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Guidelines for Allocating Public Transportation Costs Among Towns in Nonurbanized Areas

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A crucial question affecting the long-term viability of public transportation programs in nonurbanized areas concerns the allocation of deficit costs among towns receiving service. An evaluation is presented of alternative cost-allocation procedures that include one or more of the following variables: population, property valuation, passenger trips, passenger miles, vehicles miles, and vehicle hours. The procedures are evaluated based on several criteria, including simplicity, data requirements, cost of use, and equity (or perceived fairness) of the allocations. The evaluation brings into perspective the need to make trade-offs among these criteria. Sensitivity analysis is therefore conducted to determine the relative differences in allocations depending on (a) the procedure, (b) the data sampling method, and (c) the cost assignment policy. Population, ridership, and cost data on two public transportation programs in nonurbanized areas of Massachusetts are used to conduct the evaluation. One service, operated in Barnstable County, is offered on a prearranged demand-responsive basis. The other provides fixed-route, fixed-schedule service to nine towns in Franklin County.

Recent government actions have responded to the need for public transportation programs in nonurbanized areas (1-4). Starting with the Federal-Aid Highway Act of 1973 (Section 147) and continuing with the Urban Mass Transportation Act of 1964 as amended (Section 18), increasing amounts of federal aid have been committed to support these programs. Many states have supplemented this federal aid with financial assistance of their own. In many cases, local governments are financially responsible for as much as 25 percent of the deficit costs of such programs.

A crucial question affecting the long-term viability of these programs concerns the allocation of deficit costs among towns receiving service. Many communities desire precise information on the manner in which deficit costs will be allocated before deciding to participate in such programs. At the same time, these towns lack the resources to carry out adequate cost-allocation analyses themselves.

The purpose of this paper is to present a critical evaluation of cost-allocation procedures available for use in nonurbanized areas. The procedures discussed are applicable to fixed-route and demand-responsive systems and may be pertinent to urban transportation programs as well. Twelve selected procedures are applied by using population, ridership, and cost data on two public transportation programs in nonurbanized areas of Massachusetts (Franklin and Barnstable Counties). Both programs were initiated several years ago under the Federal Highway Administration (FHWA) Section 147 Demonstration Program and are currently being supported with federal Section 18 funds and state and local resources.

Based on the results of this evaluation, conclusions about the overall usefulness of the various procedures are presented. The paper is intended to serve as a guide for regional and local transportation officials who are considering the implementation of public transportation programs in their nonurbanized areas.

DEFINITION OF TERMS

Before we proceed, some clarification is in order regarding the definition of certain terms. For the purposes of this paper, a cost-allocation procedure is a means of determining what portion of the local share of the deficit each town should pay. A procedure consists of an equation or formula that determines town allocations based on one or more variables. Depending on the procedure favored by regional and local officials, variables can represent the level of service available to each town, the amount of service actually used by each town, or a town's ability to pay.

The total costs of public transportation services may be broken down into capital costs (e.g., purchase of vehicles and other equipment) and operating costs (e.g., driver's wages, fuel, and oil). These total costs can be annualized (i.e., expressed on an annual basis). The difference between the total annual costs and total annual revenue is the annual deficit costs (assuming that costs exceed revenues).

BASIC ISSUES IN COST ALLOCATION AMONG TOWNS

Many different cost-allocation procedures are available for use by regional transportation agencies in nonurbanized areas (5). The various procedures differ in their variables. The most common procedures use one or more of the following variables: population, property valuation, passenger trips, passenger miles, vehicle miles, or vehicle hours. In cases where a multivariable procedure is used, weights can be assigned so that one factor is counted more heavily than another. The choice of variables or weighting schemes depends on a number of criteria, such as simplicity, data requirements, cost to use, and equity of results. Each criterion must be balanced against another to produce a procedure that is acceptable to a particular region. A discussion of these criteria can provide the context within which the comparative evaluation of procedures can be carried out. For discussion purposes, the criteria have been grouped into two categories: (a) ease and cost of implementation and (b) equity. The implementation criteria relate to the ease and cost with which procedures can be used. Equity criteria relate to the ability of the procedures to produce results that are considered fair by the member towns.

Ease and Cost of Implementation

One consideration in choosing a cost-allocation procedure is the ease with which it can be implemented and understood by the public. Included in this category are the criteria of simplicity, data requirements, and costs of implementation. All are wed to the notion that a procedure that is simple, requires little collection of new data, does not require a computer, and costs little to implement will have an easier time gaining acceptance from transit authority members and the public at large. Examples of such simple procedures are single-variable formulas based on general population, elderly population, and/or real estate valuation.

The advantage of these procedures is that they are based on information that is readily available to the public. No new data collection is required, which reduces the costs and the time required for implementation. Because no complex formulas are used, the procedures can be readily understood by the public. On the negative side, the simplest procedures often bear no relation to the relative level of services provided or to the operating costs incurred in service to each town. Consequently, procedures based on a single variable, the level of service provided to each town, may be considered as an answer to the above concern. Although these procedures are in general easy to understand, the data regarding the level of service to each town may not be as readily available as population or real estate valuation.

Multivariable procedures are more complex, as indicated by both the number of variables included and the process required to derive the necessary data for implementing the procedure. As a result, multivariable procedures are usually adopted for implementation only when local officials have multiple views regarding the basis on which cost allocations should be made.

The cost and the time required for implementing these procedures are usually less for the single-variable procedures than for the multivariable ones. The cost and time required for implementation can be expected to increase as the complexity of the procedure increases.

Equity

As mentioned previously, procedures for allocating transportation costs are designed to satisfy the criterion of equity, among others, as determined by the towns receiving service. However, care must be taken in defining the term equity, since its perception may differ from one town to the next. Whereas one town may argue that for a procedure to be deemed "equitable" it must incorporate measures of the level of service available and/or the amount of service used, these principles may be rejected by another town. It is therefore safe to state that, due to possible different interpretations of what is equitable, no single cost-allocation procedure may be deemed "correct" or equitable in all circumstances. In the final analysis, the most equitable procedures will be those that are economically and politically acceptable to all participants.

It is pertinent to note that procedures that seek to satisfy equity concerns may occasionally achieve their "fair" results at the expense of the implementation factors just discussed. This is particularly so if the attempt is to reflect several aspects of the transportation service in the procedure to be implemented. In addition, due to the sensitivity of the complex equitable formula to changes in the values of the variables included, data on level of service and use must be continuously updated. This increases the cost of maintaining the fairness of the results obtainable from a complex procedure.

Finally, it is worth noting that the criteria of simplicity, cost, and equity are not mutually exclusive. It is entirely possible to create a formula that combines variables that satisfy, to a certain extent, the demands of all three criteria. For instance, a formula could be developed that measures the quantity of service available to a particular town and also considers the relative population of that town. In such a case, weights could be assigned to the variables so that one measure would count more than the other within the procedure.

It has been found (5) that the ultimate goal of most regional transit authorities in designing a cost-allocation procedure is to find the optimum balance between ease and cost of implementation and fairness of results. Where that optimum point is located depends largely on the specific desires of the towns that make up the region.

EVALUATION OF ALTERNATIVE PROCEDURES

An evaluation of alternative procedures to allocate costs among towns is presented below. Population, ridership, and cost data from two nonurbanized areas are used to evaluate 12 procedures as they relate to the criteria of ease and cost of use and fairness of results as well as to overall economic and political acceptability.

In Barnstable County, the Cape Cod Regional Transit Authority (CCRTA) provides advance-reservation, demand-responsive service to the general public in 15 towns (total population 126 481). The Franklin Regional Transit Authority (FRTA) operates fixed-route, fixed-schedule service to 9 towns (total population 15 562).

Barnstable County: Demand-Responsive Service

Selection and Use of Current Procedure

The overriding objective of CCRTA members in selecting a cost-allocation procedure was to adopt a "pay for what you get" approach. Simple, low-cost procedures based on population were rejected because they did not consider the relative quantity of services received by participating towns. One factor in the decision to adopt a use-based procedure was the current existence of rider identification passes, which made it easy to collect passenger data. This informtion, which was being collected, keypunched, and processed for monitoring and evaluation purposes, could be used to determine town-by-town levels of use at little extra cost to CCRTA.

In determining how to measure levels of use for cost-allocation purposes, CCRTA decided that trip length should be incorporated into the procedure along with trip volume. Trip volume alone, although easier to measure, was not viewed as an adequate indicator of use due to the extreme variability in trip length. The average trip length for town residents had been shown to range from 5.1 miles (Barnstable) to 21.2 miles (Bourne). This variability is caused by the elongated nature of the service area and the fact that many of the trips, regardless of origin, terminate in Hyannis, a major activity center. It was believed that many of the major costs of providing the service varied proportionately with trip length rather than being associated with trip volume.

Description of Procedure

CCRTA instituted a two-variable procedure based on passenger trips (trip volume) and passenger miles

Table 1. Comparative assessments based on alternative procedures: CCRTA demand-responsive service.

Town	Population		Elderly Population		Property Valuation		Passenger Trips and Passenger Miles		Elderly Population, Valuation, Passenger Trips and Miles	
	Amount ($)	Percent	Amount ($)	Percent	Amount ($)	Percent	Amount ($)	Percent	Amount ($)	Percent
Barnstable	8 776	17.6	7 270	14.5	7 110	14.2	9 204	18.4	7 412	14.8
Bourne	6 223	12.4	2 735	5.5	3 290	6.6	2 415	4.8	2 734	5.5
Brewster	8 899	1.8	1 533	3.1	1 811	3.6	835	1.7	1 948	3.9
Chatham	3 349	6.7	4 221	8.4	4 856	9.7	912	1.8	3 198	6.4
Dennis	2 059	4.1	4 279	8.6	3 882	7.8	5 185	10.4	4 184	8.4
Eastham	1 367	2.7	1 684	3.4	2 080	4.2	478	1.0	1 361	2.7
Falmouth	9 787	19.6	7 091	14.2	6 536	13.0	9 311	18.6	7 329	14.7
Harwich	3 787	7.6	6 562	13.1	3 629	7.2	2 908	5.8	5 873	11.7
Mashpee	602	1.2	126	0.3	1 553	3.1	3 095	6.2	1 565	3.1
Orleans	848	1.7	1 957	3.9	2 512	5.0	2 340	4.7	2 164	4.3
Provincetown	1 202	2.4	885	1.8	576	1.2	5 787	11.5	2 313	4.6
Sandwich	3 612	7.2	1 630	3.3	5 317	10.6	2 485	5.0	3 091	6.2
Truro	417	0.8	100	0.2	1 130	2.3	165	0.3	432	0.9
Wellfleet	957	1.9	560	1.1	2 384	4.8	1 428	2.9	1 431	2.9
Yarmouth	6 117	12.3	9 367	18.7	3 342	6.7	3 466	6.9	4 969	9.9
Total	58 002		50 000		50 008		50 014		50 004	

(trip length). These two use variables are weighted to reflect the different costs associated with each. The costs of dispatching and administrative costs were assigned to passenger trips, and all other operating costs were assigned to passenger miles. The ratios of these costs to total operating costs are coefficients that are used to obtain systemwide unit costs per trip and per passenger mile. A unit cost is calculated for each use variable. These unit costs are multiplied by each town's respective number of trips and miles, and the products are added to obtain a total allocation for each town. Town revenues, derived from data on pass sales, are then subtracted to obtain a net local allocation.

The procedure can be illustrated by delineating the assignment of costs to each of the two variables, as follows:

1. Passenger miles (approximately 75 percent)--Drivers, fuel, repairs, insurance, advertising and promotion, and special equipment; and
2. Passenger trips (approximately 25 percent)--Dispatching, office expenses, and monitoring and evaluation.

The coefficients for passenger miles and passenger trips are 0.75 and 0.25, respectively, which means that three-quarters of the system's costs relates to vehicle operations and one-quarter relates to dispatching and administration. The formula for calculating assessments can thus be shown as follows:

$$D_A = 0.25[0.75(OC)(M_A/M_T) + 0.25(OC)(T_A/T_T) - R_A] \quad (1)$$

where

D_A = deficit to be paid by town A,
OC = total operating costs,
M_A = passenger miles for residents of town A,
M_T = passenger miles for residents of all towns,
T_A = passenger trips for residents of town A,
T_T = passenger trips for residents of all towns, and
R_A = revenues generated by town A.

This procedure was examined by CCRTA using 1978 data, in preparation for eventual implementation, after the termination of the Section 147 grant. The procedure has been in use officially since February 1979. The resulting assessments have been accepted generally by member towns as being equitable, although some concern has been expressed that the 75/25 allocation of costs to the two variables results in a penalty being imposed on peripheral towns whose average trip length is high. Representatives of these towns have expressed the opinion that the initial assignment of costs to the categories of passenger trips and passenger miles was to some extent arbitrary and contended specifically that all costs except drivers, fuel, and repairs are of a fixed nature and should be assigned to passenger trips. This type of alteration would change the weighting from 75/25 to 50/50 and, consequently, could lessen the burden on towns that have relatively high average trip lengths.

Comparative Evaluation of Procedure

This evaluation compares the CCRTA cost-assessment procedure with four alternative procedures that have been suggested for use in other demand-responsive systems. The alternative procedures differ in terms of their ease and cost of application and their ability to produce results that all parties consider fair.

Table 1 compares the allocations produced by the five tested procedures. It is worth noting the widespread variation in results. Of greatest significance is the discrepancy between allocations produced by the single-variable, non-use-based procedures (population and property valuation) and the use-based CCRTA procedure (passenger trips and miles). The differences between population and passenger use are clearly evident in towns such as Bourne, Chatham, Eastham, Mashpee, Orleans, and Provincetown, where allocations under the two procedures vary as much as fivefold.

Differences also exist between elderly population and passenger use. Mashpee's allocation increases 24 times, from $126 to $3095, when passenger use replaces elderly population as the basis for assessment. It is also significant to note that elderly population and general population do not show a close comparison.

Property valuation produces significantly different allocations when compared with passenger trips and miles. As an example, Chatham's valuation-based allocation is 5 times greater than its use-based allocation; conversely, Provincetown is allocated 10 times more under passenger use than under valuation. If "ability to pay" were to be the overriding criterion for choosing a procedure, the valuation-based allocations might be acceptable. If

Table 2. Summary of data: CCRTA demand-responsive service.

Town	Population		Elderly Population		Property Valuation		Passenger Trips		Passenger Miles		Revenue	
	No.	Percent	No.	Percent	Amount ($000 000s)	Percent	No.	Percent	No.	Percent	Amount ($)	Percent
Barnstable	26 699	21.1	6 362	19.2	926.3	19.0	12 059	32.1	61 368	18.2	7 952	27.2
Bourne	11 262	9.0	1 524	4.6	257.8	5.3	782	2.1	16 561	4.9	919	3.1
Brewster	3 709	2.9	1 226	3.7	197.6	4.1	1 078	2.9	9 471	2.8	1 400	4.8
Chatham	6 027	4.8	1 955	5.9	324.7	6.7	370	0.1	6 666	2.0	456	1.6
Dennis	9 351	7.4	3 380	10.2	471.0	9.7	3 229	8.6	41 426	12.2	3 808	13.0
Eastham	3 069	2.4	928	2.8	163.3	3.3	723	1.9	3 595	1.1	536	1.8
Falmouth	20 648	16.3	4 275	12.9	596.0	12.2	4 129	11.0	58 356	17.3	3 136	10.7
Harwich	7 786	6.2	3 214	9.7	292.8	6.0	1 336	3.5	18 929	5.6	1 128	3.8
Mashpee	2 496	2.0	464	1.4	154.1	3.2	1 356	3.6	19 113	5.6	984	3.4
Orleans	4 369	3.4	1 591	4.8	266.1	5.5	2 597	6.9	16 022	4.7	1 848	6.3
Provincetown	3 947	4.1	895	2.7	113.8	2.3	3 726	9.9	28 916	8.5	1 256	4.3
Sandwich	6 358	5.0	828	2.5	349.0	7.2	975	2.6	13 200	3.4	352	1.2
Truro	1 260	1.0	199	0.6	94.1	1.9	153	0.4	2 615	0.8	367	1.3
Wellfleet	1 973	1.6	365	1.1	168.1	3.4	612	1.6	8 054	2.4	312	1.1
Yarmouth	17 427	13.8	5 932	17.9	503.6	10.3	4 469	11.9	33 723	10.0	4 824	16.5
Total	126 381		33 138		4878.3		37 594		338 015		29 271	

Table 3. Impacts of different assignments of costs to variables.

Town	75/25 Ratio		50/50 Ratio	
	Amount ($)	Percent	Amount ($)	Percent
Barnstable	10 938	20.9	12 860	24.5
Bourne	2 278	4.3	1 889	3.6
Brewster	1 334	2.4	1 343	2.6
Chatham	917	1.7	780	1.5
Dennis	5 822	11.1	5 317	10.1
Eastham	630	1.2	748	1.4
Falmouth	8 592	16.4	7 726	14.7
Harwich	2 758	5.3	2 476	4.7
Mashpee	2 826	5.4	2 544	4.9
Orleans	2 694	5.1	2 993	6.7
Provincetown	4 999	9.5	5 187	9.9
Sandwich	2 049	3.9	1 868	3.6
Truro	313	0.6	263	0.5
Wellfleet	1 233	2.4	1 129	2.2
Yarmouth	5 040	9.6	5 304	10.1
Total	52 423		52 427	

Table 4. Impacts of sampling methods.

Town	12-Month Data		3-Month Data		1-Month Data	
	Amount ($)	Percent	Amount ($)	Percent	Amount ($)	Percent
Barnstable	10 938	20.9	10 322	19.7	9 940	19.0
Bourne	2 278	4.3	2 472	4.7	2 843	5.4
Brewster	1 334	2.5	966	1.8	909	1.7
Chatham	917	1.7	824	1.6	633	1.2
Dennis	5 822	11.1	6 504	12.4	6 984	13.3
Eastham	630	1.2	642	1.2	848	1.6
Falmouth	8 592	16.4	8 447	16.1	7 979	16.2
Harwich	2 758	5.3	3 322	6.3	3 443	6.6
Mashpee	2 826	5.4	3 615	6.9	3 924	7.6
Orleans	2 694	5.1	2 504	4.8	2 576	4.9
Provincetown	4 999	9.5	3 127	6.0	2 832	5.4
Sandwich	2 049	3.9	2 459	4.9	2 304	4.4
Truro	313	0.6	535	1.0	1 046	2.0
Wellfleet	1 233	2.4	1 204	2.3	881	1.7
Yarmouth	5 040	9.6	5 466	10.4	5 282	10.1
Total	52 423		52 409		52 424	

the desire of member towns is to pay in proportion to the service they receive, a valuation-based procedure is likely to raise considerable opposition.

The allocations that result from the application of the comprehensive, three-variable procedure are also significantly different from those based on the CCRTA procedure. In general, however, the allocations fall in between those that result from the individual use of elderly population, valuation, or passenger use. It appears that a comprehensive formula has the ability to moderate the extreme effect of any one variable on a town.

To test the impact of using different methods of assigning costs, a sensitivity analysis was undertaken. As indicated earlier, several towns in the outlying area of Barnstable County have contended that the method that yields the 75/25 ratio imposes an unfair burden on them because their residents make fewer trips than do residents in towns near the center of the county. The differences between passenger trips and passenger miles in the towns can be seen in Table 2, where Barnstable, a "core" town, is shown to have three times as many passenger trips as Falmouth, a "peripheral" town. Passenger miles for the two towns, however, are almost equal. In the analysis, allocations were estimated with a 50/50 ratio and compared with the allocations that used a 75/25 ratio. The results, as given in Table 3, reveal that, with the exception of the two major towns in the region, differences are minor. Barnstable's allocation is significantly higher where trips and miles are weighted equally, and Falmouth's share is somewhat lower under the same scheme. All other towns' allocations differ by less than one percentage point.

Finally, an analysis of the impact of data-sampling methods on the allocations was performed. The high cost of collecting and processing 100 percent data has led CCRTA to examine the viability of data sampling. In order to address this concern, allocations based on the full 12 months' data were compared with those based on 1 and 3 months' data. The sample time periods selected for the analysis were found to be most representative of the 12-month totals, based on aggregate monthly ridership statistics. The results of the analysis can be seen in Table 4. Differences between the 3-month and 12-month figures are generally insignificant, although there appears to be a slightly greater disparity between the 1- and 12-month figures, particularly in the cases of Mashpee, Provincetown, and Truro. The overall significance of these differences negating the viability of the sampling techniques must be weighted against the lower costs for data collection and processing. It should be noted that data-sampling techniques constitute one means of improving the efficiency and reducing the costs of data collection and processing. Other means, such as the use of a minicomputer, are also being considered by CCRTA.

Major Findings

Based on the Barnstable County data for 1978, alternative procedures for allocating public transportation costs among towns produce significantly different allocations.

Single-variable procedures (population, elderly population, and property valuation) tend to promote extreme results that bear little relation to passenger use. If simplicity and cost-of-use criteria are of overriding importance, such procedures may be acceptable. If "paying for services received" is the main criterion, such procedures are clearly unacceptable.

Comprehensive procedures that include population and ridership variables have the advantage of addressing a broader set of concerns in relation to cost allocation. Such procedures also tend to moderate the extreme effects of individual variables on towns.

The two-variable CCRTA procedure provides an adequate reflection of services received by member towns. The weighting of the two variables can significantly affect assessments for some of the towns.

The sole drawback to the CCRTA procedure is the cost of its use, which results from high data requirements. To mitigate that limitation, CCRTA is exploring several cost-reduction mechanisms, including data-sampling methods and the use of a minicomputer for data collection and processing. The use of data samples does not appear to significantly affect allocations, although care must be taken in selecting time periods where ridership is most representative of the full 12-month period.

Franklin County: Fixed-Route, Fixed-Schedule Service

Selection and Use of Current Procedure

During the fall of 1979, the members of FRTA adopted a cost-assessment procedure that was significantly more complex in nature than those adopted by other regional transportation authorities (RTAs) in New England. This complexity reflects a high degree of concern on the part of FRTA members that allocations be considered equitable by all parties.

This concern was particularly evident in the case of two adjacent towns, Shelburne and Buckland, which are linked by the village of Shelburne Falls, a major stop along one of the three FRTA routes. Shelburne is particularly sensitive to the possibility of being overassessed in relation to Buckland, if the only component in the cost-allocation procedure is a vehicle-hours or vehicle-miles variable. Vehicle hours and miles accrue almost entirely to Shelburne; consequently, costs incurred by the transit operator are much greater in that town than in Buckland. However, it is generally perceived that ridership for the two towns is reasonably similar. This has created a delicate political situation and has served as the main catalyst behind the formation of a procedure that is comprehensive enough to negate inequities associated with individual variables.

Although this is one example of an important issue that had to be dealt with in the formation of the procedure, other factors were considered by transit officials to be of significance. These can be summarized as follows:

1. Population, either by itself or in combination with other variables, is related neither to ridership nor to service availability and should not be part of the cost-allocation procedure.
2. Passenger use is an important consideration and should be incorporated into the procedure.
3. Because trip length tends to be disproportionately high in rural areas, time-based variables (e.g., vehicle hours) are considered to be more equitable than distance-based variables (e.g., vehicle miles).

Description of Procedure

The procedure adopted by towns receiving fixed-route service uses three variables, each weighted equally. The variables are (a) vehicle hours, (b) vehicle trips, and (c) number of passengers. Each town's proportion of systemwide totals is determined separately for the three variables. An average of the three ratios is obtained, and this is then multiplied by systemwide gross operating costs to determine "gross costs incurred" in each town. Town revenues, obtained from sample data, are then subtracted from this figure to obtain "net costs incurred". This figure is multiplied by 0.25 (local share under Section 18) to obtain the town's share of the operating deficit.

The procedure can be illustrated through the following formula:

$$D_A = 0.25 \left\{GC_T[(VH_A/VH_T) + (VT_A/VT_T) + (P_A/P_T)]/3 - R_A \right. \quad (2)$$

where

D_A = deficit share for town A,
GC_T = gross operating costs systemwide,
VH_A = vehicle hours for town A,
VH_T = vehicle hours systemwide,
VT_A = vehicle trips for town A,
VT_T = vehicle trips systemwide,
P_A = passengers for town A,
P_T = passengers systemwide, and
R_A = revenue for town A.

The local share of FRTA's administrative costs is assessed according to the town's proportion of the total operating deficit.

Data-Collection and Processing Methods

Because FRTA provides fixed-route, fixed-schedule service, many of the required data (vehicle hours and vehicle trips) can be obtained from the route schedule. Only passenger and revenue data must be obtained on-board. FRTA intends to conduct periodic sample surveys to obtain such information.

The cost of data collection and processing essentially equals the cost of the on-board sample surveys, plus the cost of manually tabulating the statistics. Because the schedule is fixed, the data are tabulated only once, and slight alterations are made for month-to-month variations. Separate calculations are required only when new or seasonal schedules are put into effect. Since a summer schedule was in effect for part of the July through September period studied in this analysis, two tabulations were needed. Each tabulation required approximately 20-30 person-hours of time.

Comparative Evaluation of Procedures

The evaluation of the three-variable formula currently used by FRTA could not be included in this data analysis because of the lack of data regarding the third variable, passenger use. As a result, only the alternative procedures are tested with real data. The concluding statements do, however, include some general comments about the FRTA procedure.

The data used for the analysis cover the first quarter of fiscal year 1980. Allocations made from the full three months' data are compared with allo-

Table 5. Comparative local assessments based on alternative procedures: three-month and one-month data for FRTA fixed-route service.

Town	Population		Vehicle Miles		Vehicle Hours		Vehicle Miles and Vehicle Hours		Population, Vehicle Miles, and Vehicle Hours	
	Amount ($)	Percent	Amount ($)	Percent	Amount ($)	Percent	Amount ($)	Percent	Amount ($)	Percent
3-Month Data										
Bernardston	293	5.2	437	7.6	406	7.2	414	7.4	401	7.1
Buckland	947	16.8	0[a]	0.0	184	3.3	104	1.8	192	3.4
Charlemont	399	7.1	987	17.2	832	14.8	871	15.5	822	14.6
Colrain	776	13.8	302	5.3	436	7.8	403	7.2	442	7.9
Deerfield	615	10.9	1997	34.8	1203	21.4	1401	24.9	1319	23.5
Gill	692	12.3	73	1.3	84	1.5	81	1.4	145	2.6
Northfield	1075	19.1	323	5.6	941	16.7	787	14.0	817	14.5
Shelburne	719	12.8	1492	26.0	1369	24.3	1400	24.9	1329	23.6
Rowe	111	2.0	132	2.3	173	3.1	162	2.9	157	2.8
Total	5627		5743[b]		5628		5623		5624	
1-Month Data										
Bernardston	293	5.2	437	7.6	437	7.7	437	7.8	422	7.5
Buckland	947	16.8	0[c]	0.0	174	3.1	96	1.7	185	3.3
Charlemont	399	7.1	987	17.2	853	15.2	886	15.8	835	14.9
Colrain	776	13.3	292	5.1	385	6.9	362	6.4	405	7.2
Deerfield	615	10.9	2182	37.9	1368	24.3	1571	28.0	1472	26.2
Gill	692	12.3	42	0.7	42	0.7	42	0.7	110	1.9
Northfield	1075	19.1	323	5.6	983	17.5	818	14.6	844	15.0
Shelburne	719	12.8	1441	25.0	1338	23.8	1313	24.3	1296	23.1
Rowe	111	2.0	49	0.9	39	0.7	41	0.7	49	0.9
Total	5627		5753[d]		5619		5616		5618	

[a] -$136. [b] $5607. [c] -$36. [d] $5517.

cations made from a one-month data sample. As in the previous analyses of Barnstable data, the examination of data-sampling methods is an integral part of the evaluation.

The following discussion begins with the assumptions under which each data analysis was carried out, briefly describes and analyzes the alternative procedures, and concludes with the comparative evaluation. Allocations based on these data are given in Table 5.

In a comparison of the allocations produced by the five alternative procedures for the three-month period, several noteworthy factors stand out. First, most of the procedures yield significantly different allocations. This dissimilarity is particularly noticeable among the single-variable procedures, where the use of population produces assessments that differ as much as ninefold from the level of service-based procedures (vehicle miles and hours). Buckland, Colrain, and Gill are relatively overassessed when population is used, whereas Charlemont, Deerfield, and Shelburne are relatively underassessed. Based on these widely varying assessments, it is difficult to envision the use of any one of these single-variable procedures without significant opposition from certain towns.

A closer examination of the single-variable (vehicle-miles- or vehicle-hours-based) procedures reveals substantial evidence of a lack of correlation between the allocations, particularly in regard to Northfield and Deerfield. Note, for instance, the negative assessment that Buckland receives under the vehicle-miles-based procedure. This anomaly is the result of the revenue (6.6 percent of total) being much greater than the cost attributed to vehicle miles (1.7 percent of total). It clearly portrays the importance of analyzing route design and other site-specific geographic and service features before a decision is made on the use of a procedure. In regard to the contention that a vehicle-miles-based procedure penalizes outlying towns and a vehicle-hours-based procedure penalizes core towns, no significant conclusions can be drawn from this analysis. Since the only undisputed core town in the region, Greenfield, is not included in the analysis, any potential findings are inconclusive.

The two multivariable procedures result in allocations that are less extreme than those that result from the single-variable procedures. Differences between the two procedures are generally minor. The towns with the lowest levels of service (Buckland and Gill) have somewhat higher allocations from the three-variable procedure, where the population variable is introduced, whereas allocations for the towns with the highest levels of service (Deerfield and Shelburne) decrease slightly.

In comparing allocations based on the full three months' data with those based on the one-month sample (Table 5), significant differences are generally found only in those towns that were affected by the transition from the summer to fall schedule. The month chosen for the sample was July, when the full summer schedule was in effect. The town of Rowe, for example, received only Saturday service during the summer. Under the "hours-miles" procedure, the allocation for Rowe for the month of July amounted to 0.7 percent of the total deficit. The town started receiving daily service after September 17, which was enough to raise its three-month share of the deficit (2.9 percent) to four times its one-month share. It appears, then, that sampling is a valid technique in a fixed-route, fixed-schedule service but that data samples must take into account different schedules that may be in effect during the course of a year.

It must be recognized that sampling does not have the same implications for a fixed-route system as it does for a demand-responsive system. In the latter, costs of collecting and processing passenger-use data can be high and significant savings can be realized from sampling. In a fixed-route system, however, such costs are minor to start with, which reduces the potential impact and overall level of importance of sampling. If sampling is used, it appears that the only variables that are likely to change over time are passenger use and revenue. This analysis has shown the sensitivity of allocations to a variable such as revenue and in the process pointed out that a one-day data sample may not be sufficient or valid.

Table 6. Summary of cost-allocation procedures.

Type of Operation	Variable	Equity Implications of Variable	Ease of Understanding	Data Requirements	Cost of Use	Computer Needed
Demand-responsive	Population	Service availability	High	Low	Low	No
	Elderly population	Service availability	High	Low	Low	No
	Property valuation	Ability to pay	High	Low	Low	No
	Passenger miles	Use levels	Medium	Medium-high	Medium	Yes
	Passenger trips	Use levels	Medium	Medium	Low-medium	No
	Population, property valuation, passenger trips and miles	Service availability, ability to pay, use	Low	High	High	Yes
	Passenger trips and miles	Use levels	Low-medium	High	High	Yes
Fixed-route	Population	Service availability	High	Low	Low	No
	Vehicle miles	Service availability	Medium-high	Low-medium	Low-medium	No
	Vehicle hours	Service availability	Medium-high	Low-medium	Low-medium	No
	Vehicle miles and hours	Service availability	Low-medium	Medium	Medium	No
	Population, vehicle miles and hours	Service availability	Low-medium	Medium	Medium	No

Finally, some mention should be made of the absence of passenger-use variables (e.g., passenger trips) in this analysis and what effect that absence may have on the alternative allocations. Because revenues are being applied to the towns and passenger use is not, towns are being rewarded for their use of the system. If the underlying objective of the towns is to pay for what they get, these procedures do not achieve that objective. Buckland's "negative assessment" under the vehicle-miles-based procedure is a clear example of what can result when revenue, but not passenger use, is considered.

Major Findings

In the case of FRTA, the tested procedures yield widely varying assessments, partly due to unique service and geographic characteristics.

Single-variable procedures (population, vehicle miles, and vehicle hours) produce particularly extreme assessments. Conversely, multivariable procedures tend to moderate the extreme effect of individual variables and promote results that are more balanced.

There appears to be a very weak relation between townwide population and either of the two vehicle-based variables. If population is to be used in a fixed-route procedure, one suggestion might be to include only those people living within a reasonable distance of the routes.

A clear advantage of the three-variable FRTA procedure over the procedures that were tested is its consideration of passenger use. If, as in the case of the five tested alternatives, revenues are credited to towns but passenger use is not, towns are rewarded for using the system.

The issue of data sampling is not pertinent to this analysis because data-collection and processing costs are low to start with. Vehicle data must, however, reflect seasonal schedule changes.

SUMMARY

The study described in this paper has evaluated a variety of procedures for allocating public transportation costs among towns and discussed their applicability to various types of public transportation programs in nonurbanized areas. These procedures are summarized in Table 6. It is intended that the information presented in this table, together with the specific findings of the evaluation, will serve as a guide to public transportation officials who may be in the process of selecting a procedure.

CONCLUSIONS

Based on evaluation, a number of general conclusions can be made about the usefulness of the various types of cost-allocation procedures:

1. Single-variable procedures, such as those based on population and ability to pay, clearly are the easiest to understand and least costly to use. However, they are not likely to meet expectations of fairness, if fairness is to be equated with relative quantity of services available or used.
2. Multivariable procedures have the ability to combine and weight potentially conflicting perspectives and cost-allocation philosophies, thus providing the decision maker with an added degree of flexibility. They also tend to moderate inequities that may arise from the use of any one variable.
3. Procedures based on passenger miles and/or passenger trips have the advantage of being able to relate cost allocations to the amount of service consumed or used by each town. Such procedures may be relatively expensive to use, but this drawback can be mitigated through the use of alternative data-collection methods or data-sampling techniques.
4. The review of the current procedures being used in Franklin and Barnstable Counties shows a clear preference on the part of transit officials for procedures that are based on availability and/or use levels. Although simplicity and cost-of-use factors are of considerable concern, the overriding desire of the officials and the towns they represent is to base allocations on the amount of services received.
5. Procedures that incorporate passenger-use variables (e.g., passenger miles) are more suitable for demand-responsive systems, whereas those that incorporate level-of-service variables (e.g., vehicle miles) are more suitable for fixed-route systems. This distinction, although not rigid, is due to the difference in data-collection and processing methods appropriate to the two types of service. However, the use of certain procedures can help a transit authority to achieve other service-related objectives. For instance, procedures based on vehicle miles serve to encourage group ridership in a demand-responsive system. Ridesharing can result in more service to a town at less cost, but, more importantly, it can lead to more efficient vehicle use and higher system productivity.

It is important to reiterate that there is no single procedure that is ideal for any particular transportation program. The variety of procedures identified in this study all correspond to different sets of philosophies and personal values concerning equity. In addition, site-specific political and financial considerations play an ever-increasing role in the determination of an appropriate procedure.

The decision-making process for choosing among alternative procedures does appear to follow somewhat standard lines, despite the importance of highly variable local political factors. The goals of maximizing fairness and minimizing complexity and cost of use appear to be shared by most public officials. As mentioned earlier, the satisfaction of these objectives presents a potential conflict for the decision maker, whose role it is to find the appropriate trade-off point between the two goal orientations. On the one hand, the procedure must be understandable to the public and not overly difficult or expensive to use. On the other hand, it must be comprehensive enough to satisfy the numerous demands for fairness made by the towns in the service area. It appears that the fairness objective tends to be dominant in the perspective of most decision makers. Simplicity may be of overriding importance when the system is new or when the number of participants is small, but as the service grows in scope equity becomes increasingly significant. It is particularly important when the system is trying to extend services to new communities. The willingness of a town to join an RTA and receive service often hinges on the perception that its future financial obligation will be fair and equitable.

Regardless of which approach is taken and which procedure is ultimately selected, it is clear that cost allocation is playing a more important role in the development of comprehensive, coordinated rural public transportation systems and will play an even larger role in the future. With a continuation of federal operating assistance expected in the future (a proposed $420 million for the Section 18 program through fiscal year 1985), there will be ample opportunity for regions to initiate new programs or expand existing ones. In many cases, the only barrier to successful implementation will be the lack of local political and financial support. Without this support, the region may have to settle for a very basic system or no system at all. A cost-allocation procedure that is acceptable to all the towns in the region can help bring about the necessary political support and thereby reduce uncertainty over financial commitment. In doing so, it can help achieve the major goal of providing a public transportation service to those who need it.

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