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Abridgment

Impact of the Relative Transit and Highway Service Levels on Trip Distribution

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The purpose of this investigation is to measure the impact of the public transit service level on the destination choices of trip makers. It is often hypothesized that trip makers will have a tendency, first, to make more trips to areas with a relatively high level of public transit, particularly if the service there is superior to that provided by the auto and, second, to make fewer trips to areas with poorer transit accessibility. This propensity is measured by comparing the error in travel volumes predicted by a standard Bureau of Public Roads highway time gravity model with the relative transit and highway service levels, as measured by the disutility difference measure used in most utilitarian modal split models. A well-defined and logical bias in gravity model output was discovered with respect to the relative transit and highway service levels. The impact of this bias on simulated person trips is evaluated by correcting the gravity model output and comparing the corrected and uncorrected trip tables.

GRAVITY MODEL TRIP DISTRIBUTION

Doubly constrained gravity models were calibrated on the basis of highway travel times for three trip purposes: home-based work, home-based nonwork, and non-home-based nonwork (1). The formulation of the models was the standard Bureau of Public Roads (BPR) gravity model (2). For the most part, the procedures outlined in that report were followed during the calibration process.

The formulation of the BPR gravity model is

$$T_{ij} = P_i A_j F_{ij} \Big/ \sum_{j=1}^{n} A_j F_{ij} \tag{1}$$

where

T_{ij} = number of trip interchanges from zone i to zone j,
P_i = number of trip productions in zone i,
A_j = number of attractions in zone j, and
F_{ij} = empirically derived highway travel time factor, which expresses the overall areawide effect of spatial separation on trip interchanges between zones t_i minutes apart. This factor approximates $1/t^n$.

Specific zone-to-zone adjustment factors, or K-factors, were not used in this application of the BPR gravity model.

The trip data used to calibrate the gravity model were obtained from 1960 Penn-Jersey travel survey data, which were reformatted into standard production-attraction format and trip tables built for each purpose on the basis of an 832-zone area system.

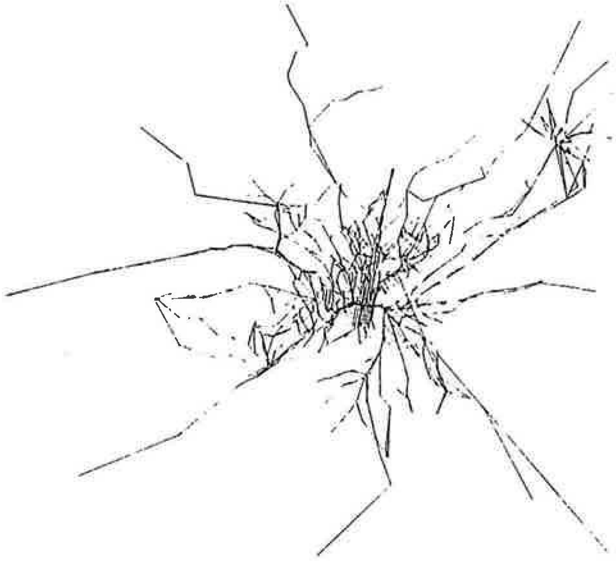
Highway travel times were obtained from a 1960 street and highway network, which was coded to the same zone system. Highway speeds were inserted into the network from a look-up table on the basis of functional class and area type. The highway travel times were then updated with terminal and interzonal times and with bridge penalties across the Schuylkill and Delaware rivers. These parameters were calibrated by using recommended BPR procedures. The updated set of highway travel times was used for all three trip purpose models.

BIAS WITH RESPECT TO RELATIVE TRANSIT AND HIGHWAY SERVICE LEVEL

The Test

If the public transit service level has a measurable impact on the distribution of person trips, then a distribution solely on the basis of highway travel time should lead to an underestimation of person trips for interchanges with good transit service and poor highway service, and should lead to overestimation where transit service is poor relative to highway service. This hypothesis was tested by comparing the relative transit and highway service levels (as measured by the disutility or impedance difference measure shown in Equation 2) with the ratio of the 1960 gravity model synthetic trips to 1960 survey person trips. This comparison was done for each of the three trip purposes and for total trips.

Figure 1. Coded transit network.



$$ID = K_1(TE - HE) + K_2(TR - HR) + K_3(TF - HOP - PKG) + K_4(TRFR + 1) + 200 \quad (2)$$

where

ID = disutility or impedance difference,
HE = highway out-of-vehicle time,
TE = transit excess or out-of-vehicle time,
HR = highway in-vehicle time,
TR = transit in-vehicle time,
TF = transit fare (cents, in 1960 dollars),
HOP = highway operating cost (in 1960 dollars),
PKG = auto parking cost,
$TRFR$ = number of transit transfers,
$K_1 = 2.50$,
$K_2 = 1.67$,
$K_3 = 1.0$, and
$K_4 = 16.0$.

This impedance difference is similar to the standard disutility measure used in most modal split models (3, 4).

The 1960 transit travel times and costs were obtained from a morning peak-hour transit network with travel times and headways taken from operating schedules. The network as it existed in 1960 is shown in Figure 1. Coded to the same 832-zone area system as the highway network, it contained all significant commuter rail, subway-elevated, and bus facilities within the 1960 Penn-Jersey cordon line. The same morning peak-hour network was used for all three trip purposes.

Results

The ratio of 1960 synthetic to 1960 survey trip interchanges was plotted versus the transit-highway disutility difference for home-based work, home-based nonwork, non-home-based, and total trips. The curves clearly showed a systematic bias in the magnitude of synthetic trip interchanges with respect to the relative transit and highway service levels. This bias exists for all three trip purposes; its magnitude is greatest for home-based work trips and least for non-home-based trips.

INCLUDING THE TRANSIT SERVICE LEVEL

Correction Procedure

Several approaches are available for attempting to correct the bias with respect to the relative highway and transit service levels. The most common approach is to construct a combined interzone time or impedance measure and then to calibrate the gravity models on this basis. An appealing way to accomplish this is to construct a weighted average of the highway and transit service levels, using some function of the percentage of transit as a weighting factor. However, this approach is difficult to calibrate, and most studies simply assume an arbitrary weighting scheme.

Rather than adopt an arbitrarily calibrated formulation that would use an estimated modal split to weight the highway and transit travel times, the inverse of the bias curve was used to calculate an adjustment factor that would then be translated into a revised highway travel time through the inverse of the gravity model friction curve. As was shown in the previous section, the difference in bias curves for each trip purpose was only marginal. Therefore only the total-purpose curve was used to adjust the travel times; this resulted in one revised travel time matrix for all three trip purposes. The inverse total person trip bias curve shown in Equation 3 was fitted by least squares.

$$Z^{-1} = 1.299 - 0.000\,87(ID) \quad (3)$$

The coefficient of determination of the above equation was 0.64. In estimating bias corrections, Z^{-1} was constrained to vary between 1.2 and 0.8.

It should be noted that this process is similar to the more usual practice of weighting the travel times with respect to the percentage of transit, since the bias is measured with respect to a disutility or impedance difference similar to the relative service measure used in most post-distribution modal split models.

However, it is more appropriate for two reasons. First, it is based on an explicit measurement of the bias with respect to the transit service level and hence was calibrated with base-year data. Second, it does not require recalibration of the existing highway time-based trip distribution model, which was performing reasonably well.

Impact of the Combined Skim Adjustment on Person Trips

The combined skim adjustment was applied to the estimation of 1977 person trips for the nine-county Delaware Valley region, and the results were compared with the output of the gravity models by using a set of highway interzone travel times. When the resulting differences were aggregated to superdistricts, the average change was approximately 16 percent of the mean trip interchange volume. Spatially, the combined skim adjustment reduced circumferential movements, which had a poor level of transit service relative to highway; it also increased radial movements, which had relatively good transit service.

The combined skim adjustment tended to increase the average trip length in high-speed rail corridors because these facilities provide generally good service relative to the automobile for longer movements but poor service for trips involving short interstation movements.

CONCLUSIONS

After examining the model results, I have drawn the following conclusions.

1. A highway-based gravity trip distribution model has a measurable bias in the Delaware Valley region with respect to the relative public transit and highway service levels.
2. This bias is well defined, rational, and statistically significant for home-based work, home-based nonwork, and non-home-based trips.
3. The bias varies only marginally by trip purpose; only the non-home-based trips are significantly different from home-based work trips and total trips.
4. The highway time-based gravity model has a significant tendency to underestimate person-trip interchanges even when the transit and highway service levels are equal.
5. The correction of the bias results in significant changes in the synthetic person-trip tables. This change is primarily a shift of person trips from circumferential corridors with poor transit to radial corridors with relatively good public transportation service.

The above results were obtained for the Delaware Valley region, which has an extensive public transportation system—some 2900 route kilometers (1800 route miles) of surface transit service and some 1100 route kilometers (700 route miles) of high-type rail facilities. However, the basic conclusions can probably be generalized to other regions that now have or are considering some form of high-speed public transit service, because the total amount of transit service may not be as significant as the relative quality of transit service in individual corridors.

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Abridgment

Automobile Availability per Worker: A Transportation-System-Sensitive Socioeconomic Variable

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Environmental and energy impacts of transportation are related to vehicle-kilometers of travel. To reduce vehicle-kilometers traveled, strategies are needed to attack its two components: the number of vehicles and the distance the vehicles move. Transit has been suggested as an alternative to driving the automobile to work (thereby, presumably, leaving the automobile parked at home) and as an alternative to owning a second or third car. The research reported in this paper was an exploration of possible relationships between transit and automobile ownership and a determination of causality if such relationships were found (1).

RESEARCH OBJECTIVES AND APPROACH

The general objective of the research reported in this paper was to investigate the impact of a viable transit alternative on household decisions to have automobiles for use in making home-based trips. The specific objectives were, first, to determine differences in automobiles available per worker (APERW) between households in areas served by transit and similar areas not served by transit and to determine causality, and, second, to recommend socioeconomic variables that appear to have high correlation and possible causal effects on APERW for consideration in travel demand models.

Automobile availability per worker was used in this research rather than car ownership or car availability because of findings from other completed or ongoing research. In recent years there has been general agreement among travel demand forecasters that car ownership should be replaced by car availability in mode-choice models (2). It is argued that mode choice and, in fact, travel behavior in general are influenced more by the cars available to a household than by the cars owned by the household. Company cars and rental cars