Comparison of Small-Area OD Estimation Techniques

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ABSTRACT

Three different techniques for estimating or forecasting the vehicular origin-destination (OD) patterns within small areas such as central business districts are evaluated. The proportional technique estimates the OD table based solely on cordon gate traffic counts and internal zone trip generation estimates within the small study area. The LINKOD model technique estimates the OD table based on cordon counts, trip generation estimates, and traffic counts made within the study area. The regional technique employs a regional travel behavior model to identify regional travel patterns and extract a vehicular OD table for the small study area within the region. The regional technique was found to be the most accurate and the proportional technique the least accurate at estimating OD tables that, when assigned to the small study area street network, reproduced observed traffic volumes within the small area. However, the trade-off between accuracy and data requirements was not linear. The regional technique required significantly more data and yet was only moderately more accurate than the proportional technique. The three techniques yielded very different estimates of the small-area OD table and yet when the three different OD tables were assigned to the street network, much of the difference was masked out by the assignment process. It was concluded that large errors in the OD estimation process could be tolerated at the expense of a small sacrifice in accuracy in the estimated traffic volumes. Based on this result, the potential of simplifying the OD estimation problem was then investigated. The internal zones were aggregated and all internal-internal cells in the OD table were deleted from the matrix. The result was a minor loss in accuracy when estimating traffic volume. The conclusion of this research is that the small-area vehicular OD table estimate does not have to be very precise to yield useful traffic volume estimates. One can simplify the OD estimation problem through aggregation and the use of simple OD estimation techniques. Although simpler OD estimation techniques are less accurate, the loss in accuracy is small compared with the savings in effort.

Increased interest in the refinement and optimization of traffic operations in small areas, such as central business districts (CBDs), has led to the development of refined traffic forecasting tools such as the CONTRAM (1) and MICROASSIGNMENT (2) traffic assignment models. However, these detailed analytical tools require as one of their inputs a vehicular OD table for the small study area, which traditionally has been obtained by means of expensive and time-consuming license plate, postcard, or roadside interview surveys. The difficulty of conducting OD field surveys at the fine level of detail required for CBDs has discouraged practitioners from using these refined traffic models for small study areas; consequently, investigators have begun to explore alternative, simpler techniques for estimating the vehicular OD patterns in a small study area.

Representative samples of these simple OD estimation techniques are investigated in this paper; their relative data requirements and performance are compared; techniques for simplifying the OD estimation problem are suggested; and the conditions for applying each technique are recommended.

TERMINOLOGY

A small study area is a subarea of a larger region. A typical small study area may be a 1-mi^2 (2.6-km^2) central business district located in a region with a 30-mi (50-km) radius. A study area is small when most of the trips observed in the study area are external trips (trips entering and/or leaving the small study area).

For purposes of OD estimation, it may be necessary to look at a larger area such as the whole region; however, the purpose of the effort is to develop OD data and traffic forecasts for only a small subarea within the region. Thus, the term "small study area" refers to a small area for which detailed traffic forecasts are desired and not the potentially larger area that may be considered in estimating the small area OD table.

The small study area is isolated from the region by a cordon line that has entry and exit points called gates where traffic can enter or leave the small study area. The region is defined as a large area containing the end points of more than 90 percent of the trips observed in the small study area.

The small study area OD table consists of zone-to-zone trips (internal-internal), zone-to-gate trips (internal-external), gate-to-zone trips (external-internal), and gate-to-gate trips (external-external).

OD ESTIMATION TECHNIQUES

Three OD estimation techniques will be discussed in this section: the regional technique, the LINKOD technique, and the proportional technique.

Regional Technique

When one does not have OD information for a small study area, the conventional approach has been to extract the small-area OD table from a travel behavior model calibrated for the region in which the small study area is located. The regional model is used to estimate the regional OD patterns; assign the vehicle trips to the regional network; and identify those trips entering, leaving, or passing through the small study area. Most standard traffic modeling packages have routines to identify the vehicular OD table for a small subarea.

This regional technique is theoretically straightforward; however, practically it is quite difficult. A regional model must be developed and calibrated if one does not exist or is not accessible to the investigator. If a preexisting model for the region is used, one must often revise the regional model zone system and network for the small study area and update the input data for the model; within the small study area, one must also relocate the person-trip end points to their respective vehicle-trip end points.

The regional technique is necessary to be able to forecast the effects of network changes (both within and outside the small study area) on the small-area OD patterns, but may not be necessary if one wishes to only simulate existing small-area OD patterns. Alternatively, one could estimate the small-area OD table strictly on the basis of information obtained within the small study area.

LINKOD Model Technique

Gur et al. (3-5) have developed a gravity model for small study areas that weights the likelihood of external trips by using each cordon gate according to the type of street facility at the entry and exit gates, and the change in direction of travel between the entry and exit gates. This initial estimate of the OD table (from the gravity model) is then adjusted so that an equilibrium assignment of this OD table reproduces the observed traffic volumes on the street within the small study area. This technique is used in the computer model LINKOD (3-5). This LINKOD model technique thus reduces the data requirements for estimating a small-area OD table to traffic counts and trip generation data collected exclusively within the small study area.

Proportional Technique

An even simpler approach is available. Again focusing on the small study area alone, one can estimate the small-area vehicular OD table by using the proportional technique. The row and column totals of the OD table are estimated from cordon gate counts and trip generation estimates for the internal zones. The estimated number of trips for each cell of the table is then as follows:

$$T_{ij} = T_i \times T_j/T \tag{1}$$

where

T_{ij} = number of trips from i to j,
T_i = total number of trips originating at i,
T_j = total number of trips destined to j, and
T = total number of trips in table.

These estimates (T_{ij}) are then Furness adjusted (6) to sum to the desired row and column totals.

Comparison of Techniques

The proportional technique requires the least amount of data and consequently would be expected to produce the least accurate simulation of the existing small-area vehicular OD table. In contrast, the regional technique requires the most data and analytical effort and would be expected to be the most accurate. The LINKOD model technique would be expected to be intermediate in accuracy. This is indeed the case as demonstrated in the next section; however, as will be shown, the trade-off between accuracy and data requirements is not strictly linear.

EVALUATION

The accuracy of the three techniques was determined by comparing the ability of the estimated OD tables (when assigned to the small study-area street network) to reproduce observed traffic volumes. The small study area selected for this evaluation was the CBD of San Jose, California. The San Jose CBD includes about 69 city blocks covering an area of about 1 mi^2 (2.6 km^2) (see Figure 1).

Chenu (7) used the regional technique to simulate a 1975 OD table for the San Jose CBD. The model-estimated OD table was Furness adjusted to match the observed cordon gate volumes for the CBD. This CBD OD table was then used to test and validate the MICROASSIGNMENT model.

Later, Han et al. (8) tested the ability of the LINKOD model to simulate the same 1975 OD table for the San Jose CBD. The same MICROASSIGNMENT model was used to simulate the extensive traffic count input information for LINKOD as well as to subsequently test the OD table output by LINKOD. This was admittedly a hypothetical test of LINKOD with 100 percent turning movement count information synthesized by the MICROASSIGNMENT model.

A simple, proportional OD table was developed by using the same cordon gate traffic counts and trip generation estimates that were derived by Chenu and used by Han. This table was also assigned to the San Jose CBD network by using the MICROASSIGNMENT model.

The resulting traffic-volume estimates of the three tables (regional, LINKOD, and proportional) were compared at three screen lines crossing the CBD (see Figure 1). The results are given in Table 1. Figures 2, 3, and 4 show the resulting scatter diagrams for each technique.

As the results indicate, the regional technique is most accurate and the proportional technique is least accurate. The LINKOD model technique is fairly close in accuracy to the regional technique. Considering the large difference in data requirements for each OD estimation technique, the resulting volume estimates are fairly close. The regional technique requires not only the same information as does the proportional technique (CBD trip generation and cordon counts) but requires as well trip distribution and network data for the entire region. Yet for all of this extra information and computational effort, one improves the accuracy of the estimated traffic volumes by just one-third over that of the simple proportional technique.

However, a direct comparison of the LINKOD- and proportional-estimated OD tables with the regional-technique estimated table (shown in Table 2) shows that the three tables are very different. The mean absolute difference between tables approaches or exceeds 100 percent of the mean number of trips per cell. The root mean square (RMS) difference is 5 to 8 times the mean trips per cell.

As has been found in previous research [see e.g., Texas DOT (9)], Tables 1 and 2 show that much of the difference among OD table estimates is masked by the traffic assignment technique. This would appear to indicate that one could be less elaborate in estimating the OD table without unduly sacrificing projection accuracy of traffic volume.

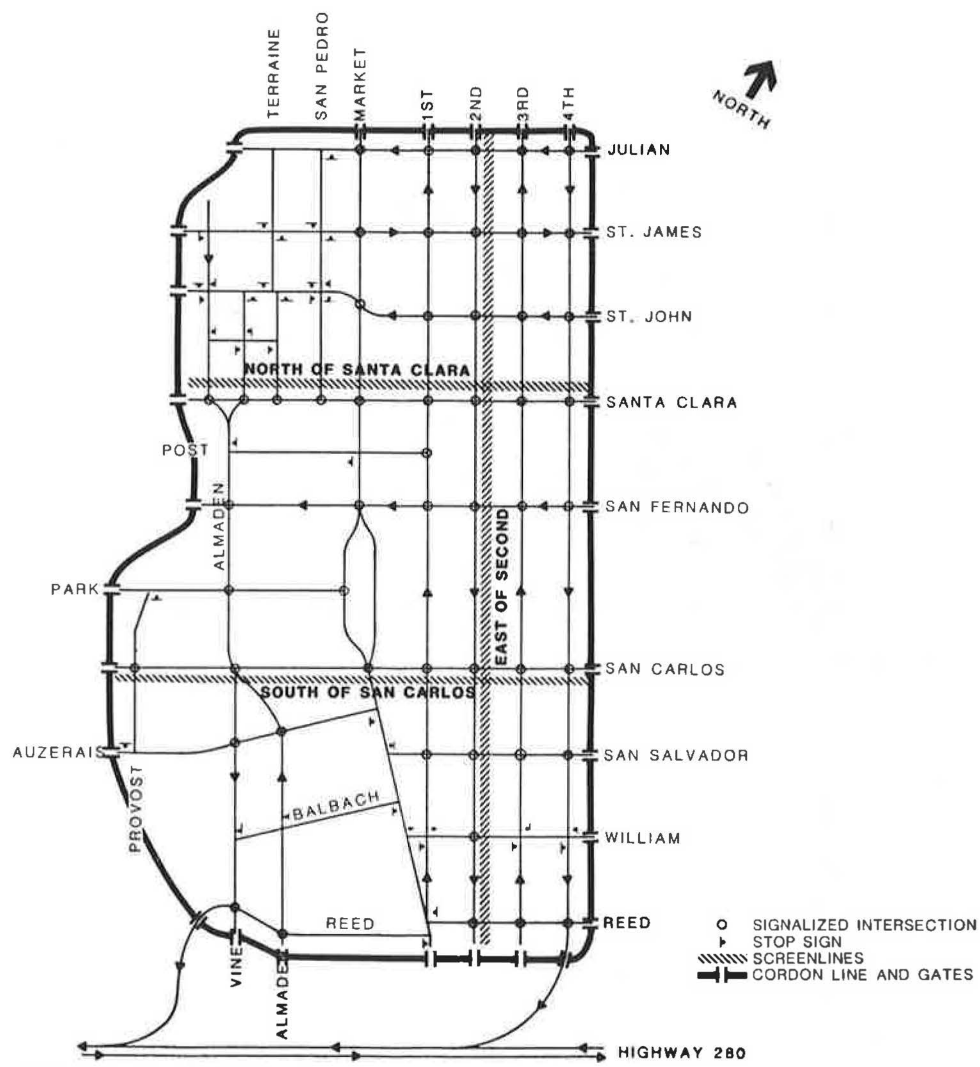

FIGURE 1 San Jose CBD study area.

TABLE 1 Comparison of Estimated Screen-Line Volumes

Statistic[a]	OD Estimation Technique: Regional	LINKOD	Proportional
Total no. of screen-line trips	19,700	19,400	23,400
Percent of counts	96	94	114
Mean absolute error	100	112	147
Percent of mean volume[b]	15	16	21
Root mean square error	125	142	188
Percent of mean value[b]	18	21	27

[a]Estimates compared with 30 traffic counts totaling 20,600 peak-hour trips for 3 screen lines as shown in Figure 1.
[b]Ratio of error to mean trips per cell times 100 percent.

A review of the OD table estimated by using the regional technique indicated that the vast majority (80 percent) of the cells in this table contained zero trips. Less than 2 percent of the 18,000 cells in this table contained more than 10 trips and yet these few cells contained 69 percent of the total trips in the table. In particular, the cells representing internal-internal trips represented 50 percent of the cells in the OD table and yet contained only 1 percent of the trips.

Thus, it was decided to test the option of simplifying the OD estimation problem by aggregating the 100 internal zones to 13 internal zones and eliminating internal-internal cells from the OD table. The three OD tables were each aggregated and truncated to about 1,000 cells.

The original MICROASSIGNMENT model, which had been used to estimate traffic volumes for a finely detailed CBD network with each turning movement represented by a link, was no longer appropriate for a highly aggregated OD table. Therefore, a much simpler network was selected (with intersections represented as nodes) and a standard incremental, capacity-restrained algorithm was used to assign the traffic [TRANPLAN (10)].

The screen-line volume results showed a moderate decrease in accuracy when each OD table was aggregated. The RMS error for the regional technique increased from 18 percent at the disaggregate level to 30 percent at the aggregate level. For the proportional technique, the RMS error increased from 27 to 36 percent. The LINKOD model could not be tested at the aggregate level because of time constraints unrelated to the LINKOD model; however, its results at the aggregate level would also be expected to be intermediate between those of the regional and proportional techniques.

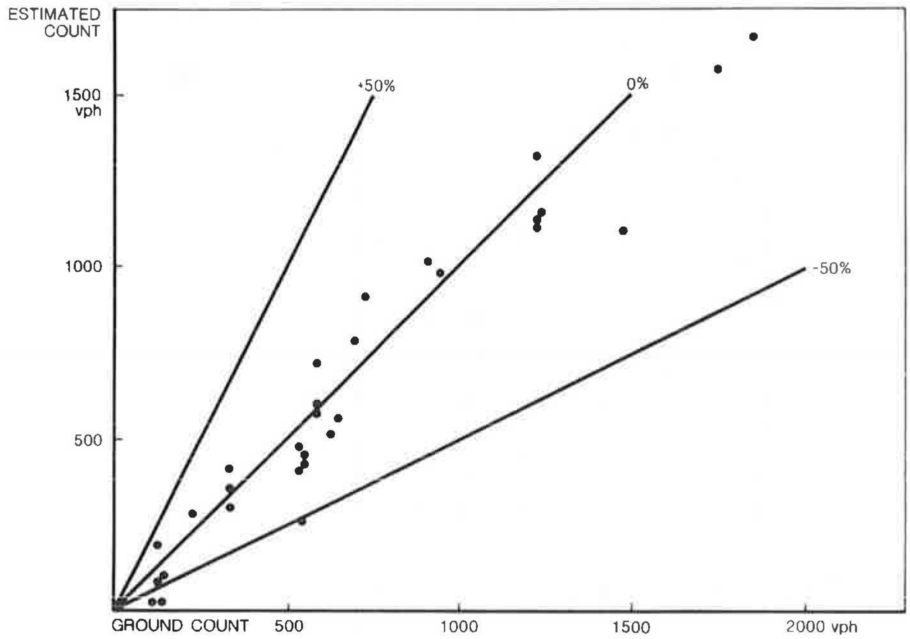

FIGURE 2 Screen-line scatter diagram—regional technique.

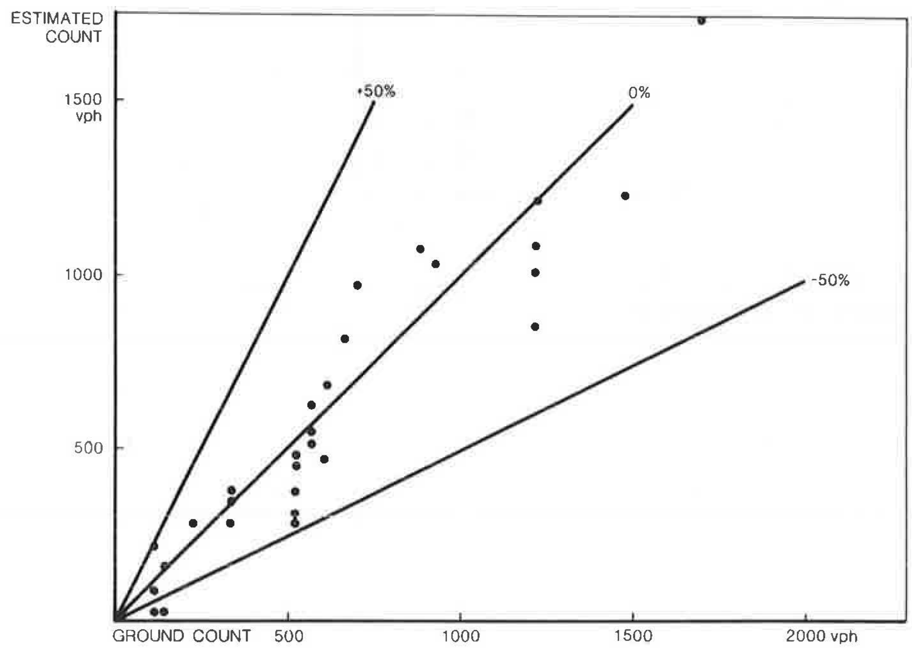

FIGURE 3 Screen-line scatter diagram—LINKOD model technique (100 percent counts).

Figures 5 and 6 show the scattered diagrams comparing the model-estimated screen-line volumes for the regional and proportional techniques with the observed traffic counts.

Figure 7 is a summary of the results of these tests, comparing the accuracy of the resulting internal screen-line volume estimates with the amount of data required for each technique.

To show how rapidly the error in traffic volume estimates is reduced by simple information, two additional points are shown in Figure 7. One point, Table with Zero Trips, is the know-nothing estimate in which no information is available and all volumes are estimated to be zero. The second point, Table of Mean Cell Volumes, shows the improved accuracy if just one piece of information, the total number of trips in the system, is known. The best estimate for each cell of the OD table is then the total number of trips divided by the number of cells in the table.

As can be seen in Figure 7, there is a rapid flattening of the curves when the row and column totals (trip generation and cordon gate counts) of

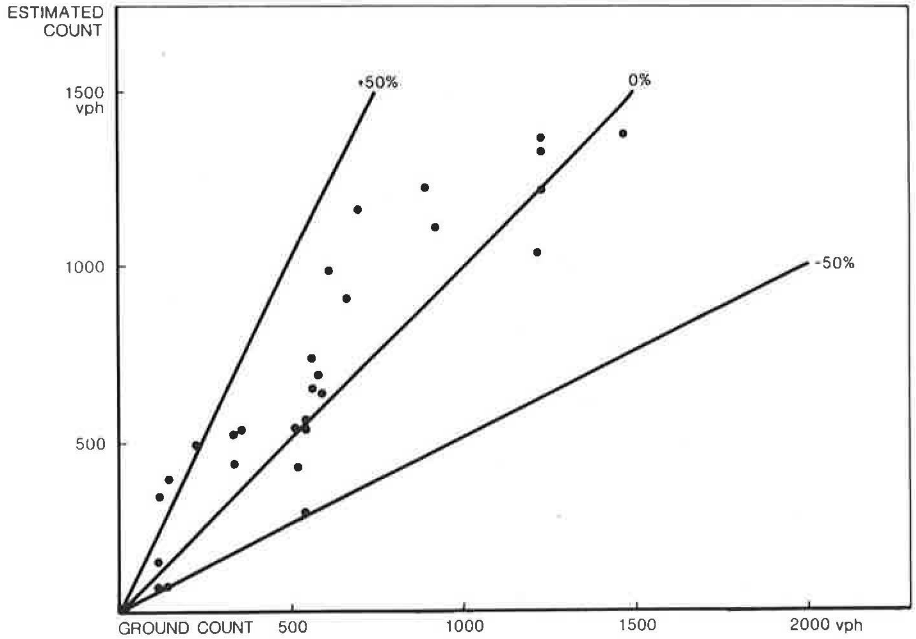

FIGURE 4 Screen-line scatter diagram—proportional technique.

TABLE 2 Comparison of Estimated OD Tables

	OD Estimation Technique		
Statistic[a]	Regional	LINKOD	Proportional
Total no. of trips in table	16,200	16,400	15,800
Percent of regional approach	100	101	98
Mean absolute error (MABS) (trips)	0	0.87	1.02
Percent of mean cell value[b]	0	89	105
Root mean square error (trips)	0	6.28	9.46
Percent of mean cell value[b]	0	645	973

[a]All tables compared with OD table estimated by regional technique.
[b]Ratio of error (MABS or RMS) to number of mean trips per cell of the regional-technique estimated OD table.

the small-area OD table are known. Further large increases in data result in only minor improvements in accuracy.

CONCLUSIONS AND RECOMMENDATIONS

The comparison of these three techniques for estimating small-area vehicular OD tables has demonstrated that a relatively large amount of error and aggregation can be tolerated in the estimated OD table without unduly reducing the accuracy of the traffic volume estimates. Indeed, when the row and column totals of the OD table are known, it is difficult to further improve the accuracy of resulting

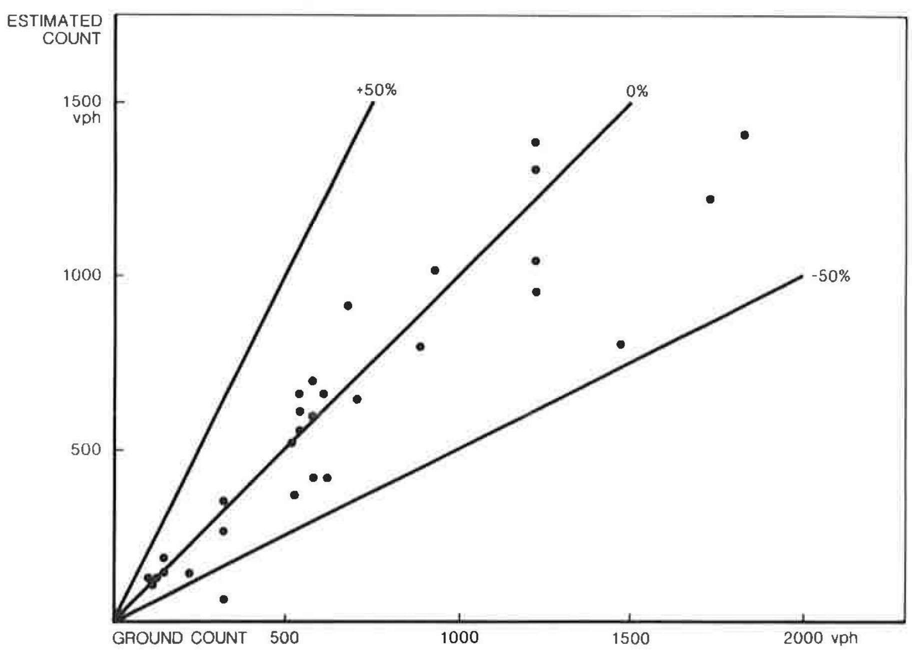

FIGURE 5 Screen-line scatter diagram—regional technique (aggregated, truncated table).

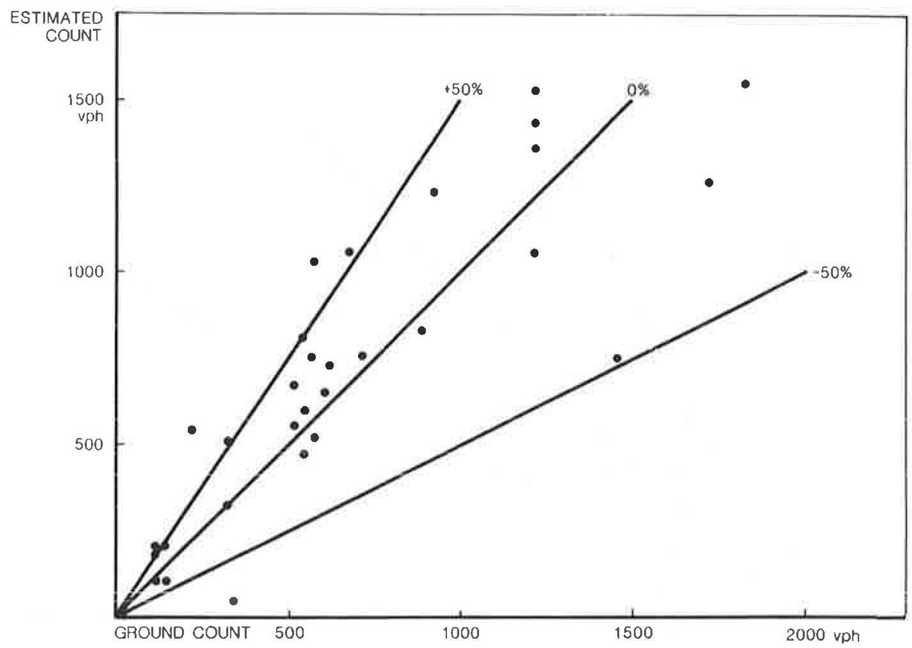

FIGURE 6 Screen-line scatter diagram—proportional technique (aggregated, truncated table).

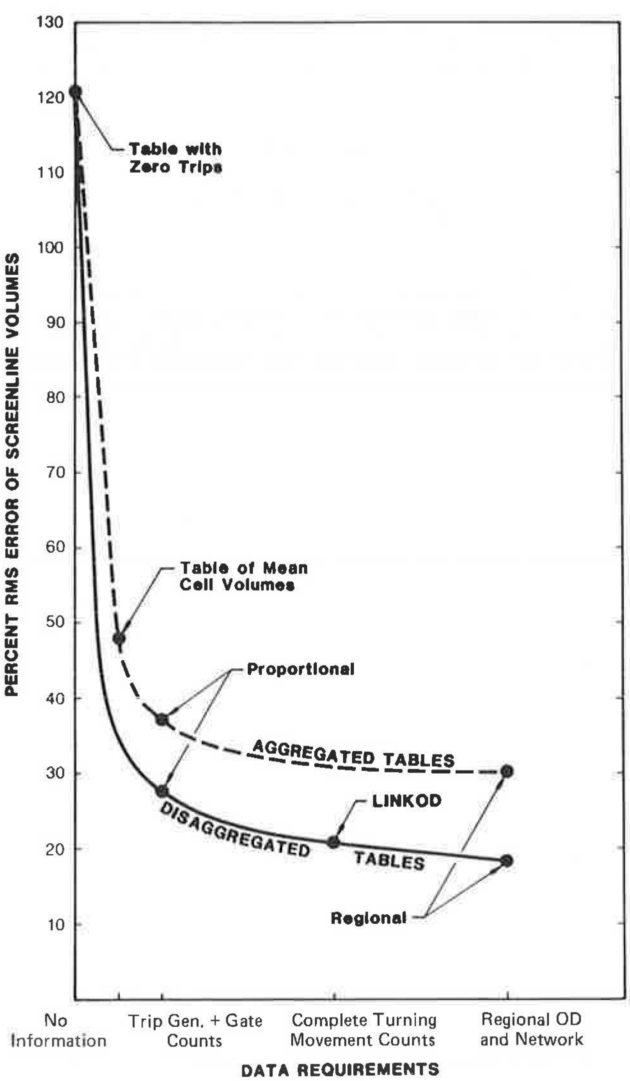

FIGURE 7 Cost-effectiveness of OD estimation techniques.

traffic volume estimates. The regional and LINKOD model techniques require a significant amount of additional data and yet yield only moderate improvements in accuracy.

It must be pointed out, however, that often the purpose of CBD traffic studies is to make very detailed evaluations of circulation improvement alternatives and therefore a high degree of accuracy in the traffic volume estimates may be required. Nevertheless, even the most accurate technique considered in this paper, the regional disaggregate technique, still has a great deal of error in its volume estimates.

Figure 8 gives a summary of the recommended applications for each of the techniques. Where accuracy is less critical but forecasting is still required, there appears to be an opportunity for a simplified version of the regional technique that could reduce the data requirements of this approach without unduly sacrificing accuracy. One possible technique for simplifying the regional technique is described by Dowling (11).

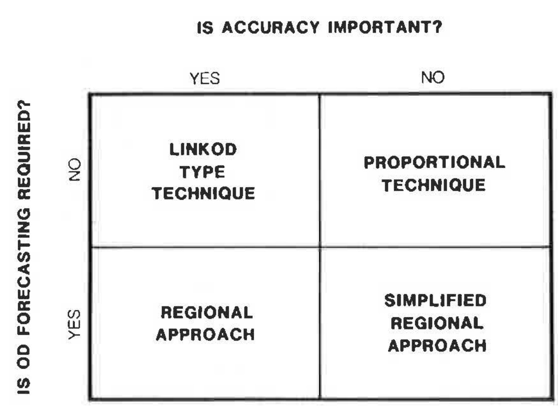

FIGURE 8 Recommended applications for small-area OD techniques.

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Publication of this paper sponsored by Committee on Transportation Planning Needs and Requirements of Small and Medium-Sized Communities.

Estimating OD Tables Using Empirical Route-Choice Information with Application to Bicycle Traffic

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ABSTRACT

A new method for estimating origin-destination (OD) tables is presented that uses road counts and route-choice information. The innovative feature of the estimation method, a refined version of the information-minimizing approach, is the use of empirical route-choice information. The method has been applied in an evaluation study of a cycleway network in a medium-sized city in the western part of The Netherlands. In this study, OD matrices were estimated to determine changes in travel patterns of bicycle users caused by the implementation of a new bicycle network scheme. The method that proved to be useful can be applied equally well to automobile traffic by using route information derived from, for example, license-plate surveys.

Unlike in the United States, the bicycle is a major transportation mode for urban travel in The Netherlands. A modal share of 50 percent is not uncommon. After a period of steady decline of bicycle use, policies are being designed to enhance this inexpensive, low-energy mode without any negative effects on the environment.

BICYCLE NETWORK SCHEME

In October 1982, the public works department of Delft, a medium-sized city with a population of 100,000 in the western part of The Netherlands, started implementing an ambitious bicycle network scheme. This scheme consisted of a considerable ex-