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PROCEEDINGS OF THE 40TH
ANNUAL MEETING OF THE
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Welcome to the Transportation Research Forum's 1998 Annual Meeting

These proceedings contain those papers presented at the 40th Annual Meeting of the Transportation Research Forum, held in Philadelphia from October 29-31, 1998, that were received by the deadline publishing date. All papers were reviewed by the Program Vice President to assess their suitability for inclusion in these volumes. Additional papers may be made available by some of the presenters at the time of the Conference.

The Transportation Research Forum (TRF) is an independent organization of transportation professionals providing pertinent and timely information to those who conduct research and those who use and benefit from research. It functions as an impartial meeting ground for carriers, shippers, government officials, consultants, university researchers, suppliers, and others seeking an exchange of information and ideas related to both passenger and freight transportation. The Transportation Research Forum started with a small group of transportation researchers in New York in 1958 and the first national meeting was held in St. Louis in 1960. National meetings have been held annually since 1960 at various cities throughout the U.S. and Canada.

Numerous TRF members and supporters aided in the development of this year's Forum, but it is authors of the papers, the organizers and contributors to the various panels, and the session chairs who make TRF annual meetings so worthwhile and enjoyable. The conference program simply reflects the interests, enthusiasm and commitment of those members of the transportation community. Special thanks go to Patrick and Judy Little who graciously agreed to assemble this year's proceedings for me. Without their help, the job of Program Chair would have been much more of a burden.

A number of other TRF members also assisted in the development of this meeting. Randy Resor and Jim Blaze were constant sources of ideas and encouragement. When help was asked for, they came through repeatedly. Other TRF members provided help with the program in their areas of interest. I want to thank Alan Bender, Michael Belzer, Ken Erickson, Paul Gessner, Harold Kurzman, Scott Ormstein, Clint Oster, and Peter Smith for their help. Claire LaVaye at the University of Texas assisted with promoting the meeting on TRF's website. Finally, Rick Guggolz provided valuable assistance on the business arrangements for the conference.

We are also grateful to those companies and organizations who have sponsored awards or made other contributions to the success of the Forum. These include: LTK Engineering, The Metropolitan Transit Association, and RailTex. Among our own members, we are especially indebted to the TRF Foundation, the Cost Analysis Chapter and the Aviation Chapter for their assistance and support.

These proceedings are prepared and distributed at the TRF Annual Forum as a means of disseminating information and stimulating an exchange of ideas during the meeting. Every effort has been made to reproduce these papers accurately. TRF, however, assumes no responsibility for the content of the papers contained in these volumes.

Richard Golaszewski
Program Vice President
October, 1998

THE CHICAGO FARE STUDY*

by

Frank Berardino and William Spitz
GRA, Inc.

Abstract

The purpose of this study was to evaluate airfares paid by Chicago originating passengers at O'Hare International Airport (ORD) versus those paid by passengers originating at seven other Midwestern hubs. A statistical analysis was undertaken to explain the variance in yield (cents per mile) paid by passengers flying to domestic points within the U.S. The analysis focused on originating passengers flying in non-stop markets because they are the ones more likely to be affected by hub-carrier dominance. The results show that market specific factors (including whether or not the market includes a vacation destination, or slot controlled airport, whether there is competition from another airport in the immediate region and the number and type of competitors in the market) play important roles in fare determination. These findings cast doubt on the efficacy of making fare comparisons across markets without adjusting for these important variables.

THE CHICAGO FARE STUDY*

by
Frank Berardino and William Spitz
GRA, Incorporated

The purpose of this study was to evaluate airfares paid by Chicago passengers at O'Hare International Airport (ORD) versus those at seven other Midwestern hubs in the United States. A statistical analysis was undertaken to explain the variance in yields (cents per mile) paid by passengers originating at each of the eight hub airports flying non-stop to domestic points within the U.S. The eight hub airports evaluated were: Chicago O'Hare, Cincinnati, Dallas/Fort Worth, Detroit, Memphis, Minneapolis/St. Paul, Pittsburgh and St. Louis. Data were for the period year-end, third quarter 1997, the latest period for which yield data were available.

The analysis focused on these non-stop markets because fares paid by passengers originating at hub airports are more likely to be affected by hub-carrier dominance than others. Passengers originating at a hub may be susceptible to the city power (the cumulative effect of a high market share of airport enplanements and the reinforcing effects of CRS systems and frequent flyer programs), and are also more likely to fly in markets with only one or two non-stop competitors. In contrast, passengers originating at a non-hub point may be susceptible to the effects of having only one or two non-stop competitors but would not be directly affected by city power. Passengers who choose to connect are also less likely to pay high fares, all other things being the same, because there are far more competitive options for one-stop or multi-stop service than for non-stop service.

An advantage of a multivariate statistical analysis of yields is that it is possible to isolate the effects of individual factors that affect prices paid by air passengers. This is a particular advantage relative to other studies which make price comparisons across different markets; such comparisons are hampered by difficulties in making adjustments for market-specific and airport-specific factors:

- Airport-specific factors: city power, income, and population which may have an influence on fares

*This study was supported by the Chicago Airport System; the conclusions are those of the authors and do not necessarily represent the position of the Chicago Airport System. The authors gratefully acknowledge comments by Mary Rose Loney and Dennis Culloton of the Chicago Airport System; Ken Quinn of Winthrop Stimson

Putnam and Roberts, and Richard Golaszewski and Chris Frankel of GRA. All remaining errors are our responsibility.

- Market-specific factors: industry structure (the number and type of competitors in a specific origin-destination pair), the composition of demand in the market (business versus leisure travel), the existence of slot controls at either the origin or destination airport, and the existence of service from a second airport.

The relative importance of these variables may help determine appropriate public policy regarding airline competition.

SUMMARY OF RESULTS

From a public policy perspective, the main questions to answer are whether fares at O'Hare are too high and whether there are likely to be policy changes that could improve economic welfare; following are the conclusions from the analysis:

- Taking into account both market- and airport-specific circumstances, the average originating passenger at O'Hare pays only 0.7% more than would be the case if every market had three or more non-stop competitors; only St. Louis (where Southwest has a strong presence) shows a similar negligible premium. Relative to other Midwest hubs, Chicago's (and St. Louis') performance exhibits more of the benefits of competition.
- Entry by low fare carriers at O'Hare is unlikely to dramatically affect average fares for originating passengers because such carriers are most likely to be viable in only a limited number of vacation markets. Under plausible assumptions, entry by low fare carriers would reduce average yields for all originating passengers at O'Hare by only one percent. This result is due in part to the fact that 67% of the passengers departing O'Hare to vacation destinations already enjoy access to competing service at Midway.
- O'Hare's performance is particularly noteworthy in view of the finding that the slot rule increases fares by about 16 percent above what they would be without the rule; the effects of the slot rule at O'Hare are at least four times greater than at any other Midwestern hub.

DESCRIPTION OF THE MODEL

Specific variables utilized in the analysis are summarized below. The dependent variable was: **Yield**, or cents per mile flown, defined as average fare paid by a passenger originating at a hub in a non-stop, origin-destination market divided by distance.¹

The independent or explanatory variables are as follows:

- **Distance:** Non-stop mileage between the origin hub airport and the destination²
- **Herfindahl Index (HHI) for Enplanements at the Departure Airport:** Measure of concentration for enplanements at the airport calculated as the squared market shares of total airport enplanements of each carrier³
- **Average Income:** A measure of the average household income in the Metropolitan Statistical Area (MSA) in which the hub airport resides⁴
- **Population:** The population in the MSA in which the hub airport resides⁵
- **Slot Control:** The existence of slot controls at either end of an origin-destination pair⁶
- **Percent Turboprop Flights:** The percent of flights in a city-pair performed by turboprop aircraft⁷

¹Calibrated from U.S. DOT DB1A data year-end third quarter, 1997.

²Calculated great-circle distance in statute miles.

³Salomon Smith Barney: "Airline Competition at the 50 Largest U.S. Airports-Update," (March, 12, 1998).

⁴1994 estimate from City-County Databook.

⁵Ibid for 1995

⁶Slot controls exist at O'Hare, LaGuardia, JFK and Ronald Regan National Airport.

⁷OAG, May, 1997.

- **Vacation Destination:** An indication that the destination city in a city-pair market is an attractive vacation place⁸
- **Percent Business Travel:** The percent of tickets sold in a city-pair market that are full fare (F, C or Y); all low-fare carrier tickets are assumed to be less than full fare¹
- **Monopoly:** Only a single carrier (whether low fare or not) operating in the market⁷
- **Two Carriers:** An indication that there are two air carriers in the market, neither of which is a low fare carrier⁹
- **Two Carriers/Low Fare:** An indication that there are two carriers in the market, at least one of which is a low-fare airline (including Southwest, America West and several smaller carriers)⁹
- **Two Carriers, Both Hubbing at Origin:** A situation where two carriers operate hubs at the origin in a city-pair market; such a market structure only exists at O'Hare¹⁰
- **Three Carriers:** Three or more carriers (low fare or otherwise) operating non-stop in the market⁷
- **Second Airport Service:** The existence of service in a city-pair from a second airport within the MSA¹¹

The statistical results are shown in the appendix.

SUMMARY OF RESULTS

⁸Albuquerque, Atlantic City, Aspen, Fort Lauderdale, Gulfport, Honolulu, Jackson Hole, Jacksonville, Las Vegas, Orlando, Miami, Myrtle Beach, Palm Beach, Panama City, Phoenix, Palm Springs, Reno, Fort Myers, San Diego, San Juan, Sarasota, Tampa, Tucson, Fort Walton Beach.

⁹OAG, May, 1997; low fare competition participating: Southwest, America West, Reno Air, American Trans Air, ValuJet, Carnival, Midway, Frontier, Airtran, Spirit, Kiwi, Vanguard, Air South.

¹⁰OAG, May, 1997: American and United hubs at ORD are the only instance of this market structure.

¹¹Airports operating in the same city or region are: DAL/DFW; HOU/IAH; MIA/FLL; SFO/OAK; MDW/ORD; EWR/LGA/JFK; BWI/DCA/IAD; LAX/SNA/ONT.

The results can be separated into the two key categories described earlier: airport-specific and market specific factors. In what follows, we present indications of the sensitivity of average yields (evaluated at the mean for all hub airports) to changes in each variable individually.

Airport-Specific Factors

- Average household income in the MSA was found to have a significant and positive influence on yields. This suggests that individuals with higher incomes tend to pay higher fares, perhaps because of their inclination to buy premium tickets. A 10 percent increase in MSA income caused yields to increase by 16 percent.
- Population in the MSA was significant and had the opposite effect; the larger the population in the MSA, all other things being the same, the lower the yield, possibly indicating advantages of economies of density in airline markets. A 10 percent increase in MSA population caused a decrease of 0.35 percent in fares.
- The HHI index of enplanements for the airport was marginally significant indicating that city power increases yields but that market-specific industry structure variables (see below) may have a more important effect on observed yields in a particular market. A 10 percent increase in HHI caused yields to rise by one percent.

Market-Specific Factors

All of the market-specific factors were found to have a significant effect on observed yields in specific origin-destination pairs.

- Yields tended to decline with distance; a 10 percent increase in distance caused yields to fall by one percent.
- Yields were also lower when the destination was an attractive vacation place. If 10 percent more of the city-pairs were vacation markets, average yields would fall by two percent.
- Slot controls had a significant and positive effect on yields meaning that in those specific markets where slot controls were present on either end of the trip, average yields tended to be higher. If 10 percent more of the city-pairs examined were subject to the slot rule, average yields would be two percent higher.

- The higher the percentage of turboprop flights in a market, the higher yields will tend to be, all other things being the same. If 10 percent more of the flights (a tripling) were by turboprops, average yields would increase by one percent.
- Higher percentages of full fare travel (most likely by business travelers) also tended to elevate observed yields in specific markets. If 10 percent more (twice the average level) of passengers paid full fares, average yields would increase by 16 percent.
- The existence of service in a specific origin-destination pair from a second airport in an MSA had a significant and negative effect on observed yields. If 10 percent more of the markets had second airport services, average yields would decline by 1.3 percent.
- The industry structure variables (measures of the number of types of competitors in a market) were also all significant; the results reported in Table 1 suggest that yields are highest, all other things being equal, in two carrier markets when no low cost operator was present; yields were lowest in two carrier markets where at least one low cost operator was present.

Table 1

**EFFECTS OF INDUSTRY STRUCTURE ON YIELDS
(Relative to Three Competitor Markets)**

Industry Structure in Origin-Destination Pair	Change in Average Yield for all Passengers if 10 Percent More of the Markets Were in an Industry Structure Category
Two Carriers (no low cost operator)	2.1%
Monopoly	1.8%
Two Hubbing Carriers at Origin	1.3%
Two Carriers (at least one low cost operator)	(1.6%)

The model explains approximately 80 percent of the variation in yields and has other desirable statistical properties which suggest that it provides useful insights into the variation in yields across origin-destination pairs and between airports, as described below.

INTERPRETATION

Mean values per passenger for the entire sample and for each airport separately are shown in Table 2.

The data and the results of the model generally correspond to those earlier described by GRA. Simple comparisons of yields do not reveal very much about airline markets. For example, the average yield at O'Hare is higher than at DFW, but the data in Table 2 suggest that markets at ORD may be more competitive--for example, more passengers pay full fare at DFW than at ORD and more DFW markets (72%) are in single carrier markets or two carrier markets with no low cost carrier than is the case at O'Hare.

While yields at ORD are adversely affected by the existence of the slot rule, the average passenger benefits from the fact that there are two hubbing carriers at O'Hare and that there is service from Midway Airport. As a consequence, only approximately 10 percent of the passenger originations from O'Hare are in monopoly markets. In contrast, 67 percent of the passenger trips at Cincinnati are in monopoly markets. All of the other hub airports examined also have a higher incidence of monopoly routings:

- Dallas/Fort Worth: 13 percent
- Detroit: 36 percent
- Memphis: 65 percent
- Minneapolis/St. Paul: 43 percent
- Pittsburgh: 72 percent
- St. Louis: 34 percent

However, some observers have expressed concerns about the effects on airfares of the slot rule in the presence of the two hubbing carriers at O'Hare, and have also noted the lack of significant low-fare carriers operating at the airport. An important question is whether these concerns offset the competitive benefits described earlier for O'Hare.

Table 2
Mean Values Per Passenger

Variable	All Hub Airports	CVG	DFW	DTW	MEM	MSP	ORD	PIT	STL
Average yield	29.5	39.6	25.7	30.1	33.7	30.3	28.2	46.2	23.8
Average household income (000)	\$24.2	21.9	23.5	24.5	21.6	25.2	25.3	22.8	23.6
MSA population (000)	5,100	1,907	4,450	5,280	1,069	2,723	8,590	2,395	2,548
Airport HHI (enplanements)	5,360	8,860	4,810	6,510	6,310	7,180	3,420	8,001	5,220
Passenger one-way distance (miles)	831	785	875	827	634	893	875	671	720
Passenger trips to percent vacation destination	22%	24	17	33	17	20	22	21	18%
Percent passenger trips in city-pairs w/slot controls at either origin or destination	38%	16	10	12	15	11	100	13	10%
Percent passenger flights in turboprops	5%	6	10	3	11	3	4	8	3%
Percent full fare (F, C, Y) passenger tickets	9%	30	14	7	10	10	5	26	1%
Percent passenger trips where second airport service available	39%	25	33	31	9	27	63	20	30%
Percent of passenger trips occurring as markets with:									
Single carrier	28%	67	13	36	65	43	10	72	34%
Two carriers, neither low cost	22%	19	59	20	12	19	4	27	11%
Two carriers, both hubs	14%	0	0	0	0	0	47	0	0%
Two carriers, > 1 low cost	11%	6	3	34	0	14	0	0	31%
Three carriers	25%	9	26	10	23	24	39	1	25%

To answer this important question, we have examined the effects of the variables which could conceivably be affected by public policy on observed yields at each of the airports.

One important question is how far from competitive conditions is the observed performance at each airport. That is, how much less would the average passenger departing from these hub airports pay if competitive circumstances existed in every city-pair market? The following is a discussion of the results summarized in Table 3.

Table 3
**PERCENT CHANGE FROM PREDICTED AVERAGE
 PASSENGERS YIELD AT EACH AIRPORT**

Airport	Without Slots	All Markets with 3 Competitors	All Markets w/2 Carriers, > 1 Low-Cost
CVG	-3.9%	-9.7%	-26.5%
DFW	-1.8%	-9.3%	-26.5%
DTW	-2.9%	-4.6%	-22.6%
MEM	-2.5%	-11.7%	-25.7%
MSP	-2.3%	-6.0%	-23.2%
ORD	-16.1%	-0.7%	-22.2%
PIT	-3.5%	-14.0%	-29.2%
STL	-2.2%	-0.3%	-18.2%

- **Slots:** Slots tend to have a relatively large effect at O'Hare where every origin-destination market is affected by restrictions on capacity; these are further compounded by the existence of EAS and exempt flights at O'Hare since such flights may not be economic on a standalone basis, but consume valuable slots which could be utilized by economically viable flights. In the absence of the slot rule at O'Hare, the average passenger would pay 16 percent less per mile flown.
- **Three Competitors in Each Market:** If there were three non-stop competitors in every market, average fares at each of the hub airports would be lower; it is significant to note, however, that the average reduction in fare at O'Hare (and St. Louis) would be negligible and less than at other hub airports; this suggests that typical markets at O'Hare are more competitive than at other airports.

- **Industry Structure Resulting in the Lowest Average Prices:** The results in the model suggest that the lowest prices exist in two carrier markets where at least one is a low-cost entity; if every market at each of the airports had this industry structure, average yields would be lower.

Of course, in the real world not all markets will support three non-stop competitors. Low cost carriers in the sample generally serve dense markets, where point-to-point service (without hub support) is economic. Similarly, three network competitors can only be supported in dense markets where there is sufficient demand to justify a high level of activity. Therefore, the potential reduction in yields implied in the last two columns of Table 3 may not be realizable in every market.

With this caveat, we note that among the eight hubs examined, O'Hare's performance is superior to all of the others except St. Louis, where Southwest has a large and growing presence and where the hubbing carrier, TWA, has suffered for years from financial weakness. Putting the unique circumstances at St. Louis aside, the average passenger at O'Hare pays yields that are closer to very competitive conditions than at other hubs:

- The average passenger at O'Hare pays only 0.7% more than would be the case if all ORD markets had three competitors

O'Hare's actual yields reflect the fact that for 47% of the passenger originations, the competitors in the market are the two O'Hare hubbing carriers and their simultaneous presence creates a more competitive environment than would be the case at a single carrier hub. Furthermore, the majority of O'Hare originating passengers (63 percent) benefit from having competitive services available at Midway Airport.

EFFECT OF LOW FARE OPERATORS

Some observers note that yields would be lower if more low cost operators competed at O'Hare. This is true, but an important question is how much would average yields paid by originating passengers decline if an economically viable pattern of low cost service was available at O'Hare.

We have considered what would happen if a low fare carrier entered in markets most likely to support low fare service. To determine which kinds of markets low fare carriers enter, we note that there is a dichotomy in the marketplace:

- Southwest is able to serve both dense vacation markets and less dense, business-oriented markets
- Other low fare carriers tend to concentrate in dense vacation markets¹²

Since Southwest already has a large operation at Midway, it is unlikely that they would enter at O'Hare. Therefore, the most likely incursion by low fare carriers at O'Hare would be in vacation markets.

We have therefore assumed a change in the market structure in each vacation market served by O'Hare by adding a carrier where less than three carriers participated in the market. The results are shown in Table 4.

The results in Table 4 suggest that entry by an additional carrier in vacation markets would reduce average yields paid by all passengers by one percent and yields paid by passengers in vacation markets by nine percent. The former measure is more relevant for judging the overall impact of a policy designed to encourage low fare operations at O'Hare.

¹²An evaluation of the markets served by Air Tran, America West, America Trans Air, Carnival, Eastwind, Frontier, Kiwi, Reno, Spirit, Valujet, Vanguard, and Westpac in May 1997 shows that in 543 of the 761 city pairs served (71%) a leisure destination made up at least one of the two cities in the non-stop market.

Table 4
EFFECT OF PLAUSIBLE LOW FARE CARRIER ENTRY ON YIELDS AT O'HARE

Vacation Destination	Actual Market Structure	Alternative Market Structure ¹³
Albuquerque	One Carrier	Two Carriers, One Low Cost
Fort Lauderdale	Two Carriers, Both ORD Hub	Three Carriers
Honolulu	Two Carrier, Both ORD Hub	Three Carriers
Jacksonville	One Carrier	Two Carriers, One Low Cost
Las Vegas	Three Carriers	Three Carriers
Orlando	Three Carriers	Three Carriers
Miami	Two Carriers, Both ORD Hub	Three Carriers
Palm Beach	Two Carriers, Both ORD Hub	Three Carriers
Phoenix	Three Carriers	Three Carriers
Palm Springs	One Carrier	Two Carriers, One Low Cost
Reno	One Carrier	Two Carriers, One Low Cost
Fort Myers	One Carrier	Two Carriers, One Low Cost
San Diego	Two Carriers, Both ORD Hub	Three Carriers
San Juan	Two Carriers, Both ORD Hub	Three Carriers
Tampa	Two Carriers, Both ORD Hub	Three Carriers
Tucson	One Carrier	Two Carriers, One Low Cost

Change in Average Passenger Yield, All ORD Markets: 1.0%

Change in Passenger Yields, Vacation Markets Only: 9.1%

¹³The model does not distinguish between types of competitors (low cost or otherwise) when three airlines are in a market, nor does it distinguish between cases if there are three or more competitors.

APPENDIX: STATISTICAL RESULTS

Variable	Coefficient Estimate	Standard Error	t-statistic	z-value	Mean
Constant	1.9489	0.835	2.335	0.0195	1.0000
Log(Distance)	-0.5933	0.017	-34.483	0.0000	6.5303
Log(HHI)	0.0790	0.058	1.367	0.1715	1.6310
Log(Average Income)	1.5992	0.308	5.190	0.0000	3.1863
Log(Population)	-0.0370	0.034	-1.100	0.2714	8.3975
Slot Control	0.1761	0.030	5.915	0.0000	0.3805
Percent Business Travel	0.0149	0.001	16.110	0.0000	9.3824
Percent Turboprop Flights	0.0012	0.001	2.278	0.0228	5.2162
Vacation Destination	-0.1982	0.025	-7.951	0.0000	0.2184
Two Carriers	0.2118	0.028	7.551	0.0000	0.2200
Two Carriers/Low Fare	-0.1637	0.035	-4.667	0.0000	0.1082
Two Carriers, Both Hubbing at Origin	0.1238	0.031	3.948	0.0001	0.1408
Monopoly	0.1746	0.027	6.462	0.0000	0.2837
Second Airport Service	-0.1264	0.020	-6.423	0.0000	0.3905

Note: Those markets involving three or more markets were treated as the numeraire (with an implied coefficient of 0); the two carrier and monopoly coefficients should be interpreted as effects relative to the numeraire.