FORECASTING DIAL-A-BUS RIDERSHIP IN SMALL URBAN AREAS

David T. Hartgen and Carol A. Keck, Planning and Research Bureau,
New York State Department of Transportation

A method is developed for estimating potential demand for innovative transit services such as dial-a-bus and park-and-ride in small urban areas and suburban communities currently lacking such services. The method assumes that the rate of usage of a particular type of service is similar for particular population groupings, regardless of their geographical location. The rate of usage is presumed to depend on factors such as age, sex, and service attributes rather than characteristics of the community under consideration. The procedure is applied in the analysis of demand for dial-a-bus service in Oneonta, New York, by using the existing system in Batavia, New York, as the base for determining actual rates of response to such a service. Results indicate that the method gives reasonable estimates of demand and demand sensitivity to policy variables such as fare and gasoline price.

•THE BASIC PROBLEM addressed in this research is as follows: Forecast the probable usage of innovative transportation services such as dial-a-bus and park-and-ride in a variety of urban and rural environments. Dial-a-bus has been used successfully in Batavia, New York, and it is important to know whether such service is applicable to other communities throughout the state. Similarly, the success of park-and-ride in suburban Rochester suggests that its application be extended to other communities. A third type of service that may be feasible is conventional transit service operating in suburban communities or isolated towns.

Three considerations from these situations bind them together.

1. Generally speaking, none of these services has been previously provided to the communities being studied. In other words, demand is being forecast in situations where extrapolation from existing service is not possible.
2. In addition, the community attitudes toward the use of such services in study locations may be significantly different from those in the locations in which such services exist. Therefore, it would be unwise to estimate demand for these services in the study communities based solely on demand experiences in existing systems.
3. Further, upward or downward revisions of the estimates of demand for these services based on the energy crisis (particularly the price of gasoline) or the cost of the service are desirable. Therefore, knowledge of the sensitivity of demand to such variables is needed.

The procedure for estimating remote park-and-ride demand has already been documented and developed (1, 2). Criteria for implementing park-and-ride service have been documented (3), and the procedures for conducting small urban area surveys to estimate demand for park-and-ride have also been detailed (4). Procedures for forecasting peripheral park-and-ride demand have also been documented recently (5).

The method described extends the previously devised method of forecasting demand for remote park-and-ride, with emphasis placed on dial-a-bus and conventional service, in communities where no such service now exists. The procedure is based on the following key assumption: Although individual preferences for modes in the test community may be different from those in communities where the service currently operates, the rate of response (by user groups) to these new modes will be the same in the test community as in the control community. In other words, if we can determine the rate of usage of the innovative service where the service exists, then this rate (adjusted for differences in service level) will be the same in other communities in which we use the methods.

Schematically, the procedure is shown in Figure 1. In the control area, the observed rate of usage (point A) for the service being operated in that community is estimated from an on-board survey. These rates are then translated to a resident base so that the rate of usage per urban resident of a given type may be estimated.

In the test area, no such rate can be determined inasmuch as the service does not exist there. However, through a survey of community residents we may obtain noncommitment rates of usage (curve B, Figure 1) at different levels of a given policy variable. This is the rate at which residents indicate they would use the service if it were implemented; actual usage, of course, is likely to be considerably less.

The true demand for the innovative service in the test area is estimated by applying the noncommitment bias ratio from the control area to the test area, based on this ratio at point A. In other words, the survey of residents in the test area provides information on the shape of the demand curve, and the survey of riders in the control area determines the height of the curve.

DETAILS OF THE METHOD

The following outlines in detail the procedure for conducting this method.

Determine Observed Response for the Innovative Service

As mentioned, this information is obtained through an on-board survey in the area with innovative service. From the on-board survey, the observed rate of ridership for the service in this control area can be estimated. Let

f = frequency of use (trips/week),
n_{ijf} = number of interviewed riders of type i who indicate they use the service f times/week for purpose j (existing policy level k),
t_{ij} = total trips made by all system riders of type i for purpose j (policy level k),
factor = expansion factor, to raise on-board sample to total on-board ridership,
N_i = number of urban area residents of type i, and
R_{ij} = rate of usage (trips/week/resident) by residents of type i, for purpose j (policy level k).

Clearly, the total number of trips per week by all system riders of type i for purpose j is

$$t_{ij} = (\text{factor}) \left[\sum_f (f)\,(n_{ijf}) \right]$$

The rate of usage for this person-purpose-policy combination is

$$R_{ij} = \frac{t_{ij}}{N_i}$$

It may be useful at this point to discuss the kinds of stratifiers (i and j) to be used. If the major stratifier (i) is a person-related attribute rather than a household-related attribute, the usage rates for the control and the test area can be calculated directly. Further, the variables chosen should efficiently partition the market by different usage rates, for trip purposes. Parallel data (i.e., N_i) should, of course, be available from the 1970 census for these urban areas by person types. Therefore, variables such as sex and age are recommended as the primary stratifiers for riders, and work-school and other are adequate for trip purpose stratification. This procedure has an additional advantage in that it permits differential factoring of the data to account for different response rates by individuals within households. One survey, for instance, turned up a very large proportion of women and elderly individuals answering the questionnaire.

Determine Noncommitment Usage of the Innovative System in the Test Area

In Figure 1, the noncommitment curve (B) is estimated for the test area. Bear in mind that this is done in reference to a specific new technology (e.g., dial-a-bus) and must be repeated for each combination of person and trip purpose. Noncommitment demand is determined by computing the noncommitment rates anticipated for this service, based on the above summary tabulations. The method is as follows. Let

n_{ijfk} = number of interviewed respondents of type i who indicated they would use the service f times/week, for purpose j (at an assumed policy level k),
t_{ijk} = total number of noncommitment trips/week, from respondents of type i for purpose j (at an assumed policy level k),
n_i = number of interviewed respondents of type i, and
R_{ijk} = noncommitment rate of use (trips/week/resident) of type i for purpose j, in response to policy level k.

The total number of noncommitment trips from the sample for combination ijk is

$$t_{ijk} = \sum_f (f)\,(n_{ijfk})$$

From the entire area, for combination ijk, one expects $(t_{ijk})(N_i/n_i)$ trips. The anticipated rate of usage per urban resident for combination ijk is

$$R_{ijk} = (t_{ijk})\left(\frac{N_i}{n_i}\right)\left(\frac{1}{N_i}\right) = \frac{t_{ijk}}{n_i}$$

Note that the computation of the noncommitment rates for the community survey is different from that for the on-board survey. This is because the on-board survey must be reduced to a resident base, but the community survey noncommitment rates are themselves a community resident base (because the community survey is a random sample of residents rather than riders).

Estimate True Demand for the Innovative Service in the Test Area

As Figure 1 shows, the procedure for estimating the true demand curve is as follows.

First the position of the observed rate of usage for the control area (A) is estimated at the present policy level. The noncommitment rate of use in the test area is expressed by B. The true demand curve for the test area (C) is then estimated by stepping

Figure 1. Demand forecasting procedure.

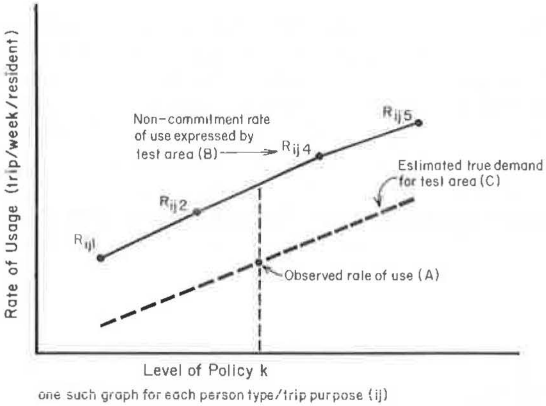


Table 1. Stratification of data from Oneonta home-interview survey.

Respondent	1970 Census Number	1970 Census Percent	1974 Sample Number	1974 Sample Percent
Male				
16 to 24	2,677	20.1	10	3.3
25 to 54	1,717	12.9	34	11.3
55 and over	1,183	8.8	42	13.9
Female				
16 to 24	4,083	30.6	15	5.0
25 to 54	1,862	14.0	105	35.7
55 and over	1,816	13.6	95	31.5
Total	13,338		301	

Table 2. Noncommitment response rates for dial-a-bus in trips per week per respondent.

Population Group	Trip Purpose	Fare Free	$0.50	$0.75	$1
Males					
16 to 24	Work	7.0	3.0	1.9	1.6
	Shop	2.0	0.6	0.2	0.1
Total		9.0	3.6	2.1	1.7
25 to 54	Work	0.8	0.5	0.3	0.2
	Shop	2.2	1.4	0.6	0.4
Total		3.0	1.9	0.9	0.6
55 and over	Work	0.6	0.4	0.2	0.2
	Shop	2.1	1.3	1.0	0.6
Total		2.7	1.7	1.2	0.8
Females					
16 to 24	Work	1.8	0.7	0.5	0.1
	Shop	3.5	1.8	1.5	1.0
Total		5.3	2.5	2.0	1.1
25 to 54	Work	1.5	1.0	0.7	0.6
	Shop	2.0	1.5	1.1	0.9
Total		3.5	2.5	1.8	1.5
55 and over	Work	0.5	0.4	0.4	0.2
	Shop	2.6	1.9	1.4	1.2
Total		3.1	2.3	1.8	1.4

Table 3. Estimated noncommitment ridership in trips per week.

Population Group	Fare $0.50	$0.75	$1
Males			
16 to 24	9,600	5,600	4,600
25 to 54	3,200	1,500	1,000
55 and over	2,000	1,400	900
Females			
16 to 24	10,100	8,100	4,500
25 to 54	4,700	3,300	2,800
55 and over	4,100	3,200	2,600
Total	33,700	23,100	16,400

Table 4. Comparison of reported and factored trips per week from Batavia on-board study.

Population Group	Reported Work	Reported Shop	Factored Work	Factored Shop
Males				
16 to 24	34	8	41.70	26.58
25 to 54	51	10	62.55	33.23
55 and over	17	3	20.85	9.97
Females				
16 to 24	207	9	253.86	29.91
25 to 54	277	38	339.71	126.28
55 and over	240	79	294.34	262.52
Total	826	147	1,013.01	488.49

down the noncommitment curve obtained in B proportional to the difference between the noncommitment and observed rates in the control area (A versus comparable point on curve B). Curves such as C are the demand curves that are used for forecasting demand in the test area. They are constructed to be sensitive to different levels of the policy variable k and therefore may be used to estimate the differential demand for service as a function of this policy.

PLANNING APPLICATION

To illustrate the procedure with a fairly detailed example, a recent study in Oneonta, New York, is discussed. Oneonta has a population of approximately 16,000 and is located in the east central portion of New York State. It is the central urban place in a predominantly rural area. The city is the home of two colleges with a combined enrollment of approximately 7,000 students. There are no large industrial employers in the area; the colleges are the city's major employers. The city currently has one bus that provides service along the main street, once per hour, between 9 a.m. and 5 p.m. The bus does not serve the college campuses. In December 1973, the city considered the possibility of instituting an improved, municipally owned and operated transit service if a significant need and demand for such service could be demonstrated. The New York State Department of Transportation was asked for assistance in determining the nature and magnitude of this demand.

Oneonta Home-Interview Survey

To assess this need, we selected a small sample (301 households) of urban residences from telephone directories. Individual responses (one per household) showed an overrepresentation of older women in the sample (primarily because of the time of day of the interviews). For analysis purposes the sample was therefore stratified into six categories (Table 1).

From the survey results, tabulations were made of total noncommitment trips (one-way) per week on a resident base. Two trip purposes (work-school and shop-other), six person categories, and four fare levels were used. This analysis was completed for dial-a-bus service. Table 2 gives the results. As expected, noncommitment rates of usage decrease as fare level increases. These rates are shown plotted versus fare for each person-purpose combination for dial-a-bus (DAB) service in Figures 2 and 3 and are represented by the Oneonta noncommitment curves.

Multiplication of these noncommitment rates by the total population in each category of user is given in Table 3. Clearly, these border on the absurd: The ridership estimated for DAB in a Batavia type of situation (50-cent fare) is 33,700 one-way trips/week, compared to 1,500 trips/week actually observed in Batavia! (Both communities are the same size!) Therefore, using noncommitment response data directly requires great care.

Batavia On-Board Survey

To estimate the probable usage of dial-a-bus in Oneonta, we used data collected from an on-board survey in Batavia. As in Figure 1, the first step in the procedure was to calculate the observed rate of use (A) for each category of rider and trip purpose in Batavia. Under the existing fare structure in Batavia, trips can be made at various fare levels; therefore, an average fare (in cents) for each rider category was calculated as follows:

Figure 2. Noncommitment and estimated actual ridership on proposed Oneonta dial-a-bus system for males (a) 16 to 24, (b) 25 to 54, and (c) 55 and over.

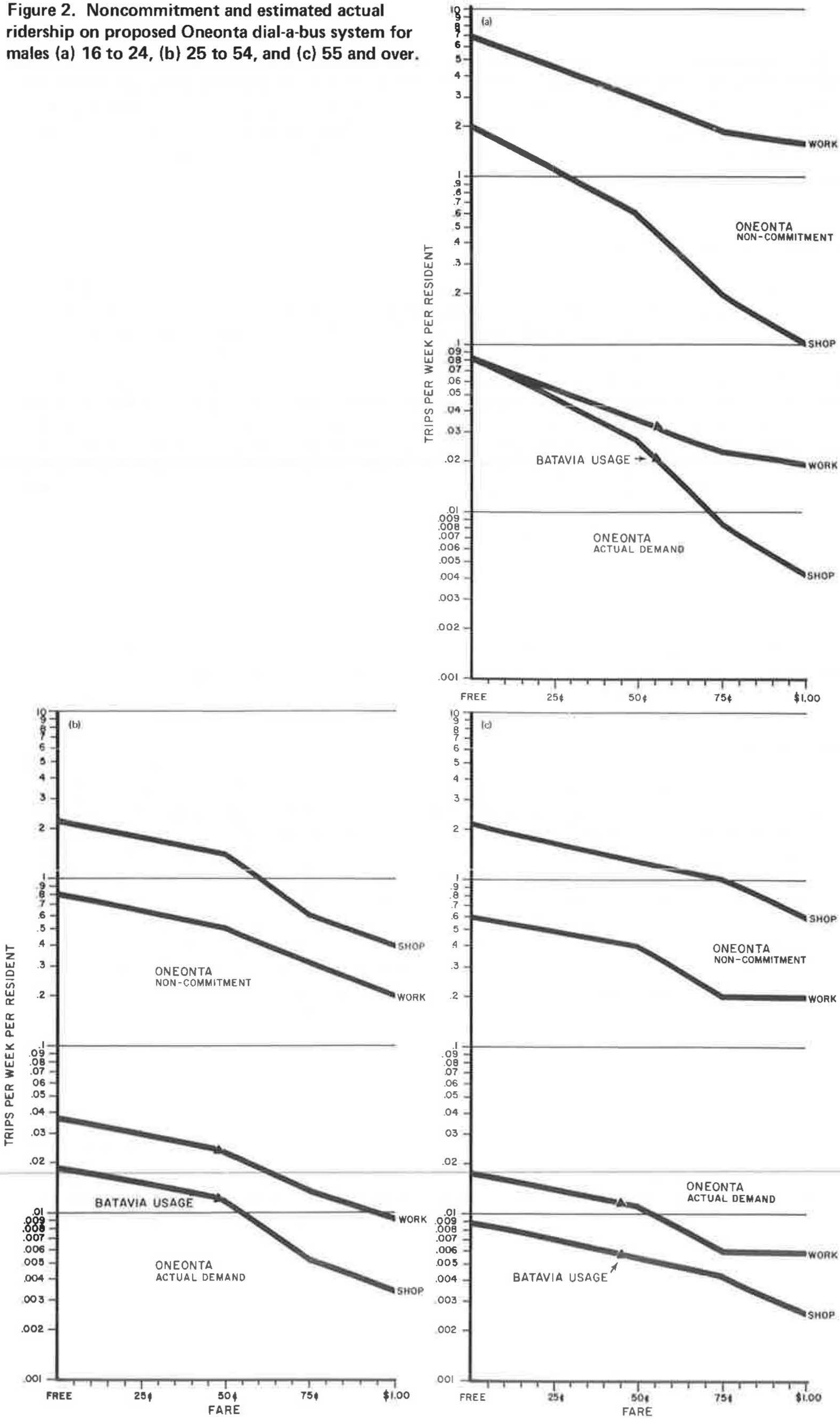
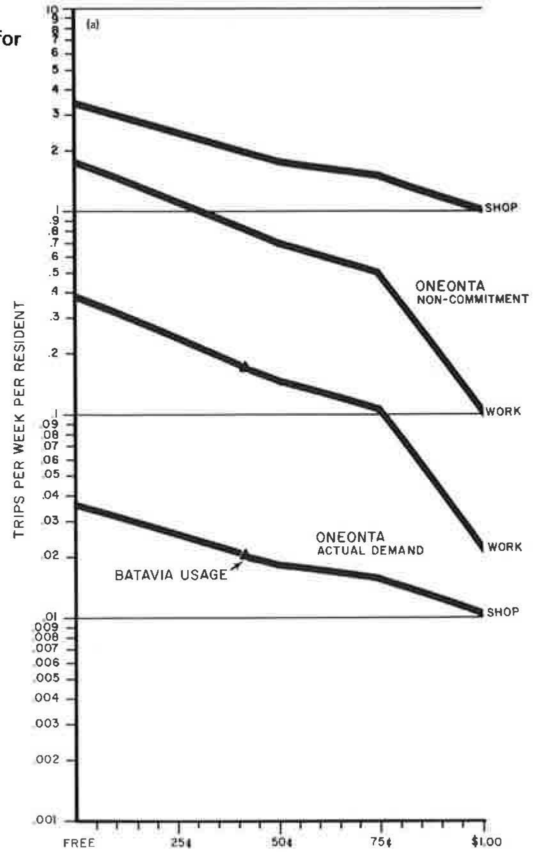
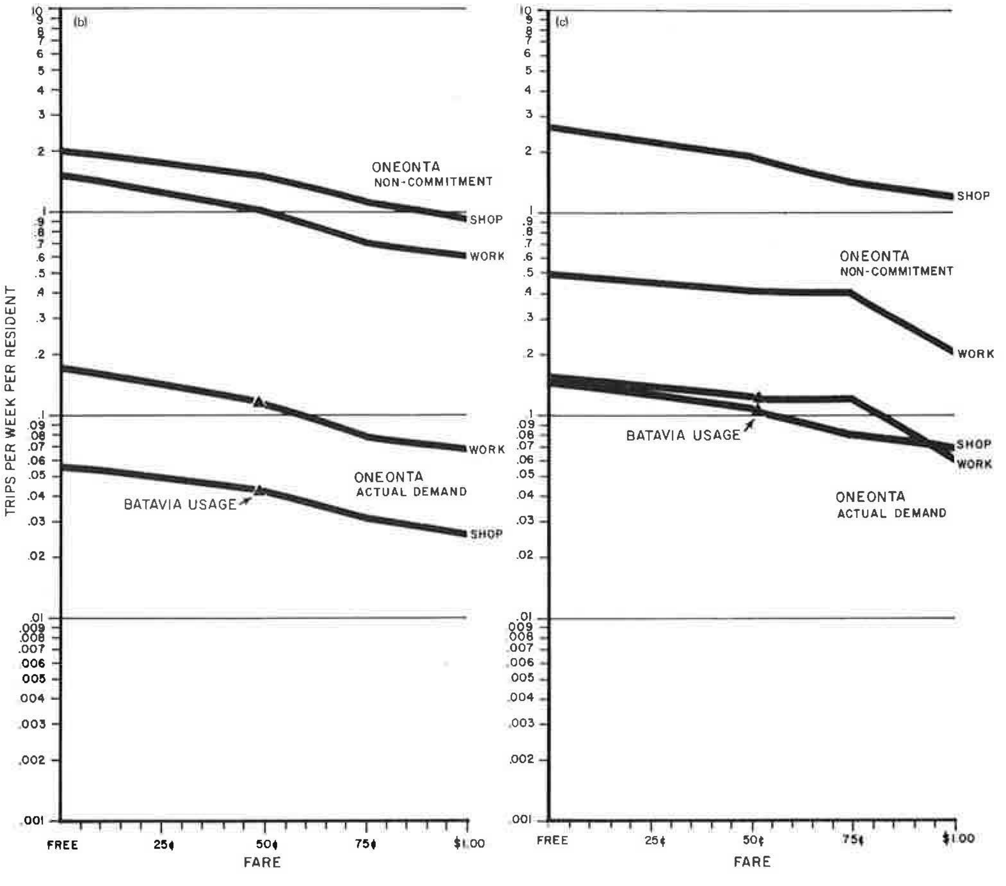


Figure 3. Noncommitment and estimated actual ridership on proposed Oneonta dial-a-bus system for females (a) 16 to 24, (b) 25 to 54, and (c) 55 and over.





Population Group	Average Fare
Males	
16 to 24	54
25 to 54	49
55 and over	45
Females	
16 to 24	42
25 to 54	49
55 and over	51

The observed trip rates of the riders of the Batavia system, then, represent trip rates at those fare levels.

The observed trip rates were calculated by using the responses obtained from the on-board survey and factoring to represent the total number of trips on the system. (Data on average weekly ridership obtained from the system operator were used for this purpose.) A comparison of the trips actually reported and the factored results is given in Table 4.

The results obtained by using the factored trips per week (TPWs) and applying them to the entire Batavia population to obtain TPW/resident are given in Table 5.

Probable Demand for Dial-a-Bus in Oneonta

These trip rates, at the average fare level for each particular population group, were then plotted (Figures 2 and 3, indicated by Batavia actual usage) and correspond to point A in Figure 1 for each population group and trip purpose. The shape of the curve is then assumed to be similar to the noncommitment response rate curve obtained from the Oneonta survey (curve B, Figure 1) with point A being one point on that curve. This resulted in the development of the Oneonta actual demand curves in Figures 2 and 3. The graphical results are given in Table 6 for the three fare levels that appeared feasible for the proposed Oneonta service.

The application of these rates to the Oneonta population resulted in the ridership estimates given in Table 7. Although these estimates appear to be reasonable when compared with the experience of Batavia, the test of their accuracy would of course be the initiation of dial-a-bus service in Oneonta.

Discussion of Results

Policy level variables are expressed in the survey design in two ways: (a) by assuming a constant fare and an increase in the price of gas and (b) by assuming a constant gasoline price and an increase in fare. In the previous example for Oneonta, the fare variable has been chosen as the policy, but the analysis may be redone with the gasoline price variable as the policy.

The questionnaire design also permits evaluation of noncommitment demand for the improved local service as well as dial-a-bus. However, an on-board survey for estimating the background demand for local service has not yet been conducted but is planned.

To date experience with the method shows that an estimate of the noncommitment demand curve can be easily obtained with a sample of 300 households in an urban area, regardless of the size of the region. Estimates of the demand for the service are made by multiplying the estimated true response rate for dial-a-bus by the number of persons in the urban area of a given type. From this data estimates could be made of the amount of revenue accruing to the system, and thereby the probable deficit the system would incur with a level of service similar to that suggested in the description as presented in the questionnaire. Significant differences in service levels proposed or implemented

Table 5. Trips per week per resident from Batavia on-board study.

Population Group	Trip Purpose		Population Group	Trip Purpose	
	Work	Shop		Work	Shop
Males			Females		
16 to 24	0.0331	0.0211	16 to 24	0.1872	0.0220
25 to 54	0.0229	0.0121	25 to 54	0.1140	0.0423
55 and over	0.0121	0.0057	55 and over	0.1224	0.1091

Table 6. Oneonta actual demand rate in trips per week per resident.

Population Group	$0.50 Fare		$0.75 Fare		$1 Fare	
	Work	Shop	Work	Shop	Work	Shop
Males						
16 to 24	0.0360	0.0253	0.0228	0.0084	0.0192	0.0042
25 to 54	0.0229	0.0120	0.0137	0.0052	0.0092	0.0034
55 and over	0.0115	0.0055	0.0058	0.0042	0.0058	0.0025
Females						
16 to 24	0.1472	0.0185	0.1052	0.0155	0.0210	0.0103
25 to 54	0.1140	0.0423	0.0798	0.0310	0.0684	0.0254
55 and over	0.1224	0.1091	0.1224	0.0804	0.0612	0.0689

Table 7. Estimated actual ridership per week.

Population Group	$0.50 Fare			$0.75 Fare			$1 Fare		
	Work	Shop	Total	Work	Shop	Total	Work	Shop	Total
Males									
16 to 24	96	68	164	61	22	83	51	11	62
25 to 54	39	21	60	24	9	33	16	6	22
55 and over	14	6	20	7	5	12	7	3	10
Females									
16 to 24	601	76	677	430	63	493	86	42	128
25 to 54	212	79	291	148	58	206	127	47	174
55 and over	222	198	420	222	146	368	111	125	236
Total	1,184	448	1,632	892	303	1,195	398	234	632

would, of course, yield different results.

SUMMARY AND CONCLUSIONS

This paper has presented a method of estimating demand for innovative transit services in small urban areas or suburban communities. The method is based on a small home-interview survey in the area of interest, and the results of a survey of users of an existing service of that type in another community. Small-sample surveys have been found sufficient for these estimates and allow the planning agency to apply this procedure with minimal cost and time expenditures.

This methodology, however, should not be considered final or not requiring further tests before its acceptance. It appears to result in reasonable estimates of patronage on an innovative system, but it is necessary to implement such a system to test the validity of these estimates.

In the meantime, transit needs of several other small urban areas are being evaluated in New York State by using this same procedure. It is hoped that the results of these analyses will present at least one opportunity to test the validity of this procedure.

The authors would appreciate comments on this methodology and information on any applications of it in areas outside of New York State.

REFERENCES

1. D. T. Hartgen. Forecasting Remote Park-and-Ride Transit Usage. New York State Department of Transportation, Preliminary Research Rept. 39, 1972.
2. D. T. Hartgen. Forecasting Demand for Improved-Quality Transit Service With Small-Sample Surveys. New York State Department of Transportation, Preliminary Research Rept. 51, 1973.
3. G. H. Tanner and R. Barba. Park-and-Ride Service: Some Guidelines and Considerations for Service Implementation. New York State Department of Transportation, Preliminary Research Rept. 44, 1973.
4. R. J. Schaefer, G. H. Tanner, and D. T. Hartgen. Surveys of Park-and-Ride Transit Demand. New York State Department of Transportation, Preliminary Research Rept. 43, 1973.
5. C. A. Keck and P. S. Liou. Forecasting Demand for Peripheral Park-and-Ride Service. Printed in this Record.