

# Financing Urban Mass Transportation Systems: A Study of Alternative Methods to Allocate Operating Deficits

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This study examines allocation procedures to apportion transit operating deficits among user communities. These allocations were formulated in terms of allocation plans that incorporate factors to identify, accumulate, and distribute costs to a final cost objective. For urban transit systems such a plan combines an allocation performed within the system for cost determination purposes with an allocation that assigns deficit amounts to parties external to the system. External deficit allocations consist only of an allocation base; internal allocations consist of a cost hierarchy, an accounting technique, and an allocation base. An experimental environment is created to apply alternative allocation methods under identical operating conditions by using a computer model to simulate a transit system. Deficit amounts assigned to each community served are then examined to determine the effects of alternative allocation plans for the computation and distribution of transit system operating deficits. An analysis that focuses on the amounts allocated to individual communities shows that a high degree of variation is produced by alternative plans for allocating a transit operating deficit. Another analysis, which views each allocation plan as a single variable, reveals that plans that employ only an external deficit allocation and plans that use a systemwide average operating cost produce results distinctly different from plans that do not employ such procedures.

Cooperative agreements between communities in a metropolitan area to share the burden of a transit system's operating deficit is one alternative for financing urban transit systems. Through these agreements, financial support of a transit system is based on farebox revenues as well as on the assessment of an operating deficit to individual communities in the system's service area. The dollar amount assessed to a community is determined by an allocation procedure that is based on a factor or combination of factors descriptive of either the service provided or the community served. Proper selection of the allocation procedure is important because it affects not only the amount of system operating deficit calculated for a period of operations but also the portion of the deficit assigned to individual communities in the urban area.

In general, the allocation of a transit system's operating deficit among communities should include factors that describe the level of costs incurred in operating the transit service as well as factors that relate revenues directly to the service provided. The accumulated costs reflect the level of service provided and the operating characteristics of vehicles for different speeds and terrain. Revenues reflect the fare schedule and the demand for transit based on the social and economic makeup of each community and the density of its population. Where possible, determination of the factors that will represent costs and revenues should be made at the route level of an urban transit system. At this level, a proper accounting can be made of the results of providing service to each community on a route; that is, an amount of deficit can be identified with a specific community that received a defined level of transit service. This is a desirable objective because each route or community may possess characteristics that result in the accumulation of costs or revenues at rates different from those of other routes or communities.

The allocation of operating deficits among user communities is currently practiced in the field of urban transportation; however, the allocation procedures employed differ markedly in each instance. Industry practices can be categorized into two general forms: (a) an overall or systemwide approach for calculation and allocation of the deficit amount and (b) a more limited approach based on calculation of the deficit for a single segment of a system. The former is found in the regional approach to calculation of an allocation percentage; the latter approach focuses on identifying losses where they were incurred (i.e., cost reimbursement for individual routes or within specified geographic subdivisions of the urban area).

The allocation of operating deficits is basically a cost-allocation procedure, and information on cost allocations applied to the cost-determination process of private sector profit-seeking firms is available in the literature of accounting. In this study, cost allocations in the private sector were conceptualized in a framework that identified the specific factors that make up an allocation. A set of alternative operating deficit allocations were then applied by employing a computer model to simulate the operation of an urban transit system. Two approaches for allocating an operating deficit were compared: a highly aggregated one, which allocated at the system level, and a more detailed one, which made allocations at the route level. Analysis of the data revealed a degree of variation greater than anticipated in the allocation percentages assigned to communities when the only variable altered in calculating those percentages is the allocation applied. Further examination of the amounts of deficit assigned to individual communities showed that they are dependent on the specific factors of the allocation used. Given such results, it is important for transit administrators to understand the allocation process more clearly in order to foresee the implications of selecting an allocation procedure.

## CONCEPTS OF COST ALLOCATION

As an ideal, every item of cost incurred should be assigned to the cost objective that benefited from the cost or, alternatively, that caused the incurrence of the cost. In practice, though, this ideal is rarely attained because many costs are incurred at a point significantly removed from the cost objective that ultimately benefited or that caused its incurrence. Intermediate cost objectives, or cost centers, are then used to pass the cost through an organization to the final cost objective—the product produced. Costs not directly identified with final cost objectives are grouped into logical and homogeneous cost pools and assigned through a hierarchy of intermediate cost objectives by employing an allocation procedure at each hierarchical level. Thus, cost allocation is basically the accumulation of costs into cost pools and assignment of those costs to other cost pools or final cost

objective through the use of an allocation procedure.

Many factors are considered in deciding on the use of a particular cost-allocation procedure, including (a) selection of a cost-accounting technique, (b) designation of the cost objectives, (c) identification of the allocation bases, and (d) formulation of the allocation ratio to be applied.

The cost-accounting technique encompasses the principles and practices of accounting that make up the basic means of associating costs with units produced. Variation in unit costs can result due to the use of different cost techniques.

A cost objective is an activity or transaction for which a cost is to be determined. It can be a product, business activity, or department or other administrative unit of an organization. The cost objective represents the purpose for which a particular cost has been incurred, and different levels of cost objectives exist in an organization, corresponding to the administrative hierarchy. Cost objectives within the hierarchy are called intermediate cost objectives when the output produced is at the lowest level of the hierarchy. The number of intermediate cost objectives directly affects the number of cost allocations made internally, which can result in accumulating different dollar amounts for each final cost objective.

The allocation of costs to defined cost objects requires the selection of a surrogate to measure the amount of cost to be assigned. This surrogate measure is an allocation base, which is a quantitative measure, that bears a relationship to both the amount of cost accumulated and the activity levels of the cost object. A number of potential bases exist in any situation, and the one that is most appropriate in the circumstances must be selected. Difficulties arise when an association between a cost and the cost object is indirect and unclear, or perhaps when the relationship is multiple, and often impossible to measure. Inequitable allocations result if the proper allocation base is not determined.

The allocation ratio establishes the form of a relation between the dollar amount allocated and the quantity of allocation base for each activity or product charged. Improper definition of this relation can produce discrepancies in allocated amounts through disproportionate weighting of factors, erroneous measurement of allocation base amounts, or use of an incorrect number of activities or products to be charged.

All of the above factors are interdependent and must be considered simultaneously in a cost-allocation decision. This study considers these interrelationships within a single framework, called a cost-allocation plan, which is defined as a complete enumeration of the factors included in identification, accumulation, and distribution of costs to final cost objectives. Given the objective of determining the full cost of final cost objectives, a conceptual cost-allocation-plan model can be formulated as follows:

$$A = A \text{ function of } (T, H, B, R) \quad (1)$$

where

A = the allocation plan,  
T = the cost-accounting technique,  
H = the cost-objective hierarchy,  
B = the allocation base, and  
R = the allocation ratio.

After all necessary data are input, an allocation plan can be applied to determine the unit cost for the products produced. Various combinations of the basic factors of an allocation plan can be evaluated according to their ef-

fect on the unit cost of the output produced. This is the objective of experiments performed as part of this study—to ascertain the effects of different cost-allocation plans on final cost objectives of an urban transit system.

The cost-allocation framework was then applied to urban public transportation by matching the parameters of a cost-allocation plan with descriptive features of urban transit systems. Public transportation was viewed as part of a hierarchy of systems in a metropolitan area as follows:

1. Urban area,
2. Transportation system, and
3. Cities or communities.

The second level of the hierarchy would consist of the specific modes of transportation provided in the urban area, including the automobile, public transit systems, and even walking. If the second-level cost objective is a transit system, the intermediate cost-objective hierarchy within the system might appear as follows:

1. System,
2. Department,
3. Route, and
4. Vehicle trip.

The system level is the transit organization taken as a whole. The department level entails separating the system into the various functions performed (i.e., segregating administrative activities, centralized services, and operational activities). Administrative departments consist of the business manager, accounting and data processing, and other activities such as legal, marketing, and public relations. Centralized services are scheduling, maintenance and repair, and equipment servicing. Operational activities include everything under the heading of transportation, which generally includes operators, supervision, dispatching, and operator training. Individual cities and communities that receive transit service in an urban area are the final cost objectives of the urban transit system hierarchy.

With this hierarchy, the operating deficit allocation problem of an urban transit system can be categorized in two parts:

1. Allocations performed within the transit system itself and
2. Allocation of transit system operating results to cities or communities.

Allocations within the transit system assign system overhead to various segments of the system. Such allocations are hereafter referred to as internal allocations. These allocations would be made in a manner similar to the cost allocations performed by a business entity operating in the private sector. Assigning results of transit system operations to communities served is referred to as external allocation and results in charging to participating communities a portion of the cost of providing transportation in the urban area.

The specific cost-allocation techniques applied in this study fall into two categories: average costing and joint costing.

The average-costing technique assigns costs to output by using an average unit cost, which is obtained by dividing the total amount of cost by the total number of units produced. The logic behind such an approach is that all products turned out by the same process should receive a proportionate share of the total costs based strictly on the quantity of units produced. Average costing is the prevailing practice of the urban transit industry for cost

determination. Calculation of the average operating cost consists of dividing the total amount of an operating characteristic accumulated over a period of transit operations into the total cost of operating the system during the same time period. The characteristic employed is either vehicle distance or vehicle hours operated. The average cost per unit (e.g., vehicle kilometers or vehicle hours) is then applied to the amount of base units actually used in a time period to determine the operating cost of the period.

The joint-costing approach recognizes that the cost of producing products involves both direct costs and overhead costs. The direct costs are identified readily with individual products or processes. Overhead costs are incurred for the general benefit of the organization as a whole. The problem of allocating this overhead can generally be looked on as one dealing with the assignment of joint costs. A joint cost is one incurred for a combination of products or processes, but the amount of cost applicable to any one item or process cannot be traced by direct observation. Joint costing is the process of assigning the amount of cost incurred for a process to the products produced by that process.

The specific elements of allocation plans applied in the experimental phase are as follows:

Allocation Plan	Element
Cost-accounting technique (T)	Average costing Joint costing
Cost-objective hierarchy (H)	Level 1-transit system Level 2-individual routes Level 3-communities
Allocation bases applied (B)	
In external allocation	Population Assessed value Total dwellings Total employment Vehicle trips scheduled Passenger revenue Boarding passengers
In internal allocation	Vehicle hours Vehicle kilometers Passengers carried Revenue collected

The allocation ratio (R) is determined by the decision of whether to use a one- or two-step allocation procedure. External allocations assign the transit system's operating deficit directly to communities. Internal allocations first reassign costs within the transit system by using a cost-accounting technique before applying an external allocation. Thus, deficit allocations based solely on external allocations are a one-step process of selecting the allocation plan to apply, but deficit allocations that use internal allocations are a two-step process where system operating costs are first allocated to individual routes of the transit system and revenues earned on the route are matched against these costs. The route operating deficit determined by this matching process is then allocated to communities served on the route by using an external allocation method.

The complete specification of an allocation plan actually involves a sequence of decisions to identify each of the basic factors included in the plan. This decision process can be graphically illustrated in the form of a decision tree. Starting at the origin, decisions are made at branching points, or nodes, of the tree. Only one branch can be selected at each node, and, by following the selected branch, another decision point is reached. Proceeding along a series of selected branches leads eventually to an end point of the tree and the complete determination of an allocation plan for apportioning a

transit system's operating deficit. Figure 1 presents a decision tree and identifies basic elements of the allocation plans examined in the experiment phase of this study.

## EXPERIMENT PHASE

As indicated in Figure 1, six different internal allocations are applied in addition to one plan in which only an external allocation is performed. Each plan employs one of the seven possible bases of external allocations; thus, 49 different allocation plans were examined. These allocation plans were applied through the use of a computerized simulation model called BUSMAN, an acronym for bus system management analysis. This model takes into account the interdependencies and interactions that occur within the transit system and between it and the people of the communities it serves. The principal factors represented are

1. Prediction of the travel pattern and total volume of travel in an urban area,
2. Level of transit service provided,
3. Cost-behavior patterns of system operation, and
4. Accounting system for accumulating and reporting financial information.

The interaction of these factors influences the amount of revenue earned and the cost of system operation; thus, the profitability of the system and the system's need for supplemental revenues is thereby established. Another portion of the model applies the different allocation plans for apportioning the amount of operating deficit incurred in a period of transit operations. Output of this segment is the shares of deficit charged to each community served by the transit system.

Data generated for each allocation plan applied are accumulated in the allocation plan matrix (APM). The cells of this matrix, formed across the top by internal allocations and along the side by external allocations, consist of results produced by applying an allocation plan—the unique combination of an internal cost allocation with an external deficit allocation. More specifically, each APM cell contains the percentage amounts of a transit operating deficit allocated to the final cost objectives of the allocation plan (i.e., individual communities in the urban area). The allocation plan matrix is shown in Table 1.

## Analysis of Results

Examination of the APM data was organized into two parts:

1. Effects of alternative allocation plans on individual communities and
2. Comparison of results by viewing each allocation plan as a whole.

In the first part, with a community as the cost object, the focus is on allocation percentages of each community rather than the allocation process used in order to identify the extent of variation present in the results. In the second part, the results assigned under each allocation plan are viewed as a unique combination of results and sets of results are compared in order to disclose those allocation plans that produce substantially similar results and those that generate highly divergent results.

## Results by Individual Communities

The third column in Table 2 gives the overall range of



Table 1. Allocation plan matrix.

External Deficit Allocation Base	City Number	Internal Cost Allocation						
		None	Average Cost (%)		Joint Cost (%)			Revenue
			Vehicle Hours	Vehicle Kilometers	Vehicle Hours	Vehicle Kilometers	Passengers	
Population	2	8.22	7.22	10.08	4.12	4.85	3.47	5.19
	3	2.56	2.24	3.15	1.28	1.51	1.08	1.61
	4	5.65	4.96	6.93	2.83	3.33	2.39	3.57
	5	12.33	10.83	15.13	6.19	7.27	5.22	7.79
	6	6.47	10.43	10.37	10.47	10.46	11.22	9.29
	7	22.61	36.42	36.27	36.58	36.54	39.21	32.44
	8	4.31	6.95	6.91	6.98	6.97	7.48	6.19
	9	6.98	3.85	2.04	5.81	5.35	5.51	6.25
	10	30.83	17.03	9.04	25.67	23.64	24.34	27.60
Assessed value	2	7.48	5.87	8.20	3.35	3.95	2.83	4.22
	3	3.44	2.70	3.77	1.54	1.81	1.29	1.94
	4	8.98	7.05	9.84	4.02	4.73	3.40	5.07
	5	12.27	9.63	13.46	5.51	6.47	4.65	6.93
	6	4.94	7.68	7.65	7.71	7.70	8.27	6.84
	7	25.44	39.59	39.43	39.77	39.73	42.63	35.27
	8	4.19	6.52	6.48	6.54	6.53	7.01	5.80
	9	10.77	6.77	3.59	10.21	9.40	9.68	10.97
	10	22.45	14.12	7.49	21.27	19.59	20.17	22.87
Total dwellings	2	9.32	7.90	11.04	4.51	5.30	3.81	5.68
	3	2.04	1.72	2.40	0.98	1.15	0.83	1.23
	4	4.47	3.78	5.29	2.16	2.54	1.82	2.72
	5	13.99	11.85	16.56	6.77	7.97	5.72	8.53
	6	5.83	10.02	9.98	10.06	10.05	10.79	8.93
	7	22.15	38.09	37.93	38.26	38.22	41.01	33.94
	8	3.30	5.67	5.65	5.70	5.69	6.11	5.05
	9	6.60	3.54	1.87	5.35	4.92	5.07	5.75
	10	32.26	17.34	9.20	26.13	24.07	24.77	28.09
Employment	2	11.95	6.89	9.63	3.94	4.63	3.32	4.96
	3	1.71	0.98	1.38	0.56	0.66	0.47	0.70
	4	3.23	1.86	2.60	1.06	1.25	0.90	1.33
	5	26.90	15.51	21.68	8.87	10.43	7.49	11.17
	6	6.47	9.16	9.13	9.20	9.20	9.87	8.17
	7	29.39	41.62	41.45	41.81	41.77	44.82	37.09
	8	2.11	2.99	2.98	3.00	3.00	3.22	2.67
	9	4.73	5.43	2.88	8.18	7.54	7.76	8.80
	10	13.45	15.46	8.20	23.29	21.45	22.08	25.03
Vehicle trips	2	11.11	6.31	8.82	3.60	4.24	3.04	4.54
	3	11.11	6.31	8.82	3.60	4.24	3.04	4.54
	4	11.11	6.31	8.82	3.60	4.24	3.04	4.54
	5	11.11	6.31	8.82	3.60	4.24	3.04	4.54
	6	11.11	17.92	17.85	18.01	17.99	19.30	15.97
	7	11.11	17.92	17.85	18.01	17.99	19.30	15.97
	8	11.11	17.92	17.85	18.01	17.99	19.30	15.97
	9	11.11	10.44	5.54	15.74	14.49	14.92	16.92
	10	11.11	10.44	5.54	15.74	14.49	14.92	16.92
Passenger revenue	2	7.03	4.43	6.20	2.53	2.98	2.14	3.19
	3	2.26	1.42	1.98	0.80	0.95	0.68	1.01
	4	6.77	4.27	5.97	2.44	2.87	2.06	3.07
	5	23.98	15.13	21.14	8.65	10.16	7.30	10.89
	6	6.08	11.39	11.34	11.44	11.43	12.26	10.15
	7	19.17	35.90	35.75	36.06	36.02	38.65	31.99
	8	3.46	6.49	6.46	6.52	6.51	6.99	5.78
	9	5.17	3.46	1.83	5.21	4.80	4.94	5.60
	10	26.03	17.44	9.25	26.27	24.20	24.90	28.24
Boarding passengers	2	10.45	7.16	10.00	4.09	4.81	3.45	5.15
	3	2.57	1.76	2.46	1.00	1.17	0.85	1.26
	4	6.49	4.44	6.20	2.53	2.98	2.14	3.20
	5	17.36	11.89	16.62	6.79	7.99	5.73	8.56
	6	7.36	11.55	11.50	11.60	11.59	12.43	10.29
	7	23.31	36.56	36.41	36.73	36.69	39.37	32.58
	8	3.62	5.67	5.65	5.70	5.69	6.10	5.05
	9	5.97	4.33	2.30	6.52	6.01	6.19	7.01
	10	22.83	16.56	8.78	24.95	22.99	23.66	26.83

Table 2. Summary of results.

Community		Allocation (%)				Standard Deviation	Coefficient of Variation
Number	Name	High	Low	Range	Mean		
2	Nearnorth City	11.95	2.14	9.81	5.86	2.61	0.446
3	Midnorth City	11.11	0.47	10.64	2.22	2.01	0.907
4	Northmost City	11.11	0.90	10.21	4.18	2.32	0.555
5	Northeast City	26.90	3.04	23.86	10.43	5.36	0.514
6	South City	19.30	4.94	14.36	10.51	3.31	0.315
7	Midsouth City	44.82	11.11	33.71	33.12	8.65	0.261
8	Southeast City	19.30	2.11	17.19	7.02	4.40	0.627
9	Southwest City	16.92	1.83	15.09	6.82	3.53	0.518
10	Farwest City	32.26	5.54	26.72	19.78	6.84	0.346

Table 3. Summary of the elements of the allocation plans that form the final clusters.

Internal Allocation			External Allocation Base	Plan Number	Final Cluster Assignment										
Hierarchy Level	Costing Technique	Allocation Base			1	2	3	4	5	6	7	8	9	10	11
System	None	None	Population	1			x								
			Assessment	2										x	
			Dwelling	3			x								
			Employment	4						x					
			Vehicle trips	5							x				
			Revenue	6									x		
			Passengers	7										x	
Route	Average	Vehicle hours	Population	8			x								
			Assessment	9			x								
			Dwellings	10			x								
			Employment	11			x								
			Vehicle trips	12				x							
			Revenue	13			x								
			Passengers	14			x								
Route	Average	Vehicle kilo-meters	Population	15								x			
			Assessment	16								x			
			Dwellings	17								x			
			Employment	18								x			
			Vehicle trips	19					x						
			Revenue	20								x			
			Passengers	21								x			
Route	Joint	Vehicle hours	Population	22	x										
			Assessment	23											x
			Dwellings	24	x										
			Employment	25											x
			Vehicle trips	26		x									
			Revenue	27	x										
			Passengers	28	x										
Route	Joint	Vehicle kilo-meters	Population	29	x										
			Assessment	30											x
			Dwellings	31	x										
			Employment	32											x
			Vehicle trips	33		x									
			Revenue	34	x										
			Passengers	35	x										
Route	Joint	Passengers carried	Population	36	x										
			Assessment	37											x
			Dwellings	38	x										
			Employment	39											x
			Vehicle trips	40		x									
			Revenue	41	x										
			Passengers	42	x										
Route	Joint	Revenue collected	Population	43	x										
			Assessment	44											x
			Dwellings	45	x										
			Employment	46	x										
			Vehicle trips	47		x									
			Revenue	48	x										
			Passengers	49	x										

higher the percentage, the greater is the variation existing in the data.

For the simulated urban area of this study, the highest coefficient of variation observed was 0.907, or 91 percent; the lowest value was 0.261, or 26 percent. City number 3 experienced the highest coefficient of variation and city number 7 experienced the smallest value. Criteria have not been established for objective evaluation of the range of ambiguity or the coefficients of variation for each community; but logically, it seems unusual that the lowest range of ambiguity would be as high as 10 percent and that one community's results could vary by as much as 34 percent of the operating deficit incurred and that the relative variation could range from 26 to 91 percent. The impact of this variation is apparent when these percentages are expressed in dollar terms by assuming that a transit system's annual operating deficit was \$100 000. Then the amounts allocated would vary from a maximum of \$44 820 down to a minimum of \$11 110—solely dependent on the choice of allocation plan applied. It would be most likely that this degree of variation in the amounts assigned would be considered significant.

#### Effects of Allocation Plans

Given the degree of variability that exists in individual

amounts assigned to a community, it is desirable to determine the extent of difference, or similarity, between allocation plans viewed as a single variable instead of as a combination of factors. Homogeneity of allocation plans was tested by using cluster analysis applied in a simulation-type procedure where the number of clusters is increased by one in each successive run of the program. The objective of the procedure is to group data into clusters such that data sets within a cluster have a high degree of likeness among themselves, but each cluster is relatively distinct from one another.

Data input to the clustering program were the percentage amounts of operating deficit assigned to each community (given in Table 1). The 49 allocation plans that form the first cluster in the cluster-analysis program were numbered sequentially (as shown in Figure 1).

The simulation procedure terminated when substantial variation was removed from the data. This occurred after 10 iterations when 11 clusters had been formed and more than 88 percent of the total variation in the original data had been removed. Table 3 summarizes these results by disclosing the elements of the allocation plans included in each cluster.

Several patterns of allocation plans are observable from a review of these final clusters. For example, 5 of 11 clusters (3, 6, 7, 9, and 10) consist of allocation plans

that use only external allocations—no internal cost allocation is performed. Three clusters (2, 5, and 7) contain all those allocation plans that use vehicle trips as the basis of external allocation. The remaining clusters consist of plans that have common internal cost-allocation techniques. For example, clusters 4 and 8 consist of plans that use average costing as the technique for performing internal allocations. Six of the plans in cluster 4 use a vehicle-hours base; however, in cluster 8, 6 of the 7 plans use vehicle kilometers as the allocation base. Cluster 11 is formed by 7 plans that use joint costing, and cluster 1 consists of 17 plans, all of which use joint costing for internal cost allocations.

Thus, after a cluster-analysis technique has removed substantial variation from the APM data, the resulting clusters are each homogeneous over the cost-accounting technique employed. Several clusters even contain identical internal cost allocations, notably clusters 4 and 8. The largest number of plans (17) are included in cluster 1, where 16 plans result from a permutation of the four bases for joint costing with four specific bases of external allocation: vehicle hours, vehicle kilometers, passengers carried, or revenue collected. Each of the above are combined with an external allocation by using population, total dwellings, passengers carried, and revenue collected for the allocation base. Thus, cluster 1 consists of a distinct combination of allocation plan elements that are basically homogeneous (i.e., there would be small differences between the results produced if any one of these plans were selected).

The implication of this final pattern of data sets is that the joint-costing technique provides results that are distinctly different from the transit industry's preferred method of cost determination, average costing. Finally, the fact that a large block of homogeneous joint-costing plans (24 plans) remained together in cluster 1 through 10 iterations can be viewed as an indication that joint costing provides more homogeneous results over a fairly wide selection of allocation plan elements. Therefore, a conclusion that can be drawn from the final pattern of data sets is that deficit allocation plans can be distinguished on the basis of the internal costing technique employed.

In a cluster-analysis routine, the amount of variation remaining in the data is reduced with each new cluster formed. The allocation plans removed earliest from the main grouping of data sets, therefore, are those that reduce variation by the greatest amount. An alternative statement would be that the first plans segregated from the main body of data sets are those plans that differ by the greatest degree from all other plans. A summary of the movement of each allocation plan and the amount of variation removed from the data by each successive iteration appears in Figure 2. Of the 10 iterations performed, 5 resulted in minor changes in the variation removed and were generally of little significance. The largest amounts of variation were removed in the first three iterations, the seventh, and the last iteration. The second cluster was initially formed around the allocation plan that made no internal allocations and used vehicle trips as the base in the external allocation. Since these were the first plans removed from the main body of data sets, they are the ones that are most divergent from all the other allocation plans examined. (Note that an option of using no internal allocation is considered as a choice of cost-accounting technique.)

On the second iteration, cluster 3 included six of seven possible plans that made no internal allocation of costs. The single plan missing from this cluster was the one that uses vehicle trips as the base for external allocations previously included in cluster 2 in the first

iteration. Thus, the absence of an internal allocation of costs was a significant element of allocation plans, which caused a lack of homogeneity in this experiment. This condition is due to the fact that vehicle trips are based on demand, which is fairly uniform throughout the simulated urban area. Using vehicle trips as an external allocation base results in near-equal allocation to communities and eliminates the effect of factors representing various levels of transit activities.

The third iteration resulted in the movement of 13 data sets to the new cluster, number 4. Twelve of these plans shifted from cluster 1, all of which employed average costing in performing internal cost allocations. Half of these used vehicle hours as the base, and half allocated on the basis of vehicle kilometers. These 12 plans remained clustered together through six iterations. Thus, the use of the average-costing technique for internal allocation appears to produce results that are substantially similar, whether vehicle kilometers or vehicle hours are used as the allocation base. The average-costing plans in cluster 4 were divided into two equal groups. In the seventh iteration, 6 plans that use vehicle kilometers as the basis of allocation shifted to cluster 8, and 16 percent of the remaining variation was removed; however, this division of average-costing plans into separate clusters is not as significant as the initial segregation of these plans from the main body of data sets.

The last significant movement of data sets removed 17 percent of the remaining variation in the 10th iteration and resulted in the formation of cluster 11 by the removal of seven joint-costing plans from cluster 1. All of these plans used either assessed value (four plans) or employment (three plans) as the basis of external deficit allocation.

## CONCLUSIONS

This study has made a logical evaluation of the results of applying alternative deficit-allocation plans. Attention was focused on the homogeneity of allocation plans, given a greater amount of variation in results than anticipated. Analysis of the experiment results confirmed that the allocation plans examined were not homogeneous, but homogeneity did exist within the clusters generated. The final clusters and the process of forming these clusters revealed that certain allocation plans may introduce disparities into the process of allocating an operating deficit among participating communities. Given such a condition, it is important for transit administrators to understand the allocation process more clearly in order to foresee the implications of selecting an allocation plan.

The finding of primary interest is that the method preferred by the transit industry for allocating an operating deficit among user communities leads to results that are fairly distinct (nonhomogeneous) from other methods examined. The industry's preferred practice of performing only an external deficit allocation produced results significantly different from those allocation plans that first employed an internal allocation of operating costs in that all such plans were among the earliest to be removed from the main body of allocation plans (by the second iteration).

Another finding of interest concerns the industry's preferred method of calculating the unit cost of operation. The prevailing practice of averaging total costs over a descriptive operating characteristic (e.g., vehicle kilometers) was not included among those plans that demonstrated the greatest degree of homogeneity, as indicated by the bulk of the joint-costing plans that remained intact in clusters 1 through 10 iterations.

Figure 2. Movement of allocation plans for each iteration of the cluster-analysis program.

Allocation Plan Elements		Plan Number	Iteration <sup>a</sup>									
Costing Technique /Base	External Base		1	2	3	4	5	6	7	8	9	10
None	Population	1	→3									
None	Assessment	2	→3								→10	
None	Dwellings	3	→3									
None	Employment	4	→3	→4			→6					
None	Vehicle trips	5	→2			→5		→7				
None	Revenue	6	→3							→9		
None	Passengers	7	→3							→9	→10	
Average/Hours	Population	8		→4								
Average/Hours	Assessment	9		→4								
Average/Hours	Dwellings	10		→4								
Average/Hours	Employment	11		→4								
Average/Hours	Vehicle trips	12	→2					→5				
Average/Hours	Revenue	13		→4								
Average/Hours	Passengers	14		→4								
Average/Miles	Population	15		→4						→8		
Average/Miles	Assessment	16		→4						→8		
Average/Miles	Dwellings	17		→4						→8		
Average/Miles	Employment	18		→4						→8		
Average/Miles	Vehicle trips	19	→2			→5						
Average/Miles	Revenue	20		→4						→8		
Average/Miles	Passengers	21		→4						→8		
Joint/Hours	Population	22										
Joint/Hours	Assessment	23									→11	
Joint/Hours	Dwellings	24										
Joint/Hours	Employment	25									→11	
Joint/Hours	Vehicle trips	26	→2									
Joint/Hours	Revenue	27										
Joint/Hours	Passengers	28										
Joint/Miles	Population	29										
Joint/Miles	Assessment	30									→11	
Joint/Miles	Dwellings	31										
Joint/Miles	Employment	32									→11	
Joint/Miles	Vehicle trips	33	→2									
Joint/Miles	Revenue	34										
Joint/Miles	Passengers	35										
Joint/Passengers	Population	36										
Joint/Passengers	Assessment	37									→11	
Joint/Passengers	Dwellings	38										
Joint/Passengers	Employment	39									→11	
Joint/Passengers	Vehicle trips	40	→2									
Joint/Passengers	Revenue	41										
Joint/Passengers	Passengers	42										
Joint/Revenue	Population	43										
Joint/Revenue	Assessment	44									→11	
Joint/Revenue	Dwellings	45										
Joint/Revenue	Employment	46										
Joint/Revenue	Vehicle trips	47	→2									
Joint/Revenue	Revenue	48										
Joint/Revenue	Passengers	49										
Percentage of variation Removed			39	12	18	8	2	2	3	1	1	2
Percentage change			39	20	36	27	10	10	16	6	6	17

<sup>a</sup>Columns represent an iteration of the clustering program. Arrows indicate the movement of a plan between clusters while the numbers in the body of table identify the clusters involved. Plan numbers without movements remained in cluster 1.

Thus, inequities may exist in the use of a systemwide average cost in lieu of a more accurate determination of unit costs, where variable operating costs are assigned directly and then indirect costs, such as system overhead, are allocated by using an operating characteristic related to a route or segment of the system (i.e., joint costing as applied in this study).

These findings suggest the need for further study and evaluation of the transit industry's practice of applying only an external deficit-allocation plan and the use of a systemwide average cost per kilometer in decision-making situations, especially decisions involving changes in service levels such as adding, deleting, or extending a route.

In closing, a general observation about allocation should be noted. This study has contrasted two approaches for deficit allocation: a highly aggregated one, which allocated at the system level, and a more detailed one, which made allocations at the route level. In evaluating which approach to follow, note that the difficulty of application and the number of variables involved increases in moving from system-level to route-level allocation plans. But, at the same time, the relevancy and validity of the amounts assigned increases. Also, the amount of time, effort, and expense of administering the allocation process increases with the amount of detail required by the plan selected.

## REFERENCE

1. A. Thomas. The Allocation Problem in Financial Accounting Theory. American Accounting Assn., Evanston, IL, Studies in Accounting Research No. 3, 1969.  
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