1980. Although 17 of the 23 forecasts are not significantly different than the actual figures at the 95 percent level of confidence, the model tends to overpredict in general. This problem is alleviated substantially when the forecasts are updated each month with additional data points for 1979 and 1980.

In an attempt to add descriptive variables to the analysis, a bivariate time-series model is developed by using the average coach fare from mainland North America to Hawaii as the explanatory variable. The magnitude and significance of the fare parameter are low and the demand appears to be price inelastic. Alternative fare-pricing scenarios are studied, and their effect on forecasted demand is evident but not pronounced.

These results indicate that the Box-Jenkins methodology can be a useful tool in the analysis of an extensive time series of intercity travel demand. In cases where explanatory variables are poorly understood or where these data are unavailable, univariate analysis can result in a model that will produce useful short-term forecasts. Where a structural analysis is desired, explanatory variables can be added to the autoregressive components and transfer function models can be estimated. These are particularly useful to management and policy analysts who have some control over these variables. They can develop alternative future scenarios and study the effect these will have on future demand. Various elasticities of these variables with respect to demand can also be derived.

In terms of the Hawaii travel market, the bivariate model is a measure of the effect that fare alone has on demand. Research that uses a total visitor cost index would be useful in determining an overall cost elasticity of demand. Air carriers and other visitor industries could then determine their impact on this overall cost elasticity. Additional research might well be directed at the joint effect of price, economic activity, and changes in attractiveness of the destination market.

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Economic Justification of Air Service to Small Communities

JOHN HULET AND GORDON P. FISHER

This study is concerned with the allocation of air service to small communities (less than 50 000 population) at a time when the supply of that service is seriously diminishing and changing in character, especially since the Airline Deregulation Act of 1978. A quantitative methodology is developed as a tool for planning for short-haul service and establishes the minimum ridership required to justify the provision of air service. The model underlying the criterion takes into account two main factors: (a) the spatial separation of the community from a major hub and (b) the level of service offered at the nearest alternate airport and, if implemented, the local airport. The criterion equates the monetarized time savings of local air service and the incremental costs to implement the service. This paper emphasizes the description of the trade-off mechanism between time and money by using classical cost elements of economic theory. A graphic analysis illustrates the validity of the functional shape of the disutility concept. The ultimate product of the methodology is an optimal configuration of local air service in terms of (a) link to be served, (b) airport investment level, (c) type of flight equipment, and (d) frequency of service.

The provision of air service to small communities, those with less than 50 000 population, has seriously declined over the past several years as a result of changing carrier characteristics. Conversion by regional carriers to jet aircraft that are generally inappropriate to short-haul service and the escalating price of jet fuel have been principal causes of diminished service. The decline has been hastened by recent airline deregulation, which has made it easier for airlines to trim out unprofitable operations, typically the small communities with marginal air travel demand. The Airline Deregulation Act of 1978, in recognition of this problem, contains provisions aimed at guaranteeing at least "essential" air service to communities designated as "eligible points." Difficulty in implementing these provisions arises, of course, in the definition of "essential" and "eligible."

This paper, based on work by Hulet (1), proposes a rational quantitative criterion for determining the minimum air travel demand necessary in a community in order to justify a given type and level of air service. As a policy tool, the criterion is useful in selecting communities that ought to be on the air service network and, furthermore, provides a uniform basis for equitable treatment among those that should be included and excluded. The criterion determines the minimum ridership necessary to support local air service by equating the monetarized passengers' travel time savings--reflecting the demand--and the incremental costs to supply that service. Based on cost, the criterion essentially establishes the break-even point between supply and demand. It does not incorporate subjective sociopolitical factors associated with the notion of essentiality, but it does give a baseline solution against which to judge the proper level of service and any subsidy needed to maintain it.

A principal component of the criterion is the (generic) cost to a traveler of the delay caused by infrequent aircraft departures. A major part of this paper consists of the development of a proposed frequency delay function to define the disutility cost associated with the level of air service offered.

CRITERION FOR JUSTIFYING AIR SERVICE

Level of Service

A widely used measure of the level of service at an airport is the flight frequency F at the station (e.g., number of flights per day to all destinations) or, alternatively, the time between flights, the headway H = 1/F. Frequency is, of course, only one component of air service quality. Another component is the provision of adequate capacity by the carrier. In the following analysis, it is assumed that carriers usually respond to market demands with the type and the amount of equipment to provide proper capacity. Therefore, capacity is not explicitly dealt with, though it is recognized that capacity and frequency are intertwined service variables that work in opposite direction to satisfy a given travel demand: higher capacity versus lower frequency. This assumption is likely true for most major trunkline operations and reasonable as well for commuter airlines. In major markets that link important hubs, the airline industry in fact generally provides overcapacity. The assumption of adequate aircraft capacity is even more reasonable as airlines, in the deregulated environment of today, concentrate on their larger and longer market sectors to use their aircraft more efficiently. Curtailed flights due to frequency limitations, as an aftermath of the recent air traffic controllers' strike, have accentuated this trend, at least over the short run.

Various measures have been proposed to specify quantitatively the convenience of flight schedule in terms of the wait time associated with flight frequency. The one most commonly used is half the headway (H/2), i.e., the average time between departures. This measure implicitly assumes a random arrival of passengers at the airport, as if there were complete lack of knowledge about scheduled departures, and is not in accord with what is known about air traveler behavior, especially at small airports that typically offer infrequent service. Therefore, a better level-of-service indicator is sought.

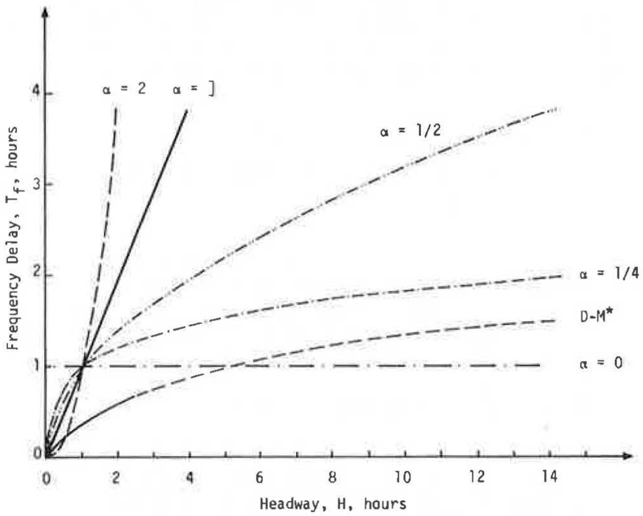
An alternative approach was taken by Douglas and Miller (2,3), which proposed a measure of service quality related to levels of delay incurred by passengers, thus introducing the concept of schedule delay as the total delay arising from two sources (3, pp. 110 and 120):

> Frequency delay, which is the mean absolute difference between the traveler's desired departure time and the scheduled departure time, in recognition that a departure might be scheduled at a time not convenient to or not desired by the traveler. As the daily frequency of flights increases, a decrease of frequency delay is to be expected.
>
> Stochastic delay, the time lost when the traveller cannot board his preferred flight and is caused to take another, less desirable flight. The preferred flight might be filled, for example, because of the not uncommon airline practice of "overbooking" flights to compensate for seasonal and stochastic demand fluctuations and "no-show" cases. This delay is a queuing phenomenon. When the level of service increases as additional flights are scheduled, the probability of being delayed and the expected magnitude of the delay will decrease.

Douglas and Miller simulated these delay processes. For the frequency delay, the daily time pattern of demand of a typical trunkline route--800 passengers/day served by at least 7 daily flights, corresponding with a maximum headway of about 2.5 h--was transformed into a discrete frequency distribution. Then a procedure was used to schedule 'F' flights during the day, such that each flight faced demand of equal size, optimizing the operator's schedule and cost. The difference between each traveler's desired departure time and the nearest scheduled flight was computed, and their absolute value summed for all travelers. The mean, or average delay, for each traveler was computed. The procedure was repeated for F+1, F+2, etc., thus generating the average or "expected" value of frequency delays as a function of the daily flight frequency. These observations were fitted to the function $T_f = 92\ F^{-0.456}$, where T_f is the expected frequency delay per passenger (measured in minutes) and F is the daily flight frequency. [See Douglas (3) for the detailed treatment of the stochastic component of delay, which, as explained later, is not an issue here.]

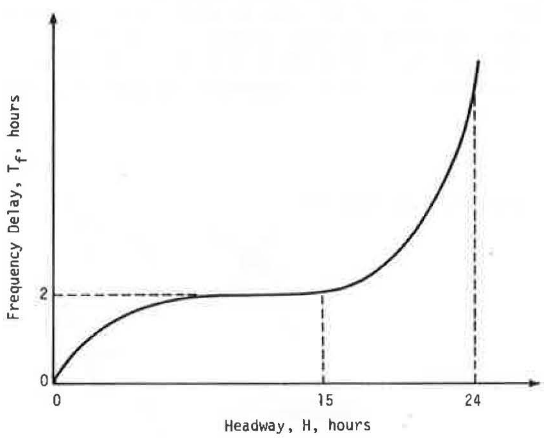
It should not be expected that the Douglas-Miller expression, having been calibrated for headways of less than 2.5 h in a major air corridor, can be extrapolated to high headways typical of the local, short-haul market that has radically different demand and flight frequency characteristics. Consequently, this paper attempts to develop a more general schedule delay function that can apply to both high- and low-frequency regimes.

Figure 1. Frequency delay versus headway for selected values of exponent α.



*D-M = Douglas and Miller: $T_f = 0.445\ H^{0.456}$, not calibrated for values of $H \geq 2.5$ hours.

Figure 2. Disutility of schedule: functional form.



The approach taken here departs from that of Douglas and Miller in two respects. First, for simplicity, the stochastic component of schedule delay is omitted, assuming that it will be minimized by adjustment of the load factor to provide a cushioning effect. Travel demand thus is taken as fixed. The use of a fixed load factor--actually an average load factor over the operating period--in lieu of unknown stochastic values imposes some lack of refinement on the analysis, but it is our opinion that the resulting imprecision is likely to be small, especially in low-density markets with infrequent flights. Moreover, the lack of data in these markets precludes reliable estimation of stochastic variation of demand. Second, frequency delay is not taken as an absolute time difference as used by Douglas and Miller, but is associated with the notion of disutility to the passenger--that is, with the level of inconvenience corresponding with a given flight frequency. Disutility is difficult to quantify, so the analysis adopts wait time as its surrogate and the operational measure of inconvenience. In this context, frequency delay is a virtual rather than actual wait time--more so for high headways--and is synonymous with disutility.

A relationship between frequency delay and flight frequency can be postulated in the general form: $T_f = (1/F)^\alpha = H^\alpha$, where T_f = frequency delay per passenger (h), F = daily flight frequency, H = headway (h), and α = a dimensionless exponent that is a measure of inconvenience associated with delay imposed by flight frequency. This relationship is depicted in Figure 1 for various exponent values:

$\alpha = 0$, implying total indifference of passengers to flight and disutility constant over all levels of service--an unrealistic case;
$0 < \alpha < 1$, marginally decreasing disutility;
$\alpha = 1$, linearly proportional disutility--also unrealistic; and
$\alpha > 1$, marginally increasing disutility (as headway increases, virtual wait time increases sharply, far exceeding actual wait time).

The Douglas-Miller expression, also shown in Figure 1, is of the second case. It is considered invalid for large headways, although its tendency to an upper bound is of some interest. The common assumption of $T_f = H/2$ is of the third case.

The other case of interest is $\alpha > 1$, which is proposed here as the form for describing the large headway region. Infrequent flights, say once every two days or even once a week, clearly are a source of great inconvenience and dissatisfaction to the passenger, who perceives his or her loss of value as far greater than the actual time delay incurred--and more so as headway increases. That is, the disutility the passenger experiences increases sharply as represented by the up-trending curve. In contrast, the Douglas-Miller curve, by tending to an upper bound, implies increasing indifference to schedule and decreasing marginal disutility and, therefore, is inappropriate at high headways. In short, it is deduced that the case of $\alpha < 1$, as proposed by Douglas and Miller, better describes the small headway range, that the case of $\alpha > 1$ better describes the large headway range, and that a general disutility relationship accounting for the underlying phenomenological differences of the two regimes is some combination of the two cases.

The proposed form of the disutility function is presented in Figure 2 as a relationship between frequency delay and headway. Conceptually, the function combines three main elements, namely (a) a concave portion at low headways, (b) a maximum wait time that travelers will tolerate under normal service conditions, and to which the concave part tends, and (c) a convex portion at high headways.

The nature of the trip (business or leisure) also has a bearing on the perception of the level of service. Timing of the departure is another crucial issue to the business person. Some of these considerations are discussed here.

For very low headways, corresponding with excellent service, any delay is viewed as a high level of inconvenience, especially to travelers who closely time their airport arrival in expectation of frequent and reliable air service. This would be the case of highly paid business executives planning their activities on an "air-shuttle" type of operation. A delay of an hour could have disastrous business consequences. The concave shape of the disutility function is the only form that picks up this high level of inconvenience as soon as the service deteriorates (steep rise in disutility at first).

As headway increases, the timing now becomes crucial if the air service is to provide a meaningful travel alternative to businesspersons. If the service deteriorates beyond a certain level, travelers will adjust their expectations to less-frequent service: they now are the business persons who unfortunately have no other alternative and the people who travel for personal reasons (leisure, family, etc.) and are less sensitive to either the timing or the frequency of service. If the timing of flights is poor, say departures 4-10 h apart, any delay will be viewed as equally bad and will entail an equal wait at the airport before the flight (personal contingency time plus airport processing time). For the captive customers facing a deteriorating quality of air service and with no other choice, the level of inconvenience runs high, but translates practically into the physical wait to be incurred in the process of traveling by air. However, it is reasonable to suppose that there is a maximum wait, say as long as 2 h, that travelers will tolerate under normal service conditions; this limit is determined by the difference between air travel time--including access, contingency, airport processing, and egress times--and the time required for the same trip by the next best travel alternative (e.g., automobile), if there is one for the short-haul market being considered (≤300 miles). Thus the marginal disutility of wait time (slope of T_f) gradually tends to zero, explaining the flat portion of the disutility function. Beyond a certain level of service, say 15-h headway or 1 flight/day, disutility can be expected to increase sharply and convexly, reflecting severe loss of attractiveness and convenience as the traveler is forced to postpone his or her departure to another day. It is conceivable, of course, that local air service of one flight every other day, or even one a week, may be preferable to no service at all.

For simplicity and mathematical tractability, the subsequent analysis adopts a disutility function of the polynomial form:

$$T_f = H^3/600 - H^2/30 + H/4 \tag{1}$$

where T_f equals frequency delay and H equals headway (h). This curve approximates the one shown in Figure 2, with convexity beginning at a headway of about 15 h (1 flight/day) and a maximum acceptable wait time under less-frequent scheduling of about 2 h. Although other forms might be adopted, Equation 1 is quite satisfactory to illustrate this methodology.

Benefit-Cost Criterion

The foregoing discussion has been principally motivated by a desire to include the traveler disutility as an element of a cost function with the purpose of determining minimum ridership necessary to justify local air service. A basic formulation of a trade-off function between time savings and cost has been given by Dick (4). This analysis follows Dick but differs principally in the inclusion of the disutility concept, again to be able to model the large headway regime more realistically.

The spatial setting of the problem, shown in Figure 3, comprises a local airport at the trip origin L, destination D, and a nearby alternative airport A. Travelers may fly from L to D if offered direct air service. If not, they may drive to airport A and fly from there. In order to justify economically the provision of direct air service from L to D, the problem is framed as a balance between travel time savings and money costs, computed on an annual basis, for the two alternatives of (a) provision of an airport at L and operating flight $\overline{LD}$ and (b) driving to airport A and operating flight $\overline{AD}$. The notation for this analysis is summarized in Table 1.

The benefits are the net time savings of direct trip $\overline{LD}$ over indirect trip $\overline{LAD}$. The $\overline{LAD}$ trip time has three elements, namely $\overline{LA}$ driving time, $\overline{AD}$ flight time, and the frequency delay (disutility) at A as described by Equation 1. Taking the headway H_L at the local airport as a function of annual traffic X (i.e., $H_L = 15 \times 365\ L/X$), the annual net time savings are

$$\begin{aligned} TS = PX[&(D_{LA} - D_{HL})/V_1 + (D_{AD} - D_{LD})/V_2 + H_A^3/600 \\ &- H_A^2/30 + H_A/4 - (2.73 \times 10^8)(L/X)^3 + (9.99 \times 10^5)(L/X)^2 \\ &- (1.37 \times 10^3)(L/X)] \end{aligned} \tag{2}$$

The annual incremental costs of providing direct air service from L comprise the operating costs of flight $\overline{LD}$ less the avoided operating costs of trip $\overline{LAD}$, plus the annualized costs of the airport at L (construction and maintenance), namely:

$$IC = X[C_1(D_{HL} - D_{LA}) + (C_2/L)(D_{LD} - D_{AD})] + I_2 + M \tag{3}$$

Direct air service $\overline{LD}$, including its associated airport costs, is justified when benefits exceed costs. The break-even point then is defined by

$$TS - IC = 0 \tag{4}$$

The unknown X, which satisfies this break-even point is the minimum annual ridership required to justify direct $\overline{LD}$ air service and the cost of an airport of size I_2. Frequency of air service at the local airport can be computed as the annual ridership divided by the capacity of the selected flight equipment. It should be noted that the required ridership is smaller as the passenger disutility is higher.

Figure 3. Geographical setting of problem.

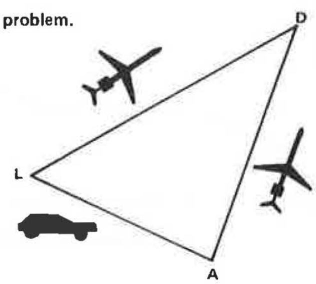


Table 1. Notation used in cost-benefit analysis.

Symbol	Definition
X	Total number of passengers to travel from L to D per year to justify building an airport at L
D_{LD}	Distance (air) $\overline{LD}$ (miles)
D_{AD}	Distance (air) $\overline{AD}$ (miles)
D_{LA}	Distance (surface) $\overline{LA}$ (miles)
D_{HL}	Distance from center of city L to local airport (miles)
L	Number of passengers per flight = seating capacity of plane x the planned load factor (say, 65 percent)
P	Passenger time value (e.g., \$10/h)
V_1	Car speed (mph)
V_2	Aircraft speed (mph)
C_1	Car costs, including amortization of original cost (\$/mile)
C_2	Aircraft costs, including amortization of original cost (\$/mile)
I_1	Initial airport capital investment (\$)
I_2	Annualized airport capital investment (\$): $I_2 = I_1 \cdot CRF$
CRF	Capital recovery factor = $i(1 + i)^n/(1 + i)^n - 1$
i	Annual rate of interest (%)
n	Economic life of airport (years)
M	Operating and maintenance costs of airport (\$/year)
F_A, F_L	Frequency at alternate airport A, at local airport L (number of flights per day)
T_{f_A}, T_{f_L}	Frequency delay at A, L = disutility associated with schedule at A, L (h)
H_A, H_L	Headway at airport A, L (h)

Equilibrium Analysis

To gain a better insight of the trade-off mechanism between time and money costs embedded in the formulation, the following graphical representation of the money is useful.

The time savings accruing from local airport operations at L were described by Equation 2. This equation is of the form

$$f(X) = P \cdot X \cdot (\alpha - \beta X^{-3} + \gamma X^{-2} - \delta X^{-1})$$

which, plotted on a graph displaying on the abscissa axis the yearly passenger volumes, X, and the time savings (in dollar units) on the ordinate axis, has the inverted S-shape shown in Figure 4. Time savings have negative values (from $-\infty$ to 0) over the range of patronage increases from 0 to X_E. This point illustrates the fact that, below the patronage level X_E, the flight frequency associated with lower passenger volumes at the local airport (e.g., one flight every two weeks) is too low to realize any time savings compared with the existing situation (drive to the nearest alternate hub). Only the positive values of time savings are of interest in the analysis.

The incremental costs were previously defined by Equation 3, which is of the general form $g(X) = aX + b$. The slope a represents the difference between variable operating costs of the direct and indirect trips. It is to be expected that, for an approximately equal flight distance from the alternate or local community to the desired destination, the biggest contribution in variable costs is attributable to driving to alternate airport A. So the coefficient a is always ≤ 0, that is, $D_{LA} \geq D_{HL}$. This relationship also is represented on Figure 4. The incremental cost function exhibits the correct slope in that the costs are distributed over a larger number of passengers as use increases.

The equilibrium values of X_i^* correspond with the minimum patronage level, which justifies a given level of investment for the local airport and direct air service operations. As the value of passengers' time increases, the minimum level of patronage decreases, which appears intuitively correct (shift from X_1^* to X_2^* on the graph). From passenger volume X_E onward, time savings are realized (positive values) but incremental costs are still greater than monetary time benefits derived from the local airport service. The increase in ridership from X_E to X_i^* is necessary to equalize benefits and costs. The shaded area on Figure 4 shows a region where the marginal benefit of providing the local service exceeds its marginal cost.

A more traditional representation in economics for the decision criterion between two alternatives (in the present case, the trip $\overline{LAD}$ and the trip $\overline{LD}$) is depicted in Figure 5. X^* is the threshold value, in terms of passenger volume, to justify the introduction of the second alternative, and AC_i is the average cost per passenger for alternative i. The same analysis can be used for this specific model and clearly illustrates the trade-off accomplished by the formulation between frequent and convenient local air service, as well as its associated cost.

Figure 6 displays the average cost per passenger for both alternatives (local airport and use of alternate airport). For the local airport, the costs consist of the direct monetary outlay m_L (construction of facility and flight operating expenses) and the time cost t_L associated with the frequency delay, converted into dollars by the use of the passengers' time value P. The curve m_L exhibits the classical hyperbolic shape of average fixed costs being distributed over more and more users. As the frequency of service at the local airport L increases, the wait related to the level of service is expected to decrease, which explains the decreasing time contribution being added to m_L. For the alternate airport A, already in existence and operational, the direct money outlay m_A is a fixed amount per passenger (marginal cost

Figure 4. General equilibrium: time savings/cost of local airport versus yearly traffic for selected time values.

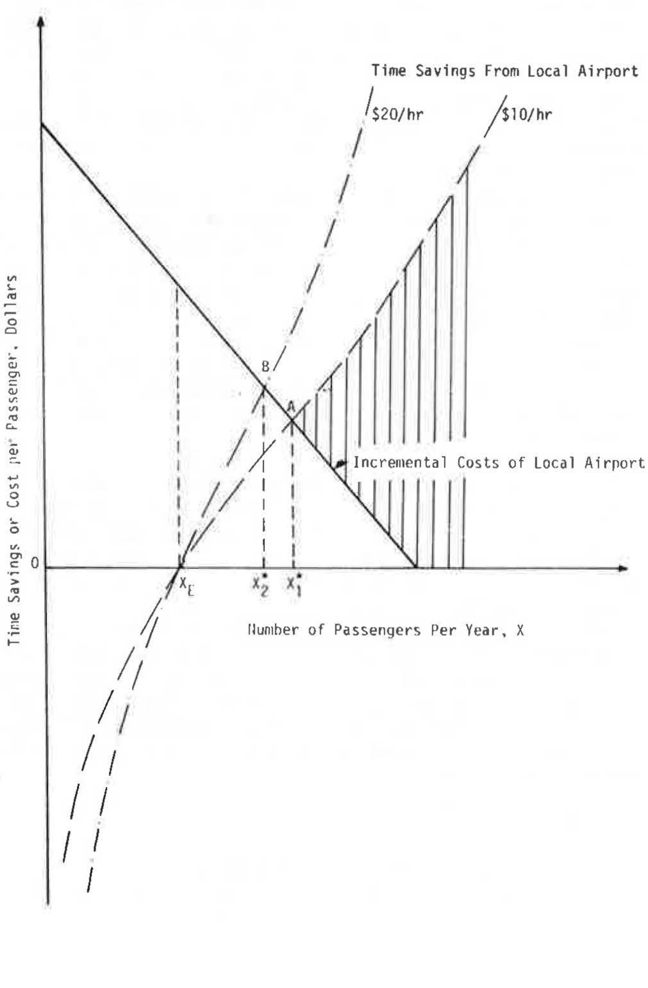
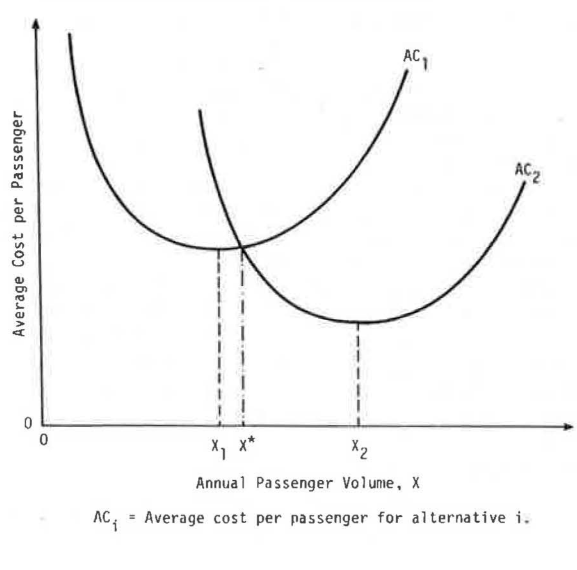
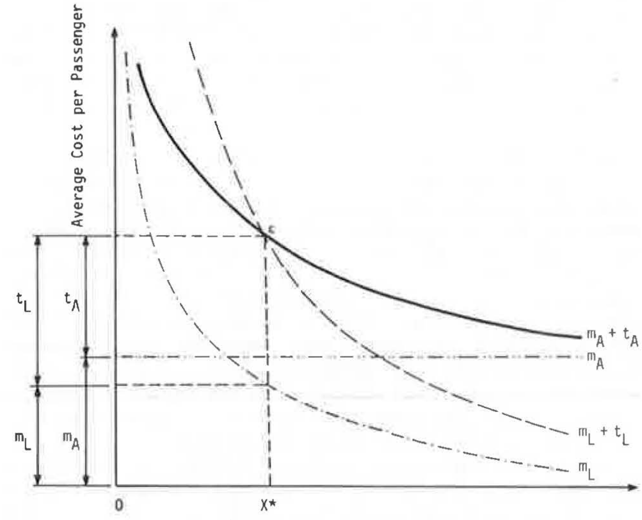


Figure 5. Economic comparison of two alternatives.



AC_i = Average cost per passenger for alternative i.

Figure 6. Economic comparison of local and alternate airports.



assumed to be zero) whereas the time cost t_A displays the same behavior as for location L, assuming the trunkline reacts to increased traffic level by increased flight frequency.

X^* is the equilibrium value below which the solution of local air service is more expensive ($M_L + t_L > m_A + t_A$) and above which the reverse is true ($m_L + t_L < m_A + t_A$).

The decomposition of the vertical segment ϵX^* into its money (m_A, m_L) and time (t_A, t_L) components for both alternatives reveals the compromise attained at the equilibrium solution: For the patronage X^*, the local airport L is cheaper in money terms ($m_L < m_A$) whereas the level of frequency at the local airport will never (except in special circumstances) rival the frequency offered at a medium or major trunkline air service center. This inconvenience of local operations is reflected in the inequality $t_L > t_A$ at equilibrium. In other words, the formulation provides the decisionmaker with a minimum value of patronage to justify local direct air operations, but that solution implies a sacrifice: In most cases, a small community can hardly expect the same level of service (flight frequency) as that offered at the nearest trunkline hub.

Time Savings per Passenger: A Measure of Merit

Comparison of the merit of various air service options can be further assisted by introducing the concept of time savings per passenger, $\overline{TS}$ (in monetary terms). The average time savings per passenger by definition are the total time savings divided by the total ridership, at equilibrium. In referring to Figure 4, which displays the general equilibrium between the time-savings and the incremental-cost curves regarding the local air service, the average time savings for a given passenger time value (say, \$10/h on the graph) are total time benefits (vertical segment AX_1^*) divided by the total patronage (horizontal segment OX_1^*). $\overline{TS}$, thus, may be viewed as a factor of merit of the air service and is mainly sensitive to flight frequency.

Isolation-Usage Index

From the foregoing concepts, a tool for planning and policy purposes, called the isolation-usage index, has been developed that can be used to characterize a community regarding its access to air service. The index, in its simplest form, is merely the ratio of the theoretical ridership X as predicted by the benefit-cost criterion of Equation 4 (degree of "isolation") to the actual or forecast air travel demand of the local community (usage). Its value will indicate whether the community is over- or under-supplied with air service, or if supply and demand are reasonably balanced. This matter, along with an illustrative application of the methodology to New York State communities, is covered in detail elsewhere by Hulet and Fisher (5).

SUMMARY AND CONCLUSIONS

A disutility function, relating air passenger inconvenience to delay imposed by flight scheduling, has been conceptualized and employed as an element of a benefit-cost criterion for the determination of the minimum theoretical travel demand necessary to justify air service from a local airport. The tradeoff mechanism between time and money is described by using classical elements of economic theory and a graphical equilibrium analysis shows the validity of the time savings curve as shaped by the disutility function.

The proposed methodology is particularly useful in planning and policymaking for short-haul, light-density air service markets--typified by small communities--and provides a uniform basis for selection of communities that should be part of an air service network.

If local air service from a community cannot be theoretically justified on the basis of an objective economic criterion as proposed herein and yet is provided as "essential" for subjective reasons, subsidy is usually called for. The proposed methodology is advantageous in making the need for and level of subsidy more visible, as well as the cost categories to which subsidy should be directed: capital investment (airport, aircraft) or operating costs (aircraft type, frequency, etc.). Thus, it may be helpful in the optimal allocation of federal funding for airport facilities, as in the National Airport System Plan.

The suitability of the model to parametric variation provides a means of studying the impact of various regulatory policies regarding minimum standards of service in terms, for example, of flight frequency, aircraft capacity, and load factor. Moreover, the range of variables in which the optimal configuration of local air service is specified allows the decisionmaker to study a variety of options for matching supply and demand, as well as to estimate the financial commitment required for each course of action.

Reliable and realistic application of the proposed methodology hinges on perfection of the concept of disutility associated with flight frequency, in particular the accurate estimate of maximum acceptable wait time and maximum acceptable headway. It would be highly desirable to develop an experimental methodology that would substantiate analytically the proposed concept suggested here. It is our opinion that it is better to include the disutility, even in its currently imperfect form, than to omit it entirely. All things considered the methodology provides a uniform and systematic framework for the rational allocation of air service to small communities.

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General Aviation and the Airport and Airway System: An Analysis of Cost Allocation and Recovery

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Since 1967 it has been the policy of the National Business Aircraft Association that all beneficiaries of the nation's airways system have an obligation to pay a share of its costs. As airport and airway user charges are taken up in the 97th Congress in 1981, the questions are, What is the fair share of system costs that should be recovered from general aviation, and how much of that share was recovered under the 1970 legislation, which has expired? This study addresses these questions and finds that between 58 and 73 percent of general aviation's fair share was recovered in FY 1978 (used herein as the study year) by the taxes enacted in 1970. This does not take into account any public (nonuser) benefit that Congress may assign to general aviation activities. Costs of federal expenditures on the airport and airway system allocable to general aviation amounted to $368.8 million, 13.2 percent of the total system cost, based on data in a Federal Aviation Administration cost-allocation and recovery report for FY 1978. Other allocated cost shares were $1400.5 million for air carriers, 50.3 percent of the total; $281.2 million for military and government aviation, 10.1 percent of the total; and $735.0 million for the public (nonusers), 26.4 percent of the total. Recovery of costs by taxes depends on federal policies that are based on the efficient allocation of national resources, maintaining fair competition among the several modes of transportation, and fair taxation. Absent a cohesive national transportation policy, applying a consistent policy for percentage of costs recovered for like transportation activities to the general aviation primary use categories results in general aviation's fair share of costs that should be recovered to lie within the range of $126.1-$157.5 million for the study year. A comparison, therefore, of the fair share of costs that should be recovered from general aviation, with recovery from the taxes imposed by the Airport and Airway Development and Revenue Acts of 1970, which amounted to $91.5 million in the FY 1978 study year, shows that between 58.1 and 72.6 percent of general aviation's share was recovered by that tax structure. The fourfold increase in petroleum prices since 1974 and the enactment of the Airline Deregulation Act of 1978 emphasize the increasing role of general aviation in the air taxi, executive, and business primary-use categories as a vital and unique transportation resource in the United States.

COST ALLOCATION IN EXPERIENCE AND THEORY

Earlier proposals to tax or charge users for federal expenditures on airports and airways finally resulted in passage of the Airport and Airway Development and Revenue Act of 1970 (1), which provided for the taxes set forth in Table 1 (5), many of which expired or were reduced on October 1, 1980. The legislation provided that receipts from collection of these taxes be paid into a trust fund to offset certain federal expenditures on airports and airways. There was an uncommitted balance in that fund of $3225 million at the beginning of FY 1981 (2).

Experience With Cost Allocation

Four cost-allocation studies are summarized in Table 2: Three were conducted by the Federal Aviation Administration (FAA) and predecessor organizations (in 1950, 1962, and 1978) and one in 1973 by the Office of the Secretary of the U.S. Department of Transportation (DOT). These works show that the annual federal costs of the airport and airway system have grown almost fiftyfold in the 30 years from FY 1949 to FY 1978 covered by these studies. The share of federal airport and airway costs allocable to general aviation varies from a low of 13 percent of all costs to a high of 32.1 percent of all costs, depending on the method of cost allocation used in the study. The existence of this wide range of costs, determined to have been attributable to general aviation, may be used to illustrate the difficulties of allocating costs (the cost-allocation process) and to illustrate what has been learned about that process over the years represented by studies.

Where the costs of providing a facility or service are uniquely and exclusively traceable to a single user, they are said to be clearly allocable or clearly assignable costs and may be charged entirely to that user. Unfortunately, most of the facilities and services provided by federal expenditures on the airport and airway system cannot be so uniquely traced. The system serves all users pretty much on a first-come, first-served basis--considered to be one of its great strengths by many in the aviation community. But in such cases, the so-called "joint" costs or "common" costs must be allocated to the different users and user groups. This--the first flaw in the cost-allocation process--is a flaw because any known way of allocating joint costs [and there are many (3)] is necessarily arbitrary and imperfect, although some methods are generally considered to be more fair and more reasonable than others (4).

Thus, user costs in the two earlier studies were allocated between general aviation [the 1961 FAA study allocated costs only between commercial aviation and military aviation (6)], air carrier, and military aviation simply on the basis of use: so many landings at FAA-manned tower airports, so many enroute fix-postings, and the like. There are at least two objections to the application of this method. First, the resulting allocation of joint or common costs to a user does not necessarily reflect