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An Evaluation of the Procedures for Allocating Operating Deficits from Urban Transit Systems

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A POPULAR PREMISE of transit planners is that while urban transit systems are needed, they invariably result in operating losses. Cities continue to build and maintain transit facilities despite decreasing ridership and/or projected operating losses. This condition is obviously inconsistent with sound economic thinking where the fulfillment of a "need" is conditioned by the desirability and capability of paying for value.

The rationale of foregoing optimal resource allocation in developing transit systems comes from several directions. Sociologists advocate the development of central cities as a focus for cultural, institutional, commercial, recreational and economic activity. Environmentalists espouse the benefits of reduced air and noise pollution as well as the conservation of energy. And politicians, in the alleged interest of equity, promise to serve all of their constituents — a feat sometimes demonstrated by a transit system.

It is not the purpose of this paper to defend the need for economic analysis in planning urban transit systems. Not only is the literature satiated with this argument, but the energy crises has made self-supporting transit systems at best a dubious concept. And though there are those who will argue that operating losses an accounting, rather than in the economic measure (because of the social benefits of transit systems), such losses are a reality that must be allocated to political jurisdictions. The evidence is that the same avoidance of economic analysis in planning transit systems has been carried over into the problem of allocating operating losses. As discussed later in this paper, those cities which have already implemented deficit allocation procedures have minimized economic considerations.

This paper suggests several methods for allocating deficits of interjurisdictional bus service.[1] While not optimal in the pure economic sense, the procedures blend sound economics with political realities, and thus offer alternatives to the more simple, but uneconomical methods currently being utilized.

I. STATE OF THE ART

Theoretical models dealing with interjurisdictional deficits are virtually nonexistent in the economic literature. This void is probably due to two factors. First, many economists maintain that allocating joint costs cannot be done in a rational way.[2] Second, a political jurisdiction represents a geographic accounting unit rather than a functional economic unit.

The divergence between the analytical and political is exemplified by the interrelationships of jurisdictional transportation use. For instance, non-resident, bus and car riders in a city affect the revenue and cost of that city's bus service; furthermore, the ridership levels of one jurisdiction affect the demand in a neighboring jurisdiction. To quantify the total externality revenue or cost incurred for each jurisdiction is not as much an economic issue as it is a measurement problem. Also, although benefit and ability-to-pay theories deal with such issues as social wants and financial sources, the analytical unit is often restricted to an individual, or individuals, without specifying jurisdictional dimensions.

Despite the above limitations many bus cost (as opposed to deficit) models have been developed. They are mainly used for either explaining differentials in bus costs as related to different routes and/or systems, or for predicting the future costs for the same transit system. Almost all of the models found in the literature reflect some combination of the following factors affecting operating costs:[3]

Output Measures
Vehicle-miles
Vehicle-hours
Passenger revenue
[illegible]venue passengers

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Miles per hour
Minutes per mile

System Characteristics
Peak vehicles
Average fleet age
Average seats/bus
Scheduled speed
Ownership
Proportion of fleet purchased with capital grant
Wage rates

Environmental Factors
City age
Population density

There are two major categories of cost models: cost-causal and total cost. Cost-causal models are further divided into three categories: average daily cost, annual cost, and cost per bus-mile. Where there are some philosophical differences between the cost-causal categories, a major share of the difference is in the number of variables employed.

Cost-Causal Models

Average Daily Cost

The major purpose of the models within this category is to develop a general formula which allocates daily operating costs to the variables responsible for causing these costs. Three models presented in this category differ in only one respect — the number of variables considered. The two-variable model uses vehicle-miles and vehicle-hours as explanatory factors. The three-variable model adds passenger revenue and the four-variable model uses both passenger revenue and peak vehicles.

Generally, standard costs can be related to either vehicle-miles or vehicle-hours. Even accident costs are essentially a function of exposure and could be included in the allocation. In fact, passenger revenue is also used as a cost-causal measure. Still, there are many individual expense items which do not vary with miles, hours, or passenger revenue; these are allocated on the basis of peak-hour vehicle needs.

Using fiscal year 1965 MTA (Metropolitan Dade County Transit Authority) data, the following results were obtained by Ferreri (Footnote 3) when each operating expense item was allocated to its appropriate cost-causal factor.

Causal Factor	Percent of Total Cost
Vehicle-hours	54.3%
Vehicle-miles	27.9
Peak vehicles	10.5
Passenger revenue	7.3
Total	100.0%

Ferreri used all three of the daily cost models in calculating the costs of MTA operations. The results indicated a close agreement among the three models — a conclusion expected because more than 80 percent of the costs are attributable to vehicle miles (28%) and vehicle hours (54%) under all of the models.

In equation form, all three of the daily cost models take a linear form as follows:

$$C = aM + bH$$
$$C = aM + bH + cR$$
$$C = aM = bH = cR + dV$$

where C = average daily cost of route
M = average daily vehicle-miles of service on route
H = average daily vehicle-hours of service on route
R = average daily passenger revenue on route
V = peak vehicle needs on route

The parameters of a, b, c and d are the unit cost calculated from various accounting cost items for any single year:

a = cents per vehicle-mile
b = dollars per vehicle-hour
c = percent of passenger revenue (costs related to passenger revenue expressed as percent of revenue)
d = dollars per vehicle

It should be noted that either the three or four-variable cost model is not completely independent of what happens on the revenue side. Cost allocation would be responsive, though not too sensitive, to changes in future revenue, depending upon both estimated ridership and fares.

Annual Cost

As with the daily models, there are three basic types of annual cost models as shown below:

Annual Cost (c) Models

Factor	Two-variable Regression Model	Four-variable Unit-cost Model	Four-variable Regression Model
Vehicle-miles (M)	X	X	X
Vehicle-hours (H)	X	X	X
Peak Vehicles (V)		X	X
Revenue Passengers (P)		X	X

Annual cost models have many similarities to daily models. Issues addressed and general philosophy are the same and a linear equation form is assumed for both types of models. Also, while the annual models determine costs on a yearly basis instead of a daily calculation, this difference is insignificant for purposes of multi-jurisdictional allocations. Finally, the daily cost, two-variable model and the annual cost, two-variable regression model use the same cost-causal factors (vehicle-miles and vehicle-hours).

The differences in the two types of models are as follows:

— parameters are estimated on a unit-cost basis in the daily cost models and by regression analysis in the annual cost models (with the exception of one four-variable model)

— the four-variable unit cost or regression models uses number of passengers instead of passenger revenue which is employed in the daily cost four-variable model

— advertising expenses are related to vehicle-miles in the annual cost models; they are assigned on the basis of peak-hour vehicle needs in the daily cost models, and

— for estimating parameters and using the models, time series data are required for the regression model, while the unit cost model only needs a single year's data.

The two-variable regression model has been implemented with the MTA data and a regression coefficient (R^2) of 99.5 was obtained. The four-variable unit cost model was tested against 1970 data from D.C. Transit System and Pittsburgh (Pa.) Skybus. When the resulting D.C. equation was used to predict 1990 costs, the error came within five percent of an estimate obtained from detailed engineering cost studies. Based on 1970 Pittsburgh Skybus data, the model predicted 1980 costs within three percent.

The four-variable regression model has been calibrated from three sets of data with the following results in terms of R^2:

Property	R^2
D.C. Transit System, Inc.	.9966
New York City Transit Authority	1.0000
American Transit Association's sample of 69 firms	0.52

Although the model explains 99.66 percent of the variation in actual costs for D.C. Transit, it underestimated future costs by 68.8 percent when applied to planned operating characteristics of the same system. On the basis of explanatory ability, the four-variable regression model is obviously superior for time-series data, but not suitable for cross-sectional data. The model only explained 52 percent of the variation in 69 firms' costs. For this reason, it was rejected for D.C. Transit. Furthermore, the model is incapable of explaining variations in costs from cross-sectional data.

Cost Per Bus-Mile

The primary purpose of bus-mile models is to explain variations in unit costs (e.g., bus operating cost per bus-mile) instead of daily or annual total operating costs. Two such models are presented in this category: the so-called Slowness Model and the Urban Environmental Cost Model.

The Slowness Model is based on the premise that the two most important determinants of bus operating costs are vehicle-hours and vehicle-miles operated. These two factors can be further combined into one ratio variable called "slowness" (S), which is vehicle-hours divided by vehicle-miles, thus measuring speed in minutes per mile. All other factors such as peak-vehicle needs are but a function of this slowness variable; hence, they can be dropped in the formulation of the model. The final form of this model becomes:

$$\frac{C}{M} = a + b \cdot S$$

Applications of the slowness model are many and the results vary.[4] The model explained 98.88 percent of the variation in cost when implemented with line-by-line data for the New York City Transit Authority, while explaining only 45 percent of the variation using data from the Miami Transit Authority. The advantage of the slowness model is its simplicity in terms of the structure and data requirements. It often does a poor job of predicting. Apparently, the single slowness variable is not a good indicator of all other cost-causal factors. The model is not suitable for general application. It appears that the model can only be calibrated from data on individual routes of a single transit system at one point in time.

The Urban Environmental Cost Model attempts, again, to explain the wide range in bus operating cost per mile although the philosophy underlying this model is somewhat different than the slowness model. Since managerial efficiency alone can not explain variations in unit costs among firms, the assumption here is that the cost is more directly related to environmental operating context. The urban environment factors selected for calibration include the age of a city, labor costs, scheduled speed, population density and the age of the fleet. Generally, only the first three variables are statistically significant; the last two are either inaccurate or inappropriate.

Total Cost Model

The total cost model was developed by Gary R. Nelson in a study for the Department of Transportation (DOT),[5] whose purpose was to construct an econometric model of the urban bus transit market, consisting of a demand equation, a supply function, a cost/revenue ratio and an identity. The model incorporated transit regulation. Three issues were central to the model

1. Are there economies of scale for large firms?
2. What is the impact of wage rates on the cost of bus transit?
3. What are the effects of bus fleet characteristics on costs?

The model has a complicated form involving seven explanatory variables, some in logarithmic form, and some in absolute terms, as follows:

$$\ln C = a_0 + a_1 \ln M = a_2 \ln W + a_3 \ln \frac{M}{H} + a_4 \cdot A + a_5 \cdot S + a_6 \cdot O + a_7 G$$

where

- C = total costs
- M = bus-miles
- W = hourly wage rate of operating personnel
- $\frac{M}{H}$ = bus-miles per bus hour
- A = average age of fleet
- S = average seats per bus
- O = form of ownership (dummy variable):
  - 1 = publicly owned
  - 0 = otherwise
- G = proportion of fleet purchased with capital grant

The model was implemented with the data from two samples of 45 bus firms in 1960 and 40 bus firms in 1968, as supplied to the American Transit Association. Empirical evidence suggests that neither economies nor diseconomies of scale exist, but rather a constant cost per bus-mile. An increase of bus-miles by one percent will increase total costs by 1.013 or .982 percent — not significantly far from one percent. Also, minor differences in unit costs observed between small and large firms are explained by differences in wage rates. Differences in fleet ages have a rather weak effect on total costs. Apparently, lower maintenance costs required by newer buses are offset by higher interest and depreciation costs.

II. DEFICIT ALLOCATION PROCEDURES CURRENTLY IN USE BY REGIONAL BUS AUTHORITIES

There are two broadly-defined procedures for allocating transit deficits among political jurisdictions: models that allocate costs and revenues separately, and (2) models that allocate the deficit (known as gross net cost) of the entire bus operation. Although the same variables can be applied in either procedure, there is a basic philosophical difference between the two categories of models. Separate cost/revenue (C/R) models implicitly recognize the need of economic incentives for individual political units and do not assume a deficit for each jurisdiction. On the other hand, gross net cost (GNC) models assume a loss for all parties as part of the payment for enjoying indirect (including non-user) benefits. Jurisdictional characteristics are sometimes recognized in deficit models, but only after the system deficit has been calculated. In the C/R models, jurisdictional differences affect both the cost and revenue allocations.

An examination of the methods used by various cities to allocate deficits discloses an overwhelming preference for the GNC approach. The most common apportionment authorizes a uniform rate of dedicated taxation in the area served by the transit agency. Within this principle there are many variations. Sales, property, payroll and tobacco taxes are all used. Sometimes the sales tax applies only to gasoline. Sometimes the property-related tax is actually a tax on mortgage transfers. The flat tax rate procedure grants no credits nor debits for actual revenue or expenses and leaves to negotiation the service levels to be provided by the transit agencies.

Another type of GNC procedure is to employ operating and/or socio-economic factors to reach an apportionment that is recognized by the participants as "equitable." In practice, the transit deficit is sometimes apportioned among the jurisdictions on the basis on their relative property assessment. Sometimes, population is substituted for assessment. Operating factors which have been used are the relative miles of route (Boston) and passenger miles (Philadelphia).

The C/R procedure is used only in instances where a multi-jurisdictional transit agency provides services outside the area of its supporting jurisdictions. Frequently, the supporting jurisdictions require by statute that these outside services must be fully compensatory. In at least one instance the contribution to profit or deficit of these outside operations is ignored. Outside services are usually performed and compensated under the terms of a service contract. In another instance specific costs are picked up by the jurisdiction receiving the services generated by the cost. Specifically, local security forces and local station maintenance are paid directly by the benefiting jurisdictions.

Probably the major point of commonality among the allocating procedures is the lack of economic criteria supporting their justifications. Granted that in certain cities bus fares are set in order to increase ridership, irrespective of the accounting loss, but the allocation systems generally have no objectives such as increased ridership or reducing excess capacity. The lack of objectives leads to the conclusion that implicitly, transit authorities ignore the relationships between bus fares, the physical allocation of buses, and the allocation of operating deficits. As a result (at least partially), operating deficits continue to increase. In Boston, where deficits reach record highs annually, recommendations from management consultants to set budget goals for each political jurisdiction, with an accompanying reward and penalty system, have been ignored by legislators.

III. DEVELOPING THE ALTERNATIVES

The problems of constructing a deficit allocation formula center around the variables to include and the weight to give to each. A suggested embarkation point is to identify and evaluate cost causal, passenger utilization and socio-economic factors without regard to weighting. Once the impact of each variable on every jurisdiction served by the transit system is known, the political forces will compromise on an agreed weighting system. This was precisely the method employed in a recent study undertaken for the Washington, D.C., Area Metropolitan Transit Authority.[6]

Prior to constructing alternative variables for possible use in the allocation formula, attention focussed on evaluation criteria. After numerous meetings with local political representatives, their technical staff and the transit authority, evaluation criteria were generalized as follows:

Incentives
- —increase ridership
- —reduce excess capacity

Practicality
- —politically acceptable
- —present availability of data

Administrative Effectiveness and Efficiency
- —ease of calculation
- —simplicity
- —cost including data collection

Other Economic Considerations
- —focus on peak/off-peak issue
- —sensitivity to service levels, passenger use and fare changes

In essence, the optimal allocation formula would provide the same kinds of economic incentives expected of the fare structure and service policies (economic efficiency), would be equitable in the minds of each participating jurisdiction, would be relatively easy to understand and administer, and would address certain specific economic problems such as off-peak cost and service changes. No particular weights were assigned to any of the criteria measures as the costs of avoiding any of the measures were not readily available.

A list of alternative allocation variables was constructed and evaluated in terms of the above criteria. The allocation variables fell under three major headings: (1) levels of service, or capacity — obviously made up of cost-causal factors (2) use measures, which not only contain cost elements, but also ratios of passenger use to service availability, and (3) socio-economic factors, which include general benefits and ability-to-pay measures.

The allocation variables were then evaluated in terms of the established criteria and given a rating from one (1.0) for excellent to five (5.0) for inadequate. As shown in Table I, these ratings were for each variable assuming that they would be used individually in a GNC allocation (as opposed to cost/revenue) formula. A number of observations resulting from Table I are of import to the start of the art as well as for future implementation of similar allocation procedures.

— With the exception of several utilization ratios, none of the variables induce an increase in ridership because an increase in those variables also mean an increase in cost. The cost may not be offset by the benefits because in a deficit model benefits attributable to one jurisdiction are shared by all jurisdictions. Thus, the only variables inducing an increase in ridership are such utilization factors as passenger per resident, bus rider per commuter, etc. This is not true for C/R models where revenue allocations can provide efficiency incentives.

— The capacity variables of bus miles (or seat miles) and bus hours are the only such measures which provide incentives for economic efficiency, but their effectiveness is a function of the inclusion of utilization standards in a GNC formula.

— Because the mileage related variables (bus-miles, seat-miles and passenger-miles) are both used in other cities and easily understood by political representatives, other capacity, use and/or socio-economic factors are accompanied by a more difficult acceptance level.

— Data for most capacity and socio-economic factors are readily available, but such is not the case for measure-of use data. Also, use elements are characterized by definitional problems.

— With the exception of passenger miles, no one measure is solely sensitive to changes in fares and service.

In conclusion, no single variable provides an effective deficit allocation meas-

EVALUATION OF VARIABLES FOR A GNC ALLOCATION

KEY
1 - EXCELLENT
2 - GOOD
3 - FAIR
4 - POOR
5 - INADEQUATE

Variable	Incentives		Practicality			Present Availability Of Data (6)	Administrative Effectiveness and Efficiency		
	Increase Ridership (1)	Reduce Excess Capacity (2)	Politically Acceptable (3)	Peak/Off Peak Focus (4)	Production Efficiency (5)		Ease Of Calculation (7)	Simplicity (8)	Cost (Including Data Collection) (9)
A. LEVELS OF SERVICE (Capacity)									
1. Bus-Miles	4	1	1	4	2	2	1	1	2
2. Bus-Hours In Revenue Service	4	1	2	4	1	2	1	1	2
3. Miles Of Route	4	4	4	5	5	1	1	1	1
4. Number Of Bus Stops	4	4	5	5	5	1	1	1	1
5. Number Of Buses	5	3	5	5	5	1	1	1	1
6. Peak-Hour Buses At Origin Locale	5	3	5	2	3	1	1	1	1
7. Seat-Miles	4	1	1	5	2	2	1	1	2
B. MEASURES OF USE									
1. Passenger Miles	4	3	1	4	1	4	1	1	4
2. Number Of Passengers	4	5	5	4	4	3	1	1	3
3. Passengers Per Residents	1	5	4	4	4	3	2	3	3
4. Passengers Per Commuters	1	5	3	4	4	4	2	3	4
5. Passengers Per Commuters Close To Service	1	5	3	4	4	4	2	3	4
C. SOCIO-ECONOMIC FACTORS									
1. Number Of Residents	5	5	2	5	5	2	1	1	1
2. Adult Population	5	5	3	5	5	2	1	1	1
3. Number Of Commuters	5	5	5	5	5	3	1	1	4
4. Business Activity (Retail Sales)	5	5	4	5	5	3	1	1	3
5. Employment	5	5	4	5	5	2	1	1	2
6. Incomes	5	5	4	5	5	2	1	1	2
7. Real Estate Tax Assessments	5	5	3	5	5	1	1	1	1
8. Area (Square Miles	5	5	3	5	5	1	1	1	1

TABLE I

ure. Even if passenger miles were used, no consideration is provided for the number of buses carrying those passengers over the designated miles, the time in service, or the corresponding revenues generated. Thus, at a minimum, a deficit model should include bus miles and bus hours as cost-causal factors and some measure of passenger utilization.

At this time, a tangential point should be noted concerning Table I. Quality-of-service measures were excluded from consideration.[7] A number of quality considerations are built into other variables in the levels-of-service category. Also, those quality variables not within the capacity measures are generally outside the control of jurisdictions (reliability), are often vague (comfort), and change so frequently that their measurement is obsolete upon completion (transit-to-auto-time ratio). Another factor is that if better quality of service were to result in a higher share of the deficit, then an incentive would be provided to lower the quality of service. On the other hand, if superior quality meant a lower share of the deficit, individual jurisdictions would be subject to paying relatively higher costs for relatively inferior service. Finally, quality of service is somewhat reflected in fares and ultimately in passenger use, and this is accounted for in some of the variables under the measures-of-use heading.

In order to overcome the shortcomings of evaluating potential formula variables separately, as well as for the intention of examining C/R formulae, Table II was constructed. As indicated in Table II, the most effective model appears to be the so-called "direct incentive" formula where costs and revenues are calculated for each individual route; allocations are based on different criterion depending on how the routes are classified. For instance, closed-door commuter routes result in the entire route cost and revenue being assigned to the jurisdiction served; thus, a closed-door Maryland commuter bus (i.e., no pick-ups other than in Maryland) destined for D.C. would be characterized by all bus-mile and bus-hour costs of that operation being assigned to Maryland, as well as total revenues. On the return trip, while all fares would be collected in D.C., since all passengers would depart in Maryland, Maryland again gets all of the costs and revenues. Thus, the closed-door commuter bus would be treated like a local operation with all costs and revenues attributed to one jurisdiction. For other types of routes, allocations would be based largely on the purpose of the trip. In essence, the direct incentive formula is nothing more than declaring each route a profit center. But as shown in Table II, the overwhelming roadblock to a practical implementation of such a formula is that revenue data is neither available on a route-by-route basis, nor is it easy and inexpensive to collect; furthermore, the reliability of such data is dubious at best. And finally, the formula is unlikely to be politically acceptable because of its sophistication (e.g., the impact of the formula is difficult for politicians to understand and explain to their constituents) and fragmentation of a service which is thought to be regional in nature.

The unavailability of data, at least in a reliable form, is probably the significant roadblock to implementing a C/R formula. Data availability is inversely related to the comprehensiveness of allocation formulae. Socio-economic measures are readily available as are level-of-service measures — especially bus-miles and bus-hours. Use measures are more difficult to acquire; passenger-mile data requires on-and-off surveys and such ratios as passenger per resident and/or commuter are controversial from a definitional point of view. Finally, revenue data are difficult to come by as collected fares are not generally segregated by jurisdictional classifications.

Before several allocation formulae are presented as being candidates for practical acceptance, one further caveat should be stressed. The issue of allocating the cost of off-peak service was eventually avoided in the D.C. study, although not initially ignored. There are two diametrically opposed ways to view the cost of excess capacity caused by peak service. If one assumes that the bus system is geared to operate at off-peak levels, then the cost of excess capacity could be assigned to the heavy-peak jurisdictions. In fact the entire deficit could be assigned to suburban communities largely responsible for peak volumes. On the other hand, if one believes that the major purpose of the bus system is to serve the commuter, then penalizing the bordering jurisdictions would undermine the objective of the system. Because of this controversy, in the D.C. study the off-peak costs were ignored thereby implicitly assigning them to jurisdictions in proportion to other cost allocations.

Given the myriad of limitations previously discussed, two formulae stood out in the D.C. study as containing high probabilities for potential political acceptance, while at the same time addressing some of the major economic issues —e.g., increasing ridership and reducing excess capacity. One procedure, a suggested C/R formula, utilizes the open-door, closed-door separation of the "direct incentive" formula previously discussed, but uses revenue inputs which are more easily collected than on an individual route basis. As before, the bus-mile and bus-hour costs of closed-door operations, as well as a portion of fixed costs and total collected fares, are all assigned to the jurisdiction being served by the service (i.e., the suburb for closed-door commuter service. For open-door service, variable costs are allocated to jurisdictions based on their relative share of bus-miles and bus-hours, while fixed costs are assigned to a socio-economic factor(s) like population—reflecting at least some benefits to the entire metropolitan community from a regional bus service. Revenues are allocated to the boarding jurisdiction. The

EVALUATION OF C/R MODELS

Model Description	General Explanation: Costs	General Explanation: Revenues	Impact	Incentives: Increase Ridership (1)	Incentives: Reduce Excess Capacity (2)	Practicality: Politically Acceptable (3)	Practicality: Peak/Off Peak Focus (4)	Practicality: Production Efficiency (5)	Present Availability Of Data (6)	Administrative Effectiveness and Efficiency: Ease Of Calculation (7)	Administrative Effectiveness and Efficiency: Simplicity (8)	Administrative Effectiveness and Efficiency: Cost (Including Data Collection) (9)
A. GEOGRAPHIC ALLOCATION												
1. Use	-Variable costs allocated to bus-miles and bus-hours. -Fixed costs allocated on relationship of variable costs.	Allocated to boarding jurisdiction.	On a round trip, each jurisdiction receives 50 percent of the revenue, but the costs are allocated to where the miles and time are experienced.	3	1	3	4	1	4	1	1	3
2. Use And Benefits	-Variable costs allocated to bus-miles and bus-hours. -Fixed costs allocated by general benefits (i.e., population, etc., basis).	Allocated to boarding jurisdiction.	Same as above, but each jurisdiction pays at least some costs for the availability of the system.	3	1	2	4	1	4	1	2	4
3. Use And Benefits By Residence	-Variable costs allocated to bus-miles and bus-hours. -Fixed costs allocated on either of above two methods.	Allocated to passengers' residential jurisdiction. This proceedure does not deal with bus riders who live outside of the WMATA jurisdiction.	The jurisdictions with driver-bus riders will get revenues for certain routes without incurring the costs.	3	1	4	4	1	4	1	2	4
B. DIRECT INCENTIVE												
	-Individual routes and services designated by purpose. a. Closed-door commuter b. Local c. Inter-jurisdictional d. Charter e. Contract (i.e., Reston, Federal Government contracts, etc.).		Each individual route and/or service will realize a profit or loss by its own performance irrespective of the aggregate deficit.	1	1	3	4	1	5	3	3	4
C. PEAK-OFF PEAK ALLOCATION (This is really a variable, rather than a model).												
	-All costs separated by bus-mile, bus-hour and peak-hour categories.	-Revenues allocated by any of above methods.	The suburbs will incur a relatively greater share of the costs (compared with geographic allocations) because of the costing for peak usage. This method can be used in concert with either the geographic or direct incentive models.	Rating depends on which of the above models are used in conjunction with peak-hour variable.			1	Rating depends on which of the above models are used in conjunction with peak-hour variable.				

KEY
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4 - POOR
5 - INADEQUATE

TABLE II

slight bias of the suggested C/R model is that on certain open-door routes, one jurisdiction will be burdened with the majority of cost, but will receive only half the revenue (assuming a round trip). This bias is minimized by the separation of variable and fixed costs as well as the separation of open and closed-door service. The liabilities of the bias are thought to be less than the cost of obtaining revenue data for other allocation methods.

A GNC model which goes beyond the popular tax-base allocations used by other cities is one which adopts cost (bus-mile and bus-hour), passenger utilization (jurisdictional boarders as a percentage of commuters), and general benefit (population) measures. While the weights given to each of the measures is a chore to be worked out by the political process, an order of magnitude which has warranted further discussion in the D.C. study is as follows:

Deficit Percentage	Allocation
60%	—bus-miles and bus-hours
20	—1-passenger utilization rate
20	—population
100%	

In essence, the above allocation recognizes the two major cost causal elements of bus service, rewards jurisdictions for the efficient use of service, and recognizes that the population at large benefits from the existence of multi-jurisdictional bus service. While not placing the same level of stress on jurisdictional efficiency as the C/R allocation, the GNC model addresses the efficiency issue and has an apparent overriding attribute; it assumes the bus (or transit) system to be regional not only in its operation, but also in its cost and revenue sharing. This latter point, along with simplicity, appears to have been the major argument behind the adoption of GNC models by the numerous cities having deficit transit systems. Letting the pricing structure and bus assignment criteria handle efficiency incentives, GNC models reflect a growing trend of aligning economic systems (e.g., transit) with geographic and political jurisdictions.

REFERENCES

1 Although geared to bus systems, the general concepts of this article also apply to transit systems in general.

2 R. L. Weil, Jr., "Allocating Joint Costs," The American Economic Review, December, 1968, p. 1342.

3 For a detailed discussion of these factors see Michael G. Ferreri, "Development of a Transit Cost Allocation Formula," Highway Research Record, No. 285, 1969.

4 For a discussion of the varying results in different geographic areas, see James H. Miller and John C. Rea, "Comparison of Cost Models for Urban Transit," Highway Research Record, No. 435, 1973.

5 Economic Characteristics of the Urban Public Transportation Industry, United States Government Printing Office, Washington, D.C., February, 1972.

6 The discussion that follows mainly results from a study directed by Dr. Levine as a Senior Economist for R. L. Banks & Associates, Inc., together with URS/Coverdale & Colpitts, Inc. The study was initiated in 1973 and dealt with the allocation of operating deficits from the Metrobus system.

7 Quality-of-service measures include accessibility (number of residents living close to bus stops), connectivity (integration into overall transit system), transit-to-auto-time ratio, reliability (ratio of on-time hours to total hours of service), comfort (ratio of sitting passengers to total passengers) and frequency of service (number of buses per route).