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Transportation Planning for Small Communities: Western Canadian Experience

S. Teply

The paper discusses the principles, constraints, and objectives of transportation planning in small communities. It compares some of the basic relationships derived in the United States with those found in several western Canadian communities. A synthetic planning process called the four-purpose trip generation and distribution model is described in detail. It uses an analogy approach by starting with estimated data found applicable in similar communities. In this way it avoids the costly and time-consuming data collection stage. The model is verified and calibrated after data processing. Computer traffic volumes are compared with traffic counts and, if necessary, the input values are adjusted. Sensitivity of the model to errors in the initial estimated data is analyzed in relation to the basic zonal land use characteristics (i.e., population and employment). A set of graphs is presented to expedite the calibration process. They relate the size of the unit outcome error (i.e., the difference between the computer and the surveyed traffic volume) to the required adjustment of initial estimates of trip purpose distribution.

Small communities in western Canada must determine the directions of their future development. Oil, gas, lumber, agriculture, and initial industrialization form the basis for a dynamic economy, especially in Alberta. The towns and cities have experienced a period of steady growth and strive to maintain a balanced development in all aspects of urban life in the future. This goal creates a need to plan ahead in order (a) to influence the demand, (b) to provide and control the supply of facilities, or (c) to do both. Planning in small expanding communities is rather difficult because even small unforeseen facilities, activities, or policies may have dramatic effects. The decision of a single industrial company to move into the area and locate at an opportune (yet at the planning stage unconsidered) location may make previous transportation plans invalid. The range of effects of such uncertainties is much more pronounced than in large, established cities.

THE PROBLEM

In the past 10 years, the trend in urban transportation planning has been to recognize the specifics of small communities and to adjust procedures and models accordingly. Identifying features of small communities may be listed as follows:

1. Population size of up to about 100 000 inhabitants [several research studies dealt with smaller (up to 50 000) or larger (up to 250 000) communities];
2. Economy usually pivots around several key activities;
3. Life-style in smaller communities is simpler;
4. Scenarios that are easily identifiable can cause significant migration into or out of the area;
5. Civic governments, both in elected and administrative portions, lack the expertise or resources for solving unusual problems (i.e., those that exceed day-to-day operations); and
6. Strain on financial resources, especially when considered on a per capita basis, is usually much larger because small communities cannot use the luxury of economy of scale.

Size of a community seems to be only the most visible indication of the other community characteristics that should be considered in their full context. The economic balance of the community may be influenced drastically by outside forces. Social activities in small communities are less diversified and identifiable than are those in larger urban centers. In some instances, the governing bodies of smaller communities lack the necessary political maturity and stability for efficient decision making.

The purpose of transportation plans for small communities may be one or more of the following:

1. Identification of the consequences of major development alternatives;
2. Assistance in selection of the best land use master plan;
3. Definition of the transportation requirements of a specific land use plan; and
4. Identification and testing of specific solutions, such as new bridge locations.

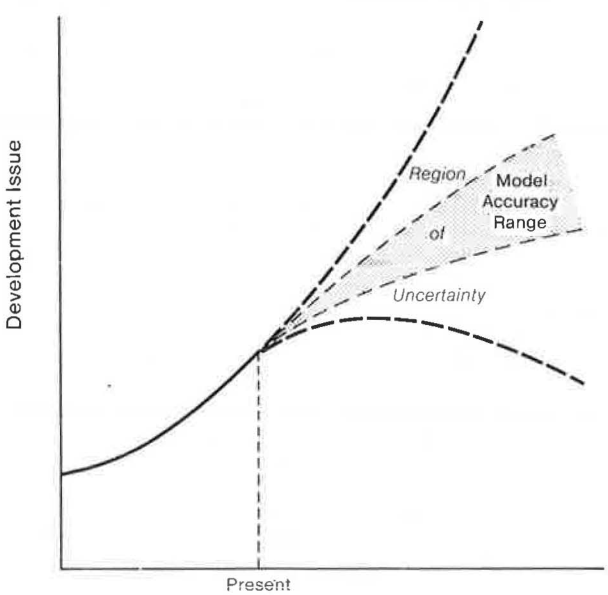
Constraints of comprehensive transportation plans for small communities usually are the following:

1. Minimum cost,
2. Minimum time,
3. Reasonable accuracy,
4. Large number of time frames,
5. Studies are more goal oriented, and
6. Population interest.

Traditional transportation planning methodology, common in large communities, is prohibitively expensive for small communities, both for their data collection and for modeling. The marginal per capita cost of such studies may be several times higher in small communities than in large cities.

Although small communities have recognized the benefits of a continuous planning process and plan evolution, the nature of community life and population expectations demands expedient answers. In addition, time spent on a study, even during its inactive stage, increases cost.

Figure 1. Symbolic representation of model predictive ability.



The concept of model accuracy in transportation planning is based on the predictability of independent variables and on model cost. In small communities, the economic future and consequent transportation development is less predictable than in larger, more diversified communities (Figure 1). Highly sophisticated, accurate models, even when coupled with a scenario or alternative future approach, may not perform better than their simplified versions or other crude models. Also, in a small community, achievement of the same accuracy goal as that required for a large city would be proportionately more expensive. In simple terms, a high degree of accuracy is not required.

Models used should be easily applicable to a variety of problems that may range in time from immediate needs to those that are 10 or more years in the future. In past studies, much time, money, and attention were spent on data collection, analysis, and model development. On the other hand, in some instances, generation of solution alternatives and their evaluation left much to be desired. Small communities, however, are usually more goal oriented than large communities.

In a small community, a major transportation study may quickly become a matter of everyday community talk. Lack of competing issues as well as community expectations generate public interest and, for that reason, require a reasonable openness of the planning process.

MODEL CHARACTERISTICS

The traditional structure of the four-step transportation model (i.e., trip generation, modal split, trip distribution, and trip assignment) has a special appeal for small communities in that it is straightforward and easily understandable. In addition, individual steps are relatively independent, can be treated at different levels of sophistication, and can be easily verified or calibrated individually.

Bates (1) postulated that the primary assumption in transportation planning (i.e., consistency in time of relationships between travel demand and certain social, economic, and physical parameters) can be logically extended to consistency in space. This seems to be a reasonable assumption, especially when cultural and behavioral differences between communities are also considered. Based on this premise, Bates reasoned that it may be feasible to formulate models that can synthesize results of field data collection and thus eliminate the necessity for this expensive and time-consuming phase of transportation planning.

Recognition of the analogy approach to transportation planning in small communities is widespread today. It is a simplified but valid approach, whose capabilities are in line with the constraints of the planning process.

The following is a brief review of planning characteristics described in the literature and applied in several western Canadian studies for small communities.

Trip Generation

Jefferies and Carter (2) list specific characteristics for trip generation models for small communities as follows. Data used to develop independent variables should be (a) easily obtainable from existing records or simple and inexpensive surveys, (b) capable of explaining future as well as existing trip-generating characteristics, and (c) able to reflect the influence of the change on trip generation rates. Reliable and inexpensive methods should be available for forecasting data used as independent variables. The final trip generation equation should be easy to use and should contain the fewest variables

consistent with the amount of accuracy required.

A condition of an easy validation and calibration of the relationships between the independent and dependent variables can be added. The types of independent variables used in various studies for both trip production and attraction include population, dwelling units, automobiles, employment, retail employment, industrial employment, other than industrial employment, government and finance employment, and school enrollment. Dependent variables used include total trips, home-based work trips, home-based nonwork trips, home-based shopping trips, and non-home-based trips.

Figure 2 shows the relation between population size and total automobile trips based on an analysis of 14 small U.S. communities (3-12). Other sources also indicate that the variability of the total number of trips in small communities is larger than that for larger cities. In general, the number of trips per capita per working day ranges from 1.6 to 3.0; a major cluster of values falls between 1.8 and 2.2. The list of values found applicable to seven western Canadian small communities

Figure 2. Relationship between population size and total vehicle trips.

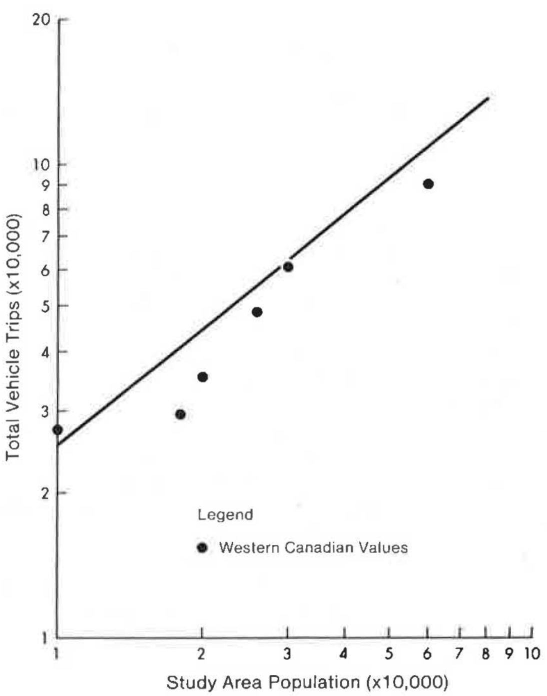


Table 1. Trip generation rates determined in the studies.

Community	Year Studied	Population	Trips per Capita per Day
Fort McMurray, Alberta[a]	1974	10 000	4.20[b]
Medicine Hat, Alberta	1977	30 000	3.25[b]
Medicine Hat, Alberta[a]	1971	26 000	2.60[b]
Kelowna, British Columbia[a]	1973	20 000	2.60[b]
Grande Prairie, Alberta	1977	18 000	2.50[b]
Prince George, British Columbia[a]	1974	60 000	2.35[b]
Murray, Kentucky	1967	10 000	2.80[c]
Joplin, Missouri	1960	16 000	2.93[c]
Clarksville, Tennessee	1965	11 000	2.29[c]
Gainesville, Florida	1960	21 000	1.94[c]
Pittsburg, Kansas	1961	22 000	2.38[c]
Staunton, Virginia	1965	32 000	1.69[c]

[a] Studies used in sensitivity analysis.
[b] Person trips per capita per day.
[c] Vehicle trips per capita per day.

is shown in Table 1 and interpreted in Figure 2. The U.S. studies were taken from Hajj (13). The higher value for Fort McMurray may be attributed to the dynamic nature of the town; many young people were attracted by the opportunities of the Alberta oil sands regions (14).

Car ownership may also be a partial explanation for higher than usual values of trip production in some small communities. For example, the average provincial ratio of population to vehicles in private use in Alberta in 1978 was about 1.5 persons/vehicle. For rural areas and small communities the ratio may be considerably higher than the average.

Although a number of regression equations for trip production that use many of the previously mentioned independent variables have been developed elsewhere (1, 2, 13, 15-17), a formula that is based solely on population size and trips per capita per day has been found sufficiently accurate for western Canadian communities. The problem of predicting future population still remains. Refined methods, such as the cohort survival method, do not work well in western Canadian small communities because of the migration phenomenon. For that reason, economic models based on industrial or agricultural potential have been applied in some instances.

A more complex situation exists in trip attraction models, although regression equations for trip attraction quoted in the literature employ independent variables that are similar or identical to those for trip production. Western Canadian models generally use only population, employment, and retail employment.

The problem at hand is data collection. Large-scale interviews are costly and small samples in small communities do not always guarantee the required statistical significance. This is one of the reasons why the analogy approach has become increasingly popular.

Modal Split

With few exceptions, public transit does not play a major role in small western Canadian communities. If transit is provided at all, its share usually does not exceed 5 percent or, in a few cases, 10 percent. In small communities, roadway capacity is plentiful at almost any time of day, and high automobilization and a neighborhood spirit exist. A private automobile, therefore, can provide the least expensive transportation service from a community point of view. Nevertheless, as a community grows, the need for transit or for more transit emerges.

In those studies in which trip production and trip attraction have been determined in person trips (as opposed to a direct determination of vehicular trips), a conversion must be made. Usually, when trips per day are used, an overall daily average vehicle occupancy factor is applied (around 1.5 in western Canada). For those cases where peak-hour trips are determined, differentiation of occupancy among various trip purposes is necessary.

Trip Distribution

The shopping list of models available for small communities includes growth factor and gravity approaches. Both have been applied successfully.

An interesting variation of a Fratar method was described by Rhodes and Hillegass (16). It combines both the trip distribution and trip assignment stage in that pseudoattraction factors are used to determine the distribution table and, after trip assignment, growth factors for individual network links are determined.

Although full versions of gravity models have been applied elsewhere, it is interesting to observe the effect

Figure 3. Relationship between population size and the maximum trip length.

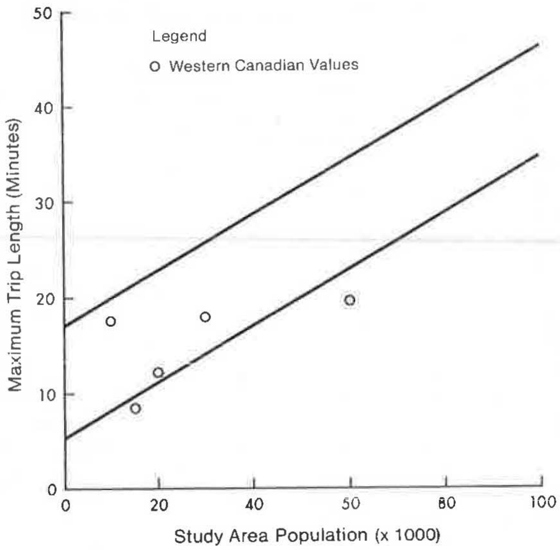
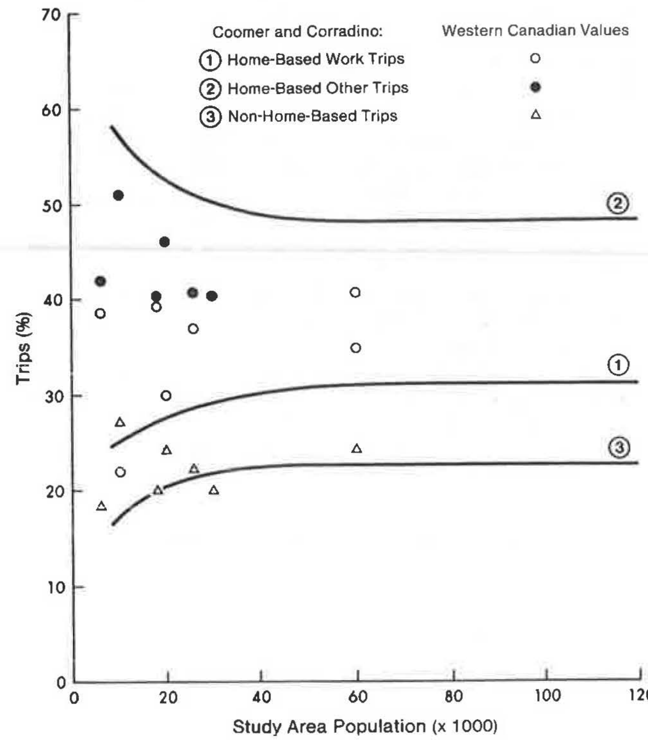


Table 2. Calibrated trip purpose distributions.

Community	Vehicle Trips by Purpose (%) Home-Based Work	Home-Based Shopping	Home-Based Other	Non-Home-Based
Fort McMurray, Alberta[a]	22	24	27	27
Medicine Hat, Alberta, 1977	40	15	25	20
Medicine Hat, Alberta, 1971[a]	37	13	28	22
Kelowna, British Columbia[a]	30	15	31	24
Grande Prairie, Alberta	40	15	25	20
Prince George, British Columbia[a]	35	15	26	24
Leduc, Alberta	39.7	24.2	17.8	18.3
Murray, Kentucky[a]	14.9	48.1		37.0[b]
Pine Bluff, Arkansas	13.5	48.6		37.9[b]
Fort Smith, Arkansas	22.5	38.7		38.8[b]
Kingsport, Tennessee	20.4	42.9		36.7[b]
Greenville, South Carolina	16.9	39.6		43.5[b]
Memphis, Tennessee	21.2	41.5		37.3[b]
Pulaski, Arkansas	21.8	47.3		30.9[b]

[a]Studies used in sensitivity analysis. [b]Includes truck and taxi trips.

Figure 4. Relationship between population size and trip purpose distribution.



of trip impedance on trip distribution. Small communities are not only limited in area; they usually have fewer problems with traffic congestion. Trip lengths are therefore rather short in terms of time.

Hajj (13) documented a sharp distribution for Madisonville. An average trip, regardless of its purpose, was between 6 and 7 min long. The relationship between the longest trip and community size were determined by Bates (1), as shown in Figure 3, and compared with approximate values for several western Canadian communities (4-12). Bates also observed that the ratio of average and longest trips is relatively stable for all small communities and depends, to a certain degree, on trip purpose. For home-based work trips the ratio is 0.362; for home-based other trips, 0.317; and for non-home-based trips, 0.287. Graphs by Hajj (13) indicate ratios of 0.380, 0.397, and 0.402, respectively, where the non-home-based trips include trucks and taxis.

In view of the physical size of small communities and the fact that average trip duration is only about one-third of that of the longest trip, trip impedance does not seem to play a significant role in trip distribution. An indirect confirmation of this phenomenon can be found in the fact that several small western Canadian communities (such as Prince George, British Columbia—population 60 000) experience the highest and directionally most diversified traffic peak of the day (up to 13 percent) around noon, when employees go home for lunch. Jefferies and Carter (2) also observed that accurate trip productions and attractions, not the distance, appeared to be the key to gravity model calibration.

Because of the insignificance of distance, the trip distribution model can be simplified and trips from one zone distributed only in proportion to the relative attraction of the other zones. This is the basis of the proportionate trip distribution model popular in the Canadian west. Four internal trip purposes (home-based work trips, home-based shopping trips, home-based other trips, and non-home-based trips) are usually considered from the attraction point of view. The values used in seven western Canadian studies are listed in Table 2. The U.S. data were taken from Hajj (13). Figure 4 indicates their relation to the values determined by Coomer and Corradino (3-12).

All studies and literature indicate a separate treatment of external-internal relationships, because they may be subject to different laws.

Validation and calibration of trip distribution models are carried out in the usual way (i.e., by aggregating zones and comparing resulting volumes across selected screen or cordon lines). In strictly synthetic models, which do not employ any interviews and use analogy data from similar communities, this is also the opportunity to adjust trip generation or originally estimated occupancy values. A discussion of some of the aspects of calibration follows.

Trip Assignments

The number of available route choices in small communities is small and capacity constraint does not usually enter the problem in a significant way. Individual routes

are easy to recognize, especially if the planner has some insight into population habits and network operation. For these reasons, either a standard all-or-nothing approach or assignment of trips between each pair of zones to a number of empirically determined available routes is favored.

In both cases, computer programs can be used. Nevertheless, resulting volumes for certain links may be unrealistic. Assignments must therefore be reviewed and corrected. For this reason, some planners prefer to perform the assignment stage manually to provide themselves with better understanding of network load performance. Some adjustments may then be incorporated as the analysis proceeds.

FOUR-PURPOSE PROPORTIONATE TRIP GENERATION AND DISTRIBUTION MODEL

This model evolved in the late 1960s and, for reasons mentioned before, has become very popular in western Canada. It was described in a 1972 internal manual of the Alberta Department of Highways (18). A case study of the town of Fort McMurray, Alberta, was presented by Sargious and Morrall in 1975 (14). The following description is based on a refined version of the model as used in a computer program developed at the University of Alberta by Kondo in 1975 (19).

The process involves the following steps:

1. Divide the study area into zones.
2. For each zone, identify the population, total employment, and retail employment for the base year and for each of the future scenarios.
3. Conduct screen and selected link classification counts, as well as an external cordon count or a roadside interview survey. Include occupancy counts for selected locations.
4. By using an analogy with similar communities, estimate the initial present trip generation rates per capita per working day. Although rates per evening peak hour have been employed in several instances, they are more difficult to use. For communities of larger size, a morning peak-hour base seems to be a more promising approach.
5. Estimate the current modal split.
6. Determine the current average automobile occupancy; if counts are not available, estimate them.
7. To determine vehicle trip generation for each zone, use

$$G_i = [P_i t(1 - r)/v] + (P_i trB/b) \qquad (1)$$

where

G_i = trip generation of zone i (two-way, i.e., single vehicular trips),
P_i = population of zone i (people),
t = trip generation rate (trips/day),
r = transit ridership,
b = average bus occupancy (passengers),
v = average automobile occupancy (passengers), and
B = passenger-car equivalent for buses.

8. By using an analogy with similar communities and estimated adjustments, determine the current trip purpose percentages, i.e., internal home-based work (HBW), internal home-based shopping (HBS), internal home-based other (HBO), and internal non-home-based trips (NHB).
9. Distribute the trips generated in each zone in proportion to the relative attractiveness of other individual zones, expressed in their shares of population, total employment, and retail employment. In the model used by the University of Alberta, the central business district (CBD) is subject to a slightly different treatment because it was found that a strictly proportionate distribution underestimated its attractiveness. In mathematical terms, the initial distribution of internal trips to the CBD (zone 1) can be expressed as follows:

$${}_1D_{i1} = G_i(HBW)(E_1/\Sigma E_j) + G_i(HBS)(R_1/\Sigma R_j) + G_i(HBO)k_1 \qquad (2)$$

where

${}_1D_{i1}$ = trips to CBD from zone i,
HBW = ratio of home-based work trips,
HBS = ratio of home-based shopping trips,
HBO = ratio of home-based other trips,
E_j = zonal employment,
R_j = zonal retail employment, and
k_1 = CBD coefficient for attraction of home-based other trips (0.1 was found to be a reasonably accurate value for four of the studies tested).

The initial distribution to the other zones can be written as follows:

$${}_1D_{ij} = G_i(HBW)(E_j/\Sigma E_j) + G_i(HBS)(R_j/\Sigma R_j) + G_i(HBO)(1 - k_1)(P_j/\sum_{j\neq 1} P_j) \qquad (3)$$

The final distribution of internal trips to all zones is computed by using the proportion of trips already attracted as a distribution rule for non-home-based trips:

$${}_2D_{ij} = {}_1D_{ij} + G_i(NHB)(\sum_i {}_1D_{ij}/\sum_i \sum_j {}_1D_{ij}) \qquad (4)$$

where ${}_2D_{ij}$ = exchange of trips internal to the study area between zone i and j and NHB = ratio of non-home-based trips.

10. Distribute the external-internal trips from points on the external cordon according to the external origin-destination survey, if available. If such a survey was not conducted, distribute the number of external-internal trips determined on cordon counts in proportion to the attraction of the zones for internal trips; that is, the final distribution table involves values as follows:

$${}_3D_{ij} = {}_2D_{ij} + T_k(\sum_i {}_2D_{ij}/\sum_i \sum_i {}_2D_{ij}) \qquad (5)$$

where

${}_3D_{ij}$ = exchange of all trips between the zones,
i = a zone that includes external cordon count point k, and
T_k = number of vehicles that enter the study area at point k.

If external trips include buses, such as those used to transport workers to an external industrial plant, passenger trips and occupancies must also be considered.

11. Aggregate zones on each side of screen lines and compare their volumes with traffic counts. If all computed volumes are higher or lower than the counts, adjust the estimated input values of trip generation and vehicle occupancy. If the computed volumes fluctuate on both sides of the counted volumes, adjust trip purpose distributions.
12. Assign the distribution table to the present network by using a full all-or-nothing model or split the values into the number of available routes.
13. Compare the computed link volumes with traffic counts where available and with perceived volume ranges

for less important links that were not counted. Adjust the assignments in order to obtain the best fit.

14. Find those links for which a good volume fit can be achieved only by illogical assignments and identify zones that contribute most of the volumes on such links. By using the zonal values and graphs described in the next section, adjust the estimated present trip purpose percentages. Repeat the process until the inconsistencies are rectified.

15. By using future population, total employment, retail employment, the values of trip generation, and vehicle occupancy adjusted to express future trends, apply the developed model to future situations. Adjustment of trip purpose distribution is also possible but not advisable in more standard cases, since the model would lose much of its transparency.

MODEL SENSITIVITY TO LAND USE CHARACTERISTICS

The sensitivity of the input-output values of the four-purpose trip generation and distribution model was analyzed at the University of Alberta during 1975-1978. The objective was to determine how initial input estimates influence the output trip distribution table with respect to different zonal land uses.

Four western Canadian communities that had recent transportation studies available were investigated: Medicine Hat, Alberta (1971); Kelowna, British Columbia (1973); Prince George, British Columbia (1974); and Fort McMurray, Alberta (1974) (4-7). Independent variables were population, employment, and retail employment. The rate of change of the zonal attractiveness was used as the dependent variable. For each zone, the following relation was examined:

$$y = cx + b \quad (6)$$

where

y = change of trips attracted to the zone (i.e., number of trips calculated from the given trip purpose distribution divided by the number of trips calculated from the calibrated trip purpose distribution minus 1.0) expressed as a percentage;
x = error in home-based work, home-based shopping, or home-based other trip percentages;
c = coefficient that expresses the rate of change of trips attracted to the zone for a unit error in trip purpose distribution (this coefficient was used as the dependent variable in the final sensitivity analysis); and
b = constant (found to be negligible).

Since the objective was to find the relation between c, which may be called the sensitivity coefficient, and some zonal land use characteristics, the study concentrated on finding suitable independent variables based on population, employment, and retail employment. In order to normalize the zonal characteristics, ratios of zonal population to total population, zonal employment to total employment, and zonal retail employment to total retail employment were first used. They did not, however, produce very consistent results. Several other measures, such as the ratios of zonal population to zonal employment or to zonal retail employment, were also tried. They, too, did not bring about any reasonable consistency. The best results were obtained by using the ratio of the ratio between zonal population and total population to the ratio of zonal employment to total employment, that is,

$$k = (P_i/\Sigma P_j)/(E_i/\Sigma E_j) \quad (7)$$

where

k = land use measure,
P_i = zonal population,
E_i = zonal employment,
ΣP_j = total population, and
ΣE_j = total employment.

All the values obtained were examined by regression analysis and, with one exception, the results were found significant at the 95 percent confidence level.

The distribution of trip purposes, as calibrated and used in the studies, was assumed to be correct. In order to simplify the analysis, four combinations of modified trip distribution were analyzed. They are shown in Table 3.

The combined results of the analysis for all four communities are graphically shown in Figures 5-8. They may be interpreted as follows.

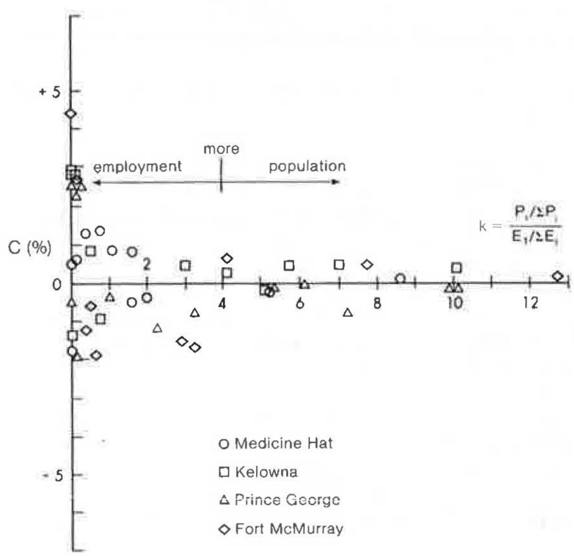
In Figure 5, overestimation of the share of home-based work trips and underestimation of the share of home-based shopping trips (or vice versa) by 1 percent produces about ±1 percent error in the attractiveness of residential zones and between +4 and -2 percent error in the attractiveness of zones that have pronounced employment characteristics. This means that, for an initial error of 5 percent of overestimation of the percentage of home-based work trips and 5 percent of underestima-

Table 3. Combinations of trip purpose distributions used in sensitivity analysis.

	Modification of Trip Purpose Distribution[a] (%)			
Data	Home-Based Work	Home-Based Shopping	Home-Based Other	Non-Home-Based
1	+5 to -5	-5 to +5	0	0
2	+5 to -5	0	-5 to +5	0
3	+5 to -5	0	0	-5 to +5
4	+5 to -5	-2.5 to +2.5	-2.5 to +2.5	0

[a]Deviation from the calibrated value (see Table 2).

Figure 5. Sensitivity of trip attraction to zonal population and employment and to errors in the share of home-based work and home-based shopping trips (data 1).



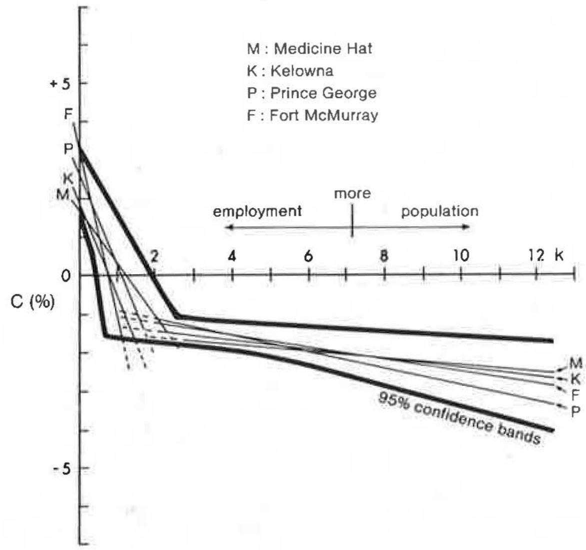


Figure 6. Sensitivity of trip attraction to zonal population and employment and to errors in the share of home-based work and home-based other trips (data 2).

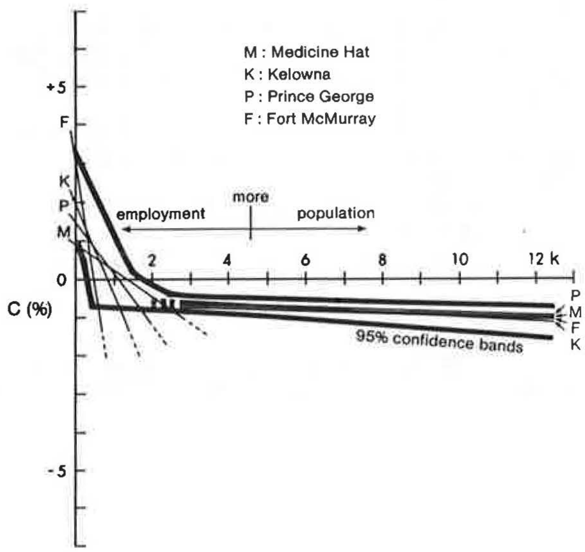


Figure 7. Sensitivity of trip attraction to zonal population and employment and to errors in the share of home-based work and non-home-based trips (data 3).

tion of the percentage of home-based shopping trips, the magnitude of the outcome error in the attractiveness of the individual zones will be in the range of ±5 percent for residential zones and between + 20 percent and -10 percent for employment zones. The sign of the outcome error in relation to the sign of the initial error in home-based work trips cannot be predicted.

In Figure 6, overestimation of the share of home-based work trips and underestimation of the share of home-based other trips by 1 percent produces about 2-3 percent of the underestimation of the attractiveness of residential zones and up to about 3 percent of overestimation of the attractiveness of employment zones. Conversely, underestimation of home-based other trips produces similar magnitudes of overestimation of residential attractiveness and underestimation of employment attractiveness.

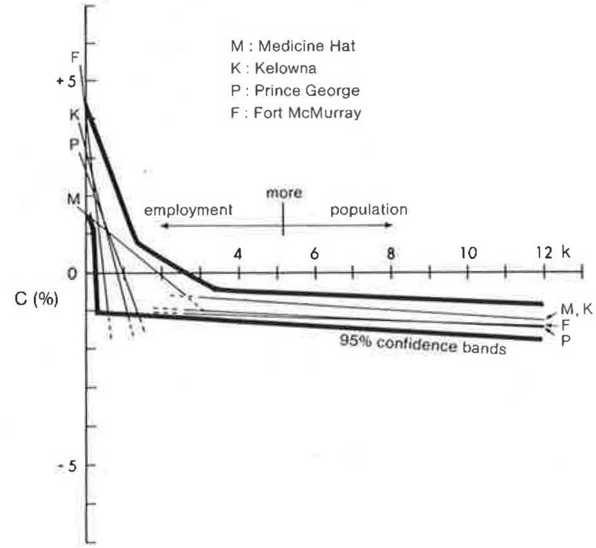


Figure 8. Sensitivity of trip attraction to zonal population and employment and to errors in the share of home-based work, home-based shopping, and home-based other trips (data 4).

In Figure 7, overestimation of the share of home-based work trips and underestimation of the share of non-home-based trips by 1 percent produces about 1 percent of the underestimation of the attractiveness of residential zones and up to about 3 percent of overestimation of the attractiveness of employment zones and vice versa.

In Figure 8, overestimation of the share of home-based work trips by 1 percent and simultaneous underestimation of home-based shopping and home-based other trips by 0.5 percent each produces about 1 percent of the underestimation of the attractiveness of residential zones and up to about 4 percent of the overestimation of the attractiveness of employment zones and vice versa.

In Figures 6-8, zones that are combined residential and employment in character, for which the independent variable k is about 1.0 (i.e., their percentage of the area population is about the same as their percentage of the area employment), are almost indifferent to errors in trip purpose distribution. Shopping trips (Figure 6) are an exception. An interesting observation in Figures 5-8 is that a dynamic community (Fort McMurray) generates a higher degree of error instability (especially for employment zones).

Practical implications of this sensitivity analysis can be inserted into the following steps of the four-purpose trip generation and distribution model as follows:

Step 3, addition—The screen lines should preferably be defined in such a way that the residential and employment zones are separated, or that the number of trips to and from selected residential or employment zones or zone clusters can be identified.

Step 11, addition—The counted number of trips to and from the selected zones or zone clusters should be compared with those computed. Determine the percentage error. For the zones involved, determine their k value. By using Figures 5-8, estimate realistic values of the sensitivity coefficients c. Divide the percentage error by the sensitivity coefficient, thus obtaining an approximate value of adjustment of the share of home-based work trips. By using the character of the analyzed zones, decide which other trip purposes should compensate for the adjustment of the home-based work trips. Repeat the process until a satisfactory fit is found.

CONCLUSIONS

The experience with the synthetic four-purpose trip generation and distribution model in small communities in western Canada has been good. It suits the needs and constraints of the communities and provides an appropriate level of accuracy at a reasonable cost. The model's sensitivity analysis helps to speed up the calibration and may increase the planner's confidence in the validity of the process and its results. There is sometimes a need, however, to carry out a full transportation analysis of a selected community in order to verify the basic data that can be used in other communities.

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Transferability of Trip Generation Models

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Cross-classification, disaggregate regression, and aggregate regression trip generation models and trip rates were developed for three cities. The model for each of the cities was transferred to the two other cities and comparisons were made. The comparisons revealed that models calibrated on aggregate zonal data perform better than models calibrated with disaggregate household data when aggregate data are used for forecasting. However, if cross-classification models are acceptable, they can be transferred between cities if good judgment is used to select cities that are similar enough for this purpose. Recommended is the establishment of a standard procedure for data collection and trip generation analysis in selected studies of the near future so that the transferability question can be properly addressed. The emphasis should be on the development of new prototype models for application in groups of cities.

Trip generation is that phase of the urban transportation planning process that establishes relations between urban activity and travel. In the past, each transportation study has calibrated its own set of trip generation procedures based on origin-destination (O-D) data from home interview surveys. Data collection through O-D surveys is costly, especially in small cities where a high sample rate is required. Accordingly, the Federal Highway Administration (FHWA) has advocated planning methods that reduce data collection requirements (1). In this regard, the goal of FHWA is to develop a travel simulation procedure that is based on using information