TRANSPORT NODES AND LOCAL SERVICE AIRPORTS IN THE MIDWEST

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INTRODUCTION

This paper considers what variables affect the volume of air passenger originations at the local service airports which link the smaller cities to the hub airports of the nation. Analysis of this type may provide useful information for the formulation of policy on the spatial distribution of local service airports.

A current problem is the continued dependence of the local air carriers upon government subsidy. The amount of subsidy required by the local carriers has declined from a high of $67 million in 1963 to $52 million in 1968 [8], but the stated objectives of the Civil Aeronautics Board (CAB) with regard to local service airlines are: further reduction in cost to the government, the financial health of the carriers, and improved service to the public [9]. To accomplish these objectives will undoubtedly require changes in the existing local service air transport network.

In many large metropolitan areas the trip from the centre of the city to the airport requires between 30 and 60 minutes. At the same time many small cities in the United States have subsidised air service, though they are about the same travel time from a hub airport. In view of this inequity, it seems appropriate to ask whether the airlines serving the smaller cities should continue to be subsidised. For example, in the states of Illinois, Iowa, Indiana, Minnesota, Missouri, Ohio and Wisconsin twenty-one cities which have air service are within one hour travel time of a larger hub airport. These cities are:

- Bloomington, Illinois
- Danville, Illinois
- Decatur, Illinois
- Galesburg, Illinois
- Mattoon, Illinois
- Sterling, Illinois
- Rockford, Illinois
- Clinton, Iowa
- Iowa City, Iowa
- Bloomington, Indiana
- Marion, Indiana
- Mankato, Minnesota
- Worthington, Minnesota
- Winona, Minnesota
- Joplin, Missouri
- St. Joseph, Missouri
- Portsmouth, Ohio
- Zanesville, Ohio
- Beloit, Wisconsin
- Manitowoc, Wisconsin
- Oshkosh, Wisconsin

The question may be raised whether termination of air service to any of these cities would constitute a serious hardship.

Improved service and reduced cost (that is, more efficient use of resources) are worthy objectives. In the extreme, government subsidisation of local air service could be entirely eliminated, but the result would be termination of air service to many of
the nation's smaller communities. Access to the nation's air transport system is a necessity if the smaller cities and their hinterlands are not to be left out of the main stream of national economic growth and development. Indeed, given the current focus on the development of the smaller cities, as a means of both preventing economic stagnation in rural areas and alleviating the congestion in our larger metropolitan centres, it is important to consider the restructuring of the nation's local air service systems to facilitate economic growth of these areas and at the same time reduce, or eliminate, the subsidisation of local air service.

Because of the present method of basing subsidy on class rate, it is not possible to directly assign a specific amount of subsidy for service to a particular air route or city. However, it seems reasonable, in view of the relatively high fixed cost of airline operations, that the fewer the passengers originating at a given airport, the greater is the subsidy required to provide service to that area. Thus, elimination of air service to cities providing small numbers of passengers would cut down the required subsidy to local air carriers. Currently, the major criterion used by the C.A.B. in determining continued operation is the "use it or lose it" rule, which states that a local service airport must have an average of five passenger origins per day to be allowed continued operation ([4], p. 810).

The goal in planning air transport for the smaller cities may be stated simply as to reduce cost to the government (elimination of subsidy) without substantially reducing service to the public. But there is lack of information on the factors that affect the number of passengers using an airport. To what extent do such factors as size of the population served, their income, and the proximity of other airports affect the volume of passenger origins at a local service airport?

There is a need to determine the variables that affect the volume of passenger traffic in a spatial context. We are concerned with the alternative scale and spatial distributions of air service. For example, fewer but larger airports make possible greater volume and variety of flights to various destinations and generally faster service between destinations. On the other hand, fewer airports mean greater distances to be covered by surface transport. Thus, we are attempting to determine the behavioural relationships of the population in their use of local service airports.

**MODEL OF LOCAL SERVICE PASSENGER ORIGINATIONS**

An identification problem exists in the specification of a model to explain the variation in passenger origins at non-hub airports (i.e., demand for passenger services at the ith airport), because the observed number of passenger origins at a non-hub airport is a function not only of certain independent variables that are hypothesised to affect demand, but also of the supply of air passenger services. Passenger origins at a given airport are not just a measure of the demand for air service, but result from the interplay of that demand and the supply of service offered in terms of frequency of flights, different destinations, and connections in the national air transport network. The situation is further complicated because supply is regulated: any change in service must be approved by the C.A.B. Since any decisions on changes in service by an air carrier are essentially based on demand (i.e., the price and quantity of air service is regulated, and supply in terms of destinations and
frequency of flights is changed only as demand changes and approval is granted by the C.A.B.), the model developed to explain passenger originations is essentially demand oriented.

A regression model is specified in which passenger originations at mid-western non-hub airports are a function of the following independent variables: (1) per capita income in the service area, (2) population of the service area, (3) number of departures at the nearest hub airport, (4) college enrolment in the service area, (5) travel time (or distance) to the nearest hub airport. The hypothesised relationships between the dependent and independent variables are:

(1) The greater the per capita income of the county, the greater the number of passenger originations.

(2) The greater the population of the airport service area, the greater the number of passenger originations.

(3) The number of flights leaving the nearest hub airport and the number of passenger originations at the local airport are inversely related.

(4) The greater the college enrolment in the city in which the airport is located, the greater the number of passenger originations in that city.

(5) The greater the travelling time to the nearest hub airport, the greater the number of passenger originations at the local airport.

The model using 1966 cross-section data on passenger originations from the 60 local service airports in the midwest\(^1\) was specified in the following form:

\[ Y_i = B_1 \cdot X_{51}^{b_2} \cdot X_{51}^{b_3} \cdot X_{51}^{b_4} \cdot X_{51}^{b_5} \cdot X_{61}^{b_6} \cdot 10^{w_i} \]

where:

- \( Y_i \) = the number of passenger originations at the \( i^{th} \) local service airport
- \( X_{51} \) = disposable personal income per capita\(^2\) of the \( i^{th} \) service area
- \( X_{51} \) = population of the \( i^{th} \) service area
- \( X_{51} \) = the number of departures at the hub airport nearest the \( i^{th} \) local service airport
- \( X_{51} \) = travel time in minutes between the nearest hub airport and the \( i^{th} \) local airport
- \( X_{51} \) = college enrolment at the city of the \( i^{th} \) local service airport.

The assumption of a multiplicative relationship between the dependent and independent variables is common in demand studies. The double logarithmic transformation has been made by other economists when explaining or predicting passenger usage of air service. Samuel B. Richmond ([5], p. 440), Lansing, Liu and Suits ([3], pp. 107–108), and Irving Saginor and S. L. Brown ([6], p. 9) found that the relationship between the dependent variable and the specified independent variables was multiplicative.

In specification of the model explaining passenger originations at non-hub airports, the question arises: What is the relevant geographic market area for data collection?

\(^1\)The midwestern states included in this analysis are: Illinois, Iowa, Indiana, Kansas, Minnesota, Missouri, Ohio, and Wisconsin.

\(^2\)Per capita county income data were not available; thus we had to resort to the use of sales management estimates of effective buying income per capita for counties. The concept of effective buying income per capita is similar to disposable personal income per capita [7].
How large the market area is depends in part upon the distance to other airports. For example, the Goodland, Kansas, airport, relatively isolated from other airports, would be expected to serve a multi-county area. On the other hand, the airport at Clinton, Iowa, which lies between the airports at Moline (Illinois), Dubuque (Iowa) and Sterling (Illinois), would be expected to serve a much smaller area.

To determine airport service areas, it was assumed that people would use the closest airport. On this assumption, airport service areas were delineated by bisecting the distance between an airport and each of the surrounding airports and then connecting the mid-points of the bisected lines (see Figure 1). In many cases this delineation procedure would divide a county so that half the county was in the service area of one airport and the other half was in the area of another airport. In most of these cases, for ease of data collection, the entire county was placed in the
service area of one of the airports on criteria such as the surface transport system and the location of the major population centre of the county.

The size of market area as measured by population was used to explain the volume of passenger originsations. The importance of population in explaining the usage of transport appears widely accepted. Lansing, Liu and Suits included the population of the Standard Metropolitan Statistical Area as a variable in their analysis of interurban air travel ([3], pp. 107–108).

In studying demand, the quantity demanded is usually considered to be a function of price and income of the consumer. Price variations in airline fares are not considered, because of lack of data and because prices are regulated; hence per capita income differentials are used to explain differences in airport usage. Lansing and Blood ([2], p. 96) found that income is a significant determinant of the quantity of air service an individual uses.

An alternative to using the local service airport, with its limited facilities and few daily flights, is to drive to the nearest hub airport to take advantage of the greater number and variety of flights. In demand analysis this is similar to the case of product substitutes. The greater the number and variety of flights from a hub airport, the higher is the assumed level of service. Thus, it is hypothesised that the greater the number of flights leaving the hub airport, the fewer the passenger originsations at the local non-hub airport.

An alternative to the use of local service airlines is to use a different mode of transport. However, variables accounting for substitution of automobile, rail and bus transport for air travel are not included in this study. On the empirical side, it is difficult to measure the availability of these alternative modes in terms of quantity, quality of service, and connections within the transport system. On the theoretical side, it is questionable whether these modes are substitutes for air travel. The decline of railroads in recent years has resulted in a reduction in service to many smaller cities, such as the cities of interest in this study. Also, for the main types of air travel, such as long-distance trips and business trips, which place a premium on speed, air travel is the most used mode ([2], p. 177).

The importance of college enrolment in explaining passenger usage of local service facilities was not initially recognised. A study of the plot of residuals from the regression equation using county data indicated that cities for which the predicted value of passenger origination was low relative to the actual value were in many cases cities which contained a major educational institution. Among these “outliers” were Lafayette, Indiana; Terre Haute, Indiana; Manhattan, Kansas; and Columbia, Missouri. All these cities have colleges or universities with large enrolments.

In retrospect, the importance of the college enrolment variable may not be so surprising. Lansing and Blood point out ([2], p. 99) that the occupational group which most frequently uses air transport is the professional and technical group. In a relatively small town with a large university, one would expect the university personnel to comprise a large part of the professional and technical group. Another explanation for the importance of the college enrolment variable is that business

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3One might also argue that the volume of flights at the hub airport is larger because the population of the non-hub airport prefers to use the hub facility for some other reason, such as better terminal facilities, jet service, etc.
trips constitute approximately two-thirds of all air travel ([2], p. 23). In the small and generally non-industrialised towns included in the sample the major business may be higher education. Thirdly, college enrolment measures the size of a group of people who might be travelling to and from the city several times in a year.

Travel time and distance are considered an important variable in determining population behaviour. For example, Karl Fox's delineation of the functional economic area is based upon the population's behavioural parameter of the one-hour travel time that people are willing to travel to a job or to shop for certain goods and services [1]. We are interested in determining to what extent time (distance) of travelling to a hub airport might affect local passenger origination. In the regression analysis the variable is stated as estimated travel time to the hub airport, taking into consideration use of two-lane or four-lane highways. It is hypothesised that the greater the distance to the nearest hub airport the greater are the passenger originations at the local airport.

The hypothesised relationship is depicted in Figure 2. In the double log transformation model the regression coefficient is expected to be positive with $B > 1$, and with the function eventually reaching a limit based upon the population of the
service area, per capita income, etc. The argument for $B > 1$, i.e., passenger originations increasing at an increasing rate as time from the hub airport is increased, is that the greater the travel time (distance) between the local service and hub airports, the stronger would be the inclination of passengers to use the local airport. At some limit, distance between airports would become such a barrier that all potential air passengers of the local service area would use the local airport.

EMPIRICAL RESULTS

The estimated regression coefficients obtained when the regression model was tested on data for 60 mid-western non-hub airports are presented in Table 1. All the regression coefficients are in agreement with the hypothesised sign. The coefficients of per capita income, population, time and college enrolment are positive. The number of flight departures at the nearest hub airport, as hypothesised, is inversely related to the number of passenger originations at the local airport.

Interpretation of the data in Table 1 indicates that a 1 per cent change in per capita effective buying income results in a 2·4 per cent increase in passenger originations. A 1 per cent increase in the population of the service area results in an 0·9 per cent increase in passenger originations. A 1 per cent increase in departures at the nearest hub airport reduces passenger originations at the local airport by −0·34 per cent. A 1 per cent increase in the travel time between the local airport and the hub airport results in an increase of 0·53 per cent in local departures. Lastly, a 1 per cent increase in college enrolment in the local area will increase passenger originations by 0·06 per cent.

There is need for further discussion of the hub departures variable and the time (distance) variable, because it could be argued that they are just the two sides of the same variable. We have postulated in the model that hub departures and local passenger originations are inversely related, i.e., when hub departures are large, this has a strong pull on passengers from the local airport service area. But it could be argued that this is because the travel time (distance) between the hub and local airport is not great and passengers are travelling to the hub airport. Thus it is possible that the two variables are just the inverse of each other. We contend, however, that this is probably not the case, because the correlation between the log of hub departures and the log of time (distance) is low, only 0·245 (see Table 2).

The estimated value of the regression coefficient for the time (distance) variable in the double log transformation model is $0 < B < 1$, as expected, given the least squares fit of the double log model to the hypothesised functional form (see Figure 2). The estimated value of the regression coefficient is 0·525, which indicates that passenger originations at the local airport increase as time (distance) between the local airport and the hub airport increases, but at a decreasing rate instead of an increasing rate which eventually reaches a maximum.

The percentage of explained variation of the dependent variable, passenger originations, by the five variables is 0·49 per cent ($R^2 = 0·487$). While this is relatively low, it may be considered satisfactory, given the fact that it is estimated from cross-section data where there is a high degree of heterogeneity in area, economic base, location aspects, attributes of the population, etc., of the local service areas.
TABLE 1

Estimated Coefficients of Local Service Passenger Originations Model, Midwestern United States, 1966a

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-Valueb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-7.324</td>
<td>-2.623</td>
</tr>
<tr>
<td>log (per capita disposable income)</td>
<td>2.803</td>
<td>3.522</td>
</tr>
<tr>
<td>log (population of service area)</td>
<td>0.9023</td>
<td>4.783</td>
</tr>
<tr>
<td>log (hub departures)</td>
<td>-0.3419</td>
<td>-2.749</td>
</tr>
<tr>
<td>log (time)</td>
<td>0.5250</td>
<td>2.294</td>
</tr>
<tr>
<td>log (college enrolment)</td>
<td>0.0630</td>
<td>2.458</td>
</tr>
</tbody>
</table>

a n = 60, $R^2 = 0.487$
b All coefficients significant at the 0.05 level

TABLE 2

Correlation Matrix of Independent Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>$X_1$</th>
<th>$X_2$</th>
<th>$X_3$</th>
<th>$X_4$</th>
<th>$X_5$a</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_1$ — log (per capita disposable income)</td>
<td>0.213</td>
<td>0.162</td>
<td>-0.327</td>
<td>0.134</td>
<td></td>
</tr>
<tr>
<td>$X_2$ — log (population of service area)</td>
<td></td>
<td></td>
<td>-0.349</td>
<td>0.255</td>
<td></td>
</tr>
<tr>
<td>$X_3$ — log (hub departures)</td>
<td></td>
<td></td>
<td>0.245</td>
<td>0.059</td>
<td></td>
</tr>
<tr>
<td>$X_4$ — log (time – in minutes)</td>
<td></td>
<td></td>
<td></td>
<td>-0.185</td>
<td></td>
</tr>
</tbody>
</table>

aVariable $X_5$ is log (college enrolment)

considered. The coefficients of independent variables are all statistically significant at the 0.05 level.

The reliability of the estimates of the coefficients and their t-values, and therefore the conclusions drawn from a regression model, depend, in part, upon the fulfilment of certain assumptions and the absence of certain conditions regarding multicollinearity and heteroscedasticity. Table 2 shows the simple correlation between the independent variables in the regression model. Since all the correlation coefficients are low, it would appear that multicollinearity is not a serious problem in the regression analysis.

One of the assumptions of the linear regression model is homoscedasticity, a constant variance of the disturbance term. To test for the opposite condition, heteroscedasticity, we used the inspection method. A scatter diagram of the residuals and the predicted values of the dependent variable was plotted. Inspection of the graph showed no evidence of heteroscedasticity.
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SUMMARY AND CONCLUSIONS

This study is concerned with local service air carriers and their service to the small local service airports. Because of the low volume of passenger traffic generated at some local service airports, the carriers that serve them require federal government subsidy. This study is an attempt to determine the factors that explain the volume of passenger originations from the small local service airports as an information input in changing and planning the national air service network.

The regression model results of this study suggest that the following relationships exist:

1. County per capita disposable incomes and the number of passenger originations at non-hub airports are directly related. The regression results indicate that passenger usage of air service is elastic (greater than 2·0) with respect to income.

2. The population of the service area of the non-hub airport and the number of passenger originations are directly related.

3. The number of flights leaving the nearest hub airport and the number of passenger originations at the local airport are inversely related.

4. College enrolment in the city in which the non-hub airport is located and the number of originations are directly related.

5. The longer the travelling time to the nearest hub airport, the larger the number of passenger originations at the local airport.

The results of this study suggest that the spatial distribution of air service is an important determinant of passenger usage of the non-hub airports. First, the greater the number of airports, both hub and non-hub, the smaller will be the service area and hence population base. Second, the regression results also indicate that the larger the number of flights offered at the nearest hub airport, the fewer the passenger originations at the local airport. Although there may be some question of causality, it would appear that the greater the volume of flights offered at the hub, the stronger is the "pull" on passengers away from the local airport to the hub airport. Thirdly, the distance from the local airport to the hub airport is important in determining the number of local passenger originations. The results indicate that passenger originations will increase at the local airport as distance increases from the nearest hub airport.

The question raised in this study is whether there is any distribution of air service which might adequately serve the public with less subsidy. The results suggest that a number of variables need to be taken into consideration in determining whether service should be discontinued or started at any of the smaller cities. However, any recommendation to terminate or begin air service to a particular community should be based on a more complete investigation.

It should be pointed out that this study into the determinants of passenger usage of local air service and the effects of a nearby hub airport on the passenger originations at local airports has used an indirect approach. A more direct investigation of passenger preference, such as a record of place of residence and place of boarding from airline tickets, and through the interview and questionnaire methods, would be a relevant direction for further study.
REFERENCES


University of Iowa