Tests of the Temporal Stability of Travel Simulation Models in Southeastern Wisconsin

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The assumption of the stability of travel simulation models over time is an essential element of the urban transportation planning process. This assumption was tested using travel simulation models developed with data from an origin and destination survey conducted in 1963 and travel inventory data from a similar study conducted in 1972. Both surveys were conducted by the Southeastern Wisconsin Regional Planning Commission; the travel models tested were those that had been used in the preparation of a regional land use and transportation plan for southeastern Wisconsin that was completed in 1966. The testing performed as a part of the reappraisal of the land use and transportation recommendations of 1966, which was of the temporal stability of the three major travel simulation models—trip generation, modal split, and trip distribution—indicated that 1972 trip generation, transit use, and trip length characteristics within southeastern Wisconsin were predicted with adequate accuracy through the application of the original 1963 models.

A basic assumption of most urban transportation studies is that travel simulation models defined through analysis of base-year origin and destination survey data will remain stable over time, thus allowing the evaluation of alternative transportation plans for the future. In recent years considerable interest has been directed toward the validity of this assumption. The doubts of the validity of the assumption have been a result of assertions that the travel simulation models employed in most transportation planning efforts, which are based on a system of spatial aggregation and do not consider all the variables known to affect travel, have been developed on a descriptive, rather than a causative, basis (1). In consequence, the ability of such models to accurately predict future travel under conditions substantially different from those of the base year has been questioned. This assumption of temporal stability has never been adequately tested, as comparable data for the same area for two points in time have been available in only a limited number of instances (2). However, as a result of major origin and destination (O-D) surveys now being conducted in areas in which similar surveys were completed in the 1960s, the testing of this assumption—over short periods of time (10 years)—is now possible.

One of the areas in which two compatible O-D studies have been completed is the seven counties of southeastern Wisconsin. Major travel studies have been conducted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC), which was established in 1960 to assist in solving areawide problems and in planning the physical development of the region. The first O-D study, performed in 1963, was part of the basis for the preparation of a regional land use and transportation plan for the area that was completed in late 1966. The second O-D study was conducted in 1972 and used in the reevaluation of the original land use and transportation recommendations. One of the factors prompting this reappraisal of the original planning effort was the recognized need to update the plans in light of changing conditions within the region, particularly the changes in those factors that would influence transportation system development.

A significant part of the analysis of changing conditions was the review of the ability of the travel simulation models used in the initial planning effort to predict 1972 travel, i.e., a test of the temporal stability of the relationships defined in the travel simulation models. The 1972 travel was predicted by applying the models developed in the original planning effort and comparing the results with the results of the O-D survey. The following sections summarize the approaches used by the three major travel simulation models—trip generation, model split, and trip distribution—and evaluate their continual validity.

TRIP GENERATION

In the SEWRPC 1963 regional land use and transportation study, trip generation was analyzed and simulated through the development of nine equations, four of which related total trip production by trip purpose to the land use within each traffic analysis zone and five of which related total trip attractions by trip purpose to such land use. The nine equations were developed with multiple regression analysis applied in a stepwise manner for the trip purposes of home-based work, home-based shopping, home-based other (a combination of personal business, medical-dental, social, and recreation), and non-home-based. Home-based school trips were analyzed and forecast using a growth factor technique. A balancing procedure was used for trip generation forecasts, which adjusted zonal totals of home-based shopping, home-based other, and non-home-based trip

attractions so that the total trip attractions were equivalent to the total trip productions for these three purposes. For the home-based work trip purpose, zonal trip productions were adjusted so that regional home-based work trip productions were equivalent to total home-based work trip attractions.

The ability of the trip generation equations developed in the original land use and transportation planning program to simulate 1972 trip making was investigated by comparing the predictions of the equations to the actual 1972 travel survey data. Travel surveys conducted by the commission indicated that trip generation within southeastern Wisconsin increased by about 25 percent from 1963 to 1972, with work trips having the smallest increase (19 percent) and shopping trips the largest (30 percent). The ability of the trip generation equations developed and applied in 1963 to accurately predict these changes in regional trip generation is shown in the comparison of estimated and observed number of trips in 1972 given below.

Trip Purpose	Estimated No. of Trips	$\left(\frac{\text{Estimated}}{\text{Observed}}\right) \times 100\%$
Home-based work	1 151 800	108.2
Home-based shopping	770 600	113.6
Home-based other	1 552 700	99.8
Non-home-based	749 100	90.0
Total	4 435 100	102.5

The equations predicted regional trip generation with a high degree of accuracy considering the nature of the phenomena involved. That is, the actual 1972 regional trip generation data used as the basis for comparison, the 1963 trip generation data used to calibrate the original equations, and much of the data necessary to prepare predictions of 1972 trip generation—household socioeconomic characteristics—are all estimates derived from travel surveys. Thus, considering the limitations inherent in the data, the total trips generated in 1972 were predicted by the equations with a high degree of accuracy, although with some divergence with respect to trip purpose.

The ability of the original equations to estimate 1972 trip generation on the level of a small geographic area or traffic analysis zone is shown in Figures 1 and 2. These figures indicate the correspondence between observed and estimated 1972 zonal trip productions for the trip purposes of home-based work and home-based other; similar results were obtained for other trip purposes. Although there are considerable differences between actual and predicted trip generation by zone, there is no consistent bias of overestimation or underestimation. Moreover, much of the variance can be attributed to the random variations expected in any survey data, as well as to zonal characteristics not considered in the trip generation equations—both of which may cause deviations between observed and estimated values from regression procedures in a base year—rather than to possible changes over the past decade in the relationship between trip generation and the variables used to explain trip making in the equations developed in the initial planning effort (3). Again, considering the nature of the data used to develop the equations and to compare observed and estimated trip generation, and the detailed level at which this analysis and comparison were conducted, the 1972 trip generation was predicted with an adequate degree of accuracy on a zonal level.

MODAL SPLIT

Modal split was determined prior to trip distribution in the initial regional land use and transportation study for southeastern Wisconsin. The trip end models used were based on the relationships between the percent transit use in a traffic analysis zone, the average household automobile availability in the zone, and the relative availability and quality of highway and transit service as measured by an accessibility ratio (4). Two separate sets of modal split models were calibrated for the three urban areas within the region in which there was transit service in 1963: one set for the Milwaukee area and the other for the Racine and Kenosha areas combined. In the Milwaukee urban area the modal split relationships were developed for four trip purposes: home-based work, home-based shopping, home-based other, and non-home-based. The Racine and Kenosha urban area models were developed for three trip purposes: home-based work, home-based other and shopping, and non-home-based. The modal split relationships were defined mathematically by developing by hand three-dimensional surfaces whose axes were: automobile availability expressed in terms of the number of automobiles per household in a zone, the accessibility ratio of a zone for the trip purpose considered, and the percent transit use.

The modal split modeling procedure used in the initial land use and transportation study for the Milwaukee area was reviewed and modified slightly as a part of a Mass Transit Technical Planning Study in Milwaukee County begun in 1968 and completed in 1971. This modification included the consideration of home-based shopping, home-based other, and non-home-based trips in a single combined model as opposed to the three separate models of the initial study, and a redefinition of the accessibility ratio as used in the original model formulation (5).

The ability of the modal split models developed and used in the initial land use and transportation study and the Milwaukee County Mass Transit Technical Planning Study to predict 1972 transit use within the region was evaluated using actual 1972 O-D survey data. From 1963 to 1972 transit use in southeastern Wisconsin decreased significantly, in both the total number of transit trips and the percentage of the total market that used transit for trip making. The reduction in transit trip making was about 50 percent in the Milwaukee urban area and almost 80 percent in the Racine and Kenosha urban areas. The ability of the modal split models formulated and calibrated in the initial transportation study to estimate this change in regional transit use over the past 9 years is illustrated in Table 1. The model from the original land use and transportation study overestimated 1972 transit use within the region by approximately 10 percent; the modified model underestimated transit use within the Milwaukee area by about six percent. However, since the data—such as transit travel and total person travel by zone, zonal automobile availability, trip attractions, and transit and highway zonal interchange travel times—used in the application of the model are estimates, and since substantial changes in automobile availability and transit service and use have occurred over the past decade, the 1972 regional transit use predicted through application of the original and modified modal split models has a high degree of accuracy.

The ability of the modal split model to estimate transit use on a traffic analysis zone level in the Milwaukee urban area is shown in Figure 3, which displays the correspondence between predicted and observed 1972 zonal total transit trip productions. Similar results were obtained with the modified modal split model and, in the Racine-Kenosha areas, with the original predic-

Figure 1. Comparison of predicted and observed 1972 total person home-based work trip generation by zone.

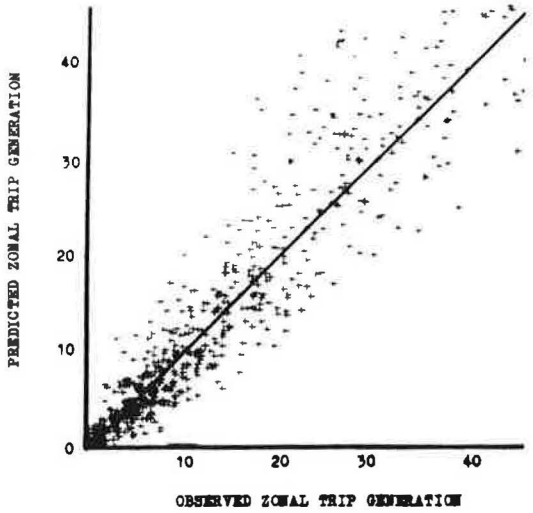


Figure 2. Comparison of predicted and observed 1972 total person home-based other trip generation by zone.

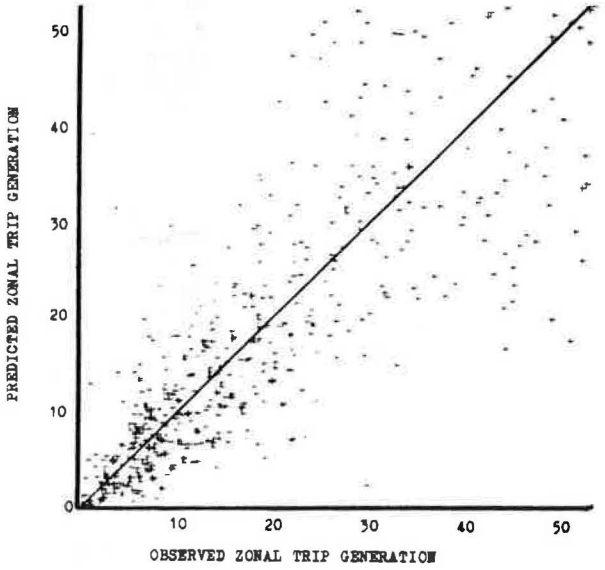


Table 1. Comparison of observed and estimated 1972 transit use within the southeastern Wisconsin region.

Trip Purpose	Estimated No. of Trips		(Estimated/Observed)[a]	
	1963 Model	Modified 1963 Model	1963 Model	Modified 1963 Model
Milwaukee				
Home-based work	78 810	72 070	111.9	102.3
Home-based nonwork[b]	63 860	48 850	108.7	83.1
Home-based shopping	21 310		117.0	
Home-based other	25 070		90.5	
Non-home-based	17 370		136.6	
Subtotal trips[b]	142 670	120 920	110.4	93.6
Racine-Kenosha				
Home-based work	1 040		100.2	
Home-based shopping/other	1 510		125.8	
Non-home-based	240		82.0	
Subtotal	2 790		110.2	
Total[b]	145 460		110.4	

[a] No. of Trips x 100%. [b] Also includes school trips.

Figure 3. Comparison by zone of predicted and observed 1972 total transit trips in the Milwaukee urban area.

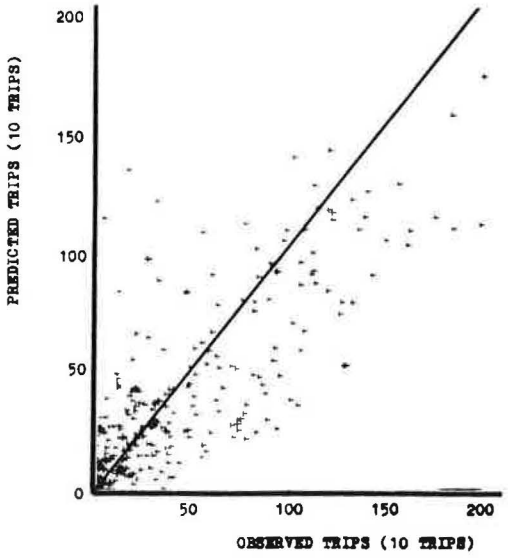


Figure 4. Comparison of observed total person trip length frequency distributions for home-based work travel within the region: 1963 and 1972.

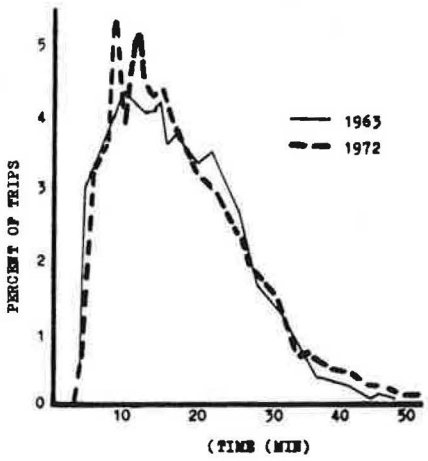
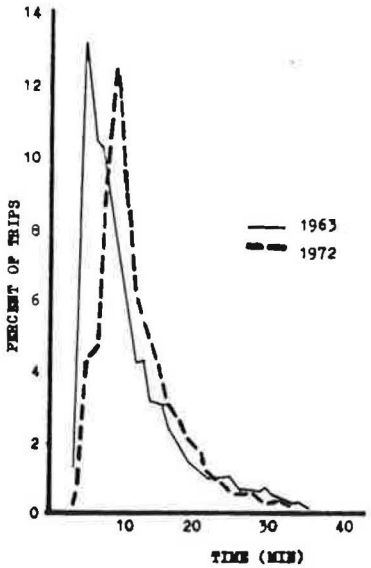


Figure 5. Comparison of observed total person trip length frequency distributions for home-based shopping travel within the region: 1963 and 1972.



tion procedures. Although there are considerable differences between the observed and predicted zonal transit trips, there is no consistent bias of substantial overestimation or underestimation. Much of the variance can again be attributed to random variation in survey data, rather than to changes in the relationship between modal split and automobile availability and the relative quality and quantity of highway and transit service over the past decade.

TRIP DISTRIBUTION

In the initial study internal person trip distribution was simulated by mode, following modal split through the uses of automobile driver and transit person gravity models, for travel with the trip purposes of home-based work, home-based shopping, home-based other, and non-home-based. For each of these gravity models, the calibrated friction factors were assumed to remain valid for the future. Zonal adjustment factors, although investigated, were not used for forecasting future travel patterns.

The stability of the 1963 trip distribution procedure was tested through a comparison of predicted and observed 1972 trip length characteristics. Trip length characteristics within southeastern Wisconsin have remained fairly stable from 1963 to 1972. As shown below, the average trip length for automobile and transit travel increased only slightly over the past 9 years for both modes for all trip purposes except automobile travel with the trip purpose of home-based shopping, which increased significantly. Another measure of the trip length characteristics simulated in trip distribution is the trip length frequency distribution, a determination of the percentage of total trips that occur in 1-min time increments. From 1963 to 1972 the trip length frequency distribution for combined automobile and transit travel for the trip purpose of home-based work remained stable, as shown in Figure 4, but the frequency distributions for combined automobile and transit travel for all other trip purposes changed slightly. This change consisted of a shift in the peak trip length, as shown in Figure 5, which compares 1963 and 1972 trip length frequency distribution for aggregated automobile and transit travel for the trip purpose of home-based shopping.

Trip Purpose	Average Trip Length 1963	1972	Change (%)
Transit			
Home-based work	35.9	37.2	+3.7
Home-based shopping	28.5	31.9	+11.9
Home-based other	32.5	36.3	+11.7
Non-home-based	28.4	31.2	+9.9
Automobile driver			
Home-based work	17.9	17.9	0.0
Home-based shopping	9.2	11.6	+26.5
Home-based other	12.4	13.5	+9.4
Non-home-based	12.6	14.0	+11.9

The ability of the automobile driver and transit person gravity models, as calibrated in 1963, to estimate this change, measured in terms of average trip length and trip length frequency distributions, is shown below and in Figures 6 and 7. The average trip lengths for trips with a purpose of home-based work for both automobile driver and transit person were accurately predicted. The average trip lengths for home-based shopping, home-based other, and non-home-based trips for both automobile driver and transit person were predicted with reasonable accuracy, considering that the data used to establish both the actual and estimated trip distributions were estimates derived from travel surveys. The predicted trip length frequency distributions generally corresponded with the observed distributions; however, for all modes and all trip purposes except home-based work, the peak percentage of trips within a single time increment had been predicted to occur in a time increment shorter than that observed in the 1972 travel survey data. Figure 6 displays the accuracy with which the transit trip length frequency distributions of 1972 for the trip purpose of home-based work were predicted. The differences between predicted and observed 1972 automobile and transit trip length distributions for other trip purposes are shown by the example of Figure 7, which compares observed and predicted 1972 distributions for home-based other travel by the automobile. However, although trip length characteristics were predicted with reasonable accuracy with the 1963 models, a better test of the time stability of the trip distribution procedure would have been a test of its ability to predict zone-to-zone trip interchanges over time.

Figure 6. Comparison of 1972 predicted and observed transit trip length frequency distributions for home-based work travel within the region.

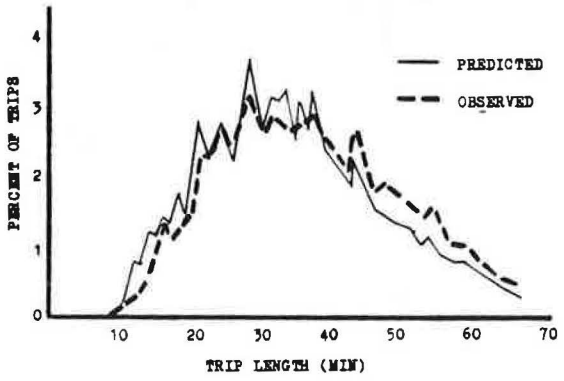
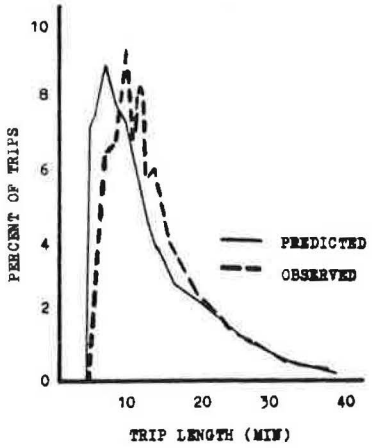


Figure 7. Comparison of 1972 predicted and observed automobile driver trip length frequency distribution for home-based other travel within the region.



Trip Purpose	1972 Average Trip Length Predicted	Actual	Difference (%)
Automobile driver			
Home-based work	17.9	17.9	0.0
Home-based shopping	9.3	11.6	-19.8
Home-based other	12.7	13.5	-5.9
Non-home-based	12.4	14.0	-11.4
Transit			
Home-based work	36.9	37.2	-0.8
Home-based shopping	29.6	31.9	-7.2
Home-based other	32.3	36.3	-11.0
Non-home-based	27.2	31.2	-12.8

SUMMARY AND CONCLUSIONS

The assumption of the stability over time of travel simulation models calibrated with base-year data is an essential element of present urban transportation planning. This assumption was tested in southeastern Wisconsin by using travel simulation models calibrated with data from an O-D survey conducted in 1963 and travel inventory data from a second survey completed in 1972. This was accomplished by comparing observed 1972 trip generation, transit use, and trip length characteristics with estimates derived by applying the original 1963 trip generation, modal split, and trip distribution models individually to 1972 observed independent variable data; the testing indicated that the predictions of the models on both regional and zonal levels were reasonably accurate. Even though the model relationships for travel forecasting purposes had remained stable over time, changes were made in the travel simulation modeling framework used in the reevaluation of the original land use and transportation plan for southeastern Wisconsin. These changes were made primarily as a result of advances in the state of the art in travel simulation and included the use of cross-classification analysis for trip generation as opposed to the aggregate technique used in the original study.

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