the following guidelines.

1. The regional airport system should be planned and operated to provide the public with the safest and most efficient air transportation service possible and to ensure adequate capacity to accommodate current and forecasted aviation demand.

2. Airport planning and development within a metropolitan region should be conducted in cooperation with the metropolitan transportation planning process to ensure the best use of resources compatible with land use, general development, and surface transportation plans for the region.

3. Metropolitan planning organizations should develop and maintain organizational capacity in aviation planning including forecasting, demand analysis, environmental impact, ground transportation requirements, and economic impact.

4. Airport operators should be active and influential participants in the metropolitan transportation planning process through such mechanisms as technical advisory committees and metropolitan planning organization policy boards to ensure maximum consistency between surface and aviation plans.

5. Local governments and airport operators are encouraged to make optimal use of exiting regional airport and aviation facilities and capacity in meeting current and future air transportation demand, and to plan for additional airport and aviation facilities and capacity as, when and where future transportation demand warrants. (p. 3)

METHODOLOGY

The Survey was suggested by a study completed by the Committee for the Study of Long-Term Airport Capacity Needs of the Transportation Research Board entitled *Airport System Capacity: Strategic Choices* (1992). Survey participants included those Metropolitan Planning Organizations where the twenty-three most congested airports are located as identified by the TRB study (See Figure 1). Of those twenty-three airports, twenty metropolitan planning organizations (MPOs) were identified from a list provided the Association of Metropolitan Planning Organizations on the World Wide Web (www.narc.org/ampo/). The addresses for possible MPOs in the Charlotte, Orlando and Pittsburgh regions were not accessible to the researchers at the onset of the study. Therefore, only twenty MPOs were surveyed out of twenty-three identified by the TRB study.

A survey instrument was composed of twelve questions. The first three questions inventoried the MPO name, region covered, and in what year the airport system plan for the MPO was updated. The second section of the questionnaire had three main objectives. The first objective was to find out if the airport system plan for the MPO's region recommended that a new primary airport be built within the next twenty years. The second objective was to determine what alternative the system plan had recommended instead of building a new primary airport. The third objective was to ask the participants to rank certain factors in the order of importance to their respective region in selecting a new primary airport site regardless if such an airport is included in their twenty-year plan. The final objective was to ask the participants to list any new primary airports that have been opened in their region since 1970 and to list any additional comments they might have.

The questionnaire was mailed to twenty Metropolitan Planning Organizations. However, if airports were not part of the local MPOs planning functions, the questionnaire was then passed on to the respective planning authority responsible for airports in that area (Honolulu - Hawaii DOT, Boston - Massachusetts Port Authority, and Miami - Miami International Airports Planning Office). The addresses of the MPOs were obtained from the Association of Metropolitan Planning Organization's web page. The first mailing produced ten responses for a response rate of 50 percent. A second mailing was then conducted resulting in eight more responses for a total of eighteen responses, an overall response rate of 90 percent.

RESULTS

Of the twenty metropolitan areas sent a questionnaire, only two (North New Jersey Transportation Planning Association and San Diego Association of Governments) did not respond. Of those responding, the majority (60 percent) reported that the airport system plan for their respective metropolitan area had been updated in the last five years. Of these, three (Detroit, Honolulu, and New York) updated this year. At the other end of the spectrum, two metropolitan areas (Chicago and Washington-Baltimore) had not updated their airport system plan since 1984 and 1988, respectively (See Figure 5 and Table 1).

In response to one of the key questions in the survey, "Does your airport system plan recommend that a new primary airport be built with in the next twenty years?" two responded yes. Those responses came from the Southern California Association of Governments representing all of Southern California except San Diego County, and the Atlanta Regional Commission, representing the City of Atlanta and the ten surrounding counties (See Figure 6). Both MPOs responded that the time frame for implementing this recommendation would be in the range of five to ten years from now (2003-2008 timeframe). The Southern California Association of Governments states that the primary reason for the new primary airport is passenger demand/terminal - gate capacity. In the case of the Atlanta Regional Commission, the reason is aircraft operations demand/capacity. When asked if the sponsoring agency would be the same for the new primary airport as

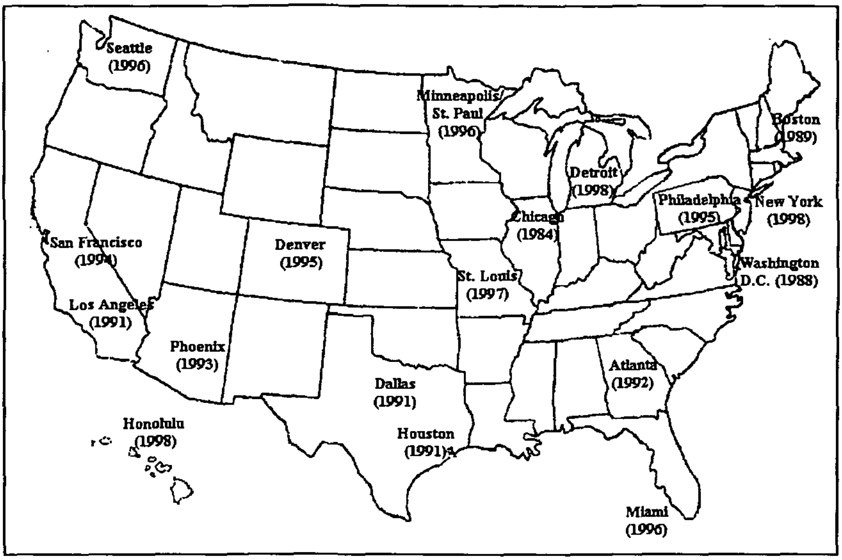

Figure 5. The year in which the MPO Based Airport System Plan was last completed, by respondent (N = 18)

Table 1
Year current MPO Airport System Plan was Complete
(N = 18)

	Number	*Percent*
1990 or before	3	17
1991	3	17
1992	1	5
1993	1	5
1994	1	5
1995	2	12
1996	3	17
1997	1	5
1998	3	17
Total	18	100

for the existing primary airport only the Southern California Association of Governments answered yes.

A total of eight MPOs indicated that new primary airport studies were conducted by agencies **other than the MPO** since 1990. The MPO areas affected by these studies, are Atlanta, Boston, Chicago, Los Angeles/Orange County, Minneapolis-St. Paul, Phoenix, St. Louis, and San Francisco/Oakland (See Figure 6). The Boston MPO indicated that a study of a new primary airport conducted in the early 1990s concluded that no new primary airport was needed. The Chicago area MPO indicated that extreme controversy exists related to

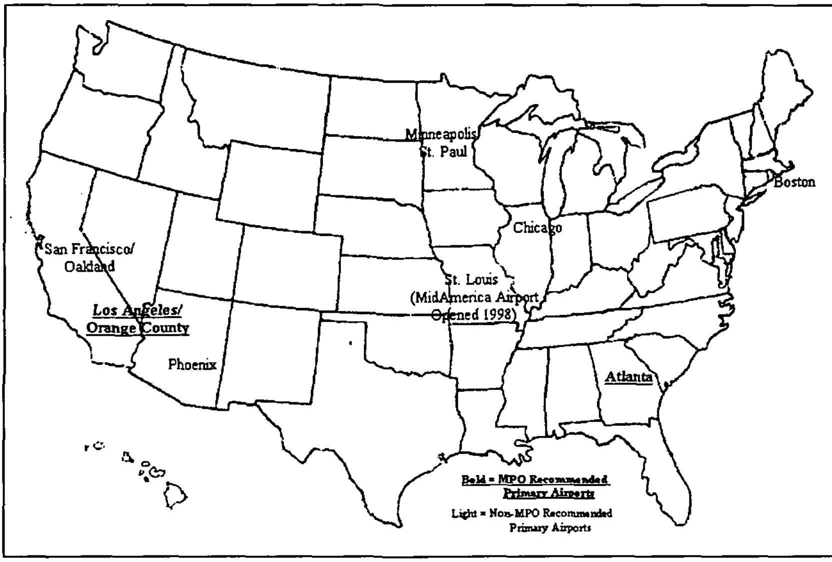

Figure 6. New primary airports studies in MPO areas conducted by non-MPO agencies and MPO-recommended new primary airports

planning for new primary airports in the Chicago area due to policy differences between the Governor of Illinois and the Mayor of the City of Chicago. The Illinois Department of Transportation has proposed a new primary airport in the far southern suburbs but the City of Chicago opposes this airport. Note also that two of the metropolitan areas (Atlanta and Los Angeles) with studies by agencies other than an MPO also were identified in MPO-sponsored airport plans as areas needing a new primary airport.

If a composite of the four sources of new primary airports in metropolitan area is created from the list of primary airports under study, those recommended by MPOs, those in the NPIAS, and those identified as potential by TRB are put into one table, the result is as shown in Table 2. As can be seen in this table, there is little or no agreement among all four lists. Only three areas (Atlanta, Chicago, and Los Angeles) are mentioned in three of the four lists. Finally, two of the four lists mention Boston, Phoenix, and San Francisco-Oakland / Bay area.

The next question on the survey instrument asked the MPOs that did not recommend a new primary airport what was recommended **instead** of a new primary airport. The results, as noted in Figure 7, note that four MPO's (27 percent) answered Expand one existing, main primary airport.

This response goes along with the parallel federal policy to invest heavily in the **existing** primary airports. This policy is reflected in both the FAA's *Aviation Capacity Enhancement Plan*, which is exclusively focused on **existing** primary airports and the in the FAA's National Plan of Integrated Airports (NPIAS). Another MPO (Detroit area) indicated they would expand one existing satellite airport in their region. A total of eight MPOs or 53 percent of respondents com-

Table 2
New Primary Airports List

1990 TRB List of Ten Metro Areas with Primary Airport Potential	*1995 NPIAS New Primary Airport List*	*Survey Results: New Primary Airports Actively Under Study By non MPO Agencies*	*1984-1997 MPO-Sponsosred Airport System Plans with New Primary Airports*
Atlanta	-	Atlanta	Atlanta
Boston	-	Boston	-
Chicago	New supplemental	Chicago	-
Dallas - Ft. Worth	-	-	-
Denver	(DIA Opened)	(DIA Opened)	-
Los Angeles Basin	-	Los Angeles/Orange County	Los Angeles Basin
Miami	-	-	-
New York	-	-	-
Phoenix - Tucson	-	Phoenix	-
San Francisco Bay Area	-	San Francisco-Oakland	-
Others:	*Others:*	*Others:*	*Others:*
None	Birmingham	St. Louis, MO (Mid-America opened)	None
	Fayetteville, AR	Minneapolis - St. Paul, MN	
	San Diego, CA		
	Austin, TX		
	Seattle, WA		
(See Figure 2)	(See Figure 4)	(See Figure 6)	(See Figure 6)

bined the two previous options by answering that they would combine the expansion of exiting primary airports with the expansion of existing satellite airports. These MPOs are: East/West Gateway Coordinating Council (St. Louis area), Maricopa Association of Governments (Phoenix area), Metropolitan Council (Minneapolis/St. Paul area), Metropolitan Transportation Commission (San Francisco/San Jose/Oakland area), Miami-Dade Aviation Department (on behalf of Miami Region), North Central Texas Council of Governments (Dallas/Ft. Worth area), New York Metropolitan Transportation Council and Oahu MPO (Honolulu area). Finally, two other MPOs (Houston area and Washington D.C. area) responding to the survey indicated that they would each expand **three** airports to meet future primary airport needs.

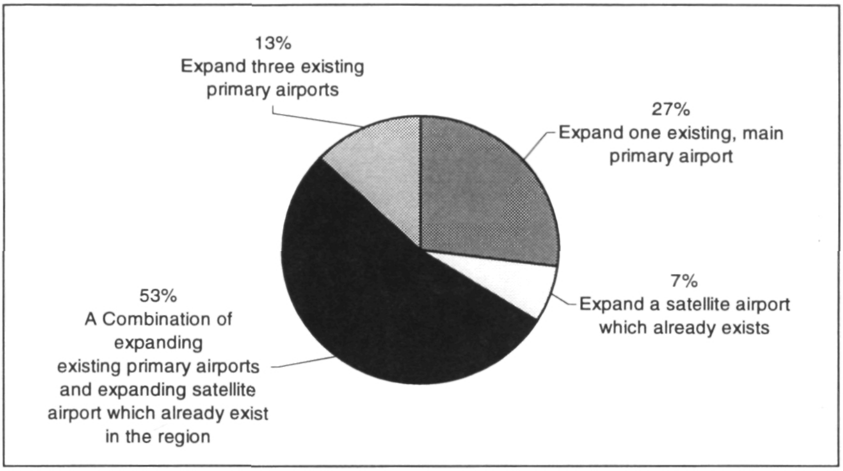

Figure 7. Alternatives to building new primary airports

So, why are so few MPOs stepping up to the challenge to build all-new primary airports? One answer would be the significant barriers that face the planners of a new primary airport within a busy, congested metropolitan area. Sixteen of the eighteen respondents ranked a number of important factors in selecting a new primary airport site. Four factors, access to customers, suitable site/topography, land use/noise compatibility and airspace, were ranked significantly above all of the other factors (See Figure 8).

CONCLUSIONS

One of the key conclusions to be made from the data collected on this study is that, while MPOs are doing significant amounts of metropolitan-wide airport system planning, only two of eighteen (11.1 percent) respondents reported that the MPO-generated airport system plan included a new primary airport. This mean that nearly 90 percent of the respondent MPOs - representing nearly 80 percent of the top 23 busiest primary airport in the nation - are NOT planning for a new primary airport. The reasons for this are revealed in the data concerning the most important factors in selecting a new primary airport site. A total of 90 percent to 95 percent of MPO respondents, identified the following as the top three such factors:

- Access to Customers/Passengers (90 percent)
- Compatible Land Use (90 percent)
- Suitable Site in Terms of Topography (95 percent)

These three reasons point to the difficulty of finding a large land area for a primary airport that is accessible to customers, suitable to build a primary airport on, and in a location that would be compatible to its neighbors.

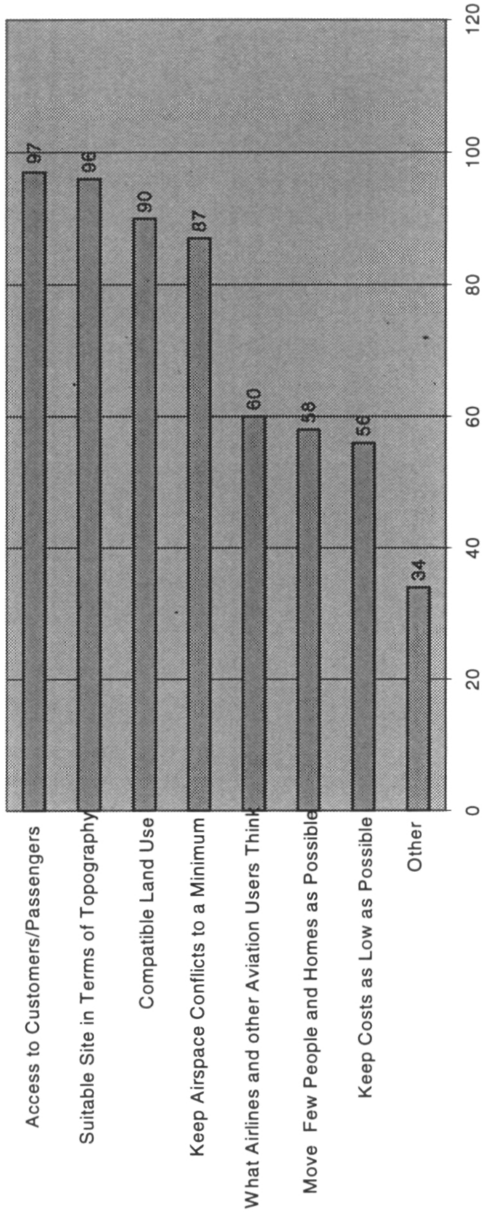

Figure 8. Most important factors in selecting a new primary airport site

The data from the survey also show that, even though most MPOs have not included a new primary airport in their most recent airport system plan, eight **other** entities **have** included primary airports in MPO areas in their plans. This indicates two likely scenarios: (1) There is a need for, and the possibility of, **greater numbers of new primary airports** in major metropolitan areas than is reflected in MPO-generated airport system plan; and/or, (2) It is difficult for MPOs to tackle large issues like a new primary airport in their airport system plans unless there is consensus on the topic.

Another interesting conclusion reached after receiving the survey data and comparing them to the FAA's NPIAS is that the only MPO area with a recommended primary airport common between the survey results and the NPIAS is Chicago. And, in the instance of Chicago, it is an entity **other than the** MPO which is recommending the new primary airport. Another way to put it is that the two MPO-recommended new primary airports (Atlanta and the Los Angeles Basin) do **not** appear on the latest NPIAS as recommended new primary airports. Technically, this means that, until the NPIAS is amended, the new primary airports in Atlanta and Los Angeles are **not** eligible for Federal AIP funding. However, the two MPO-recommended primary airports **do** match to the 1990 TRB list of metropolitan areas with primary airport potential.

An interesting and unexpected aspect of the data generated by this study is the data regarding the somewhat dated nature of MPO-based airport system planning in general in the U.S. For example, there are three existing airport system plans that are nine years old, or older:

MPO Name	*Year MPO Airport System Plan was Updated*
Boston MPO	1989
Chicago Area Transportation Study	1984
Metropolitan Washington (D.C.) Council of Governments	1988

There are an additional five MPO-based Airport System Plans which are five years old or older. These means 44.4 percent of the respondent's plans are five years old or older. One of the MPOs in this later group alluded to one of the issues facing some MPOs in the process of trying to do MPO-based airport system plans:

> After many attempts to secure additional planning funds from the FAA to do Aviation planning in the region since 1991, we have decided to quit wasting our time. There is an individual in the regional office of FAA who does not believe in planning and is the principal stumbling block to any MPO in Texas receiving planning funds. In the meantime, the State DOT provides an adequate job in serving the general aviation community and the primary airports deal directly with the FAA.

Finally, it is not always possible for an MPO to create an MPO-generated airport system plan for a metropolitan area. For example, it was obvious that airport system planning is handled vastly differently from one MPO to another based on the way in which the survey instruments from several MPOs were forwarded to non-MPO agencies for a response. These included Boston, New York-New Jersey, Honolulu, and Miami. The MPOs in these areas believed that the MPO did not have the expertise or manpower to complete a survey related to MPO airport system planning, and, therefore the questionnaire was forwarded to another agency with the expertise or manpower.

Overall, it is clear that MPO-based airport system planning provides an important vehicle for airport planning at the sub-state level, especially in densely populated metropolitan areas. However, it is also clear that MPO-based airport system planning can not be considered to be a significant original source of plans for all-new primary airports in metropolitan areas. Plans for new primary airports in metropolitan areas seem to be generated first at other levels and, once the plans are clarified and obtain broad-based support, they can be expected to be included in MPO-based airport system plans.

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THE EFFECT OF CORPORATE INFLUENCE IN THE SHORT HAUL BUSINESS TRAVEL MARKET

413/16

Keith J. Mason
Cranfield University Bedfordshire, UK

ABSTRACT

The importance of corporate involvement in the decision making process for business related air travel is being increasingly recognised in the literature. Business travellers consume air services (i.e. they take airline flights), however; they may not be the principal decision-maker in the purchase. Also it is the organisation that employs the traveller that incurs the cost for air travel. Consequently this research addresses the relationship between the traveller and the employing organisation in the purchase of air travel. In this paper traveller opinions on their corporate travel policy are evaluated using a Likert summated rating scale. The benefits sought, by the traveller, from the air service are also investigated and these benefits are used to segment the short haul business air travel market in the EU. Changes in the market for short haul business travel since the full liberalisation of the aviation market in the EU are evaluated by comparing the data to an earlier study of similar travellers in 1992.

INTRODUCTION

The importance of corporate involvement in the decision making process for business related air travel is being increasingly recognised in the literature. Business travellers consume air services (i.e. they take airline flights), however; they may not be the principal decision-maker in the purchase. Also it is the organisation that employs the traveller that incurs the cost for air travel. Consequently this research addresses the relationship between the traveller and his/her employing organisation in the purchase of air travel.

In this paper traveller opinions on his or her corporate travel policy are evaluated using a Likert summated rating scale. The benefits sought, by the traveller, from the air service are also investigated and these benefits are used to segment the short haul business air travel market in the EU. Changes in the market for short haul business travel since the full liberalisation of the aviation market in the EU are evaluated by comparing the data to an earlier study of similar travellers in 1992.

The author would like to thank Elaine Argent of Air UK ltd. for her help in obtaining authorisation to survey passengers at Stansted airport, and David Edwards who assisted in the collection of the data.

The common notion of business travellers is that they tend to travel more frequently than leisure travellers and they tend to pay higher prices for these services. The business travel sector of the market is prepared to pay higher fares as it is the company and not the individual traveller that bears the cost of the travel. This cost is then subsumed within the costs of the business. Airlines, not surprisingly, value this segment of the market very highly. Airlines can practice price discrimination in fare structures as business travellers have been prepared to pay higher fares to ensure travelling flexibility (i.e. to be able to change their flight bookings freely should, say, a business meeting run-over). In the domestic U.S. market about 50 percent of passengers are travelling for business purposes, however, this market represents two-thirds of passenger revenues (Stephenson, and Bender, 1996). In the EU the passenger number figure may be as high as two-thirds (Doganis, 1991), indicating the revenue figure would be even higher. The business travel market is, therefore, very important to the EU airlines.

The airline industry in the EU until recently has been one in which operators face very little competition. Bilateral agreements between national governments within the EU had ensured that most routes were only served by two airlines. Duopolistic arrangements ensured that consumers were given little choice of airlines, schedules, and prices. The market for short haul air services in the European Union has experienced a period of major change since 1990 when the first effective initiatives to liberalise the market were introduced. The final elements of a single market for airline services, completed in April 1997, has created an regulatory regime where any airline can offer any route within the EU at any price. Evidence suggests that increasing competition can have a significant effect on the market. Studies indicate that when more than two airlines operate on a particular route, tariffs and yields fall significantly, although there tends to be an increase in passenger numbers stimulated by the falling prices (Barratt, 1991; Doganis, 1994). The number of routes where more than two airlines operate has been small (only 2 percent of European routes in 1992) but changes in the industry can be observed. A number of marketing agreements and alliances have been created between short haul operators and larger transcontinental operators in a bid to gain from potential economies of scale and scope, and marketing benefits (e.g. increased interline business through code-sharing agreements, and shared frequent flier programmes) (Williams, 1993, Doganis, 1994). Opportunities to use the tariff as a competitive tool have been taken by a number of start-up airlines. Fourteen new carriers of this nature begun operations between March 1995 and September 1996 (Jones, 1996). These no-frills, low-cost operators can offer lower prices because of the following reasons:

- sell directly to passengers, thereby avoiding travel agency commissions;
- tend not to offer flights through a computer reservation system (CRS) thereby avoiding these costs;
- tend not to offer in-flight food, seat assignments, and interlining;

- outsource as many services as possible; and
- operate from uncongested airports with low charges (Whittiker, 1998).

The concept has proved to be sufficiently popular in the U.S. that major operators have introduced their own low-cost subsidiaries to halt declining market-share. In what can be seen as a similar move, British Airways has also announced its plan for a low-cost subsidiary operating in Europe.

As the supply side of the airline industry with the EU changes, airlines need to assess whether the factors of demand for their services will also change. If the principal concerns of business travellers are having fully flexible tickets, free in-flight food and beverages, and the opportunity to earn points on frequent flier programmes, then increased choice, and reduced tariffs in the traditional market and the introduction of low-cost operations will not greatly affect the business travel sector of the short haul market. If, however, the lack of airline and schedule choice and the non-availability of heavily discounted fares has meant that the market has been required to pay higher fares then a re-assessment of the attitudes and likely future behaviour of the market is appropriate. This paper, therefore, is concerned with investigating the business travel market.

THE BUSINESS TRAVEL MARKET

The behaviour and attitudes of the business travel market has been the focus of a number of recent studies. The most substantive and comprehensive of these studies is the Stephenson and Bender's analysis of the U.S. business travel market (1996). From a noted reduction in the proportion of business related travel in the market from 55 percent in 1979 to 48 percent in 1993, the authors dismiss this reduced proportion as the result of an increase in non-business related travel and investigate the reasons for the reduction in business travel, attempt to determine the effect of air travel substitution by other modes of travel and increased use of telecommunications such as videoconferencing and the internet. The paper is based on two studies; one of 421 corporate travel managers and one of 701 business travellers as part of the 3,061 people surveyed as part of a national travel study. They found that the demand for business related air travel was reducing. This finding was supported by both travel managers and the travellers. They conclude that the primary reason for reduction in business travel is both companies and travellers frustration with high airline prices, and internal corporate pressure to reduce travel expenditure. Evidence was also given for significant substitution by other modes and also alternative communications methods.

The cost of business travel traditionally has been viewed as being not important as the employing company bears the cost. In Stephenson and Bender's (1994) study it is not surprising that cost is identified as being important as they survey corporate travel managers. Corporate involvement in the business travel market has been somewhat limited in the academic literature but more acknowledged in commercial studies of the industry.

Quoting figures from the American Express Travel & Expenditure Expense Survey, Bourne (1991) notes the growth of large companies employing travel managers. For UK companies, this figure had grown from 11 percent in 1986 to 42 percent in 1991. Skapinker (1992) notes pressures by companies on both their travelling employees and on their travel agents to reduce the cost of travel by down-grading (forcing business travellers to travel on economy tickets) and also to evaluate in a more systematic way the purpose and value of travel.

Although liberalisation is leading to more competition, some evidence indicates that its overall effect on cost is not downward. In 1996, spending on travel via the Guild of Business Travel Agents who handle about 75 percent of UK corporate travel increased by 17 percent, while the number of flight increased by 8.5 percent (Cohen, 1997). The author then argues that strong involvement in the management of travel expenditure is vital by corporations that have large travel costs.

Another UK based study of corporate travel (Cook, Davies, and Haver, 1994), undertaken by the University of Westminster, indicates some of the ways that corporations are involved in the business travel market. A survey of 128 companies revealed that 77 percent had a written travel policy, but that 70 percent of these policies granted travel choice discretion to travelling executives. However 20 percent were looking to reduce this choice in future. Indeed IATAs 1997 Corporate Air Travel Survey showed that 70 percent of business travellers were willing to try "no-frills" airlines (IATA, 1997).

Corporate involvement in the purchase of business air travel can be in seen in a number of activities. Travel policies either written or unwritten may be used to influence choice of airline, and fare type thus reducing cost. Travel managers or travel departments may be involved in the selection and purchase process of airline tickets. Travel management may include bulk purchasing deals from preferred airlines thereby influencing future travel choices. Travel managers may use their travel agent to find the airline ticket, which gives them the greater perceived value for money.

Individual travellers may be adverse to corporate influence in their travelling behaviour. Corporate choices may be contrary to the preferred choice of the traveller if the traveller is a member of a frequent flier programme (FFP), or if the choice of airline is perceived to reduce the travelling comfort, flexibility, status, or convenience. A number of studies have tried to assess the effectiveness of FFPs to influence airline choice. One empirical study of the U.S. market concluded that FFPs have a significant effect on airline choice (Nako, 1992). This view is partially supported by a study of Australian business travellers. Browne, Toh, and Hu, (1995) found that membership of a FFP was a factor considered by travellers in the purchase decision but not one as important as on-time performance, schedule convenience or low fares. Gilbert (1996) concludes that the proliferation of FFPs and the build-up of unredeemed rewards have affected the effectiveness of these schemes.

Mason and Gray (1995) argue that corporate involvement in the business travel purchase decision is sufficiently important that the market should be treated for marketing purposes as a hybrid market, displaying characteristics of both consumer and industrial markets. A stakeholder model of the purchase decision process is used to analyse the market. They identify three stakeholders in the purchase of air travel; the traveller, the travel organiser and the employing organisation, and argue that each stakeholder will have a set of purchase benefits. The actual purchase benefits sought will be based on the competition between the stakeholders. A sample of 824 business travellers is segmented into three distinct market groupings based on the key purchase benefits and demonstrate that these groupings are affected by corporate involvement in the purchase decision.

This brief consideration of the demand side of the business travel market has shown that the validity of the high consumption, high yield airline passenger is questionable, and that traveller choice may well be influenced by corporate involvement in the purchase. This, combined with the changing supply side of the industry, suggests that further investigation of the business travel market is required so that marketing strategies may be based on a sound understanding of the factors that affect the market.

METHODOLOGY

To investigate corporate influence in the EU short haul business travel market a quantitative survey was undertaken. The survey was administered in Stansted in the UK over two separate periods. Agreement to survey passengers was gained from Air UK Ltd. that operates the largest number of flights from this airport. The survey was carried out over three days in April 1997 and five days in November 1997. A scale of traveller attitudes towards corporate travel policies was included. Behavioural data regarding the traveller, the travel organiser and the employing organisation were collected. An attitude scale of business traveller purchase benefits previously developed by the author (Mason, 1995) was included to evaluate the importance to travellers of various product elements. An earlier survey of business travellers was undertaken at the same airport on the same target sample in 1992. Thus the new survey provided data to enable an examination of the reliability of this scale, and will allow the investigation of changes in the market over a five-year period. One thousand self-completion survey forms were distributed to short haul international and domestic travellers of which 450 useable survey forms were collected. This represents a 45 percent response rate for distributed survey forms, which is similar to the response rate achieved by Stephenson and Bender (1996) in their Corporate Travel Manager study. Analysis of the passenger figures during the survey period indicates that the sample represents about 5 percent of all Air UK travellers (both leisure and business) from this airport during the survey periods. The sample size allows an estimate of average number of trips to be calculated with 95 percent confidence within a 1.5 trip interval. Although this does not meet a preferred 1-trip confidence interval as achieved in the earlier survey (Mason & Gray, 1995) this sample is deemed to be acceptable.

Demographic data about the respondent and his or her company were collected. Also collected were data about the respondent's travelling behaviour including the number of trips taken in the past twelve months, how the flight was selected, and booked, and whether the respondent's employing company had a corporate travel policy (CTP) or a travel manager or department. Fifteen attitude statements about corporate travel policies were developed through the views about travel policies comments reported in various trade journals and also from asking a number of business travellers their views about such policies. The most extreme and some fairly neutral comments were kept for inclusion in the survey. These comments were both positive and negative, and are included in Appendix I. Attitude statements regarding twenty-five product attributes were also included in the survey. This list (see Appendix II) is similar to the list included in the earlier survey and reported in Mason and Gray (1995). The authors indicated that repeated survey administration and comparison would provide data to evaluate the validity of the results of the first study and this study will serve this purpose.

RESULTS

A demographic profile of the respondents did not reveal any surprises. The sample was predominately male (90.3 percent), with the vast majority working in senior roles in their respective organisations. Nearly one-fifth of the respondents indicated that they were company directors, a further one third worked as senior managers, while another one-quarter worked in other management positions. Together this means that 86.9 percent of the respondents fell into the A or B social stratifications. An age profile of the respondents shows business travellers tend to be in middle age with 36.3 percent aged between 35 and 44, and 40.8 percent aged between 45 and 64.

The respondents worked in many different industries and from very small to very large companies. The majority (64.1 percent) of respondents worked in services industries of various types. 27.9 percent of the sample were employed in the manufacturing sector while extractive industries accounted for 19.7 percent of business travellers in the sample. The author believes that the large extractive industries sector is partially influenced by the routes offered by Air UK at Stansted. The east Scottish coast and Stavanger in Norway, both that have significant oil sectors, are both important destinations for Air UK at Stansted. However the large services sector is surprising. One-fifth of the respondents worked for small companies with less than 100 employees. Another 23.2 percent of the sample worked in medium size companies (up to 1000 employees), and the remaining 57.0 percent of the sample worked for companies with more than 1000 employees.

The respondents on average made 19.75 business trips per annum. This may be compared to the figure found in the earlier survey which was 16.61 (Mason, 1995). Assuming the sample to be normally distributed (although it is slightly skewed), the amount of trips made by business travellers in 1997 is significantly higher than in 1992. This results provides some evidence to the on-going importance of the business travel market in the EU and distinguishes this market from the U.S. market where Stephenson and Bender (1996) provide evidence that the market seems to be travelling less. EU short haul business travellers make fairly short business trips. A total of 30.1 percent of the sample were making a day return, with a further 28.1 percent staying just one night. A majority (91.3 percent) of all respondents made trips of no more than two nights away. Respondents, on average were members of 1.99 frequent flier schemes. Free flights were the main benefit claimed from membership of such schemes with, on average, each respondent redeeming 1.03 free flights during the preceding twelve months. This benefit seems about three times more popular than free upgrades, of which 0.34 were claimed by respondents during the year on average.

Business travellers collect information about available flights from three key sources: 40.1 percent of respondents made travel agency enquiries, while 19.0 percent used in-house travel managers or departments to find out about available flights, and 27.7 planned their flights using airline printed schedules. The large amount of flights taken by the sample would infer that travellers become familiar with the available airlines operating from a particular airport and may collect printed schedules directly from the airline. The majority of flights (71.0 percent) are booked through specialist business travel agents, with a further 10.9 percent of flights booked directly with the airline.

The majority (64.0 percent) of short haul business travellers still select their own flight. This figure, however, is significantly lower than the figure in the 1992 survey where 69.8 percent or travellers selected their own flights. Business travellers it would seem are becoming less involved in the purchase decision for air services. This reduced involvement may be explained by greater corporate involvement in the market.

Almost half (42.7 percent) of respondents worked for companies that either employed a travel manager or had a travel department (this figure has risen from 36.3 percent in 1992), and 70.7 percent worked for companies that had a corporate travel policy (60.3 percent in 1992).

The survey does provide some evidence that fewer companies provide their travelling executives with full-fare fully flexible travel. Only 14.4 percent of the sample were travelling on full-fare tickets while this figure was 25 percent in 1992. This figure cannot be fully off-set by a rise in the proportion of travellers that do not know the fare type they are travelling on (29.3 percent, as opposed to 25 percent in 1992), but the fact that such a large proportion of travellers do not know what type of ticket they hold indicates low involvement in the purchase.

This brief analysis shows that business travellers seems to be becoming less involved in the selection and booking of airline services, while travel managers and travel department have an increasingly important roles to play in this area. The effect of corporate involvement is having some identifiable effect on the selected airline service, where the effect is tending toward cost reduction rather than increased traveller flexibility.

An Attitude Scale for Corporate Travel Policies

A Likert summated rating scale was used to assess business traveller attitude towards corporate travel policies (CTPs). Fifteen attitude statements, some positive and some negative in nature, were developed for use on the scale. Respondents were asked to indicate their level of agreement with each of the statements on a five-point scale, from "strongly agree" to "strongly disagree". Statements that were positive about CTPs were scaled from five for "strongly agree" to one for "strongly disagree," and vice versa for negative statements. A total attitude score for each respondent was calculated by totalling the individual item scores. Therefore the range of potential scores on the total scale was between 15 to 75. The mean score was 50.06 with a standard deviation of 6.21. The lowest score, i.e. most opposed to CTPs, was 27 and the highest 72. The scores were normally distributed, and to assist in the analysis of the scale respondents were divided into three equal groups; respondents against CTPs, respondents with neutral attitudes towards CTPs, and those with positive attitudes towards CTPs. A correlation of the summated scores with the scores given for each individual item shows the statements in the scale that most discriminated between respondents attitudes. These state.

"CTPs are a good idea" ($r^2 = 0.6036$)
"CTPs are a constraint which serve no great purpose" ($r^2 = 0.6395$)
"CTPs are a hindrance when planning a business trip" ($r^2 = 0.6399$)
"CTPs tend to infringe on employment travel benefits" ($r^2 = 0.6588$)

A chi-square test of independence was used to identify which demographic and behavioural variables influenced respondent's attitudes towards CTPs. Table 1 below provides a tabulation of variables that were shown, at the 95 percent level, to influence respondent attitude to CTPs.

The table shows that business traveller attitudes towards CTPs are influenced by the size of company that he or she works for. Almost three-fourths (70.6 percent) of respondents who had positive attitudes towards CTPs worked for companies with more than 1000 employees. Compared to the proportion of the respondents with negative attitudes towards CTPs, less than one-half (47 percent) worked for companies with more than 1000 employees. A larger proportion of the group with negative attitudes towards CTPs worked for small companies with less than 100 employees compared to the positive group (35.0 percent compared to 11.8 percent). It would seem therefore that business travellers who work for larger companies are more likely to have positive attitudes towards CTPs.

Table 1
Business Traveller Attitudes Towards Corporate Travel Policies

	Anti-CTPs (percent) 33 Percent of Sample	*Neutral to CTPs (percent) 33 Percent of Sample*	*Pro-CTPs (percent) 33 Percent of Sample*
Company size			
1-99 employees	35.0	13.4	11.8
100-999 employees	17.9	28.6	17.6
1000 employees or more	47.0	58.0	70.6
Company has a CTP			
Yes	55.2	84.7	93.2
No	44.8	15.3	6.8
Company has travel manager or department			
Yes	33.1	49.6	57.1
No	66.9	50.4	42.9
CTP type			
Written rules to be adhered to	20.0	25.7	35.7
Written guidelines	46.3	50.5	46.4
Written rules open to interpretation	13.8	5.7	7.1
Unwritten rules	20.1	18.1	10.8
Respondent selected own flight	70.9	65.2	63.1
Source of flight information			
ABC, OAG etc.	9.6	9.2	12.5
Airline produced schedule	28.9	36.8	16.1
Travel agent enquiry	51.8	25.0	44.6
Travel manager/Department enquiry	9.6	28.9	26.8
Flight booked by:			
Traveller	30.0	16.2	14.4
Traveller's department	29.1	39.6	32.4
Travel manager/Department	25.5	34.2	36.9
No of trips in last year			
1-5	48.1	53.2	30.9
6-10	26.9	25.2	32.7
more than 10	25.0	21.6	36.4

Business traveller attitudes towards CTPs may be partially explained by knowledge of CTPs based on their experience of working with them. Almost all (93.2 percent) of the group with positive feeling towards CTPs worked for companies with CTPs, whereas only 55.2 percent of the group with negative attitudes did. Those that were anti-CTPs were more likely to select their own flight (70.9 percent), while those with a positive attitude towards CTPs were more likely to allow others for select their flight (36.9 percent did not select their flight). This behaviour may be explained by the frequency with which each group travels. The results show that the negative group had made fewer trips in the last year compared to the positive group.

The presence of a travel manager or department within a company seems to have some effect on business travellers' opinions regarding CTPs. Over one-half (47.1 percent) of the positive group worked for companies that employed travel managers, while this figure was only 33.1 percent for the negative group.

It is surprising that, when questioned about the nature of the CTP employed in their company, a larger proportion of the group positive about CTPs indicated that their CTPs was quite rigid with written rules to be adhered to. About one-half (46.3 percent) of all respondents, however, indicated that the CTP under which they make business trip are written guidelines. This may be compared to the results in Table 2 (below) which shows a cross-tabulation of respondent attitudes towards CTPs and the class of travel accorded to those at different corporate levels within the employing company. It would seem that, while the proportion of traveller allowed to fly on business class increases with corporate status in all groups, the hierarchical bias is most obvious in the group of travellers that hold negative feeling towards CTPs. Business traveller attitudes towards CTPs may be most affected by companies that create travel policies that favour those at the top of the corporate hierarchy.

Table 2
Hierarchical Corporate Travel Policies and Business Travel Attitudes

	Anti-CTPs (percent)	*Neutral to CTPs (percent)*	*Pro-CTPs (percent)*
Flight allowance for various hierarchical levels in respondents company			
Company Directors			
Business Class	52.9	67.9	64.3
Economy Class	47.1	32.1	35.7
Senior Management			
Business Class	36.7	46.4	44.8
Economy Class	63.3	53.6	55.2
Other Management			
Business Class	15.5	18.7	30.1
Economy Class	84.5	81.3	69.9

Table 1 also shows differences between the groups in terms of the way in which they find out flight information and book their flights. The negative and positive groups were most likely to source flight information from travel agents (51.8 and 44.6 percent respectively), while the neutral group was more likely to make enquiries on in-house travel managers or departments or airline produced schedules. The positive group was also much less likely to book the flight themselves, relying more heavily on others in their departments or in-house travel departments.

The analysis of the scale of traveller attitudes towards CTPs shows that company size obviously will affect the likelihood of a company employing a travel manager or having a CTPs and thus it would seem that marketing approaches for different size of company may be appropriate. The evidence provided here shows that corporate involvement in the air service purchase is greater in larger companies, and it would seem that these travellers on the whole are positive or at least neutral about this involvement.

Business Travel Market Purchase Benefits

Each respondent rated the importance of each of twenty-five product elements on a 5-point ranked continuum scale. Principal component analysis of the twenty-five purchase benefit elements was performed to identify any underlying purchase benefits. The data performed well under test of sampling adequacy (KMO = .82848) and sphericity (Bartlett = 3046.8, significance = .0000) indicating the suitability of the data for principal component analysis (PCA). Six principal factors identified by PCA accounted for 59.6 percent of the variation in the data set. Tests of the internal consistency of the data (Cronbach's alpha) provided evidence of the reliability of the attitude scale. In the earlier study six factors were also identified with a very similar amount of variation (60.6 percent). Table 3 shows the variables that are closely associated with each factor.

Table 3
Factor Analysis of Business Travel Purchase Benefits

Variable	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 4*	*Factor 5*	*Factor 6*
Cronbach Alpha	*.7678*	*.7883*	*.7202*	*.7619*	*.6957*	*na*
Business Class Value						
No ticket restrictions	.57065	.23780	.02897	.15668	.08844	-.19996
Seat allocation	.65922	.31436	.03391	.19398	-.04366	.02103
Return boarding card	.55925	.07233	.09119	.19720	.12523	.35450
Business lounge	.6878	.16340	.32410	-.04926	-.05598	.21021
Business class check-in	.77315	.17992	.19039	-.14428	.00784	.09457
In-flight Comfort & Experience						
In-flight service	.08924	.55975	.49488	.00936	.00112	.02188
Seat comfort	.07395	.76291	.20197	.03497	.00881	.07153
Airline punctuality	.30155	.68146	.02857	.00530	.18568	.14435
Past experience of airline	.23953	.60507	.03287	.11572	.16232	.14435
Airline safety record	.14483	.65546	.06982	.13651	.04056	-.03888
In-flight User Benefits						
Duty free available	.12644	-.01874	.60404	.30118	-.00777	-.14626
Free newspapers	.16246	.19153	.78667	.03470	.10578	.09102
Free beverages	.03503	.20303	.81290	.05237	-.05495	.06001
Price						
Ticket price	.03640	.09447	.08475	.87992	-.05149	.10873
Ticket discount	.02671	.10934	.17720	.88152	-.06530	.13262
Schedule						
Timing of outward flight	-.06644	.08326	-.02686	-.09181	.83461	.09406
Timing of return flight	.08124	.12469	.02307	.03476	.83967	.05213
Airport						
Local airport	.00479	.12538	-.04223	.13195	.05995	.81510

Factors 1, 2, 4, 5, and 6 each have a bundle of product attributes associated with them that are very similar to those discovered in the earlier study. This provides further evidence of the reliability of the attitude scale, and indicates that there are the following purchase factors in the EU short haul business travel market; Business class value, in-flight comfort and experience, price, schedule, and local airport. Factor 3 in this survey includes duty free shopping, and free newspapers and beverages. In the earlier study this factor included ease of reservation, seat allocation, quality of ground service, and was called "air service user-friendliness." Further testing of the attitude scale is needed to investigate the reliability of this area of purchase benefits.

Following the principal component analysis, factor scores for each respondent were calculated and saved, to be used in a cluster analysis to identify segments within the business travel market.

Business Travel Segmentation Analysis

An iterative clustering algorithm was used, and a robust three-cluster solution was reached after only four iterations. To evaluate the validity of the segments, a cross-validation procedure was applied to the solution. The cluster analysis was re-applied to the top half of the sample and each respondent's cluster membership in the validation process stored. The final cluster centres of this process were then used as the initial cluster centres in the application of the cluster analysis in the bottom half of the sample. Again the validation cluster memberships were stored. The validation cluster membership data were correlated with the original cluster membership data, the correlation coefficient was 0.8799 for the top of the sample, and 0.7701 for the bottom. The result of the cross-validation procedure was deemed satisfactory.

The chi-square test of independence was used to identify the variables that differ significantly between the clusters. The variables that influenced segment membership were; management level/social classification, size of employing company, age (at the 90 percent level), the number of trips taken during the past twelve months, whether the company had a CTP, and the Likert score on the CTP attitude scale. Details of the differences are shown in Table 4.

Analysis of variance was used to examine the different importance placed by each segment on product elements 1 to 25. This process revealed significant differences for product elements 1 to 22. These differences are significant at the 95 percent level. In the attitude scale, scores can range from 1 (highly important) to 5 (low importance). Table 5 shows the mean attitude score for a number of purchase element for each segment and is organised to show the most important factors first. The segment that rates each product element the highest is highlighted.

These tables are used as a basis to develop a profile of each segment.

Profile of Segment 1. The first segment is made up of 20.5 percent of the respondents of the survey. A large proportion of members is employed in senior management positions. The age profile of this group is fairly even across the

Table 4
Business Travel Segmentation Profile

	Segment 1 (percent)	*Segment 2 (percent)*	*Segment 3 (percent)*
	20.5 percent of sample	34.8 percent of sample	44.7 percent of sample
Management Level			
Company director	18.2	17.4	32.9
Senior management	66.2	67.4	57.8
Other management	15.6	15.2	9.2
Age (significance 0.09982)			
25-43	27.3	30.5	17.6
35-44	37.7	34.4	38.2
45-64	35.1	35.1	44.1
Number of Trips in Last 12 Months			
1-5 trips	48.1	56.5	36.9
6-10	19.5	24.4	33.3
More than 10	32.5	19.1	29.8
Company Size			
1-99 employees	15.6	15.3	26.2
100-999	23.4	26.7	19.2
More than 1000	61.0	58.0	54.7
Company has CTP			
Yes	75.0	77.9	65.1
No	25.0	22.1	34.9
Views of CTP			
Anti-CTPs	11.7	39.6	34.5
Neutral to CTPs	35.0	30.2	35.2
Pro-CTPs	53.3	30.2	30.3

Table 5
Purchase Benefits Sought By Business Travel Segments

	Segment 1 Mean Attitude Score	*Segment 2 Mean Attitude Score*	*Segment 3 Mean Attitude Score*
Most Important Purchase Factors			
Timing of outward flight	1.0519	1.9015	1.0058
Timing of return flight	1.3247	2.1818	1.1503
Flight from local airport	1.2597	1.7803	1.5202
Airline punctuality record	1.4545	1.8939	1.6127
Seat comfort	1.4416	1.8106	1.7341
Fast-track check-in	1.6047	1.9615	1.6716
In-flight service	1.8961	2.1818	2.1445
Lack of ticket restrictions	2.7532	2.2803	2.0405
Frequent flier programme	2.6134	2.4987	2.0142
Ease of reservation	3.1169	2.3712	1.9191
Business lounge available at airport	2.7662	2.5758	2.4220
Ticket price	3.4675	2.5227	2.1792
Duty free available	4.0260	2.4091	3.4162

spectrum, however, the largest proportion of the segment (37.7 percent) are aged between 35-44. This is consistent with the management positions they hold.

With regard to business travel consumption, the largest proportion of the segment (48.1 percent) have made five trips or less in the last twelve months. However, when compared with the other segments, this segment has the largest proportion of the members who have made more than ten trips in the last year (32.5 percent). Members of this segment are most likely to work for large companies, with 61 percent of the group working for companies with more than 1000 employees. Three-fourths of members of this segment work for companies that have a CTP, with 53.3 percent of the group holding positive attitudes towards these policies.

By identifying the product attributes that most closely associate with the purchase factors identified in the factor analysis above, we can see that segment 1 seems to rate factors 2 (in-flight comfort and experience) and 6 (local airport) most highly. A flight from a local airport is the most important purchase item to members of this segment. Members of this segment are keen to ensure that their time is not wasted, and thus airline punctuality and fast-track check-in are important purchase considerations. It is interesting to note that it is this group that rates airport business lounges least highly of the three segments, but this may reflect the groups propensity not to waste time. Once onboard members of this segment rate seat comfort and in-flight service more highly than members of the other segments, but places least importance on the price of the airline service.

This segment, therefore, works for large companies, is not interested in the price of the product but wants a smooth and pleasant product delivery during the consumption of the service. As long as these items are met, members of this segment would be least bothered by corporate involvement in their travel arrangements.

Profile of Segment 2. Representing 34.8 percent of the sample, a similar proportion of this segment is employed in senior management positions (67.4). The age distribution of this segment is similar to that found in segment 1, however this group tends to travel the least of all the groups. 56.5 percent of this segment have made five or less trips in the last twelve months. Although a smaller proportion of this group work for very large companies (58.0 percent), 77.9 percent of this group work for companies that have CTPs. The effect of corporate size on attitudes towards CTPs may explain the high proportion of the group with negative attitudes towards CTPs.

As can be seen by Table 5, members of this segment, on average, do not rate any product attributes more highly than members of other segments with the exception of duty free shopping. Consequently, to investigate this segment we will look at the product attributes they rated most highly and also look at those product attributes where this group recorded a similar score to segment that scored the product highest. The most important factor to this group is flight from a local airport, which is rated higher than the timing of the outward flight. Punctuality and seat comfort are also important. The availability of a business lounge is relatively important, as is the ease in which tickets may be reserved.

The profile indicates that members of this segment tend to travel less than the other segments. As they travel less the evidence suggest they get more involved in the purchase of their flights, and have negative feelings towards CTPs. To market to this segment, airlines should concentrate on the traveller not the corporation, promote ease of access to the local airport, the connections available from the airport, and quality of the duty free shopping and the business lounge facilities.

Profile of Segment 3. Representing 44.7 percent of the sample, this segment is the largest group of business travellers. One-third (32.9 percent) of the segment indicated that they work as company directors, with a further 57.8 percent working in senior management. This segment has the largest proportion of members who work for small companies (26.2 percent), although over one-half (54.7 percent) work for companies with more than 1000 employees. Members of this group are fairly evenly distributed in the frequency of business trips made. Less than one-third (29.8 percent) of the group have made more than ten trips in the last year but 36.9 percent have made five or less. The age distribution is more distinctive, however, with 44.1 percent of the group being aged 44 or over.

Members of this segment were the least likely of all segments (65.1 percent versus 75.0 and 77.9 percent) to work for a company that had a CTP. However, the high percentage of companies with CTPs demonstrates the reach they have in the business travel market. Attitudes towards CTPs were fairly evenly distributed between members of this segment, the largest proportion holding neutral opinions (35.2 percent).

The identifiable characteristics of this segment however are the purchase factors that they rate highly. Table 5 shows the large amount of product elements that members of this segment rated more highly than members of other segments. The scheduling factors were most important but members of this segment also rated purchase factors 1 (Business class value), and 4 (price), more highly than other segments.

This segment represents a large section of the short haul business travel market that want good schedules at low prices but also want to have the ability to change their flight bookings without restriction and want to use well-equipped business class lounges.

These factors combined with the slight tendency of this segment towards smaller companies possibly indicate that travellers in this segment have a greater involvement in the purchase decision than, particularly, segment 1 where there seems to be more evidence of corporate involvement. Airlines or travel agents may wish to develop products aimed at this market segment that reduces the need for traveller involvement and makes the purchase easier.

Travel agency management of smaller companies travel expenditure accounts may be mutually beneficial for the companies and agents.

This research has identified and profiled three market segment within the EU short haul market that are not obviously comparable with the market segments identified in the earlier study. The most striking difference between the earlier study and this research is that company size can be used to distinguish between segments in this study, whereas this was not possible in the earlier study. Company size is obviously a useful segmentation basis and when combined with the findings regarding corporate travel policies and corporate involvement in the purchase decision and procedures, the findings in this survey are very useful.

CONCLUSION

This paper has provided additional information regarding the business traveller and his or her employing organisation in the purchase of air travel. The scale for traveller attitudes towards CTPs can be evaluated by its application in other markets. Other attitude statements could be developed that might gain greater insight into business traveller attitude constructs. The scale for purchase attributes which was previously developed has been assessed and surprisingly similar results were found in terms of the key purchase attributes in the short haul business travel market which provide strong evidence of the key purchase benefits sought by the business travel market. A new market segmentation based on these product elements reaped further insight into the market and how it has changed in the last five years.

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APPENDIX I

1. CTPs are a good idea.
2. CTPs make the whole process of travel more easy.
3. CTPs are a constraint which serve no great purpose.
4. CTPs benefit those at the top of the hierarchy.
5. CTPs take transport decisions away from the individual traveller.
6. CTPs allow the company to save money on travel.
7. CTPs are a sensible business decision.
8. CTPs are a hindrance when planning a business trip.
9. CTPs force travellers onto other transport modes for short distance travel (up to 300 miles).
10. CTPs tend to infringe of employment travel benefits.
11. CTPs require advance planning of business trips.
12. CTPs downgrade the class of travel allowed.
13. CTPs have resulted in companies having preferred airlines.
14. Frequent flier points should be awarded to the company rather than the traveller.
15. CTPs increase the use of video conferencing and e-mail while reducing air travel.

APPENDIX II

1. Timing of the outward flight
2. Timing of the return flight
3. Flight frequency
4. Ticket price
5. Ticket discount
6. Ease of reservation
7. Lack of ticket restrictions
8. Direct route
9. Seat allocation at reservation
10. Fast-track check-in
11. Quality of ground service
12. Flight from local airport
13. Return boarding card on departure
14. Business lounge available at airport
15. Automated check-in
16. Exclusive Business Class check-in
17. In-flight service
18. Seat comfort
19. Duty Free available
20. Free daily newspapers
21. Free beverages
22. Frequent flier programme
23. Airline punctuality record
24. Past experience of an airline
25. Airline safety record

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THE ROLE OF CAPITAL PRODUCTIVITY IN BRITISH AIRWAYS' FINANCIAL RECOVERY

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Peter Morrell
Cranfield University, Cranfield, UK

ABSTRACT

British Airways (BA) was privatised in 1987, but its financial recovery occurred a number of years earlier. This recovery was sustained throughout the early 1990s economic recession, a period when few major airlines were operating profitably. This paper examines the role of productivity developments at British Airways from the early 1980s through 1996. The emphasis is on capital productivity and investment, but changes in capital intensity and labour productivity are also evaluated.

Various measures are considered for both capital and labour productivity: outputs are measured in available tonne-kms (ATKs) and revenue tonne-kms (RTKs), with the former preferred over the latter two measures, after adjustment for work performed by BA for others. Capital inputs are measured in equivalent lease costs adjusted to constant prices with a different treatment of flight and ground equipment or assets. Labour inputs are derived from total payroll costs deflated by a UK wage price index.

The airline made considerable capital investments over the period and at the same time went through two major processes of labour restructuring. This resulted in a gradual increase in capital intensity, relative high labour productivity growth, but poor capital productivity performance. However, capital investment played an important role in the airline's sustained labour and total factor productivity over the whole period.

INTRODUCTION

Considerable attention has been given to airline labour productivity, both by researchers and management (see for example Alamdari & Morrell, 1997). Often, the word productivity is used to describe labour productivity with no recognition of the role played by capital and total factor productivity.[1] At the same time, airlines generally emphasise their prowess in technological developments, even though these might not compare as well with other industries as they have in the past.

The airline industry has often been described as capital intensive, although this is somewhat misleading, since labour costs account for up to 35-40 percent of total costs for some airlines, compared to capital costs of 10-15 percent. The capital-intensive label is probably derived from the fact that airlines operate aircraft costing as much as $150 million each. These aircraft, together with spares and related flight equipment, account for a very large proportion of an airline's fixed assets.

Given the importance of aircraft to an airline's success, much research has been undertaken in the area of technical aircraft efficiency, and some analysis has taken place of aircraft utilisation. However, little work has been published on the relationship between technical efficiency and the intensity of aircraft use on the one hand, and the cost of aircraft and related finance on the other. Some studies have examined total factor productivity and, by implication, capital productivity (see for example, Forsythe, 1985 and Oum & Yu, 1995). But most focus on labour productivity, partly because of trends in the 1970s and 1980s towards overmanning and labour inefficiency, and partly because simple measures can be used with readily available data.

While much attention has recently been applied to labour, there are signs that the airline industry is becoming more capital intensive. In aircraft maintenance, expensive test and monitoring equipment is replacing more labour intensive component repair, while at airports self-service check-in and ticketing machines are becoming more common. In the air, two pilot operations are fast becoming the norm. Capital charges (depreciation, rentals and net interest) increased from 5.6 percent of total costs in 1980 to 11.8 percent in 1995 for British Airways. Capacity costs (depreciation and lease) per ATK for the same airline increased at a compound average growth rate of 8.2 percent a year between 1979 and 1994, compared with 3.1 percent for labour costs per ATK, 1.2 percent for fuel and oil costs, and 3.6 percent for other operating costs.

The purpose of this paper is to examine capital productivity trends for BA pre- and post-privatisation. The analysis covers a period from 1982/83[2] through the privatisation in February 1987 to the early 1990s major economic recession and subsequent recovery in 1996/97. It is of note that BA were one of the few airlines to continue to be profitable throughout the post Gulf War recession (Figure 1). Sustainable airline profitability can only be achieved in the long-term by growth in total factor productivity, which is in turn driven by investment and technical innovation, and it is their achievements in these areas that this paper addresses.

Thus, while the focus of this paper is on the efficiency with which capital is used, this will be considered in the context of total factor productivity, as well as the efficiency with which other inputs were used, notably labour. Just as labour productivity can increase because of the amount of capital equipment used per employee, so will capital productivity depend on the amount of labour employed, staff skills and organisation, as well as technical improvements.

By limiting the analysis to one airline, with a reasonably consistent accounting system over the period adopted, and based largely in one country, problems of comparability are minimised. Furthermore, a time series approach also enables money value to be converted to volume or quantity estimates by means of price deflators or indexes.

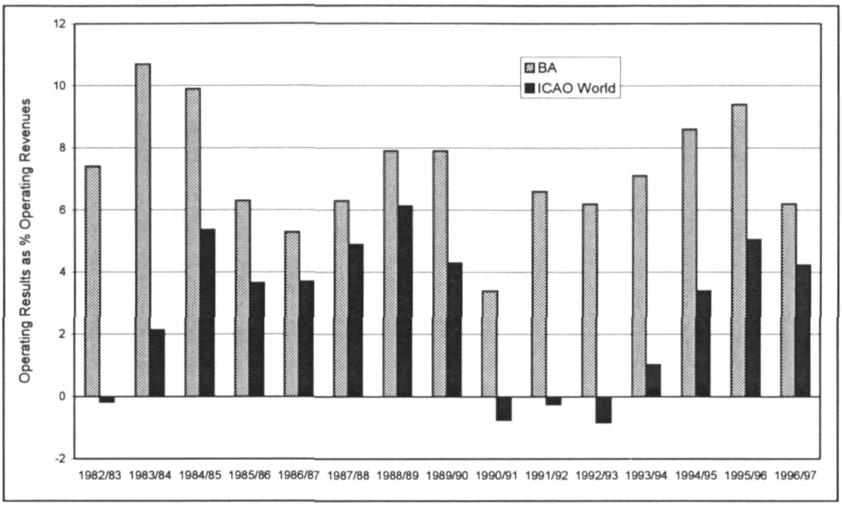

Figure 1. Trends in operating margins: BA vs ICAO World

The questions to be addressed in this paper are:

- What was the role of capital investment both in BA's pre-privatisation turnaround, and their subsequent strong profit growth?
- How did the airline's capital productivity growth compare with labour and total factor productivity growth?

To answer these questions, a consistent set of data was needed from the early 1980s to the present. These were available from the airline's annual reports, which gave reasonably consistent data for revenues, expenses, assets, the fleet and employees, and where policy changes were made (e.g. in the treatment of leased assets), these were clearly identified in the published accounts.

There have been numerous studies that have evaluated partial productivity measures, and many of these have also considered total productivity in terms of aggregate measures such as operating cost per ATK. There have been some more interesting attempts to provide a meaningful analysis of productivity. An earlier study examined airline managerial efficiency using data for 16 European scheduled airlines, regressing labour productivity against five explanatory variables (Pearson, 1976). One of the variables included in the model was aircraft productivity, defined as average aircraft utilisation. Another equation explained unit costs in terms of four explanatory variables including labour but not capital productivity. Managerial efficiency was then measured by each airline's standardised residuals from the two models. Apart from the lack of rigorous statistical testing of the regression models, this work failed to address marketing efficiency, revenues or quality of output, although the author pointed out this weakness.

Another earlier study focused entirely on labour productivity, examining partial measures for the various airline staff categories for 10 European and North American airlines (McKinsey, 1977). The study concluded that North American carriers had much higher labour productivity in all staff categories, *because of their generally greater size and network density*. This was one of the few studies that adjusted the data for contracting out and contracting in by converting third part amounts paid or received into man-years, although the precise method for doing this was not revealed.

The previous weakness of the omission of marketing efficiency in the Pearson productivity study was rectified in a study of 26 airlines from Europe, North America and the Asia/Pacific regions (Doganis and others, 1995). However, lack of data prevented any adjustments to be made for third party work. The study allows a useful time series and cross-sectional comparison of the world's major airlines, both across and within regions, and includes some disaggregate measures such as pilot productivity.

International differences in capital productivity have been studied very little, according to a recent study (McKinsey Global Institute, 1996), and *'even less is known about what causes capital productivity differences.'* This study's main objective was to identify reasons for capital productivity differences between Germany, Japan, and the United States. It followed on from earlier research into labour productivity and employment performance. The study combined a top-down macro analysis with a micro study of five industries: automobiles, food processing, retailing, telecommunications, and electric utilities.

The McKinsey researchers defined capital input as the flow of services generated from a given stock of capital, rather than the stock itself. This they measured by identifying each type and age of asset, and diving the cost by the useful life in years. In some cases they also added financing costs to the original purchase cost of the investment goods. Output was measured where possible in physical units (e.g. kilowatt-hours for electric utilities) and value added for industries with more heterogeneous outputs. Inputs and outputs were denominated in local currencies and converted into a common currency by using purchasing power parities (PPPs).

MEASUREMENT OF PRODUCTIVITY

Definition of Airline Output

Airline output can be defined in physical or money terms. Physical units most often used in aggregate measures are available tonne-kms (ATKs) or revenue tonne-kms (RTKs). The first describes production or capacity and is relevant to those inputs such as flight operations whose effort is related to this, while the second is a measure of traffic, of greater relevance to sales and handling personnel. Monetary measures of output include total revenue and gross or net value added.

Financial performance measures would clearly relate profit to capital invested in the business. This is not a productivity measure but a measure of financial rather than economic success in meeting the firm's objectives. Its relevance here, however, is the common need to define capital stock or investment.

McKinsey (1996) has a preference for physical measures, but this is not always feasible due both to the difficulty of adding units of a variety of types of output, and also because of quality differences. They also suggest value added or gross output, which overcome both of these difficulties: different types of output can be summed, and higher quality tends to be reflected in higher prices and thus higher revenues or value added. They used value added for all industries except telecommunications (call minutes) and electric utilities (kilowatt hours), where outputs are relatively homogeneous and of constant quality. Value added was defined as factory-gate gross output less purchases of materials and energy. Gross output (also in money terms) was also considered. But both these measures require conversion to a common currency, and this was done using PPPs.

The advantage of monetary measures is that they allow aggregation of both an airline's own services and work performed for others, such as handling and maintenance (see Oum & Yu, 1998). On the other hand, appropriate deflators need to be found for a variety of outputs to accommodate price and exchange rate changes. Physical measures such as ATKs and RTKs record only an airline's own air services, but other services can be converted to equivalent traffic units, as suggested below.

Definition of Airline Inputs

Airlines require inputs of capital, labour, and materials in order to offer flights and associated booking, ground and other services. Inputs, such as airport and air traffic control services purchased from others are themselves the product of capital, labour and materials managed by other agencies.

Labour. The simplest measure of labour is average annual employee numbers. This should be adjusted for part-time staff and many airlines publish annual equivalent levels of staffing. Actual man-hours per annum worked would be a better measure, to take into account differences in holiday entitlement, sickness and absenteeism, but this number is not usually available.

The major problem in using equivalent annual employee numbers on the payroll is in its relationship to output. Employees may work on contracts for other airlines and this will not appear in physical measures of output, although it will appear in total revenues under third party work. Conversely, part of ATK output may be produced by employees of other firms, where part of the production is outsourced. This would show up in the cost of services provided by other firms. Both these could be converted into equivalent staff numbers. A recent paper avoided this problem by including incidental revenues in outputs (third party work for other airlines), and material and other services brought in as inputs (Oum and Yu, 1995 and 1998).

Here total payroll costs have been deflated by the UK index of average earnings. Output from BA staff working on services to other airlines has been taken into account above. However, the problem of any significant move towards outsourcing has not been addressed. The only major examples of this over the period studied have been the sale of the engine overhaul business to GE in December 1991. The loss of the third party work provided by this unit would result in a reduction in both outputs and inputs. The distortion arises from a shift of the staff and capital employed in overhauling BA's engines to an outside company, which would reduce only inputs (or transfer them to goods and services bought in), and artificially raise productivity.

Capital. The measurement and definition of capital is more complex than labour. The main question is how much capital has actually been consumed over a given period of time?

The stock of capital assets produces a flow or consumption of capital over its useful life. This flow is more appropriate to use as an input of capital, but depreciation is likely to be misleading as a proxy for this, since depreciation allowances are often much greater than the decline in an asset's output producing capacity (Kendrick, 1991). The 1996 McKinsey study highlighted the need to consider monetary values of various capital assets (because of the difficulty in adding physical units of diverse and heterogeneous assets), but converted these to comparable physical units by deflating expenditure-based estimates by the investment goods PPP.

McKinsey considered the flow of service from an asset to be the payments that would be made as if the asset were leased. This would therefore include both depreciation and interest payments. They used this approach for some industries, and for others they divided the capital stock by the useful life for each type of asset, and aggregated these costs to arrive at the total flow of capital services. McKinsey estimated capital stock using the perpetual inventory method. This infers the capital stock from the gross fixed capital formation expenditures and presumed depreciation schedules for each type of asset.

Many authors agree on the inclusion of both depreciation and interest in any measure of capital consumption (see Deakin and Seward, 1969). Some go further to suggest that both dividends and retained earnings should also be included on the basis that, if the return on loan capital investment (e.g. interest) is considered, so should the return on equity capital (Kendrick and Creamar, 1961).

One study converted capital (defined in some way) into equivalent man-years of labour, so that labour and capital could be combined to obtain total factor inputs (Smith and Beeching, 1948)

Another study distinguished between the cost of flight equipment and ground property and equipment (Oum and Yu, 1995). An index of flight equipment input quantity was constructed by multiplying the annual lease cost by the number of each aircraft in the fleet and then weighting the result by the lease price of each aircraft type. The weighting was performed using the translog multilateral index procedure. The real stock of ground property and equipment was estimated using the perpetual inventory method. The annual cost was then computed by multiplying this real stock by a service price. The latter was estimated using the method proposed by Christensen and Jorgenson (1969). This accounts for interest, depreciation, corporate income and property taxes and capital gains. The flight equipment and ground property indexes were then combined into one index, again using the translog procedure.

BRITISH AIRWAYS' CAPITAL PRODUCTIVITY

Output Measurement

Available tonne-kms (ATK) were initially used as a measure of output, reflecting the total airline production. However, the carrier increased its average load factor consistently over the period, the gains from which would be better reflected in revenue tonne-kms (RTK). The second of the two problems referred to above, namely quality, was not considered to introduce any major distortion. Quality of service has many dimensions, but aircraft types used were broadly similar in terms and increasing length of haul is reflected in ATKs and RTKs. On the other hand, some increases in average frequencies per route may have occurred, and executive lounges in airport became more common.

The first problem, namely the combination of different types of output, was more significant. In 1996/97, non-RTK generating revenues amounted to 751 million, or nine percent of total turnover. These revenues were converted into equivalent RTKs by applying the average yields in each year on BA's own scheduled and charter air services (e.g., 53.1 pence in 1996/97).

Output growth was relatively modest in the earlier part of the 1980s, especially in the restructuring period that was largely completed by 1983/84 (see Figure 2). This involved the deletion of some routes. Faster growth occurred in the period 1986/87 to 1989/90, when the recession set in. This probably finished a year or so earlier in the UK and U.S. compared to other European countries, and growth was resumed in 1992/93 at around 10 percent a year.

Input Measurement

It was shown above that there is no entirely consistent and satisfactory way to measure capital inputs. It was decided, however, that the flow of capital consumed in each year, rather than the stock of capital, would be the best indicator of what was available to provide airline and related services in that year. Similarly, labour wages and salaries provide better indicators of what was available, reflecting hours actually worked rather than numbers of employees, which represent the stock of labour.

Airline capital available consists principally of aircraft, but also of ground equipment, buildings and land. Those that are owned or on finance leases are

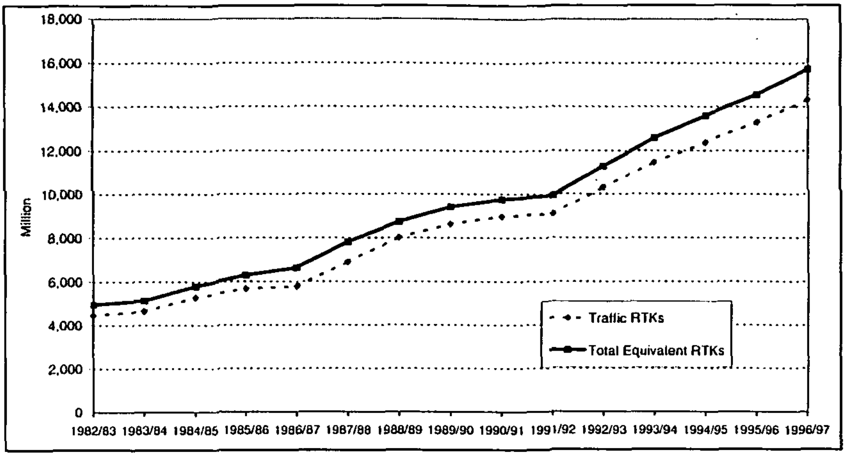

Figure 2. Traffic and total output for BA

depreciated over various service lives in the accounts to give some measure of capital consumed. Capital is also available through shorter term or operating leases, which appear in the accounts as an operating expense, combining depreciation and interest charges. Capital input needs to combine both owned and leased assets into an annual estimate of consumption. This money amount then needs to be deflated to take out any price effects to give a volume indicator of input.

Off-balance sheet aircraft operating leases for BA currently account for just under 30 percent of the total fleet numbers. Rental expenditure for these aircraft gives a good estimate of capital consumption in any year. For owned aircraft, the equivalent lease amount needed to be determined so that total capital input from aircraft could be estimated. This was done by taking the average gross value of the fleet in each year (i.e. before depreciation) and calculating the lease equivalent using the following standard lease formula:

$$\text{Periodic Rental Payment} = PV \div a$$

where: PV = the present value, or equipment cost
a = the rental factor, which is:

$$a = \frac{1-(1+i)^{-(n-x)}}{i} + x$$

where: x = number of rentals payable in advance
n = number of payments in lease term
i = interest rate per period

The gross fleet value is based on historical costs, updated each year following aircraft withdrawals and additions. For 1996/97, the average gross fleet value was 8.7 billion. These aircraft costs were largely incurred in U.S. dollars and converted to sterling at end year exchange rates. The lease calculation requires inputs of both remaining service or economic life and interest rate. The former was initially set at 25 years less the average age of the fleet in each year, with the interest rate for each year varying at 50 basis points over LIBOR (London Interbank Offered Rate), or for 1996/97 6.0 percent. This rate of interest is considered the level at which BA would have borrowed, and a variable or floating rate reflected more realistic in relation to both owned and leased aircraft. For lease payments in arrears (x = 0), the lease equivalent of the on-balance sheet aircraft amounted to 910 million in 1996/97, to which the off-balance sheet lease aircraft rentals of 119 million were added.

For capital inputs other than aircraft, a lease equivalent was calculated in the same way as for aircraft, but an average remaining life of five years was taken, applied to balance sheet gross asset values. It is likely that the majority of these assets would have been acquired in sterling, so that a UK capital goods deflator would be the most appropriate way to convert value estimates to volumes.

The conversion of these aircraft value estimates to volumes would ideally use a U.S. aircraft manufacturing price index applied to the original U.S. dollar capital costs,[3] and then converted at PPP exchange rates. However, only sterling costs were given, so that a deflator was constructed by converting a U.S.$ index of aircraft prices to sterling using average /$ rates of exchange actually applied by BA.

Figure 3 summarises the changes in real inputs over the period studied. It can be seen that after the rationalisation in 1983/84, which continued from the previous year, investment grew over the recovery period to the end of the decade. BA was no exception to the prevailing industry tendency to over-order at the end of a cyclical upswing. However, this was confined to the year 1990/91 when 11 Boeing 747-400s were delivered, together with 5 B767-300s. This was partly

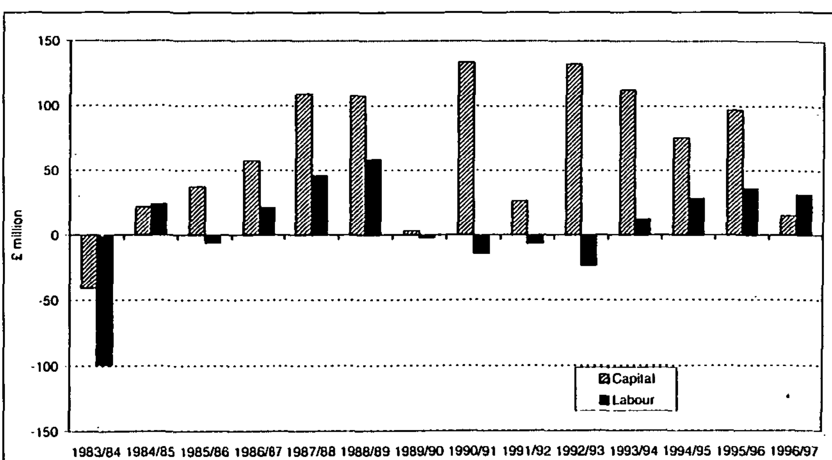

Figure 3. Net real additions to capital and labour for BA

financed by a sale and leaseback on 20 B737-200s; a deal which captured a relatively good average price for these aircraft before it declined.

Average aircraft prices expressed in sterling increased sharply up to 1985/86, mainly as a result of sterling's depreciation (which would have boosted revenues). The converse was true over the next period to 1988/89, when U.S.$ aircraft prices hardened as a result of increased demand. While prices turned down as a result of the industry's cyclical downturn, by 1996/97 the index had climbed again to its 1990 high point.

Changes in real labour inputs are also shown in Figure 3 for comparison. The large 1983/84 reflects the last year of the major downsizing from 55,000 to 37,000 staff, with modest increases to match the traffic growth in the second half of the 1980s.

Capital Productivity

An initial idea of capital productivity might be gained from examining trends in average ATKs per aircraft. This ratio does not contain price or value data, but averages efficiency over the whole fleet. A change in fleet mix towards more long haul widebodies would increase the ratio without any underlying change in the true productivity of capital used for supplying a specific city-pair of given stage length. What Figure 4 shows is the tendency over the period of the average price of aircraft to increase faster than average aircraft efficiency, particularly towards the end of cyclical upturns.

In the 1960s and 1970s, new aircraft incorporated a larger number of seats, increased lower deck cargo capacity, and greater speed and range. This inevitably led to easily identifiable and quantifiable efficiency increases delivered in return for some increases in price. Over the past two decades, however, aircraft size has not grown much on average, but many cost saving improvements have

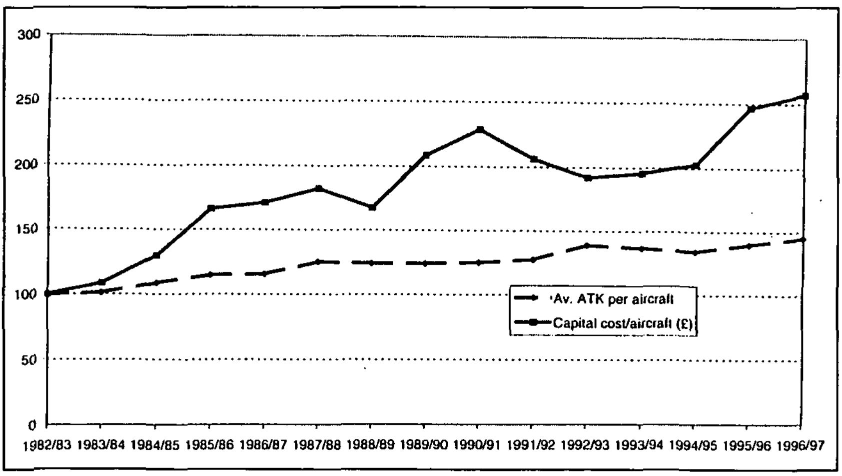

Figure 4. BA aircraft cost and productivity trends

nevertheless been incorporated in the aircraft (e.g., automated flight deck, modular design for lower maintenance costs). The average payload per aircraft in the BA fleet rose from 29 tonnes in 1982/83 to 35 tonnes in 1996/97.

The capital productivity measure described below was adjusted RTK output per total lease equivalent input, deflated by a capital price index. It was concluded that this ratio minimised the key problems discussed in the previous sections. Figure 5 shows that after a rise in the first two years, capital productivity on this basis subsequently declined over the remaining part of the decade, after which it remained stable. The early rise was principally due to an increase in the overall load factors from 61.9 percent in 1982/83 to 67.2 percent in 1984/85. At the same time there was a shift in emphasis from passengers to cargo, the latter utilising spare lower deck capacity. A marked increase occurred in charter flights, especially in 1983/84, which are inherently more capital efficient through high load factors and higher seat density.

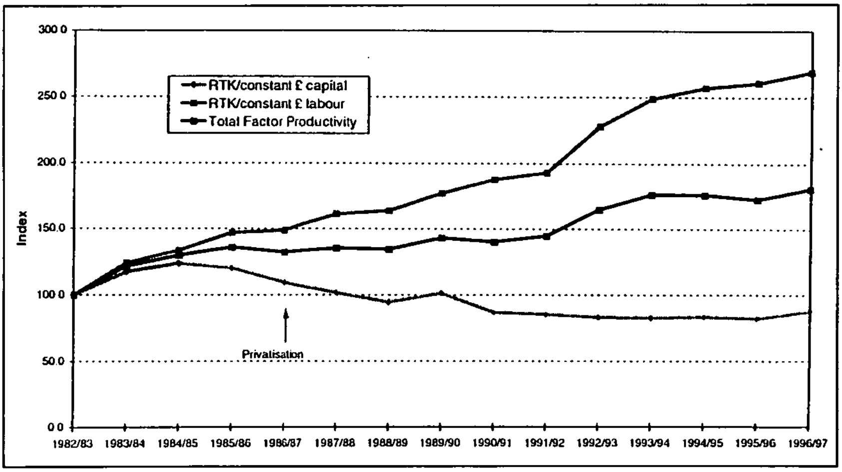

Figure 5. BA capital and labour productivity

The more productive use of existing capital through more efficient organisation or better trained staff is probably difficult to achieve in any sizeable way in the air transport industry. Flying crew are already highly trained and improvements may show up more in better quality service than higher output.

Aircraft accounted for around two thirds of the total annual capital consumption up to 1990/91, but this share subsequently declined to around 60 percent. The faster growth in shorter life investments which are not directly related to aircraft would tend to depress any measure of capital productivity which did not take into account the output quality improvements that such investments tend to produce. This is likely to be the case here, since it has been impossible to incorporate such qualitative changes in the output variable even though they would certainly have affected inputs, especially those of capital.

Capital and Labour Price Developments

Figure 6 shows developments in output and input prices expressed in sterling terms. The output price index was based on total revenue per RTK. After an increase in the first year, helped by sterling's marked depreciation, it remained stable or drifted down. Airlines had traditionally reacted to a recession by raising fares and sustaining yield increases; however, in the early 1990s recession, competitive discounting led to a decline in local currency yields. For BA this was offset by favourable exchange rate developments, at least against the U.S. dollar, between 1991/92 and 1993/94.

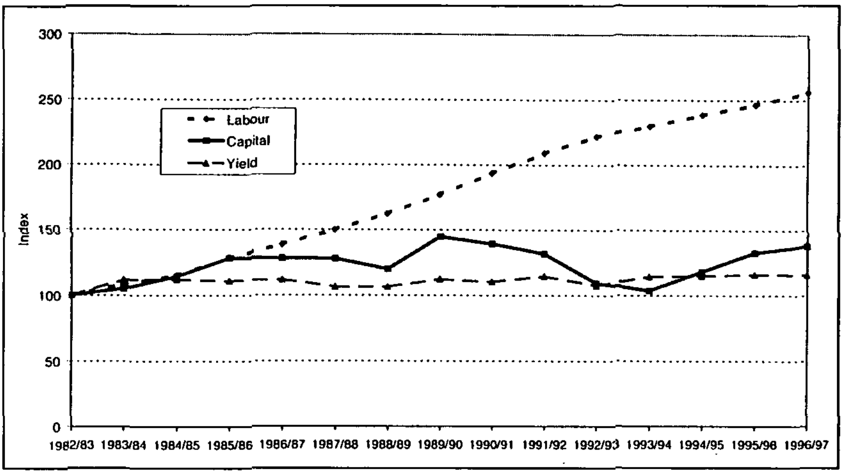

Figure 6. Input and output price indices for BA (£)

Dollar/sterling exchange rate fluctuations also helped dampen down BA's capital input price index expressed in sterling (Figure 7). This was based on Avmark's estimates of the new price of a B757 aircraft. This was an aircraft type that was offered in relatively standard form over the whole period, and was also an important aircraft in the BA fleet.[4] The aircraft price index was combined with LIBOR interest rates, upon which the majority of BA's loans and leases are based, to form an overall capital price index.

The UK index of average earnings was taken as the labour price index, given the largely UK based composition of BA's employees. This rose by an average of 6.6 percent over the period, compared with BA's average staff remuneration per employee of 6.5 percent. Average UK prices rose by 4.9 percent over the period. Survival for BA therefore depended on producing labour productivity gains to allow real pay increases and generate adequate returns to capital and shareholders.

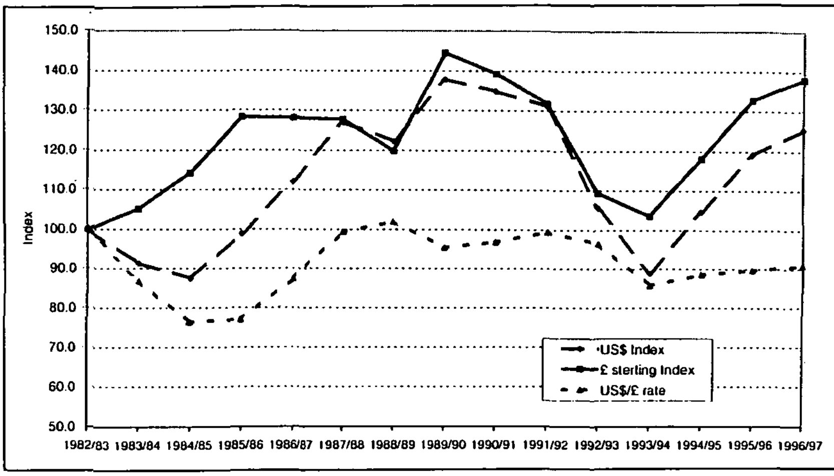

Figure 7. BA capital prices indices and exchange rate

Labour/Capital Ratio

The capital/labour ratio was around 1.7:1 in 1982/83, but experienced a marked reduction to 1.3:1 by the date of privatisation. This was due to the shake out of labour rather than any planned move towards increasing capital per employee. Once this had occurred, capital inputs tended to rise somewhat faster than labour inputs, with this ratio declining to 1.1:1 by 1996/97.

This suggests that BA, as with many other state-owned carriers, was overstaffed prior to the recovery measures initiated in the early 1980s. This is less likely the case now, although continued labour union power and restrictions in competition (e.g., BA's slot holdings at Heathrow Airport) suggests that some inefficiencies may remain.

A further lay-off of staff in early 1991 as a result of the Gulf War recession might have led to greater capital intensity, but capital was reduced more markedly in that year. This was the result of the withdrawal from all Irish and a number of other routes, and the retirement of seven BAC 1-11s and five Tristar 200s.

What emerges from this analysis is the fact that BA did not achieve any further substitution of capital for labour post-privatisation, even though labour wage rates increased very significantly in relation to capital prices. The extent to which this was possible in any large way in a service industry may have been limited, if the airline were to retain its reputation for high service standards. Some investment in automation led to reduced labour requirements. Examples of this were:

- The replacement of B747-100/200 aircraft which required a flight engineer with B747-400s which did not (from Summer 1989)

- Computerisation in areas such as accounts and management information which reduced staff needs

It is noteworthy that BA's Information Technology budget increased from 35 million in 1982/83, or 1.3 percent of turnover, to 130 million or 2.7 percent of turnover in 1989/90. This was expected to reach five percent of turnover in 1995 (British Airways, 1990). However, many IT or communications applications result in increased service quality rather than greater efficiency. One example of this is issuing passenger service staff with hand-held computers at check-in. It should be added that the air transport industry has been slow to adopt automation in areas such as check-in and ticketing, whereas other industries such as banking have developed faster. Some progress has been held up by the need for industry wide standardisation (e.g., the Automated Ticket and Boarding pass, and electronic ticketing). This is because of the continued importance of interline sales.

Key Factors in BA's Recovery and Above Average Financial Performance

From the discussion above it was evident that labour productivity was the principal agent of BA's recovery, as well as its above average performance during the recession in the first half of the 1990s. Sterling's large fall, at least against the U.S. dollar, also helped over the recovery period to 1984/85.

For the period as a whole, capital productivity by itself only contributed to the recovery between 1982/83 and 1984/85 and, for the rest of the period, growth in capital inputs exceeded output growth. This was partly because additions to capital tended to be aircraft of similar capabilities and size to existing aircraft. The benefits from these aircraft came from qualitative improvements, which could not be allowed for in the output index used in this paper. For example, more overhead locker space, improved seating, or lower cabin noise might have improved the yield from a similar volume of traffic. Non-aircraft investments, which grew faster than aircraft investment after 1992, would also have given the airline a qualitative advantage.

However, capital investment also enables the airline's staff to be more productive. BA's total lease equivalent capital per employee increased in real terms from 5,100 in 1982/83 to 19,860 in 1996/97. This by itself would have been a major reason for the airline's success in increasing labour productivity.

Total factor productivity (the weighted average of labour and capital productivity) was shown in Figure 5 to have increased by just under 30 percent up to privatisation in early 1987. A further 30 percent advance occurred between 1991/92 and 1996/97, again driven by labour productivity achievements. BA's total factor productivity based on the above measures increased at an average rate of 3.4 percent a year between 1986 and 1995 compared with other research which estimated an identical rate for seven of the largest EU airlines over the same period (Oum & Yu, 1998). This is surprising, given that the same study reported a decline in TFP between 1990 and 1992 for the EU airlines, whereas

BA was shown here to have increased productivity by 20 percent over these three years of recession.

The productivity of inputs other than labour and capital should also be mentioned, although this paper has not focused on these. Fuel and airport/ATC services are probably the two most important. The latter have increased in price substantially over the period, with little scope for increased efficiency, except by using larger aircraft, which was not the case. Fuel efficiency increased gradually over the period, as new aircraft were introduced. However, the fuel price declined significantly over both the first half of the 1980s and the 1990s largely taken as a whole. BA benefited from this in its pre-privatisation period, even after taking into account the weaker U.S.$ exchange rate. The same was the case in the early 1990s, although the exchange rate did not decline as much.

ENDNOTES

1. For example, Air Canada in its 1997 Annual Report, p. 33.

2. The second complete financial year following the appointment of Lord King as Chairman.

3. The majority of BA's aircraft are U.S. built, although some have UK manufactured engines. A price index based on the manufacturer's labour and materials cost is normaly used in the aircraft purchase contract to escalate the agreed price to a delivery year value.

4. BA's B757s increased from 4 in April 1993 to 41 in April 1997.

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THE INTEGRATED AIRPORT COMPETITION MODEL, 1998

J. Veldhuis, I. Essers
Directorate General of Civil Aviation (DGCA), Netherlands
D. Bakker, N. Cohn, E. Kroes
Hague Consulting Group (HCG), Netherlands

ABSTRACT

This paper addresses recent model development by the Directorate General of Civil Aviation (DGCA) and Hague Consulting Group (HCG) concerning long-distance travel. Long-distance travel demand is growing very quickly and raising a great deal of economic and policy issues. There is increasing competition among the main Western European airports, and smaller, regional airports are fighting for market share. New modes of transport, such as high speed rail, are also coming into the picture and affect the mode split for medium distance transport within Europe.

Developments such as these are demanding the attention of policy makers and a tool is required for their analysis. For DGCA, Hague Consulting Group has developed a model system to provide answers to the policy questions posed by these expected trends, and to identify areas where policy makers can influence the traveller choices. The development of this model system, the Integrated Airport Competition Model/Integraal Luchthaven Competitie Model (ILCM), began in 1992. Since that time the sub-models, input data and user interface have been expanded, updated and improved. HCG and DGCA have transformed the ILCM from a prototype into an operational forecasting tool.

INTRODUCTION

The growth of air traffic at Dutch airports is a hotly debated issue in current national politics. In particular, limits on the capacity growth of Amsterdam Airport Schiphol pose a major problem because of excessive demand. Recently the Dutch government made the decision to build a new (fifth) runway. The essential question now is whether Schiphol can handle the future growth within the agreed environmental restrictions or if a new airport is needed.

Another large transport infrastructure project is the construction of high-speed rail lines. The government recently made the decision to build one of these (between Amsterdam and Antwerp, connecting to Brussels, Paris and London), and others may follow. The government is currently in search of private investors in order to reduce the public costs of this new infrastructure. These rail lines will include a stop at Schiphol Airport and could have significant impact on long-distance travel flows to specific destinations. Policy-makers recognise that changes in one transport mode affect each of the others. This is due to competition as well as complementarity between modes. It is important to consider these interactions when developing new transport policy and planning tools.

The Integrated Airport Competition Model (ILCM) was developed in response to policy questions about the future of air transport in the Netherlands. It is based on several sub-models that act as building blocks for a comprehensive system. These sub-models correspond to each stage of the decision process for a long distance trip and include airport access mode choice, airport/air route choice, main mode choice, and trip frequency models. The airport/air route and main mode choice models have recently been updated and calibrated.

The current ILCM is the result of a continuous process of improvements of the prototype system that is described in earlier papers (Veldhuis, Bradley, Brouwer, and Kroes, 1995). This paper gives an overview of the model structure, the sub-models and some examples of possible applications of the system.

STRUCTURE

ILCM Behavioural Assumptions

Before a traveller undertakes a long distance trip, he or she makes a series of decisions. The ILCM assumes that a decision chain, illustrated in Figure 1, can reasonably represent these choices. Each decision in the chain is represented in the ILCM by a choice model.

- The first choice a potential traveller makes is whether to make the trip or not. This is represented by a *trip frequency model* in the ILCM.
- Next, he or she decides either to fly or to use another mode, such as car, train or coach. This is dealt with in the *main mode choice model.*
- If a traveller decides to fly, he can often choose either a direct flight or a route that involves a transfer. Related to this is the choice between different departure airports in the area. Each airport may have different accessibility, availability of parking places, frequency of flights, etc. This part of the system is called the *air route choice model.*
- Finally, the traveller can go to the airport by public transport, by taxi, by driving and parking at the airport, or be dropped off by friends, family or colleagues. This choice is represented in the *access mode choice model.*

In the ILCM, all these dimensions of the choice process are combined in a coherent manner. A change in the frequency of flights from a certain airport, for instance, can affect all choices in the decision chain, either directly (air route and/or main mode choice) or indirectly (access mode via the choice of another departure airport).

In order to model the choices of travellers potentially making use of Schiphol Airport, the ILCM includes a market area that extends beyond the borders of the

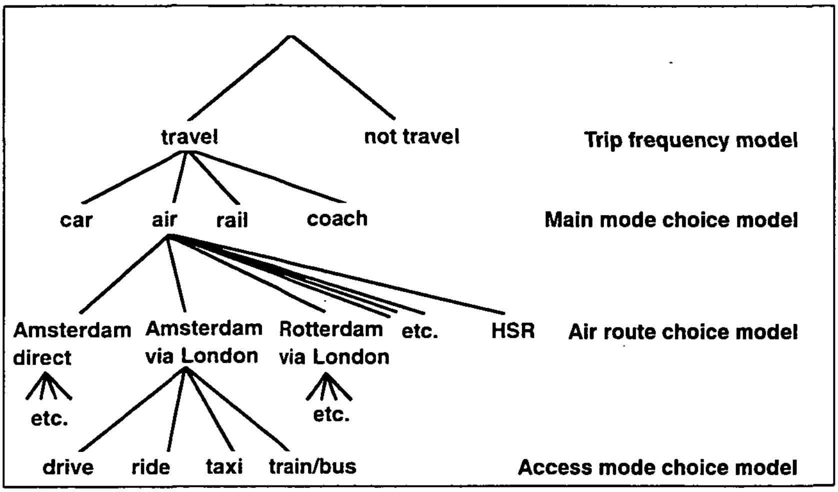

Figure 1. Decision chain for long distance travel

Netherlands to include Belgium and parts of western Germany. Brussels and Dusseldorf airports are likewise included as airports which compete for travellers with origins and/or destinations in the Netherlands.

The THEORY Behind the ILCM

The structure of the ILCM is based on the fact that a traveller has to make a series of decisions before he or she actually makes a long distance trip. These decisions are not independent. The ILCM is a combination of models such that the choice at a lower level will influence the choices at higher levels. This is modelled by a nested or tree logit structure. The theory behind this type of modelling is described in Ben-Akiva and Lerman (1985).

The basic assumption of multinomial logit models is that people choose the option, for example the access mode, that gives them maximum utility. For each available access mode, a utility function is determined. Utility functions are assumed to be of the form

$$U^{access}(i) = \alpha + \beta*\text{Cost} + \delta*\text{Time} + \varepsilon*\text{Age} + \phi*\text{Sex} + \eta*\text{Travel Purpose} + \ldots\ldots$$

The probability of choosing alternative i in Logit modelling can be written as:

$$P(i) = \text{Exp}(U^{access}(i)) / \Sigma_j \ \text{Exp}(U^{access}(j))$$

where U(i) is the utility function of alternative i and summation Σ_j is overall alternative j.

The person and travel characteristics which are to be included in the utility function are determined during the estimation process.

In the nested model structure (shown in Figure 1), each choice lower down the tree is conditional on the choice above it. The attractiveness of the alternatives for that choice also affects the choice that will be made above it.

The levels in the tree structure influence each other. Improvement of public transport access to regional airports, for instance, not only implies that more people who already travel via a regional airport will choose public transport as an access mode (direct effect). Also the number of travellers via regional airports will increase (first order effect), and to a lesser extent the number of air travellers overall will go up (second order effect).

This interaction between the choice levels is included in the model structure through so-called logsums. The logsum is a measure of the overall attractiveness of all alternatives at a given level of the tree structure and is computed as the logarithm of the sum of the exponential utilities:

$$\mathrm{Log}(\Sigma_i\ \mathrm{Exp}(U(i))).$$

In the route choice model, logsums are included from the access mode choice model for each airport. Thus, the utility function for travel via Rotterdam airport, for instance is described as:

$$U^{route}(\mathrm{Rotterdam}) = \alpha + \beta^*\mathrm{Log}(\ \Sigma_i\ \mathrm{Exp}(U^{access}(i))) + \delta^*\mathrm{Time} + \varepsilon^*\mathrm{Cost} + \ldots\ldots\ldots$$

where (i is over all access mode and $U^{access}(i)$ is the utility of travelling to Rotterdam airport using access mode i. Thus, if public transport access to Rotterdam airport is improved, $U^{access}(i)$ increases for i=public transport; consequently the logsum for access to Rotterdam goes up, which increases the value of U^{route}(Rotterdam).

The interaction between the main mode choice model and the air route choice model is taken care of in the same way. Logsums are used for travel via all airports and using all available air routes, giving a utility function for air travel:

$$U^{main}(\mathrm{Air}) = \alpha + \beta^*\mathrm{Log}(\Sigma_i\ \mathrm{Exp}(U^{route}(i))) + \delta^*\mathrm{Time} + \varepsilon^*\mathrm{Cost} + \ldots\ldots\ldots$$

In this application, Σ_i is over all air routes and $U^{route}(i)$ is the utility of travelling by air via route i (including departure airport choice). This means that if (for instance) tickets via Maastricht airport become cheaper, travel to all destinations by way of direct and indirect flights from U^{route}(Maastricht) becomes more attractive. Also, if (for example) tickets with a transfer at London are sold at lower prices, air becomes more attractive through U^{route}(via London) for all departure airports and all final destinations. In the previous example where public transport access to Rotterdam airport is improved, U^{route}(Rotterdam) increases and thus U^{main}(Air) also goes up.

The final interaction is that between the total number of trips and overall attractiveness of all main modes. The choice between travelling or not travelling is at this phase of the ILCM not made through logit modelling. The current ILCM models frequency by use of a fixed elasticity-based model that includes an elasticity for generalised cost.

$$\mathrm{Log}(\Sigma_i \mathrm{Exp}(U^{main}(i)))/\varepsilon$$

where Σ_i is over all main modes, $U^{main}(i)$ is the utility of main mode i and ε is the main mode choice model cost coefficient ($\varepsilon < 0$). Improved overall accessibility (e.g. through the introduction of high speed rail, more frequent flights etc.) means that the generalised cost of travel decreases since $\varepsilon < 0$. The elasticities therefore have the same sign as the cost coefficient to assure that a higher attractiveness of travel means that the number of trips increases. An elasticity value of -0.3, for example, means that if the generalised costs increase by ten percent, the number of trips decreases by three percent. Another element of the frequency model is growth based on economic variables.

Recalling the example of improving access to Rotterdam Airport, this would decrease generalised costs through higher values of U^{access}(Access), U^{route}(Rotterdam) and U^{main}(Air), respectively. It is important to realise that the influence of a change at a certain level of the decision chain has the largest influence on the choice made at that level. The effect on higher level choices decreases with each step higher in the chain. Thus, improvement of public transport access to Rotterdam airport has the largest effect on access mode choice to Rotterdam airport, a smaller but usually measurable effect on the number of trips via Rotterdam airport, an even smaller effect on the number of air trips overall. The least amount of effect will be on the number of long distance trips made by all modes.

The models were estimated separately starting at the bottom of the tree (see Figure 1) with the access models. The process of finding the optimal set of parameters is carried out using HCG's estimation package ALOGIT. Various data sources were used for this estimation. These are described in later sections of this paper.

Descriptions of the Models

Access Mode Choice Models. The airport access mode choice models were estimated based on the actual choice observed in the 1991 Schiphol survey data. For the estimation of access mode choice models for travel to the airport, nine different segments were distinguished, each having their own typical travel behaviour. Five categories were developed for residents (those living in the hinterland of Schiphol) and four for non-residents.

Hinterland residents (Benelux and west of Germany):	*Other travellers from Europe/ICA:*
Business (trips longer than 2 days)	Business (trips longer than 2 days)
Short Business	Short Business
Vacation	Vacation
Other Purposes	Other Purposes
Charter	

For each of these segments, separate access mode choice models were estimated. In the access mode choice models, four mode alternatives were included.

They differ by residents and non-residents.

Residents:	*Non Residents:*
Car Drop-off (car passenger)	Car Drop-off
Car Parked (car driver)	Rental Car
Taxi	Taxi
Public Transport/high speed rail*	Public Transport/high speed rail*

*airport access by high-speed rail (HSR) is only possible for specific airports when main mode choice is air.

The most important variables in the choice between modes are usually travel cost and travel time. All costs in these models are based on distance except for parking, which is based on duration of stay at the destination. The costs of a rental car are not included, since it is assumed that the car will mainly be used for trips other than to and from the airport. The main explanatory variables are the following.

- *The number of flights a traveller has made during the previous months* has a negative influence on the choice of the car passenger alternative and a positive influence on the taxi and car driver alternatives.
- *Flying to an intercontinental destination or staying away a large number of days* has a negative influence on the choice for train. Too many bags to carry might be the underlying reason. For the choice of car drop-off, this influence is positive.
- *Women are less likely to use a car* and, for the short market segments, more likely to be dropped-off at the airport than men.
- *There is a strong dependence between age and the use of taxi.* The older the traveller, the more likely that he or she will travel to the airport by taxi. This effect is especially significant for the non-business segments. People over 50 are relatively often taken to the airport. People under 30 are more likely to use train and less likely to use car.
- *Scandinavian visitors use taxi relatively often.* Visitors from the United Kingdom, however, are more likely to use train. Taxi is more likely to be used by business travellers.

The values of travel time inferred from the estimated model are quite high for both business and non-business travellers. This result is typical for airport access models, since the cost of the access trip is quite small compared to the potential cost of being late for the flight.

Air Route Choice Models. This model assumes that the destination airport is fixed and predicts the choice of air route to that destination, including the choice of departure airport and possibly a transfer airport. Because there was no data available in the Netherlands to estimate such a model, a stated preference survey was carried out in 1992 at Amsterdam, Eindhoven and Brussels airports. The survey provided data to estimate models of the choice of departure airport and air route (direct vs. transfer) as a function of fare, frequency, travel time, access time, etc. In the SP route choice data, respondents often had the choice between travelling from the actual departure airport or switching to an alternative airport to take advantage of a better or cheaper flight. The SP experiment and analysis are described in some detail in Bradley (1994).

Although we expect the SP data to give the best estimates of the **relative** importance of the variables (e.g. fare versus frequency), SP and RP data typically show different **overall** sensitivities (the scale of the coefficients), as well as different residual constants. It was therefore necessary to calibrate the models as much as possible to RP route choice data.

The access mode choice models are linked to the route choice models by a logsum variable that is the composite utility of access to a given airport across all available access modes.

Air route choice models were estimated for seven different market segments. Both business and non-business segments are split into short (major nearby destinations such as Paris, Frankfurt, London, Manchester and Copenhagen), the rest of Europe and intercontinental (ICA). Charter trips form the seventh segment.

The main variables in the model are:

- *Fare:* A linear coefficient per guilder, highly significant in all the models. The coefficient tends to decrease with journey distance, but is always 3 to 4 times as high for non-business as for business. The charter coefficient is even higher still when compared to the non-business Europe coefficient.
- *Frequency:* The logarithm of the frequency per week. For transfer routes, the lowest frequency of the two flights is used. The effect is strongest for the shortest routes, and stronger for business than non-business — particularly relative to fare.
- *Journey time:* The in-flight time plus 3 times the transfer wait time. Because there was not enough variation between flight times in the SP data to estimate a significant effect in most of the segments, the ratio of 1 to 3 was determined from the segments where an effect could be estimated (i.e., the transfer wait time is perceived to be 3 times as onerous as in-flight time). This is also similar to the ratio often estimated for wait time relative to in-vehicle time in other modes. For the short and charter flights, no effect could be estimated. For the other segments, journey time is more important for business than for non-business.
- *Transfer dummy:* Transfer routes are significantly less preferred than direct ones, even after accounting for the in-flight and wait time differences. The effect is only slightly higher for business than for non-business.

- *Airport constants:* Since we are using SP data from a choice-based sample, the constants will need to be recalibrated, so the results here are not critical. The constants for the various airports relative to Schiphol are not significant in most cases, and do not show any marked trend across the segments.
- *Access model logsums:* For application, all logsum coefficients should be in the theoretically valid range of 0 to 1.0. For some segments, the logsum coefficient had to be constrained to 1.0.

Our survey sample contains 985 observed choices of airports and air routes. Using those choices, an RP model was estimated of the choice between a direct or transfer route from either Amsterdam, Eindhoven or Brussels airport. In addition, information on passenger volumes at the different airports within the Hinterland was used to ensure a realistic distribution of passengers among these airports. This information was provided by DGCA and the Contraal Bureau voor de Statistiek (CBS) report *'Statistiek van de Luchtvaart'* (1994).

The airport/air route models were adjusted at several levels prior to implementation. The models for the Business Short and Non-business Short segments do not have coefficients for journey time or transfer dummy. No observations in these segments transferred during their trips by air, which is to be expected, and so no transfer dummy could be estimated. While an effort was made to estimate journey time coefficients for these segments, the results were not significant. It is desirable to include journey time and a transfer dummy in these models so that future policy and network changes have an effect on air travel in these segments. Therefore, in the ILCM application, the values of time estimated in the Business Europe and Non-business Europe segment models were used together with the fare coefficients in the Business Short and Non-business Short segments to estimate journey time coefficients. Similarly, the values of transfers in the Europe segments were used to estimate transfer dummies for the Short segments.

Main Mode Choice Models. In 1995 HCG investigated a source of information called the European Travel Monitor (ETM). The ETM is a collection of different surveys across Europe and includes trip-level information across purposes, travel modes and destinations. Because of inconsistencies between these surveys and the very high cost of the data, HCG and DGCA obtained only the data concerning long-distance trips made by residents of the Netherlands in 1994. In theory the ETM files obtained by HCG include a representative sample of these trips. Because of serious interpretation problems it was not possible to determine the proper weighting of the records. However, there were enough unweighted observations to proceed with estimating main mode choice models.

As described earlier, the access models are linked to the route choice models, and the route choice models are linked to the main mode choice models. The link from the route choice models to the main mode choice models consists of a logsum term for the airport/air route choice.

Separate main mode choice models were estimated for four market segments:

- Business Short: business trips to London, Paris, and nearby portions of Germany;
- Business Europe: business trips to the rest of Europe;
- Non-business Short: non-business trips to London, Paris and nearby portions of Germany; and
- Non-business Europe: non-business trips to the rest of Europe.

These are the same market segments for which airport/air route choice models were estimated, with the exception that no models were estimated for business or non-business travel to intercontinental destinations. The reason for this is that travellers to these destinations are assumed to have no main mode choice: they must travel by air.

Four main mode alternatives are offered:

- air or HSR (highly competitive, high quality connections);
- train (low comfort level);
- car; or
- coach.

Some assumptions had to be made to incorporate the attractiveness of charter flights into the models, because it is not clear when the air alternative is charter for a given destination. According to the Schiphol survey, the main charter destinations are Spain, Portugal and Greece. For estimation purposes it was assumed that all non-business trips to these destinations fall under the charter route choice segment. A separate logsum coefficient for charter was necessary to deal with the fact that the charter and scheduled air route choice logsums are of different orders of magnitude.

Almost all of the important destinations in Europe for trips from the Netherlands have unique characteristics that are determining factors for mode choice. Because the UK is an island, a much larger share of trips with UK destinations use air as main mode than might be expected on the basis of distance. France is an important destination for particular types of holidays, such as camping. This is reflected in the dominant use of the car as main mode. Car is more important for very long distance trips (to southern France, for example) than might be expected. Non-business trips to Switzerland and Austria are clustered in the winter, which is to be expected. Again more of these trips are made by car than would be expected on the basis of distance. It may be that because winter destinations tend to be far from airports and that a high number of local train transfers are required (with sports equipment being carried), many travellers choose to use a car.

The main variables in the main mode models are the following.

- *Air route logsum:* Theoretically for application the logsum coefficient should be in between 0.0 and 1.0. For non-business the coefficient is lower than for business.
- *Cost:* A linear coefficient per guilder. Highly significant for non-business purposes.
- *Travel and wait time:* For non-business short the wait time coefficient is 2.5 times the travel time coefficient. For longer distances this ratio is 6.3 for non-business and 10.0 for business. For business short the ratio is set to 3.0 because it was not possible to estimate a separate wait time coefficient.
- *Duration variables:* For longer trips car is more likely to be taken, because of multiple destinations. For business trips shorter than six days, air is more likely to be chosen. Bus is less attractive for business trips shorter than three days and holidays longer than two weeks. This has to do with the amount of time and comfort relative to the duration of the trip.
- *Season:* Car is more likely to be taken in summer. For non-business air is less likely to be taken in summer for European destinations and bus less likely in the winter.
- *Age:* As expected younger and older people tend to use more public transport than cars.
- *Long distance:* For non-business Europe shorter than 750 km car is more likely. This are people travelling from the southern Netherlands. For non-business short the train is less likely above 750 km.

The low number of business observations in the ETM resulted in statistically weak time and cost coefficients for the business segments, but these still provide acceptable values of time.

Table 1
Main Mode Values of Time

Segment	*time coefficient*	*cost coefficient*	*value of time*	*number of observations*
Business Short	-0.001755	-0.002788	f 37.77	275
Business Europe	-0.002143	-0.002317	f 55.49	258
Non-business Short	-0.004176	-0.010160	f 24.66	2119
Non-business Europe	-0.002413	-0.005874	f 24.65	7028

Calibration of the Model System. The Schiphol Survey is used as the main source of data for the ILCM. This survey contains some 100,000 interviews per year amongst all passengers departing from Schiphol, including transfer and charter passengers. As this survey contains only air trips from Schiphol, this data could not be used in the ILCM directly to provide a representative sample of all long distance trips. Therefore, the ILCM model system creates a synthetic database based on the Schiphol Survey.

The creation of the synthetic sample was done using the models that are implemented in the ILCM to infer the number of relevant trips not observed in the Schiphol Survey. The underlying assumption is that if for a certain trip from a known origin and to a known destination, the model gives probability α of using air from Schiphol, this trip represents $1/\alpha$ trips between this origin and destination departing from all airports and using all modes. If, for instance, 100 vacation trips are observed between Gouda and Marseilles departing from Schiphol, and the model gives probability 0.25 that such a trip will go by air from Schiphol, we can infer that there have been 400 trips in total from Gouda to Marseilles. Of those, 300 are either using another airport or going by road or rail. The redistribution of these remaining unobserved trips is also done using the probabilities from the ILCM models.

Problems with the ETM data made it impossible to estimate models using weighted, expanded observations. In addition, lack of data necessitated using the same models for residents of the Netherlands as for non-residents. As a result, extra calibration of the main mode models was required in order to obtain a realistic base year main mode split.

This calibration is based on three data sources:

1. *Prognose des Personenverkehrs in Europa bis zum Jahr 2005*, tabellenband (IFO Institut fr Wirtschafstsforschung, (1996);
2. *Vakantie van Nederlanders 1996* (CBS, 1997); and
3. *Buitenlandse toeristen in Nederland 1993/1994* (CBS, 1995).

The calibration data sources show that residents of the Netherlands and residents of other countries do not have identical main mode choice behaviour. Because we use the same main mode models for residents and non-residents, it was necessary to introduce an extra penalty for all non-Hinterland production zones in Europe (except in the case of UK and Ireland).

During calibration it appeared that the main mode models for business purposes, when compared to the non-business models, had unexpectedly high train and/or coach shares for Switzerland/Austria, Spain, Portugal and Italy, which needed to be corrected.

In particular, the mode shares for the destinations Denmark, Switzerland/Austria, Portugal and Greece are quite different in the calibrated results.

Germany: The targets from the available data sources could not be used directly, because a part of Germany is Hinterland and can not be seen as a destination.

France: According to the two CBS data sources, residents of France travelling to the Netherlands have a significantly different mode split from residents of the Netherlands travelling to France. In particular, the air mode has a much higher share among French than among Dutch residents.

Table 2
Main Mode Choice Final Calibrated Model (by percentage*)

Destination	*Air*	*Car*	*Train*	*Coach*	*Total*
Germany	16.2	66.6	7.7	9.4	99.9
UK	45.0	35.3	8.6	11.2	100.1
Ireland	82.6	13.7	1.7	2.0	100.0
France	10.2	63.8	9.5	16.4	99.9
Denmark	54.2	39.2	1.9	4.6	99.9
Sweden/Norw.	64.3	22.9	5.0	7.8	100.0
Finland/Ice.	72.6	21.4	0.4	5.5	99.9
Switz/Austr.	20.8	57.6	6.0	15.6	100.0
Spain	53.4	22.5	3.2	21.0	100.1
Portugal	83.1	8.3	0.8	7.8	100.0
Italy	37.4	36.6	10.0	16.0	100.0
Greece	86.0	6.0	5.9	2.1	100.0
SE Europe	72.8	17.0	3.3	6.9	100.0
East Europe	36.7	45.8	5.5	12.0	100.0
ICA	100.0	0.0	0.0	0.0	100.0
Total	46.3	37.0	5.8	10.9	100.0

*Totals may not equal 100.0 percent due to rounding.

Scandinavia: The uncalibrated models did not adequately reflect the very high air share for these origins/destinations which appears in all three calibration data sources.

Switzerland/Austria: The uncalibrated models underestimated the air share to these destinations, largely because the ETM sample included a large number of winter holiday travellers to these countries going by car. This was not a good representation of non-Dutch residents from this zone travelling to the Netherlands.

Italy: The high mode share of train and coach was caused by trips from non-Dutch Hinterland origins, i.e. Belgium and Western part of Germany.

Trip Frequency Models. The market growth models in the ILCM are based on general economic indicators, changes in the level of service (defined as the sum of the utilities of the main mode model) and an exogenous trend. Four market segments are defined:

- business direct and negative transfer
- non-business direct and negative transfer,
- business positive transfer, and
- non-business positive transfer.

The market growth model is multiplicative and consists of the following factors:

- *Change in generalised costs:* growth factor $= (e^{(\text{new logsum - base logsum})})^{\text{elasticity}}$.

- *Income growth:* (for non-business) expressed as an index, based on the input GDP growth over the base year for the given scenario.
- *Trade growth:* (for business) expressed as an average index for the production and attraction side of the journey.
- *Exogenous trend:* expressed as an index.

The elasticity for generalised costs and trade growth can easily be changed with the user interface. The default generalised cost elasticity is set to 0.1 for non-business and 0.0 for business. These values are based on experience with other models developed by HCG, but sensitivity tests of the ILCM were used to determine them.

In the current version of the ILCM, the positive transfer market has a choice of air and combined HST/air routes. Positive transfer passengers are not permitted by the ILCM to choose transfer airports other than Schiphol, or to travel by modes other than air. One of the results of this structure is that, given the current market growth models, any change in air level of service can result in extreme changes in the size of the positive transfer market. For this reason we have not included generalised cost in the positive transfer market growth calculations.

The business elasticity with respect to trade was estimated to be approximately 0.8.

The DGCA provided income elasticities for various time periods based on a standard Euro 1 scenario.[1] The income elasticities are not applied exactly as they appear in Table 3. A single income elasticity value is used. This single elasticity is calculated as follows.

1. An income elasticity is calculated for each year between 1990 and 2030 by interpolation based on the original values shown in Table 3.
2. The ILCM base year is 1994 and the new ILCM forecast year is 2020; a single income elasticity for the period 1994-2020 is calculated by averaging the interpolated values across the period 1994-2020.

Table 3
Income Elasticities for Euro 1 Scenario

	1990	*2015*	*2030*
Eur- Eur	1.35	0.9	0.7
Eur- ICA	2.5	1.35	1.1

The average income elasticity for 1994-2020 that is applied in the ILCM is **1.04** for intra-European travel and **1.71** for Europe-ICA travel. This elasticity is applied to the total income growth over the entire forecast period.

HIGH-SPEED RAIL IN THE ILCM

High-speed rail (HSR) has an impact on the travel choice on two levels: as an access mode and as a main mode. As an access mode, HSR is treated as a fast train. Introducing HSR as an alternative means that the access by train to relevant airports improves. HSR can be used as an access mode from specific zones to four airports in the ILCM: Schiphol, Brussels, Dusseldorf and Antwerp. As a main mode, HSR is included as a separately defined, high quality travel alternative.

During the course of ILCM development, there was much discussion by HCG and DGCA about exactly how high speed rail should be incorporated in the model system. Evidence from other studies indicates that there is much stronger competition between HSR and air travel than between HSR and any other mode.[2] In addition, several studies have incorporated the idea of air-rail integration. This integration entails a single-ticket trip made by a combination of HSR and air with a seamless transfer at a HSR station located at an airport. Integration means that the traveller experiences no difference in service level (reservations, baggage handling, etc.) between the HSR portion of the trip and the air portion. In other words, the HSR segment of the trip is the same as the segment travelled by airplane, except that the HSR travels on the surface. The HSR travel time is also comparable to air travel time for many destinations when considering the high speed together with shortened access/egress time.

The ILCM includes HSR as a main mode by considering HSR routes to be alternative air routes. This means that HSR is treated as an extension of the air mode. No explicit choice between HSR and other modes takes place in the main mode models. Instead, the determination of whether a trip is made by HSR depends on the route choice.

Three types of HSR connections are incorporated in the ILCM:

- a trip made with a direct HSR route without any transfer,
- a trip made by HSR with a transfer from one train to another (longer distance), or
- a trip made using a combination of HSR and air segments.

The origin and destination of a given trip determine the availability of HSR as a route alternative. For example, from Amsterdam to Paris, HSR may be an attractive alternative. A person making a trip from Amsterdam to New York could take HSR to Paris and fly from there to New York. It is unlikely, however, that someone would take HSR to Paris and then fly to Marseilles. In the current version of the ILCM, HSR may be used as the main mode for trips with destinations in Europe. The combination for HSR and Air is only available for intercontinental trips. For each destination only one HST or HST/Air alternative route is modelled.

The incorporation of HSR into the airport/air route choice model entails not only the use of a file of HSR routes but also the definition of 8 extra "ports", or HSR stations. Each origin zone has access to a maximum of three HSR stations (including possible HSR stations at selected airports). Depending on the corridor of the destination, South, East or North, one HSR station is selected.

Positive transfer trips, which have origins and destinations outside the Hinterland but transfer at Schiphol may use high-speed rail for one part of their routes. In the ILCM, the choice between air routes and HSR routes for positive transfer trips is determined by the route choice models. While the introduction of new HSR routes, as well as new air routes, could change the transfer location of the positive transfer trips (from, say, Schiphol to Frankfurt), the current version of the ILCM does not model this. The change in competition between airports is not part of this model. The positive transfers in the ILCM are based on 1994 information from the Schiphol survey. The only changes to these trips in the ILCM are made in the market growth model, based on economic changes, and route choice models.

In the ILCM, positive transfer trips are constrained to using Schiphol. One result of this is that they can only use HSR if they transfer at Schiphol, also for direct HSR connections. This is a limitation placed on the ILCM to avoid processing large and complex air and HSR networks and may be removed in future versions of the system.

For transfers originating outside Europe with destinations outside Europe, HSR is not an option. The market growth model is executed for these trips, but not the route choice model.

THE ILCM IN DETAIL

Market Definitions

The main area of interest for Dutch policy makers is, of course, the demand for use of Dutch airports. The passenger markets for Schiphol and the regional airports of Rotterdam, Eindhoven and Maastricht form the context in which the model system is developed. HCG and DGCA recognised that the catchment area for these airports does not consist solely of the Netherlands, but stretches beyond country borders.

Three different areas were identified for the model system.

- Twenty-eight zones in the Hinterland, which is the area from which Dutch airports can reasonably be used as ports of departure for residents and visitors. It contains the Benelux and the western parts of Germany. In addition to the four Dutch airports, three competing departure airports in the hinterland are taken into account: Brussels, Antwerp and Dusseldorf.
- Twenty-two zones in the Rest of Europe can be reached from the hinterland by air and by the competing land modes. The full model structure applies here. Important European airports such as London, Paris and

Frankfurt are not considered as possible departure airports, but are taken into account as possible transfer airports en route.

- Fifteen zones in the Rest of the World can only be reached by air from the hinterland, and thus the main mode choice model is not relevant for these areas. The choice of air route is more often an important issue for intercontinental travel. One can often reach these destinations either via the main European airports or via other key hubs such as New York or Singapore.

TRAVEL INCLUDED IN THE ILCM

Travel between the origin zones in the hinterland and the destination zones outside the hinterland is represented in the ILCM, along with travel from origins outside the hinterland to destinations within. Shorter trips with both origin and destination within the hinterland are excluded — these trips generate very little air travel. Some trips with both origin and destination *outside* the hinterland can be important for the hub airports; these transfers account for a substantial fraction of the passengers using Schiphol airport. The transfer market is included in the ILCM but the choice behaviour of this market is not modelled as completely as that of the non-transfer market.

Transfer trips can be split into two categories: positive transfers and negative transfers. Positive transfers are made by passengers originating outside the Hinterland, changing planes at Schiphol, and continuing on to a destination outside the Hinterland (Europe or ICA). Negative transfers are defined as trips made by passengers originating *inside* the Hinterland, changing planes at an airport outside the Hinterland (other European zones) and continuing on to a destination outside the Hinterland (Europe or ICA), *when a direct route from the Hinterland to the destination exists.*

The specific types of travel alternatives included in the ILCM are outlined in Table 4.

Table 4
Hinterland-Europe/ICA Alternatives

<table>
<tr><th>Alternative</th><th>Access Mode</th><th>Departure Airport</th><th>Transfer Airport</th><th>Main Mode</th></tr>
<tr><td>Direct Air</td><td>*</td><td>*</td><td></td><td rowspan="4">*</td></tr>
<tr><td>Indirect Air</td><td>*</td><td>*</td><td>*</td></tr>
<tr><td>HSR / Air</td><td>*</td><td>**</td><td>**</td></tr>
<tr><td>HSR</td><td>*</td><td>**</td><td></td></tr>
<tr><td>Train</td><td></td><td></td><td></td><td>*</td></tr>
<tr><td>Coach</td><td></td><td></td><td></td><td>*</td></tr>
<tr><td>Car</td><td></td><td></td><td></td><td>*</td></tr>
</table>

* Predicted by the ILCM
** The HSR route alternative is pre-defined Departure Port in Hinterland, Transfer Port outside Hinterland

Table 4 shows that a long distance traveller can choose between either a land mode or an air mode. In the future it is expected that HSR will allow convenient transfer to air at the major Western European airports, so it is treated as an air mode for our purposes. For all air modes, a traveller can choose between different access modes to get to the departure airport, which is one of the airports in the hinterland. For HSR, which in the ILCM has a limited number of departure stations, an access mode is also predicted in the decision chain. An air and/or HSR traveller can either travel directly (by air or HSR) or indirectly via a transfer airport. This is predicted by the air route choice model. For modelling purposes, we currently assume that the transfer airport is outside the hinterland, although in reality a small number of Schiphol passengers do change flights at Brussels or Dusseldorf, both of which are in the hinterland. The large majority of transfers, however, are via hub airports such as London, Paris, Frankfurt, Copenhagen and Madrid.

Note that at the destination end of the trip, the choices of arrival airport and egress mode are not modelled. Although these are also decisions that the traveller may have to make, they are not very relevant for local policy purposes. Also note that the models deal exclusively with outbound trips leaving the hinterland, although the ILCM does take into account whether those trips are made by residents or by visitors returning home. We implicitly assume that the choices for the inbound trips are symmetric, i.e. that the traveller will return by the same mode, and that an air traveller will return to the same airport.

INPUTS TO THE ILCM SYSTEM

Used in this way, the model system is essentially a pivot point procedure that predicts changes in demand for Schiphol Airport. It can also provide estimates of changes in demand for competing modes and airports, but these will clearly be less accurate than those for Schiphol for which we have accurate base data.

In addition to the demand database, the supply side inputs are very important for the model system to function properly. These inputs include travel times, distances and, for some modes, cost and transfers between origins and destinations. For the development of the ILCM, several data sources were used. Access mode travel times and distances to airports were derived from the National Model System (LMS). For road and rail in Europe, new European main networks were created to derive shortest paths. For air travel times and frequencies, the ABC Guide database was used that contains details for all scheduled flights serving the possible departure and transfer airports. Air fares were based on regression equations derived from a sample of actual fares. The main variables in the regressions are distance and fare class, with some variations allowed by destination region (e.g. higher fares to Scandinavia).

For the HSR a kind of default level of service is created. This means that the travel times are based on a full operational HSR network, the frequency is set to ten times a day and the prices are set equal to the air fares. From this point by the user interface it is easy to define specific scenarios. Fare changes can be made for combined HSR/air travelling separate from the air fares. Assumptions have been made about HSR check-in and transfer times in combination with air travel. For within Europe, check-in time for HSR trips is set at five minutes except for UK destinations, for which a 30-minute check-in is required (more restrictive border controls). Transfer times are equal to check-in times. For Hinterland-ICA combination routes, check-in is set at 90 minutes and transfer to air at 60 minutes. This compares with 60 and 120-minute check-in times for air within Europe and to ICA zones, respectively. Air-to-air transfer time is 60 minutes. While integration of ticketing between HSR and air is implicit in the assumption of interchangeable routes, no special integration of trains with airline check-in is assumed.

THE ILCM USER INTERFACE

HCG has developed a new ILCM user interface based on the specifications provided by DGCA (Jan Veldhuis). The ILCM user shell has been developed to allow users of the ILCM to perform the following functions:

- specify two types of modifications to model inputs: scenario changes and policy changes;
- apply (run) the model system; and
- view output results in the EXSYS program.

The structure from the user's perspective is shown in Figure 2.

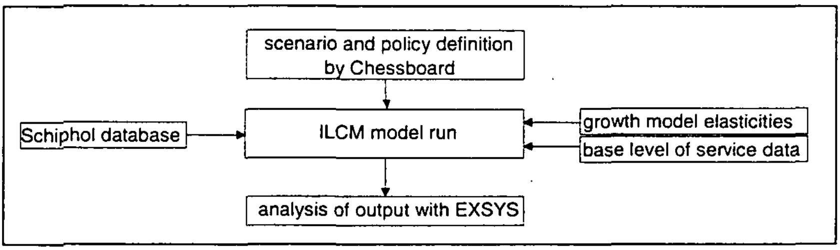

Figure 2. ILCM application structure

For the scenario specifications the Chessboard (see Figure 3) allows the user to specify aggregate or disaggregate changes on the main level of service variables. The user modifications of these variables are organised into two categories: scenario changes and policy changes. Scenario changes are meant to be background changes in economic growth and national transport regulations, while policy changes are meant to be policies implemented directly by the user of the ILCM (such as DGCA). Policy changes can also be specified as additional tests beyond the changes in a standard forecast such as 'Global Competition' (Central Planbureau, 1997).

The tool to analyse the result of ILCM runs is called EXSYS. With Exsys it is possible to compare different scenarios in a standard way. In addition to tables, it is possible to create graphical output in EXSYS. This may be in the form of bar or pie charts as well as in the form of simple maps. Below two examples of EXSYS graphics output are shown.

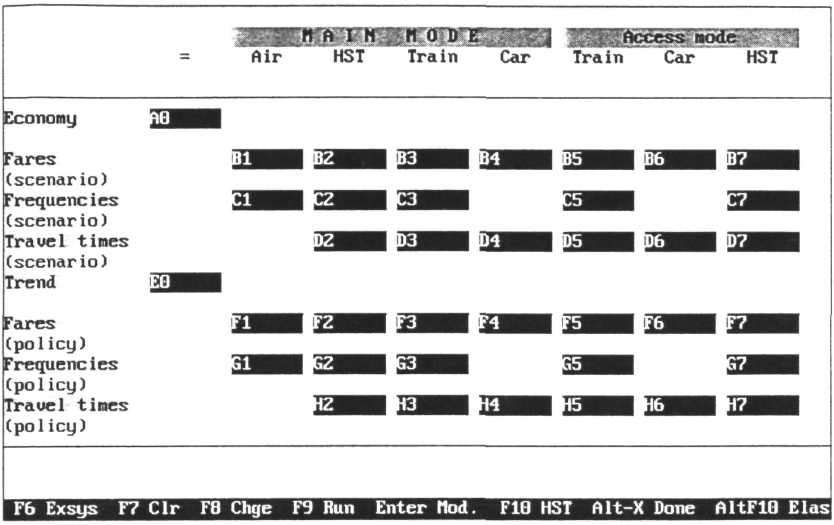

Figure 3. Chessboard

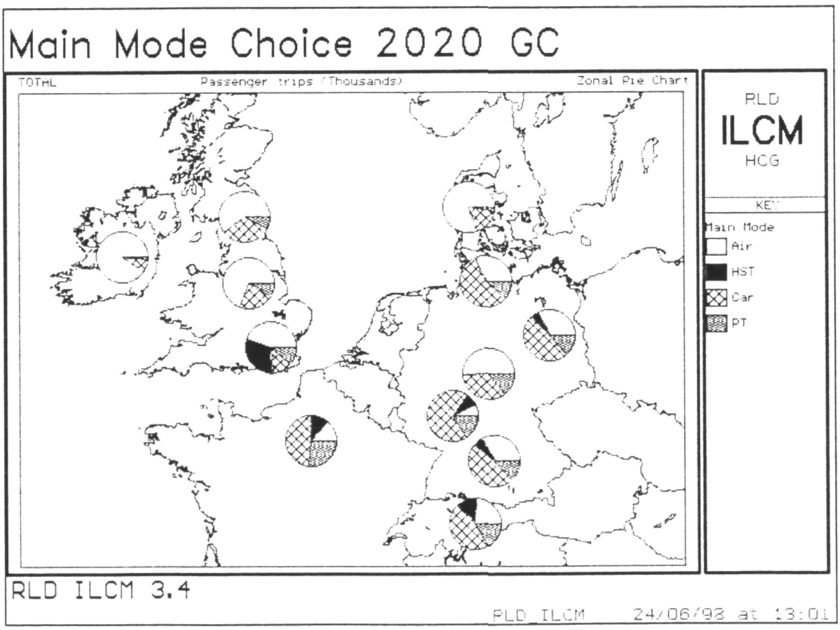

Figure 4. Output graphic of the ILCM

The graphs shown here are based on the Global Competition forecasts made for the Centraal Planbureau (1997). Three different scenarios were defined: Divided Europe, European Co-ordination and Global Competition. This resulted in forecasts for passengers from Schiphol and HSR-substitution of between 57 and 90 million and 3.8 and 6.4 million trips, respectively. The graph in Figure 5 shows that there are also HSR travellers attracted from car and train modes. The bars in the second graph show, respectively, the Global Competition scenario without HSR and with HSR East and South fully available for relevant destinations. The German and French destinations are aggregated.

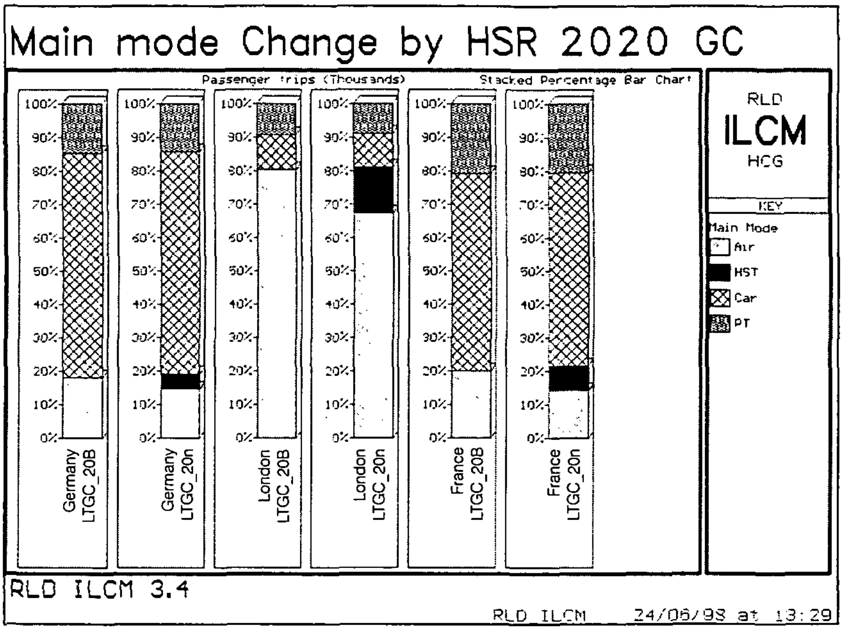

Figure 5. Output graphic of the ILCM: Main mode choice for trips with Dutch origins

FUTURE MODEL DEVELOPMENT

The ILCM provides analysis of Amsterdam Airport Schiphol in relation to surrounding, competing airports and competing surface travel modes. While it is highly developed in terms of estimating total passenger travel demand, main mode choice and air route choice, it does not yet provide any information relating to freight. The ILCM's demand forecasts are not capacity-constrained, nor do they provide data on aircraft movements. The next phase of ILCM development is likely to include the incorporation of new modules for freight demand, aircraft movements and fleet composition.

ENDNOTES

1. Based on definitions from the Netherlands Central Bureau of Statistics.

2. See Dick Ettema, with N. Cohn and F. Savelberg, 'Monitoring the effects of the Thalys high speed train,' to be presented at PTRC, September, 1998.

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BENCHMARK AIRPORT CHARGES

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A. de Wit
Directorate General Civil Aviation (DGCA)
and
N. Cohn
Hague Consulting Group (HCG)

ABSTRACT

The Netherlands Directorate General of Civil Aviation (DGCA) commissioned Hague Consulting Group (HCG) to complete a benchmark study of airport charges at twenty eight airports in Europe and around the world, based on 1996 charges. This study followed previous DGCA research on the topic but included more airports in much more detail. The main purpose of this new benchmark study was to provide insight into the levels and types of airport charges worldwide and into recent changes in airport charge policy and structure. This paper describes the 1996 analysis. It is intended that this work be repeated every year in order to follow developing trends and provide the most up-to-date information possible.

INTRODUCTION

Objectives

The Netherlands Directorate General of Civil Aviation (DGCA) commissioned Hague Consulting Group (HCG) to complete a benchmark study of airport charges at twenty eight airports in Europe and around the world, based on 1996 charges. This study followed previous DGCA research on the topic but included more airports in much more detail. The main purpose of this new benchmark study was to provide insight into the levels and types of airport charges worldwide and into recent changes in airport charge policy and structure.

The 1996 Benchmark Airport Charges study was completed for a selection of important passenger and freight airports and included a wide variety of aircraft types. Airport charges as of July 15, 1996, were calculated for each aircraft type at each airport[1], based on one landing and one take-off from/to an international airport by a non-domestic carrier (one international turnaround). The calculations were performed using the Airport Charges Model (ACM), which was developed for DGCA.

The 1996 study does not include handling or fuel charges. DGCA and HCG intend to include these charges in a 1997 update.

The 1996 Benchmark Airport Charges report was used by DGCA for the following purposes:

- gaining insight into the competitive position of Schiphol in terms of airport charges;
- verification of the findings of other research into Schiphol's competitive position, both for parliamentary questions and as input for an international comparison of infrastructure;
- data input for research projects carried out by DGCA and other organisations;
- insight into the ways in which airports and governments in different countries include the environmental costs of aviation activities in their charging systems; and
- background information for the revision of charges at Schiphol.

This paper describes the 1996 analysis. More detail regarding input data and assumptions, as well as a comparison between 1995 and 1996 daytime airport charges in Europe, may be found in the DGCA publication Benchmark of Airport Charges 1996. It is intended that this work be repeated every year in order to follow developing trends and provide the most up-to-date information possible.

Background

The importance of determining and tracking airport charges across different airports has been made clear by recent developments in aviation.

- Due to the stiff competition in the aviation sector, airlines are constantly looking for ways of minimising costs. This includes minimising costs that are to a limited extent under the direct control of airlines, such as airport turnaround costs. The annual International Civil Aviation Organization (ICAO) report, Financial Data, contains information about the cost structure of a number of airlines. According to this source, airport charges make up about five percent of the costs of large, international airlines. For smaller, short-haul airlines the percentage can be as much as 15 percent.[2]
- The costs of negative externalities related to the environmental impact of aviation activities are increasingly being quantified and passed through to the airlines. Fees based on aircraft noise levels and night flight surcharges are examples of this.
- The phasing-out of a large share of duty-free shopping at many European airports may affect the structure and level of their airport charges.

The airport charges discussed in this report form only one part of the total turnaround costs at airports. Including handling costs and fuel costs would make the analysis more complete; however, at this time, insufficient data are available to DGCA and HCG. Additional research is required in order to include them in the near future. Current information indicates that total handling charges are approximately 50 percent as large as total airport charges, and that fuel costs amount to more than the sum of airport charges and handling costs.[3]

AIRPORT CHARGES

The ACM processes several different types of airport charges to complete the comparison of airports and aircraft types. The types of fees included are based primarily on the information published in the *IATA Airport and En Route Aviation Charges Manual.* While ICAO also compiles airport charge information, IATA provides the most recent data. With further research it may be possible to expand the types of fees included in the ACM calculations, but at this time the list is limited to the charges described here.

Basic landing fees are usually based on the maximum take-off weight (MTOW). Some airports charge per tonne while others apply a fixed charge plus a variable charge based on MTOW. There are a few airports that vary these charges by time of day or season (peak/off-peak) or by the frequency of a given carrier's operations. Some airports include lighting or terminal navigation aid in the landing charge.

Noise charges require special attention because they are sometimes complicated to calculate and are of increasing importance in public and political debates on airport infrastructure. In this paper, a distinction is made between noise-related landing charges and other noise taxes/charges.

Many airports have higher landing charges for noisier types of aircraft, for example Chapter 2 aircraft.[4] In the ACM, the additional landing charges assessed for these aircraft are calculated separately from the basic landing charge. For any given aircraft, the basic landing charge is calculated as the amount to be paid for the cheapest, most advantageous situation for example, Chapter 3 aircraft. The noise related landing charge is the difference between this basic landing charge and the actual landing charge that must be paid for the given aircraft. Several airports charge an extra tax based on aircraft noise levels that is independent of all landing charges. In the ACM, these noise taxes or charges are included as a separate category.

In some cases the tariff differentiation is based on airport- or country-specific aircraft acoustic group classifications (France, Belgium, Switzerland and Korea). At other airports the ICAO classification is used (i.e. Chapter 2, Chapter 3).

Passenger charges are usually levied for services provided to departing passengers, although some airports charge for both departing and arriving passengers. A number of airports charge lower rates for transfer passengers and infants than for other passengers, while others exempt these types of passengers from charges completely. Some passenger charges are paid by the airlines, some by passengers themselves. For the purposes of this analysis, all passenger charges were included in the calculations as if they are paid by the airlines. This allows for consistent comparison between airports and avoids any second-guessing about how these charges are handled by each airline and each airport.

Security service charges are often calculated per departing passenger. In a few cases they are based on MTOW which is then a proxy for the number of passengers.

Runway lighting charges usually only apply to night flights, but may be charged incidentally depending on weather conditions. The charges are usually made per landing and several airports included in the study incorporate lighting charges in their landing charges.

Aircraft parking charges are based on the number of hours an aircraft is parked at the airport. In some instances these charges are also related to aircraft weight or wingspan. Most airports provide one to four hours of free parking time, which is usually enough to allow for a complete turnaround. Others provide free overnight parking or differentiate parking charges by location at the airport (e.g. remote stands).

Terminal navigation aid charges cover navigational assistance during arrival and departure. They are commonly charged per arrival and/or departure and are sometimes based on MTOW.

Aviobridge fees apply to the facilities used for passenger boarding and alighting. In some cases this is a bus service instead of an aviobridge. These fees could be considered handling charges, but in this study they were treated as airport charges.

Cargo charges are usually based on the weight of the loaded or unloaded cargo. Note that the passenger variants in the ACM do not include any passenger/cargo combi aircraft. The cargo charges are only included in the ACM cargo variants.

Other Charges

Fuel costs and handling costs are two important types of airport-related costs that are not currently included in the ACM calculations. Details concerning these charges are not reported by airports with any consistency and are rarely published. Such charges are also very difficult to generalise across airports and aircraft types because of specific contractual agreements that often exist between airlines, handlers, fuel vendors and airports. The prices agreed upon in these contracts could vary a great deal depending on the supplier and the size of the customer. There are a few other types of charges that are also excluded from the analysis because their interpretation was unclear or because no consistent data were available. These range from fire fighting service, aircraft cleaning, storage facility use and hangar charges to terminal and quarantine surcharges.

Assumptions

Although a good deal of detailed information is available about airport charges, quite a few assumptions are required in order to create a complete and consistent picture of these costs over all airports and aircraft types. These assumptions make comparisons between airports possible. An effort was made to base these assumptions on the most common or average situation. Three of the most important assumptions are given here.

- The total number of passengers in an aircraft is equal to the number of seats in the aircraft multiplied by a load factor of 0.65.
- The number of passengers that are transfer passengers depends on the flight destination and the aircraft type. For example, intercontinental (ICA) flights usually contain a higher percentage of passengers that must transfer to reach the final destination airports than intra-European flights. The same is true for larger aircraft used for longer distances between major hub airports when compared to smaller aircraft used for shorter distances.
- The number of airport parking hours required for a given flight depends on the flight destination and aircraft type (full freighter and passenger aircraft).

Table 1
Transfer Passengers and Parking Hours

Flight Destination Group	*Percent Passengers Transfer*	*Parking Hours*
Europe	20	1
Europe or ICA	30	2
ICA	40	3

In each variant, every aircraft type is assigned to a flight destination group. Table 1 shows how the flight destination group determines the assumed share of transfer passengers and required parking hours for each aircraft. Only flight operations with international origins or destinations are included in this analysis. Domestic operations are not included.

In the freight variants, there are two types of freight aircraft which require five parking hours (they are assumed to have longer turnaround times). Also important for the freight variants is the assumption that the amount of cargo carried is equal to 70 percent of the maximum payload of the given freighter.

All airport charges have been calculated in terms of Netherlands Guilders. Exchange rates have been used from July 15, 1996[5] (for the 1995 variant, July 15, 1995[6]).

It is important to note that there are significant differences among airports in which types of charges are levied and in how these charges are calculated. Any comparison or analysis requires interpretation and a number of assumptions. The expertise of a number of persons at the DGCA, Schiphol Airport and at other airports was essential for the completion of this report.

AIRPORT CHARGES MODEL

The Airport Charges Model (ACM), developed for the DGCA, is a flexible program designed to calculate the airport charges[7] to airlines for a turnaround, based on aircraft type. These charges can be calculated for any number of airports, limited only by data availability. This allows for comparison of airport charges among airports and aircraft types. The user can select the airports, aircraft types and fees which are to be included in the model calculations. The specification of the formulas for calculating the airport charges can be made for each airport and, if necessary, for each time period.

The most important data source for this work was the *IATA Airport and En Route Aviation Charges Manual*. This source is updated several times per year because airports regularly change both the levels of the fees charged as well as the charging formulas. The fees and formulas in the ACM are based largely on the information contained in this publication. The charges valid as of July 15, 1996 were used except for calculating charges for airports with seasonal peak and off-peak periods. In these cases the published rates for each season as of July 15, 1996 were used. Aside from the IATA manual, many airports and aviation authorities were contacted directly with specific questions and to verify that the IATA information was correct and complete. Additional information was provided by DGCA staff, various airport and civil aviation authorities and the Transportation Office of the Royal Netherlands Embassy, Washington, DC. The Airport Information Publication (AIP) was also consulted, as were several other studies of airport charges. The most important of these were the following:

- *Airport Charges in Europe*, Andre Wrobel, Institute of Air Transport, Paris, 1997 and
- *User Costs at Airports in Europe, SE Asia and the USA*, The Air Transport Group, Cranfield College of Aeronautics, February 1998.

While it would obviously be preferable to calculate charges based on, say, current 1998 tariffs, the data collection required for the update of the IATA manual is extensive and time consuming. In addition, in many cases it is necessary to consult airports or civil aviation authorities to clarify specific issues for individual airports, and this feedback process is quite time-consuming.

VARIANTS

The variants were designed to provide a picture of the relative competitiveness of airports in each of the following market contexts:

1. Europe 1995: daytime passenger operations at major European airports
2. Europe 1996: daytime passenger operations at major European airports

3. Europe Night 1996: night-time passenger operations at major European airports
4. Europe Freight 1996: daytime freight operations at major European airports
5. Europe Night Freight 1996: night-time freight operations at major European airports
6. Regional 1996: daytime passenger operations at regional airports in the Netherlands and a number of surrounding countries
7. World 1996: daytime passenger operations at major airports around the world.

A selection of airports and aircraft types was made for each of these variants. The selection criteria for the airports to be included in each variant were the following:

- Europe 1996: European airports with more than 4 million international passengers and dominated by scheduled air services;
- Europe Night 1996: the same airports as in Europe 1996;
- Europe Freight and Night Freight 1996: the same airports as in Europe 1996 but expanded to include a few other important freight airports;
- Regional 1996: a number of medium-sized airports were selected in the Netherlands and the five surrounding countries, as well as the main airports in these countries; and
- World 1996: this includes the largest airports in the world based on international scheduled passenger volumes (an effort was made to include airports on all continents).

The selection of aircraft types to be included in the ACM was based on information from the *1996 ABC Guide*. The aircraft types most frequently landing at and taking off from the selected airports in each variant were chosen. Also important was obtaining a mix of large and small aircraft types as well as both Chapter 3 and Chapter 2 aircraft. In the freight variants, a mix of the most commonly used freight aircraft was selected.

Table 2 and Table 3 list the airports and aircraft types for each of the 1996 variants. The Europe 1995 variant is also shown for comparison purposes and because it was revised for this report based on more recent data.

Many airports vary their charges by time of day or by season. Each time period is included in the ACM as a separate airport so that clear comparisons can be made. For example, airport charges at London Gatwick have been calculated three times for the Europe 1996 variant: once for the peak period, once for the shoulder period and once for the off-peak period. Averaging the costs across

Table 2
Airports by Variant

Europe 1995	*Europe 1996*	*Europe Night 1996*	*Europe Freight /Night Freight 1996*	*Regional 1996*	*World 1996*
London (Heathrow)	London (Heathrow)	London (Heathrow)	Frankfurt (Main)	Brussels (Zaventem)	Johannesburg (Jan Smuts)
Frankfurt (Main)	Frankfurt (Main)	Frankfurt (Main)	London (Heathrow)	Charleroi	Sydney (Kingford)
Paris (Charles de Gaulle/Orly)	Paris (Charles de Gaulle)	Paris (Charles de Gaulle)	Amsterdam (Schiphol)	Antwerpen	London (Heathrow)
Amsterdam (Schiphol)	Amsterdam (Schiphol)	Amsterdam (Schiphol)	Paris (Charles de Gaulle)	Luik	Frankfurt (Main)
London (Gatwick)	London (Gatwick)	London (Gatwick)	Brussels (Zaventem)	Oostende	Paris (Charles de Gaulle)
Zurich (Kloten)	Zurich (Kloten)	Zurich (Kloten)	Zurich (Kloten)	Frankfurt (Main)	Amsterdam (Schiphol)
Manchester	Manchester	Manchester	Paris (Orly)	Bremen	Zurich (Kloten)
Copenhagen (Kastrup)	Copenhagen (Kastrup)	Copenhagen (Kastrup)	Rome (Fiumicino)	Munster Osnabruck	Mexico City (Benito Juarez)
Brussels (Zaventem)	Brussels (Zaventem)	Brussels (Zaventem)	Copenhagen (Kastrup)	Nurnberg	Tel Aviv (Ben Gurion)
Rome (Fiumicino)	Rome (Fiumicino)	Rome (Fiumicino)	Luxembourg (Findel)	Erfurt	Cairo (Cairo)
Dusseldorf	Paris (Orly)	Paris (Orly)	Koln	Leipzig	New York (J.F. Kennedy)
Madrid (Barajas)	Dusseldorf	Dusseldorf	London (Gatwick)	Dresden	Miami (Miami)
Munchen	Madrid (Barajas)	Madrid (Barajas)	Madrid (Barajas)	Paris (Charles de Gaulle)	Los Angeles (Los Angeles)
Vienna (Schwechat)	Munchen	Munchen	Istanbul	Bordeaux	Toronto (Pearson)
Dublin	Vienna (Schwechat)	Vienna (Schwechat)	Milan (Malpensa)	Strasbourg	Chicago (O'Hare)
Athens	Dublin	Dublin	Athens	Toulouse	Hong Kong (Kai Tak)
Stockholm (Arlanda)	Athens	Athens	Manchester	Bale/Mulhouse	Tokyo (New Tokyo/Narita)
Milan (Linate)	Stockholm (Arlanda)	Stockholm (Arlanda)	London (Stansted)	Luxembourg	Singapore (Changi)
Geneva	Milan (Linate)	Milan (Linate)	Stockholm (Arlanda)	Amsterdam (Schiphol)	Bangkok (Bangkok Int.)
Helsinki (Vantaa)	Geneva	Geneva	Vienna (Schwechat)	Eindhoven	Seoul (Kimpo)
Lisbon	Helsinki (Vantaa)	Helsinki (Vantaa)	Lisbon	Maastricht	Buenos Aires (Ezeiza)
	Lisbon	Lisbon	Helsinki (Vantaa)	Rotterdam	
			Dublin	London (Heathrow)	
			Milan (Linate)	Belfast (Int)	
			Geneva	East Midlands	
			Munchen	London City	
			Barcelona	Stansted	
			East Midlands	Prestwick	
			Dusseldorf		
			Oslo (Fornebu)		

Table 3
Aircraft by Variant

Europe 1995	*Europe 1996*	*Europe Night 1996*	*Europe Freight/Night Freight 1996*	*Regional 1996*	*World 1996*
Boeing 747 400 passenger	Boeing 747 400 passenger	Boeing 747 400 passenger	Boeing 747 freighter	McDonnell Douglas DC 10 passenger	Airbus Industrie A320 200
McDonnell Douglas DC 10 passenger	McDonnell Douglas DC 10 passenger	McDonnell Douglas DC 10 passenger	McDonnell Douglas MD 11 freighter	Boeing 757 200 passenger	Boeing 737 300
Boeing 767 300/300ER	Boeing 767 300/300ER	Boeing 767 300/300ER	McDonnell Douglas DC 10 freighter	Airbus Industrie 320 200	Boeing 747 400
Airbus Industrie A300 passenger	Airbus Industrie A300 passenger	Airbus Industrie A300 passenger	Ilyushin IL 76	Boeing 737 300	Boeing 767 300/300ER
Boeing 757 200 passenger	Boeing 757 200 passenger	Boeing 757 200 passenger	Boeing 707 freighter	Boeing 737 400	Boeing 757 200 passenger
Boeing 727 200 passenger	Boeing 727 200 passenger	Boeing 727 200 passenger	McDonnell Douglas DC 8	Boeing 737 200 passenger	Airbus Industrie A300 passenger
Airbus Industrie A320 200	Airbus Industrie A320 200	Airbus Industrie A320 200	Boeing 757 freighter	Fokker 100	McDonnell Douglas MD 81
McDonnell Douglas MD 81	McDonnell Douglas MD 81	McDonnell Douglas MD 81	Tupolev TU 154	Fokker F28 Fellowship	McDonnell Douglas MD 11 passenger
Boeing 737 500	Boeing 737 500	Boeing 737 500	Boeing 727 freighter	Saab 2000	McDonnell Douglas DC 10 passenger
Boeing 737 200 passenger	Boeing 737 200 passenger	Boeing 737 200 passenger	Lockheed L100 Hercules freighter	Canadair Regional Jet	Fokker 100

Table 3 – continued
Aircraft by Variant

Europe 1995	*Europe 1996*	*Europe Night 1996*	*Europe Freight/Night Freight 1996*	*Regional 1996*	*World 1996*
McDonnell Douglas DC 9 30 passenger	McDonnell Douglas DC 9 30 passenger	McDonnell Douglas DC 9 30 passenger	Boeing 737 200 freighter	Fokker 50	Boeing 727 200 passenger
	Fokker 100	Fokker 100		Aerospatiale/Alenia ATR 42/72	Boeing 737 400
	Canadair Regional Jet	Canadair Regional Jet		de Havilland DHC 8 Dash 8	Airbus Industrie A310 passenger
	Fokker 50	Fokker 50		Saab SF 340	Boeing 737 500
	Aerospatiale/Alenia ATR 42/72	Aerospatiale/Alenia ATR 42/72		Embraer EMB 120 Brasilia	Boeing 737 200 passenger
	Saab SF 340	Saab SF 340		Fairchild(Swaeringen)Metro/Merlin	McDonnell Douglas DC 9 30 passenger
				British Aerospace Jetstream 31	Aerospatiale/Alenia ATR 42/72
				Beechcraft super king air 200	

these periods would not allow for realistic comparisons between Gatwick and other airports. Note that peak and off-peak periods can refer to either time of day or season. Note also that in the variants Europe Night 1996 and Freight Night 1996 there are fewer airport entries for which charges are calculated than in the corresponding daytime variants. This is because certain time periods, such as Athens airport peak period, are not applicable for night flight charges.

INTERPRETATION ISSUES

Any review of airport charges between airports has inherent comparison and interpretation problems. While it is clear that there are many common elements across airports in terms of the types of charges they levy and how they calculate these charges, there are more exceptions than consistencies. The analysis completed by HCG and DGCA dealt with as many of these as possible while preserving a comprehensible overview across all the airports and aircraft types included. However, there are a number of differences between airports that are important to consider when making international comparisons of charges.

U.S. Airports

The previous section reviewed the types of charges which airlines are required to pay for airport use. The overall structure of these charges is quite similar at most of the airports included in this study, but the structure of the airport charges at American airports is quite different. Some of the charges made at many European airports, such as lighting, security and parking, are not made at American airports. Likewise, an extra passenger tax is charged for all passengers at American airports (US$6 per international passenger in 1996) which is not levied at most European airports. The question is how to include these airports in a comparative study. Some sources argue that because this passenger tax is eventually reinvested in the U.S. airport and airspace system (by way of the Airport Improvement Program, or AIP), it should not be included in the calculation of total charges.[8] The reasoning is that the level of airport subsidy in the U.S. is such that the airlines eventually obtain benefits approximately equal to the additional passenger tax they pay.

There are several other differences between U.S. and European airports that make any comparison even more difficult.

- U.S. airport operators are involved in fewer activities than many of their European counterparts, such as handling or air traffic control, and their financial structures in general are quite different.
- Some U.S. airports levy a passenger facility charge (PFC) which goes directly toward financing improvements at that airport. Airports that levy a PFC have their AIP funding reduced.

- At many U.S. airports, airlines participate directly by participating in the financing of new facilities or even by building their own terminals. The financial agreements between airlines and airports vary a great deal among the U.S. airports.
- There are many sources of financing for aviation facilities aside from airport bonds, such as state governments, essential services grants and specific funding for intermodal facilities.

The aim of this study is to calculate the nominal (face-value) charges to an airline for an international turnaround at each airport. The government passenger taxes and any PFCs are therefore included in the calculations because they are part of the total charges. The analysis of the financial structure of U.S. or European airports is beyond the scope of this study. Furthermore, it is not possible to measure the return of this tax to specific airlines at specific airports.

In order to provide some indication of the relative importance of the government passenger tax, we have calculated the U.S. air transportation tax separately from other passenger charges. It is included in the ACM totals but shows its relative share of total charges separately from that of other passenger charges.

Similar government passenger taxes are charged at British, French and Norwegian airports. The U.K. tax is not earmarked for specific investment in aviation facilities, but it is also shown separately in Figure 2. The French tax, which is referred to as the air transport cross-subsidization tax,[9] is not included in the 1996 ACM calculations because it was not included in the IATA charges manual. It will be included in the 1997 ACM report. The Norwegian tax is used to subsidize domestic rail operations, but is not applicable in the ACM since Fornebu is only included in the freight variants. Other factors

The airport charges contained in this paper are based on published rates from different sources, in some cases modified or calculated according to additional interpretation provided by airports and aviation authorities. It is important to note that the actual charges paid by an airline could differ significantly from the figures shown here. Some negotiation takes place between airlines and specific (usually smaller) airports that can result in individual agreements and different charges on a case-by-case basis. As discussed in the section above, direct or indirect subsidies are not quantified or included in the ACM in any way. Results Some notable results of the 1996 analysis are the following:

- There are large differences in the composition and calculation of airport charges among the airports (and sometimes even within the countries) included in this study. Airport charges in the United States show the biggest difference compared with those at other airports.
- The charges at Schiphol airport are in some cases different in composition than those at many other airports. The Schiphol charges that are somewhat different from those at many other airports include lower passenger charges for transfer passengers, landing surcharges for Chapter 2 aircraft

and a specific noise charge (for financing noise insulation costs).

- Approximately one half of the airports included in the ACM variant in which 1996 European airport charges for daytime passenger operations were calculated have no form of explicit noise charges (noise related landing charges or noise taxes). Of the airports included in the 1996 worldwide variant, two-thirds have no such charges.

- Tables 4-7 show the five airports with the highest average charges and the five airports with the lowest charges for each variant, for all aircraft types and specifically for Chapter 2 and Chapter 3 aircraft. It is evident from these tables that airports in the UK and Germany as well as the Vienna and Geneva airports are the most expensive in Europe. The German airports are not among the five most expensive when only Chapter 3 aircraft are considered. Helsinki and Stockholm stand out as very expensive for night operations.[10] On a worldwide basis, New York JFK and Tokyo Narita have the highest charges, followed by other U.S. airports, Frankfurt, and London Heathrow. When passenger taxes are excluded from this comparison, London Heathrow appears much less expensive in both its peak and off-peak periods. The lowest airport charges are found in Southern Europe and, for non-peak periods, in the UK. The regional airports in Belgium and Luxembourg also have relatively low average charges. Also notable is the fact that Singapore has low average charges compared to other large airports around the world.

- About half of the airports included in the ACM variants have higher airport charges for night-time operations than for daytime operations. In most cases, the differences in charges have to do with lighting, noise and navigation aids.

- Smaller, regional airports do not always have lower charges than large mainports. For example, the regional airports in the UK, such as London City Airport and East Midlands, have higher charges than some of the large UK airports.

- The turnaround costs of a freighter are as little as one-half those for a comparable passenger aircraft at airports which do not explicitly apply cargo charges. This is largely because passenger, security and aviobridge charges do not apply. For airports which do have cargo charges, the total turnaround costs of a freighter are more comparable to those of a passenger aircraft, depending on aircraft type and the actual cargo rate.

- The average change in airport charges between 1995 and 1996 for the airports and aircraft included in the ACM was between +five percent and +nine percent.

- The competitive position of Schiphol is just below the ten most expensive airports and is comparable with the Paris and Brussels airports (see Table 7: Schiphol rankings in the ACM variants, below). Schiphol charges for Chapter 2 aircraft are higher than for Chapter 3 aircraft. Between 1995 and 1996 Schiphol became relatively less expensive overall but by a small margin.
- The position of the regional airports in the Netherlands is generally in the medium range compared to airport charges at other regional airports.

Figure 1 shows the charges for a daytime turnaround of a B747-400 at twenty[11] major international airports, world-wide. In Figure 2, the same charges are shown with the government passenger taxes split out of the passenger

Table 4
Airports With the Highest and Lowest Average Total Charges Across All Aircraft Types Included in the ACM Variants

	Europe 1995	*Europe 1996*	*Europe Night 1996*	*Europe Freight 1996*	*Europe Night Freight 1996*	*Regional 1996*	*World 1996*
Highest:							
1	Heathrow Peak	Heathrow Peak	Helsinki	Dusseldorf	Helsinki	London City peak	JFK
2	Manchester peak	Vienna	Frankfurt	Cologne	Cologne	London City off-peak	Tokyo Narita
3	Frankfurt	Manchester peak	Manchester peak	Frankfurt	Dusseldorf	East Midlands peak	Chicago
4	Vienna	Frankfurt	Dusseldorf	Munich	Stockholm	East Midlands off-peak	Heathrow peak
5	Dusseldorf	Dusseldorf	Vienna	Geneva	Frankfurt	Belfast	Frankfurt
Lowest:							
1	Rome	Rome	Madrid off-peak	Athens	Athens off-peak	Luxemburg	Mexico City 'A'
2	Milan Linate	Milan Linate	Rome	Athens peak	Athens peak	Liege	Singapore
3	Madrid	Madrid	Milan Linate	Gatwick off-peak	Gatwick off-peak	Charleroi	Mexico City 'B'
4	Madrid peak	Madrid peak	Dublin	Gatwick shoulder	Gatwick shoulder	Ostende	Johannesburg
5	Dublin	Dublin	Lisbon low	Stansted off-peak	Stansted off-peak	Stockholm	Seoul

Table 5
Airports With the Highest and Lowest Average Total Charges for Chapter 3 Aircraft Included in the ACM Variants

	Europe 1995	*Europe 1996*	*Europe Night 1996*	*Europe Freight 1996*	*Europe Night Freight 1996*	*Regional 1996*	*World 1996*
Highest:							
1	Heathrow Peak	Heathrow Peak	Helsinki	Geneva	Helsinki	London City peak	JFK
2	Manchester peak	Vienna	Manchester peak	Zuirch	Stockholm	London City off-peak	Tokyo
3	Vienna	Manchester peak	Vienna	Vienna	Geneva	East Midlands peak	Chicago
4	Gatwick peak	Manchester off-peak	Stockholm	Munich	Zurich	East Midlands off-peak	Heathrow Peak
5	Manchester off-peak	Gatwick peak	Manchester off-peak	Dusseldorf	Cologne	Belfast	Los Angeles
Lowest:							
1	Rome	Rome	Madrid	Athens off-peak	Athens off-peak	Luxemburg	Mexico City 'A'
2	Milan Linate	Milan Linate	Rome	Athens peak	Athens peak	Liege	Singapore
3	Madrid	Madrid	Milan Linate	Gatwick off-peak	Gatwick off-peak	Charleroi	Mexico City 'B'
4	Madrid peak	Madrid peak	Dublin	Gatwick shoulder	Gatwick shoulder	Ostende	Johannesburg
5	Dublin	Dublin	Lisbon low	Stansted off-peak	Stansted off-peak	Antwerp	Seoul

charges for the U.S. and UK airports. Figure 3 shows charges for a B737-500 daytime turnaround at twenty-two European airports, and Figure 4 contains the night-time charges at these airports for the same aircraft. Figure 5 shows the charges at European airports for a Chapter 2 aircraft turnaround (DC9-30). Note the sizeable noise-related landing charges at several airports. Figure 6 is an example of freighter aircraft turnaround charges in Europe. Airport codes for Figures 1-5 are shown in Table 8.

Table 6
Airports With the Highest and Lowest Average Total Charges for Chapter 2 Aircraft Included in the ACM Variants

	Europe 1995	*Europe 1996*	*Europe Night 1996*	*Freight 1996*	*Night Freight 1996*	*Regional 1996*	*World 1996*
Highest:							
1	Dusseldorf	Dusseldorf	Dusseldorf	Dusseldorf	Cologne	Nurnberg	JFK
2	Frankfurt	Frankfurt	Frankfurt	Cologne	Dusseldorf	London City peak	Tokyo Narita
3	Munich	Munich	Helsinki	Frankfurt	Frankfurt	London City off-peak	Frankfurt
4	Heathrow Peak	Heathrow Peak	Munich	Munich	Helsinki	Frankfurt	Chicago
5	Manchester peak	Manchester peak	Stockholm	Geneva	Stockholm	Bremen	Heathrow peak
Lowest:							
1	Rome	Rome	Madrid	Athens off-peak	Athens off-peak	Charleroi	Mexico City 'A'
2	Milan Linate	Milan Linate	Dublin	Athens peak	Athens peak	Liege	Singapore
3	Madrid	Madrid	Rome off-peak	Gatwick	Gatwick off-peak	Luxemburg	Mexico City 'B'
4	Madrid peak	Madrid peak	Milan Linate	Gatwick shoulder	Gatwick shoulder	Ostende	Johannesburg
5	Dublin	Dublin	Lisbon low	Stansted off-peak	Stansted off-peak	Antwerp	Seoul

Table 7
Schiphol Rankings in the ACM Variants

	Europe 1995	*Europe 1996*	*Europe Night 1996*	*Europe Freight 1996*	*Europe Night Freight 1996*	*World 1996*
Number of airports in ACM variant	28	29	25	37	37	27
Schiphol rank all aircraft (1=highest charges)	12	14	13	11	15	15
Schiphol rank Chapter 2 aircraft	12	12	12	11	15	10
Schiphol rank Chapter 3 aircraft	11	14	14	15	20	15

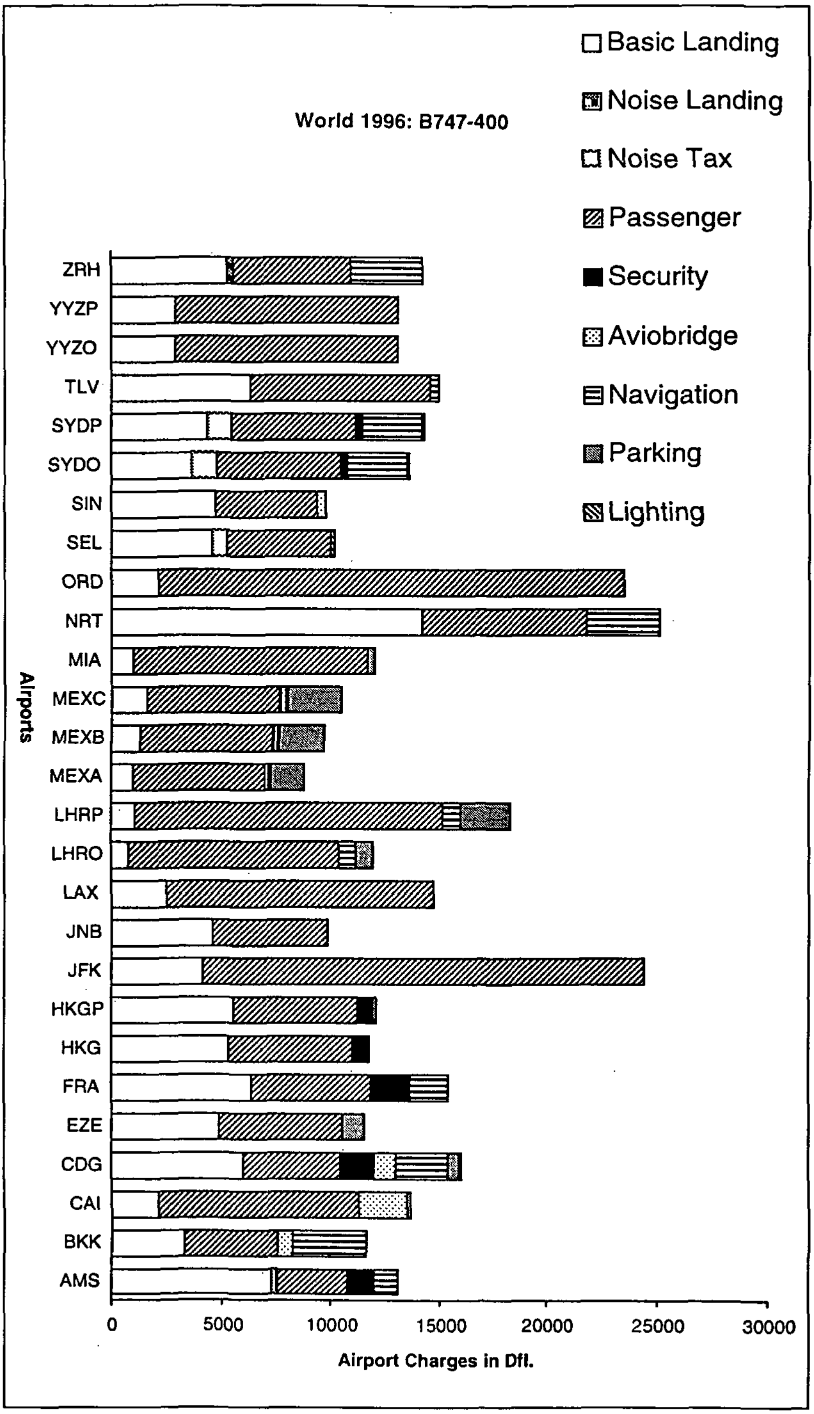

Figure 1. Airport charges for B747-400 daytime turnaround

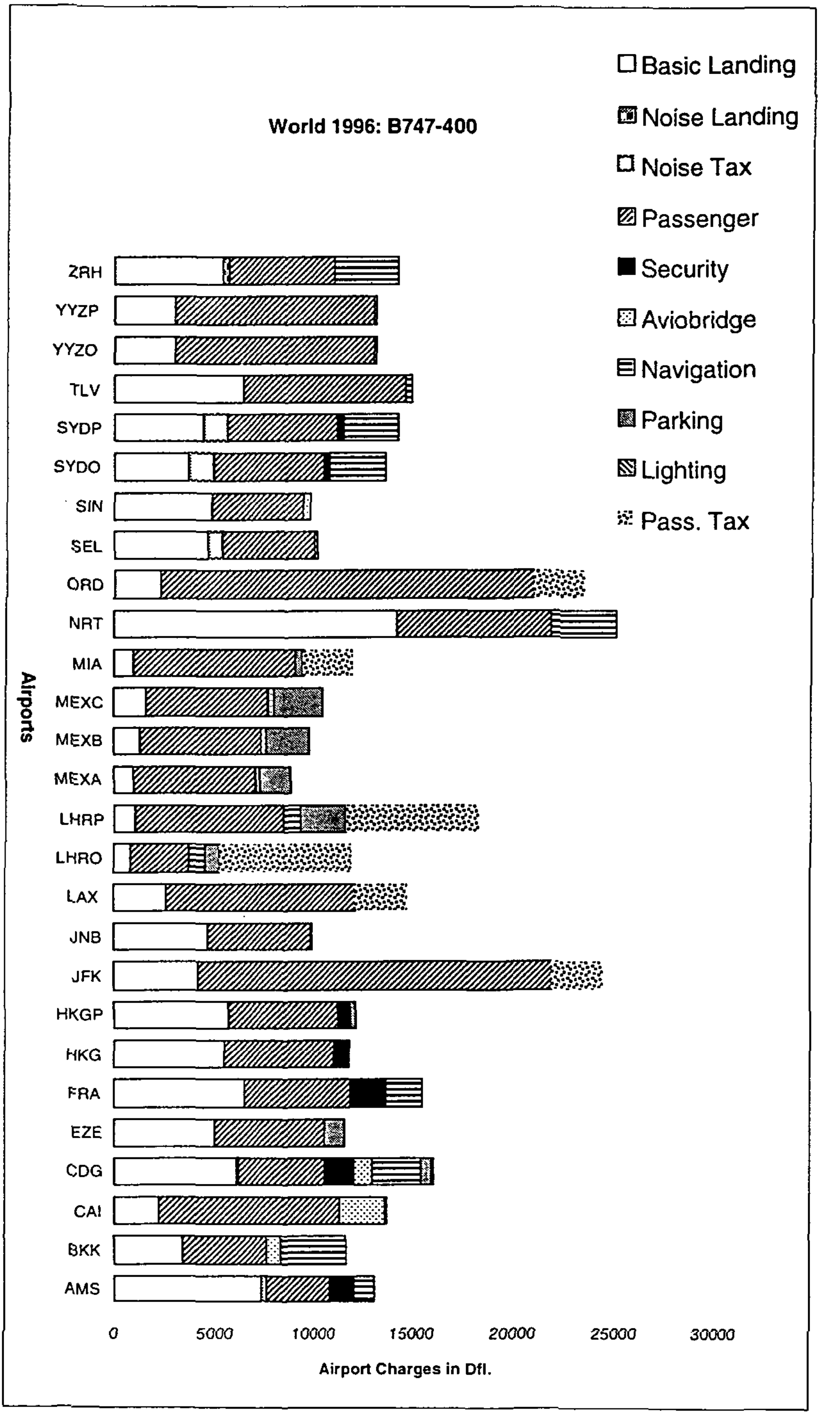

Figure 2. Airport charges for B747-400 daytime turnaround without government passenger charges

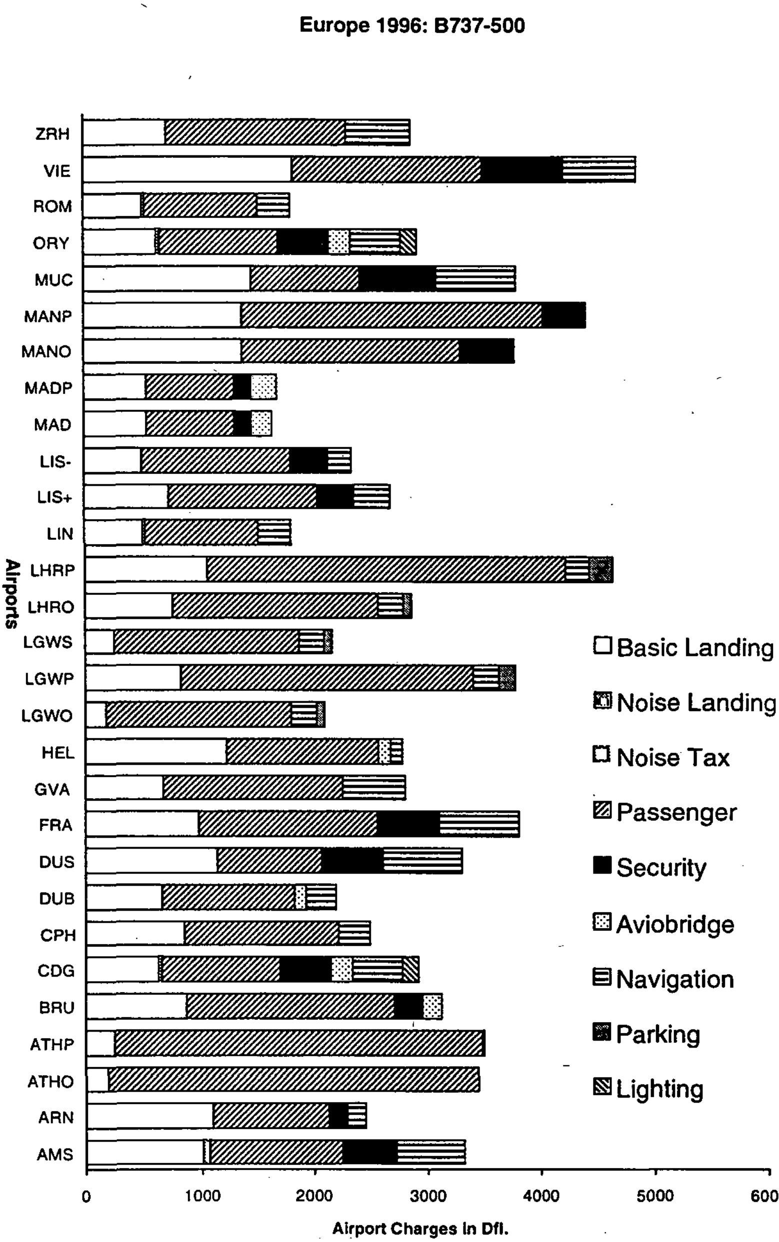

Figure 3. Airport charges for B737-500 daytime turnaround

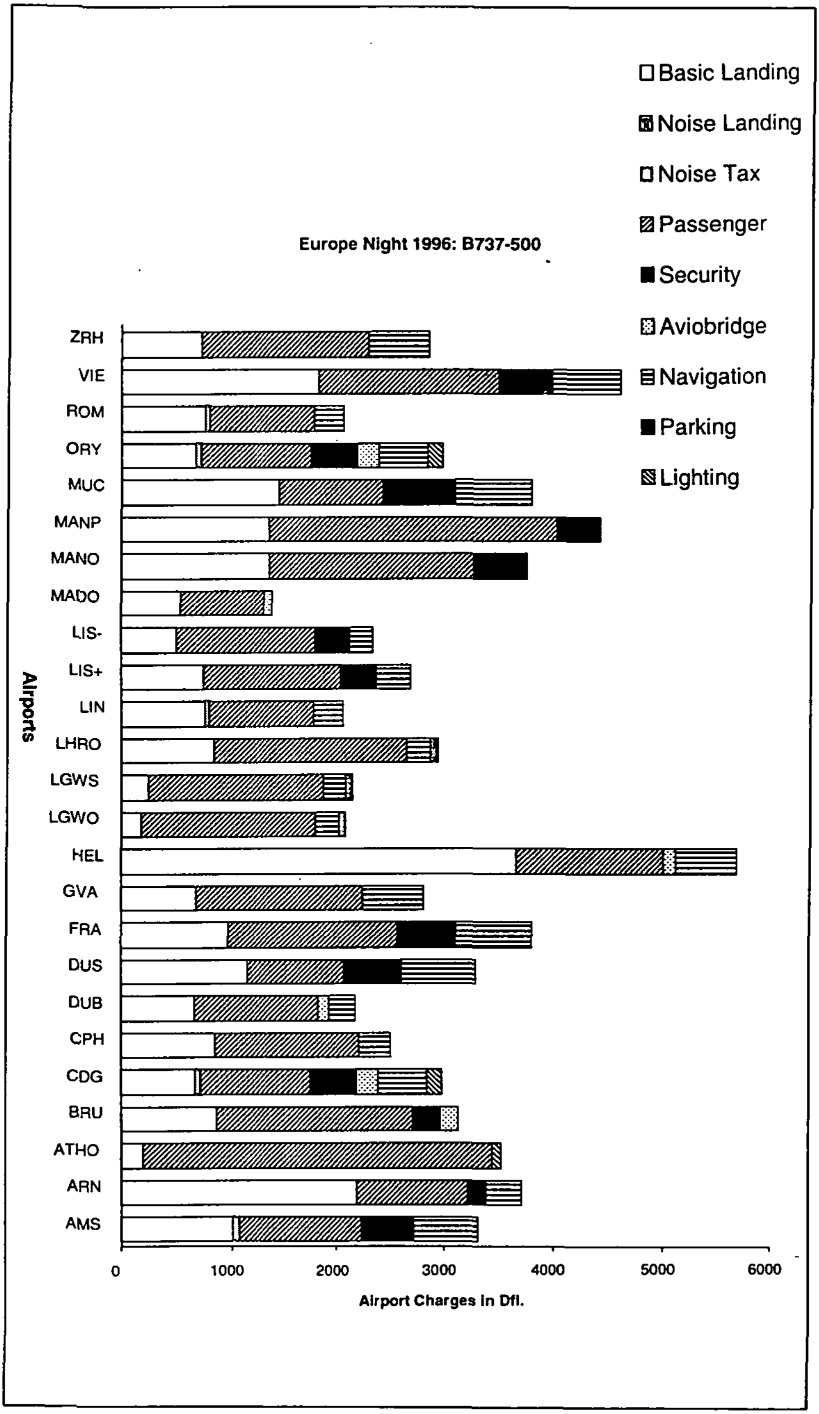

Figure 4. Airport charges for B737-500 nighttime turnaround

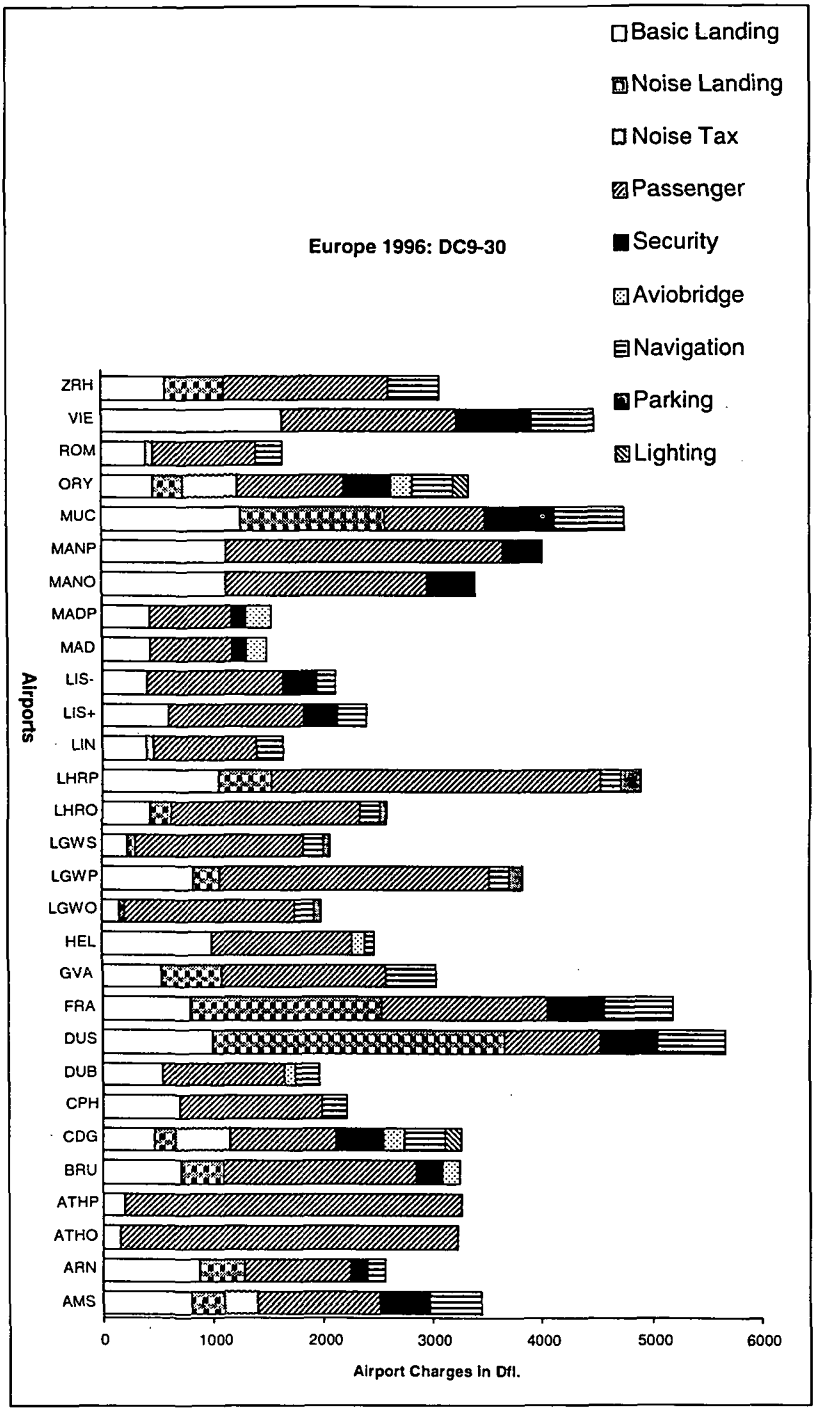

Figure 5. Airport charges for DC9-30 daytime turnaround

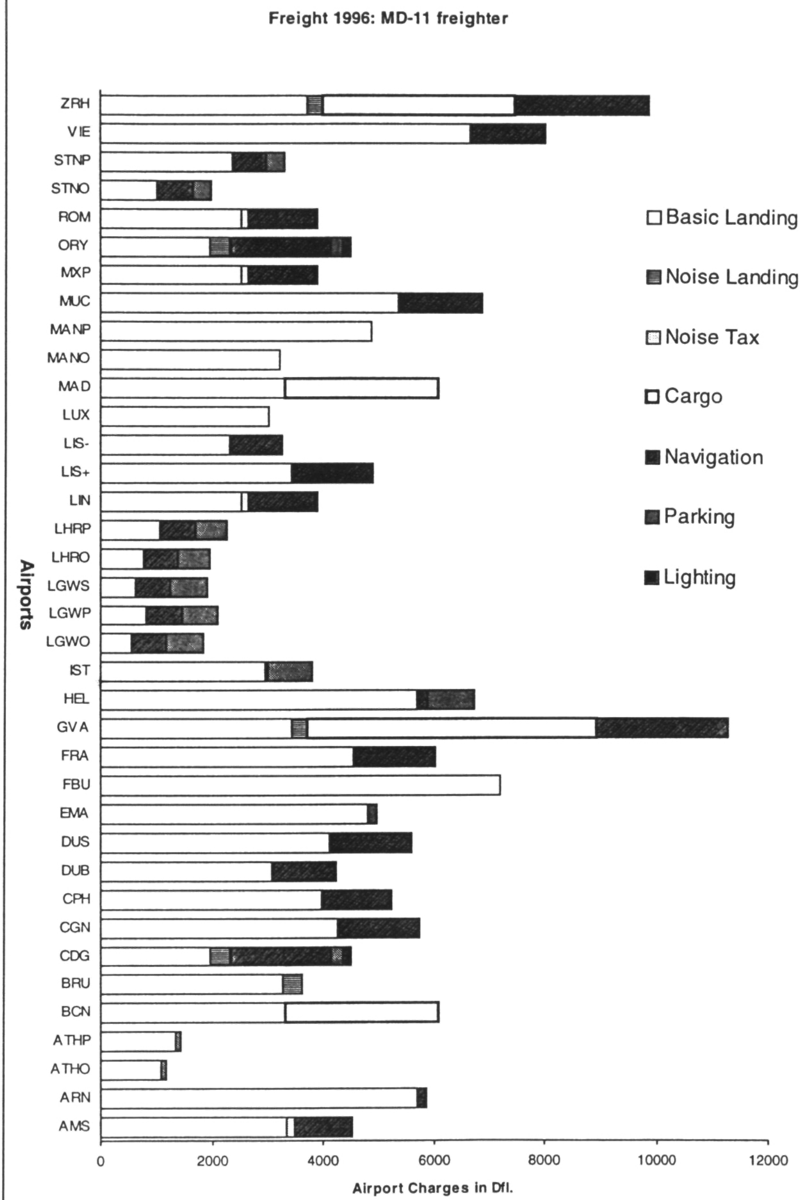

Figure 6. Airport charges for freight aircraft

Table 8
Key to Airport Codes

ZRH	Zurich, Switzerland
YYZP	Toronto, Canada
YYZO	Toronto, Canada
TLV	Tel Aviv, Israel
SYDP	Sydney, Australia
SYDO	Sydney, Australia
SIN	Singapore
SEL	Seoul, South Korea
ORD	Chicago, Illinois
NRT	Narita, Tokyo, Japan
MIA	Miami, Florida
MEXC	Mexico City
MEXB	Mexico City
MEXA	Mexico City
LHRP	London Heathrow
LHRO	London Heathrow
LAX	Los Angeles International Airport, California
JNB	Johannesburg, South Africa
JFK	John F. Kennedy Airport
HKGP	Hong Kong
HKG	Hong Kong
FRA	Frankfurt, Germany
EZE	Buenos Aires, Argentina
CDG	Paris, France
CAI	Cairo, Egypt
BKK	Bangkok, Thailand
AMS	Amsterdam, Netherlands

RECOMMENDATIONS FOR FURTHER RESEARCH

This paper contains a thorough and highly detailed inventory and comparison of standard airport charges within Europe and throughout the world. The market positions of a wide variety of airports in different contexts can be seen in terms of these airport charges. However, an analysis of airport charges alone does not provide a complete picture of either the costs faced by airlines when using a given airport, or the overall competitive position of that airport. In particular, the costs of fuel and handling are significant and probably at least as important to airlines as airport charges. These and possibly other costs should be further researched and in some form included in the ACM in order to provide a more complete comparison of the costs to airlines of using Schiphol with other airports. This will not be a simple task due to lack of data and the complexity of contracts and agreements between airlines, airports, handling companies and fuel companies.

ENDNOTES

1. A small number of exceptions were made for airports with seasonal peak charges.

2. R. Doganis, 'The Airport Business,' 1992, p. 63.

3. 1993/1994 handling and fuel costs for a Boeing 747-400 at Amsterdam Airport Schiphol, taken from *A Comparative Study of User Costs at Selected European Airports*, Cranfield University, Department of Air Transport, College of Aeronautics, February, 1994.

4. As defined by the International Civil Aviation Organization (ICAO) in 'Environmental Protection, International Standards and Recommended Practices, Annex 16 to the Convention on International Civil Aviation, Volume I: Aircraft Noise,' Third Edition, 1993.

5. Exchange rates were obtained from the Olsen & Associates Currency Converter on Internet. These rates were also checked against rates published in the NRC Handelsblad.

6. Exchange rates obtained from NRC Handelsblad.

7. Excluding handling and fuel charges.

8. 'A Comparative Study of User Costs at Selected European Airports,' Cranfield University, Department of Air Transport, College of Aeronautics, February, 1994, pp. 17-18.

9. According to the ITA study, 'Airport Charges in Europe', this passenger tax at French airports was instituted in 1995 and was FRF3 per embarking passenger in 1996 (pp. 40).

10. The night charges at Helsinki and Stockholm are incorrectly specified in the IATA manual. They are actually somewhat lower and as a result are overestimated in this study. The 1997 study will rectify this problem.

11. The ACM calculates charges separately for peak and off-peak periods if specified at a given airport. In such cases, the airport appears more than once in the figures, i.e. 'LHRP' and 'LHRO.'

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BOOK REVIEW

Oum, T. H., & Yu, C. (1997). *Winning airlines: Productivity and cost competitiveness of the world's major airlines.* Boston: Kluwer Academic Publishers. 212 pages.

Reviewed by Michaela M. Schaaf, University of Nebraska at Omaha

Winning Airlines is sixth in a seven volume series entitled 'Transportation Research, Economics and Policy,' published by Kluwer Academic Publishers. The title of this specific volume by Tae Hoon Oum and Chunyan Yu is appropriate as the authors present the environment and statistics surrounding productivity and cost competitiveness of select world airlines. The book is organized similar to a research article, befitting of the targeted academic audience familiar with the information flow of an academic article.

Winning Airlines provides a systematic analysis of airline cost competitiveness, examining the "supply side of air transport services, where airline management has considerable control" (p. 2). Oum and Yu cite this as possibly the most important determinant for success in a company. Central to the understanding of the book, Oum and Yu define an airline as cost competitive if "unit costs are consistently lower than that of competitors" (p. 1). In order to accomplish this task, Oum and Yu collaborated on four years of airline industry research, the results of which are reflected in this book. The authors also note that their methodologies are not limited to the airline industry, but could find applicability in other fields as well.

Oum and Yu have extensive qualifications in the field to appropriately handle productivity and cost competitiveness of airlines. Dr. Tae Hoon Oum is Van-Dusen Professor of the Management Division of Transportation, Logistics and Public Utilities at the University of British Columbia, Vancouver. According to Oum's vita, his research interests are centered in regulatory and industry policy analysis, demand modeling and forecasting, and cost and productivity analysis. Recently, Oum has focused his research efforts on airline policy issues including open skies and globalization of airline networks, both of which are presented in *Winning Airlines*. Dr. Chunyan Yu is a post-doctoral research associate on the same faculty as Oum at the University of British Columbia. Her expertise in productivity and efficiency analysis are evident in *Winning Airlines*. She is also published in the area of rail and air transportation.

The authors begin by reviewing historical trends in international air traffic growth and illustrating the correlation between the world economy and these air traffic levels. Since the first international airline alliance in 1986, airlines have rushed to establish alliances in order to better their stake in the competitive global air transport market. Oum and Yu predict the air transport industry is moving towards global airlines or global service networks as the cost savings and commercial benefits of such networks cannot be overlooked.

Competitiveness in the air transport industry is defined by the regulatory environment in which it operates. This regulatory environment includes an extensive network of government bilateral and multilateral agreements, the Chicago Convention of 1944, and IATA rules. The regulatory environment in North America has seen changes over the past twenty years. While the United States has increased competition through deregulation and open skies agreements, Canada has proceeded guardedly with respect to competition. The government owned carriers which once dominated the heavily regulated European market were being challenged by charter services in the 1960s and 1970s, thereby creating the need for changes in the regulatory environment. The creation of the European Community made it "the world's largest single aviation market with more than 370 million potential passengers" (p. 27). Meanwhile, the Asia-Pacific market is slower to deregulate than North America and Europe. However, through the privatization of many previously government operated airlines, the Asia-Pacific market is making progress. Oum and Yu review this significant region country by country as it is the "fastest growing air market in the world" (p. 28).

Oum and Yu selected a sample of 22 international air transport carriers to study environment and input prices. "A primary determinant of the cost of providing airline services is input prices, that is, prices per unit of [labor], fuel, aircraft and infrastructure services, as well as purchased materials and services" (p. 42). Oum and Yu provide input efficiency results in chapter five. Airline input efficiency is used to compare efficiency among airlines, while accounting for uncontrollable variables beyond airline managerial control. Oum and Yu cite two such uncontrollable variables: average stage length and composition of airline outputs. They attempt to create a baseline by removing these uncontrollable variables. However, discrepancy still exists over whether or not load factor and aircraft choice are controllable or uncontrollable variables.

After introducing some additional measurement methodologies, Oum and Yu begin to tie individual chapters of the book together in chapter six. Total factor productivity (TFP), is used to measure and compare productivity of all input factors. "TFP is defined as the amount of aggregate output produced by a unit of aggregate input" (p. 93). Results indicate most airlines improved their gross TFP levels during the period studied (1986-1995). "Productivity of a production unit refers to the ratio of its output to input" (p. 77). Labor, fuel, materials, flight equipment, and ground property and equipment constitute the categories of input, while output categories consist of scheduled passenger service, scheduled freight service, mail service, non-scheduled passenger and freight services, and incidental services. Oum and Yu infer European improvement is due to European Community regulatory and institutional changes since 1986. They propose that the decline in TFP from 1990 to 1992 may be due to the Gulf War economic recession. The residual TFP results of Oum and Yu indicate European carriers have enjoyed better growth in efficiency than American carriers. Furthermore, the results suggest the sample carriers exhibit a great deal of efficiency.

Oum and Yu state economic theory fails to provide "unequivocal propositions" on the question of whether or not government ownership impacts efficiency. Principal-agent theory maintains that government ownership is less efficient than private organizations. Oum and Yu contend this is based upon fewer managerial incentives and inadequate monitoring arrangements. Additional problems commonly associated with government ownership include over-capitalization, lower productivity, high wages, and partiality for business rather than consumer groups. Others contend that the same problems associated with principal-agent theory can arise in the private sector as well. Oum and Yu, in an attempt to resolve the debate, conduct a one-way analysis of variance (ANOVA) using residual TFP scores and the stochastic frontier model. The ANOVA results indicate majority government ownership has a "statistically significant negative effect on airline efficiency," ranging from 3 to 13 percent difference in terms of average efficiency between airlines (p. 113). Airline management should note that airline involvement in incidental businesses proved to have higher productive efficiency than those airlines not engaged in incidental businesses.

Before Oum and Yu can make their final cost competitiveness comparisons, they introduce supplementary material regarding airline cost structure. This data helps to lay the groundwork for subsequent, concluding chapters. The supplementary material introduced include capital cost shares, which have risen slightly since 1993; "an upward trend in materials cost shares...supported by growing of outsourcing/global sourcing activities" (p. 137); and unit costs in terms of cost competitiveness, where Oum and Yu identify 1200 km as the average stage length where cost effectiveness is expended. The analysis of stage length in relation to unit cost is insightful and thorough. Noting a specific point at which unit cost and stage length positively or negatively affect airline economics will assist airline management.

Next, Oum and Yu identify sources of airline cost competitiveness. Specifically, an airline is cost competitive if it sustains lower unit costs (average costs) than that of its competitors. This can be accomplished through better efficiency, lower input costs, or both. Oum and Yu contend "observed unit cost differences do not reflect true comparative cost competitiveness between the airlines, as airlines have different operating and network characteristics" (p. 160). A cost competitiveness indicator, as defined by Oum and Yu, sums input price effects and efficiency effects. The "indicator approximates the 'true' comparative cost competitiveness of airlines" (p. 162).

Throughout the book the reader anticipates Oum and Yu sharing their expertise in analyzing the data provided. Oum and Yu succinctly relay in one paragraph the practical meaning of previous chapters. The authors predict efficiency will become more important in the future as global outsourcing becomes more prevalent. Emphasis on input prices, so important in the past, will be minimized as control over these variables is beyond the airlines.

The final chapter is a review of the previous nine chapters where Oum and Yu restate the brief analyses made in earlier chapters and present conclusions of the research. It is in this last chapter that the authors mention the absence of South American carriers in the sample. The authors state, with regret, they could not compile the reliable and systematic data for the South American carriers.

The general impression of *Winning Airlines* leaves the reader considering the past trends and industry predictions offered by Oum and Yu. This book applies economic theory to airline industry data. *Winning Airlines* targets an audience familiar with the framework in which the air transport industry operates. The new aviation reader may struggle with the terminology and understanding of the airline environment. Therefore, aviation administration knowledge is helpful in analyzing some of the data provided. Faculty and graduate students in aviation, transportation, planning, and economics, and readers of the *Journal of Air Transportation World Wide* will appreciate the content of *Winning Airlines*. This volume commands a high price at $95 (U.S.), however the research contained herein is a must for all economics and transportation faculty and libraries. Faculty and graduate students will find the research has theoretical implications, while the air transport industry will appreciate the practical applicability.

Winning Airlines takes a quantitative and financial approach to evaluate airlines. Data is cited, while figures and tables abound. Oum and Yu provide a resourceful book which examines the issues relating to productivity; input prices; exchange rate dynamics; global sourcing of airline labor, maintenance, and other services; and unit cost competitiveness of the airlines.

Beaty, D. (1995). *The Naked Pilot: The Human Factor in Aircraft Accidents*. London, England: Airlift Publishing Ltd. Pp. 310. ISBN 185104825. $U.S. 19.95 Soft-cover.

Reviewed by Karisa Kane, University of Nebraska at Omaha

The Naked Pilot is a superior book for anyone interested in why human error causes aircraft accidents. The author, David Beaty, explores many different realms of human factors in the twenty chapters of the book. Topics such as the male ego, decision-making, boredom and absence of mind, human factors in management, communication, and conformity are discussed. The book is written at a level the average person could understand, but at the same time still manages to educate those knowledgeable in the aviation industry and in human factors. Beaty, a former RAF pilot, airline pilot, historian, Foreign Office principal, psychologist and author is amply qualified to speak on the subject.

Chapter One delves into the history of human error dating back to the evolution of humankind. With the explosion of technology, never has it been so important as now to understand why humans make mistakes and to try to combat these mistakes. Several major disasters, Three Mile Island, Tenerife, and Chernobyl, have brought about the urgent need to study man's mistakes in his technical environment.

In Chapter Three, Beaty labels human error as the last great frontier in aviation. The concept of pilot error is explored here. Beaty argues the term human error is an unfair and inaccurate statement for two reasons; 1) an indecent haste people feel to attribute the accident to something or someone and 2) the implicit belief that flying as a skill is very difficult.

Since the beginning of time, man has always felt the need to blame someone, a scapegoat, when something goes terribly wrong. We need somewhere to place our blame and anger when something bad occurs. The second reason is no longer true today as very few accidents are actually a result of errors in flying skill. With the advent of simulators and training programs piloting errors have become rare. However, the pilot is just as susceptible to the human condition as anyone else and most accidents are a result of human error and not piloting error.

Since the evolution of humankind, communications have become ever more complex. Beaty argues that our society has been losing the ability to communicate. Evolution has taught us that humans have a mistrust of strangers and it takes time to warm up to new people. Even if the pilots are in a situation in which they know each other, their personalities may be antipathetic. Evidence of this can be seen in many airline accidents including Air Florida (1982) in which the anti-ice was not turned on while attempting to take off in icing conditions. The 737 crashed upon take-off into the Potomac River in Washington, D.C. Incredibly, as the copilot called off the start checklist the captain answered "off" to anti-ice despite the fact the 737's wings were covered by ice and snow. The "off" response was never challenged by the copilot perhaps due to stress and time pressure, and communications broke down at a critical moment.

Beaty describes a phenomenon known as the "deadly set" in Chapter Four. It is described as a set of survival characteristics humans have inherited that predisposes us to select our environment. During an event, the human focus tends to fix on that part of the picture that is paramount at the time and ignore the rest of the environment. Pilots in the cockpit must constantly scan the environment and keep the balance between too much visual stimuli and too little. German psychologists have recognized the dangers in this "deadly set" or pattern way of thinking. Within all of us is the tendency to see things in a certain way while ignoring all other interpretations. Flight training takes advantage of these sets during training. A pilot learns a series of sets in flying maneuvers such as engine failures. Many aviation accidents can be attributed to this phenomenon including a crash landing in Orlando, Florida by a crew flying a DC-8. The crew had been alerted to traffic in the area and their attention was focused on looking for the traffic, especially since they had just canceled Instrument Flight Rules (IFR) and were looking to see and avoid. Meanwhile, they began their initial decent by throttling back the engines. This reduction in power sounded the landing-gear horn telling them the undercarriage was not down. In order to continue looking for traffic in the area and to not be distracted by the horn, they turned off the warning. The landing gear was forgotten due to the crews engrossment in looking for traffic. Subsequently, they landed on the runway with their undercarriage up causing considerable damage to the aircraft.

Beaty describes the male ego in Chapter Eight as a double-edged sword. An important part of anyone's identity is how he or she regards themselves, their place in society, and their attainments. Robbie Burns wrote that mankind needs to have a "guid conceit of himself." Freud described three parts of the man's psyche: the id, or subconscious, the ego, and the superego. Sometimes the ego grows to be over developed and inflated. This can be very dangerous in the flight environment. Flying has historically been called macho and a study showed that both men and women exhibit active-masculine personalities. One of the most infamous aviation accidents in history illustrates this notion perfectly; Tenerife. Anyone involved in aviation human factors knows the events that occurred on the island of Tenerife that cause the world's worst aviation accident. On March 27, 1977, a bomb exploded at Las Palmas airport and the airport was closed to all traffic. Two Boeing 747 aircraft (KLM and Pan Am) were told they could not land and were diverted to Tenerife as were most other aircraft. The elements of fatigue, uncertainty, and frustration were adding to a crowded airport. The KLM captain was the airline's chief flight instructor and was a man of considerable prestige in the company. His copilot had been certified by him in the 747. The Las Palmas airport opened and the Pan Am was ready for departure but found the KLM aircraft blocking the runway. The KLM moved up the runway with Pan Am following behind. The weather began to deteriorate with low clouds rolling in. KLM requested a backtrack down the runway and was to make a 180 degree turn to face the take-off direction. The Pan Am had also been cleared to backtrack down the same runway. The KLM captain was anxious to take off and probably had his expiring flight crew duty time in the back of his mind. The captain began to move the throttles as the copilot objected. The captain told the copilot to go ahead and ask for ATC clearance. As the copilot was still trying to get clearance, the captain started the take-off. The Pan Am 747 was still taxiing back up the runway as the KLM began its take-off roll. The KLM flight engineer called out that he did not think the Pan Am was clear of the runway after listening to the radio transmissions from Pan Am to ATC. He was confident the KLM did not have the proper clearance and had two options: question the captain or take action himself by shutting down the throttles and braking. Unfortunately, he chose to challenge the captain's decision while the take-off roll was occurring and it was now too late as "Vee One" was called out. The crew of Pan Am saw the KLM's landing lights through the low clouds and realized they were directly in the path of the oncoming aircraft. No one on board the KLM 747 survived and 235 died on the Pan Am 747.

The copilot of the KLM had doubts about the ATC clearance as did the flight engineer but neither one was able to overcome the captain's ego. Had the flight engineer seen any signs of support from the copilot he would have taken action. The copilot gave in to the captain's impatience to take off and his authority. No other profession is tested and challenged as often as that of a pilot. A pilot must routinely go through medical and flight checks and at any time he or she may lose their licence and their livelihood.

Beaty launches into a discussion of decision-making in Chapter Nine. An analysis of a 1977 FAA report over a four-year period showed that 50 percent of errors in judgements by pilots resulted in more than 50 percent of pilot fatalities. Pilots are routinely confronted with making decisions in a critical time environment. Not only does the pilot have to make the correct decision they also have to execute it correctly. Often the wrong decision is made and there is a tendency to stick to it through thick and thin "...because unpicking a decision is even more difficult and stressful and in some instances damaging to the person's ego" (p. 93). Psychologists have become interested in decision theory. Our ancestors developed instincts and reflexes as a basic necessity for biological and sociological survival. Pilots also learn skills and reflexes so they become highly resistant to wrong moves. However, under stress or fatigue these skill sequences may become highly disorganized. A pilot goes through many steps before he or she arrives at a decision. First, the pilot must weight the input from many information sources to understand the situation. With all of the input information, the pilot must make an assessment of all of the alternatives available from which to choose. The pro's and con's of each alternative must be weighed along with the expected outcomes. Beaty argues that one of the most important factors in decision-making is the degree of arousal involved when making a decision. Psychological research shows that under high arousal conditions, pilot thinking becomes more rigid and there is a tendency to stereotype decision-making. Extremes of arousal, whether they are very high or very low, tend to reduce the possibility of making a rational decision. Most situations encountered by a pilot are fraught with extreme arousals resulting in decision-making that is less rational. This could explain Air Florida's (1982) crash into the Potomac. Several wrong decisions were made including thinking the snow and ice on the wings were not a problem. Only at the last possible moment did the crew apply full power in an attempt to pull up and by then it was much too late.

Chapter Twelve delves into the issues of automation that Beaty argues causes boredom and absence of mind. Automation has come with a price tag. There is no doubt that automation has increased aviation safety. Ground proximity warning systems have dramatically decreased the number of controlled flight into terrain (CFIT) accidents from thirty-three in 1969 to eight in 1984. Beaty argues that automation has come at the price of loss of proficiency of pilots. A skill loss has been detected in pilots who regularly use automation. A natural human reaction to not enough stimuli is boredom and this holds true for pilots who are not sufficiently stimulated in the cockpit. An alarming example of this boredom can been seen in a 1988 Brazilian crash landing. The pilot, bored on a one hour flight from Maraba to Belem, asked the control tower how he could tune in the football match between Brazil and Chile. Completely engrossed in the football match, the pilot failed to set the autopilot correctly and put the plane on a southerly course rather than a northerly one. The pilot lost contact with Belem and was forced to crash land in dense jungle. The trees sliced off the aircraft's wings and crumbled the fuselage. Luckily, forty-three passengers survived. Rescuers reported that the first words out of the pilot's mouth after hacking his way out of the jungle was, "Who won?" (p. 133).

Beaty describes conformity as the "three headed hydra" in Chapter Thirteen. "The first head is obedience to a possibly mistaken authority, the second is going along with other people's views rather than one's own, and the third is the excessive desire to please" (p. 148). Blind obedience can be seen throughout the world in Nazi Germany and Soviet Russia in which people obeyed authority figures to a great extent and beyond what would be expected. An application of blind obedience to a mistaken authority can be seen in a 1956 Comet accident in Rome. The Comet training manual specified the take-off of the Comet's nose wheel at 80 knots. The captain obeyed the manual and attempted to take-off at a speed above 80 knots. Instead of rising, the Comet came back down on the runway. The aircraft would not fly so the captain in an attempt to save his aircraft and crew made an abrupt stop at the end of the runway. The plane was seriously damaged and yet the pilot obeyed the manual to the letter. In our society it is essential that we obey, otherwise chaos would erupt, but there is a hidden danger in blind obedience.

The second type of conformity is going along with another person's views although they are not in agreement with their own. A psychological experiment by Asch (1956) in which the task was to judge which of three lines—one of six and a quarter inches, one of six and three-quarter inches, and one of eight inches—was equal in length to the standard line of eight inches. There were nine subjects, eight of whom were 'in the know'. These subjects gave their answers first and all unanimously chose the six-and-a-quarter inch line as equal to the eight inch line. The last subject, faced with a group who had all unanimously chosen one answer, conformed to the group pressure and chose the six-and-a-quarter inch line as well. The experiment was repeated several times and 37 percent of the naive subjects gave into the group decision.

The third type of conformity, the desire to please, is a greater menace than the other two types because it wears such a benign face. In 1966, a B-707 was almost twenty hours late for a flight from Tokyo to Hong Kong. The pilot possibly trying to please his passengers for the substantial delay decided to change his flight plan to climb over Fuji rather than to the south of it. The dangerous turbulence from high winds over mountains is well known and neither the crew nor operations had informed the weather service of their intentions to fly toward Fuji. A passenger with an eight-millimeter film had recorded the fateful flight and pictures of upside-down passenger seats and torn carpet were taped. The B-707 had disintegrated in flight. The National Transportation Safety Board gave the possible cause as "the aircraft suddenly encountered gust loads exceeding the design limit and disintegrated in air in a very short period of time." The NTSB added that it was thought the climb over Fuji may have been attributed to the pilot's desire to please his restless passengers by giving them a better view of Fuji.

Beaty's many other chapters in the book such as: to see and not to see; being deceived; learning and regression; fatigue and stress; and human factor education, make this a well-rounded book on human factors. Beaty's book is by far one of the best books on the subject and I have referenced it repeatedly.

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