Method To Enhance Performance of Synthetic Origin-Destination Trip-Table Estimation Models

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The conventional methods of determining origin-destination (O-D) trip tables involve elaborate surveys, such as home interviews, that require considerable time, staff, and funds. To overcome this drawback, a number of theoretical models that synthesize O-D trip tables from link volume data have been developed. Two of these models—The Highway Emulator (THE) and the Linear Programming (LP) model—are considered. These models use target/seed tables for guiding the development of output trip tables. In research conducted by the Virginia Techical Center for Transportation Research for the Virginia Transportation Research Council, it was determined that use of a superior target/seed table potentially could enhance the performance of these models. Readily available socioeconomic data and link-volume information were used to develop a methodology for obtaining an enhanced target/seed table through application of the trip-generation and trip-distribution steps of the four-step planning process. The enhanced table then was used as the target/seed to the LP and THE models, and their performance was evaluated. The closeness of the output tables to surveyed tables and their capability to replicate observed volumes were studied. Also analyzed were the output tables' improvements when a structural table was used as target. Tests showed that the use of the enhanced target/seed table significantly improved the performance of the LP model. However, mixed trends were obtained for the THE model.

An origin-destination (O-D) trip table is a two-dimensional matrix of elements whose cell values represent the number of trips made between various O-D zone pairs in a given region. The establishment of a current O-D trip table for an urban area through conventional surveys, such as home interviews, license plate surveys, and roadside surveys, is expensive, time-consuming, and labor-intensive. In addition, most of these methods are conducted through sampling and have associated sampling errors due to the reliance on only a small sample of trip-makers. Even if all the trips on a particular day are recorded, the O-D table might not be stable over time due to daily variations (*1*).

There are other inherent drawbacks associated with conventional techniques as well. One common problem is the changes in travel pattern due to changes in influencing factors. For instance, as the land use develops or changes rapidly, so will the trip table. Thus, the previously established trip table becomes outdated and obsolete. This will necessitate resurveying, leading to further expenditures and efforts.

Recognizing the budgetary, time, and staff constraints faced by organizations needing O-D tables for planning and traffic operations purposes, researchers began exploring alternative techniques of establishing O-D tables, leading to the evolution of theoretical approaches in the early 1970s. Several approaches and models have been developed since then for establishing trip tables without the need for surveys by using link volumes.

In an earlier research effort sponsored by the Virginia Transportation Research Council (VTRC) and conducted by the Virginia Tech's Center for Transportation Research (*2*), a comprehensive review of models that estimate trip tables from link-volume information (hereinafter referred to as *synthetic models*) was performed. Two of these—the Linear Programming (LP) model developed at Virginia Tech (*3–6*) and The Highway Emulator (THE) model (*7*)—were selected for evaluation.

The LP model employs the nonproportional assignment assumption and finds a user equilibrium solution that reproduces the observed link flows whenever such a solution exists. Although the individual user is driven by the choice of a least-impedance path, the model recognizes that, due to incomplete information, the actual flow may not exactly conform to a user-equilibrium solution. Moreover, due to inherent inconsistencies in the link traffic data, there might not exist a trip table that can exactly duplicate the link flows. Accordingly, these features are accommodated into the model through suitable artificial variables and objective penalties. However, if a user-equilibrium solution that reproduces the link flows does exist, then the model, with suitable penalty parameters, will determine such a solution along with the corresponding O-D trip table.

The linear programming model is formulated as follows (*3,4*):

$$\text{Minimize} \sum_{(i,j)\in OD}\sum_{k=1}^{n_{ij}} \hat{t}_{ij}^{tk} x_{ij}^{k} + Me\cdot\left(y^{+} + y^{-}\right) + M_{\sigma} \sum_{(i,j)\in\overline{OD}} \left(Y_{ij}^{+} + Y_{ij}^{-}\right) \quad (1a)$$

$$\text{subject to} \sum_{(i,j)\in OD}\sum_{k=1}^{n_{ij}} p_{ij}^{k} x_{ij}^{k} + y^{+} - y^{-} = \bar{f} \quad (1b)$$

$$\sum_{k=1}^{n_{ij}} x_{ij}^{k} + Y_{ij}^{+} - Y_{ij}^{-} = Q_{ij} \qquad \forall(i,j)\in\overline{OD} \quad (1c)$$

$$x \geq 0, \quad y^{+} \geq 0, \quad y^{-} \geq 0, \quad Y^{+} \geq 0, \quad Y^{-} \geq 0 \quad (1d)$$

where

OD = set of O-D pairs comprising the trip table;
$\overline{OD}$ = some key O-D pairs for which target values are specified;
(i, j) = O-D pair from origin i to destination j;
k = path identifier between different O-D pairs;
n_{ij} = number of paths between each O-D pair (i, j);
$\hat{t}_{ij}^{k}$ = weighted impedance on route k between each O-D pair (i, j);

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$$= \begin{cases} t_{ij}^k & \text{if } k \in K_{ij} \\ M_1 t_{ij}^k & \text{if } k \notin K_{ij} \end{cases}$$

t_{ij}^k = impedance on route k between each O-D pair (i, j);
K_{ij} = set of paths between each O-D pair (i, j) whose path costs are equal to the shortest path for the O-D pair (i, j);
x_{ij}^k = flow on path p_{ij}^k, for each $k = 1, \Lambda, n_{ij}, (i, j) \in OD$;
e = a vector of 1's;
$y^+ (y^-)$ = vector of positive (negative) deviations in link flows;
$Y^+ (Y^-)$ = vector of positive (negative) deviations from targeted trip-table values;
p_{ij}^k = kth path between an O-D pair $(i, j) \in OD$;
$\bar{f}$ = vector of observed link volumes;
Q_{ij} = prior (target) trip-table value for O-D pair $(i, j) \in \overline{OD}$; and
M_1, M_σ = scalar penalty parameters.

In addition, due to the potentially large number of alternative paths to be considered between the different O-D pairs, an efficient column-generation technique using shortest path subproblems was developed and incorporated into the LP model to determine an optimal solution. Finally, the model was designed to handle the situation to the foregoing considerations, has a tendency toward reproducing this table as closely as possible.

Complete details of this model, its solution technique, and its initial application can be found elsewhere (*3,4*). The original linear programming model required the specification of volume data on all the links of the network. Realizing the constraint, the model was enhanced to accommodate missing volume data and to estimate O-D tables even when only a partial set of link traffic counts are available (*5,6*). The notation "LP" is used in this paper to refer to the linear programming model, in general, and not to the specific formulation and "LP" in the studies that were referred to earlier (*3,4*). Several versions and different formulations of the model evolved over the course of the development and enhancement of the approach. Thus, more than a single version/formulation has been used in this research.

The THE model (*7*) is a microcomputer highway traffic simulation model that analyzes individual communities, corridors, and small sections of counties or major cities. Two distinct modeling approaches are incorporated into the THE model. The first approach uses the traditional four-step urban transportation planning methodology, and the second approach uses the maximum entropy algorithm for estimating trip tables from link traffic volumes. It extracts a most likely trip table that will produce observed traffic counts. The trip-table estimation program is based on the maximum entropy formulation and algorithm detailed by Van Zuylen and Willumsen (*8*). A *maximum entropy algorithm* is one that attempts to define a trip table with the maximum degree of disorder or random exchange between zones. Here, the most likely trip matrix is defined as the one having the greatest number of microstates associated with it. Attempting to maximize the number of ways to select a trip matrix, Willumsen formulates the problem as

$$\max F(T) = -\sum_i \sum_j \left(t_{ij} \ln t_{ij} - t_{ij}\right) \tag{2a}$$

subject to

$$v_a = \sum_i \sum_j p_{ij}^a t_{ij} \tag{2b}$$

where

t_{ij} = number of trips between zone i and zone j,
v_a = volume of traffic on link a, and
p_{ij}^a = proportion of trips between origin i and destination j using link a.

The derived table would be the one most likely to be consistent with information contained in the link flows. Van Zuylen and Willumsen (*8*) also give an algorithm for solving the above problem.

Detailed and extensive tests were conducted to evaluate the validity of these models and to determine the sensitivity of the models to various percentages of link volumes available and target tables. The LP model was judged to be generally superior, both in terms of closeness of modeled trip tables, to the "correct/surveyed" tables and also in replicating observed link volumes. One of the validation case studies was performed by comparing the models' output tables with the tables developed from O-D surveys conducted by the Virginia Department of Transportation (VDOT) for the town of Pulaski, Virginia.

Like most of the models in this family, the LP and THE models employ some form of old/prior trip table as a target/seed to guide the solution. However, such tables are not always available, leading to the models' questionable performance. In fact, in the Pulaski research effort, VDOT was primarily interested in the case in which no prior trip-table information was available. This is significant because many of the urban areas for which a trip table is needed do not have a previously established table. Thus, the only option is the use of a *structural target table,* which is a table with 0 or 1 as the cell value (0 signifying that the O-D interchange represented by the cell is not feasible—that is, a path connecting this O-D pair does not exist, thus making it infeasible to travel between these zones; and 1 where it is feasible). The THE model produced better results than the LP model for this case, but results from neither of the models were fully satisfactory. The study did show, however, that the amount of information contained in the seed table played a key role in determining the quality of the output table.

It is possible to establish an O-D table based on readily available and easily accessible socioeconomic/census data that is a better representation of the travel patterns in the region than a structural table. This table then can be used as a target to select O-D table estimation models.

PURPOSE AND SCOPE

The primary purpose of this research was to determine if the performance of the LP and THE models could be improved through the use of a target/seed table developed from readily available and easily accessible socioeconomic data. A secondary purpose was to evaluate any improvement, as well as the relative performance, of the models by comparing their output with the results of VDOT's Pulaski survey (similar to the evaluation conducted in the aforementioned earlier study).

The Pulaski highway network and the O-D table developed by VDOT in the previous study (*2*) were used for this research. Most of the required data were available from VDOT; however, some of the data on socioeconomic variables were obtained from officials in Pulaski.

METHODOLOGY

The overall approach to the research was to obtain zone-specific socioeconomic data for the town of Pulaski, Virginia, for application in the first two steps of a conventional four-step planning model. That is, the socioeconomic data were used in a trip-generation model to generate zonal trip ends. These trip ends then were used in a trip-distribution gravity model to derive the trip table to be input as the target/seed table for the synthetic models. This approach combined the conventional wisdom that socioeconomic characteristics (which are ignored by many synthetic models) generally influence trip-making behavior with the fact that observed traffic volumes on the network provide information on the actual trips being made during the period for which the trip table is being developed. Finally, the synthesized trip tables output by the models were evaluated to determine (*a*) if there were improvements using this approach and (*b*) how closely they matched Pulaski's survey-derived tables.

The basic steps in the methodology are shown in Figure 1 and are defined in the following five steps. A detailed description of how the performance of the synthetic models was evaluated follows the five steps.

1. The first step was to collect the data necessary to apply the trip-generation and trip-distribution models. The number of dwelling units and employment data by zone were obtained from VDOT and the town of Pulaski, respectively. Unlike the procedures in the conventional four-step planning model, the trip generation was developed by using the rates and equations contained in ITE's *Trip Generation* (*9,10*). Complete details on the assumptions used in this process can be found in the final report on the research (*11*). Link-volume data that were needed to apply the synthetic models were available from the earlier study (*2*). [It should be noted that the original intent was to use the readily available and easily accessible socioeconomic data in the Census Transportation Planning Package (CTPP). Because Pulaski is categorized under the statewide element of CTPP, however, the database contains only aggregated data, not the required zonal level needed in this case.]

2. These data were used to run the trip-generation model in the transportation planning computer software package MINUTP. Output from the trip-generation model was used as input to run MINUTP's gravity model, which produced "enhanced" trip tables showing the distribution of the trips to the various zones for 24-h and peak-hour periods. Based on VDOT's recommendation, the friction/travel time factors for Lynchburg, Virginia, were used. The socioeconomic adjustment factors (K-factors) were assumed to be 1.0. Again, complete details on how this was accomplished can be found in the final report on the research (*11*). (It should be noted here that the basic philosophy in establishing the target/seed trip tables is only to guide

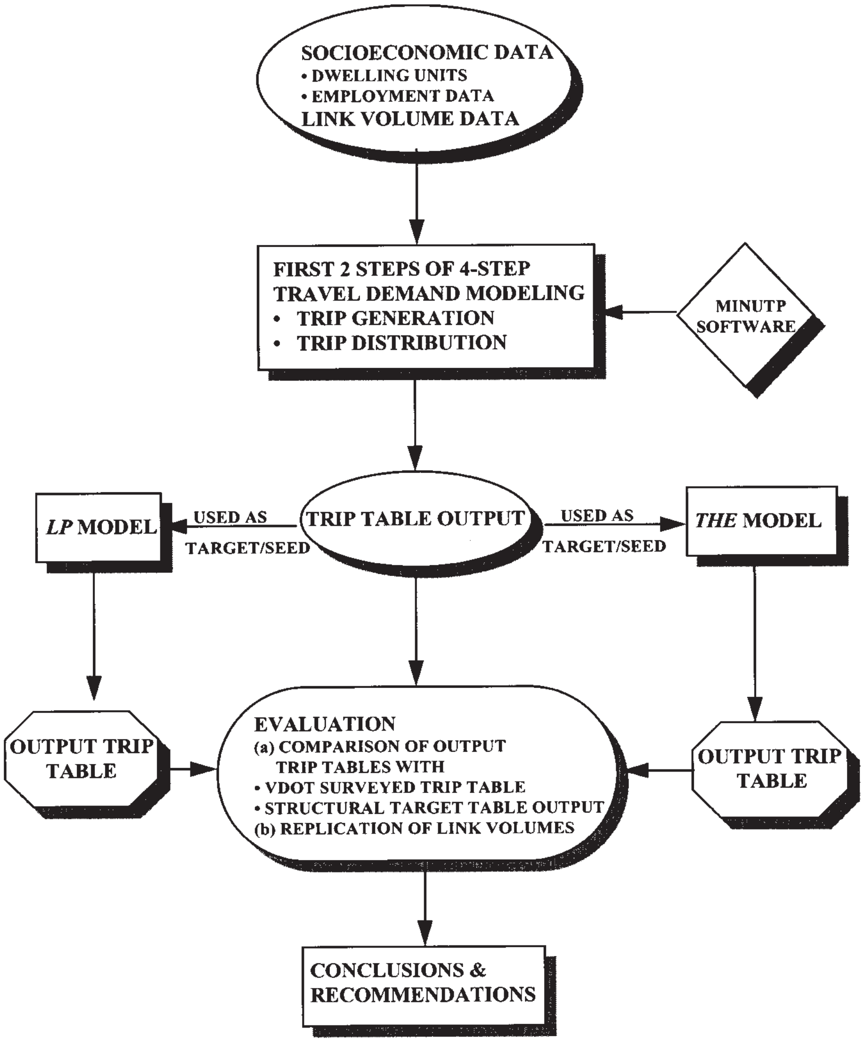

FIGURE 1 Methodology.

the synthetic O-D models' solutions. The link-volume information is the primary data that these models use to develop current O-D tables. Thus, the motivation in establishing the target/seed trip tables was to start with a table that is superior to the structural table and that will represent realistic travel patterns to a reasonable extent. Hence, some simplifications, assumptions, and approximations in the trip-generation and trip-distribution steps were considered acceptable. This target/seed table did not match very well with the survey-derived table.)

3. The link volumes and the enhanced target/seed trip tables from Step 2 were input to the LP and THE models to produce trip tables for Pulaski for the 24-h and peak-hour cases.
4. The trip tables from Step 3 were first evaluated by comparing them with synthetically produced trip tables available from the earlier research study that were derived from running the same models using a structural target/seed table. This comparison was of particular interest because the use of a structural target table would be the choice in the absence of old or prior trip tables. It was hoped that, by using the enhanced trip tables as input, the performance of the two synthetic models being used would be better than when the structural table was used. Also, the Step 3 trip tables were evaluated by comparing them with the 24-h and peak-hour trip tables derived from the VDOT surveys in Pulaski. Finally, the models (using the Step 3 trip tables) were tested for their sensitivity to varying percentages of available link volumes.
5. Conclusions and recommendations were derived from these analyses for both models. Recommendations for future research and potential areas for enhancing this research also were developed.

Evaluation of the Synthetic Models with Improved Target/Seed Tables

To evaluate the synthetically derived trip tables generated by the LP and THE models, two measures of closeness were used—the closeness of the generated table to VDOT's survey-derived table (assumed to be the "true" table) and the replication of the observed link volumes. These were obvious choices because the objective of trip-table estimation is to develop a table that is as close to the true table as possible and that replicates observed link volumes.

Closeness of Generated Trip Tables to VDOT's Survey-Derived Trip Tables

The statistics shown below are measures of error in estimation; therefore, the smaller the values of these measures, the closer the generated tables are to the true or correct tables. Ideally, values of zero for each of these statistics would mean that the generated tables are the same as the survey tables.

$$\%\ \text{RMSE} = \sqrt{\frac{\sum\left(t_{ij} - t_{ij}^{*}\right)^2}{n_{\text{OD}}}} * \frac{100 * n_{\text{OD}}}{\sum t_{ij}^{*}}$$

$$\%\ \text{MAE} = \frac{\sum\left|t_{ij} - t_{ij}^{*}\right|}{\sum t_{ij}^{*}} * 100$$

$$\phi = \sum \max\left(1, t_{ij}^{*}\right)\left|\ln \frac{\max\left(1, t_{ij}^{*}\right)}{\max\left(1, t_{ij}\right)}\right|$$

where

t_{ij}^{*} = true/correct/reasonably good/surveyed number of trips for O-D interchange (i, j);
t_{ij} = estimated or modeled number of trips for O-D interchange (i, j); and
n_{OD} = number of feasible O-D interchanges.

[Note that the definition of ϕ has been slightly modified from Smith and Hutchinson's study (*12*).]

Replication of Observed Link Volumes

In general, one of the most important measures of the quality of a trip table is its ability to replicate observed volumes on the network links once it is assigned to the network. The link volumes that were compared to the observed volumes were obtained as by-products of running the LP and THE models for Pulaski. This comparison was applied only to links for which observed volumes were provided as input.

The percent root-mean-square error (RMSE) and percent mean absolute error (MAE) were selected as the statistical measures to compare the closeness of modeled link volumes to the observed link volumes. These measures are defined as follows:

$$\%\ \text{RMSE} = \sqrt{\frac{\sum_{a \in A_v}\left(V_{\text{assign}}^{a} - V_{\text{obs}}^{a}\right)^2}{n}} * \frac{100 * n}{\sum_{a \in A_v} V_{\text{obs}}^{a}}$$

$$\%\ \text{MAE} = \frac{\sum_{a \in A_v}\left|V_{\text{assign}}^{a} - V_{\text{obs}}^{a}\right|}{\sum_{a \in A_v} V_{\text{obs}}^{a}} * 100$$

where

V_{assign}^{a} = assigned volume on link a,
V_{obs}^{a} = observed volume on link a,
n = number of links with available volumes, and
A_v = set of links with available volumes.

The smaller the values of these measures, the better the replication of observed link volumes. Ideally, values of zero for each of these measures mean perfect replication.

Test Cases

In many practical cases, a number of the link volumes on a network are unknown. Thus, the LP and THE models were tested separately for cases in which 50, 60, and 75 percent of the network link volumes were available. These links were selected randomly and allowed for the study of sensitivity of the models to volume information. Additionally, 24-h and peak-hour trip tables were available. Accordingly, in this research, the statistical measures described above were calculated for both the 24-h and peak-hour time periods at each of the three percentages of link-volume availability for the case when the MINUTP-based target/seed table was used. The same statistics for the same combination of time-period and link-volume availability were obtained from the earlier study for the case when a structural target/seed table was used. These values also were reported and used in the evaluation.

FINDINGS

24-h Trip Tables

Closeness of Generated Trip Tables to VDOT's Survey-Derived Trip Tables

The performance of the LP and THE models in replicating the surveyed trip tables is depicted in detail for the percent MAE, percent RMSE, and statistics in Figures 2 through 4, respectively. The following observations can be made (*11*):

- Applying the LP model with the socioeconomic-based, MINUTP-derived (referred to hereafter and in the figures as the *TG-TD table*) target table resulted in consistently improved performance in the closeness of the output tables to the VDOT survey table when compared to the case using the structural target table. This was true for all three cases of available link volumes and for all three measures of closeness. The decrease in percent MAE was between 40 and 56, the decrease in percent RMSE was between 125 and 236, and the percent decrease in Φ was between 73 and 77 percent for the various percentages of available link volumes that were input to the model. This represented a significant reduction in error rates.
- The THE model, on the other hand, showed improved performance only with respect to the Φ statistic, which decreased by 33 to 34 percent for the three percentages of volume availability. The increase in percent MAE was between 2 and 17, and the increase in percent RMSE was between 26 and 68 for the various percentages of available link volumes. The increase in error statistics values is counterintuitive, and possible explanations are provided at the end of this section.
- Although the values of the statistics decreased significantly with the use of the TG-TD table for the LP model, the absolute values were still relatively high. For instance, the percent MAE ranged from 140 to 145 percent, and the percent RMSE ranged from 372 to 401 percent for the various percentages of volume availability. The absolute values of the statistics for the THE model were, likewise, still relatively high. The percent MAE ranged from 181 to 191 percent, and the percent RMSE ranged from 458 to 482 percent for the various percentages of volume input.
- The LP-modeled tables were significantly better than the THE-modeled tables in their closeness to the VDOT survey table when the TG-TD table was used as the target. This was true for all three cases of volume availability.
- The values of the closeness statistics showed a mixed trend with respect to variation in available link volumes for both the LP and THE models; however, the variations were small.

Replication of Observed Link Volumes

The performance of both the LP and THE models in replicating link volumes is depicted in detail for the percent MAE and percent RMSE in Figures 5 and 6, respectively. The following observations can be made:

- Applying the LP model with the TG-TD target table resulted in consistently poorer performance in terms of replicating measured link volumes when compared to using the structural target table. This was true for all three cases of available link volumes and for both measures of closeness. The increase in percent MAE was between 0.07 and 3.02, and the increase in percent RMSE was between 0.83 and 9.45 for the various percentages of available link volumes. (It should be noted that the high percentage increase was for the 60 percent volume availability for both statistics. The increase was much smaller for the 50 and 75 percent volume availability.)
- The THE model, on the other hand, showed improved performance, with 60 and 75 percent volume availability, but poorer performance for the 50 percent volume availability. The decrease in percent MAE was 0.75 and 0.60, and the decrease in percent RMSE was 0.41 and 0.63 for the two higher volumes; however, the increase was 0.88 (percent MAE) and 1.78 (percent RMSE) when 50 percent of available volumes were input.
- Even though the values of the statistics increased for the LP model, their absolute values were still relatively low. The percent MAE was around 5 percent, and the percent RMSE ranged from 12 to 16 percent for the various percentages of volume availability. The absolute values of the statistics also were relatively low for the THE model. The percent MAE ranged from 9 to 10 percent, and the percent RMSE was around 16 percent for the various percentages of volume availability.
- Except for the percent RMSE at the 50 percent volume availability, the LP model's ability to replicate volumes was better than that of the THE model.

The qualitative differences in results between the LP and THE models can be explained as follows. The THE model attempts to define a trip table with the maximum degree of disorder, or random exchange, between zones. This is the primary objective of the model. The LP model's primary objective is to find a user-equilibrium solution that reproduces the observed link flows. It also has the tendency to reproduce the target table as closely as possible. The inferior results of the LP model (as compared to the THE model) for the structural-table target case can be attributed to the fact that it blindly attempts to replicate the target while trying to match observed link volumes, whereas the THE model develops a table that has the maximum degree of disorder.

The counterintuitive and large values of error statistics reported in this section may be attributable to three factors. First, the link volumes were not fully consistent with the surveyed O-D table; this was verified through preliminary investigations by assigning the surveyed table to the network and comparing the assigned volumes with the observed volumes. In doing so, the percent MAE was observed to be around 30 percent. Second, there may have been inconsistencies/errors in observed volume data. Third, the requirement of conservation of flow at nodes for THE could not be satisfied with the available data. This may have led to some deviations in model results.

Peak-Hour Trip Tables

The findings from the analysis of the peak-hour trip tables were generally the same as for the 24-h comparisons and are not discussed in this paper. The final report on the research (*11*) provides more detail about the peak-hour results.

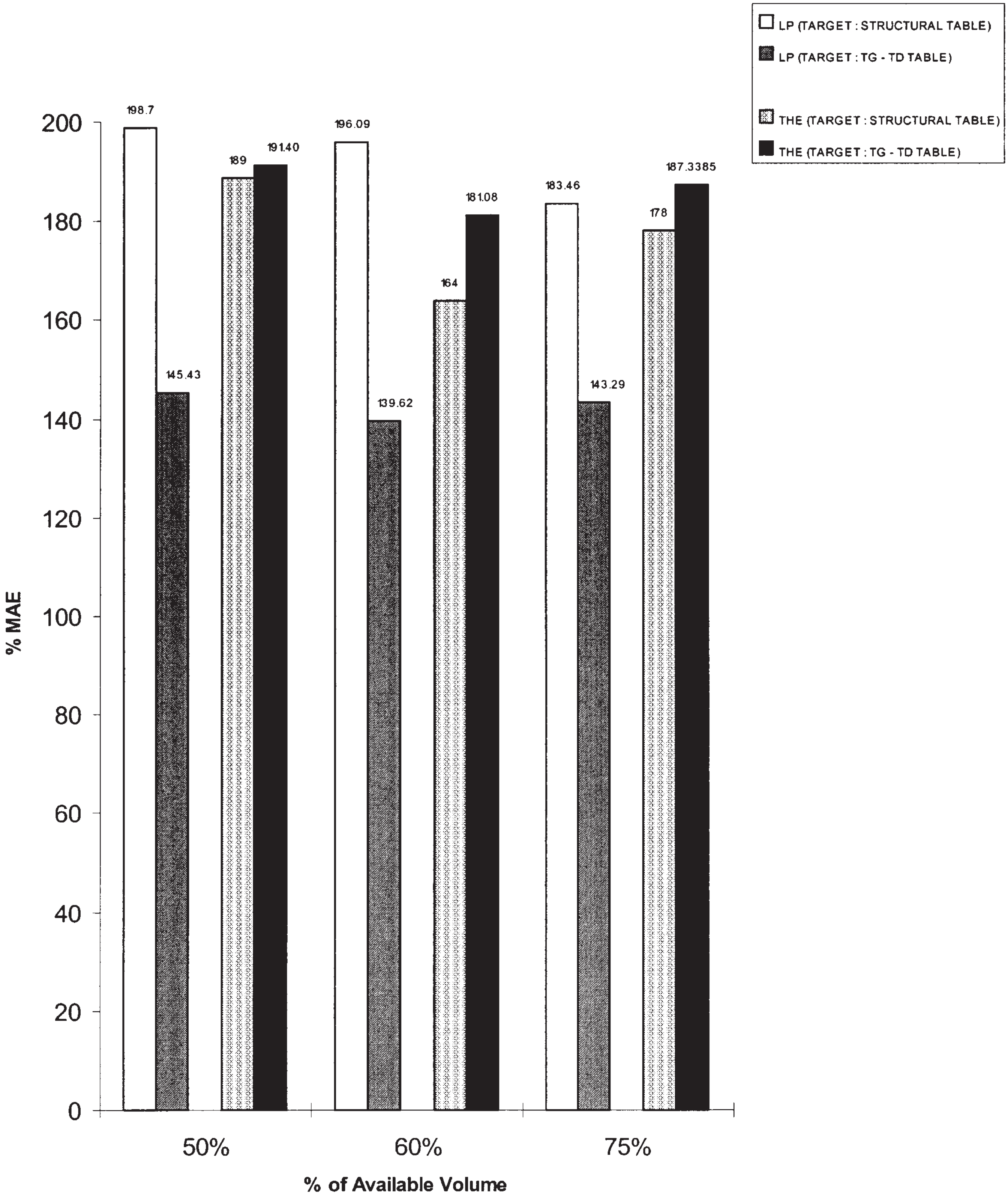

FIGURE 2 Trip table comparisons (modeled versus surveyed), 24-h case (percentage of MAE).

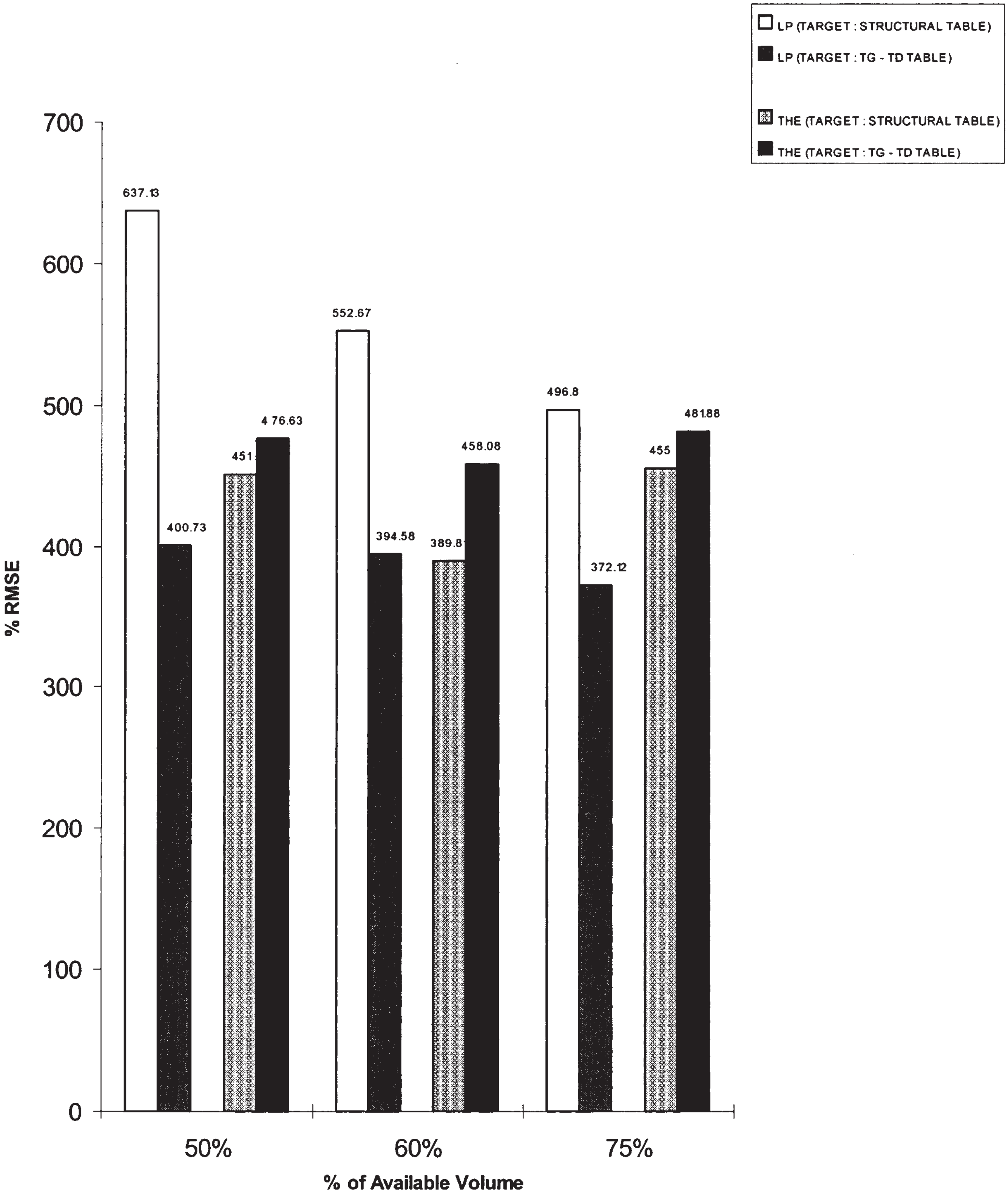

FIGURE 3 Trip table comparisons (modeled versus surveyed), 24-h case (percentage of RMSE).

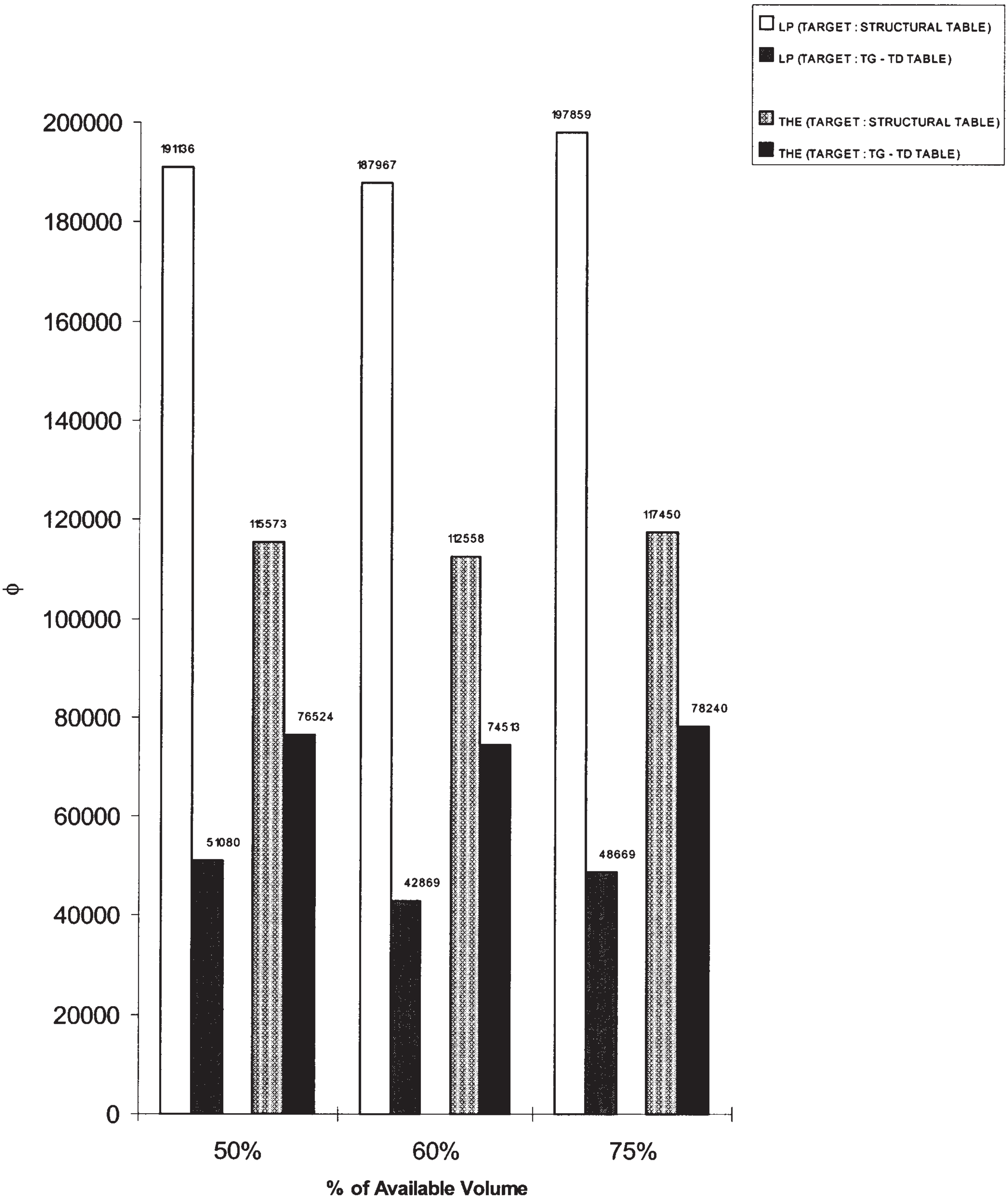

FIGURE 4 Trip table comparisons (modeled versus surveyed), 24-h case (Φ).

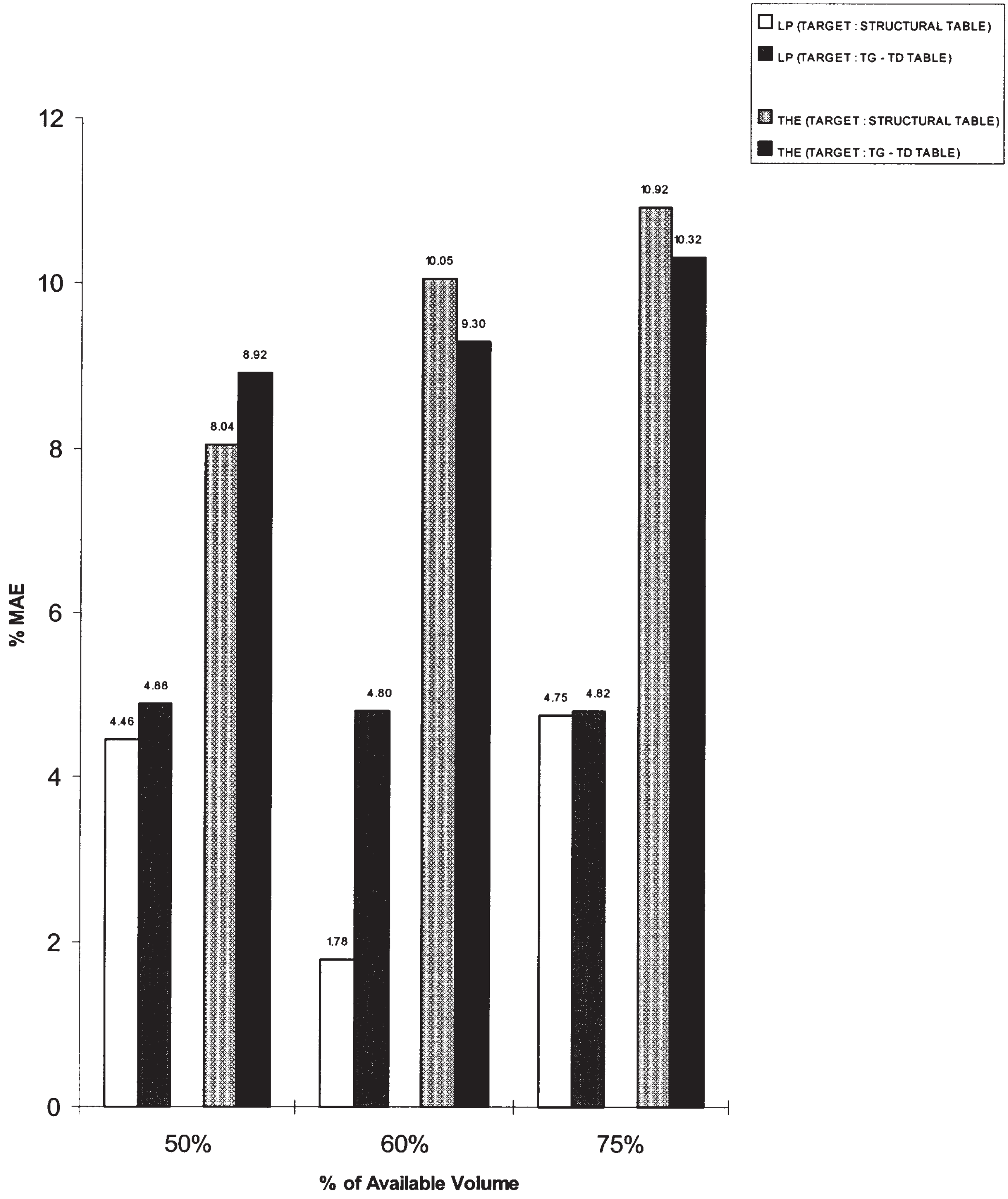

FIGURE 5 Volume comparisons (modeled versus observed), 24-h case (percentage of MAE).

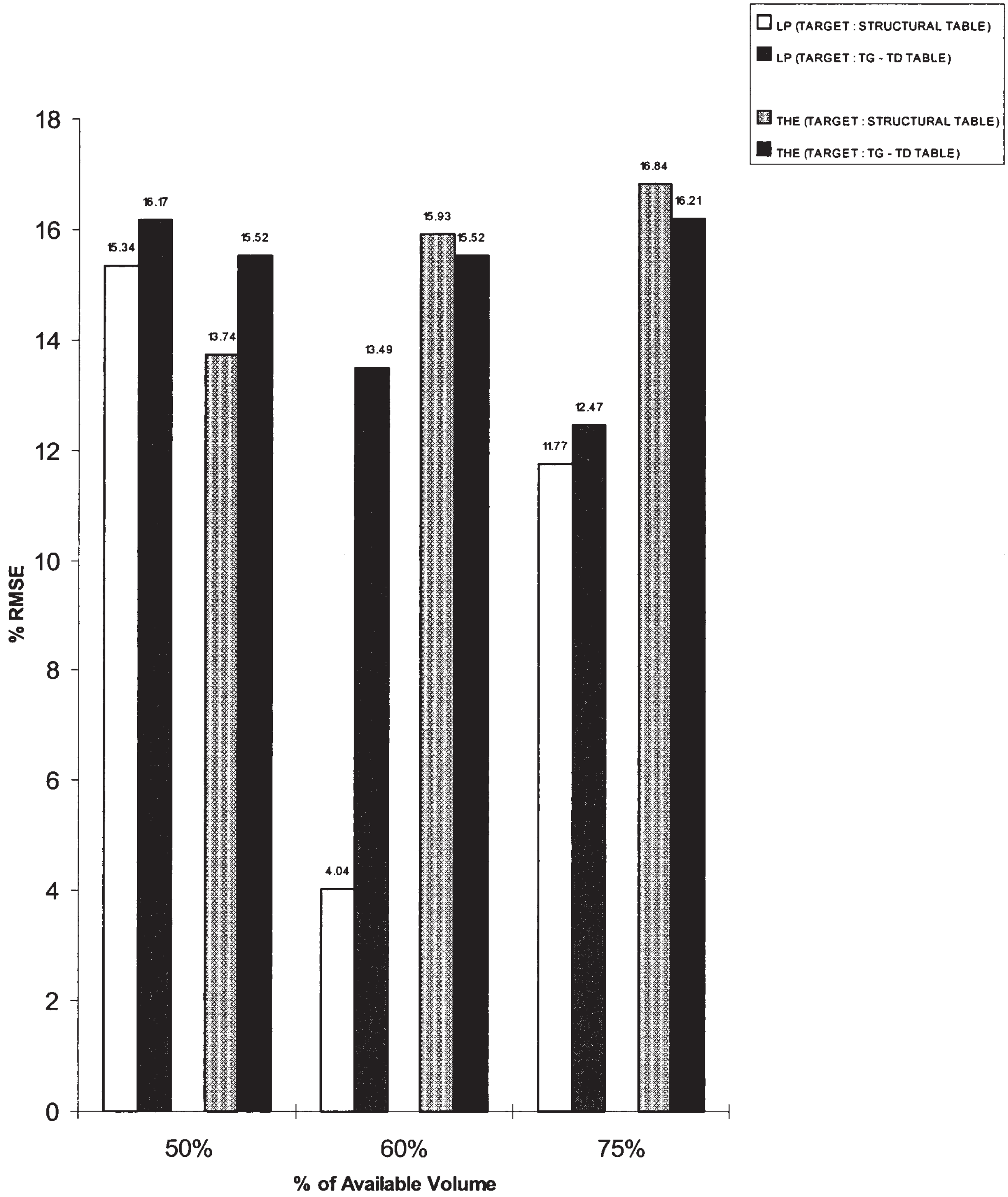

FIGURE 6 Volume comparisons (modeled versus observed), 24-h case (percentage of RMSE).

CONCLUSIONS

With regard to the primary purpose of the research to enhance the target/seed table used as input to the LP and THE models in the case when a prior trip table is not available (rather than by using a structural table with cell values of "0" or "1"), the following specific conclusions were reached from the Pulaski case study. The conclusions are generally similar for both the 24-h and peak-hour trip tables.

- The use of an improved target/seed table developed by inputting local socioeconomic data into a traditional planning model (MINUTP in this study) resulted in the following findings with regard to the quality of the output tables generated by the LP and THE models:
  - –The performance of the LP model clearly improved. That is, the LP model generated a trip table that was closer to the survey table than was the table generated by the use of a structural table as the target/seed. Although the values of the measures-of-closeness statistics decreased significantly, the absolute values were still relatively high.
  - – The performance of the THE model worsened for two of the three evaluative statistics. That is, for these two statistics, the THE model generated a trip table that was not as close to the survey table as was the table generated by the use of a structural table as the target/seed. The absolute values of the statistics were, again, still relatively high.
- The use of an improved target/seed table developed by inputting local socioeconomic data into a traditional planning model (MINUTP in this study) resulted in the following findings with regard to the replication of link volumes by the LP and THE models:
  - –The performance of the LP model worsened marginally. That is, the trip table generated by the LP model did not replicate the observed volumes as well as the table generated by the use of a structural table as the target/seed. Although the values of the statistics increased, the absolute values were relatively low.
  - –The performance of the THE model improved marginally for two of the three percentages of available input volume. That is, the trip table generated by the THE model replicated observed link volumes better than the table generated by the use of a structural table as the target/seed. Again, the absolute values of the statistics were still relatively low.

With regard to the secondary purpose of the research of evaluating the absolute and relative performances of the LP and THE models by comparing their output with the trip tables derived from VDOT's Pulaski survey, the following specific conclusions were reached from the Pulaski case study. The conclusions are generally similar for both the 24-h trip tables and the peak-hour trip tables.

1. When using an enhanced target/seed table, the LP model produced better results than the THE model when comparing the closeness of the generated trip table to the survey trip table. However, the absolute values of the comparative statistics were relatively high for both of the models.
2. When using an enhanced target/seed table, the LP model generally performed better than the THE model in replicating input link volumes. Further, the absolute values of the comparative statistics (percent MAE and percent RMSE) were relatively low. However, the caveats and suggestion for further validation mentioned should be noted.
3. There was no clear evidence to indicate that either the LP or the THE model performed better in terms of their ability to match VDOT survey tables as the percentage of input network link volumes increases.

It is important to note that the preceding findings and conclusions were based only on the Pulaski case study and on the assumption that the data used in the validation and comparison processes were, in fact, "correct." This suggests that further validation is needed for the use of the LP and THE models to generate a trip table using the proposed methodology and link volumes for cases in which there is no prior trip table for use.

Nonetheless, this research has highlighted the usefulness (as shown by improvements in the LP model results) of incorporating readily available and easily accessible socioeconomic/census data into the methodology of synthesizing O-D trip tables using link volumes.

RECOMMENDATIONS FOR FURTHER RESEARCH

Further tests and validation of the models and ways to establish even more superior target/seed tables are areas of potential further research. The results were encouraging for the Pulaski case study. Further tests on more real networks will help confirm the findings presented in this report. Other ways of establishing target tables also can be tested in the context of the methodology presented in this research. For a credible validation, the model results must be compared with tables that are known to be correct or reasonably good. More time and resources are worth investing in continuing this research due to the potential benefits—in terms of money, time, and manpower—that this approach can offer.

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