Use of Pre-Interview Trip Cards in Developing a Traffic Model for the Hamilton Area Transportation Study

WALTER KUDLICK and EWEN S. FISHER, respectively, Traffic and Planning Engineer and Assistant Traffic Engineer, C. C. Parker & Parsons, Brinckerhoff Ltd., Hamilton, Ontario

A traffic model analysis of origin-destination patterns is being made as part of a comprehensive transportation study for the City of Hamilton, Ontario. This paper describes the use of a small-scale home interview survey in the development of the model and relates the experiences encountered in the use of pre-interview trip cards in conducting the home interviews.

It was found that 59 percent of the persons making trips used the cards and that they accounted for 61 percent of the total trips. The average number of trips reported by card users was 3.4, whereas non-card users made an average of 3.1 trips. This difference was statistically significant at the 1 percent level using the t-test, and the Wilcoxon test indicated that this difference was distributed throughout the areas interviewed.

The authors conclude that the use of pre-interview trip cards in the Hamilton Area resulted in the reporting of more trips and that these trips were reported more completely and more accurately than would have been likely without the use of cards. It was also concluded that the limited home interview survey constitutes such a considerable source of local data that it should be considered an indispensable part of the development of a traffic model.

• EARLY IN 1960 a technical coordinating committee was formed for a comprehensive transportation study for the City of Hamilton, Ontario. This committee has as its chairman the director of traffic, City of Hamilton, and its members consist of representatives from the Department of Highways of the Province of Ontario, the city engineer, the superintendent of operations of the transit company, and the planning directors for the several interested areas. Subsequently, the consulting firm of C. C. Parker & Parsons, Brinckerhoff Limited was employed, first, to prepare a report on the scope and procedures of the comprehensive study and, later, to assist in carrying out the study.

The Hamilton metropolitan area is located at the head of Lake Ontario, which makes it of strategic importance as a highway and rail transportation center in the Golden Horseshoe region extending from Toronto to Niagara Falls and Buffalo. With a large protected harbor on Lake Ontario and the St. Lawrence Seaway, Hamilton is an established Great Lakes port and a fast-growing ocean port. The city is the largest steel-producing center in Canada, and attendant manufacturing is extensive, varied, and rapidly expanding. The population of the region, now about 350,000, is expected to reach about 530,000 in 1985. Present traffic volumes in the area are expected to increase four-fold by 1982.

During the scope and procedures study, it was decided that a gravity model analysis of both present and future traffic patterns would form a significant portion of the comprehensive study. It was also decided that the analysis of present patterns should be based on, among other data, the results of a small-scale home interview survey. Sub-
sequently, two papers presented at the HRB 1961 Annual Meeting were read with great interest: "Developing a Traffic Model With a Small Sample" by Davidson and "The Use of Pre-Interview Cards in Pittsburgh Research Project" by Sullivan and Pyers.

This present paper is a report on the application and extension of the findings presented in these two papers. It is hoped that it will be of interest to others seeking to develop traffic models or considering pre-interview contact and the use of trip cards.

**SELECTION OF INTERVIEWEES**

Once it was decided to incorporate a limited home interview program in the development of the traffic model, two further questions had to be resolved: how many interviews would be required and which homes should be interviewed. The paper by Davidson which was cited earlier states that a total sample of 1,000 families selected from the 825,000 families in the Boston area was sufficient to obtain an error of estimate of total trip production of within plus or minus 10 percent. An independent computation made by the Electronic Section of the Department of Highways, Ontario, demonstrated that in sampling for proportions a total sample of 900 interviews would be sufficient to provide relative certainty at the 99.7 percent confidence level (three standard deviations) if the total population is about 100,000. A copy of this computation is attached as Appendix A. Consequently, it was decided to select 1,200 dwelling units for interviewing in expectation that finding a normal rate of refusals and vacancies would still leave the desired number of interviews.

The choice then had to be made whether these 1,200 interviews should be scattered throughout the city at random or whether they should be clustered in specific regions of the city. Each alternative has its advantages and disadvantages. It was felt that selecting one home in every 70 or 75 probably would provide the best data on trip length distribution because the sample would be truly random and spread throughout the entire city. The analysis of trip production characteristics, however, requires that there be, for example, a range of automobile ownership per family. A satisfactory range of ownership may not result from a scattered sample but is almost sure to occur if interviews are made in selected areas whose characteristics are known.

Perhaps more importantly, a one-in-ten interview ratio would produce data for a particular zone comparable to the data obtained in a full-scale home interview survey. Thus it could also be used at a later stage to check trip distribution for that zone as predicted by the traffic model. It was decided ultimately to follow the cluster sampling approach, using a stratified random sample.

The sample was considered random because each tenth family within a designated zone was selected from the city assessor's records without bias. The sample was considered stratified because the zones designated for interviewing were selected in proportion to their occurrence in the total population. This was done by first dividing the city into seven traffic districts based on either land-use divisions or areas bounded by topographic barriers. The total 1,200 interviews were then distributed among the seven districts in proportion to their populations. Finally, the interviews in each district were assigned to selected zones within the district:

1. Representative of the distances from the CBD and the major industrial area.
2. Representative of the economic level or levels of the resident population of the district.
3. Representative of the population distribution within the district itself.

This procedure resulted in the selection of 17 zones and a slightly less than 10 percent sample interview was carried out in each zone. During the analysis phase, it was found desirable to combine any zone in which fewer than 30 families were interviewed with a similar zone. This was done wherever possible to provide greater stability. The characteristics of the resulting twelve areas are given in Table 1.

**METHOD**

The interviewing staff was made up almost equally of university students on summer vacation and women who recently had completed assignments as census takers. A
TABLE 1
CHARACTERISTICS OF INTERVIEW AREAS

<table>
<thead>
<tr>
<th>Area</th>
<th>Total No. of Families</th>
<th>No. of Families Interviewed</th>
<th>Autos Housed per Family</th>
<th>Economic Level</th>
<th>Distance to CBD (mi)</th>
<th>Distance to Center of Major Industry (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>320</td>
<td>30</td>
<td>0.50</td>
<td>Low</td>
<td>0.0</td>
<td>3.2</td>
</tr>
<tr>
<td>2</td>
<td>735</td>
<td>64</td>
<td>0.70</td>
<td>Low</td>
<td>3.2</td>
<td>1.5</td>
</tr>
<tr>
<td>3</td>
<td>1,389</td>
<td>127</td>
<td>0.74</td>
<td>Low</td>
<td>1.3</td>
<td>1.9</td>
</tr>
<tr>
<td>4</td>
<td>1,084</td>
<td>99</td>
<td>0.81</td>
<td>Low</td>
<td>0.9</td>
<td>4.0</td>
</tr>
<tr>
<td>5</td>
<td>679</td>
<td>55</td>
<td>0.84</td>
<td>Medium</td>
<td>0.9</td>
<td>4.0</td>
</tr>
<tr>
<td>6</td>
<td>1,075</td>
<td>99</td>
<td>0.87</td>
<td>Medium</td>
<td>3.1</td>
<td>6.4</td>
</tr>
<tr>
<td>7</td>
<td>927</td>
<td>81</td>
<td>0.89</td>
<td>Medium</td>
<td>1.9</td>
<td>1.7</td>
</tr>
<tr>
<td>8</td>
<td>812</td>
<td>77</td>
<td>0.92</td>
<td>Medium</td>
<td>5.3</td>
<td>2.4</td>
</tr>
<tr>
<td>9</td>
<td>1,316</td>
<td>124</td>
<td>0.96</td>
<td>Medium</td>
<td>1.9</td>
<td>4.3</td>
</tr>
<tr>
<td>10</td>
<td>888</td>
<td>88</td>
<td>1.03</td>
<td>High</td>
<td>3.2</td>
<td>3.0</td>
</tr>
<tr>
<td>11</td>
<td>1,064</td>
<td>104</td>
<td>1.03</td>
<td>Medium</td>
<td>4.5</td>
<td>3.6</td>
</tr>
<tr>
<td>12</td>
<td>973</td>
<td>94</td>
<td>1.11</td>
<td>High</td>
<td>2.5</td>
<td>5.7</td>
</tr>
<tr>
<td>Total</td>
<td>11,262</td>
<td>1,042</td>
<td>0.89</td>
<td>--</td>
<td>2.5</td>
<td>3.4</td>
</tr>
</tbody>
</table>

number of the permanent study staff also served as part-time interviewers when required as translators or to check refusals. On being hired each interviewer was given about three days of instruction and practice. One editor was assigned to every three interviewers, on the average, and a survey chief was in over-all charge of the interviewing. Almost all verifications and inquiries concerning omitted information were made by telephone.

All samples were selected and recorded before the start of the interviewing, which began in late July and continued until early September. Interviews generally were made between 10 AM and 8 PM, at the discretion of the interviewer, Mondays through Fridays. Each interviewer initially was assigned eight sets of trip cards to deliver each day and told to pick up eight sets of completed cards each day. It was stressed, however, that accuracy and completeness were more important than quantity. The average interviewer was dropping off and picking up somewhere between six and seven sets of cards a day by the end of the survey.

Pre-Interview Contact

The transportation study was given a good amount of publicity in the newspaper and on the local television and radio stations immediately before the start of the home interviewing. About one week before the household was scheduled to be visited, a letter was sent over the Mayor's signature telling of the interviewer's impending visit and asking for cooperation.

The interview began with the interviewer's obtaining the data required for the dwelling unit summary form. This form was printed on the outside of a 9- by 12-in. manila envelope, and thereafter all trip cards and other material pertaining to the household were kept inside this envelope. A copy of this form is given in Appendix B. The interviewer then distributed a trip card and a letter of instruction for completing the card to every member of the household over five years of age. Both of these forms are almost identical to those used in the Pittsburgh study and are shown in Appendix B. The interviewer then spent about fifteen minutes explaining how the cards were to be completed. This was done primarily by referring to the examples contained in the instruction letter. The family was asked to keep a record of their
travel on the day following the interviewer's visit (except if the interviewer called on a Friday, in which case Monday was designated as the travel day) and an appointment was made for the interviewer to come back after the travel day and collect all completed cards. If one or more of the adult members of the family were on vacation at the time the interviewer called, the interview was rescheduled to a day when all members would be back to their normal travel patterns.

If no one was at home at the time of the first call, the interviewers were instructed to return at least twice more at different times of day. If no one was found at home after repeated visits or if the persons at home refused to cooperate or if there was a language difficulty, the interview was reassigned to a permanent member of the study staff. These members succeeded in interviewing all but a negligible percentage of the selected sample. Thus for almost all households, the trip cards and letters of instructions were left personally with at least one adult member of the family.

Picking Up Completed Cards

On returning to the household after the travel day, the interviewer began by asking for the completed cards. If the cards had been filled out, the interviewer proceeded to check them for accuracy and completeness. If they had not been filled out, he tried personally to interview the person who made the trips. In many cases, this involved making an appointment to come back a third time to interview members of the family not at home when the second visit to the household was made. When a personal interview was not possible for some reason, the information was usually obtainable from another member of the family. Trips recorded by the interviewer and not by the respondent were listed on a marked trip card.

The interviewers were given a set checking procedure for examining trip cards or trips obtained by interviewing. They were told first to try to make sure that all trips made the previous day were recorded. This was done by asking the type of trips a person normally could be expected to make. Thus, for example, an employed person who reported only one trip from home to work and one trip from work to home was asked, where he normally ate lunch and did he go out to a movie or to visit friends after work. The interviewer then made sure that all information was complete and had been recorded in accordance with the instructions on the back of the cards. After the interviewer had reviewed or filled out a trip card for each member of the household, all cards were placed inside the manila envelope and turned in to the study office for editing and coding.

EVALUATION OF CARD USE

Rate of Card Use

The extent to which the trip record forms were used is given in Table 2. Of the 2,015 people making trips, 59.4 percent used the cards to record most of the details of their trips. This group accounted for 61.1 percent of the total number of trips reported.

In the twelve areas in which interviews were conducted, the rate of card use ranged from 42.9 to 79.3 percent, and only one area had a card usage of less than 50 percent. The extent to which the cards were used was slightly greater in the six areas where the rate of car ownership was higher. In the areas of lower car ownership, an average of 56.4 percent of the respondents made use of the cards as opposed to an average of 61.3 percent in the higher car-ownership areas.

Number of Trips Reported

In eight of the twelve interview areas given in Table 2, the average number of trips per person was greater for the card-user group than for the non-card users. Of the four areas where card users reported fewer trips, two are classified as low economic level, and two are medium economic level. It is felt that these results might be due to chance alone, the card users in these areas being people who made fewer trips, and to other factors unrelated to the use of trip cards. Considering all twelve areas, the card
TABLE 2
EXTENT OF CARD USE

<table>
<thead>
<tr>
<th>Area</th>
<th>Persons Using Cards</th>
<th>Persons Not Using Cards</th>
<th>No of Trips Reported</th>
<th>Trips per Person</th>
<th>Difference Between Users and Non-Users</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Percent</td>
<td>No</td>
<td>Percent</td>
<td>Users</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>42.9</td>
<td>16</td>
<td>57.1</td>
<td>51</td>
</tr>
<tr>
<td>2</td>
<td>57</td>
<td>53.3</td>
<td>50</td>
<td>46.7</td>
<td>161</td>
</tr>
<tr>
<td>3</td>
<td>103</td>
<td>50.5</td>
<td>101</td>
<td>49.5</td>
<td>300</td>
</tr>
<tr>
<td>4</td>
<td>97</td>
<td>53.0</td>
<td>86</td>
<td>47.0</td>
<td>271</td>
</tr>
<tr>
<td>5</td>
<td>69</td>
<td>79.3</td>
<td>18</td>
<td>20.7</td>
<td>241</td>
</tr>
<tr>
<td>6</td>
<td>104</td>
<td>59.4</td>
<td>71</td>
<td>40.6</td>
<td>367</td>
</tr>
<tr>
<td>7</td>
<td>99</td>
<td>59.6</td>
<td>67</td>
<td>40.4</td>
<td>340</td>
</tr>
<tr>
<td>8</td>
<td>93</td>
<td>57.4</td>
<td>69</td>
<td>42.6</td>
<td>290</td>
</tr>
<tr>
<td>9</td>
<td>190</td>
<td>69.9</td>
<td>82</td>
<td>30.1</td>
<td>660</td>
</tr>
<tr>
<td>10</td>
<td>110</td>
<td>55.0</td>
<td>90</td>
<td>45.0</td>
<td>388</td>
</tr>
<tr>
<td>11</td>
<td>143</td>
<td>63.0</td>
<td>84</td>
<td>37.0</td>
<td>481</td>
</tr>
<tr>
<td>12</td>
<td>119</td>
<td>58.3</td>
<td>85</td>
<td>41.7</td>
<td>505</td>
</tr>
<tr>
<td>Total</td>
<td>1,196</td>
<td>59.4</td>
<td>819</td>
<td>40.6</td>
<td>4,055</td>
</tr>
</tbody>
</table>

Users reported 0.25 more trips per person on the average. This increase in total trip reporting for the survey as a whole, an apparent increase of 300 trips, was felt to be the important factor, particularly because the increase applied in some measure to all economic levels and consequently did not introduce any bias to the study.

Two statistical tests were employed to determine if the increased reporting of trips by card users could be attributed to chance.

The Wilcoxon matched-pairs signed-ranks test was used to determine whether the trip frequency of the card users was generally greater than that of the non-card users for the range of socio-economic levels that the interview areas represented. The total difference in trip reporting was tested for significance through the use of the t-test. Both of these tests proved to be significant; the Wilcoxon test being significant at the 5 percent level and the t-test at the 1 percent level. The details of these analyses are given in Appendix C.

These results, of course, cannot be interpreted as complete proof that the pre-interview contact technique increases trip reporting, although they do constitute strong evidence that this is so. The results obtained in the Hamilton survey show that the card users reported a significantly greater number of trips than the non-card users. Possibly some of the difference observed can be attributed to a greater sense of civic responsibility on the part of the card users; these same people might have reported the greater number of trips had the usual form of interview been conducted. An ideal experimental design for testing the effectiveness of trip cards would be to conduct a series of regular interviews in parallel with the pre-interview contact technique and compare the difference thus obtained.

Accuracy of Information Obtained

A respondent who is an automobile driver and who makes four trips on the travel day is expected to furnish an interviewer with 48 items of information concerning his travel. This fact alone would seem to make a pre-interview contact mandatory. It appears unreasonable to expect a person to provide such extensive data without having been briefed thoroughly as to what is expected of him. It was found that many of those persons who did not use the cards had a good recollection of the details of their travel when questioned by the interviewer. This can be attributed, at least partially, to the fact that they had been personally given oral and/or written descriptions of the data required.
Those families that completed trip cards enabled the interviewer to function more as an editor than as a reporter. That is, the interviewer was able to devote his entire attention to making sure that no trips were overlooked and that all required details of the trips had been given. The opportunity to check data on the site when the memory of the travel day was still fresh in the respondent’s mind was a considerable asset.

APPLICATION OF HOME INTERVIEW DATA

The basic intent from the start of the study was to approach the development of the traffic model without any fixed commitment regarding the form the model should take. The reported findings of many researchers, of course, were studied with interest, and some of these are listed in the references. It was decided, however, that an independent check or derivation of all relationships should be made wherever possible using Hamilton area data. Consequently, more than 60 tabulations were prepared from the home interviews and dwelling unit questionnaires. Analysis of these tabulations is being carried out with the primary objective of studying the following:

1. Trip production.
2. Distribution of trip lengths.
3. Trip attraction factors.
4. Other travel characteristics and patterns.

Analysis of Trip Production

Five different forms of equations were initially fitted to 32 sets of data to determine what relationships, if any, existed between such things as total trips per family and automobiles per family, and work trips per family and persons per family. This phase of the study is shown by Figure 1.

![Figure 1. Analysis of trip production.](image-url)
A review of the initial results, along with a study of the trip length distributions, suggested that a number of trip purposes be combined. This was done, and additional regression analyses were made on the grouped data. Among the many useful relationships developed were the following:

Work trips = 0.429 + 0.219 (persons/family).
Correlation coefficient = 0.829, standard deviation = ± 0.084.

Other home-based trips = -0.882 + 2.718 (autos/family).
Correlation coefficient = 0.931, standard deviation = ± 0.187.

Non-home-based trips = -1.042 + 2.218 (autos/family).
Correlation coefficient = 0.815, standard deviation = ± 0.276.

Auto driver trips = 2.917 + 7.000 (autos/family).
Correlation coefficient = 0.941, standard deviation = ± 0.440.

Auto passenger trips = -0.652 + 2.663 (autos/family).
Correlation coefficient = 0.807, standard deviation = ± 0.341.

Distribution of Trip Lengths

The distribution of trip lengths is being studied in conjunction with trip production equations to determine how many different trip purposes need to be included in the model. At the present time, it is felt that three purposes (work, other home-based, and non-home based) will be required to define adequately present and future travel in the Hamilton area. These trip length distributions are shown in Figure 2.

The distribution of trip lengths obtained by interviewing also will be used in computing trip frequency factors for each trip purpose. This will be done by setting the frequency factors equal to unity on the first pass through the model. The ratios between the trip length distributions thus obtained and the distributions measured in the survey being by definition the required trip frequency factors.

Analysis of Attraction Factors

The home interviews furnished a description of the type of land use at the destination of each trip. Nine categories of land use were coded initially, but these have been combined into major groupings, as required. To illustrate how attraction factors will be developed for each trip purpose, it is assumed that the model incorporates the three purposes and four land-use groupings shown in Figure 3. The attraction factor for other home-based trips, for example, will reflect the fact that 23 percent of these trips can be related to population and 52 percent can be associated with retail and service employment. An additional 20 percent can be related to retail and service employment indirectly using known relationships between that category of employment and employment in public and quasi-public functions. Thus, the attraction factor for non-home-based trips can be expressed simply as a function of population and retail and service employment.

Additional Travel Characteristics and Patterns

The home interviews, besides being a source of local data for the development of a traffic model, are furnishing an extensive variety of information concerning travel habits in the area. This information is proving to be quite valuable as basic planning data for a comprehensive transportation study. It includes such things as purpose distributions by various travel modes, variation of trip purposes and mode of travel by time of day, blocks walked at the origin and destination of transit and automobile trips, parking type and fees paid, vehicle occupancy, variation of trip purposes and mode of travel by day of the week. The distribution of reported trips by grouped trip purposes by time of day is shown in Figure 4 as an example of data that, although not being incorporated directly as part of the traffic model, are still extremely useful.

OTHER SOURCE MATERIAL FOR TRAFFIC MODEL

The home interviews are being supplemented as a source of data for the traffic model in two ways: (a) supporting traffic studies are being carried out as part of the
present comprehensive transportation study, and (b) data obtained from previous
studies made in the area are being utilized as much as possible. The supporting traffic
studies currently underway include the following:

1. Roadside motorist interviews along an external cordon line and internal
   screen line.
2. A volume-counting program along arterial streets and highways and at internal
cordon lines.
3. An operating speed study for most major streets and highways within the study
   area.
4. Interviewing of employers to determine employment by categories within each
   traffic zone.
5. Interviewing a selected number of truck owners regarding the operation of com-
   mercial vehicles.
6. Making a physical inventory of the existing street system.
7. Other studies designed to furnish data on land use, transit operation, accident
   history, and other items related to transportation planning.

Important data obtained from past studies include roadside motorist interviews and
a postcard survey of transit riders made at a cordon around the core area of the
central business district in 1956; roadside motorist interviews made on internal cor-
don and screenlines in 1956; land-use and population distribution estimates; an inven-
tory of major highways in the area; and transit patronage and inventory of facilities
and material developed from location studies for isolated routes or improvements.
Figure 3. Analysis of attraction factors

Figure 4. Travel characteristics.
CONCLUSIONS

The results obtained to date in the Hamilton Area Transportation Study have been consistent, for the most part, with what other studies have reported previously. What differences exist appear attributable to the characteristics of the study area. It is felt that this emphasizes the importance of having local data as a basis for such things as trip production equations, trip length distributions, and computations of attraction factors.

A limited home interview survey of about 1,000 families selected on a stratified random sampling basis appears to be a most suitable source of the kind of local data required. Indeed, so much valuable information is obtainable from this kind of survey that the authors conclude that it should be considered an indispensable part of the development of a traffic model.

The pre-interview contact is considered a necessity for the type of home interview survey under discussion because of the large amount of data the respondents are asked to furnish. The experience with this technique was considered satisfactory by all concerned, and it is felt that it increased both the number of trips reported and the accuracy and completeness of this reporting.

ACKNOWLEDGMENTS

The authors would like to acknowledge their indebtedness to the many organizations and individuals who have provided assistance and information. Among these are the staff of the Electronic Section, Department of Highways, Ontario, who developed the necessary computer programs and who provided the computation of required sample size, Appendix A, and Alan M. Voorhees, who was consulted regarding the basic concept and approach.

Appendix A

COMPUTATION OF REQUIRED SAMPLE SIZE

Sampling for Proportions

In a simple random sample the sample size, \( n \), is given by

\[
 n = \frac{t^2 \frac{pq}{d^2}}{1 + \frac{1}{N} \left( \frac{t^2 \frac{pq}{d^2}}{d^2} - 1 \right)}
\]

in which

\[ p = \text{proportion in group of interest}; \]
\[ q = 1 - p; \]
\[ N = \text{population size}; \]
\[ t = \text{abscissa of normal curve corresponding to confidence level}; \]
\[ \pm d = \text{range of accuracy}. \]

If

\[
 n_0 = \frac{t^2 \frac{pq}{d^2}}{d^2}
\]

then,

\[
 n = \frac{n_0}{\frac{1}{N} + \frac{n_0}{N} - 1}
\]

Approx. \( \approx \) \( \frac{n_0}{\frac{1}{N} + n_0} \) for large \( N \)
\( n_0 \) is maximum when \( p = q = \frac{1}{2} \).

This can easily be shown by calculus:

\[
\begin{align*}
y &= pq \\
   &= p(1 - p) = p - p^2 \\
\frac{dy}{dp} &= 1 - 2p = 0
\end{align*}
\]

Therefore,

\[
p = \frac{1}{2} = q
\]

Using this maximum value, and letting \( N = 100,000 \) and range of accuracy = \( \pm 5 \) percent, at the 95 percent confidence level, then \( t = 2 \)

Therefore from Eq. 2

\[
\frac{n_0}{pq} = \frac{4 \times 0.5 \times 0.5}{0.0025} = 400
\]

Therefore from Eq. 3

\[
n = \frac{400}{1 + \frac{400}{100,000}} = 400
\]

Thus, a sample of 400 would be required.

For relative certainty at the 99.7 percent level (3 standard deviations)

\[
\frac{n_0}{pq} = \frac{9 \times 0.5 \times 0.5}{0.0025} = 900
\]

and

\[
n = \frac{900}{1 + \frac{900}{100,000}} \quad \text{Approx.} = 900
\]

It is apparent that for large \( N \), \( n_0 = n \) approximately.
# HAMILTON AREA TRANSPORTATION STUDY
## DWELLING UNIT SUMMARY

<table>
<thead>
<tr>
<th>Preceding number</th>
<th>Card</th>
<th>Interview address</th>
<th>Sample No.</th>
<th>Succeeding number</th>
<th>Block No.</th>
<th>Zone No.</th>
</tr>
</thead>
</table>

**Day and Date of Travel:**

**Type of Dwelling Unit:**

**A.** How many passenger cars are owned by persons living at this address?

**B.** How many persons live here?

**C.** How many are 5 years of age or older?

**D.** Household information:

<table>
<thead>
<tr>
<th>Person No.</th>
<th>Person Identification</th>
<th>Code</th>
<th>Occupation and Industry</th>
<th>Trips</th>
<th>Yes</th>
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</tbody>
</table>

**E.** Total number of trips reported at this address

1. Number of persons 5 years of age or older making trips
2. Number of persons 5 years of age or older making no trips
3. Number of persons 5 years of age or older with trips unknown

**F.** Comments and reason if complete information was not obtainable

**G.** Factor

---

**G. C. Parker and Parsons, Brinckerhoff Limited**
**TRIP RECORD FORM**

SEE BACK FOR INSTRUCTIONS

<table>
<thead>
<tr>
<th>BEGINNING OF TRIP (ORIGIN)</th>
<th>END OF TRIP (DESTINATION)</th>
<th>PURPOSE OF TRIP</th>
<th>ESTABLISHMENT AT DESTINATION</th>
<th>TIME OF TRIP</th>
<th>BLOCKS WALKED</th>
<th>MODE OF TRAVEL</th>
<th>PERSONS IN CAR</th>
<th>PARKING TYPE</th>
<th>PARKING RATE</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

**INSTRUCTIONS.**

**A TRIP IS THE ONE-WAY MOVEMENT OF A PERSON BETWEEN TWO POINTS BY A SINGLE MODE OF TRAVEL.** IF YOU ARE EMPLOYED AS AN OPERATOR OF A VEHICLE (bus, taxi, truck driver) DO NOT INCLUDE TRIPS MADE WHILE ON DUTY.

**TRIP ORIGINS AND DESTINATIONS** Record actual street address, for example 795 Main Street West, or record nearest intersection, for example Main Street West and Longwood Road. Names of prominent buildings are satisfactory. The word "home" is sufficient when the trip begins or ends at your place of residence.

**PURPOSE OF TRIP.** Describe why you made the trip, for example, to go to work, return home, buy a box of candy, catch bus, pay a bill, to eat lunch, go to doctor, pick up son.

**ESTABLISHMENT AT DESTINATION.** Give a description of the type of establishment at the destination end of the trip, for example high school, grocery store, department store, park, insurance office, bank, steel mill, fabricating plant, gas station, house or dwelling. Note whether the store is a wholesale or retail store and the kind of office or plant.

**TIME OF START AND END.** Record to the nearest minute the time you begin and end a trip. INCLUDE THE TIME IT TAKES TO PARK CAR AND WALK TO YOUR ACTUAL DESTINATION.

**BLOCKS WALKED.** Record the number of blocks walked at each end of the trip (such as home to bus or auto, at origin of trip, and from the location parked to your destination at the end of the trip).

**MODE OF TRAVEL.** Use the abbreviation for one of the following classifications:

- Auto Driver (A Dr.)
- Railroad Passenger (R. R.)
- Taxi Passenger (Taxi)
- Walked to Work (W. W.)
- Auto Passenger (A Pas.)
- Bus, Streetcar, Pass. (Bus)
- Truck Passenger (Tr. Pass.)
- Truck Driver (Tr. Dr.)

**PERSONS IN CAR.** If you drove, give the total number of people in the car, including yourself.

**PARKING TYPE.** Use the abbreviation for one of the following classifications:

- Street (St)
- Garage (Gar.)
- Residential Property (Res.)
- Not parked (N.P.)
- Lot Service & Repair (Serv)
- Cruised (Cr.)

**PARKING RATE.** Use the abbreviation for one of the following classifications:

- Hour (Hr)
- Day (D)
- Month (Mo)
- Meter (Met)
- Free (F)

IF YOU HAVE DIFFICULTIES IN RECORDING A PARTICULAR TRIP OR SEQUENCE OF TRIPS, MAKE A NOTE ON THE FACE OF THE FORM DESCRIBING THE SITUATION. THE INTERVIEWER WILL ASSIST YOU IN PREPARING THE FORM WHEN HE RETURNS TO COLLECT THE TRIP INFORMATION.

LEAVE THIS FORM HOME THE DAY FOLLOWING THE 24 HOUR PERIOD DURING WHICH YOU RECORD YOUR TRIPS.
Dear Householder:

As explained in the letter Mayor Jackson recently sent you, your household is one of a number selected from which to obtain badly needed travel information in connection with the Hamilton Area Transportation Study.

Each member of your family is being asked to record, on the attached forms, the trips which he or she makes on ____________. Our interviewer will return to your home on the following day to collect the information contained on these trip records. We realize that this is an inconvenience, but so is the traffic problem. It is only with your co-operation that your City and Provincial Governments can take action toward solving this difficult problem.

The requested information is completely confidential and will be used for statistical purposes only.

Thank you in advance for your contribution of time and information.

Yours very truly,

(W. E. Ewens)
Director.
**HAMILTON AREA TRANSPORTATION STUDY**

**GENERAL INSTRUCTIONS**

1. Each person in this household 5 years of age or older, including maids, roomers, and out-of-town guests, should keep a separate record of his or her trips.

2. Record all trips for a 24-hour period beginning 4:00 a.m. on ___________________________.

3. Record no walking trips EXCEPT walking to or from work.

4. Identify each person by his or her relationship to the head of the household, such as wife, son, mother-in-law, roomer, etc.

5. PLEASE READ INSTRUCTIONS ON THE BACK OF THE TRIP RECORD FORM.

**Example:** Refer to Trip Record form and instructions on back.

Mr. Jones drove to the bus stop with his wife. After reaching the city by bus, he walked two blocks to his office. At noon he took a taxi to and from lunch. He was driven home by a friend. Mrs. Jones rode with her husband to the bus stop in order that she could have the car during the day, driving the car home from the bus stop. Later she took her 4-year old son to the barber shop, waited for him, then drove to her daughter's home. From her daughter's home she drove to the grocery store and then home, her son accompanying her on these trips. Neither Mr. or Mrs. Jones made any trips the rest of the day.

### Zone O101 Sample 008 Person Mr. Jones (Head)

<table>
<thead>
<tr>
<th>Beginning of Trip (Origin)</th>
<th>End of Trip (Destination)</th>
<th>Purpose of Trip</th>
<th>Establishment at Destination</th>
<th>Time of Start</th>
<th>Blocks Walked</th>
<th>Mode of Travel</th>
<th>Auto Drivers Only</th>
<th>Parking at Origin</th>
<th>Parking at Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>Whitney Ave &amp; Mercourt Rd</td>
<td>Catch Bus</td>
<td>Bus Stop</td>
<td>7:51 AM AM</td>
<td>O 0</td>
<td>A Dr 2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whitney Ave &amp; Mercourt Rd</td>
<td>795 Main St West</td>
<td>Go to Work</td>
<td>Engineers Office</td>
<td>8:00 AM AM</td>
<td>O 0</td>
<td>Bus</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>795 Main St West</td>
<td>Royal Connaught Hotel</td>
<td>Lunch</td>
<td>Hotel</td>
<td>12:05 PM PM</td>
<td>0 0</td>
<td>Taxi</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Royal Connaught Hotel</td>
<td>795 Main St West</td>
<td>Back to Work</td>
<td>Engineers Office</td>
<td>12:13 PM PM</td>
<td>0 0</td>
<td>Taxi</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>795 Main St West</td>
<td>Home</td>
<td>Home From Work</td>
<td>Home</td>
<td>5:15 PM PM</td>
<td>0 0</td>
<td>A Pass</td>
<td>0</td>
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</table>

### Zone O101 Sample 008 Person Mrs. Jones (Wife)

<table>
<thead>
<tr>
<th>Beginning of Trip (Origin)</th>
<th>End of Trip (Destination)</th>
<th>Purpose of Trip</th>
<th>Establishment at Destination</th>
<th>Time of Start</th>
<th>Blocks Walked</th>
<th>Mode of Travel</th>
<th>Auto Drivers Only</th>
<th>Parking at Origin</th>
<th>Parking at Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>Whitney Ave &amp; Mercourt Rd</td>
<td>Return Home</td>
<td>Home</td>
<td>7:58 AM AM</td>
<td>O 0</td>
<td>A Dr 1</td>
<td>RES Free</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whitney Ave &amp; Mercourt Rd</td>
<td>Home</td>
<td>Return Home</td>
<td>Home</td>
<td>7:58 AM AM</td>
<td>O 0</td>
<td>A Dr 1</td>
<td>RES Free</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>King St &amp; Sterling St</td>
<td>Take Son to Barber</td>
<td>Barber Shop</td>
<td>9:35 AM AM</td>
<td>O 1/2</td>
<td>A Dr 2</td>
<td>1 ST Free</td>
<td></td>
<td></td>
</tr>
<tr>
<td>King St &amp; Sterling St</td>
<td>B61 Main St East</td>
<td>Visit Daughter</td>
<td>Residence</td>
<td>10:10 AM AM</td>
<td>1/2 1/2</td>
<td>A Dr 2</td>
<td>1 ST Free</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B61 Main St East</td>
<td>University Plaza-Downtown</td>
<td>Shopping</td>
<td>Supermarket</td>
<td>11:30 AM AM</td>
<td>0 0</td>
<td>A Dr 2</td>
<td>1 LOT Free</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Univ Plaza Downtown</td>
<td>Home</td>
<td>Return Home</td>
<td>Home</td>
<td>12:30 PM PM</td>
<td>0 0</td>
<td>A Dr 2</td>
<td>RES Free</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C

DETAILS OF WILCOXON AND t-TESTS

**Wilcoxon Test**

The Wilcoxon test considers both the direction and the relative magnitude of the differences between matched pairs. In this study, the card users and the non-card users in each area were considered to be a matched pair because of their similar socio-economic backgrounds. The hypothesis tested was that the average trips per person for the control group (the non-card users) was greater than or equal to that of the experimental group (the card users). The alternative was that the experimental group had the greater trip frequency. A one-tailed test was employed because the card users were expected to have the greater trip frequency.

Thus,

\[
\begin{align*}
H: & \quad \Sigma \text{ positive ranks} \leq \Sigma \text{ negative ranks} \\
A: & \quad \Sigma \text{ positive ranks} > \Sigma \text{ negative ranks}
\end{align*}
\]

For \( N = 12 \) and \( T = 15.5 \), as given in Table 3, \( H \) may be rejected at the 5 percent level of significance. It is apparent that the trip frequency is generally greater for the card users for the variety of socio-economic levels that the interview areas represented.

**t-Test**

The difference in trip frequency between the card users and the non-card users was analyzed by the t-test to determine whether the difference in the means was significant. Because the frequency distributions for both groups were severely skewed, a logarithmic transformation was made to reduce the skewness. The resulting distributions were still slightly skewed but the error involved in assuming normality should not be critical because of the large sample sizes. Continuity of the dependent variable was also assumed for the same reason although it was discrete. A test for homogeneity of variance was conducted and permitted the use of a pooled estimate of the population variance at the 0.01 level of significance.

\[
\begin{align*}
H: & \quad \bar{X}_e \leq \bar{X}_c \\
A: & \quad \bar{X}_e > \bar{X}_c \\
t = 3.76 & \quad df = 2013
\end{align*}
\]

**TABLE 3**

AVERAGE TRIPS PER PERSON FOR CARD USERS AND NON-CARD USERS

<table>
<thead>
<tr>
<th>Area</th>
<th>Trips per Person</th>
<th>d</th>
<th>Rank of d</th>
<th>Rank with Less Frequent Sign</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Experimental</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.63</td>
<td>4.25</td>
<td>+1.62</td>
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</tr>
<tr>
<td>2</td>
<td>3.26</td>
<td>2.82</td>
<td>-0.44</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>2.96</td>
<td>2.91</td>
<td>-0.05</td>
<td>-1.5</td>
</tr>
<tr>
<td>4</td>
<td>2.42</td>
<td>2.79</td>
<td>+0.37</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>2.67</td>
<td>3.49</td>
<td>+0.82</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>3.07</td>
<td>3.53</td>
<td>+0.46</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>2.94</td>
<td>3.43</td>
<td>+0.51</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>3.22</td>
<td>3.12</td>
<td>-0.10</td>
<td>3</td>
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<tr>
<td>9</td>
<td>2.82</td>
<td>3.47</td>
<td>+0.65</td>
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</tr>
<tr>
<td>10</td>
<td>3.48</td>
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<td>+0.05</td>
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<tr>
<td>11</td>
<td>3.56</td>
<td>3.36</td>
<td>-0.20</td>
<td>4</td>
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<tr>
<td>12</td>
<td>3.89</td>
<td>4.24</td>
<td>-0.35</td>
<td>5</td>
</tr>
</tbody>
</table>

\( T = 15.5 \)
H may be rejected at the 1 percent level of significance.
It is apparent that the average trips per person is significantly greater for the card users.

REFERENCES