A Treatise on Trip Generation

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1987

Purpose

This treatise on trip generation has been specially prepared as background material or a training document for both traffic engineers and transportation planners. This material was compiled and distributed in an attempt to bridge the gap of understanding that often divides traffic engineering and transportation planning. Two different approaches to the collection of trip generation data form the basis of the divergence between the micro (site impact) and macro (corridor or regional) analysis and projection of future traffic. If both disciplines assess the strengths and weaknesses of the data collection techniques, improvement can be made in the application and interpretation of results.

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Introduction

Trip generation is a concept or way of viewing travel behavior. It is based on the notion that people and/or goods will be regularly transported to or from a specific establishment of activity at a particular geographic location. It is further assumed that the transport requirements of the people and/or goods involved can be determined as a function of the kind of activity and the amount of that activity. These transport requirements have come to be expressed as trips (both one-way and round-trip formulations have been used).[1] For example, the occupants of a dwelling may be expected to leave home to pursue a variety of interests and/or satisfy certain needs or requirements, such as working, going to school, etc.

These departures and returns are designated as trips. In this instance they are resident trips; a distinction to which we will return. Now if one keeps track of the comings and goings over a specific period of time, say a 24-hour period, we would say that the dwelling unit generated so many trips per day. Assume four trips left the home; one to work, one to school, one to shop and one to the dentist, assume also that these same four trips resulted in a return trip to the home from each of the four activities. We could say that the dwelling unit had a trip generation rate of eight trips per day. Of course, we have not yet counted trips to that dwelling unit made by non-residents such as an insurance salesman, a furnace repairman, a furniture delivery truck, In a similar fashion one could look at a factory, a store, an office building or an entire shopping center and speak of trip generation rates for each specific type of use or generator.

Trip generation is the fundamental building block in the estimation of traffic. The trip generation concept of travel behavior is that the transport requirement of the people and goods associated with any particular type of land-use activity can be satisfactorily determined as a function of the kind of activity, modified perhaps by types of urban location and demography. This concept provides the essential connection between land use and the amount of travel, measured in trips.

The linkage provided by trip generation allows the traffic engineer to forecast vehicular traffic associated with a proposed land development. This same linkage allows the transportation planner to start with land-use projections and proceed through the chain of generation, distribution, mode choice, and assignment to obtain vehicular and passenger volume forecasts. In both cases quantitative evaluation can and usually does follow, including the assessment of capacities and impacts and determination of local or regional roadway and transit requirements.

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[1] The trip is an intuitively attractive idea. We are comfortable with things that have a beginning and an ending. But satisfactory definitions are elusive. How long is a trip? Must it leave the building, site, block or origin? Must it be vehicular or does walking qualify? What is joy riding? Does a postal delivery truck make many tiny trips as it moves from house to house?

The Use of Trip Generation Rates

Trip generation rates are used to estimate traffic, in terms of actual person or vehicle flows on the streets, or travel on the public transportation system in buses and other surface street vehicles as well as on transit vehicles with private rights-of-way. These estimates may be made for a single street or group of streets in a relatively small area, say the streets bordering a proposed shopping center site, for all the streets within a specific corridor, or for all the streets within an entire metropolitan area. The estimates may be made for the present time assuming different transport facilities or with specific near term land use/development proposals and the existing network, or both. And of course, they may be made to evaluate future conditions, such as a forecast horizon year of ten or twenty years from the present.

Thus the problems for which trip generation rates can be used range across a continuum from evaluating the traffic impacts of a proposed development project or specific site to evaluating alternative transportation plans for an entire metropolitan region at a time 25 years in the future.

While the problems range across broad space, network detail, and time spans, the techniques for 1) measuring rates, 2) expressing or specifying rates, 3) and using rates of trip generation to attack problems fall into two fairly distinct categories. These two different approached can broadly be described as site impact studies, which are typically undertaken by traffic engineers, and transportation planning studies which are undertaken by transportation planners (who may or may not be traffic engineers).

The reader may find the foregoing pretty tame stuff, perhaps even trivial. It needs stating because it is this very bifurcation of view and approach to problem solution that we will attempt to reconcile in this review. Why are the ITE trip generation rates different than the rates obtained from household travel surveys? Does the use of conventional site impact procedures overstate the traffic impacts of regional shopping centers? These issues can only be dealt with in a more encompassing analysis of trip generation rates. To deal with these issues will require rigorous and detailed attention to the areas of:

- Observation or measurement of trip generation
- Categories or activities for which trip generation rates are to be calculated
- The specification of the rate itself—modal or person rates and/or time of day
- The sensitivity of traffic estimates to rates
- The usefulness of precision
- The techniques or procedures which will be used in conjunction with the trip generation rates

A Dichotomy in Practice

The problems for which trip generation rates can be used do not fall solely at the local site and metropolitan region extremes, but instead range across a continuum that includes large scale developments, community level planning, and corridor studies. Nevertheless, two fairly distinct approaches to trip generation have grown up around the traffic engineering approach to site impact evaluations of land development versus the transportation planning approach to regional planning. In terms of trip generation data collection, one approach relies primarily on direct observation and counts of traffic entering and leaving specific land uses, while the other relies primarily on person-trip information obtained in origin-destination survey interviews.

Intuitively, it would seem that the trip generation rates obtained form these two approaches would be compatible. A dichotomy should not exist, and yet in practice it does. The dichotomy has gone so far that rates derived from site cordon counts (as exemplified in the ITE Trip Generation Rates) versus rates obtained from regional planning studies (as exemplified by the urban area's home interview survey or models derived from these regional rates) are presented by opposing sides before planning commissions, before legislative bodies, and even (and not infrequently) in the courtroom.

At worst this dichotomy is destructive and at best it is probably unnecessary. In fact, the transportation planner needs to be better able to draw upon the ITE type of rate to aid in improved trip generation estimation at trip attractions in general and at special generators in particular. Likewise, the traffic engineer often truly needs regional transportation study data to facilitate accounting for location effects, transit usage, ridesharing, pass-by trips and the like.

Observation of Trip Generation

There are two basic approaches to the calculation of trip generation; interviews with travelers and truckers, and direct observation and counts of traffic entering and leaving specific sites or areas. The interview technique most frequently used for the inventory of person movement is the home interview survey (also called the origin-destination, or O-D survey, because it locates both ends of the trip). These surveys have been and are used in transportation planning studies.

Vehicle count programs at specific locations are the basis for trip generation rates used in site planning and site impact evaluation studies. There are hybrid techniques as well. The interview technique at cordon line stations combines both approaches. It is this type of survey that gave us insight into some of the problems in the interview technique. That is, by interviewing on the screenline in transportation studies it is possible to go beyond comparing the home interview and truck and taxi interview results to the actual vehicle observations counted at the screenline, and to make comparisons by purpose of travel and time of day. These comparisons gave a check on overall under-reporting of travel by purpose and revealed that work trips, by and large, are well reported in the interview technique, whereas other trip purposes may be under-reported.

A comparison of the differences between direct observation of traffic at the site and the imputation of that traffic based on survey results may be useful to illustrate the factors that need to be considered when comparing methods and rates of trip generation (see Table 1).

Table 1
Comparison of Cordon Observation and Interview Technique for Obtaining Trip Generation Rates

Factor	*Cordon Count*	*Home Interview Survey*
1. Under-reporting	Not a Problem	Results in a significant understatement of travel. Usually non-work travel is under-reported Using screenline checks correction factors can range from 1.10 to 1.33; higher factors indicate a poor survey.
2. Day of the week (Typical data are for average weekday conditions)	Observations typically taken on a single weekday—day of week variability can be lost. Saturday or Sunday data can be obtained if needed. Must specify which is required.	Most area-wide survey data are for weekdays only—although all five weekdays are generally covered allowing some comparison by day of week. The national survey data (NPTS) is for all seven days of the week. Weekends are quite different from weekdays, so comparisons between NPTS and other data sources must consider this factor.
3. Ends of trip obtained	Only origin or destination is obtained. Makes data and corresponding trip generation rates site specific.	Both origin and destination are obtained. Permits imputation of rates of non-residential generators, especially in large samples where land use at destination is obtained. Also permits imputation of non-residential portion of area wide trip rates.
4. Calculation of trip generation rate	Direct measurement in terms of vehicles. If mixed uses are at a single site, rates will reflect this mix.	Indirect except for resident trips to and from residential activities. Subject to adjustments for under-reporting and sampling non-coverage.
5. Linking procedures are sometimes used to join trips which are incidental to some major purpose or activity	No impact.	Practice varies from study to study. It can impact non home-based trip estimation. Some studies try to collect trips in tours or round trips, but clarity to the interviewee is sometimes compromised.

Table 1 (continued)
Comparison of Cordon Observation and Interview Technique for Obtaining Trip Generation Rates

Factor	*Cordon Count*	*Home Interview Survey*
6. Person or modal rates	Typically observations are of vehicles, although car occupancy may be observed and transit trips noted or estimated.	Observations and trip generation rates are usually person trips. The planning study methodology typically models mode-split and auto occupancy
7. Truck trips	Can be observed directly is needed.	Can be imputed if 1) truck survey is done and 2) land use and O-D data obtained.
8. Transferability/ Flexibility/Variability	Vehicle rates are determined for specific generators. Comparability among generators may be obscured because of differences in mode split, land use mix, and vehicle occupancies. Variability measures must come from comparison among generators, and any comparability problems frustrate such calculations.	Survey rates, though imputed, can be disaggregated to get around land use mix problems (provided land use is included in the O-D data) and can be expressed as person trip rates to avoid problems arising from mode split/vehicle occupancy differences. Different modes and varying non-response rates can add to the problems of comparability across surveys.
9. Impact of differences in socio-economic makeup of trip makers on trip generation rates	Difficult to isolate since observations are limited to vehicle or person counts and physical characteristics of the site, such as size (acres or floor space).	Differences in socioeconomic characteristics are immediately available, limited only by the survey questions asked. In the case of residential trip generation rates this provides a strong basis for 1) examining differences in rates by purpose and 2) calculating the range of the rate for a particular category.
10. Consideration of location within the urban area and of land use mix	Observations tend to be made where individual land uses can be isolated for a cordon count. The spectrum of observations may therefore be slanted toward isolated, single land use sites.	Rates can be developed for elements within mixed land uses and for different locations within an urban area, thereby reflecting vehicle impacts of walk trip opportunities and availability of transit.

Categories or Activities for Which Trip Generation Data are Calculated

The whole concept of specific categories of trip generation is based on the premise that the number of trips generated by one specific kind of activity is different than for another kind of activity. Therefore, a uniform rate of trip generation for all purposes is inappropriate—contrast the trip generation rates of a shopping center and a regional park. Several factors are necessary to establish robust categories. First, between two proposed categories there should be significant differences in the average trip rate of trip generation for each category.

Second, within a proposed category the sites should all tend to be alike; i.e. exhibit the same trip generation rate. This tendency to be similar rather than different is critical to the accuracy of the rate and the precision of the results based on the use of the rate. For example, if the rate of vehicle trip generation for single-family residential land use is estimated at 6.0 vehicle trips per dwelling unit, we should have a measure that expresses the variability of that rate.

The standard deviation is the statistical measure most often used to describe the variability of the mean. If the standard deviation of the mean rate of 6.0 vehicle trips per dwelling unit were $\pm$ 1.0 trips per dwelling unit, we could say that two times out of three when we used a rate of 6.0 vehicle trips per dwelling unit the actual rate would be bounded by a range of 5.0 to 7.0. The calculation of the standard deviation requires the measurement of several dwelling units presumed to be in the same sample category. (30 observations is often cited as the breakpoint away from statistics of small samples).

While we are on the subject of variability we should point out that much is already known about the variability of trip generation of residential units. We know, for example, that the trips per dwelling unit are a direct function of family size. The larger the family size the larger the number of trips. We also know that vehicle trips per dwelling unit are a direct function of car ownership. The more cars owned at a household the greater number of vehicle trips produced by that household.

While family size and autos owned are positively correlated with trips per dwelling unit, it is hardly a perfect correlation. That is, there are small families that own two cars and make few trips and large families that own one or zero cars and make many trips. This independence is such that the use of both variables to define the categories of residential trip generation increases the precision of estimating residential trip productions substantially.

The categories for sample allocation might be zero, one, two, and three plus cars per household for car ownership, and one, two, three, and four or more persons per household for family size, making a total of 15 cells. The distribution of households within these categories will, of course, be different from zone to zone or project to project. Some zone would have high auto ownership or smaller household size. The overall rate of trip generation would be higher for the former and lower for the latter.

This discussion brings us to yet another consideration in category determination. In addition to being different than another category in terms of rate of trip generation, and being homogeneous within the category, the user must be able to classify the dwelling units in the zone or project within the appropriate category in order to take advantage of this special knowledge about trip generation. Who can guess how many cars will be in the garage or how many people will comprise a household of a dwelling unit that has yet to be built?

A balance must be struck in specifying categories that explain part of the variation in rates, but for which dwellings cannot be classified for lack of knowledge on the one hand, and specifying simple categories that are easily identified but whose rates exhibit enormous variability. Striking this balance is an important part of sample design. If one must err, it would seem better to err in the direction of greater detail of categories with clear procedures for aggregating categories later in the process as needed.

Of course, everything that has been said about residential trip generation rates must be considered for non-residential trip generation as well.

Introducing the Notion of Variability into Trip Generation Rates

There are two components to be considered in developing trip generation rates for residential land—trips by residents and trips by non-residents. The home interview survey collects trips by residents, and also yields a trip rate and a measure of variability, the standard deviation, directly. Sites containing a mixture of dwelling units in terms of socioeconomic variables such as household income, cars owned, family size, etc. will have a rate representing that mixture in a measure of variation which is a function of the unexplained variation. The unexplained variation is the variation in trip rates which remains after accounting for the variability explained by socioeconomic factors. This could be converted to a range in the form of a standard error of the estimate.

This would take care of residential trip generation rates completely were it not for trips to residential land by non-residents. Such trips appear to account for a large (perhaps 25 percent of the total) and growing share of the trips attracted to dwelling units. The extent to which variability of non-resident trips per household can be explained by the socioeconomic status of the dwelling unit in a zone should be examined and utilized, if significant, to reduce the range of trip generation variability.

The resulting measure of variation will be applicable to the residential trip generation rates obtained through the home interview survey. This transfer will be made possible as a result of the comparability and reconciliation analysis between rates obtained from the two different measurement approaches.

Analysis of the variability of non-residential trip rates should concentrate on the available non-residential trip data obtained by direct observation (such as a cordon count). This analysis would calculate the standard deviation for sites having the same land use composition. Because the vehicle trip rate may vary as a result of differences in transit use and auto occupancy, these variables should be standardized before calculating the variability among sites. In some cases, the analysis may indicate that the data are not an adequate basis on which to base a measure of their variability. In such cases the range appearing in the data must be disclosed with a note that significant variation cannot be measured.

Specification of Trip Generation Rates

We have discussed the concept of trip generation and also the basis of establishing categories of activities for which trip generation rates are to be calculated. Much greater study is needed to establish trip generation rates that can be sued for a variety of problems and which reconcile differences among existing rates. The final aim of such a study would be to unify, if possible, of the many sources of data on trip generation.

A major aspect of differences between data sources has to be the basis by which trips are expressed as rates. At the trip level there is the question of whether to express person trip rates or vehicle trip rates. If one is trying to assess vehicular impacts on the roadway one will ultimately be dealing with vehicle trips, although that is not to say one must start there. Much of the four-step planning process is devoted to using person trip generation as a starting point and proceeding through a model chain which distributes people into different modes (drive alone, drive with others, transit, walk, etc.) and ultimately produces vehicles on the highway network.

Therefore, vehicle-trip generation rates are dependent on the proportion of people taking transit and the average auto occupancy at a site or zone. If one employer is actively sponsoring a ride-sharing program while another is not, the former will have a lower vehicle trip generation rate even though the person trip rates to each site might be identical.

However the rate table is ultimately structured, a means of moving between vehicle rates and person rates will be critical in order to compare sources which appear to yield quite different vehicle trip rates.

Another aspect of rate comparison and reconciliation among sources is the issue of the unit of measurement of the activity. Do we measure residential activity in terms of floor area, land area, dwelling units, or what? We have used the census definition of dwelling units traditionally, to aid in forecasting. Non-residential generators may not be as transparent. Retail commercial trip rates may be expressed as trips per 1000 square foot of floor, per acre, or per employee. Differing coverage rates, service policies, and product mix all contribute to differences in rates within a particular unit of generation, such as trips per acre or trips per employee. It may well be necessary to have multiple bases for rate calculation simply to accommodate those problems for which the available data is limited to a particular unit such as acres of land.

Still another question is how much time specificity should be contained in the trip generation data. The bulk of the large scale long-range planning work has utilized a 24-

hour assignment of traffic which is then factored to time of day and peak hour estimates. Most traffic, or impact, studies require time of day specifications for rates. If trip generation rates are specified in purpose terms as home-based work, home-based shopping, etc., the temporal characteristics may be induced from the characteristics of that purpose, although the flexible workday and 24-hour shopping make assumptions in this regard more risky.

Procedures to be Used in Conjunction with Trip Generation Rates

The foregoing discussion has considered the definition and structural characteristics of trip generation rates as determined from different sources and the importance of activity or category definition.

The uses to which these rates are put represent still another dimension of trip generation that must be considered. Site impact studies use trip generation rates to calculate the number of trips that will arrive at and leave a specific site, given the kind and amount of proposed development on the site. In the main these studies attempt to layer these trips on top of the traffic that is already observed in the streets in the vicinity of the proposed development. To the extent that a portion of the trips represented by the assumed trip generation rates represent trips already being made by residents in the area, there is double counting or over-estimation of travel in a regional sense. That is, these trips were already being made somewhere in the region and are being diverted to the new development, which should be accounted for somehow.

Researchers have pointed out that the use of trip generation rates to estimate traffic impacts of a proposed regional shopping center, for instance, may overestimate the impacts. The problem, however, is not the correctness of the rates per se, but the fact that a marginal analysis is typically performed which assumes that the shopping center traffic is a net addition to the street system. That is, the total travel in the region, or even the travel in the vicinity of the shopping center that is not directly associated with the shopping center, is not reviewed—it is simply assumed to be constant.

Impacts of diverted trips are counted in the vicinity of the center but their reduced impacts on the highways from which they were diverted are not considered. Reductions in travel on the streets in the vicinity of the shopping center as a result of the increased congestion around the new development are also not considered. Clearly, this residual approach is open to some question. It is not clear at all, however, that the development of factors to represent primary shopping trips, diverted linked trips, and un-diverted linked trips will solve the problem. Such factors will vary as a function of location, size, and relative competitiveness of proposed shopping opportunities, and also by the type of area they are located in and the rate of population growth expected by the developer and experienced by the region.

In a way, in order to make the adjustments one needs to know the answer. It may be that such factors might be derived from short cut assignment procedures. In any case, it is not the rates but the process in which the rate results are applied that causes the problem.

In planning studies for regional, corridor, and sub-regional analysis, trip generation rates are used in the context of a model which, for instance, distributes the trips across zones and then allocates proportions to modes and assigns vehicle and transit trips to the appropriate networks to assess the impacts. The trip generation rates employed in this approach most often must be person trip rates, not vehicle trip rates. This is a different scale than the traffic impact study. Still, trips are trips. It seems irrational to be using one set of rates for site-specific studies and a separate set of rates for sub-regional and/or regional analyses. However, if one can move between vehicle trip rates ad person trips rates in a rational process the rates may be equivalent. That is, the person trip rates must be reconcilable to the vehicle trip rates by spelling out completely the assumptions that would make them identical.

An Example of Sensitivity Analysis

Assume that it is desired to know the sensitivity of total trips generated to an estimate of population. If a linear relationship is presumed to exist between total trips and population, then 1.0 percent change in population will produce a 1.0 percent change in total trips, and the sensitivity is 1.0. If the relationship between the dependent and independent variables is non-linear, then further information must be supplied. The sensitivity is x percent at a certain (stated) value of the independent variable. Moreover, because of their interaction, assume that not only analysis of the sensitivity of projections of population, but also number of households and number of persons per household are of interest.

Table 2 shows a distribution of households, population, and person trips per household by household size. How sensitive is the estimate of total trips to a change in the distribution of family size? The number of trips per household increase from 1.89 to 10.37 as the number of people in the household increase. The correlation between the mean household size and the average number of trips per household in Table 2 is .99 with a slope of 2.1 and an intercept of .336. In other words, each increase of one person to the household causes an increase of 2.1 trips.

In this case, however, it is assumed that the forecast of population is given. Therefore, as different assumptions of family size are made it is not the populations that varies but the number of households. Table 2 shows an average family size of 3.24. If it is assumed that the average family size will be 2.89 or 10 percent less than in Table 2, then using the regression equation trips per household would be 6.4, which is 90.5 percent of the average shown in Table 2. This suggests a high sensitivity: 9.5/10.0=.95.

However, if the population remains the same (36,045) the number of dwelling units must increase from 11,229 to 12,472 if the average family size decreases. A total of 12,472 multiplied by 6.4 trips per household yields 79,883 trips. Compared to 80,492 trips in Table 2, this is a change of only -.8 percent in trips with a change of -10.0 percent in family size, or a very low sensitivity of -.08. A one percent change in family size results in a change in trips of only .08 percent, if population is held constant.

Table 2
Households and Total Trips by Family Size

Persons per Household	Number of Households	Percent of Households	Trips per Household	Total Trips
1	1,198	10.6%	1.89	2,259
2	2,867	25.5%	4.78	13,697
3	2,144	19.1%	7.32	15,692
4	2,110	18.8%	8.82	18,616
5 and over	2,914	26.0%	10.37	30,227
Total	11,229	100.0%	7.17	80,492

On the basis of this analysis of the data, travel—or total trips—estimated from common trip generation procedures is very sensitive to changes in population estimates but relatively insensitive to household size distributions for a given population estimate. However, if the input data to trip generation are in terms of households, then a household size estimate must be used and the resulting travel estimate is extremely sensitive to the estimate of household size.

This example illustrates the changes in total trips generated, given changes in two inter-related input variables. In the case of major non-residential generators, the interrelationships between descriptive variables are not as close as that between population, number of households, and household size. However, the combined effect of two or more variables is equally of concern.

For example, assume that a new shopping center of 500,000 square feet gross floor area is to be analyzed. Using NCHRP 187, Table 1, a rate of 33.5 to 34.7 trips per 1,000 GFA is appropriate, and a peak hour generation of 11.5% of the daily total. These inputs yield (using 34 trips/1,000GFA) 17,000 trips/day and 1,955 trips during the peak.

Assume further that the standard deviation of the rate (34) is known, and 2/3 of the time the rate is between 29 and 39, and the peak hour percentage is between .10 and .13. Using these ranges there are four bracketing estimates of peak hour trip generation:

500 x 29 x .10 = 1,450
500 x 39 x .10 = 1,950
500 x 29 x .13 = 1,885
500 x 39 x .13 = 2,535

The basic sensitivity is linear, simple to calculate, and equal to 1.0:

$$\frac{1{,}885 - 1{,}450}{1{,}885} \Big/ \frac{.13 - .10}{.13} = \frac{.2308}{.2308} = 1.0$$

Moreover, assume that three-quarters of the trips generated are ‘new’ to the surrounding streets (e.g. trips that have not diverted while passing by), then a number in the range of ¾ x 1,450 to ¾ x 2,535 will be added to the adjacent streets. (Of course, this assumption also could have a range, but that is ignored for the sake of the example.) Turn now to a second ‘level’ of sensitivity: what are the implications for additional facilities?

First, if an entrance/exit lane has a capacity of 700 vehicles per hour, the site will need between 2 and 4 lanes. Of course, all vehicles will not go in one direction—some will enter and some will exit during the peak: assume 2/3 enter the shopping center. For entrance/exit capacity in the maximum direction, 2/3 of the range 1,450 to 2,535 will be required: 967 to 1,690. (Trips diverted making pass-by stops must also enter and exit). If entrance/exit lane capacity is 700 per hour, not less than two and perhaps three lanes will be required in each direction.

For adjacent street capacity, however, total travel (both directions) will be increased by ¾ of the estimate of generated trips or 1,088 to 1,901. If the adjacent streets alos have a capacity of 700 vehicles per lane per hour, they will also require between 2 and 3 additional lanes.

The sensitivity of facility needs to changes in the trip generation rate and peak hour percentages is greater than the sensitivity of the estimate of trips. Unconsidered as yet is the sensitivity to the most obvious variable of all—the size of the shopping center. This raises several additional points in addition to the linear change in total trips (and other variables) with respect to development size.

First, for a small center and entrance and exit will be built. It is likely that even the high end of rate and peak assumptions would not indicate demand for more than that. For the same small center the proportion of trips diverted to the center and representing added travel to the adjacent street probably would be smaller than for a large center. Given the real imprecision in capacity estimates and local circumstances, the probability of needing additional lanes for the capacity would be small.

On the other hand, these same linear relationships dictate considerable care in the estimates for larger centers and particularly their implications for investment in facilities. Moreover, given that large—say regional—developments are likely to divert a relatively high number of trips from other locations, some at a distance, there are implications for capacity at adjacent locations and for reduced demand in other locations. In the case where larger-scale concentrated generators are being considered, true network assignment and origin-destination analysis may be prudent, both to facilitate analysis of the impact of the new development and to provide a systematic method of controlling the total number of trips involved (to avoid double-counting).

The Power of Precise, Analytical Trip Generation

Sensitivity analysis will show how trip generation responds to changed generator characteristics or inadequate descriptions of trip generators, and analysis of trip generation over time will be instructive in revealing the extent to which older data are stale. Change always will be with us: changing household sizes, changing auto occupancy rates, changing income levels, and changing workforce composition and participation rates. A major advantage of a trip generation rate framework that incorporates socioeconomic characteristics is its robustness in the face of changing conditions.

For example, the residential rates in Table 1 of NCHRP #187 do not appear to be responsive to major demographic shifts. If family size declines substantially all of the evidence on trip generation would suggest that trips per household would decline. Overall, the total trip production by the entire population could stay relatively constant since there would be more dwellings for a fixed population. However, the trip generation rates in Table 1 of NCHRP #187 are insensitive to household size and therefore those rates, barring compensating changes in other socioeconomic variables, would be too high in the face of declining family size. The essential point is that the consumption of travel may be constant or relatively constant through time within a category or socioeconomic sub-category. Perceived secular changes in travel consumption may be little more than shifts in the distribution of households within socioeconomic variables such as income and household size.

A fairly dramatic example of such a case was found in an analysis of recent home interview data. Because there an increasing proportion of households have a female head of household, the trip characteristics of such households were examined. It was found that these households make substantially fewer trips than do households with a male head and a female spouse. A comparison of trip generation rates found in the Niagara Frontier Transportation Study is presented as an example in Tables 3 and 4.

The households with the female head make only 3.51 trips per household. Households with a male head and a spouse make 7.95 trips per household—136% more trips. However, the distribution of these households by car ownership class and persons per household are dramatically different. Female-headed households have an average of only .45 cars per household compared to 1.08 cars per household for those with a male head and female spouse.

A similar difference was found with respect to household size. The average household size for families headed by a female was 2.0 compared to 3.6 for families headed by a male with a spouse living in the household. Thus car ownership for female headed households is only one-half that of male headed households with a spouse, and family size of female-headed households is about 56 percent as large as households with a male head and a spouse.

This analysis also examined households headed by a male without a spouse. These households are much more similar to female-headed households, although the trip generation rate was 20 percent greater than female-headed households. Again, the aggregate mean rate difference disappears when distribution of households by car ownership and household size is examined.

The implications of these data are that female-headed households are significantly different than traditional households if associated differences in household size and cars owned are ignored. However, when these socioeconomic variables are included there is little, if any, difference in travel consumption.

Table 3
Comparison of Total Trips per Household
By Type of Head, Cars Owned and Family Size

Cars Owned	Household Head	Household Size					Total
		1	2	3	4	5	
Zero	Male Head + Spouse	--	1.74	3.07	3.38	4.32	2.81
	Male Head /No Spouse	1.06	1.93	3.10	1.91	2.57	1.43
	Female Head	1.18	2.27	2.79	3.70	3.40	1.85
One	Male Head + Spouse	--	5.30	7.11	8.26	9.70	7.68
	Male Head /No Spouse	3.30	4.83	7.36	7.37	9.26	5.14
	Female Head	3.03	5.20	6.78	7.98	8.63	5.08
Two or more	Male Head + Spouse	--	7.54	9.72	12.48	14.80	11.83
	Male Head /No Spouse	4.00	7.56	7.91	9.53	14.50	9.06
	Female Head	5.00	8.24	9.33	13.25	14.26	10.66
Total	Male Head + Spouse	--	4.84	7.34	8.96	10.34	7.95
	Male Head /No Spouse	2.31	4.41	6.85	7.02	9.40	4.23
	Female Head	1.70	3.96	5.35	7.10	6.81	3.51

Source: NCHRP 8-24 Draft Final Report

Table 4
Comparison of Percentage Distribution of Households
By Type of Head, Cars Owned and Family Size

Cars Owned	Household Head	Household Size 1	2	3	4	5	Total
Zero	Male Head + Spouse	0.0	5.4	2.1	1.4	3.0	
	Male Head /No Spouse	24.7	7.3	2.0	1.1	1.4	36.5
	Female Head	33.4	12.8	6.5	2.7	3.8	59.2
One	Male Head + Spouse	0.0	17.9	13.8	15.3	20.7	67.8
	Male Head /No Spouse	22.0	13.9	7.7	3.8	4.7	52.2
	Female Head	12.5	12.0	5.8	2.4	2.0	34.7
Two or more	Male Head + Spouse	0.0	3.1	5.0	5.2	6.9	20.3
	Male Head /No Spouse	0.4	3.9	3.3	1.7	2.0	11.3
	Female Head	0.2	1.6	2.1	1.1	1.2	6.2
Total	Male Head + Spouse	0.0	26.5	20.9	21.9	30.6	100.0
	Male Head /No Spouse	47.0	25.2	13.0	6.6	8.1	100.0
	Female Head	46.1	26.3	14.4	6.2	7.0	100.0

Source: NCHRP 8-24 Draft Final Report

Summary

This document has provided an overview to some of the apparent inconsistencies between trip generation rates derived from site cordon counts and those derived from home interview surveys. The two most often used sources of information on trip generation are the ITE manual Trip Generation and the NCHRP #187, Quick Response Urban Travel Estimation Techniques and Transferable Parameters: User's Guide. Each of these sources is cited for trip generation data and each uses a different data collection method—the former relying on direct observation and counts of traffic entering and leaving specific land uses and the latter on person-trip information obtained in origin-destination surveys.

Factors which contribute to discrepancies between the two basic types of trip generation rates were briefly reviewed (see Table 1). Among these factors were interview under-reporting, day of week discrepancies, rate calculation procedures, trip linking, mode split, socioeconomic differences, and consideration of location within an urban area and land use mix.

The basis of establishing categories for which trip generation rates are to be calculated was discussed. The use of specific categories for trip generation derives from the premise that the number of trips generated from one specific kind of activity is different than the number of trips generated from another kind of activity. However, within a proposed category trip generation rates should be similar. Where variation within a category can be explained, the range of variability can be reduced. At the time of application an understanding of the variability or standard deviation within a category will allow a more accurate fitting of specific developments into existing categories and a better application of rates for new facility development.

Some techniques and procedures used in conjunction with trip generation rates were reviewed and the use of sensitivity analysis to measure the responsiveness of trip generation to change—change in household size, change in labor force composition, change in income levels, was introduced. The use of this analysis will indicate the extent to which the trip generation rates available are the most accurate representations of the amount of travel consumption within the various categories.