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FORECASTING AIR PASSENGER TRAFFIC BY MULTIPLE REGRESSION ANALYSIS*

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THIS paper will describe a technique for forecasting the air passenger traffic that may be expected to travel between two communities in the event that: (1) new airline service is instituted between those two points, or (2) if there is already some type of airline service between the points, the quality of that service is changed. The technique outlined here is useful in situations where at least one of the two points studied has had scheduled airline service with, preferably, many points. By way of illustration, the use of this technique with reference to the City of Denver, Colorado will be described. Here the technique was applied to a large city with a long history of scheduled air service, and it was used to forecast the air passenger traffic that might be expected to travel between Denver and any city with which it might have new or improved air service. This technique was used as the basis for the analysis and presentation of the position of the City of Denver in a recent air route proceeding before the Civil Aeronautics Board.[1]

The Board, as is well-known, issues "certificates" to air carriers authorizing them to operate between specified points. Additions to and changes in these route certificates are made by the Board usually upon application and after consideration of the information placed before it by the parties involved.

Under the present system of federal regulation of domestic air carriers as administered by the Civil Aeronautics Board, proceedings which involve renewal or amendment of air route certificates often become complicated legal affairs involving many parties. Typically, the airlines' counsel represent a high degree of interest and competence, and they come into the proceeding with a considerable amount of carefully prepared supporting data. In such situations, where there are two or more carriers vying for certification to serve a particular city or area over a series of alternative routes, the city or cities involved may find that important issues affecting the convenience and welfare

of their citizens are at stake and may be resolved on the basis of the arguments brought forward by the carriers, who, in all fairness, can be expected to base their positions and select their issues on the basis of their own needs as determined by their costs, load factors, route patterns, expansion desires, etc. The needs of the citizens and the business communities of the cities involved will be given, at best, secondary consideration.

Thus, in spite of the genuine desire of the Board to resolve the issues so as to maximize the total benefit to all parties, the needs of the municipalities cannot be given full consideration unless they are studied, analyzed, incorporated into appropriate exhibits and supported by representatives at the various stages of the proceeding. The City of Denver had occasion to participate in just that sort of procedure in the *Denver Service Case*. Various domestic airlines including TWA, American, Braniff, Continental, Western, United, and North American, had over a period of years, applied to the Civil Aeronautics Board for authorization to inaugurate new routes or new route segments through the city of Denver, and, in August, 1953, the Civil Aeronautics Board consolidated these applications into one proceeding which was entitled the "Additional Service to Denver, Colorado Case" ("Denver Service Case"). By this procedure, the Board hoped, by simultaneously hearing all interested parties, to be able to resolve the issues most equitably.

It became obvious to the authorities in the City of Denver that the results of this proceeding could have far-reaching effects upon Denver's air transportation system and indeed upon the future development of Denver and its industries. The great number of airlines involved and the huge number of cities which are served by these various airlines and which, as a result of the proceeding, could become connected with Denver for new single carrier air service meant that the pattern of air services available at Denver could be profoundly influenced by the outcome of the proceeding.

Realizing that the carrier parties involved in the case were naturally concerned with their own interests and route development, and that such interests as the City of Denver might have in the outcome of the proceeding could command, at best, only secondary attention in the applications of these various carriers, the City of Denver therefore decided that its interests could be served adequately only by its direct and active participation in the proceeding. Such participation required, first, a determination of just what did constitute the proper interests of the City of Denver insofar as they could be achieved by the matters consolidated into the proceeding.

The air service available to the City of Denver consists of air flights to and from various other communities. Therefore any improvement in the air service pattern at the city must consist of new service to points with which flights have not been available or additional flights or improved flights to those communities which are being served.

Therefore, there were four steps involved in the delineation and preparation of the issues to be supported by the city in its case before the Board. These steps were:

1. Identification of those cities with which air service was needed.
2. Determination of the type of air service that should be offered.
3. Analysis of the extent to which these services were not being provided by the carriers serving Denver.
4. Selection of those needed services which were not available but which could become available under the applications consolidated in the *Denver Service Case.*

The identification of the cities with which air service was needed was based upon air traffic forecasts under the assumption that services were required and justified if they could generate or develop enough air passenger traffic to make them economically feasible within the present framework of air carrier operations. It is with the techniques used for the preparation of the forecasts that the remainder of this paper is concerned.

These air passenger traffic forecasts were based on a multiple correlation analysis of Denver's air traffic experience. Basically, what was done was:

1. The number of passengers flying between Denver and other cities was analyzed and related to other factors such as community of interest with Denver, distance from Denver and quality of the air service offered.
2. Since data for these other factors could be obtained or hypothecated (as in the case of quality of service) for all cities whether or not they had service with Denver, it was possible, by assuming the same relationship among these factors for the unserved cities as among the served cities, to estimate the air passenger traffic potential between Denver and all other communities.

Definition of Service

Air service was considered to exist between Denver and any other point when single-plane service was offered to that point. That is, if a flight is offered between Denver and another point such that a passenger can board the airplane in Denver and debark from that airplane in the other city (and vice versa), there is single-plane service between Denver and that other point. If it is necessary for the passenger to change airplanes, whether he changes airlines or merely changes to another airplane operated by the same airline, this is multi-plane service and is not considered, in this analysis, as satisfactory "air service." Therefore only single-plane service is considered in analyzing the relationship between air traffic and air service.

Selection of Data for Study

All of the communities with which Denver had single-plane air service offered in a selected period in 1952 were singled out and various data for the year 1952 were studied. These data included: the flight

schedules with Denver, the number of passengers traveling between these communities and Denver, the distance from Denver, and many measures of community of interest between these various cities and Denver. The data for schedules and for air passengers traveling between Denver and these other cities referred to the months of March and September, 1952. This is because it is for the months of March and September that the Civil Aeronautics Board compiles in its "Airline Traffic Survey" the number of origin and destination passengers traveling between all pairs of cities in the United States. In order that the number of passengers traveling between the various pairs of cities may be related to the actual flight schedules under which these passengers were developed, the schedules for March and September 1952 were those selected for study. The year 1952 was chosen because it was the latest year for which the "Airline Traffic Survey" was available at the time of preparation of exhibits for the proceeding.

Community of Interest

Manifestly, one highly useful measure of community of interest between pairs of cities for the purpose of determining air passenger traffic potential is the number of air passengers historically traveling between those points. This measure, although highly useful with respect to those pairs between which service has been offered, is, of course, unable to give any indication of air passenger traffic potential for pairs between which flight schedules have not been offered. Therefore a more general measure of community of interest as affecting air passenger traffic was required.

For the purposes of this analysis many different factors measuring community of interest were compiled and studied. These included: population, distance from Denver, air passengers with Denver, hotel registrants at Denver hotels, air freight to and from Denver, surface letter mail, number of telephone messages from Denver, number of telegrams from Denver, number of home offices of firms with branches in Denver, number of branch offices of firms whose home offices were in Denver, business travel characteristics as compiled from questionnaires sent to Denver business firms, rail passengers with Denver, number of persons renting cars at the Denver airport, number of visiting buyers and exhibitors at annual Denver exhibitions, number of correspondent banks of Denver banks, number of patients admitted to Denver hospitals, number of students at Denver colleges, circulation figures of newspapers and magazines published in Denver, number of bank checks cleared through Denver banks, number of charge account customers at Denver stores, and the familiar and commonly used community of interest measure, population divided by distance.[2]

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[2] The usual formula for this quantity is, *population of the first city times population of the second city divided by the distance between those two cities.* In this case, since Denver was always one of the two cities in each pair, the formula was simplified to, *population of the outside city divided by distance from Denver.*

From all of these measures of community of interest, it was desirable to select, if possible, one measure for use in the correlation analysis. The measure selected was the number of hotel registrants from various outside cities registered at Denver hotels. This measure was selected for several reasons:

1. Since the data were obtained by a hotel survey conducted for this purpose, the accuracy and suitability of the data were controlled.
2. Every city in the country, indeed, in the world, was included in the study, since all registrants, regardless of their origin were enumerated.
3. Hotel registrants are typically people who have traveled between their home city and the city in which they are registered. Thus the relationship between number of registrants and transportation requirements is a real one.
4. It was possible, with hotel registrants, to include with each outside city those places which are satellite to it, which use the same airfields, and which, for the purposes of air transportation, are effectively the same community.
5. Preliminary graphical analysis indicated a definite relationship between air passengers and hotel registrants.

For the purposes of this study, the registration records at eleven[3] Denver hotels in March and September of 1952 were examined. The survey covered 141,000 room-days and yielded 53,000 registrants giving home addresses outside the Denver region. Thus, community of interest; or, in this case, the strength of the complex of forces which lead to the generation of air travelers, was measured by hotel registrants as defined above. This measure did, of course, have the disadvantage that it tended to measure community of interest in only one direction. That is, it measured the attraction for persons from other communities to come to Denver, but it did not consider travel in the opposite direction. However, comparisons between hotel registrants and the measures of community of interest which are related to attraction in the opposite direction; such as outgoing mail, telephone calls, and telegrams from Denver, disclosed no serious systematic differences.

Quality of the Service

The desire to travel between two cities, as evidenced by community of interest considerations, cannot of itself produce air passengers unless adequate air service is offered. Thus, the second necessary factor is the availability of flight schedules that are convenient and appropriate to the needs of the potential travelers. There are many factors which reflect the "quality" of air service between two points and which therefore are the factors which influence the extent to which the community of interest between two communities can be expressed in actual realized air traffic. Some of these factors are: the number of

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[3] The hotels were: Adams, Albany, Ambassador, Argonaut, Auditorium, Brown Palace, Cory, Cosmopolitan, Kenmark, Sears and Shirley-Savoy.

en route stops, the number of flights per day, the type of equipment used, and the times of day at which service is available. Obviously many of these factors are interrelated and therefore it is not necessary for all of these factors to be considered in order to form a judgment about the quality of the air service offering. Typically an airline may be expected to offer a balanced pattern of service up to and including the best flight which it feels the traffic can support. The quality of this best flight is usually related to the number of en route stops between the points under consideration. Therefore, quality of service may be considered to be a function of the best service offered between the two points, and it may be, with limitations, evaluated in terms of the number of en route stops on that best flight.

In this analysis, quality of service was measured by the number of en route stops.

Distance

A third controlling factor in most travel decisions is the distance between the two points. The effect of distance on air travel is a composite effect of two general influences. The first is the greater tendency on the part of travelers to make trips where the distance is short. The second is the greater tendency for travelers to prefer air travel where the distance is longer, and to make by air trips that might, by any other mode of transportation, be so time-consuming as to be unfeasible.

Since hotel registrant data were used as the primary community of interest measure in the analysis, the distance between each of the communities under consideration and Denver was automatically taken into account by the influence which distance of any city from Denver exerts on the number of hotel registrants from that city registered in Denver hotels. However it was found that for the nearby cities (those within 200 miles) the effect of distance was not adequately taken into account by the use of hotel registrant data alone, but that for those communities there was a further relationship with distance. However, for communities beyond two hundred miles from Denver there was no additional relationship between distance and passengers beyond the effect of distance that was already taken into account in the hotel registrant data.

Since the *Denver Service Case* was concerned primarily with transcontinental air service through Denver, and since under the applications consolidated into that proceeding, there were no communities within two hundred miles of Denver at issue, those communities less than two hundred miles from Denver were eliminated from the analysis, and there was thus no need for separate treatment of distance as a variable in the analysis.

Multiple Correlation Analysis

There were 65 communities which had direct single-plane air service with Denver in March and September 1952, which were more than

200 miles from Denver, and which exchanged a majority of their air passengers with Denver via the carrier offering the single-plane service.

For these 65 communities there were three variables considered in the multiple correlation analysis. These were: air passengers, hotel registrants, and type of service. The data are shown in Table I, and the footnotes indicate in detail how the data for air passengers and hotel registrants were compiled.

Preliminary graphical analysis suggested that logarithmic relationships gave close approaches to linearity. This was quite logical since it indicated that for a given percentage change in hotel registrants, a proportional change might be expected to occur in air passengers, and a proportional depressing effect is produced by any reduction in quality of the service. Thus the traffic generation differential between different service qualities declines with decreasing quality of the service at a greater rate when the quality of the service is good than when it is bad, making the difference between non-stop and one-stop service greater than that between one-stop and two-stop service and that, in turn, greater than the difference between two-stop and three or more stop service. It was also noted that there was no substantial adverse effect of declining quality of single-plane service beyond three-stop service. Therefore all cases of more than three-stop service were grouped with the three-stop cases. The actual variable used in the correlation analysis to represent service was the logarithm of the number of legs (one plus the number of stops); that is, non-stop service was quoted as *one*, one-stop service was quoted as *two*, etc. The other two variables in the equation were the logarithm of air passengers and the logarithm of hotel registrants as those data appear in Table I.

The usual techniques of multiple correlation analysis were applied, and the multiple regression equation was computed. That equation was found to be:

$$\log X_1 = 1.97986 + 0.71529 \log X_2 - 0.84913 \log X_3$$

where X_1 = origin and destination passengers, 1952
   X_2 = the number of hotel registrants
   X_3 = the number of intermediate stops (best service offered) plus 1

As was to be expected the plus and minus signs, respectively, indicate that air passengers increase with increasing hotel registrants and decrease with worsening service. It must be remembered that the greater the value of the service measure; namely, the number of stops, the worse the service. The multiple correlation coefficient was found to be 0.91. The significance of this coefficient was tested by the methods of analysis of variance, and it was found to be significant.

Fig. 1 shows the multiple correlation relationship reduced to two dimensions. This was done by taking service variations into

FIG. 1

RELATIONSHIP BETWEEN
AIR PASSENGERS WITH DENVER ADJUSTED TO
LEVELS CHARACTERISTIC OF NON-STOP SERVICE
AND
HOTEL REGISTRANTS AT DENVER

account before plotting the points. That is, the generation effect of
service was taken into account by increasing the passenger figure for
all communities with less than non-stop service to the level char-
acteristic of fully developed non-stop service. This adjustment was
made on the basis of the relationship between air passengers and type
of service as described by the multiple regression equation. Thus it

TABLE I

AIR PASSENGERS WITH DENVER, HOTEL REGISTRANTS AT DENVER HOTELS,
AND TYPE OF AIR SERVICE WITH DENVER FOR THE SIXTY-FIVE COMMUNITIES

Community (1)	Air Passengers (2)	Hotel Registrants (3)	Quality of Service (No. of Stops) (4)
Birmingham, Ala.	894	29	7
Flagstaff, Ariz.	66	9	5
Prescott, Ariz.	258	7	6
Winslow, Ariz.	120	6	4
Fort Smith, Ark.	348	10	4
Little Rock, Ark.	762	13	5
Los Angeles, Calif.	30,438	2,086	0
San Francisco, Calif.	23,592	1,197	0
Durango, Colo.	2,622	253	2
Washington, D. C.	10,164	705	0
Boise, Ida.	2,016	87	1
Chicago, Ill.	20,364	2,149	0
Des Moines, Iowa	2,034	141	1
Dodge City, Kan.	210	31	4
Garden City, Kan.	246	80	3
Great Bend, Kan.	198	63	5
Hutchinson, Kan.	882	51	0
Salina, Kan.	552	53	0
Topeka, Kan.	768	127	1
Wichita, Kan.	4,212	389	1
Detroit, Mich.	3,534	342	1
Mankato, Minn.	36	8	9
Minn.-St. Paul, Minn.	7,866	445	0
Kansas City, Mo.	14,040	1,210	0
St. Louis, Mo.	5,904	626	1
Billings, Mont.	6,594	240	1
Great Falls, Mont.	2,226	81	2
Lewiston, Mont.	96	18	4
Grand Is., Neb.	414	82	2
Lincoln, Neb.	594	186	3
North Platte, Neb.	468	160	1
Omaha, Neb.	6,828	622	0
Las Vegas, Nev.	3,318	39	0
Albuquerque, N. M.	10,392	468	0
Farmington, N. M.	1,374	29	3
Gallup, N. M.	420	14	4
Las Cruces, N. M.	48	4	8
Santa Fe, N. M.	1,830	211	2
Socorro, N. M.	54	9	3
Truth or Consequences, N. M.	114	3	7

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Community (1)	Air Passengers (2)	Hotel Registrants (3)	Quality of Service (No. of Stops) (4)
New York, New York	23,916	1,996	0
Cleveland, Ohio	3,114	221	1
Bartlesville, Okla.	1,212	161	2
Oklahoma City, Okla.	5,388	489	1
Tulsa, Okla.	6,168	448	3
Portland, Ore.	3,900	233	0
Philadelphia, Pa.	3,054	229	1
Brookings, S. D.	48	4	8
Huron, S. D.	360	7	7
Pierre, S. D.	156	10	6
Rapid City, S. D.	1,530	249	5
Spearfish, S. D.	138	168	4
Amarillo, Tex.	2,952	234	0
Austin, Tex.	618	49	3
Dallas, Tex.	7,554	632	2
El Paso, Tex.	5,856	112	1
San Antonio, Tex.	3,960	164	4
Salt Lake City, Utah	14,334	839	0
Seattle-Tacoma, Wash.	7,566	410	0
Casper, Wyo.	9,804	1,156	0
Greybull, Wyo.	252	39	5
Powell, Wyo.	414	171	6
Riverton, Wyo.	798	188	4
Sheridan, Wyo.	1,980	175	2
Worland, Wyo.	600	71	4

Sources:

Col. (2): CAB Airline Traffic Surveys, March, 1952 and September 16-30, 1952, expanded to an annual total by multiplying the sum of March passengers and twice September 16-30 passengers by six.

Col. (3): Registrants at 11 Denver hotels in March and September, 1952. The survey covered 141,000 room days and yielded 53,000 registrants giving home addresses outside the Denver region. The hotels were: Adams, Albany, Ambassador, Argonaut, Auditorium, Brown Palace, Cory, Cosmopolitan, Kenmark, Sears and Shirley-Savoy.

Col. (4): Number of intermediate stops, best flight in either direction in March or September, 1952. Official Airline Guide, March and September, 1952.

shows the relationship between the service-adjusted air passengers, on the one hand; and hotel registrants, on the other hand.

The resulting equation was used to estimate the potential air passenger traffic between Denver and other communities. In order to obtain the estimate, the number of hotel registrants found in the sur-

veyed hotels during the survey period is entered into the equation and then estimates of potential air traffic can be made for any and all qualities of service. These estimates were evaluated in terms of the other available community of interest measures and such adjustments as seemed indicated were made. The most important and frequently occurring kind of adjustment was an increase in the estimated traffic potential in those cases where there was no direct single-plane service between the city in question and Denver but where the actual developed traffic under the two-plane connecting service was particularly high. This may be an indication that, in at least some of those cases, the use of hotel registrants as a measure of community of interest for the purpose of determining potential air passenger traffic erred by failing to consider attraction in the opposite direction; that is, potential travel by Denver residents to the communities in question.

From these air traffic estimates the appropriate quality of service between Denver and the other communities was determined, and this was then compared with the quality of service then being offered. For those communities where the quality of service required, as thus determined, was better than the quality of service then being offered, and where an improvement in the quality of service offered could be obtained through a determination of the issues involved in *The Denver Service Case,* the City of Denver presented exhibits and witnesses before the CAB in support of its interests as thus defined.