siderations are more important to rural commuters than they are to urban commuters. However, the increased importance placed on OVTT over IVTT is found to apply to rural and urban commuters in a similar fashion.

The test results suggest that, in the prediction of rural work-trip modal choice, the disaggregate specification developed here performs better (up to 88 percent better) than the best existing aggregate models for all locations and at all times. Of the existing models, the Micromodel appears to perform better than the Macromodel or the Poisson model, which consistently underestimate the demand.

Future work will include further testing of the disaggregate specification developed here. In particular, larger data samples will make it possible to identify a system of market segmentation so that the model can be tested on aggregate data with small aggregation bias. Research is planned toward developing improved specifications to increase the model sensitivity to a larger variety of policy options. For example, the model could be extended to handle additional modes of work travel or to include additional policy and socioeconomic variables. Research is also needed in developing similar specifications for additional trip purposes so that a more complete set of travel patterns for rural residents can be estimated.

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REFERENCES

1. T.J. Adler, S.R. Stearns, and Y.J. Stephanedes. Techniques for Analyzing the Performance of Rural Transit Systems. Office of University Research, U.S. Department of Transportation, Final Rept. DOT-RSPA-DPB-50/80/23, Vol. I, 1980.
2. E. Poka, G. Maring, P. Davison, and R. Benacquista. Rural Highway Public Transportation Demonstration Program Evaluation: First Progress Report. TRB, Transportation Research Record 661, 1977, pp. 28-31.
3. J.E. Burkhardt. Results of the Rural Highway Public Transportation Demonstration Program. Presented at 59th Annual Meeting, TRB, 1980.
4. R.L. Brown. Evaluating Performance of Demand-Response Systems. Presented at 58th Annual Meeting, TRB, 1979.
5. Recommendations for Transit Performance Measures. Applied Resource Integration, Ltd., Boston, 1978.
6. Y.J. Stephanedes, D. Eagle, and A.S.J. Amin. Analyzing the Impacts of Transportation Policies on Rural Mobility and Economic Development. Office of University Research, U.S. Department of Transportation, Final Rept. (in preparation).
7. J.E. Burkhardt and A.M. Lago. Methods of Predicting Rural Demand. Ecosometrics, Inc., Bethesda, MD, 1976.
8. E.S. Newmann and B.F. Byrne. A Poisson Model of Rural Transit Ridership. TRB, Transportation Research Record 661, 1978, pp. 21-27.
9. Potential Demand for Rural Public Transportation. ITE Journal, 1981, pp. 29-31.
10. Y.J. Stephanedes. Performance Indicators and Policy Evaluation in Rural Transit. Thayer School of Engineering, Dartmouth College, Hanover, NH, Ph.D. dissertation, 1978.
11. R.L. Smith, Jr. Evaluation of Rural Public Transportation Demand Models Which Include Level of Service Measures. TRB, Transportation Research Record 638, 1978, pp. 49-51.
12. C.V.S. Mix and J.W. Dickey. Rural Public Transportation in Virginia. TRB, Transportation Research Record 519, 1974, pp. 56-65.
13. J.E. Burkhardt and W.W. Millar. Estimating the Cost of Providing Rural Transportation Service. TRB, Transportation Research Record 578, 1976, pp. 8-15.
14. R.J. Popper, C.B. Notess, and R.N. Zapata. The Demand for Special Transit Systems to Serve the Rural Elderly. TRB, Transportation Research Record 618, 1976, pp. 1-6.
15. W.R. Ugolik and R.G. Knighton. Estimating the Effects of Alternative Levels of Service on Rural Transit Ridership. TRB, Transportation Research Record 718, 1979, pp. 34-39.
16. T. Atherton and M. Ben-Akiva. Transferability and Updating of Disaggregate Travel Demand Models. Center for Transportation Studies, Massachusetts Institute of Technology, Cambridge, Rept. 76-2, 1976.
17. D. McFadden. Conditional Logit Analysis of Qualitative Choice Behavior. _In_ Frontiers in Econometrics (P. Zarembka, ed.), Academic Press, New York, 1973.
18. T.A. Domencich and D. McFadden. Urban Travel Demand. North-Holland, Amsterdam, Netherlands, 1975.
19. M.G. Richards and M.E. Ben-Akiva. A Disaggregate Travel Demand Model. Saxon House, D.C. Heath, Ltd., Westmead, England, 1975.

Synthesized Through-Trip Table for Small Urban Areas

DAVID G. MODLIN, JR.

Research performed to develop an improved and simple-to-use set of models that would facilitate the synthesis of a through-trip table for urban areas of less than 50 000 population is described. The effects of functional classification, average daily traffic, percentage of trucks, route continuity, and urban area population were determined to be significantly correlated with through-trip patterns. A least-squares analysis led to the development of a set of simple multiple regression expressions that estimate (a) the percentage of through-trip ends at each station and (b) the distribution of these trip ends among stations. The relations developed are simple to apply. The introduction of the new parameters, especially route continuity, appears to have improved the accuracy of the resulting trip table as compared with previous applications of the technique.

The Planning and Research Branch of the North Carolina Department of Transportation (NCDOT) is responsible for implementing the 3-C (continuing cooperative, and comprehensive) planning process as mandated by the Federal-Aid Highway Act of 1962. In addition, the Branch provides planning services on a contractual basis to any of the smaller urban areas that wish to develop a thoroughfare plan. To date, 165 municipalities have taken advantage of this service and 133 of the thoroughfare plans developed have been mutually adopted by the individual areas and NCDOT.

The factors leading to the implementation of various elements of a given thoroughfare plan are many and varied in nature. However, the basic element in the determination of the need for and the structure of a given thoroughfare plan is traffic volume. An analysis of existing volumes provides the basis for the determination of deficient transportation corridors. Growth in traffic volumes and the corresponding need for new and/or improved facilities may be anticipated by using some future land use plan and an understanding of the causal relations of trip generation and attraction. Typically, in major planning studies these relations are established from data available from the external, internal, truck, and taxi origin-destination (O-D) surveys. Mathematical expressions are developed that simulate the traffic patterns determined by the O-D surveys. Alternative transportation systems are then evaluated by using the developed simulation models.

The cost today of conducting O-D surveys in order to develop unique simulation models for individual small urban areas is prohibitive. Recent cost factors reported by NCDOT are the following: portable traffic counter per installation per week, \$5.55; hourly machine count per installation per week, \$14.00; classification count per 8-h count, \$92.00; external station interview per interview, \$1.00; and internal home interview per interview, \$25.00. Additional costs are incurred in the processing of the raw O-D data into final report form.

The escalating costs described above mandate a synthetic procedure for determining travel patterns in small urban areas. Abundant literature exists that both describes and documents acceptable procedures for synthesizing internal-internal trips by modeling techniques. Given that the number of external-internal trips produced at each station could be determined by modeling techniques, then a proved procedure exists for their distribution among internal traffic zones.

The models discussed in this paper build on and validate previous attempts to synthesize through-trip (external-external) patterns by using multiple regression analysis and selected variables that are routinely available. Since the average daily traffic (ADT) at a cordon station is the sum of the external-external and external-internal traffic, if one can be estimated, the other is known. Thus, by successfully applying the procedures described in this paper, the total travel patterns for small urban areas can be synthesized and the benefits of long-range planning can be achieved at a minimum cost.

REVIEW OF LITERATURE

The Planning and Research Branch of NCDOT has been particularly successful in developing and applying techniques for synthesizing internal-internal travel patterns (1). This ability to synthesize internal-internal travel patterns helps to make long-range planning available to small urban areas (those with a population of less than 50 000). However, since the early 1970s, the cost of external O-D surveys has become a significant, and restrictive, factor in the provision of long-range planning services. To be viable, long-range planning must consider the data derived from the external O-D survey.

In 1969, a study (2) required by Section 17 of the 1968 Federal-Aid Highway Act provided a set of parameters that suggested a solution to the problem of estimating through trip patterns. By using this information, data routinely available from the annual count program, and published external O-D data from small urban areas, I was successful in developing a procedure for estimating through-trip patterns (3,4). The technique used multiple regression analysis to develop two models. The first model estimated the percentage of through-trip ends at each cordon station and the second, a composite model made up of six individual equations, estimated the distribution of the through trips among cordon stations. The result of the application of the models is a triangular through-trip table.

In 1978, Pigman (5) published a report following my work that also included the results of a comparative cross-classification analysis. Pigman concluded that the regression analysis technique provided fewer data problems and provided sufficient accuracy to make its use appropriate for planning purposes.

Pigman (5) also confirmed the importance of urban area population, ADT at the external station, and the percentage of trucks as estimators of through trips. The significance of the impact of functional classification was not proved in the estimation of through-trip productions; however, the distribution models were based on the functional classification of the origin station. The models developed by Pigman are considerably simpler and consequently less tedious to use than others (3) that have been reported. In achieving simplicity, however, there appears to be some minor loss of "statistical accuracy"

Pigman's work and continued interest by NCDOT to improve on its ability to offer transportation planning services have renewed interest in the simulation of through-trip movements. That interest and the desire to test the importance of new parameters and several modifications of old ones led to the effort reported in the remainder of this paper.

MODEL DEVELOPMENT

External O-D surveys of 14 cities and towns scattered throughout North Carolina that have populations ranging from 6600 to 50 500 were the source of data for the analyses. Based on the work of others (3,5) and the experience of NCDOT staff, a basic set of independent variables had already been identified. The experiences of the staff in applying models (3) previously developed suggested that route continuity should be important in the distribution phase and that modified forms of other parameters might prove to be more useful.

External-External Generation Model: Percentage of Through Trips

The external-external trip model estimates the percentage of through-trip ends at each external cordon station. Data on urban area population, urban area employment, ADT, percentage of trucks excluding panels and pickups, and percentage of panels and pickups were tabulated for 14 urban areas (see Table 1). Multiple linear regression analysis was used to derive a prediction equation.

The total number of observations used in the analysis was 241. Models were developed under two scenarios: (a) Functional classification was significant, and (b) functional classification could be

Table 1. O-D reports used in developing through-trip estimation model.

Urban Area	Year Conducted	Urban Area Population	Urban Area Employment	No. of External Stations	ADT	Trucks (%)
Lincolnton	1975	18 500	9 400	17	220-5 980	1.8-10.1
Dunn-Erwin	1973	17 300	7 250	21	280-15 210	2.0-19.6
Tarboro-Princeville	1973	13 500	10 500	9	1 190-5 800	4.4-11.2
Mount Airy	1974	22 900	13 750	19	340-9 010	4.2-21.9
Statesville	1971	37 000	16 050	24	90-11 200	2.5-19.9
Hickory	1973	50 500	38 650	30	340-28 190	2.0-18.0
Sanford	1977	21 900	14 200	23	270-11 170	0.3-25.7
Farmville	1976	6 600	3 550	7	1 550-5 320	5.4-16.3
Boone	1976	16 000	6 200	8	880-12 220	3.6-9.3
Shelby	1975	31 500	13 600	23	150-12 370	1.3-12.8
Canton	1972	10 000	4 150	12	90-18 000	2.1-18.1
Morganton	1970	16 500	16 500	18	210-12 400	1.6-16.2
New Bern	1975	25 350	8 650	10	180-11 400	0.6-10.5
Monroe	1974	15 900	8 300	20	300-16 110	1.3-19.5

Table 2. O-D reports used in developing through-trip distribution models.

Functional Classification	O-D Reports	ADT	Through-Trip Ends (%)	No. of Observations
Interstate	Dunn-Erwin, Hickory, Canton, and Morganton	10 000-28 190	48.1-97.5	135
Principal arterial	Tarboro-Princeville, Mount Airy, Hickory, Farmville, Boone, Shelby, and New Bern	3 660-16 230	26.6-71.8	179
Minor arterial	Tarboro-Princeville, Mount Airy, Farmville, Shelby, and Morganton	2 220-8 700	20.2-50.9	85
Major collector	Tarboro-Princeville, Mount Airy, Hickory, Farmville, Boone, Shelby, Morganton, and New Bern	1 550-8 150	6.6-25.4	166
Minor collector	Mount Airy, Boone, Shelby, and Morganton	1 020-2 400	6.2-18.1	86
Local	Mount Airy, Hickory, Boone, Shelby, Morganton, and New Bern	450-2 400	4.5-18.9	118

ignored. Under the first assumption, the data were grouped by functional classification and four equations were developed; under the second, a single equation was developed. The second case proved to be the better one. The equation that was simplest, represented all functional classes, and gave the best predicting ability (R = 0.86) was

$$Y = 9.29 - 0.000\,31\ UP + 0.0026\ ADT + 1.48\ TRK \quad (1)$$
$$(6.13) \qquad (12.72) \qquad (8.07)$$

where

Y = percentage of through-trip ends of the ADT at the external station,
UP = urban area population,
ADT = average daily traffic at the external station,
TRK = percentage of trucks excluding panels and pickups at the external station, and
( ) = t-value of the coefficient.

This equation is the exact form of the one developed by Pigman (5); even the coefficients are remarkably similar. This finding should validate the applicability of the technique and lend credence to the hypothesis (4) that the models might be transferable.

External-External Distribution Model: Percentage Distributed Among Stations

The second model developed is really a composite model in which equations for each of five functional classifications estimate the distribution of trip ends among stations. The initial groupings by functional classification and O-D reports used in this analysis are given in Table 2. The independent variables that proved to be significant were ADT at the destination station, percentage of trucks excluding panels and pickups at the destination, percentage of through trips at the destination, and route continuity as a dummy variable.

The recommended equations for the distribution phase are given in Table 3. The addition of route continuity in the data set was beneficial, and the development of an ADT attraction factor, following Pigman (5), also proved to be significant. The distribution equations are much simpler and statistically better than those previously reported (3) and are as simple as, and give better R^2 values than, those reported by Pigman (5).

STATISTICAL RESULTS OF MODEL DEVELOPMENT

Statistics provides a basis for judging the worth of prediction equations such as those presented in this paper. The format of each equation can be defended logically, and this is a first test. The ease with which the values of the independent variables can be determined at a base year and the confidence with which they can be projected to a design year are also considerations in model development. The variables in the final equations are routinely available and can be projected with reasonable confidence.

Table 4 summarizes selected statistical results for the models. The measures presented seemed to portray models that are indeed appropriate for planning purposes: They are simple, statistically sound, and reasonably accurate.

A further test is one of model performance on a station-by-station and movement-by-movement basis. A decision was made to compare the performance of the models presented in this paper with that of models previously developed (3) by using the original test cites, Ahoskie and Wilson. Based on root-mean-square error (RMSE), the model recommended in this paper for estimating percentage of through-trip ends yielded significantly poorer results for both Ahoskie (1965) and Wilson (1964) O-D data than did the previously reported models (3). Percentage of trucks seemed to be the cause of the poorer results. The old models (3) were developed by using an average 1965 data base, whereas the models reported in this paper are based on average 1975 data. Could it be that over the 10-year period an assumption that the truck-car through-trip relation had remained

Table 3. External-external trip distribution models.

Functional Classification of Origin Station	Distribution Equation	R^2
Interstate	Y = -2.70 + 0.21 PTTDES + 67.86 RTECON (5.48) (23.28)	0.96
Principal arterial	Y = -7.40 + 0.55 PTTDES + 24.68 RTECON (6.22) (9.09) + 45.62 ADT/CD (2.66)	0.87
Minor arterial	Y = -0.63 + 86.68 ADT/CD + 30.04 RTECON (8.18) (11.38)	0.86
Major collector	Y = -1.08 + 0.000 79 DESADT + 0.47 PTKDES (4.21) (2.43) + 31.78 ADT/CD (3.45)	0.69
Minor collector and local	Y = -0.40 + 109.42 ADT/CD (15.37)	0.73

Note: Y = percentage distribution of through-trip ends from an origin station to a destination station, PTTDES = percentage of estimated through-trip ends at destination station, RTECON = route continuity (1 = yes, 0 = no), ADT/CD = ADT at destination station divided by the sum of ADT at all stations, DESADT = ADT at destination station, PTKDES = percentage trucks excluding panels and pickups at the destination station, and ( ) = t-value for the coefficient.

Table 4. Statistical results for models.

Model	Total Observations	Mean of Dependent Variable	R^2	Standard Error	Coefficient of Variation
Percentage through-trip ends	241	20.58	0.74	9.66	47
Distribution of through-trip ends					
Interstate	134	5.22	0.92	5.36	103
Principal arterial	179	8.95	0.76	9.35	104
Minor arterial	85	8.24	0.74	6.63	80
Major collector	166	7.22	0.48	7.74	107
Minor collector and local	204	6.46	0.53	6.83	106

Table 5. Analysis of stability of through-trip-end estimation model.

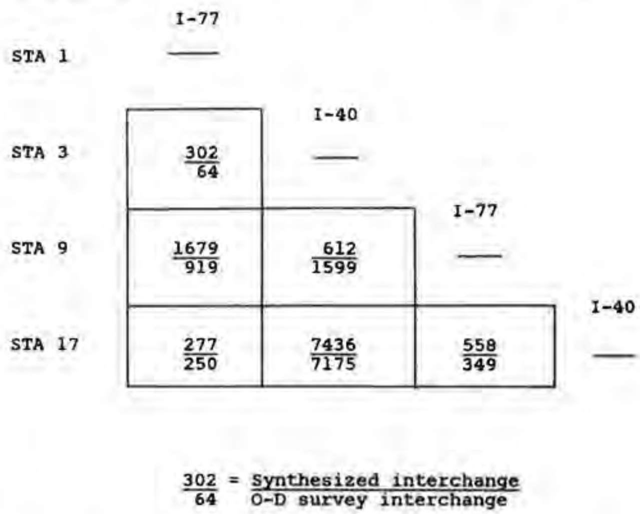
Item	1958	1973
Cordon ADT	22 798	29 790
Number of trucks excluding panels and pickups	2 705	2 407
Percentage of trucks	11.87	8.08
Through-trip ends	6 676	6 586
Percentage through-trip ends of cordon ADT	29.28	22.11
RMSE for trip-end-estimation model performance (%)	10.37	9.40

constant was indeed invalid?

As a beginning point in attempting to answer this question, the average percentage of trucks of the station volumes for the 1965 and 1975 periods was analyzed. On a 1965 basis, both Ahoskie and Wilson had more than 11 percent trucks in the traffic stream crossing the cordon, whereas the average percentage of trucks crossing the cordon in the 1975 data base was 7.1 percent. It appeared that the composition of the traffic stream had indeed changed over time and that a performance comparison that used the old test data to compare the new models with those previously reported would be invalid.

Fortunately, external O-D surveys had been conducted in Elizabeth City during two time periods, 1958 and 1973. The availability of these data provided the opportunity to test in a limited manner the hypothesis that the relation of percentage of trucks in the traffic stream to the production of through trips was changing over time. A summary of the pertinent analysis data is given in Table 5. The

Figure 1. Distribution results with major intersecting routes: Statesville, North Carolina.



models recommended in this paper performed better when compared with the 1973 O-D data than when compared with the 1958 data. This result tends to confirm the hypothesis that through-trip production models have been dynamic during the past two decades and that periodic reevaluation of the models is required in order to maintain their maximum efficiency.

Now that there was an explanation for the adverse comparison of the old versus new models utilizing the 1965 vintage O-D data, a test of the new through-trip estimation model was performed on 1975 O-D data for Laurinburg, North Carolina, a city with an urban area population of 22 500 and 20 external cordon stations. The model performed extremely well, yielding an RMSE of 7.6 percent. One station, Secondary Road 1601, had an extraordinarily high proportion of trucks, 18.3 percent, compared with the station volume of 240 vehicles/day. Removing this station from the analysis yielded an RMSE of 6.3 percent.

The next test was that of the distribution models. Again, the new distribution models were tested against those previously reported (3) by using the 1965 Ahoskie O-D data. The old distribution models had previously given an RMSE of 87.8 trips; in comparison with the same data, the new models gave an RMSE of 88.1 trips. Given that the basis for the distribution was the trip ends estimated by the generation model, it can be concluded that the new distribution models are superior to the old ones. This statement is derived from the fact that the through-trip ends estimated by the new generation model based on the 1965 Ahoskie test data had an RMSE of 13.6 percent compared with that of 11.5 percent for the old models (4). Therefore, the starting point for the new distribution models had 18 percent more error than the old models. The new models not only are much simpler but also produce a better distribution.

A problem discovered in applying the old through-trip distribution models was the poor performance of the models in handling the case of the intersection of two major facilities--e.g., I-40 and I-77 in Statesville, North Carolina. This situation was tested with the new models, and the results are shown in Figure 1. For route continuity, the paired stations are 1 and 9 and 3 and 17. The results are much better than those for the old distribution models.

Table 6. Input data for example model application.

Station No.	Functional Classification	ADT	ADT/Cordon	Trucks (%)	Route Continuity
1	Major collector	1550	0.075	5.7	No
2	Major collector	2200	0.107	7.3	No
3	Major collector	1560	0.076	5.4	No
4	Principal arterial	4380	0.214	16.3	With 6
5	Minor arterial	3130	0.153	9.7	With 7
6	Principal arterial	5320	0.260	16.2	With 4
7	Minor arterial	2360	0.115	14.4	With 5

Note: Urban population = 6600.

Table 7. Selected distribution results.

Origin Station	Destination Station	Calculated Percentage	Adjusted Percentage	Factor
1	2	7.49	10.63	1.4196
	3	5.11	7.25	
	4	16.84	23.91	
	5	10.81	15.35	
	6	18.99	26.96	
	7	11.20	15.90	
Total or avg		70.44	100.00	
4	1	6.86	6.19	0.9019
	2	10.55	9.51	
	3	6.68	6.02	
	5	15.94	14.38	
	6	53.92	48.63	
	7	16.93	15.27	
Total or avg		110.88	100.00	
5	1	5.87	5.89	1.0032
	2	8.64	8.67	
	3	5.96	5.98	
	4	17.92	17.98	
	6	21.91	21.98	
	7	39.38	39.50	
Total or avg		99.68	100.00	

EXAMPLE APPLICATION OF MODELS

A short example is offered to demonstrate the ease with which the recommended models can be applied and to illustrate some of the mathematical detail in developing the estimated through-trip table. The input data required are given in Table 6.

Estimates of the percentage of through-trip ends at each external station are developed by using the major-collector equation given in Table 3. Then each percentage is multiplied by the corresponding station ADT to produce an estimate of the number of through-trip ends passing the station. These trip ends will be used in the distribution phase. The results for the example are given below (total trips = 3575):

Station No.	Through-Trip Ends: Estimated Percentage	Calculated No.
1	19.71	306
2	23.76	523
3	19.29	301
4	42.75	1872
5	29.74	931
6	45.05	2397
7	34.69	819
Total		7149

The next step is to match each station, according to its functional classification, with the proper equation as given in Table 3. The correct equation for each distribution is chosen according to the station from which the trip ends are to be distributed, the origin station. For example, from station 1, major collector, to all other stations, one would choose Equation 4 from Table 3.

In applying any of the distribution equations, the resulting sum of the estimated percentages from one station to all others does not generally add up to 100 percent. The percentages should simply be factored so that their resulting sum is 100 percent. The results of the distribution phase for this example are given in Table 7 for stations 1, 4, and 5.

In applying the proper distribution equation at each station, the estimated two-way trip interchange between a particular origin station and all other destination stations is generated. Two-way trips are distributed because the dependent variable initially estimated was trip ends. The distribution procedure, when completed, results in two estimates of two-way trip interchange for every pair of stations, each having acted as an origin station once. The value used for this triangular trip matrix is taken as the average of the two values.

After the estimated trip interchanges are averaged and the trip matrix is summed, the total number of trip ends at individual stations will vary from the values predicted by the initial equation. This results because of the averaging procedure. A FRATAR factor is determined, and the trip table is balanced and adjusted to the initial predicted number of through-trip ends at each station. Figures 2 and 3 present the results of the above procedures for the example problem.

Figure 2. Synthesized through-trip table.

(Small corner figures printed in each cell are given in parentheses: left, right.)

STA. NO.	1	2	3	4	5	6	7
1	0						
2	37 (33, 40)	0					
3	22 (22, 22)	35 (38, 22)	0				
4	94 (73, 116)	154 (129, 178)	92 (72, 113)	0			
5	51 (47, 55)	82 (83, 81)	51 (46, 56)	218 (269, 167)	0		
6	118 (82, 153)	190 (146, 235)	115 (81, 149)	1018 (910, 1127)	280 (204, 355)	0	
7	48 (49, 47)	78 (86, 69)	48 (48, 47)	215 (286, 143)	353 (368, 339)	276 (378, 174)	0
TOTAL	370	576	363	1791	1035	1997	1018
DESIRED TOTAL	306	523	301	1872	931	2397	819
FRATAR FACTOR	0.827	0.908	0.829	1.045	0.900	1.200	0.805

Figure 3. FRATAR adjusted through-trip table.

STA. NO.	1	2	3	4	5	6	7
1	0						
2	24	0					
3	13	25	0				
4	70	124	69	0			
5	37	67	37	186	0		
6	130	229	125	1268	349	0	
7	30	56	32	156	255	293	0
TOTAL	304	525	301	1873	931	2394	822

SUMMARY AND CONCLUSIONS

The purpose of the research discussed in this paper was to try to improve the methodology for synthesizing a through-trip table for small urban areas. New parameters were introduced in an attempt to alleviate problems discovered in using previously developed models. The new variables that proved to be significant, both in leading to simpler models and avoiding old problems, were route continuity as a dummy variable and station ADT developed as an attraction factor.

Both models continue to reflect the importance of trucks in the estimation and distribution of through trips. The importance of this factor has varied since the mid-1960s. During the mid-1970s, the increased availability of the automobile and an expanded standard of living diminished the correlation between trucks and through trips. The important point is that, as relations among the independent parameters change, the models, to remain valid, must be updated.

Overall, the models presented are adequate for long-range planning purposes. They are extremely easy to apply and produce results that are reasonable and sufficiently accurate for planning purposes.

REFERENCES

1. Procedure for Synthesizing Internal Traffic Movements. North Carolina Department of Transportation, Raleigh, 1976.
2. Bureau of Public Roads. 1968 National Highway Functional Classification Study Manual. U.S. Government Printing Office, 1969.
3. D.G. Modlin, Jr. Synthetic Through Trip Patterns. Transportation Engineering Journal, Proc., ASCE, Vol. 100, No. TE2, 1974, pp. 363-378.
4. D.G. Modlin, Jr. Synthesis of Through Trip Patterns in Small Urban Areas. Department of Civil Engineering, North Carolina State Univ., Raleigh, 1971.
5. J.G. Pigman. Simulation of External-Internal and Through Trips for Small Urban Areas. Division of Research, Kentucky Bureau of Highways, Lexington, 1978.