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CANADIAN THESES ON MICROFICHE / THÈSES CANADIENNES SUR MICROFICHE

NAME OF AUTHOR / NOM DE L'AUTEUR: [illegible]

TITLE OF THESIS / TITRE DE LA THÈSE: [illegible] of the [illegible] synthetic model [illegible] generation and distribution in small cities

UNIVERSITY / UNIVERSITÉ: University of Alberta

DEGREE FOR WHICH THESIS WAS PRESENTED / GRADE POUR LEQUEL CETTE THÈSE FUT PRÉSENTÉE: [illegible] Engineering

YEAR THIS DEGREE CONFERRED / ANNÉE D'OBTENTION DE CE GRADE: [illegible]

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SENSITIVITY OF THE 'PROPORTIONATE' SYNTHETIC MODEL FOR TRIP GENERATION AND DISTRIBUTION IN SMALL COMMUNITIES

BY

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF CIVIL ENGINEERING
EDMONTON, ALBERTA

SPRING, 1976.

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "SENSITIVITY OF THE 'PROPORTIONATE' SYNTHETIC MODEL FOR TRIP GENERATION AND DISTRIBUTION IN SMALL CITIES" submitted by Tadashi Kondo in partial fulfilment of the requirements for the Degree of Master of Science in Civil Engineering.

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ABSTRACT

The main purpose of this study was to investigate the sensitivity of what we call a 'Four purpose proportionate trip generation and distribution' model, that has been often utilized in evaluating the traffic demands in small urban communities, when it is applied to small cities in Western Canada. These cities included Medicine Hat, Alberta, Kelowna, B.C., Prince George, B.C., and Fort McMurray, Alberta.

The model consists of two phases i.e. a trip generation phase and a trip distribution phase. The trip generation phase includes assumptions of person trips per capita per day, transit ridership, and vehicle occupancy rate and empirical figures obtained from the recent studies in these cities were used. In the trip distribution phase, trips were classified as Home based work trips, shopping trips, other trips and Non home based trips. In order to carry out the main purpose of this study, the question was whether different trip purpose distributions would yield different results in small cities and four combinations of different trip purpose distributions were selected. In other words, combinations of (1) Home-Work and Home-Shop trips, (2) Home-Work and Home-Other trips, (3) Home-Work and Non-Home trips, and (4) three Home-based trips were taken and the ratios were changed for each city.

An attempt was made to find a relationship

between the magnitude of the attractiveness of the traffic zones and economic factors of the zones. In this thesis, the change of this attractiveness of the traffic zones are defined as sensitivity. In analysing the results, regression analysis together with the confidence bands of 95% was employed. The following items were the major concluding remarks.

1. In the combination (1) Home-Work and Home-Shop, the magnitude of attractiveness or sensitivity coefficients, did not show a strong correlation with economic factors, however, those zones with higher employment ratio and lower population ratio showed a larger sensitivity over other zones. Central Business District and a zone with a shopping center or large retail employment showed a strong negative sensitivity in this combination.

2. In the combinations of (2) Home-Work and Home-Other, (3) Home-Work and Non-Home, and (4) All Home-based trips, sensitivity coefficients had a very strong relation with the zonal ratio of population/employment, Positive sensitivity was shown where this ratio is larger in residential areas. Commercial areas or the Central Business District did not show a large sensitivity in those combinations.

ACKNOWLEDGEMENTS

The investigation reported in this thesis were carried out at the Department of Civil Engineering, University of Alberta, under the supervision of Associate Professor S. Teply. The author expresses his sincere gratitude to Professor Teply for suggesting the topic and his continual guidance throughout the period of this study.

The author also would like to express his sincere gratitude to Associate Professor J.J. Bakker for the continual encouragement and support throughout the period of this study.

Financial assistance received from the University of Alberta is gratefully acknowledged.

The author also would like to acknowledge financial assistance from The Alberta Cooperative Research Program in Transportation Engineering.

Finally, the author wishes to acknowledge the excellent job of data entry done by Mrs. Ella Ritz at Computing Services.

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CHAPTER I

THE PROBLEM

It has always been one of the major problems in both small and large cities to estimate traffic generation and distribution because of ever changing characteristics of the cities.

Three of the empirical methods to evaluate the future traffic demands in cities or towns are categorized as growth factor method, and stochastic model such as gravity model and opportunity model. Growth factor method is only applicable where there is a complete Origin-Destination survey data, which require a time consuming and costly field investigation, provided that the growth factor of the area at issue is not excessively large. Although gravity model does not require a complete Origin-Destination survey, it involves time or physical distances in its equation. Therefore, it is only applicable in larger areas where time or physical distance influences the traffic generation and distribution to a great extent, while the opportunity model requires a sophisticated comprehension of the model.

Partly because of the reasons mentioned above, it is not appropriate to apply those methods for traffic generation and distribution in small cities.

Consequently, a method what we call a 'proportionate' traffic generation and distribution model has been introduced in various small cities for this

CHAPTER I

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Three of the empirical methods to evaluate the future traffic demands in cities or towns are categorized as growth factor method, and stochastic model such as gravity model and opportunity model. Growth factor method is only applicable where there is a complete Origin-Destination survey data; which require a time consuming and costly field investigation, provided that the growth factor of the area at issue is not excessively large. Although gravity model does not require a complete Origin-Destination survey, it involves time or physical distances in its equation. Therefore, it is only applicable in larger areas where time or physical distance influences the traffic generation and distribution to a great extent, while the opportunity model requires a sophisticated comprehension of the model.

Partly because of the reasons mentioned above, it is not appropriate to apply those methods for traffic generation and distribution in small cities.

Consequently, a method what we call a 'proportionate' traffic generation and distribution model has been introduced in various small cities for this purpose. Small cities, in this thesis, normally have a population between 10,000 and 60,000, and have little or no traffic influence from larger centers nearby.

Generally speaking, they can not spend a lot of time in transportation planning in small cities and the constraint of budget would result in an employment of an inexpensive and non-time-consuming model. In the areas where the growth rate is significantly high it is not appropriate to utilize methods which require time-consuming and expensive exercises. For example, it is anticipated that gain or loss of a single factory or the development of a shopping center can change traffic patterns considerably.

In this respect, a 'proportionate' synthetic model is a simple mathematical model for trip generation and distribution in small cities. One of the basic and valid assumptions in transportation planning is that certain relationships exist between travel demands and social, economic and physical parameters and that these relationships are consistent over time. Based on this assumption, a 'proportionate' synthetic model has completely eliminated the necessity for the expensive and time-consuming phase of transportation planning.

Four studies which have been done in Western Canada were selected in this thesis. All these studies included the assumptions of person trip per day, transit ridership and vehicle occupancy rate for trip generation phase and of the 'proportionate' model for the trip distribution phase. Since the field data in these cities is considerably scarce it is quite difficult to assure the validity of these assumptions and the accuracy of the results. As a result, it is likely to happen that the choice of different figures of these assumptions may result in a significant change in the output.

Thus the major objective of this thesis is to check the sensitivity of the 'proportionate' synthetic model and then, it will be possible to find out the reliability of the model.

The outline of the procedure of this thesis is as follows.

1) Literature review.
2) Mathematical formulation of the theory.
3) State the economic and physical structures of the selected cities.
   a) population
   b) employment
   c) location
   d) specific features of the city
4) Comparison of assumptions.
5) Application of the theory to the selected cities by changing the assumed figures.
6) Obtain the results and find the relationship between input and output, i.e. between the

change of traffic distribution and such economic and physical factors as population, employment, and retail employment.

7) Test the sensitivity of the output by different figures of input.

CHAPTER II

LITERATURE REVIEW

2.1 Georgia Metropolitan Study (1)

Various studies in transportation planning were carried out in the U.S., however, these activities were mainly concentrated to metropolitan areas of 50,000 or more in population. Time is becoming available to be concerned with small urban cities with population between 5,000 and 50,000.

In this respect, the transportation study in Georgia metropolitan area was performed based on the research which dealt with the urban area of Waynesboro, Georgia. The research study was undertaken by the State Highway Department of Georgia in cooperation with the Federal Highway administration. The purpose of the research was to develop and test a procedure for deriving models that synthesize internal trip movements in urban areas with a population of less than 50,000 without the need for expensive and time-consuming home-interviews and model development phases of the traditional comprehensive planning process.

For this reason, requests were sent to highway agencies across the country and data for possible use in the research study were received on 18 small urban areas. Among these studies, 9 urban areas of population between 5,000 and

50,000 were selected.

The procedure for trip generation and trip distribution was to develop a model from one study or group of studies and to test it by applying the model through traffic assignment and comparison with observed volumes.

Prior to the model development for trip generation and distribution, three characteristics of the selected urban areas were examined in terms of (1) population, (2) work trip length, and (3) proportionality of internal-external trips and this practice showed a reasonable consistency among the areas selected in this study.

In the phase of trip generation, six economic indicators were entered as independent variables (population(v1), dwelling units(v2), motor vehicles(v3), civil labor force(v4), employment(v5), and school enrollment(v6)), and models were developed for four trip purposes (home-based work, home-based other, non home based, and total internal trips). The results were found as follows.

Home-based work productions = 8 + 1.2 v3

Home-based work attractions = 54 + 0.9 v5

Home-based other productions = 18 + 2.7 v3

Home-based other attractions = 206 + 0.8 v2 + 0.6 v5 + 0.[illegible] v6

Non-home-based productions = 67 + 0.1 v2 + 0.1 v3

+ 0.6 v5 + 0.1 v6

Non-home-based attractions = 67 + 0.5 v2 + 0.4 v5

Total internal productions = 164 + 4.2 v3 + 0.4 v5

Total internal attractions = 221 + 2.3 v3 + 2.3 v5

where v1: population

v2: dwelling units

v3: motor vehicles

v4: civilian labor force

v5: employment

v6: school enrollment

Then these equations were applied for testing and evaluation of them were made by comparing the observed volumes and calculated volumes.

Bates(1974) concluded that the synthetic procedures appear to adequately reproduce observed conditions and that the value of the synthetic procedure in providing a quick, inexpensive approach cannot be understated. It was also recommended that the synthetic procedures be adopted for standard use as a planning methodology in urban and suburban areas of 25,000 to 50,000 population.

2.2 Study on Work Trip Generation in 6 Urban Areas (4)

The purpose of this study was to investigate simplified techniques for developing transportation plans in smaller urban areas; specifically, a study of socioeconomic and land-use characteristics of urban areas that influence work trip generation and to determine which characteristics can be efficiently used to forecast future work trip generation.

For this purpose, the following criteria had to be satisfied:

(1) The data used to develop independent variables should be (a) easily obtained from existing records or from simple and inexpensive surveys and (b) capable of expressing future as well as existing trip-generating characteristics. As far as possible, changes in these variables should reflect the influence of the change in the variable on trip generation rates.

(2) Reliable and inexpensive methods should be available for forcasting the data used as independent variables.

(3) The final trip-generating equations should be easy to use and should contain as few variables as possible, consistent with the required accuracy.

The study was limited to an estimation of home-based vehicle work trip production in urban areas of less than 200,000 population and to an internal-internal trip generation only.

Six urban areas were selected, the population of which varied from 41,000 in Hutchinson to 178,000 in Reading. Since the research was concerned with the determination of the relationship between the dependent and independent variables, regression analysis was made to define the dependent variable with as few independent variables as possible. The basic data in this study was limited to the number of persons, dwelling units, automobiles owned, and acreage in residential land use and various functions of the independent variables were generated and used as additional independent variables as well. Correlation analysis was employed to obtain insight into what kind of relation exists between the dependent and independent variables.

It was observed that vehicle ownership expressed as log (Automobiles/Dwelling) along with one or more other independent variables and log (Home based work trips/ Dwelling) as the dependent variable would produce the est trip generation equation.

It was yet necessary to verify this observation and a tear-down regression analysis was used to eliminate the terms that were not significant in explaining trip generation. This means that all independent variables were first included in the regression equation to determine how much of the sums of squares of variation about the regression line is explained by each independent variable, and that variable contributing least is eliminated if not significant. An equation is again developed by regression to find the relationship which exists between the remaining independent variables and dependent variable.

This procedure was continued until the variable contributing least when considered last is significant. This eliminating process was also continued for both the linear and log functions of the dependent variable.

Then the equations were compared and finally the results of the regression with grouped data showed that no significant lack of fit existed for a regression of log (Automobiles/Dwelling) on log (Home based work trips/Dwelling) in five of the six urban areas studied. This is shown in Table 2-1 and Figure 2-1.

Thus Jefferies and Carter (1968) concluded:

(1) The best indicator of vehicle work trip production was vehicle ownership, and the linear functions developed between log (Automobiles/Dwelling) and log (Home based work trips/Dwelling) satisfactorily explained the relationship.

(2) The correlation coefficients and the regression analysis have indicated that the other factors which affect trip generation are reflected in vehicle ownership patterns.

(3) It is feasible to develop an equation to predict vehicle work trip production in smaller urban areas without conducting an extensive Origin-Destination study.

2.3 Elizabethtown, Kentucky (2)

Elizabethtown, Kentucky is located approximately 240km. southwest of Cincinnati with 12,300 population in 1970. In order to determine future traffic demands in urban communities that have a population between 5,000 and 50,000 people, a transportation study was conducted in this area by the Kentucky Department of Highways.

Synthetic derivation of trip generation and distribution was employed and the computed volume was checked against the actual countings along the screen lines. Total automobile trips per day were estimated from the data of fourteen study areas ranging in population from 10,000 to 500,000 by linear regression analysis and a three-trip-purpose distribution was conducted. They were Home-based work trips, Home-based other trips and Non-Home-based trips. By considering both truck/taxi and internal/external activities, a final trip distribution was obtained and they were assigned to the existing network of Elizabethtown.

A link-by-link analysis was performed for every link with actual traffic count data available, employing the student 't' test, the Chi Square test and linear regression test. All these tests showed that the computed volume was close enough to the actual volume to be accepted.

A further test was employed to determine whether different trip purpose distributions would yield different results in a small urban network but not a significant difference was observed. Coomer and Corradino (1973) recommended, however, that the analysis of this type should be performed in other study areas with trip purpose splits ranging over a wide spectrum.

Area	Equation	R.
Reading	$\log HBW/DU = 0.9642 \log A/D + 0.0745$	0.91
Rock Hill	$\log HBW/DU = 1.1408 \log A/D - 0.1105$	0.95
York	$\log HBW/AU = 1.0503 \log A/D + 0.1628$	0.83
Sheboygan	$\log HBW/AU = 0.9626 \log A/D + 0.0652$	0.75
Lancaster	$\log HBW/AU = 0.6213 \log A/D + 0.0650$	0.84
Hutchinson	$\log HBW/AU = 0.7029 \log A/D + 0.1047$	0.70

TABLE 2 - 1

Vehicle Work Trip Generation Equations

With Nonsignificant Lack of Fit

Note: HBW; Home base work trips

DU ; Dwelling Unit

A/D; Automobiles per dwelling

R. ; Correlation coefficient

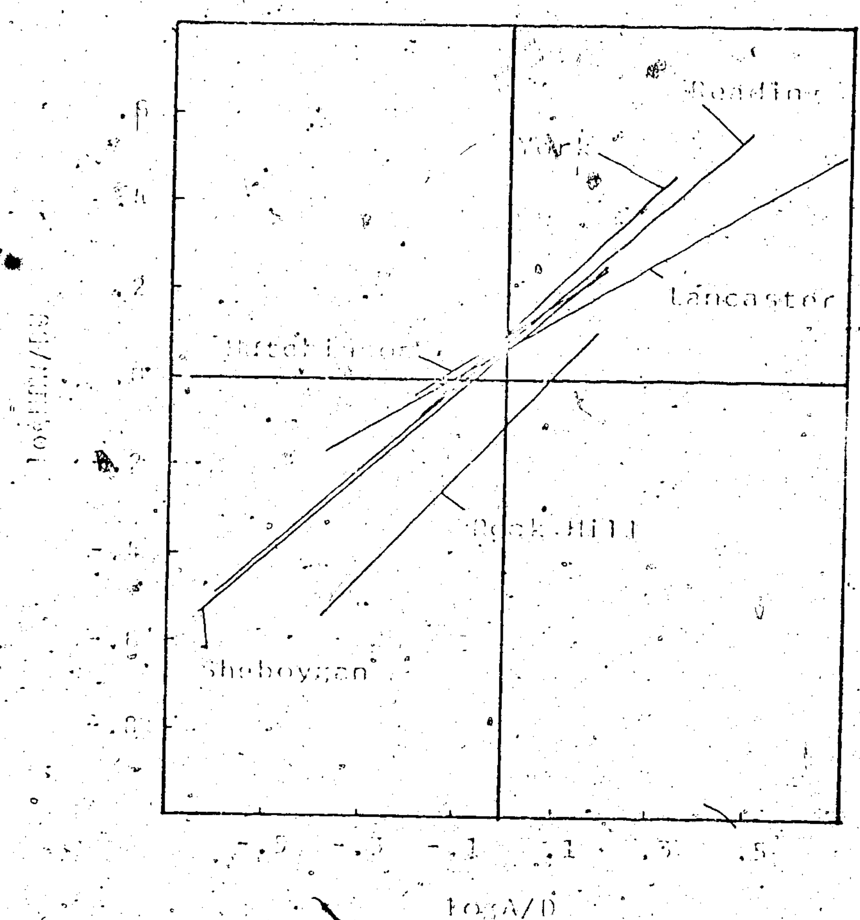

Figure 2 - 1

Vehicle work trip production curves

CHAPTER III

FORMULATION OF THE MATHEMATICAL MODEL

3.1 Assumptions

In order to avoid a lengthy manual calculation using the 'Four purpose trip generation and distribution' model, it was necessary to develop a computing program. The mathematical formulation of the theory is based on the following assumptions and this program will deal with the whole day trips for small cities at issue and it should be noted that the program does not deal with peak hour traffic estimation.

1) Proportionality of the trip generation to the population.

It has been pointed out that vehicle ownership per dwelling would well estimate the number of vehicular trips per dwelling with a higher accuracy than population(6). Since there is no such data available in the cities studied and population was the most accurate and readily available data, it was used in this study and vehicle ownership was assumed to be proportionate to resident population. This assumption necessitated the person trips/capita/day to be available to obtain the total person trip production in the city at issue.

2) Person trips/capita/day.

In the past years, travel simulation in small cities involved a sophisticated approach to build a trip table by trip purposes, however, recent ex rience shows that only total trip table based on a te of person trips/capita/day be necessary to estimate the trip production in small urban areas(2). For this purpose, the same figures that were used in the past studies were utilized in this study.

3) Transit ridership.

In many small cities, public transit does not cause major traffic problems since the trip produced by transit share only a small protion of the total trips and often this is neglected in transportation studies in such cities. In this study, the same figures obtained from the previous studies were also utilized.

4) Vehicle occupancy rate.

This figure is necessary to convert the total person trips to vehicular trips in the city at issue. This figure varies depending upon the purpose of the trips, however, 1.5 persons/vehicle was assumed for overall trip production. The same figure was employed in the previous four studies.

5) Classification of the total trips for trip distribution.

The total trips, thus obtained, were classified as:

i) Home based work trips (Home-Work)
ii) Home based shopping trips (Home-Shop)
iii) Home based other trips--social recreational trips (Home-Others)
iv) Non home based trips (Non-Home)

In this study, our concern was to obtain the sensitivity of the output by changing the above figures as input.

6) Four purpose proportionate synthetic model.

In this way, the total traffic generation has been obtained and assigned to each different trip purpose mentioned in assumption 5). Our concern, now, is to distribute these four kinds of trips to zones, that were set in each city, according to the following assumptions and this is the major feature of what we call a 'Four purpose proportionate model.'

i) Home-Work trips were distributed proportionately to the number of total employees in a zone.

It is needless to say that the magnitude of the total employment in the area has a strong relation with an attractiveness of the work trips to the zone.

ii) Home-Shop trips were distributed proportionately to the number of retail employees in a zone.

This assumption also does not require much of an explanation to verify, since empirical studies have shown that the magnitude of the retail employment or the total areas of offices or stores for retail employment in the area has a high correlation with the shopping trip attractiveness of the area (6).

iii) Home-Other trips were distributed on a basis of 10% to the Central Business District for social-recreational trips and the remainder to the other zones based on zonal population.

Home based trips other than working and shopping trips are affected not only by the population but also by the magnitude of the employment in a zone although these factors do not show strong attractiveness significantly. In this study, however, it has been assumed that 10% of the trips were assigned to the C.B.D. for social-recreational trips, which reflects the large attractiveness of downtown area in a small community, and the remainder to the other zones based on the magnitude of zonal population.

iv) Non-Home based trips were assumed to be evenly distributed in proportion to the existing number of trips assigned to the zone already.

Non-Home based trips include business trips generated from offices, intermediate trips before going home after shopping or social-recreational trips, etc. Although empirical studies have not done much about attractiveness of non-home based trips, it has been assumed that the existing attractiveness attributed to the other three kinds of trips in zones, will have the same degree of attractiveness for non-home based trips.

3.2 Formulation of the synthetic model

In formulating a simple mathematical model based on the assumptions mentioned above, the following notations were used.

i, j: Zone number

Pi : Population of zone i

Qi : Total employment of zone i

Ri : Total retail employment of zone i

t : Person trips/capita/day

r : Transit ridership.

v : Vehicle occupancy rate

h1 : Home-Work trip ratio

h2 : Home-Shop trip ratio

h3 : Home-Other trip ratio

h4 : Non-Home based trip ratio

According to the assumptions mentioned previously, trip generation from zone i will be calculated as follows with average passengers per bus (public transit) 35, and a correction factor of 2 from bus trip to an ordinary vehicle trip.

$$Gi = Pi \times t(1 - r)/v + Pi \times t \times r/15$$
$$= Pi \times t(15 - r(15 - v))/(15 \times v)$$

where Gi: Trips generated from zone i

Then the trips generated from all the zones are distributed to the Central Business District by using the following equation which only refers to Home-Work, Home-Shop, and Home-Other trips.

$$Bi1 = Gi \times h1 \times Q1/\Sigma Qi + Gi \times h2 \times R1/\Sigma Ri$$
$$+ 0.1 \times h3 \times Gi$$

where $Bi1$: Home-Work, Home-Shop, and Home-Other trips attracted to zone 1(C.B.D.) from each zone i.

ΣQi : Total employment in the city

ΣRi : Total retail employment in the city

In the similar manner, trips were distributed to other zones using the following equation which is slightly different from the above.

$$Bij = Gi \times h1 \times Qj/\Sigma Qj + Gi \times h2 \times Rj/\Sigma Rj + 0.9 \times Gi \times h3 \times Pj/(\Sigma Pj - P1) \quad (j \neq 1)$$

where Bij : Home-Work, Home-Shop, and Home-Other trips attracted to zone j from each zone i ($j \neq 1$).

ΣPj : Total population in the city

Then the whole Origin-Destination matrix is to be calculated following the equation.

$$Aij = Bij + Gi \times h4 \times Bj/\Sigma Bij$$

where Aij : All kinds of trips attracted to zone j from each zone i

Bj : Sum of the trips (Home-Work, Home-Shop, Home-Other) attracted to zone j from all the zones

The flowchart of the program is shown in Figure 3-1 and an precise interpretation and the example of calculation of the program is referred to in Appendix A.

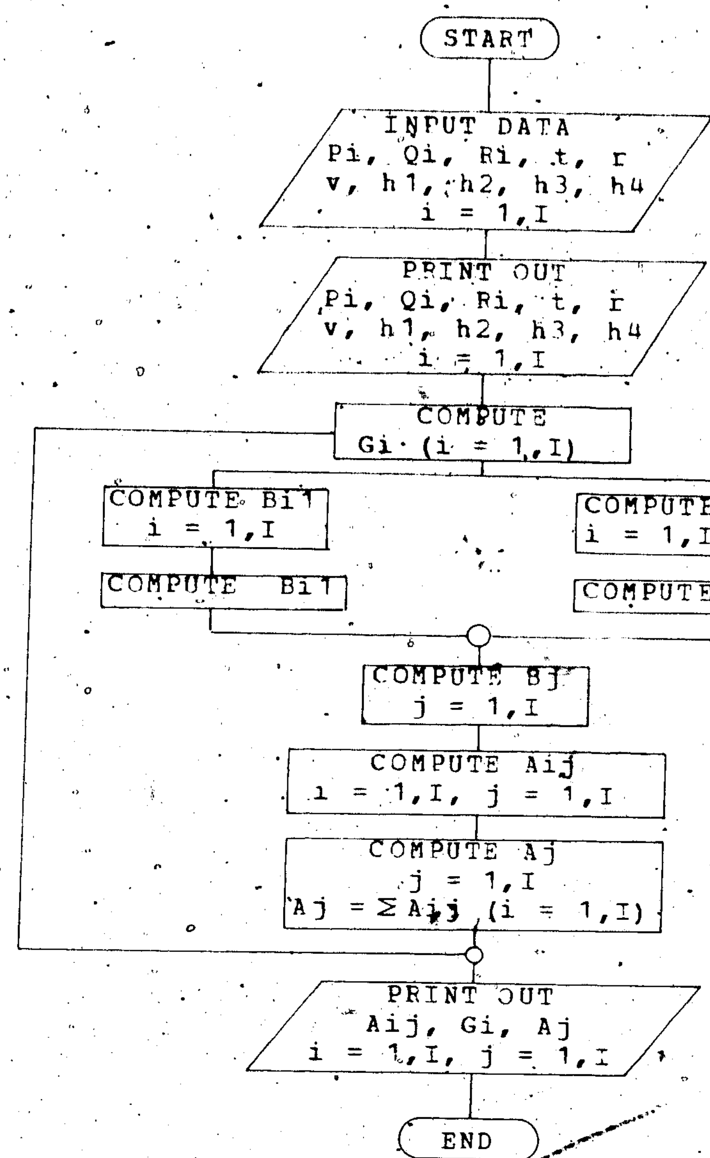

Figure 3-1
Flowchart of the program

CHAPTER IV

APPLICATION OF THE MODEL

4.1 Previous studies in Western Canada.

Small cities in the Western Canada are not the exceptions where traffic generation and distribution study is urgently required. As a matter of fact, a number of studies have been carried out and we have selected four studies that were done in Western Canada. These studies included Medicine Hat, Alberta, Kelowna, B.C., Prince George, B.C., and Fort McMurray, Alberta (7,8,9,10).

The magnitude of the population of these cities varied from 10,000 to 60,000 at the years of study and the estimated magnitude of the population at the horizon year vary from 30,000 to 150,000. The estimated growth ratios, as fas as the population is concerned, are 3.27% for Medicine Hat, 24.7% for Kelowna, 10.0% for Prince George and 28.6% for Fort McMurray on annual basis respectively.

As we have mentioned earlier, small cities cannot afford to carry out a time-consuming and expensive survey that is often necessary in transportation study.

In this respect, all these cities employed the 'Four purpose proportionate trip generation and distribution model' and the calculated trip table (Origin-Destination table) was calibrated by actual countings of traffic volume at the screen lines. The following statement was noted in the study in Medicine Hat at the beginning of it.

'Sufficient research has been conducted on small cities to make it possible to determine vehicular trip generation and distribution patterns to acceptable limits of accuracy with minimum use of time consuming and costly aids such as Origin-Destination Survey.

'Vehicle ownership is generally considered the most accurate method of determining trip generation in a city. Although previous studies have shown that population alone is not as accurate a trip estimating factor as vehicle ownership, population was used in this study because this data was readily and accurately available. Vehicle ownership was considered proportionate to resident population.'

This 'Four purpose proportionate trip generation and distribution model' was based on the assumptions mentioned in CHAPTER III. In the traffic generation phase, (1) Person trips/capita/day, (2) Masstransit ridership, and (3) Vehicle occupancy rate were taken from the actual field survey and from the counting of vehicle volumes at the screen lines. Then the figures for future traffic generation and distribution were estimated. In the trip distribution phase of these studies, the figures of internal vehicle trip ratios for different purpose of trips were taken from the previous carried out in the similar sized cities. Then the computation was done and it was found that the difference between the calculated traffic volume and actually counted volume at the screen lines amounted from 1% to 17%.

In order to compare the four studies selected in this thesis, the following items have been chosen and they were tabulated. (Table 4-1, Table 4-2, Table 4-3, Table 4-4).

1) Population of the city at the year of study.
2) Estimated or the level of population in the design year or horizon year.
3) Person trips/capita/day.
4) Masstransit ridership.
5) Vehicle occupancy rate.
6) Internal vehicle trip percentage for different purpose of trips.
7) Specific features of the city.

4.2 Application of the model--Procedures and available data

In order to investigate the attractiveness of the different types of zones such as residential area, commercial area and industrial area, assumptions in the phase of trip generation were fixed to the ones that were used in the previous studies. Only assumptions in trip distribution phase were changed. In other words, person trips/capita/day, mass transit ridership and vehicle occupancy rate were fixed and only the ratios for different types of trips were changed. Home-Work trip ratio was always changed by a 1% increment with a combination of either Home-

Shop trip ratio, or Home-Other trip ratio, or Non-Home based trip ratio, or Home-Shop and Home-Other trip ratios respectively. It goes without saying that the other trip ratio(s) was always decreased accordingly. It is noted that these combinations are extreme cases and other possible combinations were not investigated in this study. The different trip purpose distributions are shown in Table 4-13 through Table 4-16.

As mentioned above, the first computation was carried out based on the initially assumed figures. These figures are indicated in Table 4-1 through Table 4-4.

In Medicine Hat, for example, an initial ratio for Home-Work trip was 37% and this ratio was increased up to 40% and decreased to 30%, which can be seen in Table4-13. At this point, the increase of Home-Work trip ratio was defined as x(%), being x=0.0 when Home-Work trip ratio is 37%. Therefore, x=3.0 when Home-Work=40% and x=-7.0 when Home-Work=30%. It was also defined that the rate of change of trips attracted to each zone is y(%). In the similar manner to x, it was defined that y=0.0 when x=0.0. Then the relation between x and y was examined by linear regression analysis expressed by

$$y = cx + b$$

Where y: change of trips attracted to each zone

x: change of Home-Work trip ratio

c: coefficient

b: constant

In the equation above, c can be called a sensitivity coefficient. The figure of c shows the sensitivity of a particular zone to errors in estimating the trip purpose distribution. In this procedure, 'b' was found to be in the order of less than 1% of c, whose absolute value is at most 5. Therefore, the values of 'b' are small enough to be neglected.

It should be remembered that the main aim of this study was to find some relationship between the attractiveness of different types of zones and their characteristics. In this respect, an attempt was made to find the relationship between sensitivity coefficient, c, and zonal characteristics such as population, employment, retail employment, ratios between population and employment or ratios between population and retail emoloyment. The linear regression analysis was employed in this procedure and the confidence bands of 95%(3,5) were also obtained. This means that at least 95% of the used data fall in the range of area between two lines.

For example in Figure 5-3, when the value of k2 is 0.0, the value of c is appro ately 2.0. This means that the attractiveness of this zone would increase by 2% for each 1% increase of Home-Work trip ratio, therefore 10% increase of Home-Work trip ratio would yield 20% increase of the attractiveness of this zone. If the value of c is negative, it indicates that this zone has a negative sensitivity to the increase of Home-Work trip ratio, i.e.

overestimating the Home-Work trip ratio will decrease the attractiveness of that particular zone.

4.2.1 Medicine Hat, Alberta

Medicine Hat is located about 270km. southeast of Calgary along the Trans-Canada Highway. The traffic to and from the highway and the increasing population in the recent years have resulted in the increasing traffic volume on the city streets. The population counted 29,000 in 1971 will reach 48,000 in 1990 causing a great demand of traffic planning.

According to the model mentioned earlier, the city was divided into 16 zones and they were numbered beginning from the Central Business District No. 1, the map of which is shown in Figure 4-1. The basic assumptions set up here for trip generation are as follows.

i) Trip generation Factor of 2.6 person trips/capita/day, $t = 2.6$

ii) Transit ridership 5%, $r = 0.05$.

iii) Vehicle occupancy rate 1.5 persons/car, $v = 1.5$.

Zonal population(p), employment(q), and retail employment(s), are shown in Table 4-5 obtained in 1971. Table 4-6 shows the ratios between population and employment in real numbers(k1) and in percentages(k2), and population and retail employment in real numbers(l1) and in percentages

(12) for each zone.

The initial ratios for different purpose of trips were,

i) Home-Work, h1 = 37%,

ii) Home-Shop, h2 = 13%,

iii) Home-Other, h3 = 28% and

iv) Non-Home, h4 = 22%.

In this study, our concern was to find out the sensitivity of the output (resulting trip distribution) when different ratios of trip purposes are given. For this purpose the following four combinations were investigated. This procedure is applicable to all the other cities selected in this thesis, however, different figures were chosen depending upon the initial ratios for different purpose of trips. It should also be noted that the sum of four trip ratios must always be 100%.

i) Home-Work, h1 = 30% to 40%
Home-Shop, h2 = 20% to 10%
Home-Other, h3 = 28%
Non-Home, h4 = 22%

ii) Home-Work, h1 = 30% to 40%
Home-Shop, h2 = 13%
Home-Other, h3 = 35% to 25%
Non-Home, h4 = 22%

iii) Home-Work, h1 = 30% to 40%
Home-Shop, h2 = 13%

Home-Other, h3 = 28%

Non-Home, h4 = 29% to 19%

iv) Home-Work, h1 = 30% to 40%

Home-Shop, h2 = 16.5% to 11.5%

Home-Other, h3 = 31.5% to 26.5%

Non-Home, h4 = 22%

It is noted that these combinations are extreme cases and that Home-Work trip ratio was always changed. Then the results have been obtained and the relation between the changes of the trip ratio for Home-Work (x%) and the changes of the trips attracted to each zone (y%) was to be calculated, defining x = 0.0, y = 0.0 when x is at its initial ratio, by linear regression analysis to determine the relationship expressed by y= cx + b. In this procedure, all 'b' were small enough to be neglected.

The final aim of this study was to find the relationship between the coefficients, c, which can be called sensitivity coefficients, and either zonal population (p), employment (q), retail employment (s), ratios between population and employment (k1 or k2) or ratios between retail employment (l1 or l2).

4.2.2 Kelowna, British Columbia

Kelowna is located in the center of Okanagan Valley on the Okanagan Lake blessed with a moderate climate. This advantageous feature of the city has enchanted a lot of people for recreational and leisure trips. Together with the vast residential development, it is anticipated that more and more traffic in and around the Kelowna area be produced. The population of this city was some 20,000 in 1972 and is expected to increase up to 109,000 by 1991.

Similar procedure to Medicine Hat was taken. The city was divided into 16 zones and they were numbered beginning from the Central Business District No. 1. The city map is shown in Figure 4-2. The basic assumptions set up for this city were,

i) Trip generation factor of 2.6 person trips/ capita/day, $t = 2.6$,

ii) Transit ridership 0%, $r = 0.0$ and

iii) Vehicle occupancy rate 1.5 persons/car, $v = 1.5$.

Zonal population, employment, and retail employment are shown in Table 4-7 obtained in 1972. Table 4-8 shows the ratios between population and employment, and population and retail employment in both real numbers and percentages in each zone.

The combinations of trip ratios for different purposes trip purposes are tabulated from Table 4-13 through Table 4-16 for all four cities.

Then the same procedure as Medicine Hat was carried out and the results were obtained.

4.2.3 Prince George, British Columbia

Prince George, situated in the mountainous area, has increased its importance as a regional center of forest products industry and this development of the city has necessitated the operation of transportation system for the coming years. Its population, some 60,000 in 1973, is expected to become as large as 150,000 in 15 years.

The city was divided into 16 zones and they were numbered beginning from the Central Business District, the map of which is shown in Figure 4-3. The basic assumptions were,

i) Trip generation factor of 2.35 person trips/capita/day, t = 2.35,

ii) Transit ridership 6%, r= 0.06, and

iii) Vehicle occupancy rate 1.5 persons/car, v = 1.5.

Zonal population, employment, and retail employment are shown in Table 4-9 obtained in 1973. Table 4-10 shows the ratios between population and employment, and population and retail employment in both real numbers and percentages in each zone.

Then the same procedures were taken as before.

4.2.4 Fort McMurray, Alberta

Fort McMurray which is located about 400km. north of Edmonton, is a growing city in Alberta thanks to the development of Alberta's Oil Sands. As a matter of fact, the population of this city counted about 10,000 in 1974 is expected to triple to over 30,000 by 1981.

The procedure to compute traffic matrix using the 'Four purpose proportionate trip generation and distribution model' was quite similar to the previous examples except for some discrepancies in the assumed figures used. The city was divided into 11 zones and they were numbered beginning from the Central Business District No. 1, the map of which is given in Figure 4-4. The basic assumptions for trip generation were,

i) Trip generation factor of 4.2 person trips/ capita/day, t = 4.2,

ii) Transit ridership 0%, r = 0.0, and

iii) Vehicle occupancy rate 1.5 persons/car, v = 1.5.

Zonal population, employment, and retail employment are shown in Table 4-11 obtained in 1974. Table 4-12 shows the ratios between population and employment, and population and retail employment in both real numbers and percentages for each zone.

Then the same procedure was taken as before.

1)	Population at the year of study	29,600 (1971)
2)	Estimated population in the design year	48,000 (1990)
3)	Person trips/capita/day	2.6
4)	Masstransit ridership	5%
5)	Vehicle occupancy rate	1.5
6)	Internal vehicle trip ratio for different purpose of trips	Home-Work : 37% Home-Shop : 13% Home-Other: 28% Non-Home : 22%
7)	Specific features of the city	No well defined continuous crosstown arteries Traffics to and from Trans-Canada Highway

TABLE 4-1

Comparison of the four studies

Medicine Hat

1) Population at the year of study	20,000 (1973)
2) Estimated population in the design year	109,000 (1991)
3) Person-trips/capita/day	2.6
4) Masstransit ridership	No public transit
5) Vehicle occupancy rate	1.5
6) Internal vehicle trip ratio for different purpose of trips	Home-Work : 30% Home-Shop : 15% Home-Other : 31% Non-Home : 24%
7) Specific features of the city	Increasing recreational and leisure trips

TABLE 4-2

Comparison of the four studies

Kelowna

1) Population at the year of study	60,000 (1973)
2) Estimated population in the design year	150,000 (1990)
3) Person trips/capita/day	2.35 (at present) 2.40 (future)
4) Masstransit ridership	5-7 (at present) 10% (future)
5) Vehicle occupancy rate	1.5 (at present) 1.4 (future)
6) Internal vehicle trip ratio for different purpose of trips	Home-Work : 35% Home-Shop : 15% Home-Other : 26% Non-Home : 24%
7) Specific features of the city	Lunch time peak hour

TABLE 4-3

Comparison of the four studies

Prince George

1) Population at the year of study	10,000 (1974)
2) Estimated population in the design year	30,000 (1981)
3) Person trips/capita/day	4.2 (at present) 3.0 (future)
4) Masstransit ridership	Transit to oil-sands Fixed route, dial-a-bus
5) Vehicle occupancy rate	1.5 (at present) 1.4 (future)
6) Internal vehicle trip ratio for different purpose of trips	Home-Work : 22% Home-Shop : 24% Home-Other: 27% Non-Home : 27% (at present) Home-Work : 28% Home-Shop : 22% Home-Other: 25% Non-Home : 25% (future)
7) Specific features of the city	Booming city because of oilsands development

TABLE 4-4

Comparison of the four studies

Fort McMurray

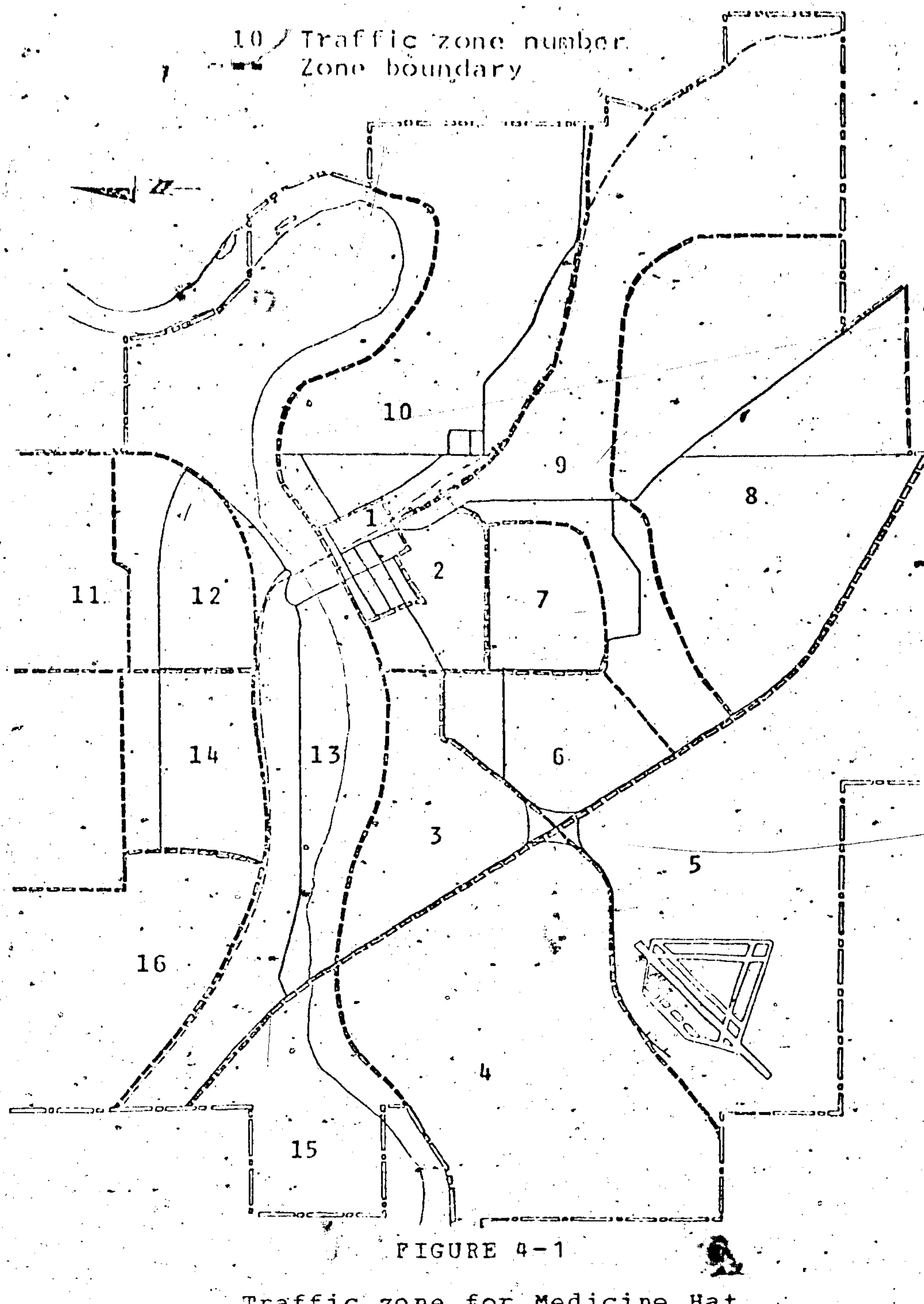

FIGURE 4-1

Traffic zone for Medicine Hat

Zone No.	Population (%)	Employment (%)	Retail Emp. (%)
1	250 (0.93)	2012 (26.96)	755 (60.40)
2	2194 (8.15)	593 (7.95)	38 (3.04)
3	2024 (7.52)	376 (5.04)	87 (6.96)
4	200 (0.74)	376 (5.04)	40 (3.20)
5	40 (0.15)	376 (5.04)	44 (3.52)
6	2649 (9.84)	368 (4.93)	81 (6.48)
7	2717 (10.09)	88 (1.18)	10 (0.80)
8	2819 (10.47)	490 (6.57)	25 (2.00)
9	1190 (4.42)	[illegible]2 (11.95)	50 (4.00)
10	3970 (14.75)	[illegible] (19.94)	50 (4.00)
11	0 (0.00)	[illegible] (0.00)	0 (0.00)
12	2813 (10.45)	44 (0.59)	6 (0.48)
13	2111 (7.87)	114 (1.53)	26 (2.80)
14	3436 (12.76)	245 (3.28)	38 (3.04)
15	0 (0.00)	0 (0.00)	0 (0.00)
16	500 (1.86)	0 (0.00)	0 (0.00)
Total	26920	7462	1250

TABLE 4-5

Medicine Hat, Population

and Employment

Zone No.	k1	k2	l1	l2
1	0.124	0.034	0.331	0.015
2	3.700	1.025	57.737	1.025
3	5.383	1.492	23.264	1.080
4	0.532	0.147	5.000	0.231
5	0.106	0.030	0.909	0.043
6	7.198	1.996	32.704	1.519
7	30.875	8.551	271.700	126.125
8	5.753	1.594	112.700	5.235
9	1.334	0.370	23.800	1.105
10	2.668	0.740	79.400	3.688
11	---	---	---	---
12	63.932	17.712	468.833	21.771
13	18.518	5.144	81.192	2.881
14	12.024	3.890	90.421	4.197
15	---	---	---	---
16	---	---	---	---

TABLE 4-6

Medicine Hat, Ratios between population and employment

Note: k1 = Pop./Emp. in real number

k2 = Pop./Emp. in %

l1 = Pop./Retail Emp. in real number

l2 = Pop./Retail Emp. in %

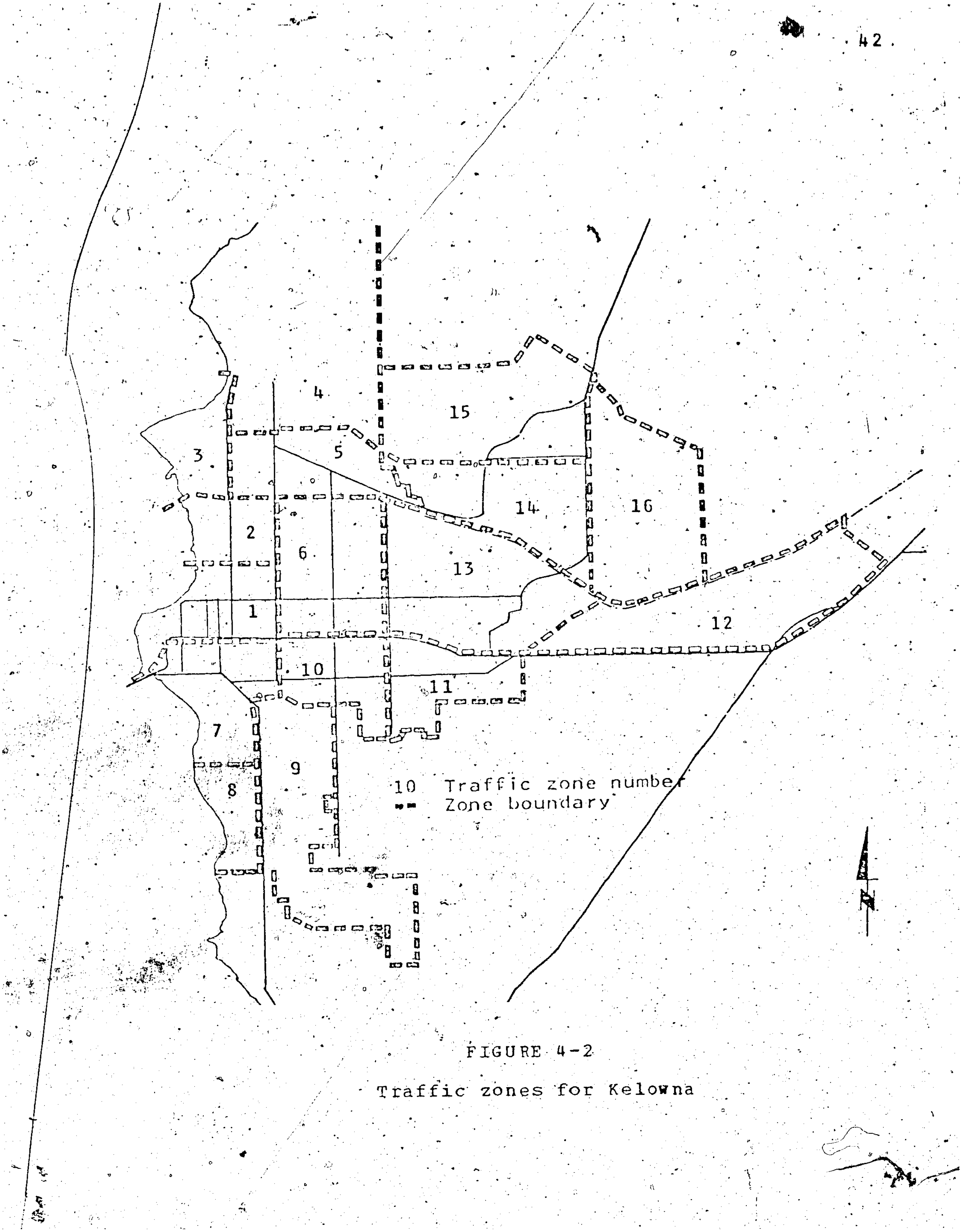

FIGURE 4-2

Traffic zones for Kelowna

Zone No.	Population (%)	Employment (%)	Retail Emp. (%)
1	603 (3.11)	3750 (41.28)	2250 (77.07)
2	401 (2.07)	1000 (11.01)	30 (1.03)
3	183 (0.94)	600 (6.61)	0 (0.00)
4	1113 (5.74)	50 (0.55)	0 (0.00)
5	225 (1.16)	800 (8.81)	0 (0.00)
6	2854 (14.73)	110 (1.21)	10 (0.34)
7	2576 (13.30)	400 (4.41)	50 (1.71)
8	736 (3.80)	600 (6.61)	100 (3.42)
9	2445 (12.62)	200 (2.21)	10 (0.34)
10	1389 (7.17)	160 (1.76)	30 (1.03)
11	995 (5.13)	600 (6.61)	325 (11.13)
12	17 (0.09)	500 (5.51)	10 (0.34)
13	2706 (13.97)	250 (2.75)	100 (3.42)
14	1624 (8.38)	5 (0.06)	3 (0.10)
15	1209 (6.24)	35 (0.39)	2 (0.07)
16	301 (1.55)	20 (0.22)	0 (0.00)
Total	19377	9080	2920

TABLE 4-7

Kelowna, Population and Employment

Zone No.	k1	k2	l1	l2
1	0.161	0.075	0.268	0.040
2	0.401	0.188	13.367	2.010
3	0.305	0.142	---	---
4	22.260	10.436	---	---
5	0.281	[illegible]	---	---
6	25.945	12.174	285.400	43.324
7	6.440	3.014	51.520	7.772
8	1.227	0.575	7.360	1.111
9	12.225	5.736	244.500	37.118
10	8.681	4.074	46.300	6.961
11	1.658	0.776	3.062	0.461
12	0.034	0.016	1.700	0.265
13	10.824	5.080	27.060	4.085
14	324.800	139.667	541.333	83.800
15	34.543	16.000	604.500	89.143
16	15.050	7.045	---	---

TABLE 4-8

Kelowna, Ratios between popultion and employment

Note: k1 = Pop./Emp. in real number

k2 = Pop./Emp. in %

l1 = Pop./Retail Emp. in real number

l2 = Pop./Retail Emp. in %

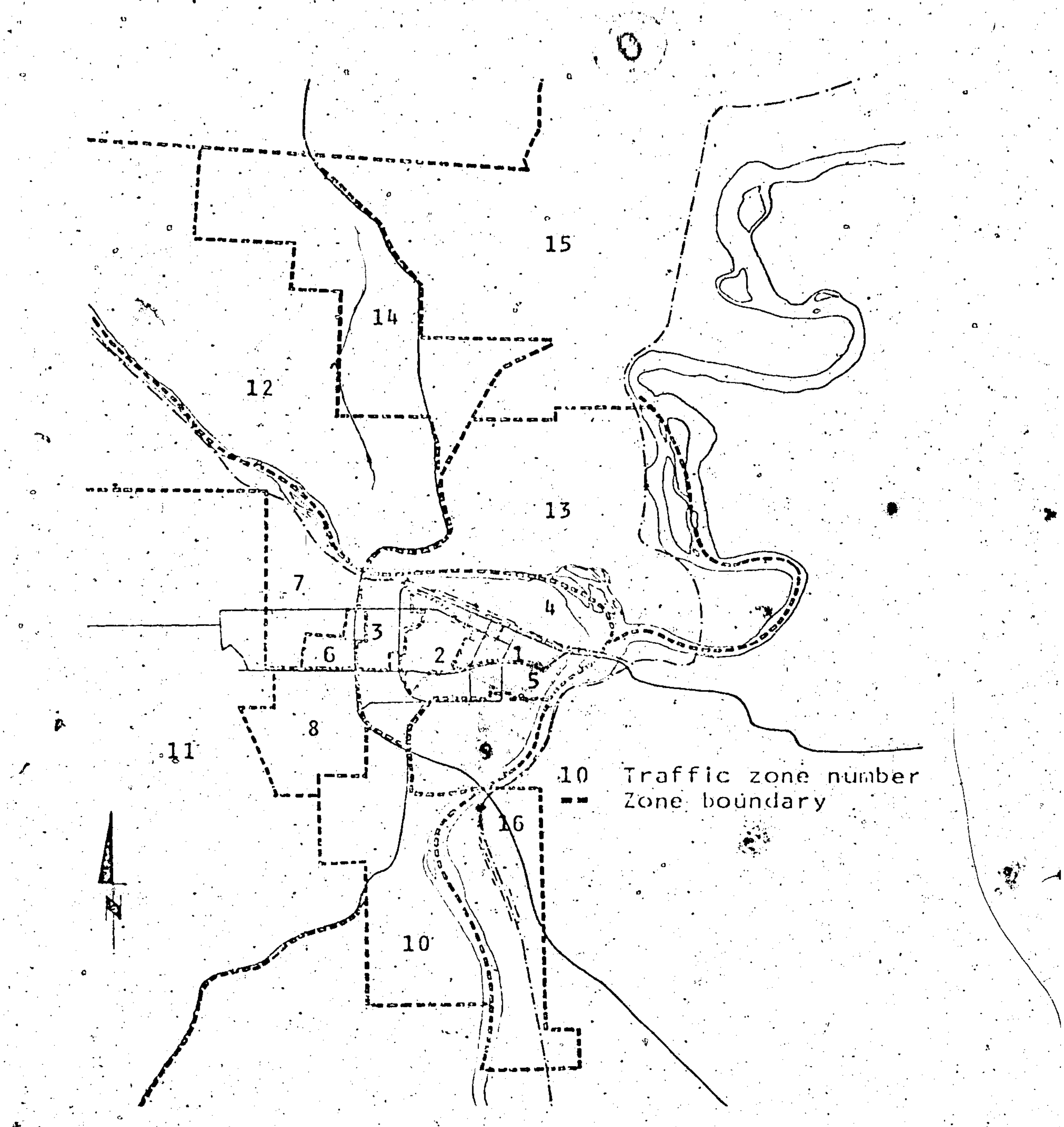

FIGURE 4-3

Traffic zones for Prince George

Zone No.	Population (%)	Employment (%)	Retail Emp. (%)
1	1105(2153)	3658 (22.98)	1132 (30.32)
2	4213 (8.18)	1193 (7.50)	361 (9.67)
3	5397 (10.49)	164 (1.03)	60 (1.61)
4	860 (1.67)	2540 (15.97)	20 (0.54)
5	6071 (11.79)	580 (3.65)	299 (8.01)
6	3765 (7.31)	500 (3.14)	304 (8.14)
7	8411 (16.35)	124 (0.78)	55 (1.47)
8	1138 (2.21)	1912 (12.02)	1163 (31.15)
9	4833 (9.39)	289 (1.82)	169 (4.53)
10	5433 (10.56)	168 (1.06)	60 (1.61)
11	2734 (5.31)	4 (0.03)	0 (0.00)
12	1863 (3.62)	133 (0.84)	40 (1.07)
13	764 (1.48)	1144 (7.19)	20 (0.54)
14	3454 (12.76)	175 (1.10)	50 (1.34)
15	1356 (2.63)	1453 (9.02)	0 (0.00)
16	76 (0.15)	1889 (11.87)	0 (0.00)
Total	51473	15908	3733

TABLE 4-9

Prince George Population and Employment

Zone No.	k1	k2	l1	l2
1	0.302	0.094	0.976	0.071
2	3.531	1.091	11.670	0.846
3	32.909	10.184	89.950	6.516
4	0.339	0.105	43.000	3.093
5	10.467	3.230	20.304	1.472
6	7.530	2.328	12.385	0.898
7	67.831	20.949	152.927	11.116
8	0.595	0.184	0.979	0.071
9	16.723	5.159	28.598	2.073
10	32.339	9.962	90.550	6.559
11	683.500	177.000	---	---
12	14.008	4.310	46.575	3.383
13	0.668	0.206	38.200	2.741
14	19.737	6.100	69.080	5.007
15	0.945	0.292	---	---
16	0.040	0.013	---	---

TABLE 4-10

Prince George, Ratios between popultion and employment

Note: k1 = Pop./Emp. in real number

k2 = Pop./Emp. in %

l1 = Pop./Retail Emp. in re. number

l2 = Pop./Retail Emp. in %

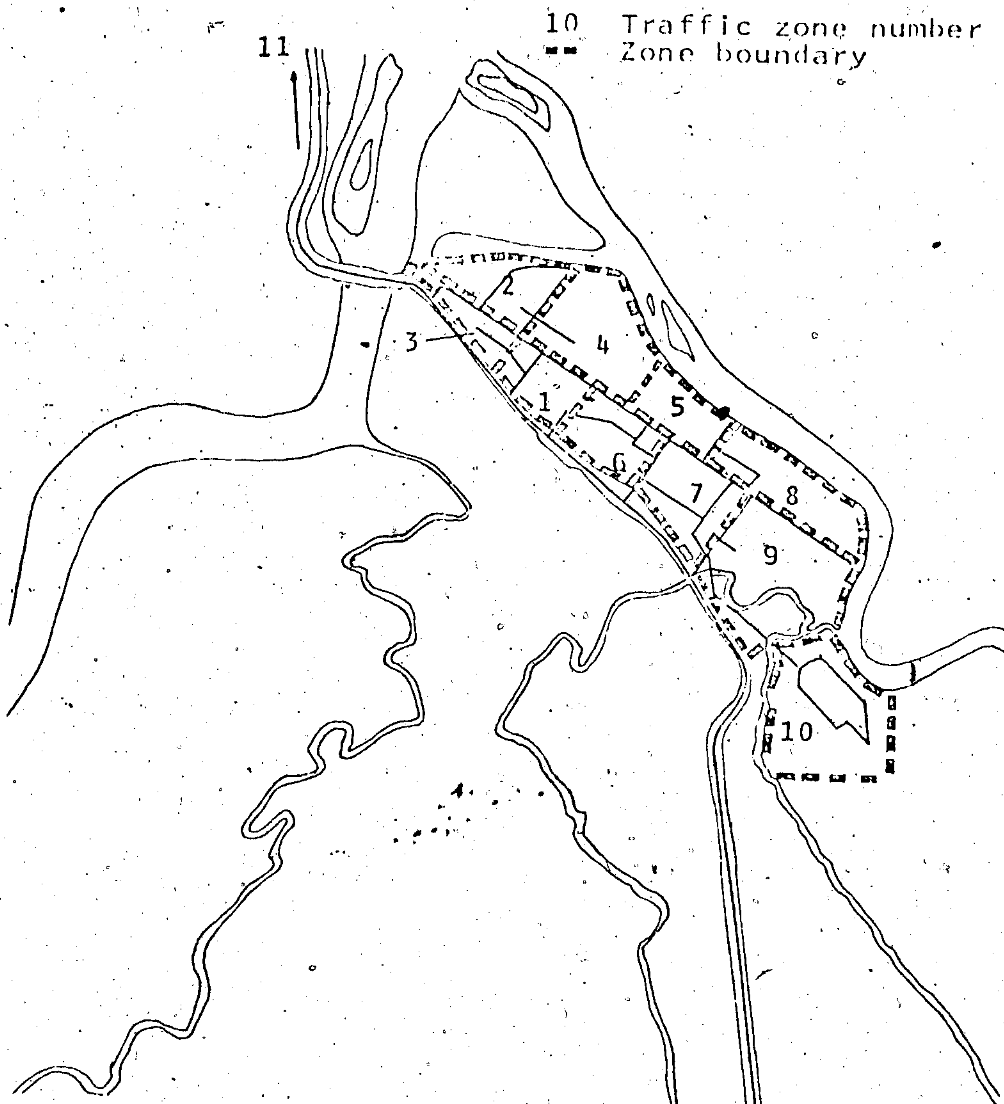

FIGURE 4-4

Traffic zones for Fort McMurray

Zone No.	Population (%)	Employment (%)	Retail Emp. (%)
1	440 (4.47)	231 (7.77)	115 (30.67)
2	667 (6.78)	209 (7.03)	81 (21.60)
3	475 (4.83)	286 (9.62)	51 (13.60)
4	1227 (12.48)	29 (0.98)	2 (0.53)
5	1171 (11.91)	122 (4.10)	63 (16.80)
6	1946 (19.78)	30 (1.01)	0 (0.00)
7	1860 (18.91)	73 (2.45)	0 (0.00)
8	283 (2.88)	234 (7.87)	58 (15.47)
9	70 (0.71)	133 (4.47)	3 (0.80)
10	1486 (15.11)	109 (3.67)	2 (0.53)
11	210 (2.14)	1518 (51.03)	0 (0.00)
Total	9835	2974	375

TABLE 4-11

Fort McMurray, Population and Employment

Zone No.	k1	k2	l1	l2
1	1.905	0.575	3.826	0.146
2	3.191	0.964	8.235	0.314
3	1.661	0.502	9.314	0.355
4	42.310	12.735	613.500	23.547
5	9.598	2.905	18.587	0.709
6	64.867	19.594	---	---
7	25.479	7.718	---	---
8	1.209	0.366	4.879	0.186
9	0.526	0.159	23.333	0.888
10	13.633	4.117	743.000	28.509
11	0.138	0.042	---	---

TABLE 4-12

Fort McMurray, Ratios between popultion and employment

Note: k1 = Pop./Emp. in real number

k2 = Pop./Emp. in %

l1 = Pop./Retail Emp. in real number

l2 = Pop./Retail Emp. in %

	H-W	H-S	H-O	N-H
1st Comb. (DATA1)	30%-40%	20%-10%	28%	22%
2nd Comb. (DATA2)	30%-40%	13%	35%-25%	22%
3rd Comb. (DATA3)	30%-40%	13%	28%	29%-19%
4th Comb. (DATA4)	30%-40%	16.5%-11.5%	31.5%-26.5%	22%

TABLE 4-13

Combination of trip ratios

for different purposes

Medicine Hat

Note: H-W = Home based work trips

H-S = Home based shopping trips

H-O = Home based other trips

N-H = Non home based trips

	H-W	H-S	H-O	N-H
1st Comb. (DATA1)	25%-35%	20%-10%	31%	24%
2nd Comb. (DATA2)	25%-35%	15%	36%-26%	24%
3rd Comb. (DATA3)	25%-35%	15%	31%	29%-19%
4th Comb. (DATA4)	25%-35%	17.5%-12.5%	33.5%-28.5%	24%

TABLE 4-14

Combination of trip ratios

for different purposes

Kelowna

Note: H-W = Home based work trips

H-S = Home based shopping trips

H-O = Home based other trips

N-H = Non home based trips

	H-W	H-S	H-O	N-H
1st Comb. (DATA1)	30%-40%	20%-10%	26%	24%
2nd Comb. (DATA2)	30%-40%	15%	31%-21%	24%
3rd Comb. (DATA3)	30%-40%	15%	26%	29%-19%
4th Comb. (DATA4)	30%-40%	17.5%-12.5%	28.5%-23.5%	24%

TABLE 4-15

Combination of trip ratios

for different purposes

Prince George

Note: H-W = Home based work trips

H-S = Home based shopping trips

H-O = Home based other trips

N-H = Non home based trips

	H-W	H-S	H-O	N-H
1st Comb. (DATA-1)	17%-27%	29%-19%	27%	27%
2nd Comb. (DATA2)	17%-27%	24%	32%-22%	27%
3rd Comb. (DATA 3)	17%-27%	24%	27%	32%-22%
4th Comb. (DATA4)	17%-27%	26.5%-21.5%	29.5%-24.5%	27%

TABLE 4-16

Combination of trip ratios
for different purposes
Fort McMurray

Note: H-W = Home based work trips
H-S = Home based shopping trips
H-O = Home based other trips
N-H = Non home based trips

CHAPTER V

RESULTS

In this way, previously mentioned procedure was executed for each city and the following results were obtained. In order for convenience, different combination of data as we referred to was named Data 1, Data 2, Data 3 and Data 4 respectively. In other words, Data 1 means the combination of changing internal trip ratio of Home-Work and Home-Shop, Home-Work and Home-Other for Data 2, Home-Work and Non-Home for Data 3, and Home-Work, Home-Shop and Home-Other for Data 4. The results, therefore, are shown in that order for each city.

5.1 Medicine Hat

5.1.1 Data 1

Correlation between coefficients, c, and population(p), employment(q) and retail employment(s) is shown in Table 5-1 and correlation between c and ratios of population/employment and population/retail employment in both real numbers and percentages(k1,k2,11,12) is shown in Table 5-2. (Refer to Appendix B for tables in this chapter.)

According to those tables it is difficult to determine what type of zone is sensitive in its attractiveness. The only observation we could have would be the fact that the zones with larger percentage of total employment and the zones with small ratios of k2(0<k2<2) have more sensitivity to the change of Home-Work trip ratio (Figure 5-1, Figure 5-2). It is also obvious that the increase of Home-Work trip ratio together with the reduction of Home-Shop trip ratio resulted in a considerable reduction of attractiveness in the Central Business District where the majority number of retail employment is dominant.

5.1.2 Data 2

Correlation between coefficients, c, and p, q, s is shown in Table 5-3 and correlation between c and k1, k2, l1, l2 is shown in Table 5-4.

It can be said from those tables that there is a certain relationship between c and k1 and c and k2. Since k2 is a relative ratio between population and employment this figure was taken for further investigation. Figure 5-3 shows the relationship between c and k2 with confidence bands of 95%(3,5) together with the original regression curves. The confidence bands of 95% means that more than 95% of estimated points fall in this range. In this regression analysis, Zone 1 was omitted from the calculation. Figure 5-3 indicates that smaller ratios of k2(less than 1) have positive attractiveness when Home-Work trip ratio increases and Home-Other trip ratio decreases. In other words, industrial and commercial areas attract more people and residential areas do less in this particular data.

5.1.3 Data 3

Correlation between coefficients, c, and p, q, s is found in Table 5-5 and correlation between c and k1, k2, l1, l2 is shown in Table 5-6. In this data, we can find similar relationship to Data2 between c and k1 and c and k2.

Figure 5-4 shows regression lines between c and k2 including confidence bands of 95%. The graph indicates that considerably stronger relationship exists between these two factors. In those zones where the ratio of k2 is less than 1.5 show positive attractiveness with increasing Home-Work trip ratio when Non-Home trip ratio is reduced. In this case, the sensitivity of the attractiveness is less than that in Data 2 therefore, the slopes of the regression lines are gentler. In spite of this fact, Zone 1 (Central Business District) shows much less sensitivity toward the change of Home-Work trip ratio, which was also the case in Data2.

5.1.4 Data 4

Correlation between coefficients, c, and p, q, s is shown in Table 5-7 and correlation between c and k1, k2, l1, l2 is shown in Table 5-8.

It is obvious that we have obtained the similar relationship to Data2 and Data3 between c and k1 and c and k2. The linear regression graph with confidence bands of 95% is shown in Figure 5-5 which shows the strong relation between c and k2. As was mentioned previously, industrial and commercial areas attract more people when Home-Work trip ratio increases with a reduction of both Home-Shop and Home-Other trip ratios. The marginal ratio of k2 from positive attractiveness to negative one would be around 1.5 judging from the graph. Central Business District showed small change in its attractiveness in this data, too.

5.2 Kelowna

5.2.1 Data 1

Correlation between coefficients, c, and p, q, s is shown in Table 5-9 and correlation between c and k1, k2, l1, l2 is shown in Table 5-10.

Similar difficulty has been found in determining the relationship between coefficients and other factors. Figure 5-6 and Figure 5-7 show that higher percentages of employment in the zone (more than 5%) and smaller ratios of population/employment in percentage (less than 1) show higher sensitivity to the change of Home-Work and Home-Shop trip ratios. It was also found that Central Business District has a strong negative attractiveness in this data, which was also found from the results in Medicine Hat.

5.2.2 Data 2

Correlation between coefficients, c, and p, q, s is shown in Table 5-11 and correlation between c and k1, k2, l1, l2 is shown in Table 5-12.

Certain relationships are found between c and k1 and c and k2. Figure 5-8 shows a significant relationship between c and k2 with 95% confidence bands. As was the case in Medicine Hat, so is the case in this data that residential areas where k2 is larger have negative attractiveness toward the change of Home-Work with Home-Other trip ratios and industrial areas where k2 is smaller have positive attractiveness in this data. However, Central Business District with high retail employment was not affected by the change of Home-Work and Home-Other trip ratios, which tendency was also found in Medicine Hat. It can also be said that the sensitivity of those zones where k2 is close to 1 is not affected by the change of trip ratios.

5.2.3 Data 3

Correlation between coefficients, c, and p, q, s is shown in Table 5-13 and correlation between c and k1, k2, l1, l2 is shown in Table 5-14.

Strong relationship between c and k1 and c and k2 were found and Figure 5-9 shows the latter relationship with 95% confidence bands. The magnitude of the sensitivity was not as large as that found in Data2, however, the graph indicates that higher ratios of k2 have negative sensitivity and that lower ratios of k2 have positive sensitivity to the change of Home-Work and Non-Home trip ratios. Central

Business District showed less sensitivity in this data compared with the similar zones to C.B.D. which have very small k2.

5.2.4 Data 4

Correlation between coefficients, c, and p, q, s is shown in Table 5-15 and correlation between c and k1, k2, l1, l2 is shown in Table 5-16.

Figure 5-10 indicates a strong relationship between c and k2 with 95% confidence bands, which was also found in the previous two data. Small ratios of k2 have positive sensitivity and large ratios of k2 have moderately negative sensitivity to the change of three home based trip ratios. In other words, industrial areas have significantly positive attractiveness and residential areas have moderately negative attractiveness in this data. It was also noted that the attractiveness of the Central Business District was not sensitive to the change of the three home based trip ratios.

5.3 Prince George

5.3.1 Data 1

Correlation between coefficients, c, and p, q, s is shown in Table 5-17 and correlation between c and k1, k2, l1, l2 is shown in Table 5-18.

Determination of significant relationship between coefficients, c, and other factors was as inaccurate as it was in other two cities. In this city, there are two major shopping zones which are Zone 1 (C.B.D.) and Zone 8. Central Business District did not show considerable reduction of its attractiveness compared to the previous studies but Zone 8 with higher retail employment than Zone 1 showed a significant drop of its attractiveness in this data. This is because Zone 8 carries lower percentage of employment than Zone 1 and this fact affected the trip attraction to both zones when Home-Work trip ratio was increased and Home-Shop ratio was decreased. It could also possibly be said that those zones with very small percentage of s (retail employment), small percentage of p (population) and large percentage of q (employment) have relatively high attractiveness hence large sensitivity (Figure 5-11, Figure 5-12, Figure 5-13).

5.3.2 Data 2

Correlation between coefficients, c, and p, q, s is shown in Table 5-19 and correlation between c and k1, k2, l1, l2 is shown in Table 5-20.

Figure 5-14 shows the relationship between c and k2 with 95% confidence bands. It is observed from the graph that those zones where k2 is less than 0.5 except for the zones with large percentage of retail employment such as Zone 1 and Zone 8 show significantly positive attractiveness, whereas residential areas, generally, show significantly negative attractiveness in this data. Such tendencies of attractiveness in various zones were also found in the previous two cities.

5.3.3 Data 3

Correlation between coefficients, c, and p, q, s is shown in Table 5-21 and correlation between c and k1, k2 l1, l2 is shown in Table 5-22.

Figure 5-15 shows the relationship between c and k2 with 95% confidence bands however, it is to be noted that the slopes of the regression lines are gentler and the confidence bands are narrower compared to those in Data 2. This indicates that the difference of input trip ratios in this combination does not affect the output as much as the combination in Data 2. It should also be noted that Zone 1 and Zone 8 have almost zero sensitivity and such a tendency as shopping areas do not have significant sensitivity seems to be dominant in downtown zones and zones with a large shopping area.

5.3.4 Data 4

Correlation between coefficients, c, and p, q, s is shown in Table 5-23 and correlation between c and k1, k2, l1, l2 is shown in Table 5-24.

The relationship between c and k2 showed a similar inclination to the previous two different data

(Figure 5-16). Zone 1 and Zone 8 showed small change in their attractiveness or sensitivity compared to the previous data.

Judging from the results in three cities, it can generally be said for Data 2, Data 3, and Data 4 that high ratio of population/employment, or mainly residential area, would affect zonal attractiveness in the negative way and that the degree of this negative attractiveness does not change drastically within the limit where the zones can be recognized as residential area. It is also pointed out that very small ratio of population/employment, or mainly industrial area, would affect zonal attractiveness in the positive way and that zonal sensitivity changes drastically in the range of $0<k2<1.5$. The Central Business District or in the zone where there are a large number of retail employees, however, is not sensitive to the change of trip ratios as far as Data 2, Data 3, and Data 4 are concerned.

5.4 Fort McMurray

5.4.1 Data 1

Correlation between coefficients, c, and p, q, s is shown in Table 5-25 and correlation between c and k1, k2, l1, l2 is shown in TAble 5-20.

The results were not positive enough to be confirmed, however, Zone 11 where more than 50% of the total employment is occupied showed a strong attractiveness to the change of Home-Shop trip ratios. At the same time, downtown zone showed a negative attractiveness in this data, which is similar to the results from the other three cities.

5.4.2 Data 2

Correlation between coefficients, c, and p, q, s is shown in Table 5-27 and correlation between c and k1, k2, l1, l2 is shown in Table 5-28.

Figure 5-17 shows a similar relationship to the previous examples between c and k2 with confidence bands of 95%, however, it is observed that the confidence bands are wider than those in the other three cities. This implies that the relation between c and k2 is not as strong as that in the other three cities. This may be partly because of the fewer number of zones, therefore fewer points in the graph, and this seems to have caused the wider confidence bands and smaller correlation coefficients of the regression lines.

At any rate, it can be said positively that small ratio of k2 of the zone affects its attractiveness in the positive way and the large ratio of k2 of the zone influences its attractiveness in the negative way.

5.4.3 Data 3

Correlation between coefficients, c, and p, q, s is shown in Table 5-29 and correlation between c and k1, k2, l1, l2 is shown in Table 5-30.

Figure 5-18 shows a strong relationship between c and k2 again with confidence bands of 95%. It is seen easily from the graph that the slopes of the regression lines are gentler than those in Data 2 and that confidence bands are narrower. It can be pointed out again that the sensitivity or attractiveness of the zone changes drastically when the ratio of k2 is less than 1, however, it changes very gradually when the ratio of k2 is larger than that.

5.4.4 Data 4

Correlation between coefficients, c, and p, q, s is shown in Table 5-31 and correlation between c and k1, k2, l1, l2 is shown in Table 5-32.

Figure 5-19 indicates the same relation between c and k2 as before. It was marked that Data 2, Data 3, and Data 4 showed strong relationship between c and k2 with slight discrepancies from example to example, however, it seems to be certain, in small cities, judging from those calculations based on 'Four purpose traffic generation and distribution model', that similar type of zones which can be classified as industrial area, have similar attractiveness and sensitivity to the change of trip ratios introduced in Data 2, Data 3 and Data 4. This tendency was well expressed in terms of the relationship between c, sensitivity coefficients, and k2, the ratios between population and employment.

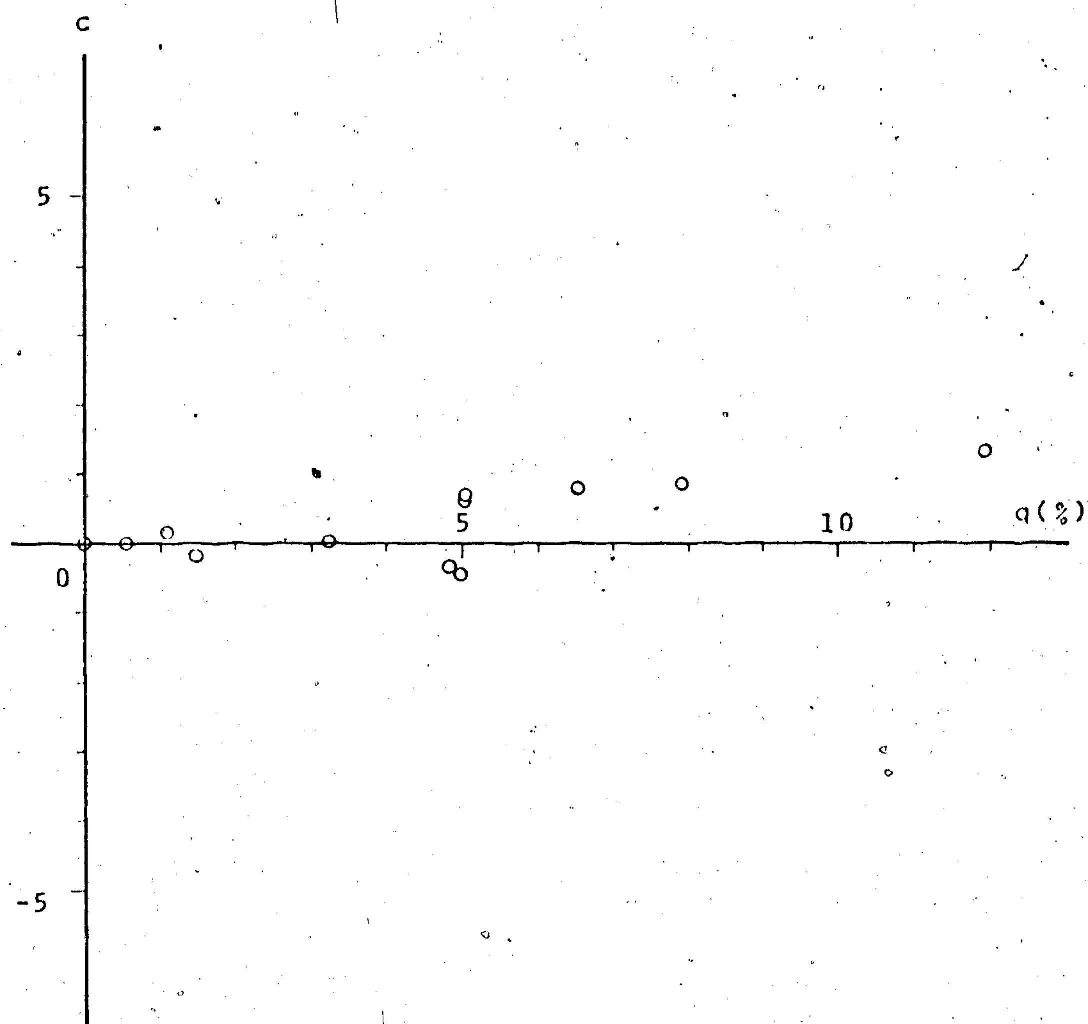

FIGURE 5-1

Medicine Hat (Data 1)

Correlation between coefficients, c, and employment (q)

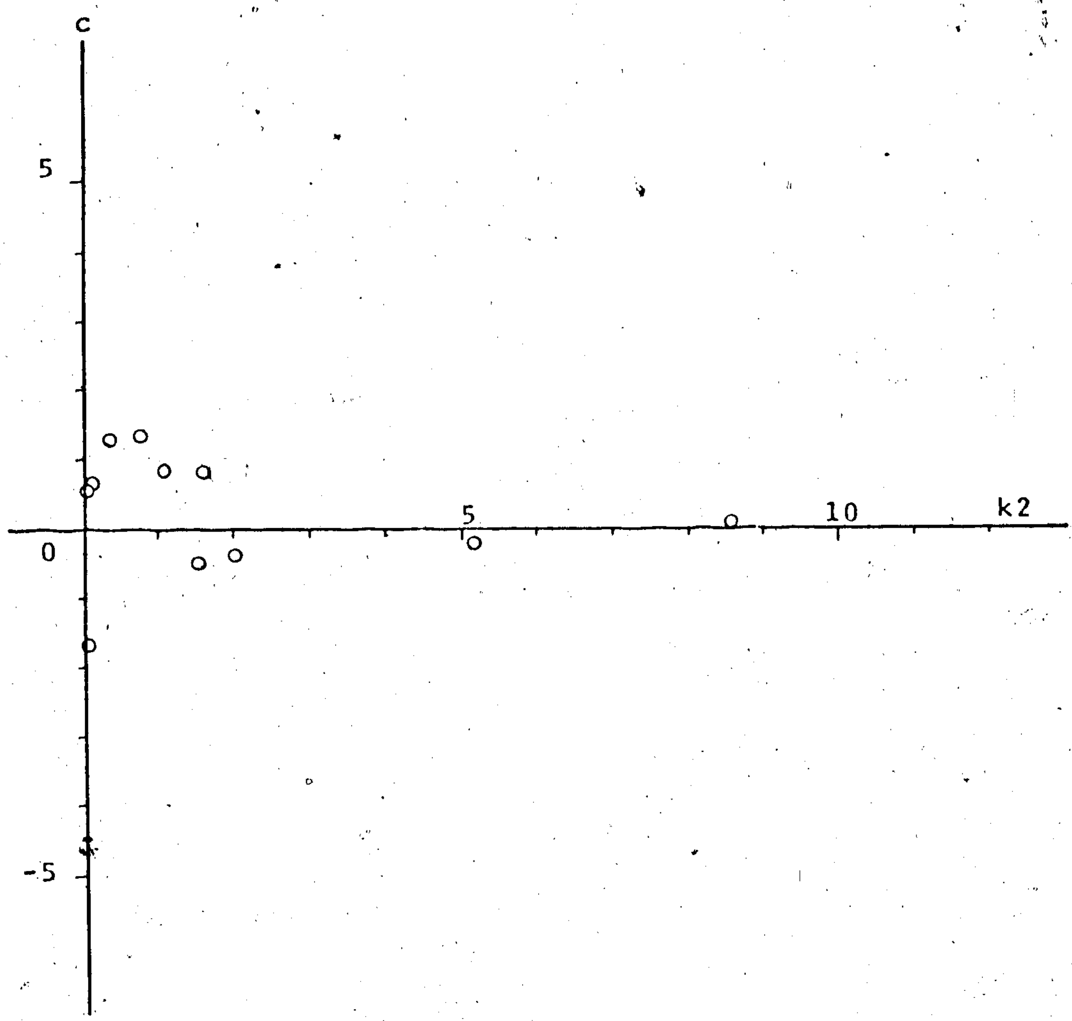

FIGURE 5-2

Medicine Hat(Data 1)

Correlation between c and the ratio of poulation/employment(k2) in percentage

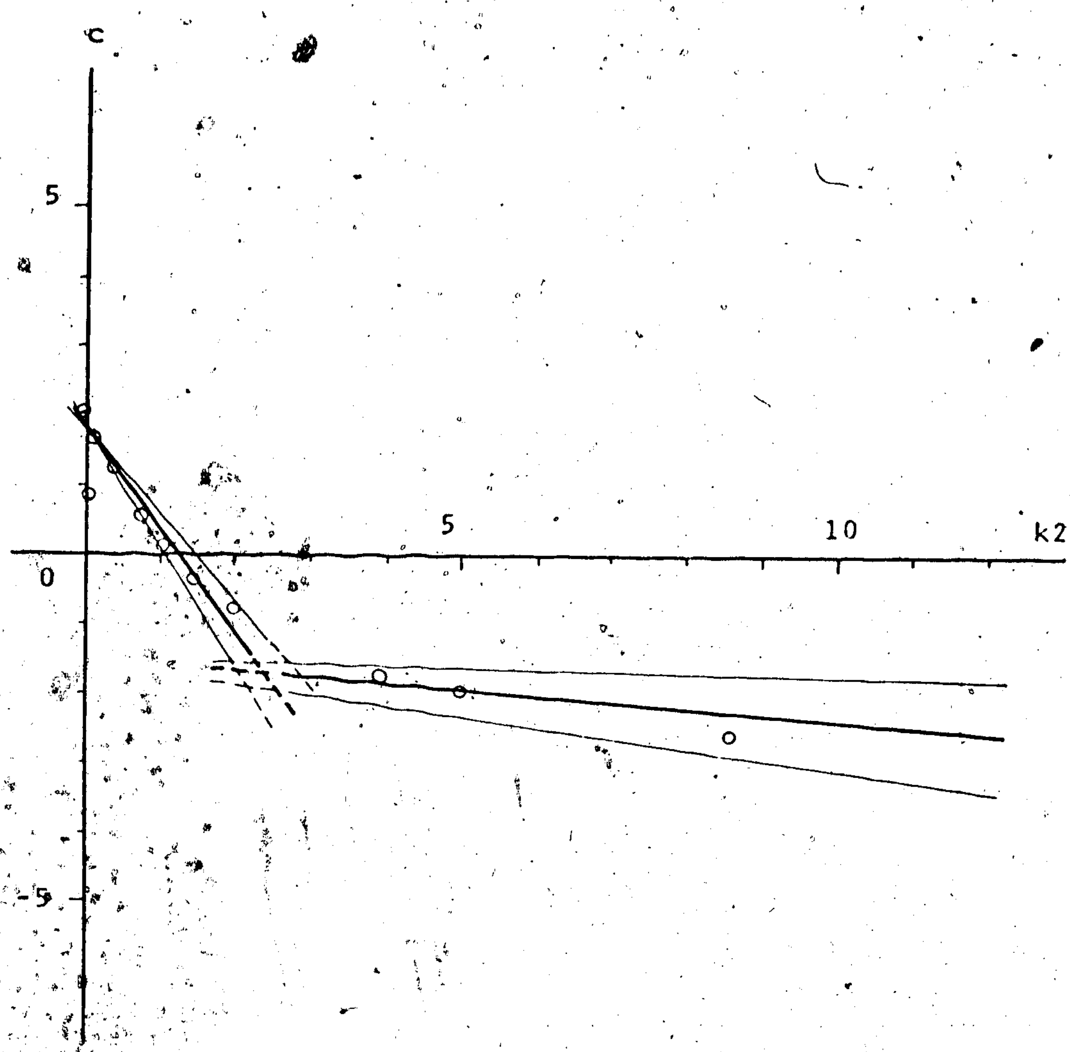

FIGURE 5-3

Medicine Hat(Data 2)

Correlation between c and k2

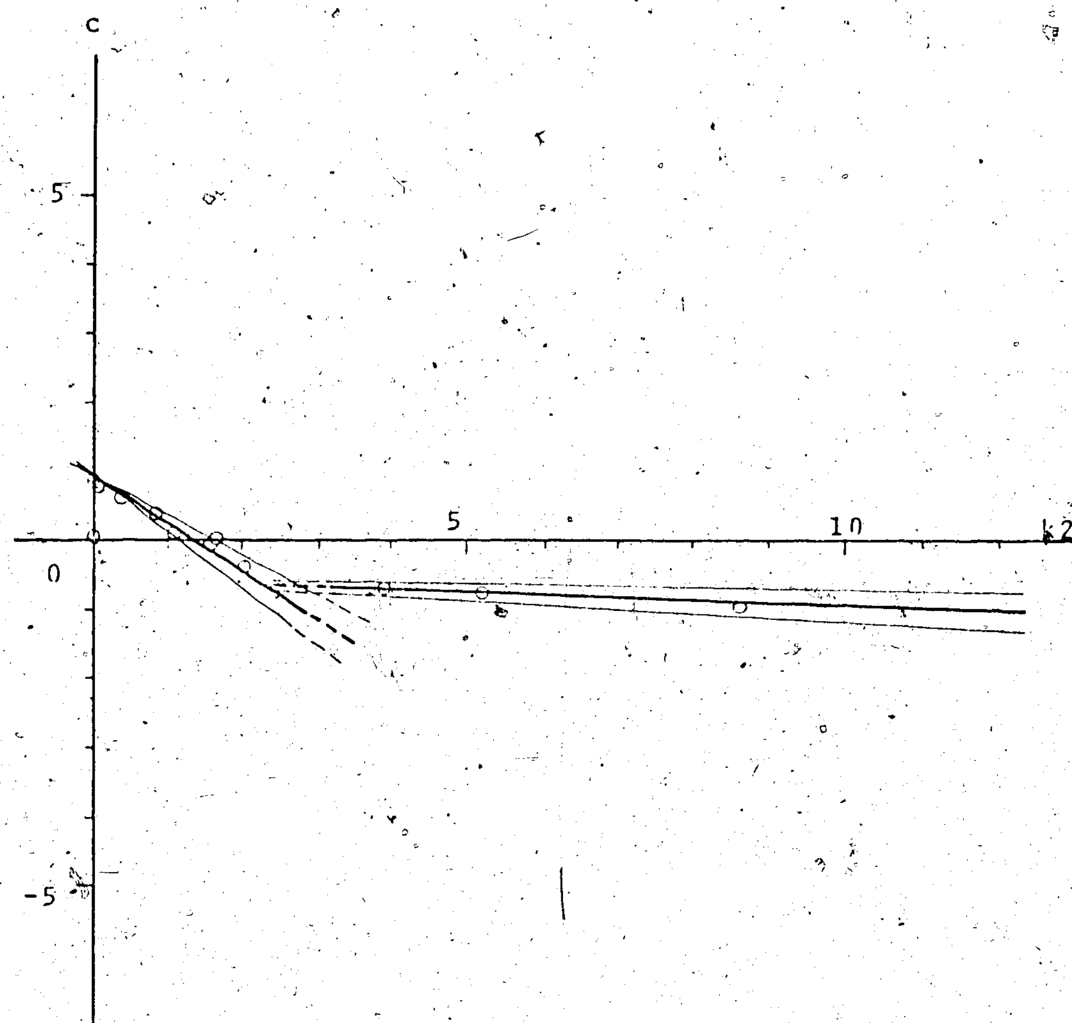

FIGURE 5-4

Medicine Hat (Data 3)

Correlation between c and k2

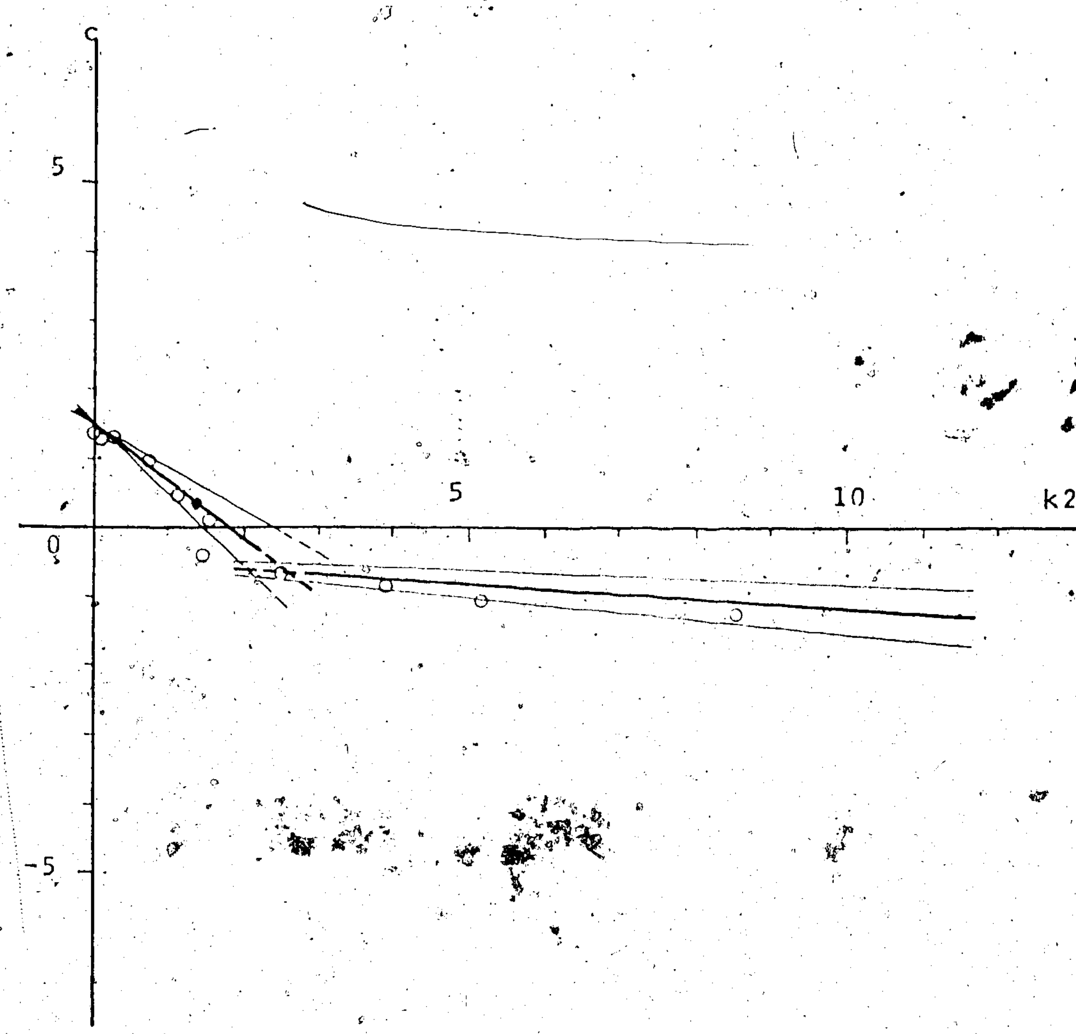

FIGURE 5-5

Medicine Hat (Data 4)

Corrleation between c and k2

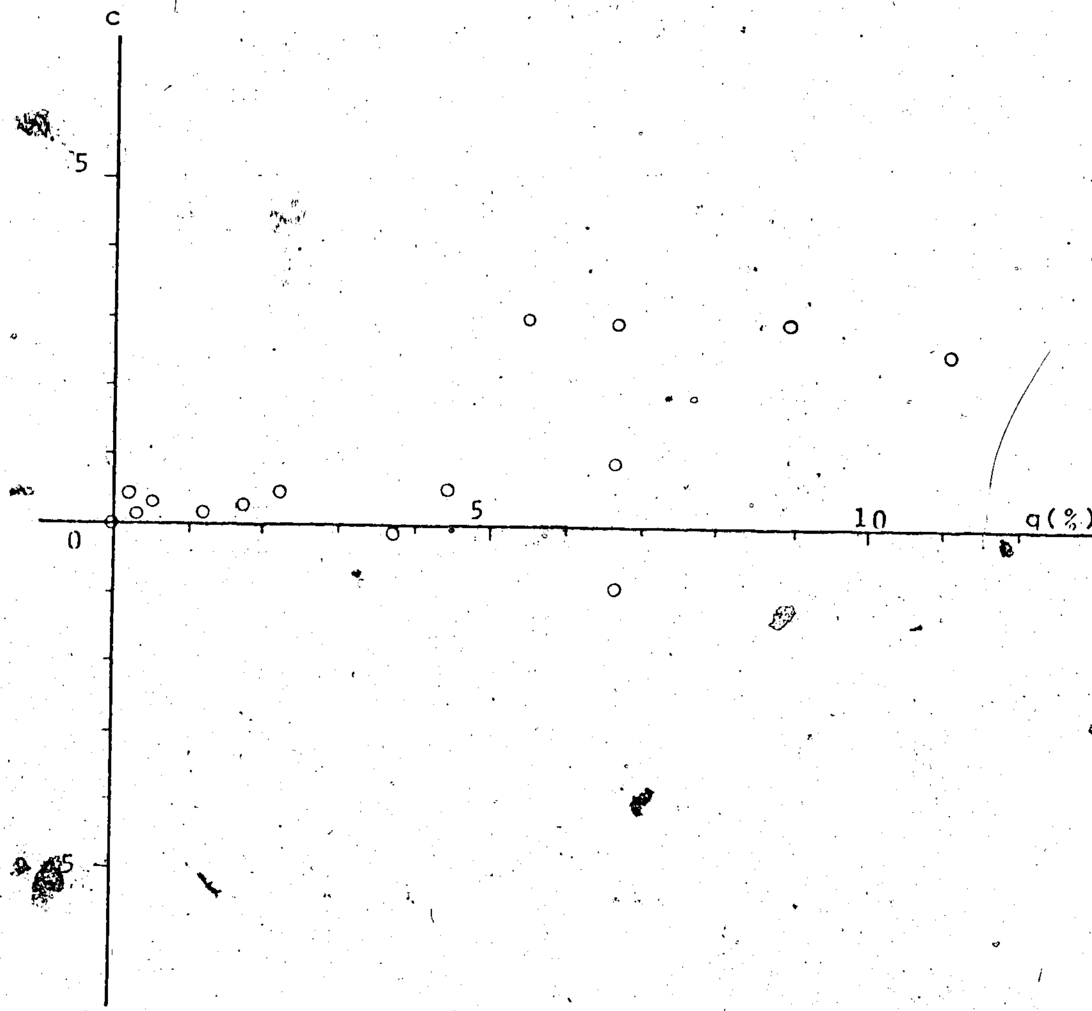

FIGURE 5-6

Kelowna (Data 1)

Correlation between c and q

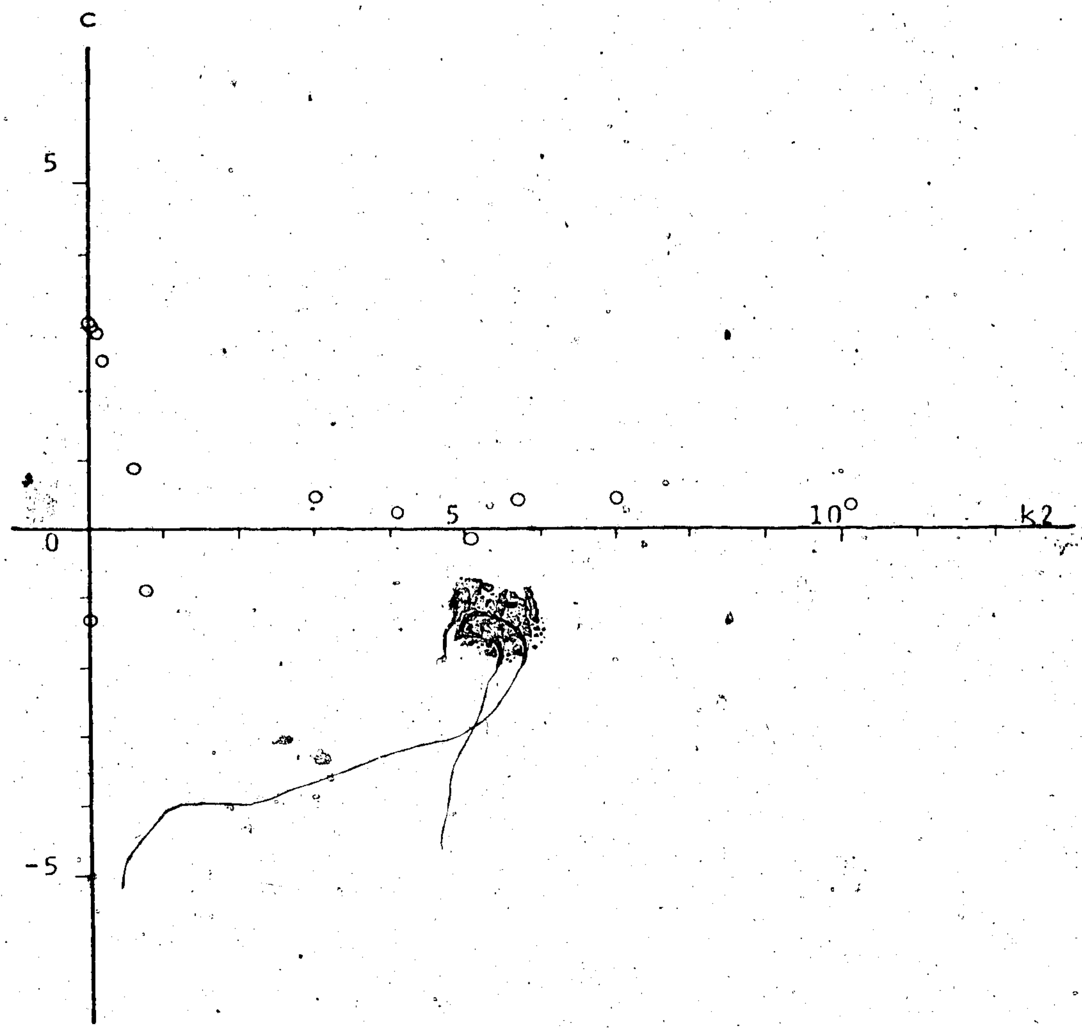

FIGURE 5-7

Kelowna (Data 1)

Correlation between c and k2

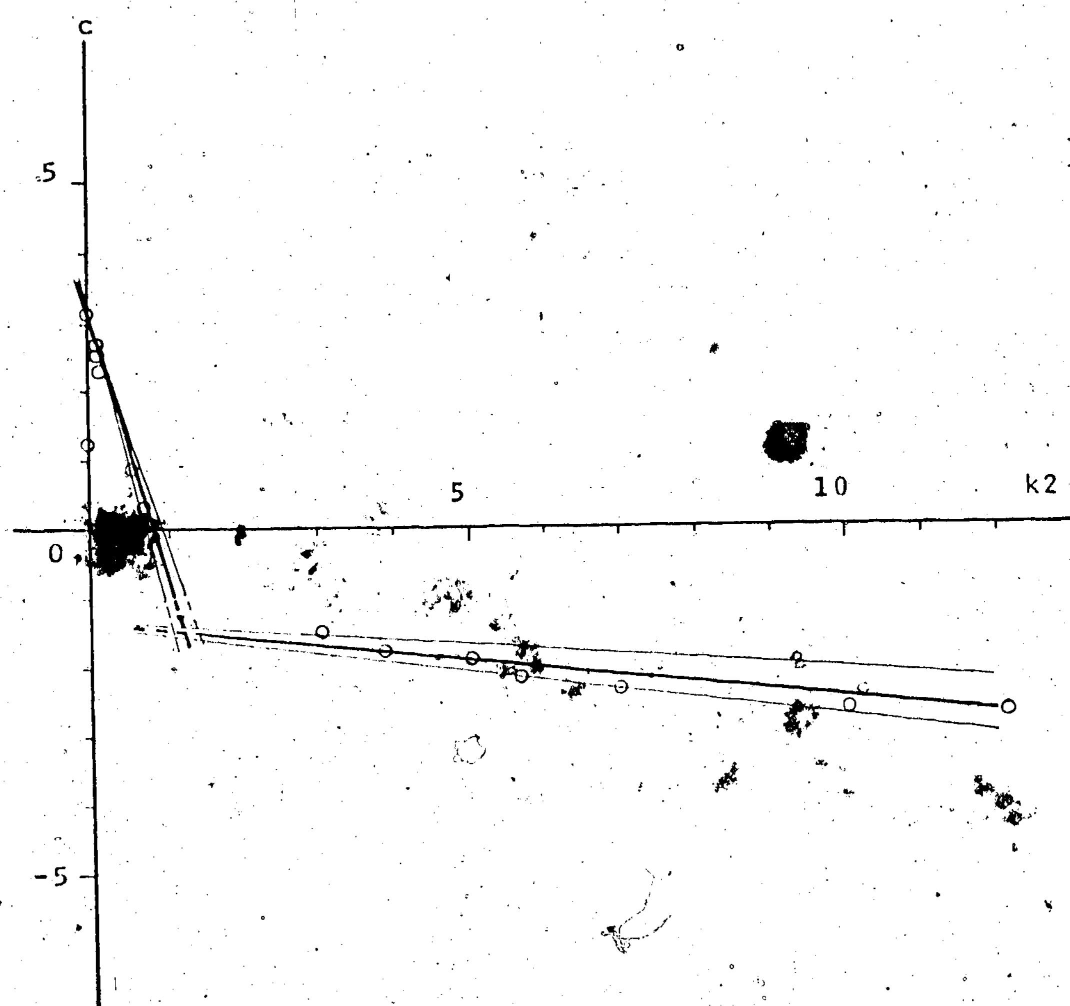

FIGURE 5-8

Kelowna (Data 2)

Correlation between c and k2

FIGURE 5-9

Kelowna(Data 3)

Correlation between c and k2

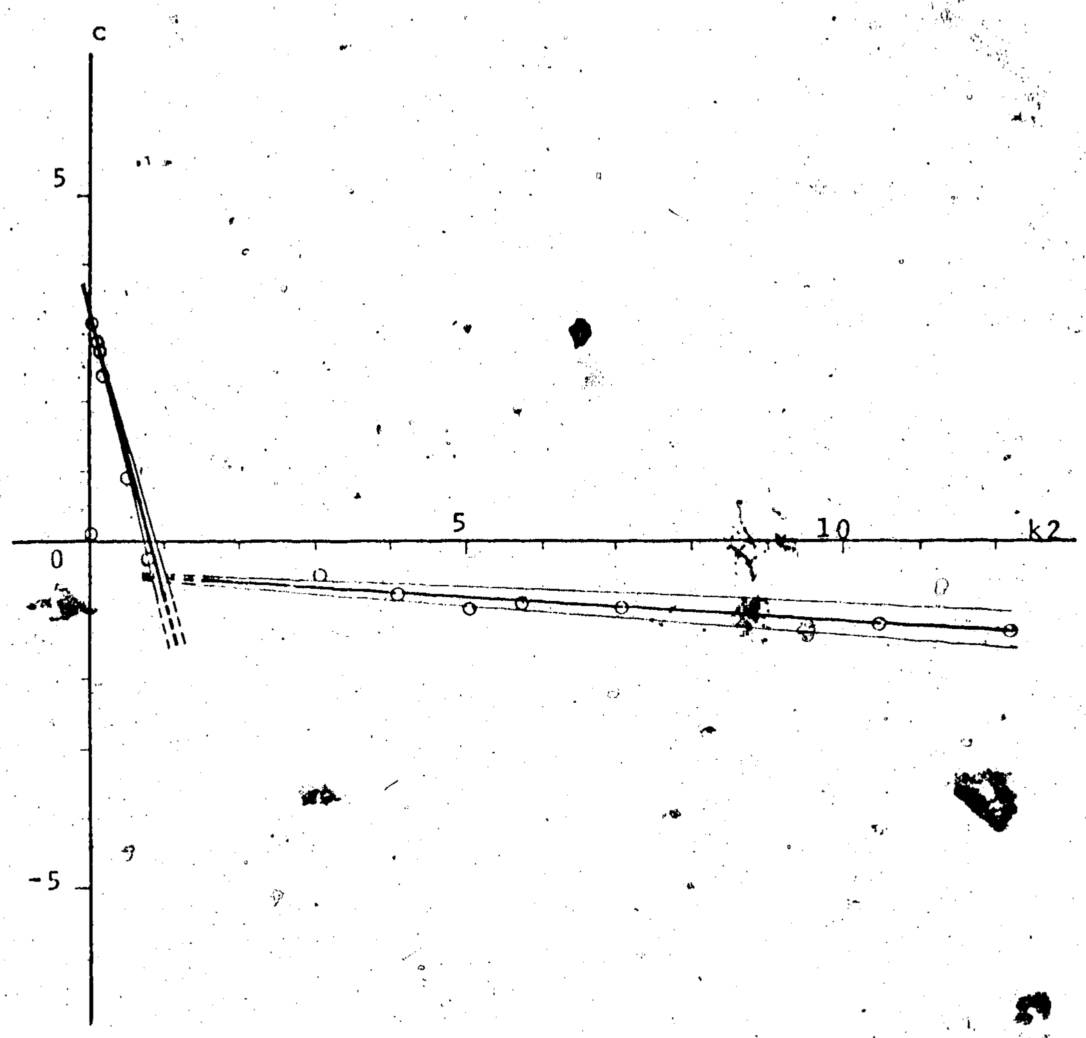

FIGURE 5-10

Kelowna (Data 4)

Correlation between c and k2

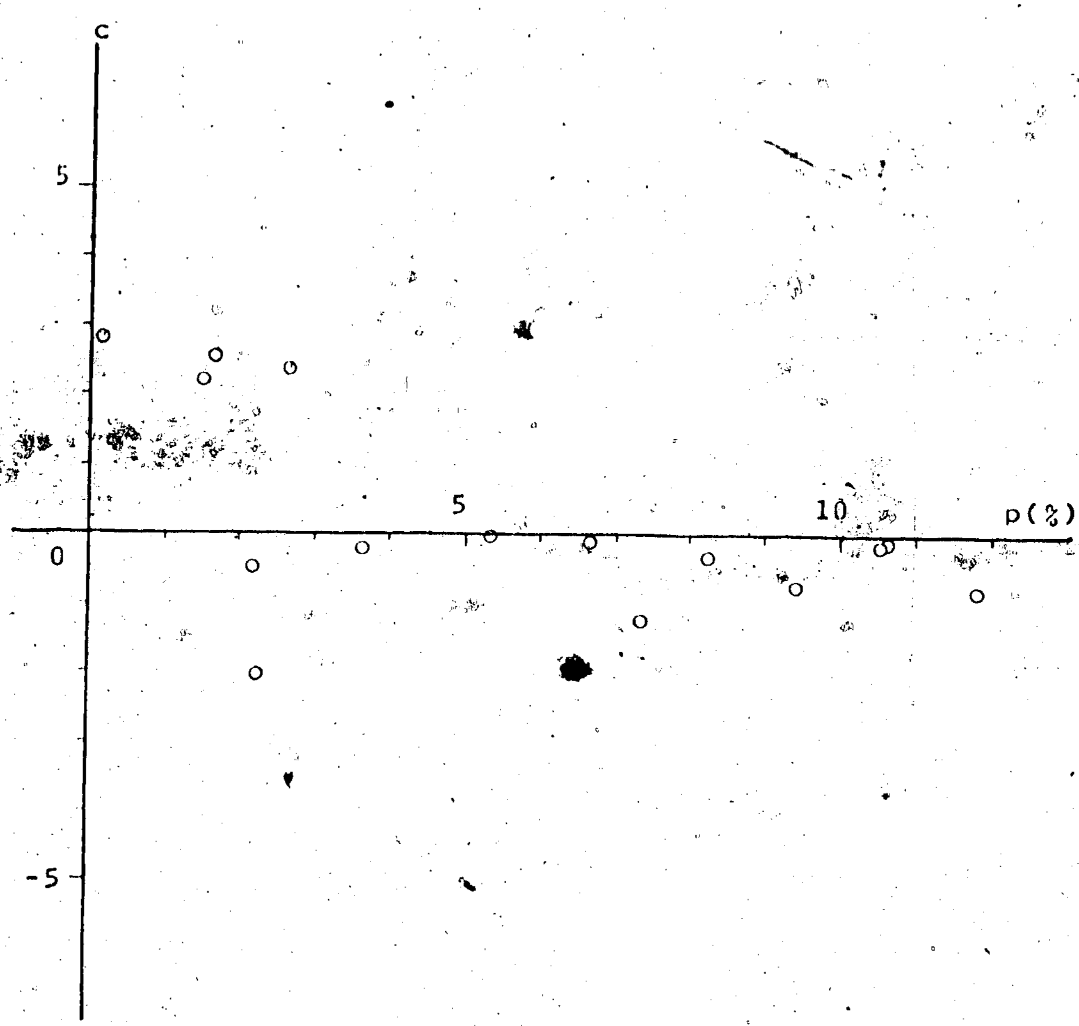

FIGURE 5-11

Prince George (Data 1)

Correlation between c and population (p)

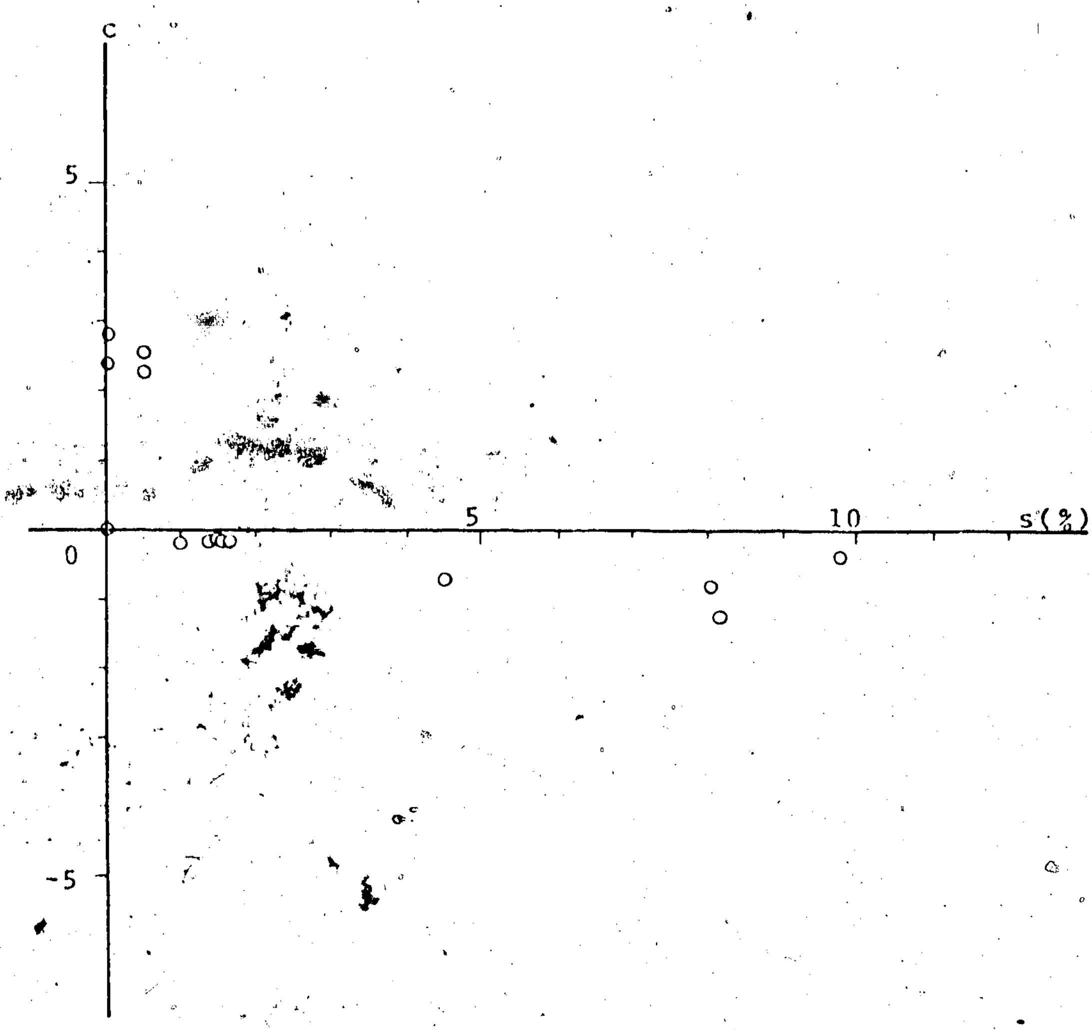

FIGURE 5-12

Prince George (Data 1)

Correlation between c and retail employment(s)

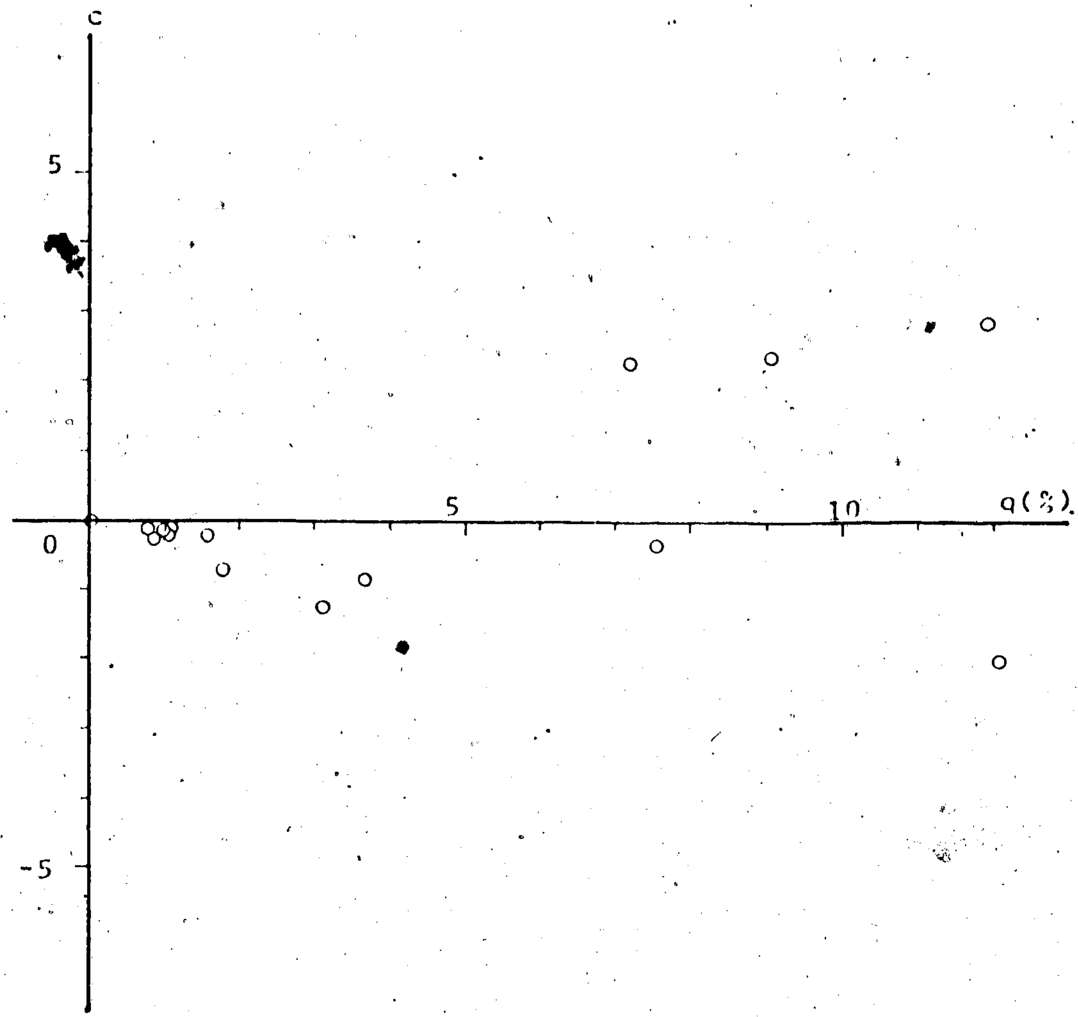

FIGURE 5-13

Prince George (Data 1)

Correlation between c and q

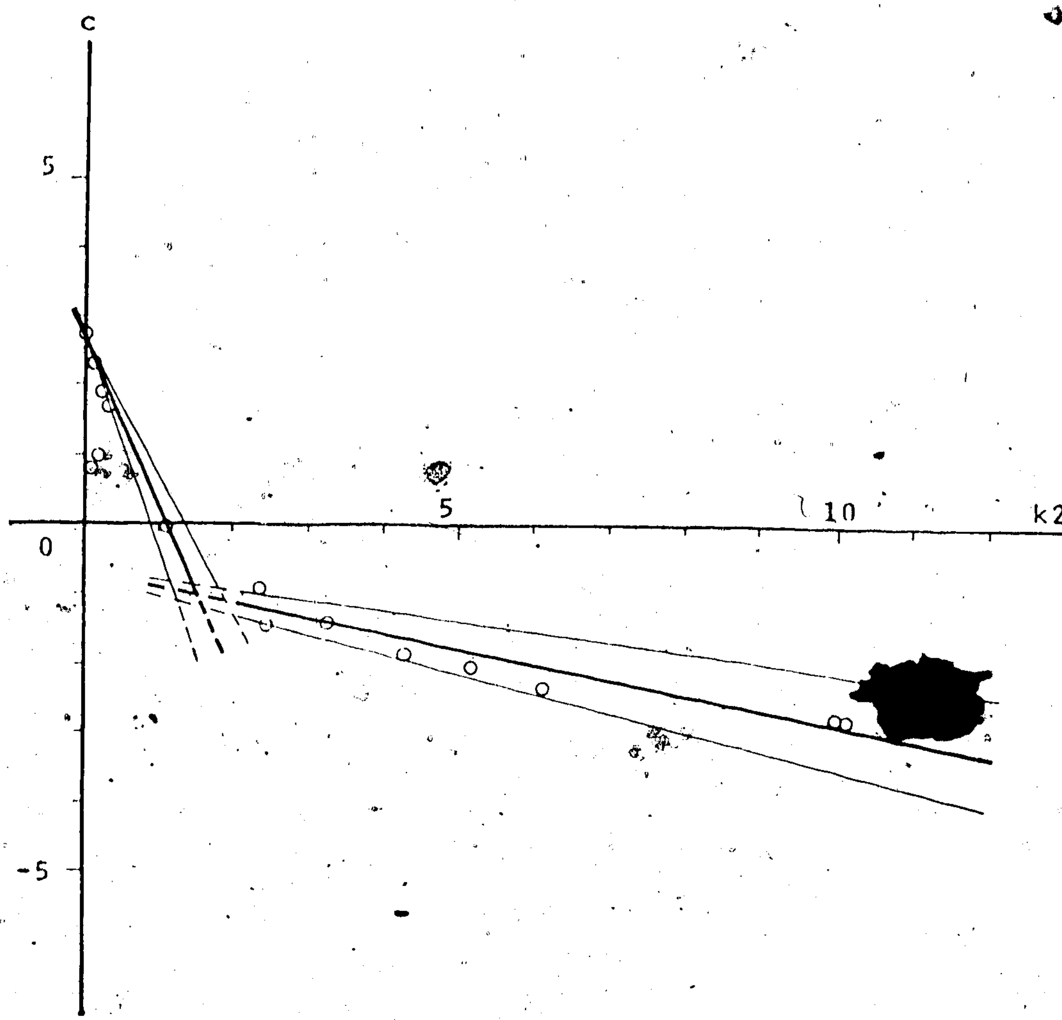

FIGURE 5-14

Prince George (Data 2)

Correlation between c and k2

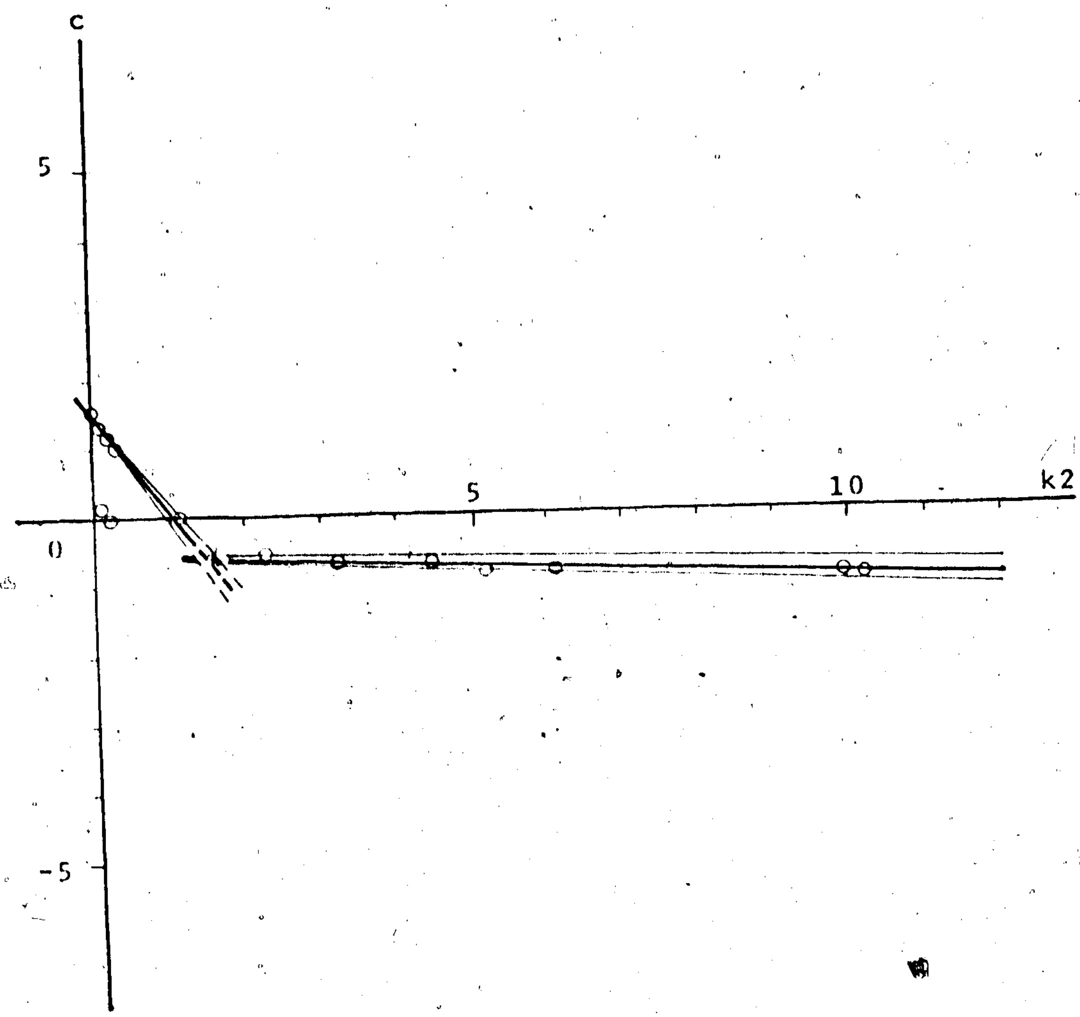

FIGURE 5-15

Prince George(Data 3)

Correlation between c and k2

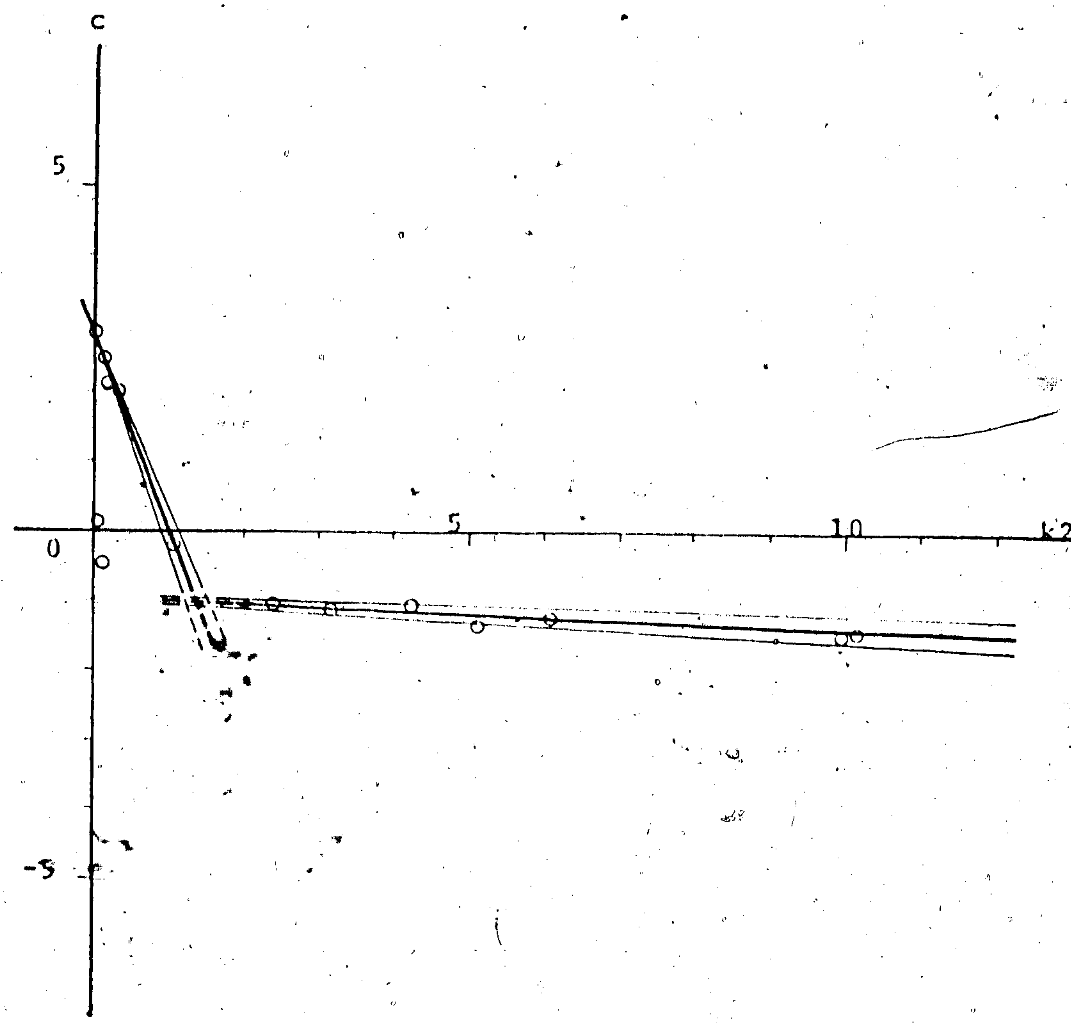

FIGURE 5-16

Prince George (Data 4)

Correlation between c and k2

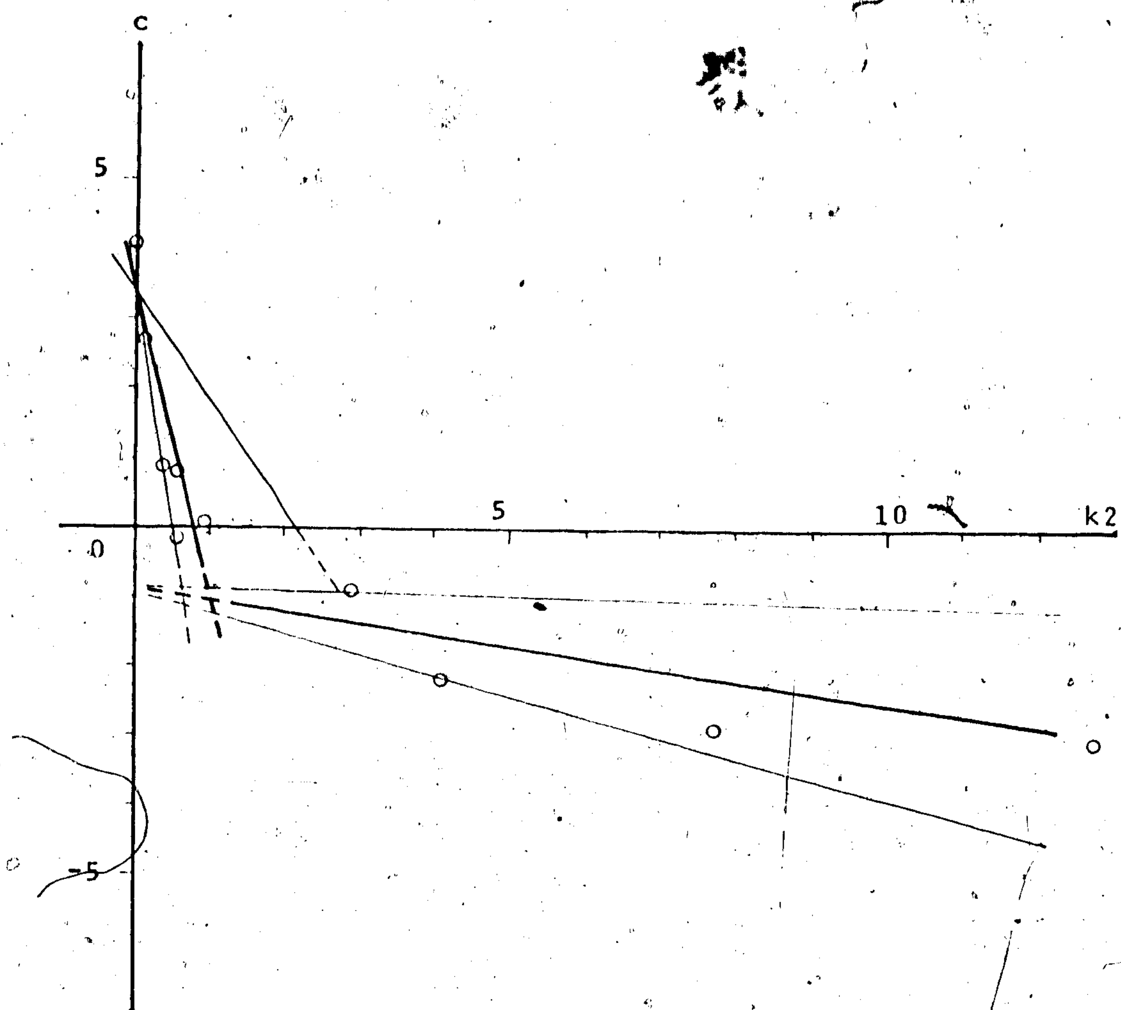

FIGURE 5-17

Fort McMurray (Data 2)

Correlation between c and k2

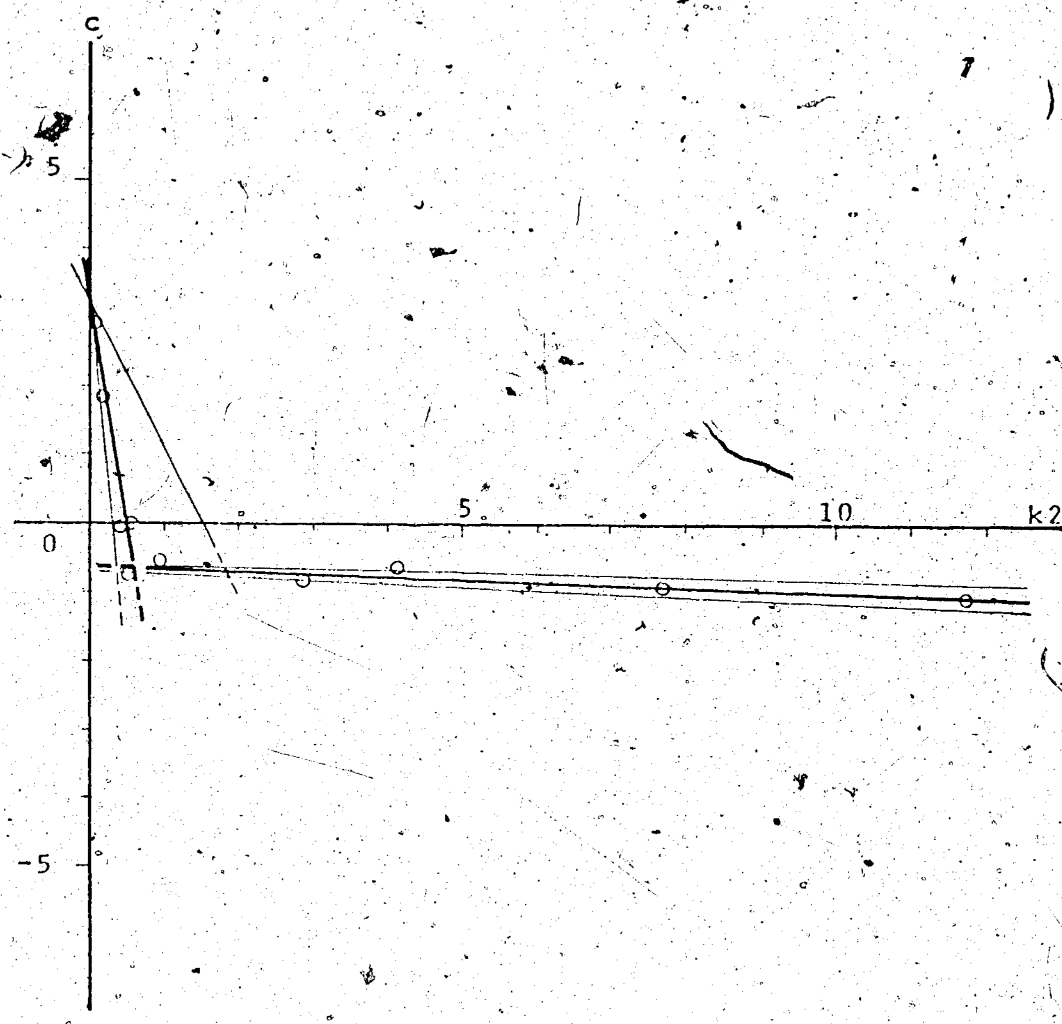

FIGURE 5-48

Fort McMurray (Data 3)

Correlation between c and k2

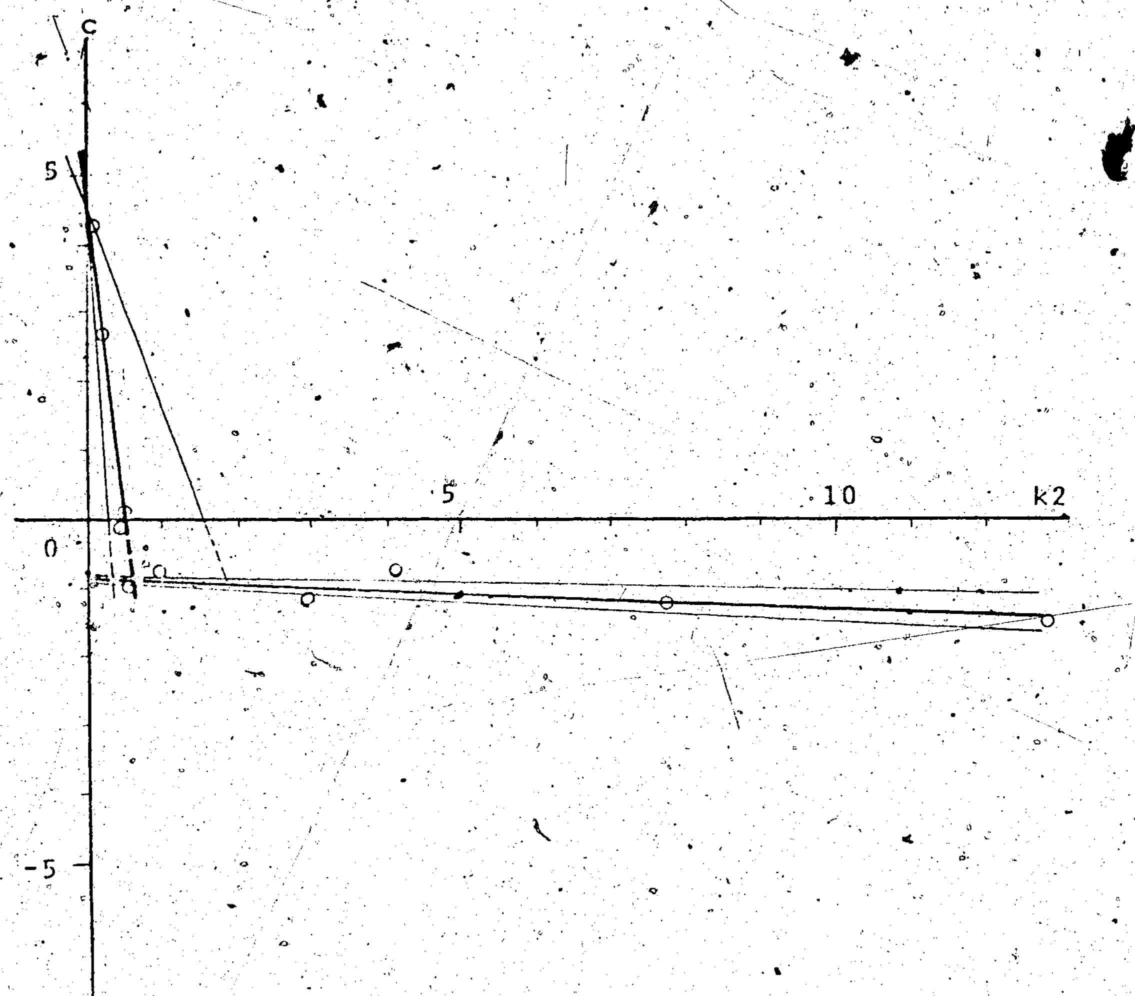

FIGURE 5-19

Fort McMurray (Data 4)

Correlation between c and k2

CHAPTER VI

CONCLUDING REMARKS

In this thesis, the sensitivity of the "Four purpose proportionate trip generation and distribution model" was examined by applying different trip purpose distributions to four small cities in Western Canada.

Four combinations of different trip purpose distributions were tested. Trip purpose ratios of (1) Home-Work and Home-Shop, (2) Home-Work and Home-Other, (3) Home-Work and Non-Home and (4) Home-Work, Home-Shop, and Home-Other were combined. In every combination, Home-Work trip ratio was always changed by 1% increment and the other ratios were decreased or increased accordingly.

Relating to the sensitivity of the "Four purpose proportionate trip generation and distribution model", the following concluding remarks emerge:

1. The first combination, Home-Work with Home-Shop, did not show a strong correlation between the sensitivity coefficients, c, and such zonal economic factors as population(p), employment(q), retail employment(s). Similarly the ratios between population and employment(k1 and k2) and ratios between population and retail employment(l1 and l2) did not show a significant correlation to this type of changes (Home-Work with Home-Shop). (Table 5-1,2,9,10,17,18,25,26) This is graphically shown in Figure 6-1 and Figure 6-2. However, it could be mentioned here that

those zones which have higher employment(ratio of zonal employment to total employment in the city) and lower population(ratio of zonal population to total population in the city) showed a larger sensitivity to changes than other zones. Such a zone as the Central Business District, or a zone with a shopping center or large retail employment revealed negative sensitivity, i.e. overestimating the Home-Work trip ratio will decrease the attractiveness of such a zone.

2. Combinations(2) Home-Work with Home-Other, (3) Home-Work with Non-Home and (4) Home-Work with Home-Shop and Home-Other trips, all indicated a strong correlation between the sensitivity coefficients, c, and the zonal economic factor of population/employment ratio(k2). Positive sensitivity i.e. resulting changes were in the same way as the errors, was obtained in those zones where the ratio of population/employment(k2) is small. The sensitivity of the zone to errors in trip distribution decreases drastically as this ratio increases until it becomes zero when the ratio of k2 is around 1.5. Then the sensitivity to the errors in trip purpose distribution decreases gradually and the sensitivity coefficient becomes negative for the zones with residential characteristics.

In Figure 6-4 for example, when k2 is greater than 2.0, the value of sensitivity coefficients, c, is between -0.5 and -1.0 in each city. This indicates that the increase of Home-Work trip ratio by 1% will yield only between 0.5% and 1.0% reduction in the attractiveness of the zones. Where the value of k2 is greater than 2.0 and the reduction rate is quite constant in this range. On the other hand, as k2 approaches 0.0, especially in the city of Fort McMurray, the value of sensitivity coefficients changes rapidly. The value of c in Fort McMurray when k2=0.0 is well over 3.0. This indicates that the increase of Home-Work trip ratio by 1% and corresponding decrease in Non-Home trip ratio will yield more than three times as much attractiveness in such a zone. Therefore, a 10% error in estimating Home-Work trip ratio would result in more than 30% error of the trips attracted to this zone. The city of Fort McMurray in Figure 6-5 shows that a 10% error in estimating Home-Work trip ratio would yield almost 45% error of the trips attracted to a zone where k2=0.0.

This tendency, however, was not observed in such a zone as the Central Business District or a zone with considerably higher zonal retail employment ratio to the total retail employment in the city. In those zones, the sensitivity to errors in estimating trip purpose distribution was far lower than in those zones that have similar ratios of k2 (population/employment) to the Central Business District.

3. A consistent tendency in terms of the sensitivity to errors in trip purpose distribution was observed in the small cities that were investigated in this study based on the "Four purpose proportionate trip

generation and distribution model" (Figure 6-3, Figure 6-4, Figure 6-5), except for the first combination (Home-Work with Home-Shop) as is shown in Figure 6-1 and Figure 6-2.

4. It is recommended that the relationship between sensitivity coefficients and some other factors which show the characteristics of the zones, such as the ratio of retail employment/employment be investigated.

5.- It is also recommended that the verification of the model against a real Origin-Destination survey for Western Canadian cities be performed.

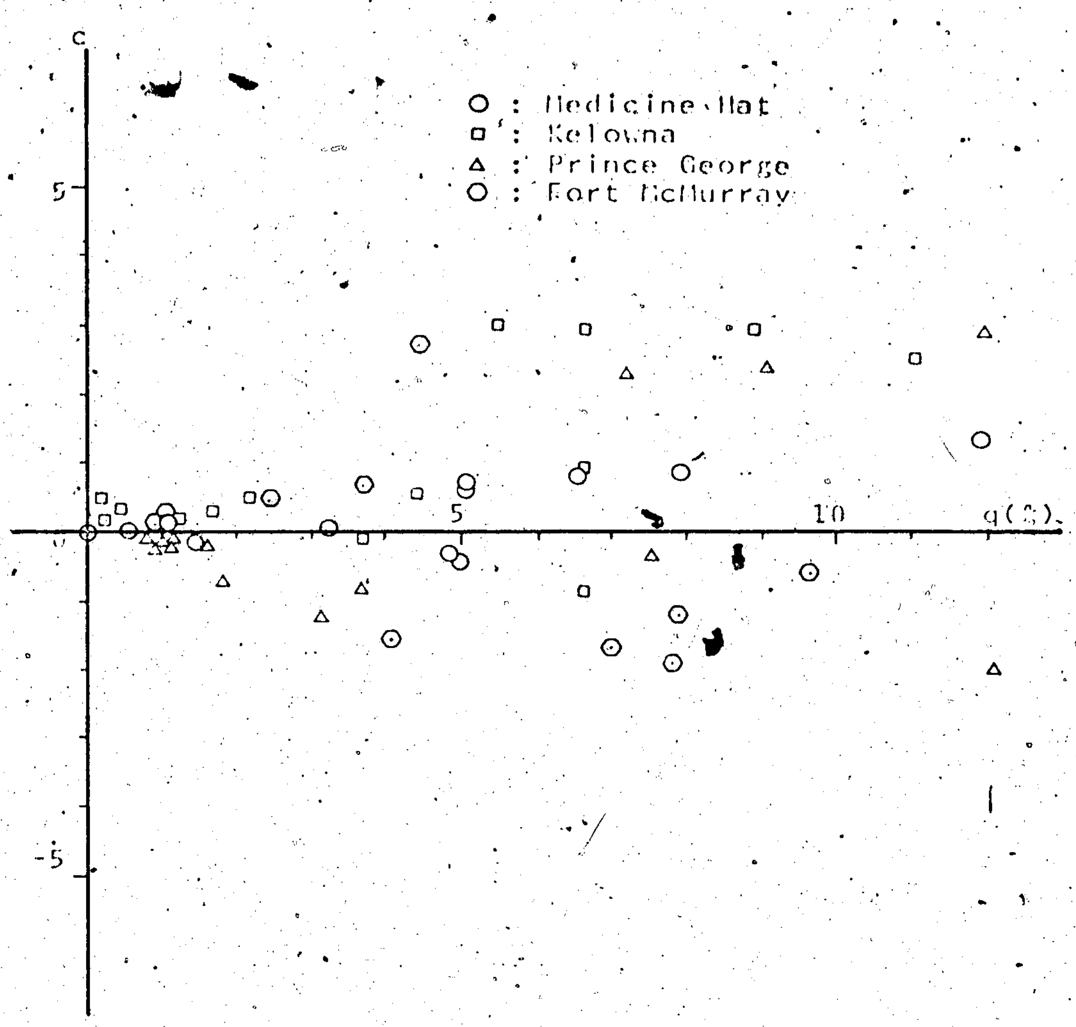

Figure 6-1

Comparison of the results (Data 1)

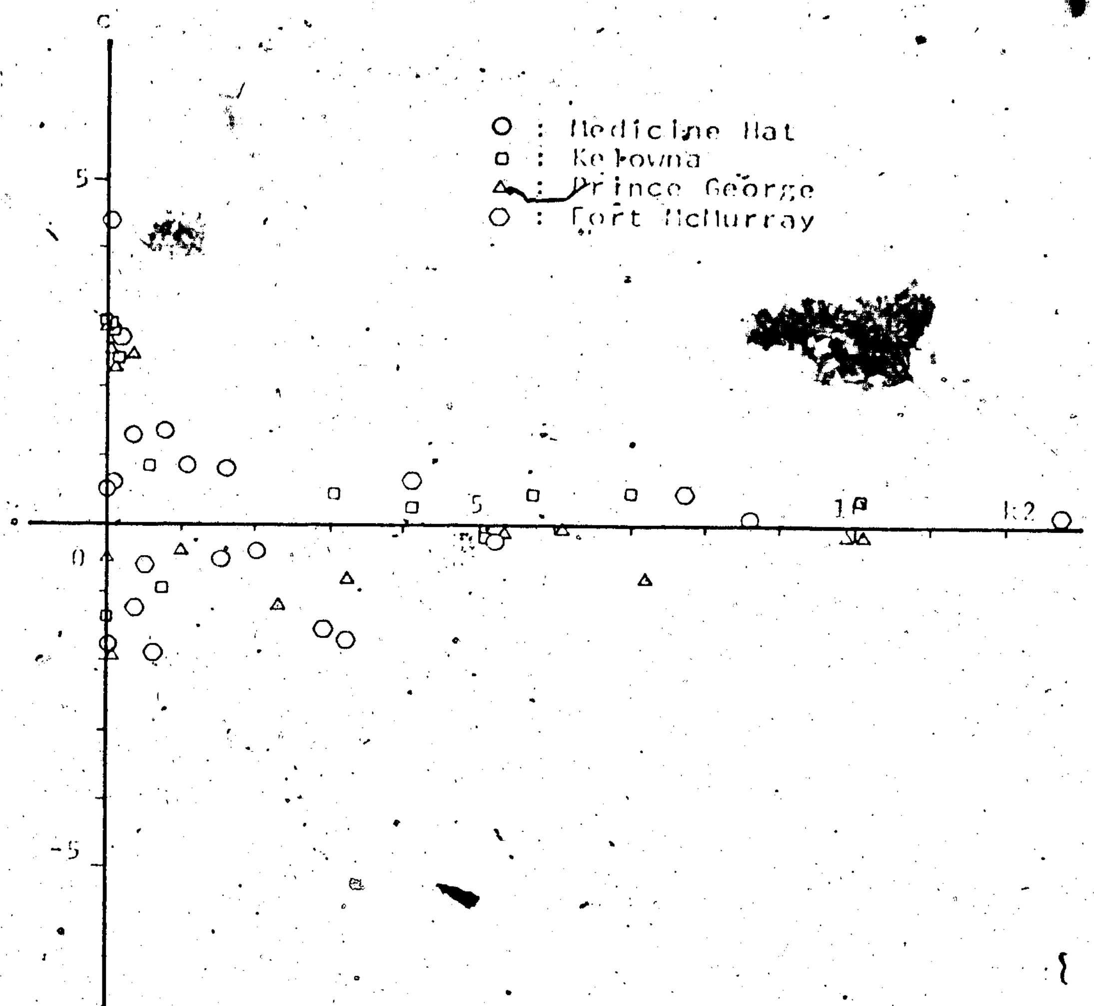

Figure 6-2

Comparison of the results(Data 1)

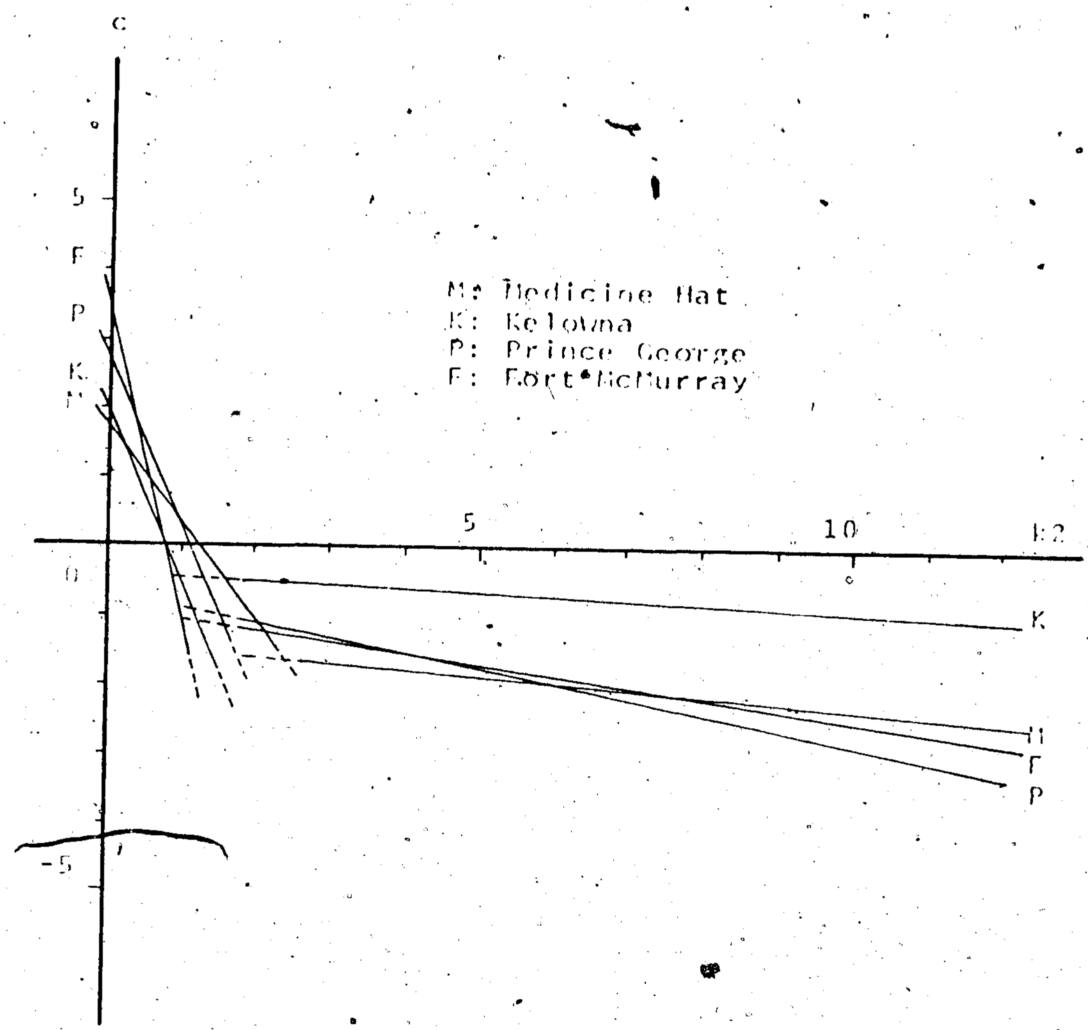

Figure 6-3

Comparison of the results (Data 2)

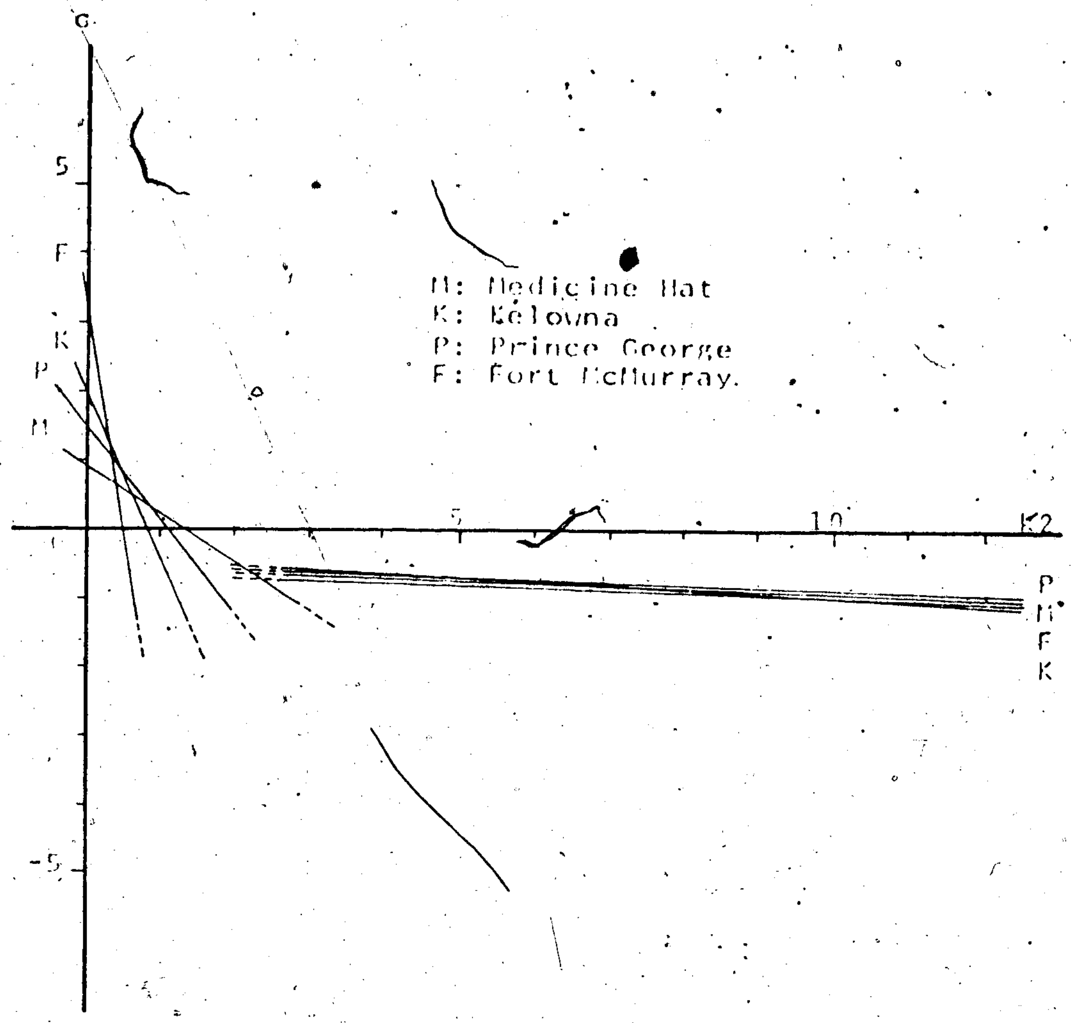

Figure 6-4

Comparison of the results(Data 3)

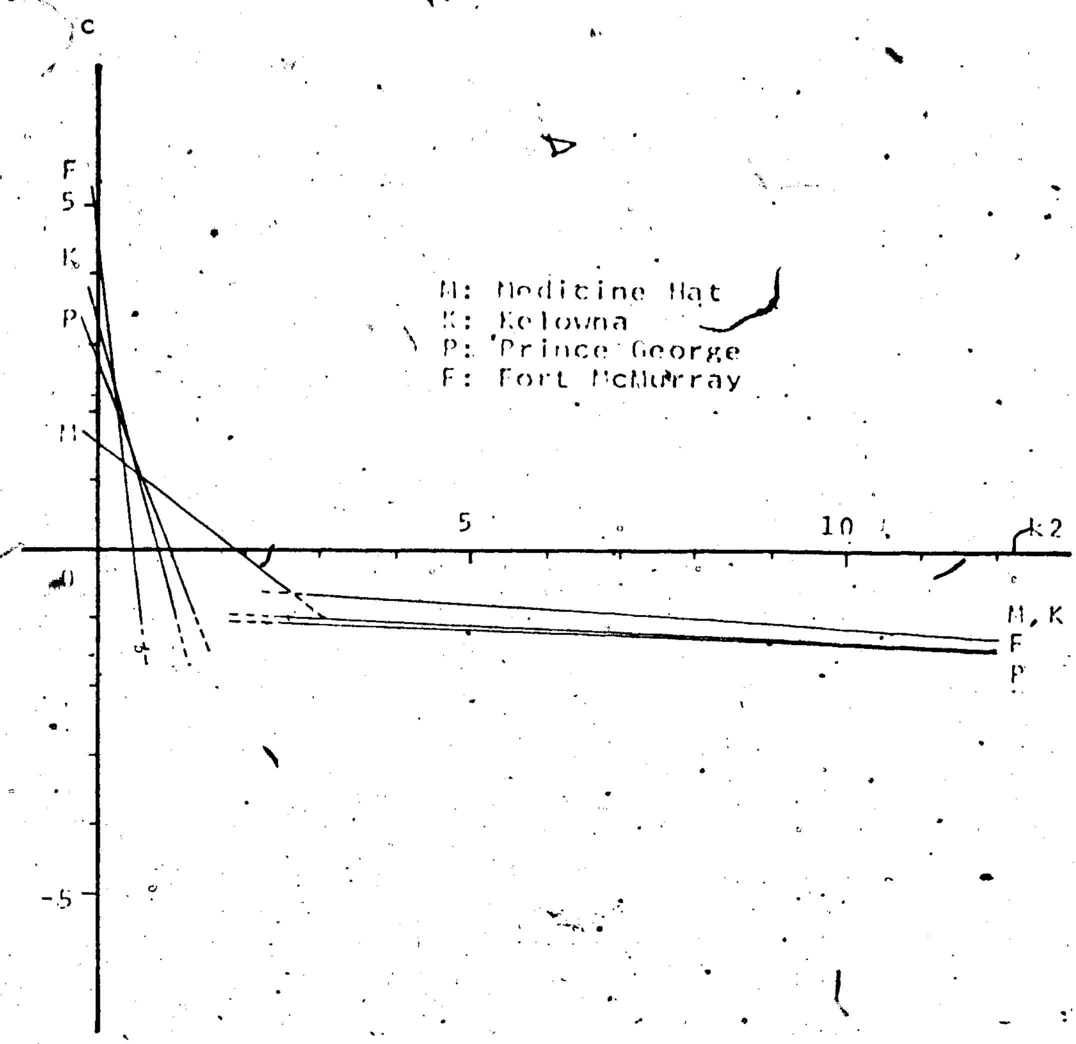

Figure 6-5

Comparison of the results (Data 4)

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APPENDIX A

LISTING OF PROGRAM

Description

This synthetic trip generation and distribution model, as we call it a "Four purpose proportionate trip generation and distribution model" will compute whole day trips generated between zones in the city at issue. The number of zone is limited to 30 and the results will be output in the formatted form of origin-destination table including all the input data which are shown in Figure A-2. The flowchart of the program is given in Figure A-1.

Input Cards

The notation 'c' refers to card columns, with the range of columns being inclusive. All the input data must be given in 'real' numbers with a decimal point as a part of the value.

Data Cards

1-4 c 1-10 population in zone 1
c 11-20 population in zone 2
etc. FORMAT(8F10.0)

5-8 c 1-10 employment in zone 1
c 11-20 employment in zone 2
etc. FORMAT(8F10.0)

9-12 c 1-10 retail employment in zone 1
c 11-20 retail employment in zone 2
etc. FORMAT(8F10.0)

13 c 1-10 person trips per capita per day

c 11-20 masstransit ridership(ex. 0.05)

c 21-30 vehicle occupancy rate

FORMAT(3F10.3)

14 c 1-10 home based work trip rate

c 11-20 home based shopping trip rate

c 21-30 home based other trip rate

c 31-40 non home based trip rate

FORMAT(4F10.3)

15 c 1-10 any number that is less than 0.0

(ex. -1.0)

FORMAT(F10.3)

<u>Example Calculation</u>

Example calculation is shown in Figure A-2 using the data from Medicine Hat.

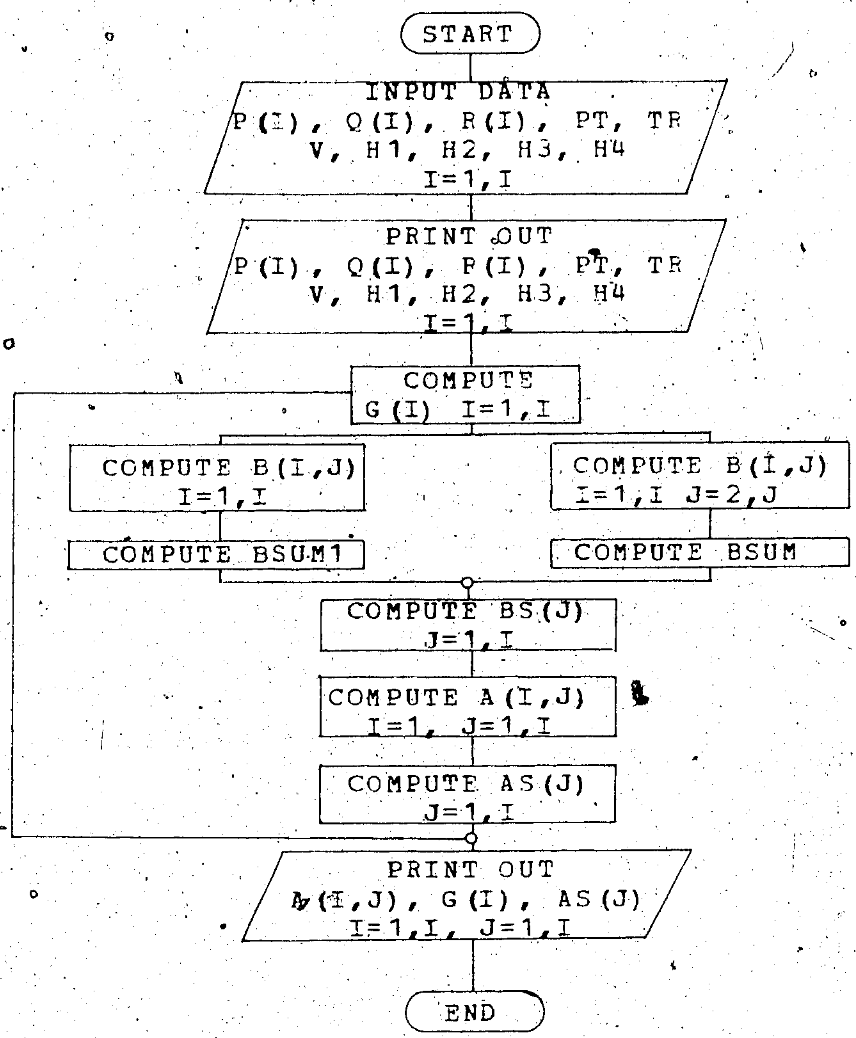

FIGURE A-1
Flowchart of the program

```
$SIGNON KOND PRINT=IN
JOB-TYPE=BATCH, PRIO=NORMAL, CLASS=INTERNAL/TEACHING,RESEARCH
**LAST SIGNON WAS: 19:18:04
 USER "KOND" SIGNED ON AT: 22:18:41 ON TUE MAR 23/76
$LIST PROG
C       DESCRIPTION OF THE PROGRAM***SMALL CITIES TRAFFIC ESTIMATION
C
C
C
C
C
C       THE CITY WAS DIVIDED INTO ZONES(I). THE FOLLOWING PROPORTIONATE MODELS
C       HAVE BEEN USED.
C
C       A)  HOME-WORK TRIPS WERE DISTRIBUTED PROPORTIONATELY TO THE NUMBER OF
C       EMPLOYEES IN A ZONE.
C
C       B)  HOME-SHOP TRIPS WERE DISTRIBUTED PROPORTIONATELY TO THE NUMBER OF
C       RETAIL EMPLOYEES IN A ZONE.
C
C       C)  HOME-OTHER TRIPS WERE DISTRIBUTED ON A BASIS OF 10% TO THE CBD FOR
C       SOCIAL-RECREATIONAL TRIPS AND THE REMAINDER TO THE OTHER ZONES BASED ON
C       ZONAL POPULATION.
C
C       D)  NON-HOME BASED TRIPS WERE ASSUMED TO BE EVENLY DISTRIBUTED IN PRO-
C       PORTION TO THE EXISTING NUMBER OF TRIPS ASSIGNED TO A ZONE.
C
C
C
C*************************************************************************
C       INPUT DATA ARE AS FOLLOWS,
C       P(I):  POPULATION OF ZONE I
C       Q(I):  TOTAL EMPLOYMENT OF ZONE I
C       R(I):  RETAIL EMPLOYMENT OF ZONE I
C       PT  :  PERSON TRIPS PER DAY BASED ON POPULATION
C       TP  :  TRANSIT RIDERSHIP
C       V   :  VEHICLE OCCUPANCY RATE
C       H1  :  HOME-WORK TRIP RATE
C       H2  :  HOME-SHOPPING TRIP RATE
C       H3  :  HOME-OTHER TRIP RATE
C       H4  :  NON HOME BASED TRIP RATE
C*************************************************************************
C
C
      DIMENSION P(30), Q(30), R(30), S(30), A(30,30), B(30,30), AS(30),
     1BS(30)
      READ(5,500) (P(I), I=1,30)
      READ(5,500) (Q(I), I=1,30)
      READ(5,500) (R(I), I=1,30)
      READ(5, 501) PT, TP, V
  999 READ(5,502) H1, H2, H3, H4
      IF(H1.LT.0.) GO TO 1000
  500 FORMAT(5F10.0)
  501 FORMAT(3F10.3)
  502 FORMAT(4F10.3)
      WRITE(6,600) (P(I), I=1,30)
  600 FORMAT(5F10.0)
      WRITE(6,601) (Q(I), I=1,30)
  601 FORMAT(5F10.0)
      WRITE(6,602) (R(I), I=1,30)
```

FIGURE A-2

List of program & example calculation

```
  602 FORMAT(8F10.0)
      WRITE(6,603) PT, TR, V
      WRITE(6,604) H1, H2, H3, H4
  603 FORMAT(//32HPERSON TRIP PER DAY          =, F5.0// 23HTRANSIT RIDERSHIP
     1    =, F5.2/, 23HVEHICLE OCCUPANCY RATE=, F5.2//)
  604 FORMAT(14HHOME-WORK     =, F5.3/, 14HHOME-SHOPPING=, F5.3/, 14HHOME
     1-OTHERS   =, F5.3/, 14HNON-HOME TRIP=, F5.3)
C
C
C     TRIP PRODUCTION FROM ZONE I
C
C
      DO 5 I=1,30
    5 G(I)=0.0
      DO 10 I=1,30
   10 G(I)=P(I)*PT*(15.-TR*(15.-V))/(15.*V)
      PSUM=0.0
      QSUM=0.0
      RSUM=0.0
      DO 15 I=1,30
   15 PSUM=PSUM+P(I)
      DO 20 I=1,30
   20 QSUM=QSUM+Q(I)
      DO 25 I=1,30
   25 RSUM=RSUM+R(I)
      WRITE(6,605) PSUM, QSUM, RSUM
  605 FORMAT(/5HPSUM=, F10.0/, 5HQSUM=, F10.0/, 5HRSUM=, F10.0/)
C
C
C     DISTRIBUTING HOME-WORK, HOME-SHOPPING, HOME-OTHER TRIPS TO CENTRAL
C     BUSINESS DISTRICT
C
C
      DO 30 I=1,30
   30 B(I,1)=G(I)*H1*Q(1)/QSUM+G(I)*H2*R(1)/RSUM+0.1*H3*G(I)
      BSUM1=0.0
      DO 35 I=1,30
   35 BSUM1=BSUM1+B(I,1)
      WRITE(6,606) BSUM1
  606 FORMAT(6HBSUM1=, F9.0)
C
C
C     DISTRIBUTING HOME-WORK, HOME-SHOPPING, HOME-OTHER TRIPS TO OTHER ZONES
C
C
      DO 40 I=1,30
      DO 40 J=2,30
   40 B(I,J)=G(I)*H1*Q(J)/QSUM+G(I)*H2*R(J)/RSUM+0.9*G(I)*H3*P(J)/(PSUM-
     1P(1))
      BSUM=0.0
      DO 45 I=1,30
      DO 45 J=2,30
   45 BSUM=BSUM+B(I,J)
      WRITE(6,607) BSUM
  607 FORMAT(5HBSUM=, F10.0)
      DO 50 J=1,30
   50 BS(J)=0.0
      DO 55 I=1,30
      DO 55 J=1,30
   55 BS(J)=BS(J)+B(I,J)
```

FIGURE A-2

```
      C
      C
      C     OBTAINING FINAL O-D MATRIX INCLUDING NON-HOME BASED TRIPS
      C
      C
            DO 60 I=1,30
            DO 60 J=1,30
         60 A(I,J)=B(I,J)+G(I)*HH*DS(J)/(DSUM1+DSUM)
            DO 65 J=1,30
         65 AS(J)=0.0
            DO 70 I=1,30
            DO 70 J=1,30
         70 AS(J)=AS(J)+A(I,J)
            TOTAL=0.0
            DO 75 J=1,30
         75 TOTAL=TOTAL+AS(J)
            WRITE(6,608) (J,J=1,16)
        608 FORMAT(1H1, 5X, 16(I3, 4X)//)
            WRITE(6,609) ((I), (A(I,J), J=1,16), I=1,16)
        609 FORMAT(2X, I2, 16F7.0//)
            WRITE(6,610) (J, J=17,30)
        610 FORMAT(1H1, 5X, 14(I3, 4X)//)
            WRITE(6,611) ((I), (A(I,J), J=17,30), (G(I)), I=1,16)
        611 FORMAT(2X, I2, 14F7.0, F8.0//)
            WRITE(6,612) (J,J=1,16)
        612 FORMAT(1H1, 5X, 16(I3, 4X)//)
            WRITE(6,613) ((I), (A(I,J), J=1,16), I=17,30)
        613 FORMAT(2X, I2, 16F7.0//)
            WRITE(6,614) (AS(J), J=1,16)
        614 FORMAT(4X, 16F7.0)
            WRITE(6,615) (J,J=17,30)
        615 FORMAT(1H1, 5X, 14(I3, 4X)//)
            WRITE(6,616) ((I), (A(I,J), J=17,30), (G(I)), I=17,30)
        616 FORMAT(2X, I2, 14F7.0, F8.0//)
            WRITE(6,617) (AS(J), J=17,30), TOTAL
        617 FORMAT(4X, 14F7.0, F8.0)
            GO TO 900
       1000 CONTINUE
            STOP
            END
END OF FILE
```

FIGURE A-2

$RUN PROGO
22:18:42

250.	2194.	2024.	200.	40.	2649.	2717.	2019.
1190.	2970.	0.	2813.	2118.	3436.	0.	500.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.		
2012.	593.	376.	376.	376.	368.	68.	490.
892.	1488.	0.	44.	114.	245.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.		
755.	39.	87.	40.	44.	81.	10.	25.
50.	50.	0.	6.	26.	38.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.		

PERSON TRIP PER DAY = 2.60
TRANSIT RIDERSHIP = 0.25
VEHICLE OCCUPANCY RATE= 1.50

HOME-WORK =0.370
HOME-SHOPPING=0.130
HOME-OTHERS =0.280
NON-HOME TRIP=0.220

PSUM= 26920.
OSUM= 7462.
PSUM= 1250.

BSUM1= 9192.
BSUM= 25565.

FIGURE A-2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	109.	29.	25.	13.	13.	27.	16.	28.	32.	62.	2.	16.	15.	26.	0.	3.
2	960.	252.	218.	115.	110.	241.	145.	249.	283.	542.	0.	137.	133.	226.	0.	22.
3	886.	232.	201.	106.	101.	222.	133.	230.	261.	500.	0.	126.	122.	209.	0.	20.
4	88.	23.	20.	10.	10.	22.	13.	23.	26.	49.	0.	12.	12.	21.	0.	22.
5	18.	5.	4.	2.	2.	4.	3.	5.	5.	10.	0.	2.	2.	4.	0.	0.
6	1160.	304.	263.	139.	133.	291.	175.	301.	341.	655.	0.	165.	159.	272.	0.	27.
7	1189.	312.	270.	142.	136.	298.	179.	309.	350.	672.	0.	169.	164.	280.	0.	27.
8	1234.	324.	280.	148.	141.	309.	186.	320.	363.	697.	0.	176.	170.	291.	0.	28.
9	521.	137.	118.	62.	60.	131.	78.	135.	153.	294.	0.	74.	72.	123.	0.	12.
10	1736.	456.	394.	208.	199.	436.	262.	451.	511.	981.	0.	248.	239.	409.	0.	40.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	1231.	323.	279.	147.	141.	309.	186.	320.	362.	695.	0.	175.	169.	293.	0.	26.
13	927.	243.	210.	111.	136.	232.	140.	241.	273.	524.	0.	132.	128.	218.	0.	21.
14	1594.	394.	341.	180.	172.	377.	227.	390.	442.	849.	0.	214.	207.	354.	0.	34.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	219.	57.	50.	26.	25.	55.	33.	57.	64.	124.	0.	31.	30.	52.	0.	5.

FIGURE A-2

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	414.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3532.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3350.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	331.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	65.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4365.
7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4498.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4660.
9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1970.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	6572.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4655.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3506.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	5656.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	828.

FIGURE A-2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	11785.	3093.	2675.	1411.	1346.	2954.	1775.	3058.	3466.	6655.	[illegible]	[illegible]	[illegible]	2775.	0.	270.

FIGURE A-2

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	**302.

22:18:43 .127 RC=0

FIGURE A-2

APPENDIX B

Zone No.	Coefficient	p (%)	q (%)	s (%)
1	-1.6200	0.919	26.962	60.400
3	-0.4067	7.519	5.039	6.960
6	-0.2996	9.840	4.932	6.480
13	-0.1972	7.861	1.528	2.080
16	0.0000	1.857	0.000	0.000
12	0.0399	10.449	0.590	0.480
14	0.0498	12.764	3.283	3.040
7	0.1233	10.093	1.179	0.800
5	0.6438	0.149	5.039	3.520
4	0.7438	0.743	5.039	3.200
8	0.8492	10.472	6.567	2.000
2	0.8912	8.150	7.947	3.040
9	1.3111	4.421	11.954	4.000
10	1.3679	14.746	19.941	4.000

TABLE 5-1

Medicine Hat -- Data1

*Correlation between coefficients, c (between x and y), and p (population), q (employment) or s (retail employment) in %.

Zone No.	Coefficient	k1	k2	l1	l2
1	-1.6200	0.124	0.034	0.331	0.015
3	-0.4067	5.383	1.492	23.264	1.080
6	-0.2996	7.198	1.996	32.704	1.519
13	-0.1972	18.518	5.144	81.192	2.811
16	0.0[illegible]	---	---	---	---
12	0.0399	63.932	17.712	486.833	21.771
14	0.0498	12.024	3.890	90.421	4.197
7	0.1233	30.875	8.551	271.700	26.125
5	0.6438	0.106	0.030	0.909	0.043
4	0.7438	0.532	0.147	5.000	0.231
8	0.8492	5.753	1.594	112.760	5.235
2	0.8912	3.700	1.025	57.737	1.025
9	1.3141	1.334	0.370	23.800	1.105
1[illegible]	1.3679	2.668	0.74[illegible]	79.400	3.688

TABLE 5-2

Medicine Hat -- Data1

Correlation between coefficients, c(between x and y), and k1(the ratio of the population to the employment in real number), k2(in %), l1(the ratio of the population to the retail employment in real number), or l2(in %).

Zone No.	Coefficient	p (%)	q (%)	s (%)
16	-3.5586	1.857	0.000	0.000
12	-3.0295	10.449	0.590	0.480
7	-2.5736	10.093	1.179	0.800
13	-2.0016	7.868	1.528	2.080
14	1.7114	12.764	3.283	3.040
6	-0.9745	9.840	4.932	6.480
8	-0.5489	10.472	6.567	2.600
3	-0.3804	7.519	5.039	6.960
2	0.1003	8.150	7.947	3.040
10	0.5613	14.746	19.941	4.000
1	0.8225	0.929	26.962	60.400
9	1.3080	4.421	11.954	4.000
4	1.7718	0.743	5.039	3.200
5	2.0770	0.149	5.039	3.520

TABLE 5-3

Medicine Hat -- Data2

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
16	-3.5586	---	---	---	---
12	-3.0295	63.932	17.712	468.833	21.771
7	-2.5736	30.875	8.551	271.700	126.175
13	-2.0016	18.518	5.144	81.192	2.811
14	-1.7114	12.024	3.890	90.421	4.197
6	0.7745	7.198	1.996	32.704	1.519
8	0.5489	5.753	1.594	112.760	5.235
3	0.3804	5.383	1.492	23.264	1.080
2	0.1003	3.700	1.052	57.737	1.025
10	0.5613	2.668	0.740	79.40[illegible]	3.688
1	0.8225	0.124	0.034	0.[illegible]1	0.015
9	1.3080	1.334	0.370	23.80[illegible]	1.105
4	1.7718	0.532	0.147	5.000	0.231
5	2.0770	0.106	0.030	0.909	0.043

TABLE 5-4

Medicine Hat -- Data2

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
16	-1.3568	1.857	0.000	0.000
12	-1.1433	10.449	0.590	0.480
7	-0.9564	10.093	1.179	0.800
13	-0.7843	7.868	1.528	2.080
14	0.6402	12.764	3.283	3.040
6	0.3459	9.840	4.932	6.480
3	0.2164	7.519	5.039	6.960
8	0.0576	10.472	6.567	2.000
1	0.0273	0.929	26.962	60.400
2	0.1994	8.150	7.947	3.040
10	0.4544	14.746	19.941	4.000
9	0.7268	4.421	11.954	4.000
4	0.8042	0.743	5.039	3.200
5	0.9323	0.149	5.039	3.520

TABLE 5-5

Medicine Hat -- Data3

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
16	-1.3568	---	---	---	---
12	-1.1433	63.932	17.712	468.833	21.771
7	-0.9564	30.875	8.551	271.700	126.125
11	-0.7843	18.518	5.144	81.192	2.811
14	-0.6402	12.024	3.890	90.421	4.197
6	-0.3459	7.198	1.996	32.704	1.519
3	-0.2164	5.383	1.492	23.264	1.080
8	-0.0576	5.753	1.594	112.760	5.235
1	0.0273	0.124	0.034	0.331	0.015
2	0.1994	3.700	1.025	57.737	1.025
10	0.4544	2.668	0.740	79.400	3.688
9	0.7268	1.334	0.370	23.800	1.105
4	0.8042	0.532	0.147	5.000	0.231
15	0.9323	0.106	0.030	0.909	0.043

TABLE 5-6

Medicine Hat -- Data3

Correlation between coefficients, c, and k1, k2, l1, or l2.

Zone No.	Coefficient	p(%)	q(%)	s(%)
15	-1.8050	1.857	0.000	0.000
12	-1.4944	10.449	0.590	0.480
7	-1.2258	10.093	1.179	0.800
13	-1.0893	7.868	1.528	2.080
14	-0.8303	12.764	3.283	3.040
6	-0.5367	9.840	4.932	6.480
1	-0.3989	0.929	26.962	60.400
3	-0.3970	7.519	5.039	6.960
8	0.1512	10.472	6.567	2.000
2	0.5039	8.150	7.947	3.040
10	0.9656	14.746	19.941	4.000
4	1.2551	0.743	5.039	3.200
9	1.3088	4.421	11.954	4.000
5	1.3596	0.149	5.039	3.520

TABLE 5-7

Medicine Hat -- Data4

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
16	-1.8050	---	---	---	---
12	-1.4944	63.932	17.712	468.833	21.771
7	-1.2258	30.875	8.551	271.700	126.125
13	-1.0893	18.518	5.144	81.192	2.811
14	-0.8303	12.024	3.890	90.421	4.197
6	-0.5367	7.198	1.996	32.704	1.519
1	-0.3989	0.124	0.034	0.331	0.015
3	-0.3970	5.383	1.492	23.264	1.080
8	0.1525	5.753	1.594	112.760	5.235
2	0.5039	3.700	1.025	57.737	1.025
10	0.9656	2.668	0.740	79.400	3.688
4	1.2551	0.532	0.147	5.000	0.231
9	1.3088	1.334	0.370	23.800	1.105
5	1.3596	0.106	0.030	0.909	0.043

TABLE 5-8

Medicine Hat -- Data1

Correlation between coefficients, c, and k1, k2, l1, or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
1	-1.3222	3.11	41.28	77.07
11	-0.8822	5.13	6.61	11.13
13	-0.1265	13.97	2.75	3.42
14	0.0000	8.38	0.06	0.[illegible]
15	0.1647	6.24	0.39	0.07
6	0.1878	14.73	1.21	0.34
10	0.2665	7.17	1.76	1.03
4	0.3002	5.74	0.55	0.00
9	0.4290	12.62	2.20	0.34
16	0.4400	1.55	0.22	0.00
7	0.4971	13.30	4.41	1.71
8	0.8913	3.80	6.61	3.42
2	2.4632	2.07	11.01	1.03
3	2.9328	0.94	6.61	0.00
5	2.9635	1.16	8.81	0.00
12	2.9852	0.09	5.51	0.34

TABLE 5-9

Kelowna -- Data1

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
1	-1.3222	0.161	0.075	0.268	0.040
11	-0.8822	1.658	0.776	3.062	0.461
13	-0.1265	10.824	5.080	27.060	4.085
14	0.0000	324.800	139.667	541.333	83.800
15	0.1647	34.543	16.000	604.500	89.143
6	0.1878	25.945	12.174	285.400	43.324
10	0.2665	8.681	4.074	46.300	6.961
4	0.3002	22.260	10.436	---	---
9	0.4290	12.225	5.736	244.500	37.118
16	0.4400	15.050	7.046	---	---
7	0.4971	6.440	3.014	51.520	7.772
8	0.8913	1.227	0.575	7.360	1.111
2	2.4632	0.401	0.188	13.367	2.010
3	2.9328	0.305	0.142	---	---
5	2.9635	0.281	0.132	---	---
12	2.9852	0.034	0.016	1.700	0.265

TABLE 5-10.

Kelowna -- Data1

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
14	-3.1573	8.38	0.06	0.10
15	-2.8085	6.24	0.39	0.07
6	-2.6785	14.73	1.21	0.34
4	-2.6351	5.74	0.55	0.00
16	-2.3745	1.55	0.22	0.00
9	-2.1946	12.62	2.20	0.34
13	-1.9069	13.97	2.75	3.42
10	-1.7840	7.17	1.76	1.03
7	-1.4720	13.30	4.41	1.71
11	0.3585	5.13	6.61	11.13
8	0.8605	3.80	6.61	3.42
1	1.1569	3.11	41.28	77.07
2	2.2397	2.07	11.01	1.03
3	2.5427	0.94	6.61	0.00
5	2.5978	1.16	8.81	0.00
12	3.1416	0.09	5.51	0.34

TABLE 5-11

Kelowna -- Data 1

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
14	-3.1573	324.800	139.667	541.333	83.800
15	-2.8085	34.543	16.000	604.500	89.143
6	-2.6785	25.945	12.174	285.400	43.324
4	-2.6351	22.260	10.436	---	---
16	-2.3745	15.050	7.046	---	---
9	-2.1946	12.225	5.736	244.500	37.118
13	-1.9069	10.824	5.080	27.060	4.085
10	-1.7840	8.681	4.074	46.300	6.961
7	-1.4720	6.440	3.014	51.520	7.772
11	0.3585	1.658	0.776	3.062	0.461
8	0.8605	1.227	0.575	7.360	1.111
1	1.1569	0.161	0.075	0.268	0.040
2	2.2397	0.401	0.188	13.367	2.010
3	2.5427	0.305	0.142	---	---
5	2.5978	0.281	0.132	---	---
12	3.1416	0.034	0.016	1.700	0.265

TABLE 5-12

Kelowna -- Data2

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
14	-1.2955	8.38	0.06	0.10
15	-1.1177	6.24	0.39	0.07
6	-1.0589	14.73	1.21	0.34
4	-1.0169	5.74	0.55	0.00
16	-0.9009	1.55	0.22	0.00
9	-0.8191	12.62	2.20	0.34
13	-0.8090	13.97	2.75	3.42
10	-0.6781	7.17	1.76	1.03
7	-0.5014	13.30	4.41	1.71
11	-0.0284	5.13	6.61	11.13
1	0.2119	3.11	41.28	77.07
8	0.5307	3.80	6.61	3.42
2	1.4038	2.07	11.01	1.03
3	1.6360	0.94	6.61	0.00
5	1.6463	1.16	8.81	0.00
12	1.8765	0.09	5.51	0.34

TABLE 5-13

Kelowna -- Data3

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
14	-1.2955	324.800	139.667	541.333	83.800
15	-1.1177	34.543	16.000	604.500	89.143
6	-1.0589	25.945	12.174	285.400	43.324
4	-1.0169	22.260	10.436	---	---
16	-0.9009	15.050	7.046	---	---
9	-0.8191	12.225	5.736	244.500	37.118
13	-0.8090	10.824	5.080	27.060	4.085
10	-0.6781	8.681	4.074	46.300	6.961
7	-0.5014	6.440	3.014	51.520	7.772
11	-0.0284	1.658	0.776	3.062	0.461
1	0.2119	0.161	0.075	0.268	0.040
8	0.5307	1.227	0.575	7.360	1.111
2	1.4038	0.401	0.188	13.367	2.010
3	1.6360	0.305	0.142	---	---
5	1.6463	0.281	0.132	---	---
12	1.8765	0.034	0.016	1.700	0.265

TABLE 5-14

Kelowna -- Data3

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
14	-1.5899	8.38	0.06	0.10
15	-1.3251	6.24	0.39	0.07
6	-1.2452	14.73	1.21	0.34
4	-1.1624	5.74	0.55	0.00
13	-1.0153	13.97	2.75	3.42
16	-0.9849	1.55	0.22	0.00
9	-0.8786	12.62	2.20	0.34
10	-0.7596	7.17	1.76	1.03
7	-0.4859	13.30	4.41	1.71
11	-0.2589	5.13	6.61	11.13
1	-0.0825	3.11	41.28	77.07
8	0.8742	3.80	6.61	3.42
2	2.3514	2.07	11.01	1.03
3	2.7395	0.94	6.61	0.00
5	2.7794	1.16	8.81	0.00
12	3.0644	0.09	5.51	0.34

TABLE 5-15

Kelowna -- Data4

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
14	-1.5899	324.800	139.667	541.333	83.800
15	-1.3251	34.543	16.080	604.500	89.143
6	-1.2452	25.945	12.174	285.400	43.324
4	-1.1624	22.260	10.436	---	----
13	-1.0153	10.824	5.080	27.060	4.085
16	-0.9849	15.050	7.046	---	---
9	-0.8786	12.225	5.736	244.500	37.118
10	-0.7596	8.6[illegible]1	4.074	46.300	6.961
7	-0.4859	6.440	3.014	51.520	7.772
11	-0.2589	1.658	0.776	3.062	0.461
1	-0.0825	0.161	0.075	0.268	0.040
8	0.8742	1.227	0.575	7.360	1.111
2	2.3514	0.401	0.188	13.367	2.010
3	2.7395	0.305	0.142	---	---
5	2.7794	0.281	0.132	---	---
12	3.0644	0.034	0.016	1.700	0.265

TABLE 5-16

Kelowna -- Data4

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p(%)	q(%)	s(%)
8	-2.0335	2.21	12.02	31.15
6	-1.2283	7.31	3.14	8.14
5	-0.8231	11.79	3.65	8.01
9	-0.7609	9.39	1.82	4.53
1	-0.4883	2.15	22.98	30.32
2	-0.3603	8.18	7.50	9.67
3	-0.1851	10.49	1.03	1.61
12	-0.1813	3.62	0.84	1.07
10	-0.1761	10.56	1.06	1.61
7	-0.1584	16.35	0.78	1.47
14	-0.1092	6.71	1.10	1.34
11	0.0000	5.31	0.03	0.00
13	2.2545	1.48	7.19	0.54
15	2.3824	2.63	9.02	0.00
4	2.5430	1.67	15.97	0.54
16	2.8342	0.15	11.87	0.00

TABLE 5-17

Prince George -- Data1

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
8	-2.0335	0.595	0.184	0.979	0.071
6	-1.2283	7.530	2.328	12.365	0.898
5	-0.8231	10.467	3.230	20.304	1.472
9	-0.7609	16.723	5.159	28.598	2.073
1	-0.4883	0.302	0.094	0.976	0.071
2	-0.3603	3.531	1.091	11.670	0.846
3	-0.1851	32.909	10.184	89.950	6.516
12	-0.1813	14.008	4.310	46.575	3.383
10	-0.1761	32.339	9.962	90.550	6.559
7	-0.1584	67.831	20.949	152.927	11.116
14	-0.1092	19.737	6.100	69.080	5.007
11	0.0000	683.500	177.000	---	---
13	2.2545	0.668	0.206	38.200	2.741
15	2.3824	0.945	0.292	---	---
4	2.5430	0.339	0.105	43.000	3.093
16	2.8342	0.040	0.013	---	---

TABLE 5-18

Prince George -- Data1

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
11	-3.7998	5.31	0.03	0.00
7	-3.2366	16.35	0.78	1.47
3	-2.7527	10.49	1.03	1.61
10	-2.7504	10.56	1.06	1.61
14	-2.3159	6.71	1.10	1.34
9	-1.9158	9.39	1.82	4.35
12	-1.8878	3.62	0.84	1.07
5	-1.3585	11.79	3.65	8.01
6	-0.8809	7.31	3.14	8.14
2	0.0000	8.18	7.50	9.67
1	0.8542	2.15	22.98	30.32
8	1.0613	2.21	12.02	31.15
15	1.7425	2.63	9.02	0.00
13	1.9745	1.48	7.19	0.54
4	2.3781	1.67	15.97	0.54
16	2.8007	0.15	11.87	0.00

TABLE 5-19

Prince George -- Data2

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
11	-3.7998	683.500	177.000	---	---
7	-3.2366	67.831	20.949	152.927	11.116
3	-2.7527	32.909	10.184	89.950	6.516
10	-2.7504	32.339	9.962	90.550	6.559
14	-2.3159	19.737	6.100	69.080	5.007
9	-1.9158	16.723	5.159	28.594	2.073
12	-1.8878	14.008	4.310	46.575	3.383
5	-1.3585	10.467	3.230	30.304	1.472
6	-0.8809	7.530	2.328	12.385	0.898
2	0.0000	3.531	1.091	11.670	0.846
1	0.8542	0.302	0.094	0.967	0.071
8	1.0613	0.595	0.184	0.979	0.071
15	1.7425	0.945	0.292	---	---
13	1.9745	0.668	0.226	38.200	2.741
4	2.3781	0.339	0.105	[illegible]3.000	3.093
16	2.8007	0.040	0.013	---	---

TABLE 5-20

Prince George -- Data2

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
11	-1.2990	5.31	0.03	0.00
7	-1.1409	16.35	0.78	1.47
3	-0.9915	10.49	1.03	1.61
10	-0.9813	10.56	1.06	1.61
14	-0.8169	6.71	1.10	1.34
9	-0.8083	9.39	1.82	4.35
12	-0.6834	3.62	0.84	1.07
5	-0.6306	11.79	3.65	8.01
6	-0.5453	7.31	3.14	8.14
2	-0.0721	8.18	7.50	9.67
8	-0.0381	2.21	12.02	30.15
1	0.2009	2.15	22.98	30.32
15	1.0684	2.63	9.02	0.00
13	1.1230	1.48	7.19	0.54
4	1.3190	1.67	15.97	0.54
16	1.5215	0.15	11.87	0.00

TABLE 5-21

Prince George -- Data3

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
11	-1.2990	683.500	177.000	---	---
7	-1.1409	67.831	20.949	152.927	11.116
3	-0.9915	32.909	10.184	89.950	6.516
10	-0.9813	32.339	9.962	90.550	6.559
14	-0.8169	19.737	6.100	69.080	5.007
9	-0.8083	16.723	5.159	28.598	2.073
12	-0.6834	14.008	4.310	46.575	3.383
5	-0.6306	10.467	3.230	20.304	1.472
6	-0.5453	7.530	2.328	12.385	0.898
2	-0.0721	3.531	1.091	11.670	0.846
8	-0.0381	0.595	0.184	0.979	0.071
1	0.2009	0.302	0.094	0.967	0.071
15	1.0684	0.945	0.292	---	---
13	1.1230	0.668	0.206	38.200	2.741
4	1.3190	0.339	0.105	43.000	3.093
16	1.5215	0.040	0.013	---	---

TABLE 5-22

Prince George -- Data3

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
11	-1.8909	5.31	0.03	0.00
7	-1.7028	16.35	0.78	1.47
3	-1.4769	10.49	1.03	1.61
10	-1.4633	10.56	1.06	1.61
9	-1.3381	9.39	1.82	4.53
14	-1.2109	6.71	1.10	1.34
5	-1.0900	11.79	3.65	8.01
6	-1.0535	7.31	3.14	8.14
12	-1.0361	3.62	0.84	1.07
8	-0.4874	2.21	12.02	31.15
2	-0.1830	8.18	7.50	9.67
1	0.1864	2.15	22.98	30.32
15	2.0611	2.63	9.02	0.00
13	2.1149	1.48	7.19	0.54
4	2.4604	1.67	15.97	0.54
16	2.8169	0.15	11.87	0.00

TABLE 5-23

Prince George -- Data4

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
11	-1.8909	683.500	177.000	---	---
7	-1.7028	67.831	20.949	152.927	11.116
3	-1.4769	32.909	10.184	89.950	6.516
10	-1.4633	32.339	9.962	90.550	6.559
9	-1.3381	16.723	5.159	28.598	2.073
14	-1.2109	19.737	6.100	69.080	5.007
5	-1.0900	10.467	3.230	20.304	1.472
6	-1.0535	7.530	2.328	12.385	0.898
12	-1.0361	14.008	4.310	46.575	3.383
8	-0.4874	0.595	0.184	0.979	0.071
2	-0.1830	3.531	1.091	11.670	0.846
1	0.1864	0.302	0.094	0.976	0.071
15	2.0611	0.945	0.292	---	---
13	2.1149	0.668	0.206	38.200	2.741
4	2.4604	0.339	0.105	43.000	3.093
16	2.8169	0.040	0.013	---	---

TABLE 5-24

Prince George -- Data4

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
1	-1.9379	4.47	7.77	30.67
2	-1.7217	6.78	7.03	21.60
5	-1.5967	11.19	4.10	16.80
8	-1.2308	2.88	7.87	15.47
3	-0.6022	4.83	9.62	13.60
4	0.1263	12.48	0.98	0.53
6	0.1921	19.78	1.01	---
7	0.4613	18.91	2.45	---
10	0.6555	15.11	3.67	0.53
9	2.7045	0.71	4.47	0.80
11	4.3365	2.14	51.03	---

TABLE 5-25

Fort McMurray -- Data1

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
1	-1.9379	1.905	0.575	3.826	0.146
2	-1.7217	3.191	0.964	8.235	0.314
5	-1.5967	9.598	2.905	18.587	0.709
8	-1.2308	1.209	0.366	4.879	0.186
3	-0.6022	1.661	0.502	9.314	0.355
4	0.1263	42.310	12.735	613.500	23.547
6	0.1921	64.867	19.594	---	---
7	0.4613	25.479	7.718	---	---
10	0.6555	13.663	4.117	743.000	28.509
9	2.7045	0.526	0.159	23.323	0.888
11	4.3365	0.138	0.042	---	---

TABLE 5-26

Fort McMurray -- Data1

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
6	-3.3568	19.78	1.01	---
4	-3.0671	12.48	0.98	0.53
7	-2.8657	18.91	2.45	---
10	-2.2124	15.11	3.67	0.53
5	-0.8935	11.91	4.10	16.80
1	-0.1905	4.47	7.77	30.67
2	0.0755	6.78	7.03	21.60
3	0.7655	4.83	9.62	13.60
8	0.8355	2.88	7.87	15.47
9	2.8013	0.71	4.47	0.80
11	4.1658	2.11	51.03	---

TABLE 5-27

Fort McMurray -- Data2

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
6	-3.3568	64.867	19.594	---	---
4	-3.0671	42.310	12.735	613.500	23.547
7	-2.8657	25.479	7.718	---	---
10	-2.2124	13.633	4.117	743.000	28.509
5	-0.8935	9.598	2.905	18.587	0.709
1	-0.1905	1.905	0.575	3.826	0.146
2	0.0755	3.191	0.964	8.235	0.314
3	0.7655	1.661	0.502	9.314	0.355
8	0.8355	1.209	0.366	4.879	0.186
9	2.8013	0.526	0.159	23.333	0.888
11	4.1658	0.138	0.042	---	---

TABLE 5-28

Fort McMurray -- Data2

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
6	-1.1814	19.78	1.01	---
4	-1.1093	12.48	0.98	0.53
7	-0.9175	18.91	2.45	---
5	-0.8572	11.91	4.10	16.80
1	-0.7127	4.47	7.77	30.67
10	-0.6037	15.11	3.67	0.53
2	-0.5402	6.78	7.03	21.60
8	-0.0954	2.88	7.87	15.47
3	0.0869	4.83	9.62	13.60
9	1.9279	0.71	4.47	0.80
11	2.9751	2.14	51.03	---

TABLE 5-29

Fort McMurray -- Data3

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
6	-1.1814	64.867	19.594	---	---
4	-1.1093	42.310	12.735	613.500	23.547
7	-0.9175	25.479	7.718	---	---
5	-0.8572	9.598	2.905	18.587	0.709
1	-0.7127	1.905	0.575	3.826	0.146
10	-0.6037	13.633	4.117	743.000	28.509
2	-0.5402	3.191	0.964	8.235	0.314
8	-0.0954	1.209	0.366	4.879	0.186
3	0.0869	1.661	0.502	9.314	0.355
9	1.9279	0.526	0.159	23.333	0.888
11	2.9751	[illegible].138	0.042	---	---

[illegible]LE 5-30

Fort McMurray -- Data3

Correlation between coefficients, c, and k1, k2, l1 or l2.

Zone No.	Coefficient	p (%)	q (%)	s (%)
6	-1.5819	19.78	1.01	---
4	-1.4705	12.48	0.98	0.53
5	-1.2438	11.91	4.10	16.80
7	-1.2142	18.91	2.45	---
1	-1.0678	4.47	7.77	30.67
2	-0.8251	6.78	7.03	21.60
10	-0.7793	15.11	3.67	0.53
8	-0.1978	2.88	7.87	15.47
3	0.0800	4.83	9.62	13.60
9	2.7502	0.71	4.47	0.80
11	4.2505	2.14	51.03	---

TABLE 5-31

Fort McMurray -- Data4

Correlation between coefficients, c, and p, q, or s in %.

Zone No.	Coefficient	k1	k2	l1	l2
6	-1.5819	64.867	19.594	---	---
4	-1.4705	42.310	12.735	613.500	23.547
5	-1.2438	9.598	2.905	18.587	0.709
7	-1.2142	25.479	7.718	---	---
1	-1.0687	1.905	0.575	3.826	0.146
2	-0.8251	3.191	0.964	8.235	0.314
10	-0.7793	13.633	4.117	743.000	28.509
8	-0.1978	1.209	0.366	4.879	0.186
3	0.0800	1.661	0.502	9.314	0.355
9	2.7502	0.526	0.159	23.333	0.888
11	4.2505	0.138	0.042	---	---

TABLE 5-32

Fort McMurray -- Data4

Correlation between coefficients, c, and k1, k2, l1 or l2.