21. J. Supernak. Travel-Time Budget: A Critique. In Transportation Research Record 879, TRB, National Research Council, Washington, D.C., 1982, pp. 15-28.
22. W.B. Tye, L. Sherman, M. Kinnucan, D. Nelson, and T. Tardiff. Application of Disaggregate Travel Demand Models. NCHRP Report 253. TRB, National Research Council, Washington, D.C., Dec. 1982.
23. W. Brög, F. Häberle, and K. Ribbeck. Mobility of Persons Who Need Nursing and Who Live at Home. In Transportation Research Record 830, TRB, National Research Council, Washington, D.C., 1981, pp. 1-7.

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Estimating the Cost of Providing Transportation Services to Elderly Clients

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ABSTRACT

The purpose of this paper is to help individuals and organizations engaged in the provision of transportation services to the transportation disadvantaged better understand and control the cost of those services. Presented is the "parametric cost estimation methodology," which resulted from a study conducted by the Institute for Economics and Social Measurement, Inc., and Ecosometrics, Inc., for the U.S. Department of Health and Human Services, Administration on Aging. In this study methodologies were developed for assessing the costs of both transportation and in-home services provided to elderly clients under Title III of the Older Americans Act. The study produced (a) a research report summarizing the application of the resource-based cost methodology that was developed for these two studies and (b) a cost assessment manual for use by local service providers. Data used to develop the cost methodology were collected from in-depth interviews with all transportation service providers in 16 randomly selected planning and service areas across the United States (a total of 49 providers were included in the sample). Providers were contacted in person for information on factors such as the basic costs of resources, the amount of resources required to produce services, service specifications, and consumption patterns and rates. From the data, parametric cost formulas were developed that relate resources used with services produced and consumed. A brief overview of the results of the research and of how to use the methodology to construct and analyze the true cost of operating transportation services is presented.

The issue of how to achieve the greatest level of program effectiveness within available resources has always been of paramount concern for service providers who find themselves operating within limited budgets. In recent years this issue has become even more critical for providers of transportation services to the disadvantaged as budgets have been cut and the cost of services has been rising. Complicating the challenge of providing cost-efficient services is the severe lack of knowledge about the actual cost of providing services and the specific factors that create substantial differences in cost from area to area or organization to organization.

Selected results of a 3-year research project, conducted by Ecosometrics, Inc., and the Institute for Economic and Social Measurements, Inc., for the U.S. Department of Health and Human Services, Administration on Aging, are presented. Although the primary purpose of these studies was to examine the difference in the cost of services to elderly clients in urban and rural areas, one of the major products of the studies is a cost estimation methodology that can be used by local service providers to estimate current or future service costs. A simpler version of the methodology applied to secondary data on transportation services was applied to secondary data in a previous phase of the study (1). The development of this new approach to cost measurement was precipitated by the realization that generally available cost estimation methodologies and previous

studies of costs have severe limitations resulting from problems of inadequate or nonuniform record keeping, lack of uniformity across service providers in terms of service and accounting definitions, failure to include all relevant costs, and lack of control for service quality (2). The limitations of this previous work, coupled with the recent reductions in governmental spending on social services, highlight the need for more complete, accurate, and simple ways to calculate the cost of services. The methodology presented here is intended to fill this gap.

The research project referred to previously resulted in both a research report describing the results of applying this resource-based cost methodology to transportation and in-home services (3) and a cost assessment manual that enables service providers to apply this methodology (4). A brief overview of both the research results and the manual is presented here. It is intended that a service provider be able to use the information in this paper to roughly estimate costs. First, cost models, which can be applied by local agencies to their situations, are presented. Second, instructions for applying the models are presented, and, finally, results of the analysis of unit costs are included. In the event that an agency is missing information on a particular cost element (e.g., administrative rates, fuel costs), average or "default" values are presented. Note that "default" cost figures presented in the tables were developed by (a) computing the average value for data on all applicable providers, (b) eliminating providers with unusually high or low values (more than one standard deviation away), and (c) recalculating to get a new "average." If more in-depth costs or more detailed instructions are required, the reader should refer directly to the manual for step-by-step instructions on calculating disaggregated costs.

DATA USED TO DEVELOP COST MODELS

The data used to develop the parametric cost models were collected in in-depth personal interviews with 49 transportation service providers nationwide. In conjunction with the University of Michigan, a sample of 16 planning and service areas (PSAs) was prepared (a number sufficient to provide data on site characteristics and to apply the cost analysis methodology). The sample was stratified to represent those characteristics of the service setting or provider that were anticipated to affect costs. Providers in the sample varied by the urban or rural nature of their service area, geographic location, agency base, type of organization, and quality of service provided (3). [Quality of service was defined by a set of performance measures and program attributes. Service provided by each provider was rated relative to the sample as a whole by using standardized scores (z scores).]

All transportation service providers derived some portion of their funds from Title III of the Older American Act of 1965, as amended. The transportation services typically were provided by human service organizations, usually private nonprofit or public social service agencies. The scale of operation was rather modest, with a median vehicle fleet size of three vehicles. The service generally was provided on an advanced reservation basis, either through telephone reservations or by signing up at meal sites or other service centers. Passengers were either picked up at their homes and taken to destinations (door-to-door service) or transported in groups. A list of trip priorities was often employed to provide some controls on the demand for trips.

BASIC FEATURES OF A COMPLETE RESOURCE-BASED COST METHODOLOGY

The comprehensive cost analysis framework used in this paper examines transportation service costs in terms of three dimensions: the service being costed in terms of requisite activities and functions, the resources necessary to provide the service, and the costs of the resources. This approach develops service costs in terms of the actual amount of resources needed to deliver a service unit and the costs of those resources as determined by a particular setting. Because this approach works by combining detailed individual cost elements, called parameters, the overall costing methodology is known as "parametric cost modeling." It can be used to estimate the unit cost of a service using simple equations.

To perform a complete resource-based cost analysis, it is necessary to

1. Specify the services in their most basic components (e.g., as institutional arrangements, client characteristics, service characteristics, developmental phase of the service) to ensure that like services are being analyzed;
2. Specify the functions or activities (e.g., administration or direct service provision) that lead to the expenditure and use of resources such as personnel, equipment, buildings, and materials;
3. Specify the amount of each type of resource that is required (e.g., the number of gallons of fuel needed per mile of service); and
4. Assign costs or values to all resources used on the basis of current resource prices, contractual or other agreements including estimated costs of volunteer or donated labor and donated or in-kind equipment, materials, and buildings.

The approach also allows an agency to track the effect on service costs of current resource prices and to study the effect of assuming different prices for each type of resource used.

TRANSPORTATION COST MODELS

The parametric cost models that were developed in this research are tools with which to estimate transportation unit costs. The relatively simple equations that follow were used to estimate and compare the cost of providing transportation services in a variety of situations by a variety of types of organization. These equations can be used along with the data presented in the tables to make such estimates and comparisons of transportation costs. The subsequent section presents instructions for using the equations.

USE OF COST MODELS

The total cost of transportation services is computed by first adding service operating costs to the cost of administering the transportation program. Transportation-specific capital costs are then added in, as is the cost of general agency administration that is allocated to the service. Both administrative cost categories are expressed as ratios of administrative costs to program or operating costs. Separate equations are specified in subsequent sections for each of the variables. This relationship can be written as the following equation:

Total transportation costs = [(Transportation operating cost) (Transportation administrative expense rate + 1) + (Transportation capital costs)] (Agency administrative expense rate + 1).

The cost elements have been grouped in three major cost categories: (a) operating costs, (b) capital costs, and (c) administrative costs. Operating costs are those expenses incurred in actual transportation operations. Capital costs represent expenses for office equipment and vehicle depreciation and interest (it has been assumed that all other capital equipment or facilities are rented). Administrative costs are those expenses incurred to administer the overall agency function and, more specifically, to administer transportation services.

Administrative Costs

Two categories of administrative expense rates were developed: a general agency administrative expense rate and a transportation administrative expense rate. The general administrative expense rate includes the cost of general agency functions such as accounting, agency management, and grant proposal writing. The transportation administrative expense rate includes the cost of transportation management functions. Both rates are expressed as ratios of the administrative costs in each category to program costs. Both rates include labor (wages and fringe benefits), office space (rent and other space costs), office equipment costs, and other administrative expenses (telephone, postage, supplies, and other). All costs are included as actual dollar values. Discussions of the two administrative rate categories follow (explanations of how to compute the four cost components included in each rate are included in the complete manual and research report).

General Administrative Expense Rate

The general agency administrative expense rate is computed as the ratio of the total general agency administrative costs divided by the total of all agency program costs:

General administrative expense rate = General administrative costs/All agency program costs.

The denominator of the ratio can either be taken directly from agency records or can be computed by taking the total agency budget minus the general administrative costs in the numerator. The numerator of the ratio includes all cost elements cited previously. Cost formulas are presented in the manual for each of the four administrative cost elements (labor, space, office equipment, other costs) and can be used in a building-block (additive) format; that is, the results of the four formulas can be added to calculate total general administrative costs.

General administrative expense rates average about 21.5 percent and do not vary considerably between urban and rural areas, even with higher labor costs and rent per square feet in urban areas. Table 1 gives a summary of general administrative rates for each area. General administrative expense rates do vary by the type of agency. General administrative expense rates for public agencies were 43 percent greater than rates for private nonprofit organizations. Single-purpose agencies and independent units with a central planning unit have higher general administrative expense rates than do agencies in which transportation services are part of a consolidated multipurpose agency. Aging services agencies have higher rates than community action agencies, governmental agencies, or senior centers. (Aging service organizations include some Area Agencies on Aging but are primarily private nonprofit agencies that exclusively serve the elderly population.) Table 2 gives a summary of administrative rates by agency type.

TABLE 1 General Administrative Expense Rates in Urban and Rural Areas

Area	General Administrative Expense Rates (%)	
Rural		
Average-cost areas (n = 14)	22.1	21.9
High-cost areas (n = 7)	21.3	
Urban		
Average-cost areas (n = 9)	22.2	21.2
High-cost areas (n = 5)	11.9	

TABLE 2 Summary of Administrative Expense Rates by Agency Type

	General Administrative Expense Rate (%)	Transportation Administration Expense Rate (%)
Organization		
Private nonprofit (n = 35)	19.0	35.6
Public (n = 11)	27.1	31.3
Management		
Single-purpose agency (n = 11)	25.3	33.8
Independent unit with central planning unit (n = 6)	29.0	30.0
Part of consolidated multipurpose agency (n = 29)	17.4	33.3
Agency		
Aging services (n = 13)	31.0	31.1
Community action (n = 9)	25.7	28.3
Government (n = 6)	18.5	45.2
Senior center (n = 12)	13.0	37.8
Average	21.5	35.1

Transportation Administrative Expense Rate

The transportation administrative expense rate is computed as the ratio of transportation administrative costs divided by transportation operating costs:

Transportation administrative expense rate = Transportation administrative costs/Transportation operating costs.

The denominator of the ratio is computed on the basis of the operating cost equation and the parameters established in the next section. The numerator of the ratio includes the same administrative cost elements that are included in the general administrative expense rate, with the exception that these particular costs are directly attributable to the administration of the transportation program. As with the general administrative costs, simple formulas were developed for each of the four cost elements (labor, space, office equipment, other costs) and the results of these four formulas can be added to arrive at total transportation administrative costs.

Transportation administrative expense rates average around 35.2 percent. Although they are not highly correlated with the urban or rural nature of

an area, transportation administrative expense rates are slightly higher in urban areas. Even though both wages and rents per square foot are higher in urban areas, transportation administrative expense rates are greater in high-cost rural areas and average-cost urban areas. Table 3 gives a summary of transportation administrative expense rates.

TABLE 3 Transportation Administrative Rates in Urban and Rural Areas

Area	Transportation Administrative Expense Rate (%)	
Rural		
Average-cost areas (n = 14)	25.4	31.1
High-cost areas (n = 8)	41.0	
Urban		
Average-cost areas (n = 15)	43.5	39.4
High-cost areas (n = 6)	29.2	

Transportation administrative expense rates do vary depending on the type of agency operating the service. Table 2 gave a summary of administrative expense rates by agency type. Transportation administrative expense rates are comparable for private nonprofit and public agencies and for various management types. Governmental agencies and senior centers have higher transportation administrative expense rates than do aging services or community action agencies. Because the reverse is true for general administrative expense rates, it may be that a trade-off is made in agencies between what is called transportation administration and what is called general administration.

Space does not permit the presentation of results and information with which to calculate the general administrative rate and transportation administrative rate for the reader's individual agency. Both the manual and the research report produced through this study contain detailed step-by-step instructions (and default values if information is missing on a system) for computing both these rates and the following individual components that are included in the rates:

- Administrative labor costs (wages and fringe benefits);
- Administrative office space costs (space, utilities, and so forth);
- Administrative office equipment (desks, photocopies, and so forth); and
- Other administrative costs (telephone, supplies, postage, printing, and so forth).

Transportation Operating Costs

Transportation operating costs are separated into three categories depending on the output measure that affects the cost:

- Operating costs dependent on vehicle-miles,
- Operating costs dependent on vehicle-hours of available service, and
- Operating costs dependent on number of vehicles.

Cost formulas have been developed for each of these categories. The results of each formula can be added to calculate total operating costs.

Operating Costs Dependent on Vehicle-Miles

There are two main cost elements that are dependent on vehicle-miles: (a) fuel and oil and (b) vehicle maintenance and repairs. Fuel and oil costs per mile do not vary by urban or rural area, but they do vary considerably by vehicle type. This means that agencies that operate larger vehicles have greater fuel and oil costs per mile. The average fuel and oil cost was $0.165 per mile. Table 4 gives default values developed for average fuel and oil costs per mile based on the survey data.

TABLE 4 Fuel and Oil Costs—1982

Vehicle Type	Approximate Miles per Gallon[a]	Fuel and Oil Cost per Mile ($)
Sedan or station wagon	10.0	0.13
Van	8.1	0.16
Small bus	6.5	0.20

[a]Assumes a 1982 price per gallon of fuel of $1.30 (leaded, $1.20; unleaded, $1.28; and leaded premium, $1.40).

Vehicle maintenance costs include all contract or in-house maintenance, or both, of vehicles. As with fuel and oil costs, vehicle maintenance costs per mile are also more dependent on the type of vehicle. However, vehicle maintenance costs per mile also vary by urban or rural areas with urban areas generally higher in cost than rural areas. Table 5 gives vehicle maintenance costs per mile by vehicle type and urban or rural areas.

TABLE 5 Vehicle Maintenance Cost per Mile—1982

Vehicle Type	Rural ($)	Urban ($)	Average ($)
Sedan or station wagon	0.0377	0.0900[a]	0.0638[a]
Van	0.0542	0.0903	0.0801
Small bus	0.1201	0.0949	0.1083

[a]Imputed on basis of urban or rural area and vehicle variables.

Operating Costs Dependent on Vehicle-Hours of Service Availability

Some categories of operating costs are dependent on the hours that service is available. Typically, the number of vehicle-hours was used as the influential output variable to explain these costs. However, data on vehicle-hours were kept by only a few agencies in the sample. As a surrogate for vehicle-hours, the number of vehicles operated times the number of hours per month that service is offered (referred to as the vehicle-hours available service) is used.

The cost elements in this category include driver and dispatch wages. Driver and dispatcher wages are the product of (a) the number of hours spent by each category of personnel, (b) the wage rate for each category, and (c) the fringe benefit rate plus one. Because information on volunteer labor was so sparse and appeared inconsistent, all labor is assumed to be paid. (Agencies that anticipate volunteer labor can account for this by either assuming a wage rate of $0.00 or by assuming a certain percentage of hours will be volunteered.)

Driver Wages

Driver wages are the product of driver-hours, driver wage rates, and driver fringe benefit rates plus one. The number of driver-hours required to provide the service is dependent on the total number of vehicle-hours available. Overall, the number of driver-hours per month is 0.78 times the number of vehicle-hours of service available per month. The ratio of driver-hours to available vehicle-hours is greater in rural areas, indicating that in rural areas there is probably more service being provided within the hours service is offered or that there may be fewer idle vehicles or vehicles not fully utilized, or both. The average number of driver-hours per month is 586 with more driver-hours per agency in rural areas than in urban. Table 6 gives driver-hours per month.

TABLE 6 Operating Hours per Month

Labor Category	Rural	Urban	Average
Drivers			
Monthly hours	608	559	586
Driver-hours per vehicle-hours available	0.811	0.736	0.776
Dispatchers			
Monthly hours	70	171	122
Dispatcher-hours per driver-hours	0.179	0.278	0.237
Other personnel		275	275
Average operating hours	650	700	683

Driver wage rates vary by the urban or rural nature of the area and by whether drivers are full time or part time. Unionization did not play a part in differences in wage rates because few of the systems were unionized. Table 7 gives driver wages found in the study. In general, driver wages are higher in urban areas and wages for full-time employees are greater than wages for part-time employees.

TABLE 7 Operator Wage Rates—1982

	Rural ($)		Urban ($)			
	Average-Cost Areas	High-Cost Areas	Average-Cost Areas	High-Cost Areas	Average	
Driver						
Full time	3.70	4.99	3.92	6.45	4.59	4.22
Part time	3.54	4.51	3.98	5.41	4.18	
Dispatcher						
Full time	4.34	4.85	5.11	8.38	5.48	4.82
Part time	3.35	4.75	3.93	5.09	4.19	

Fringe benefit rates for drivers also vary for urban or rural areas and by the full-time or part-time status of the driver. The overall fringe benefit rate for operating personnel is 25.6 percent with full-time personnel at 22.7 percent and part-time personal at 21.7 percent. The fringe benefit rate for full-time drivers is 28.1 percent and that for part-time drivers is 22.2 percent. Fringe benefit rates for operating personnel are greater in rural areas than in urban. Tables 8 and 9 give fringe benefit rates for drivers.

TABLE 8 Operator Fringe Benefit Rates by Personnel Category

Labor Category	Full Time (%)	Part Time (%)
Driver	28.1	22.2
Dispatcher	28.4	22.0
Other	22.9	17.7
Average[a]	27.7	21.7

[a]Average for all categories is 25.6.

TABLE 9 Operator Fringe Benefits as Percentage of Wages by Urban or Rural Classification

Area	Average-Cost Area	High-Cost Area	Average
Rural	26.5	28.3	27.2
Urban	23.7	25.0	24.0

Dispatcher Wages

Total dispatcher wages are the product of dispatcher-hours times dispatcher wage rates times the dispatcher fringe benefit rate plus one. The number of dispatcher-hours is dependent on the number of driver-hours required to provide the service. Overall, the number of dispatcher-hours is 24 percent of the number of driver-hours. However, the ratio of dispatcher-hours to driver-hours is much greater in urban areas than in rural areas. The average number of dispatcher-hours per month per system is 122 with considerably more hours in urban areas than in rural areas. Table 6 gives a summary of dispatcher-hours and ratios of dispatcher-hours to driver-hours for urban and rural areas.

As do driver wage rates, dispatcher wage rates vary for urban and rural areas and by the full-time or part-time status of the employee (Table 7). Dispatcher wages are generally higher than driver wages, which makes sense because dispatchers are often drivers with more seniority or persons who began as drivers and were promoted. Dispatcher wages are higher in urban areas, and full-time employee wages are higher than part-time wages.

Fringe benefit rates for dispatchers also vary by the full-time or part-time status of the dispatcher and for urban or rural areas. The fringe benefit rate for full-time dispatchers is 28.4 percent whereas the fringe benefit rate for part-time dispatchers is 22.0 percent. Tables 8 and 9 give fringe benefit rates for dispatchers and other operating personnel.

Operating Costs Dependent on Number of Vehicles

There are three categories of operating costs that are influenced by the number of vehicles an agency operates: (a) insurance costs, (b) license and registration costs, and (c) vehicle storage costs.

Insurance costs per vehicle vary by the type of vehicle and for urban or rural areas. The data in Table 10 indicate that in urban areas the average per vehicle monthly insurance cost is $51.36 and this does not appear to vary by type of vehicle. In rural areas, monthly insurance costs per vehicle vary from $52.28 for automobiles to $74.16 for small buses, with an average of $63.27.

Average cost of vehicle license and registration fees was $2.61 per month per vehicle. As the data in

TABLE 10 Monthly Insurance Costs per Vehicle--1982

Vehicle Type	Urban ($)	Rural ($)
Station wagon or sedan	51.49	52.28
Van	51.47	63.22
Small bus	50.50	74.16
Average	51.36	63.22

Table 11 indicate, vehicle license and registration fees averaged $2.00 per vehicle per month in rural areas and $3.05 per vehicle per month in urban areas.

Vehicle storage costs were only reported by three agencies and ranged from $1.50 per month per vehicle to $33.00 per month per vehicle, with an average of $32.70. Vehicle storage costs were included when they were reported but they were not added for agencies not reporting such costs because it appeared that most agencies either parked their vehicles in the agency parking lot or, in some cases, drivers took them home overnight. In the former case, vehicle storage space would be included in building rent.

TABLE 11 Vehicle License and Registration Costs per Month--1982

Area	License and Registration Cost per Vehicle ($)
Rural	2.00
Urban	3.05
Average	2.61

Transportation Capital Costs

Capital costs associated with transportation include the cost of vehicles, office equipment associated with the actual operation of those vehicles, and dispatch equipment. The following sections explain how each of these costs was treated in the study.

Vehicle Capital Costs

As were other capital costs in the study, vehicle capital costs were estimated as the cost of replacing vehicles and are expressed as the cost of depreciation on the vehicle plus interest over the useful life of the vehicle (the length of time it was estimated that the vehicle would be operational). Capital recovery factors were used to convert one-time vehicle purchases to equivalent annual or monthly costs. The capital recovery factors assumed a 12 percent interest rate and a useful life that varied by the size of vehicle. A 10 percent salvage value on vehicles was also assumed.

Thus the vehicle capital costs were estimated as

$$\text{Vehicle capital costs} = \sum^{i} (\text{Capital acquisition or replacement cost for vehicle type i}) (1 - \text{Percent residual salvage value}) (\text{Capital recovery factor for vehicle type i}).$$

Table 12 gives the monthly capital costs for various vehicle types as well as the assumed useful life, replacement costs, and monthly capital recovery factors.

TABLE 12 Vehicle Capital Costs--1982

Vehicle Type	Useful Life[a] (yr)	Replacement Acquisition ($)	Replacement Cost Minus Salvage Value ($)	Monthly Capital Recovery Factor[b]	Monthly Vehicle Cost per Vehicle ($)
Sedan	5	10,000	9,000	0.0231175	208.06
Station wagon	5	12,000	10,800	0.0231175	249.67
Van	5	18,000[c]	16,200	0.0231175	374.50
Small bus	7	40,000[c]	36,000	0.0182598	657.35
Large bus	12	150,000[c]	135,000	0.0134531	1,817.17

[a] From consumer guides and transit industry reports.
[b] Assumes 12 percent interest rate.
[c] Price includes the cost of a wheelchair lift and tiedowns.

Transportation Operating Office Equipment Costs

The cost of office equipment that was associated with the actual operation of the transportation service was treated exactly as other capital expenditures. As for vehicle capital costs, replacement values were used for items including depreciation and interest. Capital recovery factors were used to convert one-time costs to monthly expenditures (assuming 12 percent interest and a useful life of 5 years). Table 13 gives a list of common items and computed monthly expenditures for each.

These costs vary with the number of operating hours expended by an agency. The typical agency spent $40.08 per month on this cost element representing $0.066 per operating hour per month.

TABLE 13 Office Equipment Capital Costs--1982

Item	Monthly Capital Cost per Unit ($)
Desk	6.24
Chair	2.08
Table	4.16
Adding machine or printing calculator	2.70
Calculator (nonprinting)	1.04
Typewriter	20.81
File cabinet	4.16
Bookshelf	2.08

Dispatch Equipment Costs

Only two of the providers in the sample actually had radio-dispatched vehicles. For this reason, good information was not obtained on the cost of such equipment--and it was not included in the study. Almost all providers included cost for a dispatcher or scheduler and the labor cost for those employees is included in operating costs. It appears that a dispatcher labor cost is incurred regardless of whether or not the dispatcher uses a radio. If an agency is anticipating radio-dispatching of vehicles, additional capital costs for dispatch equipment and maintenance costs for that dispatch equipment can be included.

USE OF THE COST MODELS

The cost estimation methodology presented in the previous section can be applied to existing services or used to forecast expenses that will be incurred

if services are initiated. The manual describes and gives detailed instructions for following the four basic steps required to compute and analyze monthly costs and unit costs of service:

1. Gather information on resource and service specifications;
2. Using the information gathered, compute monthly costs for each cost category and add them together to arrive at total monthly costs;
3. Compute unit costs and efficiency measures; and
4. Compare unit costs, efficiency measures, and production parameters with those of similar providers.

This section is chiefly concerned with the second step--the computation of total monthly costs. This computation is performed in the following substeps:

1. Compute transportation operating costs,
2. Compute transportation capital costs,
3. Transfer administrative rate, and
4. Compute total monthly transportation costs.

Step 1: Compute Transportation Operating Costs

Transportation operating costs are separated into three categories depending on the output measure that affects the cost:

1. Operating costs dependent on vehicle-miles,
2. Operating costs dependent on vehicle-hours of available service, and
3. Operating costs dependent on vehicles.

Cost formulas have been developed for each of these categories. The results of each formula can be added to calculate total operating costs. Costs should be recorded on the worksheet for calculating monthly transportation operating costs (Figure 1). If monthly costs are known, these can be recorded. If any costs are unknown, they can be estimated using the formulas given hereafter.

Calculate Operating Costs Dependent on Vehicle-Miles

The two main cost elements dependent on vehicle-miles are fuel and oil and vehicle maintenance and repairs. Thus,

Monthly operating costs dependent on vehicle-miles = (Monthly fuel and oil costs) + (Monthly maintenance and repair costs).

As mentioned previously, if information on monthly fuel and oil costs and monthly maintenance and repair costs is available, it should be recorded on the transportation operating cost worksheet (Figure 1, Lines 1 and 2). If fuel and oil costs are not

I. CALCULATE COSTS DEPENDENT ON VEHICLE MILES

		MONTHLY COSTS
monthly vehicle miles _____ x fuel + oil cost per mile _____	=	fuel + oil costs $_____ (1)
monthly vehicle miles _____ x maintenance cost per mile _____	=	maintenance costs $_____ (2)

II. CALCULATE COSTS DEPENDENT ON AVAILABLE VEHICLE HOURS

no. vehicles _____ x hours/week service _____ x 4.22 = monthly available veh. hours

monthly available vehicle hours _____ x $\frac{\text{driver hours}}{\text{available vehicle hours}}$ _____ = monthly driver hours _____

monthly driver hours _____ x $\frac{\text{dispatcher hours}}{\text{driver hours}}$ _____ = monthly dispatcher hours _____

monthly driver hours _____ x driver hourly rate _____ x 1 + driver fringe benefit rate _____	=	monthly driver wages & fringes $_____ (3)
monthly dispatch hours _____ x dispatcher hourly rate _____ x 1 + dispatcher fringe benefit rate _____	=	monthly dispatcher wages & fringes $_____ (4)
other operating hours _____ x other hourly rate _____ x 1 + other fringe benefit rate _____	=	monthly other operating wages & fringes $_____ (5)

III. CALCULATE COSTS DEPENDENT ON NUMBER OF VEHICLES

number of vehicles _____ x monthly insurance costs per vehicle _____	=	monthly insurance costs $_____ (6)
number of vehicles _____ x monthly license and registration cost per vehicle _____	=	monthly license & registration cost $_____ (7)
	=	monthly vehicle storage cost $_____ (8)
		TOTAL MONTHLY OPERATING COSTS $_____ (9)

IV. ADD ALL OPERATING COSTS TOGETHER (Add Lines 1 through Line 8)

FIGURE 1 Worksheet for calculating monthly transportation operating costs.

available they can be estimated by taking the number of vehicle-miles times an appropriate value for fuel and oil costs per mile.

Vehicle maintenance costs include all contract or in-house maintenance, or both, of vehicles. If actual monthly maintenance costs are known, they should be recorded on the worksheet. If this information is unavailable it can be estimated on the basis of vehicle-miles by taking total monthly vehicle-miles times an appropriate maintenance cost per vehicle-mile (see Table 5 for default maintenance cost per mile).

Calculate Operating Costs Dependent on Vehicle-Hours of Service Availability

Some categories of operating costs are dependent on the hours that service is available. Typically, the number of vehicle-hours was used as the influential output variable to explain these costs. However, data on vehicle-hours are not commonly keep by most agencies. As a surrogate for vehicle-hours, it is possible to use the number of vehicles operated times the number of hours per month that service is offered. The cost elements in this category include driver and dispatcher wages:

Transportation operating costs dependent on vehicle-hours of service available = [(Available vehicle service hours) (Driver-hours/Available vehicle service hours) (Driver hourly wage rate) (1 + Driver fringe benefit rate)] + [(Driver-hours/Dispatcher-hours) (Monthly driver-hours) (Dispatcher hourly wage rate) (1 + Dispatcher fringe benefit rate)].

Although this equation is fairly complex, the operating cost worksheet (Figure 1) can be used to systematically sort data and work through the equation. The boxed areas of the worksheet can be used to estimate both monthly driver-hours and dispatcher-hours. (This section needs to be filled out only if the number of driver- or dispatcher-hours used or needed is not known.)

As was seen previously, driver and dispatcher wages are the product of (a) the number of hours spent by each category of personnel, (b) the wage rate for each category, and (c) the fringe benefit rate plus one. Again, when agency-specific information is known, it should be recorded, when unavailable, default values from the table should be used.

Calculate Operating Costs Dependent on Number of Vehicles

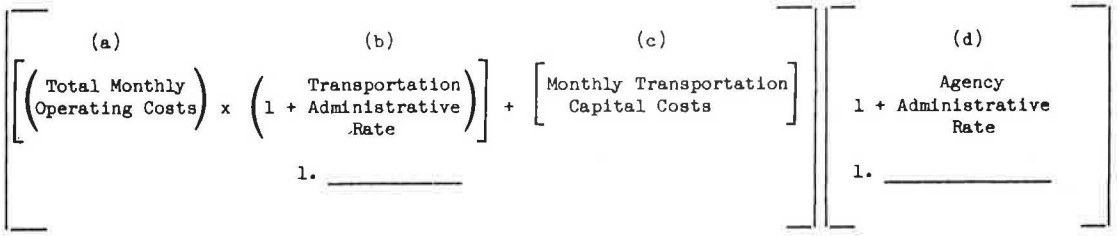
There are three categories of operating costs that are influenced by the number of vehicles an agency operates: (a) insurance costs, (b) license and registration costs, and (c) vehicle storage costs. These costs can be computed as follows:

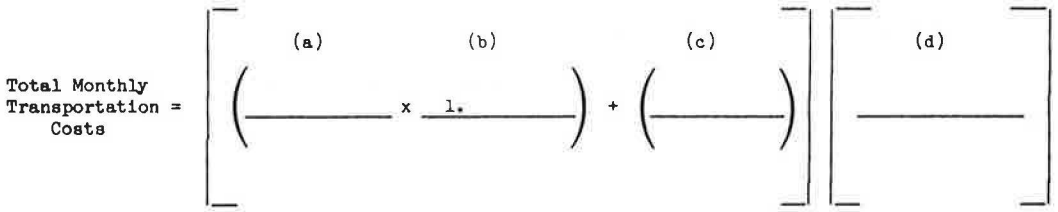
Transportation operating costs dependent on number of vehicles = $\sum_{i,j}^{n}$ (Number of vehicles of type i) (Insurance cost/Vehicle for type i in area j) (License and registration cost/vehicle in area j) (Vehicle storage cost/Vehicle).

As with other operating costs, if the actual monthly costs of these items are known, this amount should be recorded on the worksheet. If, however, this information is not available, any or all of the appropriate default values can be substituted.

Calculate Total Monthly Operating Costs

When the monthly costs for all operating cost categories, (Figure 1, Lines 1-8) have been calculated, these costs should be added to arrive at total monthly operating cost (record on Line 9). This total should also be transferred to the worksheet for calculating total transportation costs (Figure 2) under (a).





= $ _____

FIGURE 2 Worksheet for calculating total monthly transportation costs.

Step 2: Compute Transportation Capital Costs

Capital costs associated with transportation include the cost of vehicles, office equipment associated with the actual operation of those vehicles, and dispatch equipment. Transportation capital costs can be calculated as:

$$\text{Transportation capital cost} = \sum_{i}^{n} (\text{Number of items of type } i)\ [(\text{Total replacement cost or total actual purchase price of item } i) - (\text{Residual or salvage value of item})]\ (\text{Monthly capital recovery factor for useful life of item } i \text{ and interest rate}).$$

The worksheet for computing monthly transportation capital costs (Figure 3) is used to compute monthly transportation capital costs. As shown on the form there are two ways to treat transportation capital costs depending on whether it is assumed that the item will be replaced when it is no longer functional. Both ways include the cost of depreciation plus interest over the useful life of the item. However, only one way includes a provision for the replacement of capital purchases. Either method can be used here so that readers may select the most appropriate for their agency and circumstances.

Capital costs are expressed as the cost of depreciation on the item plus interest over the useful life of the vehicle (the estimated length of time that the vehicle should be operational). Capital recovery factors are used to convert one-time vehicle purchases to equivalent annual or monthly costs. The capital recovery factors can be calculated assuming various interest rates and different useful lives, which vary by size of vehicle. A 10 percent salvage value on vehicles is also assumed.

The first step in calculating capital costs is to record the number and age of each item by type on the form. If a provision is being made for replacement, the next step is to record the total replacement costs for all items in Column c. If provision

Transportation	(a) Number	(b) Age	(c) Total Replacement or Cost	(d) Purchase Cost on Items With Useful Life	(e) Total Replacement or Purchase Cost-Salvage Value (c or d x .90)	(f) Monthly Capital Recovery Factor	(g) Monthly Cost (e)x(f)
1. Office Equipment							
a. photocopies							
b. desk							
c. chair							
d. table							
e. adding machine							
f. typewriter							
h. file cabinet							
i. bookshelf							
j. other _____							
_____							
_____							
2. Vehicles							
a. Sedan							
b. Station wagon							
c. Van							
d. Small Bus							
e. Large Bus							
3. Dispatch Equipment							
f. Base Station							
g. Mobile Units							
h. Dispatch Maintenance Equipment							

Total Capital Cost $ _____

FIGURE 3 Worksheet for computing monthly transportation capital costs.

is not being made for replacement, the next step is to record the total actual purchase price for all items with remaining useful life in Column d. Because it is recommended that a 10 percent salvage values be assumed, the next step is to multiply the replacement cost/purchase price by 0.90 and record the product in Column e. This total purchase/replacement value is then converted to monthly costs by multiplying it by the capital recovery factors described previously and recorded in Column f. The monthly cost by item is the product of Column e and Column f. (Tables 12 and 13 give monthly capital costs per item for vehicles and office equipment.)

Calculate Total Capital Costs

Total capital costs should be computed (by adding all values in Column g of Figure 3) and recorded on the bottom of line of Column g. This total should also be transferred to the worksheet for computing total monthly transportation costs (Figure 2) under (c).

Step 3: Transfer General Agency Administrative Rate and Transportation Administrative Rate

If the general agency administrative rate and transportation rates for the agency are known, it will be possible to use these agency-specific values in the next step. However, if these values are not available, the most appropriate rate from Tables 1-3 should be selected for inclusion in the final calculation.

Step 4: Compute Total Monthly Transportation Cost

The final step in computing monthly transportation costs is to use the results of the calculation in each of the four cost categories to arrive at the total monthly transportation costs. A worksheet for calculating total monthly transportation costs (Figure 2) is included for this purpose.

COSTS PER UNIT OF TRANSPORTATION SERVICE

A significant deficiency of previous studies of transportation costs has been the failure to specify exactly what is being costed in specific units. This has led to confusion between costs of transportation services produced and costs of transportation services consumed. The precise identification of unit costs is crucial to the identification of costs in particular regions or areas. In particular, to make it possible to address questions about cost differentials with respect to transportation for the elderly population, both production and consumption must be fully understood, particularly because it is suspected that production costs are higher in urban areas but consumption rates are lower in rural areas, providing no a priori indication of which type of area has the highest overall costs.

Unit Costs of Transportation Services Produced

Unit costs for transportation services produced include (a) cost per vehicle-mile and (b) cost per vehicle-hour of service available. An examination was made to determine whether these overall unit production costs varied by (a) urban or rural areas, (b) quality of service, and (c) type of agency operating the service. One of the major findings was that quality of service does not affect the unit cost of producing the service. This may be because the services in the sample did not vary enough in quality and were basically the same service types. As mentioned previously, this made comparison of the cost of services in rural areas easier. (The cost for each hour of vehicle availability does vary by quality of service but these variations are erratic. There is no correlation between the two factors.) Tables 14 and 15 give unit production costs.

TABLE 14 Transportation Production Unit Costs by Quality of Service—1982

Service Quality	Cost per Mile ($)	Cost per Hour of Vehicle Availability ($)
Low (n = 25)	2.30	16.64
High (n = 24)	2.23	15.43

TABLE 15 Transportation Production Unit Costs by Urban or Rural Location—1982

Area	Cost per Mile ($)	Cost per Hour of Vehicle Availability ($)
Rural		
Low quality (n = 12)	1.87	13.75
High quality (n = 13)	1.75	16.28
Average	1.81	15.07
Urban		
Low quality (n = 13)	2.71	20.11
High quality (n = 11)	2.80	14.42
Average	2.75	17.13
Average	2.27	16.01

The cost of producing a mile or an hour of transportation service does vary by urban or rural designation with rural areas averaging about a 52 percent lower cost per vehicle-mile ($1.81 in rural areas and $2.75 in urban areas) and an almost 14 percent lower cost per available vehicle-hour ($15.07 in rural areas and $17.13 in urban areas).

The type of agency operating the service also affects the cost per mile and hour with public agencies having higher costs than private nonprofit agencies and aging services organizations having slightly lower rates than other agencies. Table 16 gives transportation unit production costs by agency type.

TABLE 16 Unit Costs for Transportation Produced by Agency Type—1982

	Cost per Mile ($)	Cost per Hour ($)
Organization		
Private nonprofit (n = 35)	2.19	15.64
Public (n = 11)	2.77	17.21
Management		
Single-purpose agency (n = 11)	2.31	16.42
Independent unit with central planning unit (n = 6)	2.15	17.13
Part of consolidated multipurpose agency (n = 29)	2.27	15.62
Agency		
Aging services (n = 13)	1.85	14.87
Community action (n = 9)	2.41	13.52
Government (n = 6)	2.05	17.13
Senior center (n = 12)	2.22	17.37
Average	2.27	16.01

Transportation Production Rates

Three transportation production rates were considered in the study: (a) trips per vehicle-mile, (b) trips per hour of vehicle availability, and (c) miles per hour of vehicle availability. Trips per mile averaged 0.437, and trips per available vehicle-hour and miles per available vehicle-hour averaged 3.88 and 9.80, respectively. Table 17 gives a summary of these production measures.

TABLE 17 Transportation Production Efficiency

Area	Trips per Mile	Trips per Available Vehicle-Hour	Miles per Available Vehicle-Hour
Rural			
Low quality (n = 12)	0.356	2.62	7.62
High quality (n = 13)	0.401	3.78	9.67
Average	0.379	3.23	8.68
Urban			
Low quality (n = 13)	0.544	6.33	14.73
High quality (n = 11)	0.411	2.45	6.51
Average	0.497	4.55	10.96
Average	0.437	3.88	9.80

As expected, trips per vehicle-mile are greater in urban areas than in rural areas (31.1 percent greater, at 0.379 in rural areas and 0.497 in urban areas). The trips per available vehicle-hour are 41 percent greater in urban areas, and miles per available vehicle-hour are 26 percent greater in urban areas.

In general, it appears that the lower the service quality, the greater the number of trips per mile, trips per hour, and miles per hour. This makes sense because higher quality trips may be more specialized. Table 18 gives production measures by service quality.

TABLE 18 Transportation Production Efficiency Service Quality

Service Quality	Trips per Mile	Trips per Available Vehicle-Hour	Miles per Available Vehicle-Hour
Low quality (n = 25)	0.454	4.55	11.31
High quality (n = 24)	0.419	3.17	8.22
Average	0.437	3.88	9.80

Unit Costs of Transportation Services Consumed

The most important measure of service costs is cost per trip because this measures what it costs to actually provide one unit of service to an elderly client. In previous research, it was suspected that, if quality were taken into account, the cost per trip would be higher in rural areas or at least comparable. The data from this study indicate that, for low-quality services, the cost per trip is 12 percent higher in rural areas. For high-quality services, the cost per trip is 51 percent higher in urban areas. Overall, the cost per trip is 14 percent higher in urban areas. Even though production rates (e.g., trips per mile) are higher in urban areas, this does not totally offset the higher unit production costs (e.g., cost per mile). Table 19 gives unit costs for transportation consumed by urban and rural areas.

The cost per trip for transportation services also varies by agency type (Table 20). Trips by public agencies cost approximately 19 percent more than trips by private nonprofit agencies. Trips by single-purpose agencies cost more than those by agencies with other management types, and trips by community action agencies and government-based agencies cost more than those by aging organizations or senior centers.

TABLE 19 Unit Costs for Transportation Consumed by Urban or Rural Classification—1982

Area	Cost per Trip ($)
Rural	
Low quality (n = 12)	6.57
High quality (n = 13)	4.60
Average	5.55
Urban	
Low quality (n = 13)	5.86
High quality (n = 11)	6.94
Average	6.35
Average	5.92

TABLE 20 Transportation Consumption Unit Costs by Agency Type—1982

	Cost per Trip ($)
Organization	
Private nonprofit (n = 35)	5.67
Public (n = 11)	6.75
Management	
Single-purpose agency (n = 11)	6.44
Independent unit with central planning unit (n = 6)	5.17
Part of consolidated multipurpose agency (n = 29)	5.89
Agency	
Aging service (n = 13)	5.43
Community action (n = 9)	6.88
Government (n = 6)	6.29
Senior center (n = 12)	4.84
Average	5.92

REFERENCES

1. S.F. Knapp and A.M. Lago. Results of a Parametric Cost Analysis of the Differences Between Urban and Rural Transportation Services for Transportation-Disadvantaged Persons. In Transportation Research Record 934, TRB, National Research Council, Washington, D.C., 1983, pp. 1-8.
2. M. Wozny et al. Review of the Reported Differences Between the Rural and Urban Elderly: Status, Needs, Service and Service Costs. Ecosometrics, Inc., Bethesda, Md.; Administration on Aging, U.S. Department of Health and Human Services, March 1981.

3. M. Wozny, S. Knapp, and M. Ramsdell. The Cost of Services to the Elderly: A Resource-Based Approach to Cost Analysis. Institute of Economic and Social Measurement, Inc.; Administration on Aging, U.S. Department of Health and Human Services, 1984.
4. M. Wozny, S. Knapp, J. Burkhardt, and A. Lago. The Cost of Services to the Elderly: A Manual for the Aging Network. Institute of Economic and Social Measurement, Inc.; Administration on Aging, U.S. Department of Health and Human Services, 1984.

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Analysis of Commuter Ridesharing Behavior at Five Urban Sites

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ABSTRACT

This paper is based on an evaluation of the National Ridesharing Demonstration Program (NRDP) established by the Department of Transportation in 1979 as a 2-year effort to develop comprehensive and innovative approaches to ridesharing. The findings presented are based on results of a workplace survey administered at five NRDP sites: Atlanta, Georgia; Cincinnati, Ohio; Houston, Texas; Portland, Oregon; and Seattle, Washington. The focus is on the characteristics of ridesharers, the workings of carpool arrangements, the relationship between firms and ridesharing, and the impact of ridesharing programs. Survey results showed that ridesharers were more likely than other commuters to have a long journey to work and to have more than zero and less than one automobile per employed worker in their households. An overwhelming majority of carpools were formed by household members or by informal work contact. Most carpools were two-person arrangements, more than half of which consisted of persons from the same household. Fifty-eight percent of those ridesharing 2 years before the survey were still ridesharing at the time of the demonstration, and about the same proportion of persons ridesharing at the time of the survey had been ridesharers 2 years earlier. Most of the movement into and out of carpools was from the drive-alone mode. Ridesharing mode split and carpool size were both positively associated with firm size. Large firms were more apt to provide ridesharing assistance to their employees, and assistance was associated with a higher ridesharing mode split. No association was found between flextime and the amount of ridesharing. Firm contact with a ridesharing program was associated with increased employee ridesharing at firms offering ridesharing assistance. Implications for ridesharing program design are briefly explored.

The market for ridesharing, both in terms of individual ridesharers and in terms of employers who are potential participants in ridesharing programs, is described. [Ridesharing is defined as motor vehicle travel in which the driver is accompanied by at least one passenger, the driving function is uncompensated or compensated in only minimal fashion, and the vehicle is owned or leased by an individual for his personal use or by an institution for the use of its employees (1,p.4). "Ridesharing" and "carpooling" are used interchangeably in the text because of survey definitions. Vanpooling is considered a subset of carpooling involving seven or more passengers.] The discussion of ridesharing arrangements and participants relies mainly on analysis of data from uniform workplace surveys of employers and employees administered in 1982 at five National Ridesharing Demonstration Program (NRDP) sites: Atlanta, Cincinnati, Houston, Portland, and Seattle. The NRDP surveys generated usable responses from more than 200 firms and 2,000 employees at each of the five sites.

Responses from the employer survey were merged with those from the employee survey for analysis of