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7/25/68

AN INVESTIGATION OF THE EFFECT OF TRAVELTIME ON TRIPS ATTRACTED TO A MAJOR RECREATIONAL AREA

A THESIS

Presented to

The Faculty of the Graduate Division

by

Clarence Dorsey Dyer, Jr.

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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AN INVESTIGATION OF THE EFFECT OF TRAVELTIME ON TRIPS ATTRACTED TO A MAJOR RECREATIONAL AREA

Approved:

Chairman

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SUMMARY

The purpose of this research was to investigate the effect of traveltime on the number of inter-city trips attracted to a major recreational facility. The facility studied was Six Flags Over Georgia, a large, modern amusement park near Atlanta.

The effect of traveltime was expressed in the form of impedance factors, approximately equal to the ratios of trips to population for areas separated from Six Flags by various traveltimes. When the impedance factors were thus determined, a mathematical expression relating the values of these factors to traveltimes was derived. Using impedance factors determined from this expression, the number of trips from an area to Six Flags can be estimated.

The results of this research indicate that these impedance factors, and therefore trips made to Six Flags, decrease according to an exponential function as traveltime increases. For traveltimes greater than fifteen hours, the rate of decrease appears to be best described by another exponential relationship.

DEFINITIONS

In order to facilitate the understanding of this research and to avoid confusion resulting from the use of similar terminology elsewhere in the literature, the following definitions are given:

Actual Trips--The number of vehicle-trips made to Six Flags Over Georgia in 1968.

Predicted Trips--The estimated number of vehicle-trips to Six Flags Over Georgia in 1968.

Reported Trips--The number of vehicle-trips made to Six Flags Over Georgia that were reported on the returned questionnaires in 1968.

Corrected Reported Trips--An adjusted value used for reported trips (for Georgia only) due to particularly low questionnaire response.

Traveltime--The estimated time required to travel via automobile from a particular area to Six Flags Over Georgia in 1968.

Impedance Factor--A value used to predict the number of vehicle-trips from an area separated from Six Flags Over Georgia by a known traveltime. The impedance factor is approximately the ratio of vehicle-trips (to Six Flags) to population (of the area from which the trips came).

Input Impedance Factor--An impedance factor value used to calculate the number of predicted trips from various areas and used as input to the two computer programs described in the Appendix.

Adjusted Impedance Factor--An impedance factor value calculated using the impedance factor program. It is equal to the product of the number of reported trips and the input impedance factor divided by the number of predicted trips calculated using the input impedance factors.

DEFINITIONS (Continued)

Adjustment Factor--The ratio of reported trips to predicted trips for a zone or group of zones.

Income Adjustment Factor--Same as Adjustment Factor. The term Income Adjustment Factor is frequently used (instead of Adjustment Factor) to emphasize that a relationship between income levels and adjustment factors is being considered.

CHAPTER I

INTRODUCTION

Americans are devoting more time to recreational activities than at any time in the past, and indications are that this trend will continue indefinitely. The United States Bureau of Outdoor Recreation, for example, expects that "by the year 2000, our participation in the major forms of summertime outdoor recreation activities will be four times greater than it was in 1960" (1). This increase is partially brought about by increased personal incomes and greater amounts of leisure time. The character of recreation trips is also influenced by this country's continually improving transportation system, which permits easier access to major recreational areas, such as parks and stadiums.

Trips made for recreational purposes are particularly important to transportation planners concerned with regional planning. The 1963 Census of Transportation, conducted by the Bureau of the Census (2), indicates that 25% of all inter-city person-trips and 26% of inter-city person-trips made by automobile were for recreational purposes. In order to permit adequate transportation planning on a regional or statewide level, therefore, a method of predicting recreational trips is needed. Before such a method can be devised, however, the effect of traveltime, as well as income and other socio-economic factors, must be more clearly understood.

The purpose of this study was to investigate the effect of traveltime (via automobile) on the number of trips made to a major recreational facility. It was belived by this writer that knowledge of the effect of traveltime would be more valuable to transportation planners than would knowledge of the effects of any socio-economic factors. Although the value of such understanding to transportation planners was the primary reason for this study, perhaps a more immediate benefit can be realized by the management of recreational facilities similar to the one studied, Six Flags Over Georgia. A better understanding of the effect of traveltime upon the number of trips made would be useful in both the planning and operational phases of such establishments.

Little research has been conducted that is concerned with the prediction of inter-city recreational trips for regional transportation planning purposes. Charles C. Cervo (3) of the Connecticut State Highway Department did some early work in this field and reached some preliminary conclusions concerning the effect of traveltime. However, his study dealt with five similar recreation areas, all of which were located in southeastern Connecticut and attracted trips primarily from a small section of New

England. Cervo was thus concerned only with traveltimes of ninety minutes or less and has not eliminated the effect of competition between two or more facilities. Andrew Ungar (4) studied the effect of recreational facilities, socio-economic characteristics, and traveltime upon trips made to Indiana state parks, but Ungar was also concerned with several similar facilities and relatively small traveltimes. James H. Evans (5) did some similar work concerned with the prediction of trips to state parks in Georgia. Like Cervo and Ungar, however, Evans was concerned with several similar facilities, each attracting trips from a relatively small area. Furthermore, Evans was unable to reach any conclusions concerning the effect of traveltime since the origins of the trips in his study were unknown. J. S. Matthias and W. L. Grecco (6) have studied the effect of traveltime on recreational trips made to multi-purpose reservoirs in Indiana. Again, however, this study involved several competing facilities and small traveltimes. G. David Boggs (7) conducted a study of recreational travel patterns in southern Ontario as a part of the Ontario Joint Highway Research Programme. However, that study was primarily concerned with factors other than traveltime, such as resort facilities and resort-user characteristics.

The recreational facility used in this study was Six Flags Over Georgia, known also as Six Flags, a modern amusement park located on Interstate 20 approximately eleven miles west of downtown Atlanta.

The park was opened in 1967 and is open week-ends from the first week-end after Easter through May and from Labor Day through the last week-end in November and is open daily from the first week in June through Labor Day. Approximately 1,600,000 persons visited Six Flags during 1968, the year for which data was used for this study. These persons, called "guests" by Six Flags personnel, came not only from the Atlanta area but also from throughout the southeastern United States and, to a lesser degree, from the entire country. Approximately one-half of the park's business in 1968 came from within Georgia.

Six Flags Over Georgia was chosen for this study because of its convenience to the writer and the availability of needed data. Also, it was important that the park attracted trips from relatively large distances and that no similar facility existed within several hundred miles of Atlanta. This minimizes the possibility of the presence of direct competition obscuring the effect of traveltime. Of course, the absence of a similar facility near Six Flags Over Georgia does not mean that Six Flags has no competition at all, since any form of recreation can be competitive with an amusement park.

CHAPTER II

HYPOTHESIZED MODEL

It was hypothesized that the number of trips from any area to Six Flags Over Georgia could be predicted if the population of that area, the traveltime from the area to Six Flags, and certain socio-economic information were known. As previously stated, the purpose of this study was to investigate the effect of traveltime. The writer's interest in any socio-economic data was limited to the possible use of such data to eliminate the effects of any factors that would obscure the effect of traveltime. Early observation of limited data indicated that income might be an important determinant of the number of trips from a particular area to Six Flags. Thus an adjustment factor based on per capita income was incorporated into the model.

The number of trips from any area to Six Flags was assumed to vary directly with the population of that area. In other words, all other things assumed equal, an area with twice the population of another area would be expected to have twice as many trips originating from it as would the second area. No such assumptions were made concerning the effects of traveltime and income. The model for predicting the number of trips from a given area to Six Flags can thus be expressed as

$$PT = P \times IF \times K$$

where PT = the predicted number of trips from the area

P = the population of the area

IF = an impedance factor indicative of the effect of the traveltime from the area to Six Flags

K = an adjustment factor based on the area's per capita income

If the above model is appropriate, then with the use of appropriate factors based on traveltime and per capita income, the number of predicted trips from an area to Six Flags will approximate the number of reported trips from that area. Letting RT represent the reported trips from an area, the model then becomes

$$RT \cong PT = P \times IF \times K, \text{ or}$$

$$RT \cong P \times IF \times K, \text{ or equivalently}$$

$$IF \cong RT/(P \times K)$$

This last relationship was the one used in this study to determine the effect of traveltime upon the number of trips made to Six Flags. As will be explained in a later chapter, the number of reported trips from a zone was used in this study to represent the number of actual trips from that zone.

In order to estimate the traveltime factors from the relationship given above, zones had to be created and certain data for each of the zones were needed, including:

1. the reported number of trips originating from each zone during the study period (1968),

2. the population of each zone during the study period,
3. the per capita income of each zone during the study period, and
4. the traveltime from each zone to Six Flags Over Georgia.

The model described above is similar in several respects to the Gravity Model of trip distribution used in transportation planning. In fact, this model was admittedly influenced by the writer's familiarity with the Gravity Model, and much of the terminology used in this report is similar to that used with the Gravity Model.

However, it is important to recognize that there are basic differences between the model used in this study and the Gravity Model. These differences arise from the different purposes of the two models. The Gravity Model distributes a given number of trips from a zone to other zones, based on a set of traveltime factors. The model formulated for this study predicts the number of trips made from a zone to a single location (Six Flags Over Georgia). In other words, while the Gravity Model uses traveltime to distribute trips, this study's model uses traveltime to predict the frequency of a particular type of trip.

CHAPTER III

PROCEDURE

The procedure used in this study to determine the effect of traveltime on trips attracted to Six Flags Over Georgia is documented in this chapter. This procedure was based on the model discussed in Chapter II.

Designation of Zones

In order to estimate the number of trips attracted to Six Flags from a particular area by the model described in the previous chapter and to compare this figure with the number of reported trips from that area, the areas to be used for analysis had to be defined. To accomplish this, the United States (excluding Alaska and Hawaii) was divided into zones. In all, 208 such zones were created, with no zone boundaries crossing county or state lines. The boundaries were so drawn in order to facilitate the acquisition of population and income data.

The counties (or states) were grouped in zones primarily according to approximate distances and traveltimes, i.e., neighboring counties which were approximately the same distance and traveltime from Six Flags Over Georgia were often placed in the same zone. The size of the zones varied with traveltime, with larger zones being utilized for areas farther from Atlanta. Zone sizes varied from one county to six states. Also taken into consideration in the creation of zones was the character of the area. Thus large urban areas (particularly in Georgia and adjacent states) were often considered as individual zones. The size of such zones depended on the size of the particular urban area and varied from one county to four counties.

The judgment of the writer was necessarily used extensively in the creation of zones. The counties and states in each zone are indicated in Table 2, included in Appendix I.

Acquisition of Data

In the course of this study, much data became necessary. The methods used to obtain the required data are discussed in this section.

Determination of Reported Trips from Each Zone

Drivers of automobiles coming to Six Flags Over Georgia were given short questionnaires that were designed to obtain certain information for the management of Six Flags. Normally, Six Flags attempts to give a questionnaire to every vehicle at the park, but for various reasons this goal is not reached. In 1968 an estimated 250,000 questionnaires were distributed among the 338,476 cars at Six Flags. Of these, approximately 27,000 were returned. It was from these returned questionnaires that the origins of trips were determined.

One of the questions asked on the questionnaire was "What is your hometown?", and the answers to this question were summarized in weekly, monthly, and annual reports for 1968. The data from the annual summary were used in this study to determine the "reported trips" from each zone.

Each town listed in the summary was assigned to the proper zone. The 1968 Rand McNally Commercial Atlas and Marketing Guide (8) was used to locate towns in the correct zones. The number of reported trips from each zone was determined by summing the numbers of reported trips from the towns in the zone.

Some problems inevitably arose when following the above process. These were resolved either by referring to the weekly reports (from which the annual report used for this study was summarized) or by the writer's judgment. In almost all cases requiring judgment, very few trips (usually only one or two) were involved, and it is not likely that any significant effect on the conclusions of this study could have resulted from incorrect judgments in these situations.

The number of reported trips from each zone is shown in Table 5, included in Appendix II.

Estimation of Zone Populations

The population figures used in this study are estimates of populations as of January 1, 1968, and they were taken from the 1968 Editor and Publisher Market Guide. (9) The population of each zone was found by summing the populations of the counties (or states) in the zone.

These zone populations are indicated in Table 4, included in Appendix I.

Estimation of Per Capita Incomes

The total personal income for each zone was determined by adding the total personal incomes for each county (or state) in the zone. The source of these estimates, which were for the calendar year 1968, was the 1968 Editor and Publisher Market Guide (10), the same source used for population estimates. The per capita income for each zone was found by dividing its total personal income by its population.

The total personal income for each zone is shown in Table 4, included in Appendix I.

Estimation of Traveltimes

In order to estimate the traveltimes from the various zones to Six Flags Over Georgia, some average speeds were assumed. The type of roadway and its location greatly influence speeds, and therefore a single average speed for all roads was not used. For the purposes of this study, roads were placed in one of three categories, for each of which an average speed had been assumed. In estimating these average speeds, the Traffic Engineering Handbook (11) was used as a reference, particularly its Table 5.15. The three types of roads and the corresponding average speeds are shown in Table 1.

Table 1. Assumed Speeds Used in Traveltime Calculations

Road Type	Description	Assumed Average Speed
A	Controlled-access freeways (urban and rural) and rural 4-lane roads	55 m.p.h.
B	2-lane rural roads	45 m.p.h.
C	All urban roads except controlled-access freeways	25 m.p.h.

For each zone a "centroid" of trip-making was approximated. It was from this point that all trips from the zone were assumed to originate, or to be "loaded" on the highway network. The <u>Traffic Assignment Manual</u> states that "the point of loading for each zone, defined as a centroid or loading point, should be located at the center of activity for the zone." (12) It further says that "the location of the centroid is determined to a large extent by judgment." (13) However, since for this study the traveltime from the zone centroid to only one destination (Six Flags) was needed, it was not necessary that the centroid be located at the "center of activity", but merely that it be placed so that its traveltime will be approximately equal to that of the center of activity. The writer's judgment was used extensively in locating zone centroids. After a zone centroid had been located within each zone, the traveltime to Six Flags Over Georgia could be determined. This was done by manual calculation, using the assumed average speeds discussed earlier. The mileage of each of the three road types was estimated from road maps and a traveltime was thus estimated for the route. In cases where the route having the shortest traveltime was not readily apparent, two or more routes were compared and the route with the smallest traveltime value was selected.

The method described above for the estimation of traveltimes is admittedly only a rough approximation, but in the absence of any better method that was feasible, it was considered sufficiently accurate for the purposes of this study.

The calculated traveltimes are given in Table 4, included in Appendix I.

Method Used in Determining Effect of Traveltime

As indicated in Chapter II, the effect of traveltime on the number of trips made to Six Flags Over Georgia was to be expressed in the form of an impedance factor approximately equal to the ratio of (reported) vehicle-trips (from the zone to Six Flags) to the zone population.

The form of the proposed impedance factor curve (plotted against traveltime) was intended to be smooth and decreasing with increasing traveltime values. As stated by the Bureau of Public Roads, the curve should be smooth, if possible, because

a. Smooth curves can be approximately defined in a mathematical expression; possibly, one that is not too complex.

b. If these curves can be approximated by a mathematical expression, meaningful comparisons can be made between these expressions for different. . . .areas with various population and density characteristics.

c. These comparisons would eventually help quantify, with a mathematical function, the effect of spatial separation between zones on trip interchange. (14)

Although the above reasons were meant to apply to urban transportation studies, they are also applicable to this study.

The use of adjustment factors, to have been based on zonal per capita income, was also planned. It had been anticipated that these adjustment factors would have been used in this study to clarify the effect of traveltime, but attempts to ascertain a clear and logical relationship between these adjustment factors and trip-making to Six Flags were not successful. The procedure that the writer had planned to use to incorporate the effect of income involved first estimating the impedance factors without any adjustments for income. These estimates of impedance factors were then to be used in calculating income adjustment factors which would in turn be used to obtain another estimate of impedance factors. This process was to be repeated until, in the writer's judgment, the effects of income and traveltime had been sufficiently segregated.

Due to the large number of calculations required in this study, an electronic computer was utilized frequently. Two programs were created by the writer and used frequently in the study. These will be referred to as the impedance factor and income factor programs. Only minimum information needed to understand the procedure used in this study is included in this section; a more complete description of the two programs can be found in Appendix III.

The impedance factor program was used primarily to compute the impedance factors for each traveltime that was designated for use. (In order to permit easier estimations of impedance factors, all possible traveltimes were not used. Instead, the traveltimes for the zones were rounded to the nearest of several values of traveltime used in the two computer programs, e.g., 30 minutes, 45 minutes, etc. A complete list of these values can be found in Table 3, included in Appendix I.)

The most important output of the impedance factor program was the adjusted impedance factors. These values were used in estimating the effect of traveltime and in calculating the income adjustment factors. These adjusted impedance factors were computed by multiplying the input impedance factors by the ratio of reported trips to predicted trips (as calculated using the input impedance factors) for zones with that traveltime, i.e.,

$$\text{Adjusted Impedance Factor} = \frac{\text{Input Impedance Factor} \times \text{Reported Trips}}{\text{Predicted Trips}}$$

The other program used, the income factor program, was devised to aid in the creation of the income adjustment factors. These factors are simply the ratios of reported trips to predicted trips for given groups of zones. In this program, the zones were grouped according to per capita income and thus it was hoped that a relationship between per capita incomes and the computed adjustment factors could be ascertained. If so, the effect of income could at least be partially incorporated into the estimation of impedance factors and thus permit a clearer indication of the effect of traveltime.

In order to permit more detailed analysis when desired, the two programs performed similar operations for each of the 208 zones individually as they did for the larger groups of zones (grouped by traveltimes for the impedance factor program and by per capita incomes for the income factor program).

First Approximation of Impedance Factors

Following the procedure discussed, the first estimate of impedance factors was made with the impedance factor program, using no corrections for per capita incomes. The resulting adjusted impedance factors were then plotted on semi-log paper, i.e., a graph with the ordinate, or Y-axis, on a logarithmic scale. A "smooth line" (actually consisting of two straight lines) was drawn through these points, and this line was used to determine the impedance factors to be used as input to the first income factor program run.

Attempted Estimation of Income Adjustment Factors

The estimated impedance factors were next used with the income factor program to calculate the income adjustment factors, and the resulting adjustment factors were plotted against per capita income on a rectilinear graph. Although there did appear to be some relationship between the adjustment factors and per capita income, the form of this relationship could not be determined because of the extreme and unaccountable variation exhibited by the adjustment factors. (These scattergrams are included in Chapter IV and Appendix II.) Therefore the effects of income could not be incorporated into the impedance factor calculations, as had originally been planned.

Observation of Low Response from Georgia

At this point it was decided to make closer observations of individual zones. The output of the impedance factor program was studied, and it was observed that reported trip rates of zones in states adjacent to Georgia were inexplicably higher than those of nearby zones in Georgia. Further investigation revealed that this was not only the case, but that there were actually more reported trips from Alabama than from Georgia.

This did not seem reasonable and created doubt concerning the reliability of the data. In order to determine whether the data that were being used (which were obtained from the questionnaire given to vehicles coming to Six Flags) were reliable, they were compared with the results of a "parking lot survey" which was conducted routinely and in 1968 sampled about 60% of all cars at Six Flags. This parking lot survey recorded the states from which automobiles in the Six Flags parking lot had come, based on the vehicles' license tags. Although the parking lot survey data were not detailed enough for extensive use in this study, they had the advantage of being more nearly random than that of the questionnaires, since they were not dependent upon the cooperation of the vehicle occupants. It was therefore believed that the percentage of trips from Georgia could be more accurately estimated by the parking lot survey than by the questionnaire results.

It was found that only 21.8 per cent of the reported trips (based on the questionnaire responses) were from Georgia, yet 50.7 per cent of automobiles included in the parking lot surveys had Georgia license plates.

In order to determine whether a similar situation existed in other states, the number of reported trips from Georgia was assumed to be 21,555 instead of 5857. This was done in order to make the percentage of reported trips from Georgia 50.7, the percentage indicated by the parking lot survey. By doing this, the percentage of reported trips from other states would not be biased by a low response from Georgia. When this was done and the percentage of the reported trips from each of the states adjacent to Georgia was calculated based on this enlarged number of total reported trips, these percentages gave reasonably good agreement with the parking lot survey percentages.

It was thus apparent that, for unknown reasons, persons who had come to Six Flage Over Georgia from places in Georgia were much less likely to return the questionnaires than were persons from other states. This tendency to not return the questionnaires did not appear to be present in other states and in many cases seemed to end suddenly at the Georgia boundary.

Since a lower response from some areas than from others could influence the estimation of the income adjustment factors, the zones were split into three groups (those in Georgia, those in Alabama, Tennessee, Mississippi, North Carolina, South Carolina, and Florida, and those in all other states), and separate adjustment factor calculations were made for these groups to determine if a clearer relationship existed between income level and reported trips than had been indicated by the first analysis. Georgia zones were considered separately because of the low response from Georgia. In addition, the remaining states were split into two groups, roughly according to whether they were in an area where a facility similar to Six Flags would be competitive. Thus any significant effect of competing facilities would be avoided in the group consisting of all zones in Alabama, Tennessee, Mississippi, South Carolina, North Carolina, and Florida.

Adjustment for Low Georgia Response

The impedance factors which appeared particularly lower than would be indicated by the smooth line drawn were those corresponding to traveltimes of 150 minutes or less. It is significant that most zones with traveltimes to Six Flags of 150 minutes or less were in Georgia. Many zones with traveltimes somewhat greater than 150 minutes lay in neighboring states, particularly Tennessee, Alabama, and South Carolina, as well as in South Georgia.

Thus the lower impedance factors as computed and plotted were apparently caused by the low response from Georgia. By multiplying these factors by the ratio of corrected reported trips to reported trips, $21{,}555/5857 \cong 3.7$, it could be seen that they would then be roughly in line with the other impedance factors.

Estimation of Impedance Factor Function

A new line was drawn to represent the estimated relationship between impedance factors and traveltimes. This line was then expressed as a mathematical function. This line was estimated by the writer without the use of statistical regression techniques for reasons discussed later in this chapter.

Use of Final Estimates of Impedance Factors

The impedance factors were calculated from this mathematical function and were then used to predict the number of trips to Six Flags from each of the 208 zones. In addition to the impedance factor program which permitted comparison of reported trips and predicted trips for individual zones as well as zones grouped by traveltimes, the income factor program was again used to calculate adjustment factors for each of the income levels, using these final impedance factor estimates. As had been done with the previously estimated impedance factors, the income adjustment factors were calculated using four different groups of zones:

(1) all zones (1-208)

(2) zones in Georgia (1-50)

(3) zones in Alabama, Mississippi, Tennessee, North Carolina, South Carolina, and Florida (51-176)

(4) zones in other states (177-208)

Adjustment for Questionnaire Response Percentage

Since all questionnaires given to drivers of vehicles at Six Flags Over Georgia were not completed and returned, the number of vehicle-trips indicated by the estimated impedance factors was lower than the actual number of such trips. For this reason, the distribution was modified so that all impedance factors were multiplied by the ratio of actual vehicle-trips (from all zones) to predicted vehicle-trips (from all zones). The new function thus obtained provided an estimate of the actual impedance factors effective in 1968 for Six Flags Over Georgia.

Reasons Statistical Techniques Not Used

Certain statistical techniques are often used to aid in defining the relationship between the dependent variable, such as impedance factors, and one or more independent variables, such as traveltime. In particular, the use of linear regression techniques might seem appropriate for this study because of the apparent exponential relationship between impedance factors and traveltimes since such a relationship indicates a linear relationship between the logarithm of the dependent variable and the independent variable. Regression methods might also have been useful in identifying the relationship between per capita income and any income adjustment factors that might have been used, had the employment of such adjustment factors been practical.

Regression methods were not used in this study, however, primarily because of the low response rate from within Georgia. In order to make the impedance factors for short traveltimes comparable to those of other traveltimes and thereby make any equation (relating impedance factors to traveltimes) meaningful, an adjustment for the low Georgia response would have been necessary. Such an adjustment, however, required a somewhat arbitrary change in the impedance factor values corresponding to low traveltimes, and it was believed that such manipulation of the data would make the use of linear regression meaningless and perhaps misleading as to the preciseness of the resulting equation.

In addition, the effects of inaccuracies in the data, normal trip interchanges between the various zones for purposes other than going to Six Flags, the inevitable inaccuracies in estimated traveltimes due to the assumed average speeds, and many other factors would cause the increased accuracy gained by using linear regression to be meaningless and possibly misleading to some persons.

Any equation, whether or not it was obtained by linear regression, could only be assumed to apply to Six Flags Over Georgia for 1968. Any other recreational facility or amusement park could not be expected to have the same impedance factors, nor could these factors be assumed to be applicable to Six Flags Over Georgia for any year other than 1968. Therefore, the form of the impedance factor curve was believed by this writer to be much more important than the parameters of the equation defining the curve, and thus even if it had been feasible, the use of linear regression would not have added significantly to the results of this study.

CHAPTER IV

EVALUATION OF RESULTS

The objective of this study was to determine the effect of traveltime on the number of trips made from a particular area to Six Flags Over Georgia. This effect was to be indicated by a set of impedance factors, approximately equal to the ratio of reported trips to total population for areas separated from Six Flags by various traveltimes.

As a first step, the ratio of vehicle-trips to population was calculated for each traveltime value used by the impedance factor program. The results of these calculations are indicated in Figure 1. The two straight lines drawn through the plotted points represent the smooth, decreasing function which was expected. It is interesting to note that the impedance factors decrease much more slowly when traveltimes are greater than fifteen hours than when they are less than fifteen hours. With the impedance factors from this smooth-line approximation being used, the average trip length of the predicted trips was 328.3 minutes, compared to an average trip length of reported trips of 318.3 minutes.

The values indicated by the two straight lines were then used as input impedance factors in the income

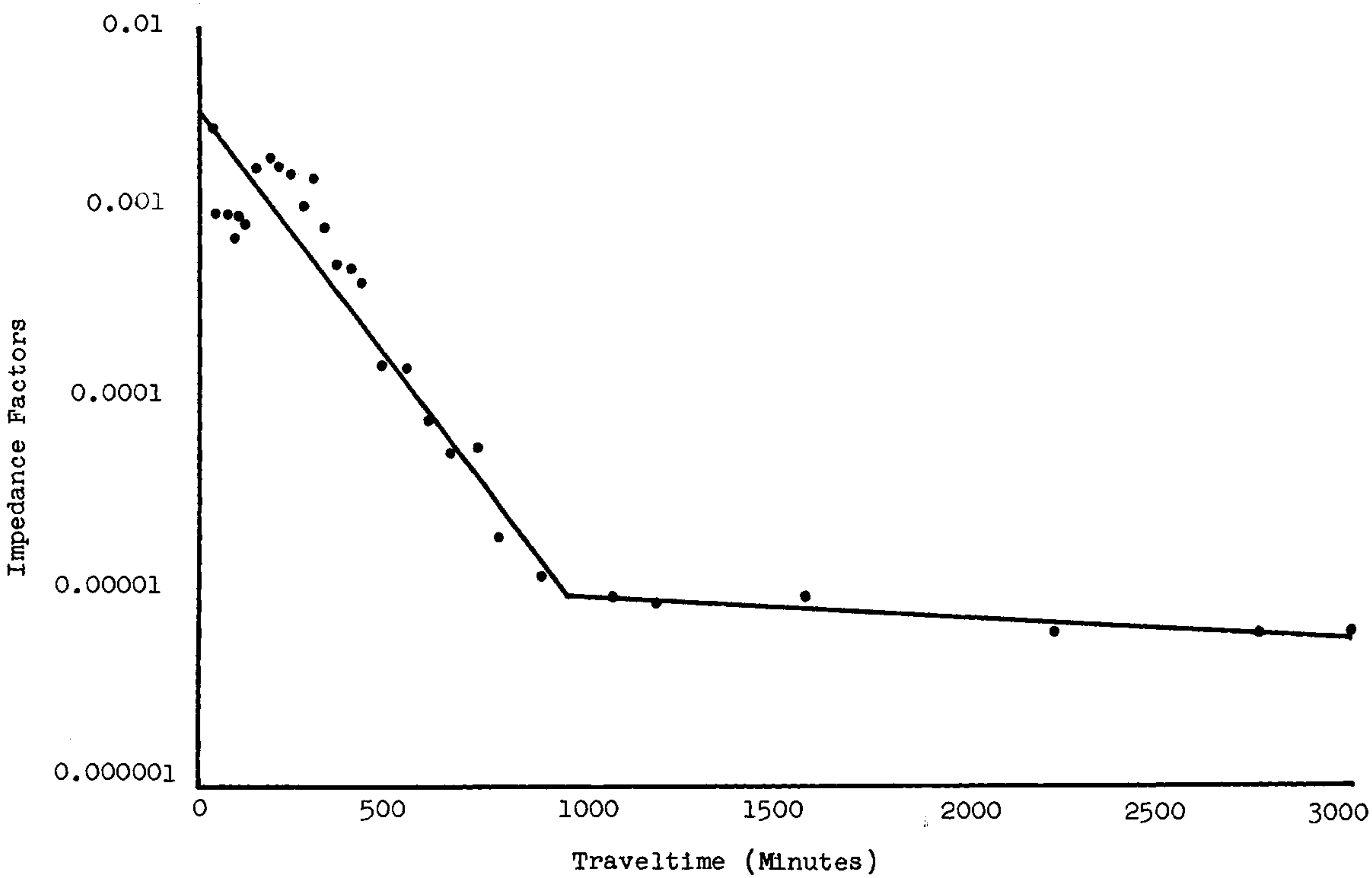

Figure 1. Initial Estimate of Impedance Factors

factor program in an effort to create income adjustment factors. When the values of average zonal per capita incomes (in hundred dollar increments) were plotted versus the corresponding adjustment factors, no clear relationship could be detected. (See Figure 2.) When the low questionnaire response rate from Georgia was observed, plots of adjustment factors versus income levels were made using data from three sub-groups of zones (those in Georgia, those in Alabama, Mississippi, Tennessee, North Carolina, South Carolina, and Florida, and those in other states) in order to determine if the relationship of the original factors (utilizing data from all 208 zones) to income had been obscured appreciably by zone locations. However, these efforts did not provide an improved understanding of the effect of income on trip-making to Six Flags. The appropriate scattergrams are included in Appendix II as Figures 5, 6, and 7.

After the adjustment for the low Georgia response was made (as described in Chapter III), a new approximation of the smooth impedance function was made, and this modified function is shown graphically in Figure 3.

In order to permit it to be expressed quantitatively, this relationship was converted to a mathematical expression, which is given below:

$$IF = 0.007\,(e^{-0.007T}), \quad T < 930$$

$$IF = 0.0000125(e^{-0.00025T}), \quad T \geq 930$$

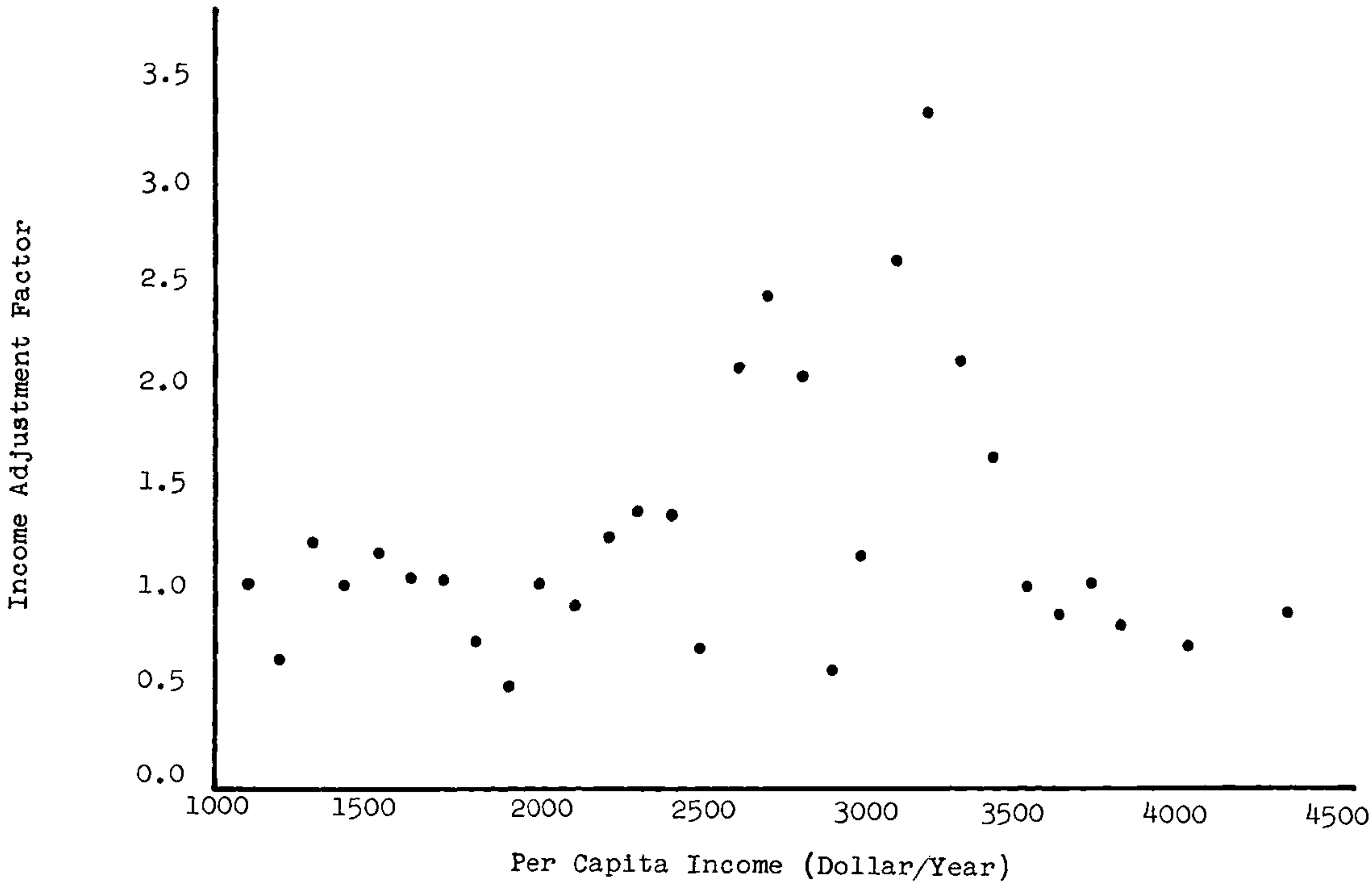

Figure 2. Income Adjustment Factors Calculated with No Adjustment for Low Georgia Response

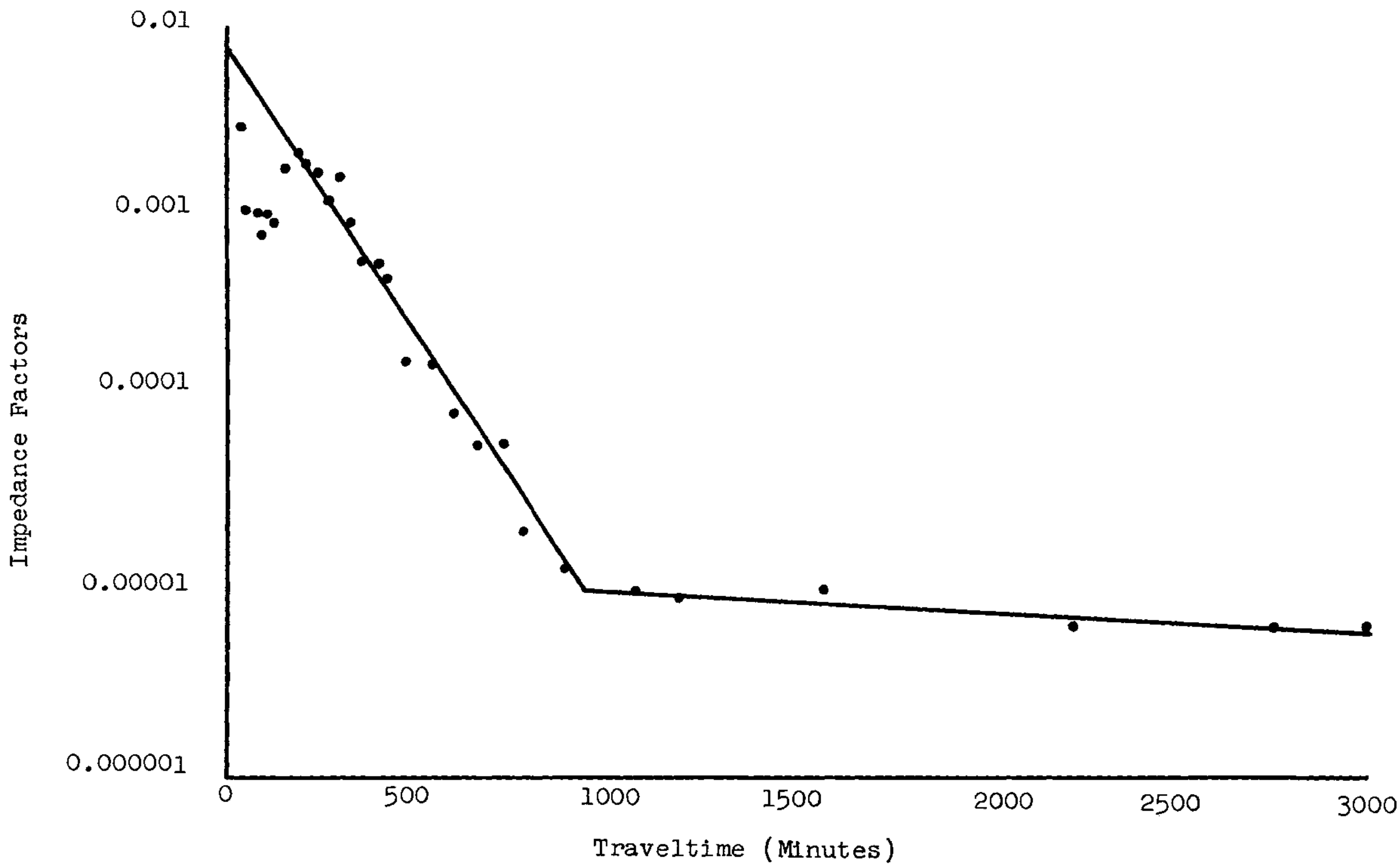

Figure 3. Final Estimate of Impedance Factors

where

IF = impedance factor

T = traveltime in minutes

e = the base of natural logarithms $\cong$ 2.718

As mentioned previously, linear regression was not used in determining this relationship, and it is only an approximate expression of the effect of traveltime on the number of reported trips (adjusted for the low Georgia response).

Using this mathematical expression, a new set of impedance factors were computed and subsequently applied to the prediction of trips from each of the zones. A comparison of reported and predicted trips can be made by observing Table 5, included in Appendix II. Using these calculated impedance factors, the average length of the predicted trips was 263.7 minutes. No calculation was made of the average length of reported trips using an adjustment for the low Georgia response.

A new set of adjustment factors was calculated, using the modified impedance factor function, and then plotted. (See Figure 4.) In addition to this calculation, the same operation was performed using only data from the three subgroups of zones mentioned previously. These scattergrams are shown in Figures 8, 9, and 10 in Appendix II. As above, no improved understanding of the effect of income on tripmaking to Six Flags could be gained from these efforts.

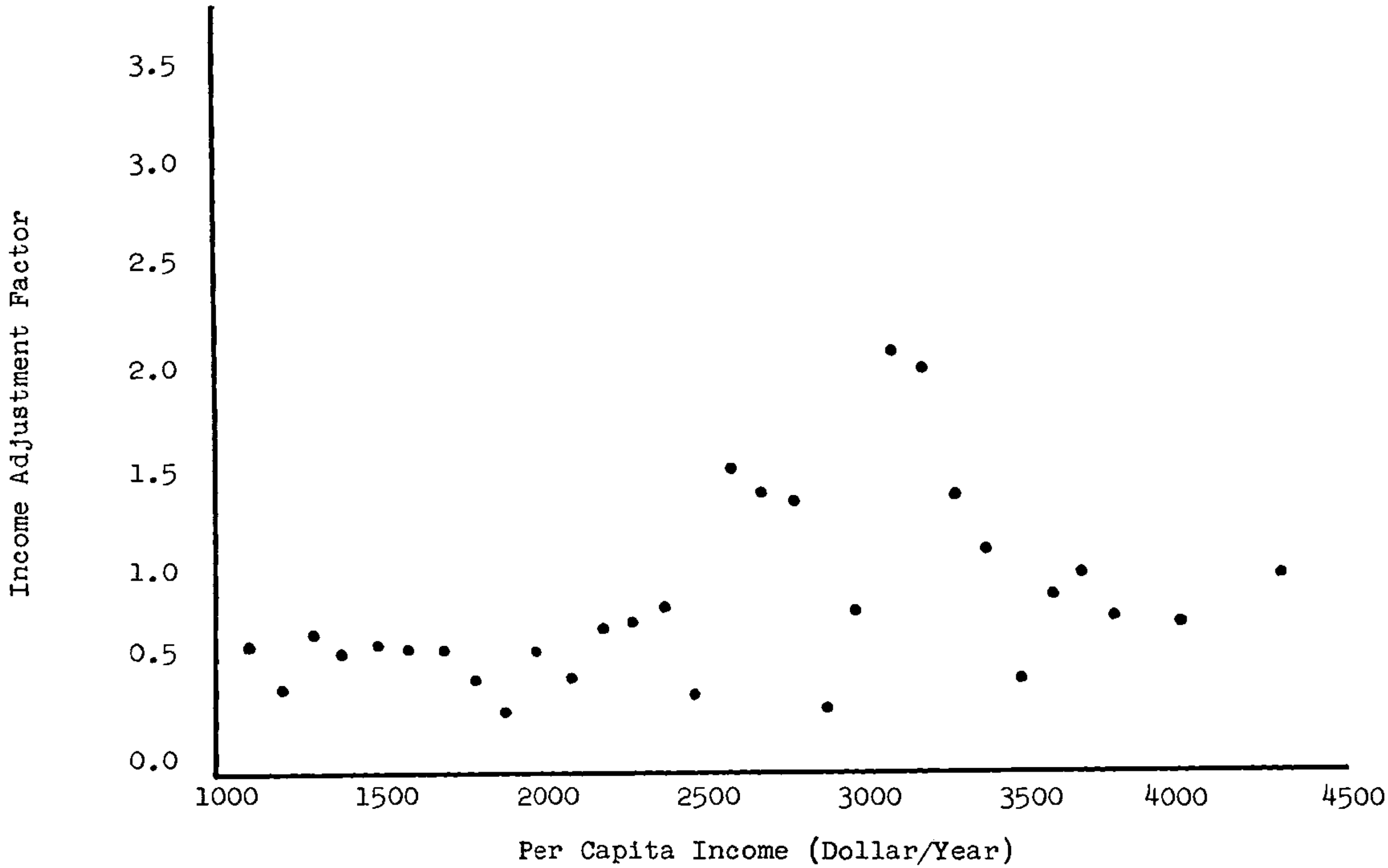

Figure 4. Income Adjustment Factors Calculated Using the Adjustment for the Low Georgia Response

The impedance factors that would be obtained from the relationships given earlier in this chapter would be based on reported trips, only adjusted for the unusually low questionnaire response from within Georgia. Since only a small percentage of the questionnaires distributed at Six Flags in 1968 were returned, another adjustment was necessary in order to permit the calculation of impedance factors that could be used in estimating the actual number of trips to Six Flags.

This adjustment was made by multiplying the coefficients of the first impedance factor function by a number approximately equal to the ratio of the number of vehicle-trips made to Six Flags in 1968 (338,476) to the number of predicted trips (32,953) based on the impedance factors computed from the final impedance factor function.

This resulted in the following impedance factor function, which yields impedance factors that are appropriate to use in estimating (by the model on page 6) the actual number of vehicle-trips from an area to Six Flags:

$$IF = 0.072\ (e^{-0.007T}), \qquad T < 930$$

$$IF = 0.000129\ (e^{-0.00025T}), \quad T \geq 930$$

where

IF = impedance factor

T = traveltime in minutes

e = the base of natural logarithms $\cong 2.718$

It is interesting to note that Matthias and Grecco (15) developed a model of the above form to predict trips to Indiana reservoirs, even though the situation studied in that research was not the same as that studied in this. Nevertheless, it is particularly noteworthy that they concluded that two separate exponential relationships should be used to predict recreational trips to Indiana reservoirs, one applicable to areas where the closest reservoir to the area is the one in question, and the other applicable to areas with an intervening reservoir. Although similar results were obtained in this study, this writer did not reach any conclusions concerning why two separate exponential relationships were applicable.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

From the research connected with this study, the conclusions listed below were reached by the writer:

1. The average number of trips made to Six Flags Over Georgia in 1968 decreased according to an exponential function as the traveltime to Six Flags Over Georgia increased.

2. There is reason to believe that when a certain value of traveltime has been exceeded, the effect of further increases in traveltime on the number of trips is much less pronounced, although this effect is still exponential. It thus appears that two separate exponential relationships describe the effect of traveltime.

3. The questionnaire results were biased by lower returns from persons who travelled short distances (generally, from within Georgia).

4. Although there appears to be a relationship between per capita income and recreational trips, efforts in this study to ascertain this relationship were unsuccessful. It is probable that other socio-economic factors had a significant influence on recreational trip-making and thus obscured the effect of per capita income from this research.

5. Although it would seem logical that the type and quality of facilities available at a recreational area would influence the number of trips made to that area, such influences were not considered in this study. Of course, since only one recreational area was studied, the effect of different facilities could not be determined.

Since this research was concerned with an area in which little work has been done, it is only a preliminary step to a full understanding of inter-city recreational trips, and it thus leaves many questions unanswered. The writer makes the following recommendations concerning further research in this area.

1. Since this study was only concerned with data for one year, further study is needed that will determine possible changes in the effect of traveltime over a period of several years.

2. Further research should be conducted to determine the effect of income and other socio-economic factors on inter-city recreational trip-making.

3. Additional study is needed to determine whether vehicle occupancy rates vary with traveltime or are independent of traveltime.

4. Additional investigation is needed to discover how the effect of traveltime varies with the day of the week, the time of year, and holidays.

5. Studies similar to this one should be conducted

in order to determine what differences, if any, in the effect of traveltime on recreational trip-making are encountered at other types of facilities. It is expected that trip-making to different types and sizes of recreation areas will be influenced differently by traveltime.

6. More research is needed to determine what caused the sharp break found in the impedance factor curve at approximately 930 minutes.

APPENDIX I

DATA

Table 2. Composition of Zones

Zone Number	State(s)	Counties
1	Georgia	Dade, Catoosa, Walker, Chattooga, Whitfield, Gordon
2	Georgia	Murray, Gilmer, Fannin
3	Georgia	Union, Towns, Rabun, White, Habersham
4	Georgia	Floyd
5	Georgia	Bartow, Cherokee
6	Georgia	Pickens, Dawson, Lumpkin
7	Georgia	Hall
8	Georgia	Stephens, Franklin, Hart, Banks
9	Georgia	Polk, Haralson
10	Georgia	Paulding, Carrol, Coweta
11	Georgia	Douglas
12	Georgia	Cobb, Fulton, Clayton, DeKalb
13	Georgia	Gwinnett, Rockdale, Forsyth
14	Georgia	Jackson, Barrow, Walton, Newton
15	Georgia	Clarke
16	Georgia	Madison, Oglethorpe
17	Georgia	Elbert, Wilkes, Lincoln
18	Georgia	Heard, Troup, Meriwether
19	Georgia	Fayette, Spalding, Henry, Butts
20	Georgia	Oconee, Morgan, Greene, Putnam, Jasper
21	Georgia	Taliaferro, McDuffie, Warren, Columbia, Glascock
22	Georgia	Pike, Upson, Lamar, Monroe, Jones
23	Georgia	Hancock, Baldwin
24	Georgia	Harris, Talbot, Taylor
25	Georgia	Crawford, Peach, Macon, Houston, Twiggs, Bleckley, Wilkinson
26	Georgia	Bibb
27	Georgia	Dodge, Laurens
28	Georgia	Washington, Jefferson, Johnson
29	Georgia	Burke, Jenkins, Emanuel
30	Georgia	Screven, Bulloch, Effingham
31	Georgia	Muscogee
32	Georgia	Chattahoochee, Marion, Schley
33	Georgia	Stewart, Webster, Quitnan, Randolph, Terrell
34	Georgia	Sumter, Lee
35	Georgia	Dooly, Crisp, Pulaski, Wilcox
36	Georgia	Treutlen, Wheeler, Montgomery, Telfair

Table 2. Composition of Zones (Continued)

Zone Number	State(s)	Counties
37	Georgia	Candler, Toombs, Tattnal, Evans
38	Georgia	Bryan, Liberty, Long, McIntosh, Wayne
39	Georgia	Chatham
40	Georgia	Clay, Calhoun, Early, Baker, Mitchell, Miller
41	Georgia	Dogherty
42	Georgia	Worth, Turner, Tift, Irwin, Ben Hill
43	Georgia	Jeff Davis, Appling, Bacon, Coffee, Atkinson
44	Georgia	Seminole, Decatur, Grady, Thomas
45	Georgia	Berrien, Lanier, Cook, Colquitt, Brooks
46	Georgia	Lowndes
47	Georgia	Pierce, Ware, Clinch, Echols
48	Georgia	Brantley, Charlton, Camden
49	Georgia	Glynn
50	Georgia	Richmond
51	South Carolina	Oconee, Pickens, Anderson
52	South Carolina	Greenville, Spartanburg
53	South Carolina	Cherokee
54	South Carolina	York, Chester, Fairfield
55	South Carolina	Union
56	South Carolina	Laurens, Abbeville, Greenwood, McCormick
57	South Carolina	Newberry, Saluda, Lexington
58	South Carolina	Edgefield, Aiken
59	South Carolina	Richland
60	South Carolina	Lancaster, Kershaw
61	South Carolina	Chesterfield, Darlington, Marlboro
62	South Carolina	Dillon, Marion, Horry, Georgetown
63	South Carolina	Lee, Sumter, Clarendon
64	South Carolina	Florence, Williamsburg
65	South Carolina	Calhoun, Orangeburg
66	South Carolina	Barnwell, Bamberg, Allendale
67	South Carolina	Hampton, Jasper, Beaufort
68	South Carolina	Dorchester, Colleton
69	South Carolina	Berkeley
70	South Carolina	Charleston
71	Florida	Escambia
72	Florida	Santa Rose, Okaloosa, Walton
73	Florida	Holmes, Washington

Table 2. Composition of Zones (Continued)

Zone Number	State(s)	Counties
74	Florida	Jackson, Gadsden
75	Florida	Bay
76	Florida	Calhoun, Liberty, Gulf, Franklin
77	Florida	Wakulla, Leon
78	Florida	Jefferson, Madison, Hamilton, Columbia, Baker, Union, Bradford, Suwanee, Lafayette, Taylor, Nassau
79	Florida	Duval
80	Florida	Dixie, Gilchrist, Levy
81	Florida	Alachua
82	Florida	Clay, Putnam, Marion
83	Florida	St. Johns, Flagler
84	Florida	Citrus, Sumter, Pasco, Hernando, Lake
85	Florida	Volusia
86	Florida	Seminole, Orange, Brevard
87	Florida	Pinellas, Hillsborough
88	Florida	Polk
89	Florida	Osceola
90	Florida	Manatee, Sarasota
91	Florida	Hardee, Highlands, Desoto, Glades, Charlotte
92	Florida	Indian River, Okeechobee, St. Lucie, Martin
93	Florida	Hendry, Lee, Collier, Monroe
94	Florida	Palm Beach, Broward
95	Florida	Dade
96	Alabama	Lauderdale, Colbert, Franklin
97	Alabama	Limestone, Lawrence, Morgan
98	Alabama	Madison
99	Alabama	Jackson, DeKalb, Marshall
100	Alabama	Marion, Lamar, Fayette
101	Alabama	Winston, Walker
102	Alabama	Cullmar, Blount
103	Alabama	Etowah, Cherokee
104	Alabama	Pickens, Greene, Hale, Sumter
105	Alabama	Tuscaloosa
106	Alabama	Jefferson
107	Alabama	St. Clair, Calhoun, Tallodega, Clay
108	Alabama	Cleburne, Randolph
109	Alabama	Shelby, Bibb
110	Alabama	Chilton, Coosa, Autauga
111	Alabama	Tallapoosa, Elmore, Macon

Table 2. Composition of Zones (Continued)

Zone Number	State(s)	Counties
112	Alabama	Chambers, Lee, Russell
113	Alabama	Perry, Dallas
114	Alabama	Marengo, Wilcox
115	Alabama	Lowndes, Butler, Crenshaw
116	Alabama	Montgomery
117	Alabama	Bullock, Barbour, Pike
118	Alabama	Washington, Choctaw
119	Alabama	Clarke, Monroe, Conecuh, Escambiea, Baldwin
120	Alabama	Covington, Coffee, Geneva
121	Alabama	Dale, Henry, Houston
122	Alabama	Mobile
123	Tennessee	Shelby
124	Tennessee	Obion, Dyer, Lauderdale, Tipton, Lake
125	Tennessee	Henry, Weakley, Gibson, Crockett Haywood, Fatette
126	Tennessee	Madison
127	Tennessee	Benton, Humphreys, Carroll, Perry, Henderson, Decatur, Chester, Hardeman, McNairy, Hardin, Dickson
128	Tennessee	Stewart, Robertson, Montgomery, Cheatham, Houston
129	Tennessee	Davidson
130	Tennessee	Sumner, Macon, Clay, Pickett, Scott, Morgan, Fentress, Overton, Jackson, Smith, Trousdale, Putnam, Wilson
131	Tennessee	Williamson, Maury, Hickman, Lewis, Lawrence, Wayne
132	Tennessee	Rutherford, Bedford, Marshall, Moore, Giles, Lincoln
133	Tennessee	Cumberland, White, DeKalb, Cannon, Warren, Van Buren, Coffee, Franklin
134	Tennessee	Campbell, Claiborne, Hancock, Union, Grainger, Hamblen
135	Tennessee	Knox, Anderson
136	Tennessee	Bledsoe, Rhea, Sequatchie, Grundy, Marion
137	Tennessee	Hamilton
138	Tennessee	Monroe, McMinn, Polk, Bradley, Meigs

Table 2. Composition of Zones (Continued)

Zone Number	State(s)	Counties
139	Tennessee	Roane, Loudon, Blount
140	Tennessee	Jefferson, Cocke, Sevier
141	Tennessee	Hawkins, Greene, Washington, Carter, Sullivan, Johnson, Unicoi
142	North Carolina	Cherokee, Clay, Graham, Swain, Jackson, Macon
143	North Carolina	Haywood, Madison, Yancey
144	North Carolina	Buncombe
145	North Carolina	Transylvania, Rutherford, Polk, Henderson
146	North Carolina	Mitchell, Avery, Caldwell, McDowell, Burke
147	North Carolina	Watauga, Ashe, Alleghany, Wilkes, Yadkin, Surry
148	North Carolina	Alexander, Catawba, Rowan, Cabarrus, Davidson, Davie, Iredell
149	North Carolina	Lincoln, Cleveland
150	North Carolina	Gaston, Mecklenburg
151	North Carolina	Stokes, Rockingham, Caswell, Person, Orange, Alamance
152	North Carolina	Forsyth, Gulford
153	North Carolina	Randolph, Chatham, Moore, Harnett, Lee
154	North Carolina	Union, Anson, Stanly, Montgomery
155	North Carolina	Richmond, Scotland, Hoke, Robeson, Bladen, Columbus, Brunswick
156	North Carolina	Cumberland
157	North Carolina	Granville, Vance, Warren, Franklin, Nash, Edgecombe, Wilson
158	North Carolina	Durham, Wake
159	North Carolina	Johnston, Wayne, Sampson, Duplin, Pender, New Hanover
160	North Carolina	Greene, Pitt, Lenoir, Craven, Jones, Onslow, Pamlico, Carteret
161	North Carolina	Northampton, Halifax, Hertford, Bertie, Martin, Washington, Beaufort, Hyde
162	North Carolina	Gates, Chowan, Tyrrell, Dare, Perquimans, Pasquotank, Camden, Currituck
163	Mississippi	DeSoto, Tate, Tunica, Panola, Quitman, Coahoma

Table 2. Composition of Zones (Continued)

Zone Number	State(s)	Counties
164	Mississippi	Marshall, Benton, Tippah, Union, Pontotoc, Lafayette
165	Mississippi	Alcorn, Tishomingo, Prentiss, Itawamba, Lee
166	Mississippi	Bolivar, Sunflower, Washington
167	Mississippi	Tallahatchie, Yalobusha, Grenada, Carroll, Leflore
168	Mississippi	Calhoun, Chickasaw, Webster, Choctaw, Montgomery, Attala
169	Mississippi	Monroe, Lowndes, Clay, Oktibbeha
170	Mississippi	Holmes, Humphreys, Yazoo, Sharkey, Issaquena, Warren, Madison
171	Mississippi	Winston, Noxubee, Leake, Neshoba, Scott, Rankin, Simpson, Smith, Jasper, Covington, Jones, Wayne
172	Mississippi	Kemper, Newton, Lauderdale, Clarke
173	Mississippi	Hinds
174	Mississippi	Claiborne, Copiah, Jefferson, Lincoln, Lawrence, Jefferson Davis, Adams, Franklin, Wilkinson, Amite, Pike, Walthall
175	Mississippi	Marion, Lamar, Forrest, Perry, Greene, Pearl River, Stone, George, Hancock
176	Mississippi	Harrison, Jackson
177	Virginia	Lee, Scott, Wise, Dickinson, Russell, Washington, Buchanan, Tazewell, Smyth, Grayson, Wythe, Bland, Giles, Pulaski, Montgomery, Floyd, Carroll, Patrick, Bristol, Galax, Norton, Radford
178	Virginia	Craig, Roanoke, Franklin, Henry, Pittsylvania, Bedford, Botetourt, Campbell, Appomattox, Charlotte, Halifax, Mecklenburg, Lunenburg, Prince Edward, Amelia, Nottoway, Brunswick, Danville, Lynchburg, Martinsville, Roanoke, South Boston
179	Virginia	Alleghany, Both, Highland, Augusta, Albermarle, Fluvanna, Cumberland, Buckingham, Nelson, Rockbridge, Buena Vista, Charlottesville, Clifton Forge, Covington, Lexington, Staunton, Waynesboro

Table 2. Composition of Zones (Continued)

Zone Number	State(s)	Counties
180	Virginia	Rockingham, Greene, Madison, Culpepper, Stafford, King George, Prince William, Loudoun, Clarke, Frederick, Warren, Page, Rappahannock, Fauquier, Harrisonburg, Winchester
181	Virginia	Arlington, Fairfax, Alexandria, Fairfax, Falls Church
182	Virginia	Orange, Spotsylvania, Caroline, Westmoreland, Northumberland, Lancaster, Richmond, Middlesex, Essex, King and Queen, King William, New Kent, Hanover, Louisa, Goochland, Powhattan, Fredericksburg
183	Virginia	Henrico, Chesterfield, Richmond
184	Virginia	Glouchester, Dinwiddie, Greensville, Southampton, Nansemond, Isle of Wight, Surry, Sussex, Prince George, Charles City, James City, York, Colonial Heights, Franklin, Hopewell, Petersburg, Suffolk, Williamsburg
185	Virginia	Norfolk, Princess Anne, Chesapeake, Hampton, Newport News, Norfolk, Portsmouth, Virginia Beach
186	Virginia	Northampton, Accomack
187	Delaware	All
188	Maryland and	All
	District of Columbia	All
189	Pennsylvania	All
	New Jersey	All
190	Ohio	All
	Indiana	All
191	Missouri	All
	Illinois	All
192	West Virginia	All
193	Kentucky	Henderson, Webster, Hopkins, Caldwell, Christian, Trigg, Daviess, McLean, Muhlenberg, Todd, Hancock, Ohio, Butler, Warren, Logan, Simpson,

Table 2. Composition of Zones (Continued)

Zone Number	State(s)	Counties
193 (Cont'd)	Kentucky	Breckinridge, Grayson, Edmonson, Barren, Allen, Meade, Hardin, Larue, Hart, Green, Metcalfe, Monroe, Taylor, Adair, Cumberland
194	Kentucky	Union, Crittenden, Livingston, Lyon, Calloway, Marshall, McCracken, Ballard, Carlisle, Hickman, Fulton, Graves
195	Kentucky	Casey, Russell, Clinton, Lincoln, Pulaski, McCreary, Wayne, Rock Castle, Laurel, Whitley, Lee, Owsley, Clay, Know, Breathitt, Perry, Leslie, Bell, Harlan, Letcher, Knott, Jackson
196	Kentucky	Trimble, Oldham, Jefferson, Bullitt, Carroll, Henry, Shelby, Spencer, Nelson, Washington, Marion, Gallatin, Grant, Owen, Scott, Franklin, Woodford, Anderson, Mercer, Boyle, Boone, Kenton, Campbell, Pendleton, Harrison, Bourbon, Fayette, Jessamine, Madison, Garrard, Brocken, Robertson, Nicholas, Clark, Estill
197	Kentucky	Mason, Fleming, Bath, Montgomery, Powell, Lewis, Rowan, Menifee, Wolfe, Greenup, Elliott, Morgan, Magoffin, Carter, Boyd, Lawrence, Johnson, Martin, Floyd, Pike
198	Arkansas	All
199	Louisiana	All
200	New York	All
201	Maine	All
	Vermont	All
	New Hampshire	All
	Massachusetts	All
	Connecticut	All
	Rhode Island	All
202	Iowa	All
	Wisconsin	All
	Michigan	All
203	Minnesota	All
	North Dakota	All
	South Dakota	All

Table 2. Composition of Zones (Continued)

Zone Number	State(s)	Counties
204	Nebraska	All
	Kansas	All
	Colorado	All
	New Mexico	All
205	Texas	All
	Oklahoma	All
206	Arizona	All
	Utah	All
	Nevada	All
	Idaho	All
	Wyoming	All
	Montana	All
207	California	All
208	Oregon	All
	Washington	All

Table 3. Values of Traveltime Used in Estimating Impedance Factors

Traveltime Value Used	Range for which This Value Was Used	Traveltime Value Used	Range for which This Value Was Used
30	0-37	2760	2700-2819
45	38-52	2880	2820-2939
60	53-67	3000	2940 and Over
75	68-82		
90	83-97		
105	98-112		
120	113-134		
150	135-164		
180	165-194		
210	195-224		
240	225-254		
270	255-284		
300	285-314		
330	315-344		
360	345-374		
390	375-404		
420	405-449		
480	450-509		
540	510-569		
600	570-629		
660	630-689		
720	690-749		
780	750-809		
840	810-869		
900	870-929		
960	930-989		
1020	990-1049		
1080	1050-1109		
1140	1110-1169		
1200	1170-1259		
1320	1260-1379		
1440	1380-1499		
1560	1500-1619		
1680	1620-1739		
1800	1740-1859		
1920	1860-1979		
2040	1980-2099		
2160	2100-2219		
2280	2220-2339		
2400	2340-2459		
2520	2460-2579		
2640	2580-2699		

Table 4. Data Used in Estimating Impedance Factors

Zone Number	Population	Total Personal Income	Traveltime
1	184311	463090	144
2	33338	45899	141
3	47856	86969	129
4	78670	212095	85
5	57271	131250	77
6	21587	40118	125
7	60383	140926	77
8	57924	117472	113
9	43392	107532	68
10	87676	211242	50
11	21278	43896	21
12	1248008	4318815	21
13	81637	167579	51
14	81230	182637	73
15	55025	147941	107
16	18369	29091	132
17	35263	68564	160
18	73462	162557	99
19	79835	171533	69
20	40936	76952	109
21	43474	69144	180
22	63400	132125	85
23	49682	108279	141
24	27455	46000	139
25	119672	277135	150
26	171194	501240	113
27	50771	96550	191
28	43784	71594	197
29	46685	77312	254
30	51055	85650	306
31	199706	531148	172
32	22633	75094	179
33	34085	52994	230
34	33069	61972	221
35	44684	83142	181
36	27584	41884	233
37	48415	89731	254
38	60149	117771	336
39	228783	587100	359
40	50606	88180	275
41	104514	247082	242
42	70874	128415	225
43	59337	102268	285
44	90402	175943	308

Table 4. Data Used in Estimating Impedance Factors (Continued)

Zone Number	Population	Total Personal Income	Traveltime
45	80356	152181	272
46	63066	149372	276
47	57904	122960	324
48	24625	52368	390
49	54372	153991	378
50	164891	463313	229
51	198851	479560	166
52	409535	1099389	196
53	35768	73339	231
54	135395	289469	250
55	29295	64141	256
56	124511	286805	208
57	116187	256331	276
58	119674	288716	239
59	246126	693535	282
60	76630	165271	289
61	114204	203526	370
62	175617	302719	444
63	138392	238220	344
64	128216	225475	386
65	79557	136752	317
66	44791	82102	294
67	89241	176811	411
68	53874	93892	358
69	45033	76055	399
70	260740	669426	409
71	204944	533523	402
72	145544	293036	416
73	24506	28078	354
74	82340	142797	363
75	69682	160741	427
76	28225	50945	440
77	94847	220502	349
78	142889	256072	358
79	548315	1781507	405
80	20705	35364	409
81	97333	226057	383
82	123968	254926	424
83	40916	99851	451
84	151731	334264	490
85	178329	441596	514
86	648239	2017749	556
87	930344	2533166	544

Table 4. Data Used in Estimating Impedance Factors (Continued)

Zone Number	Population	Total Personal Income	Traveltime
88	225776	630522	549
89	22854	42483	532
90	186863	505098	598
91	84219	177072	603
92	124624	284730	620
93	194357	510664	735
94	792613	2242223	711
95	1188445	3861438	746
96	143040	327184	359
97	130898	215389	279
98	189869	514346	250
99	132499	192556	194
100	54069	70708	310
101	71486	121368	251
102	73822	100452	255
103	119447	330556	150
104	77659	95029	324
105	121587	260937	266
106	701525	2398808	188
107	216640	491364	151
108	31485	45214	113
109	49287	83111	202
110	57584	82120	244
111	95773	166806	178
112	144338	281475	184
113	77257	126523	279
114	47394	65789	322
115	57030	78623	253
116	192392	572779	219
117	66445	93967	216
118	34498	65452	403
119	159641	271312	369
120	91811	148040	323
121	109153	237488	321
122	372761	1026732	419
123	746780	2071218	556
124	123079	241270	517
125	162513	293349	495
126	64780	176558	468
127	175949	295380	443
128	125577	254464	399
129	452909	1455142	325
130	238245	406992	346

Table 4. Data Used in Estimating Impedance Factors (Continued)

Zone Number	Population	Total Personal Income	Traveltime
131	139721	289143	345
132	158754	343052	272
133	151919	320261	262
134	116133	203759	343
135	338029	936658	289
136	62879	106468	197
137	242425	774519	157
138	121235	255904	210
139	130571	297143	259
140	80392	142512	320
141	344824	863018	420
142	65841	122534	203
143	70880	142111	326
144	140610	381180	287
145	117933	268940	253
146	171378	358758	330
147	167536	345402	390
148	455918	1211086	335
149	106412	233952	251
150	483331	1533184	293
151	300322	727231	427
152	519754	1702772	392
153	224945	516071	442
154	141451	305274	342
155	273108	480612	473
156	200364	529978	497
157	302223	585878	540
158	342252	1045019	473
159	347822	720573	541
160	410602	872598	637
161	219892	380551	610
162	81715	151344	702
163	184929	267420	545
164	112429	180918	472
165	147100	268681	409
166	197276	342712	598
167	136531	215070	517
168	95200	148151	480
169	140961	277540	389
170	174868	298941	570
171	291205	502806	486
172	131359	258110	404
173	218469	606620	508

Table 4. Data Used in Estimating Impedance Factors (Continued)

Zone Number	Population	Total Personal Income	Traveltime
174	222859	398571	593
175	195200	391213	534
176	205755	498795	483
177	539847	986748	519
178	737049	1737118	497
179	274577	712034	614
180	371851	903733	671
181	746042	3229330	730
182	202215	428455	661
183	482811	1704858	631
184	341193	756585	604
185	963368	2799610	667
186	47656	80130	752
187	544030	2026044	886
188	4561403	17062121	792
189	18803174	67401326	903
190	15691212	53591090	780
191	15447937	58768248	786
192	1778563	4612300	748
193	698329	1655668	456
194	200761	454760	541
195	374305	595625	417
196	1532501	4595563	562
197	357325	717632	564
198	2023846	4497868	725
199	3787917	9175240	703
200	18544446	74423993	1063
201	11606668	41865410	1237
202	15736420	54803650	1182
203	5022318	15753318	1529
204	7140966	21620115	1594
205	13689036	38074137	1091
206	5224161	14667357	2301
207	20165173	74992000	2745
208	5249562	18019767	3230

APPENDIX II

RESULTS

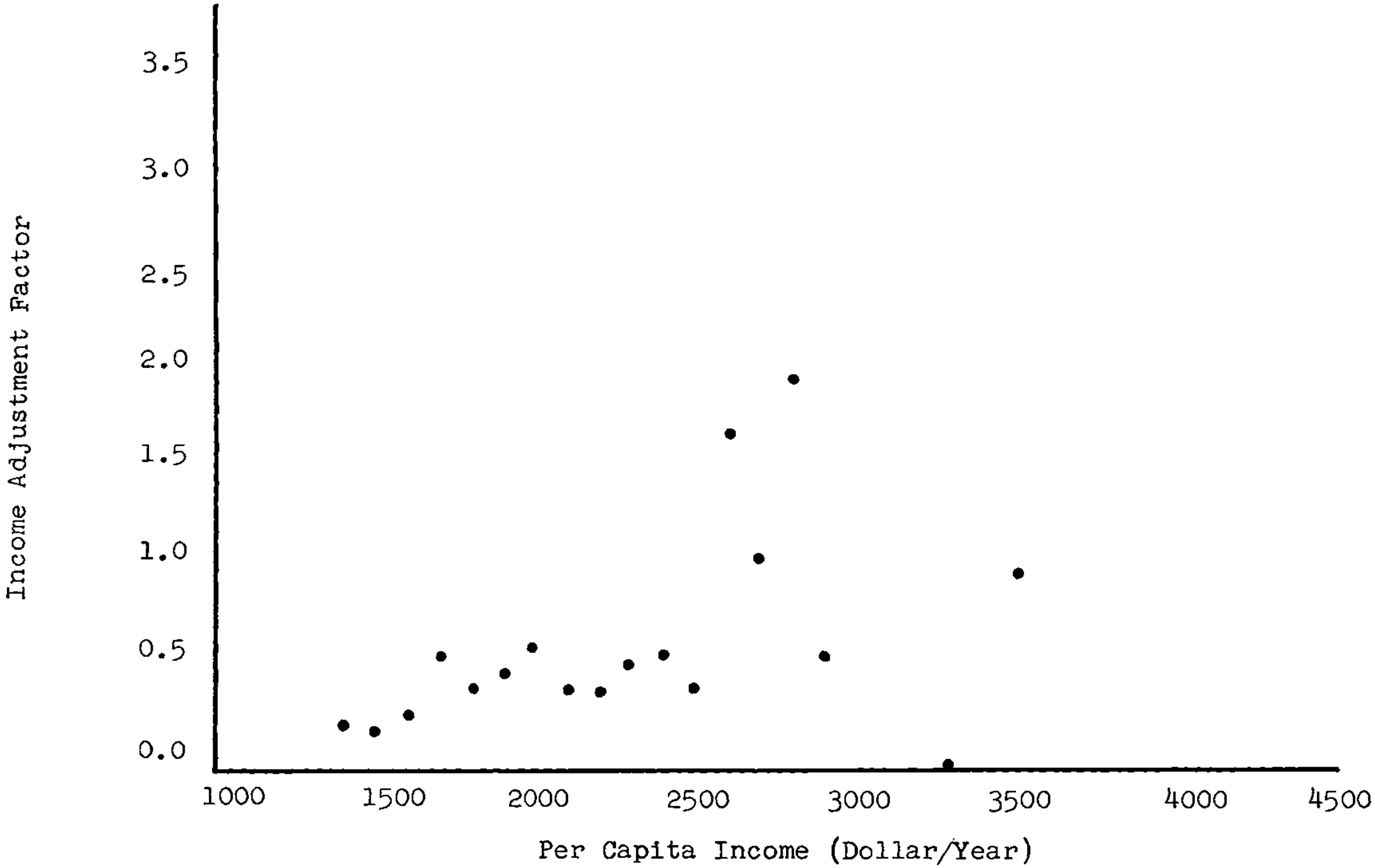

Figure 5. Income Adjustment Factors Calculated Using Zones 1-50 with No Adjustment for the Low Georgia Response

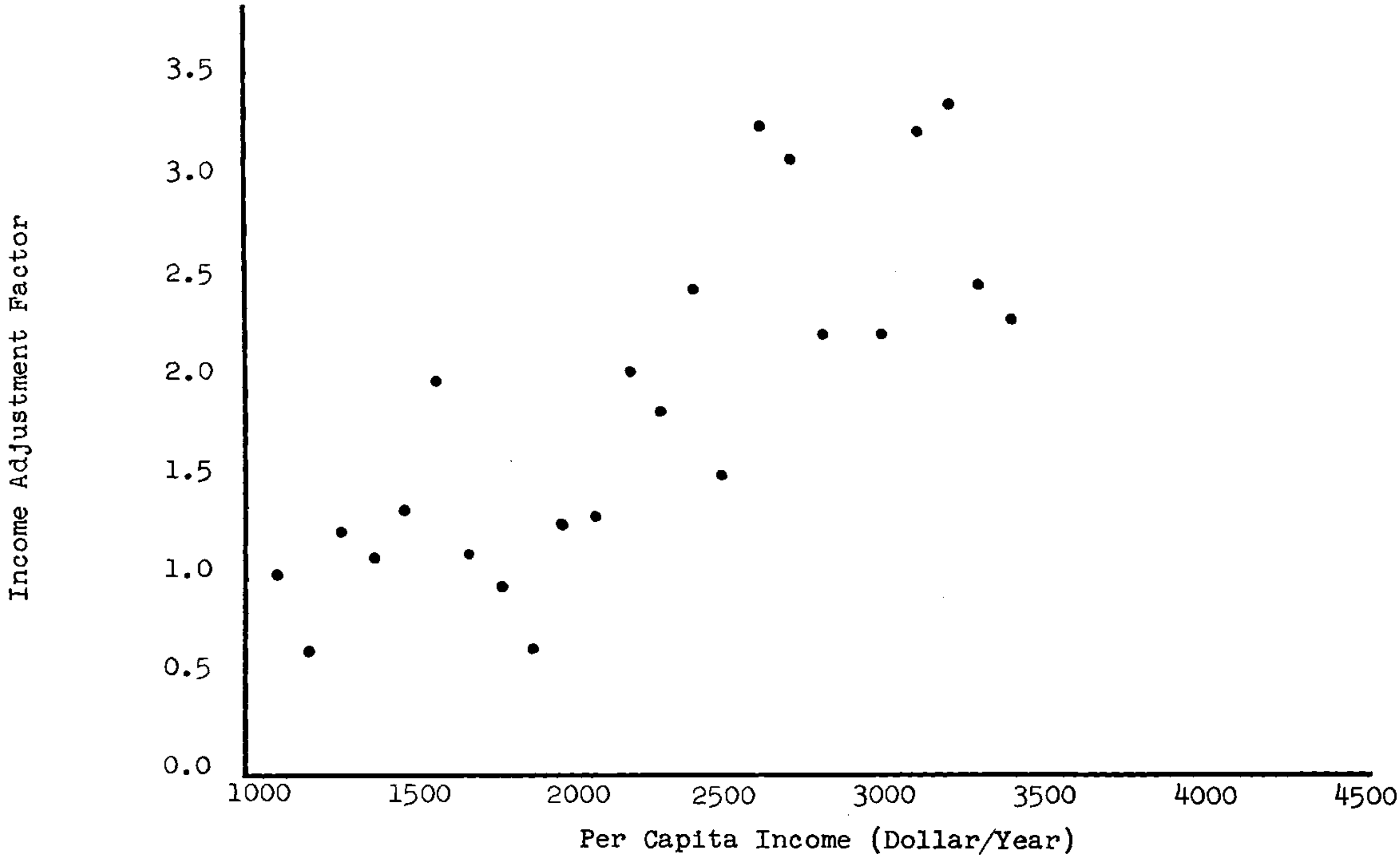

Figure 6. Income Adjustment Factors Calculated Using Zones 51-176 with No Adjustment for the Low Georgia Response

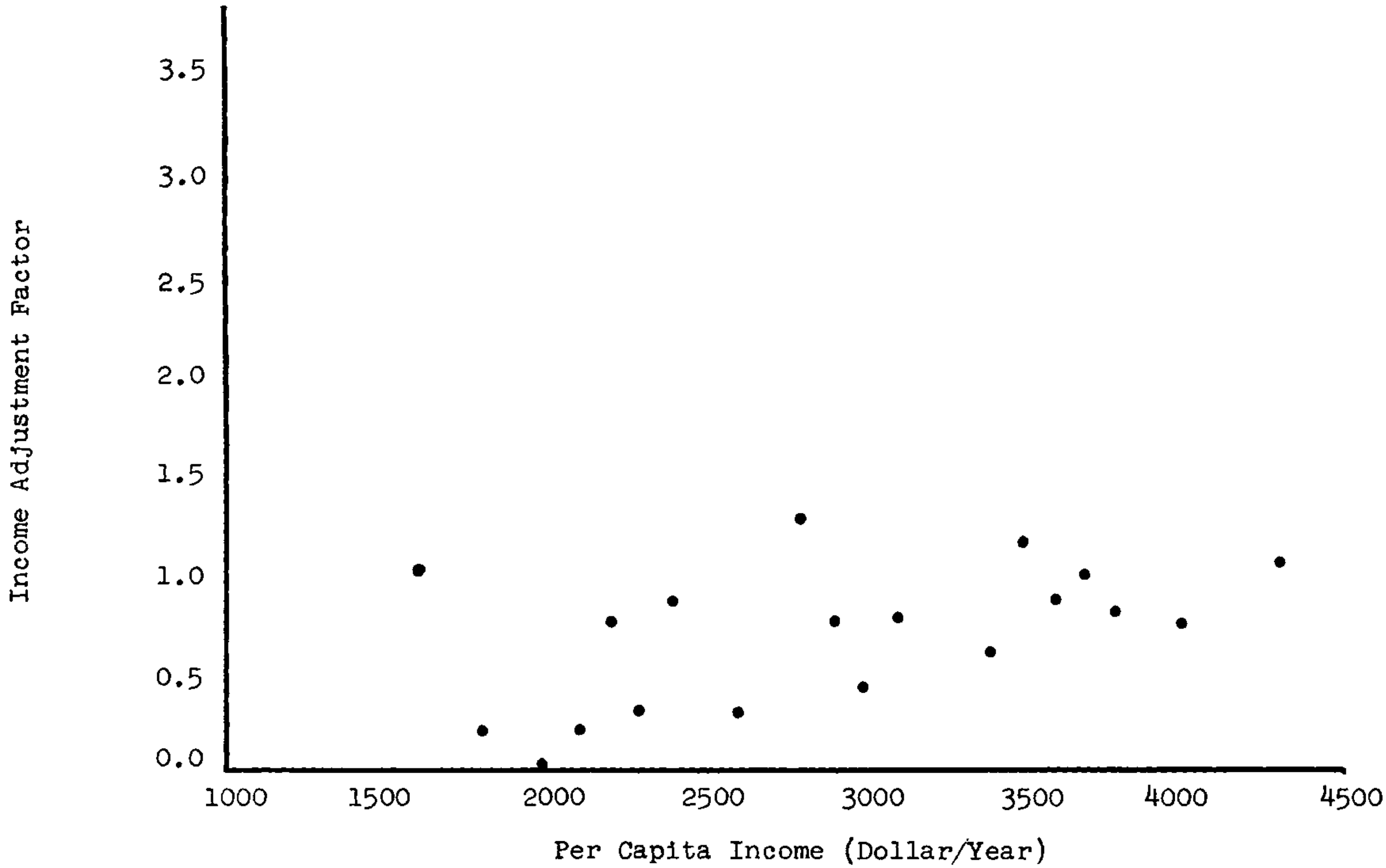

Figure 7. Income Adjustment Factors Calculated Using Zones 177-208 with No Adjustment for the Low Georgia Response

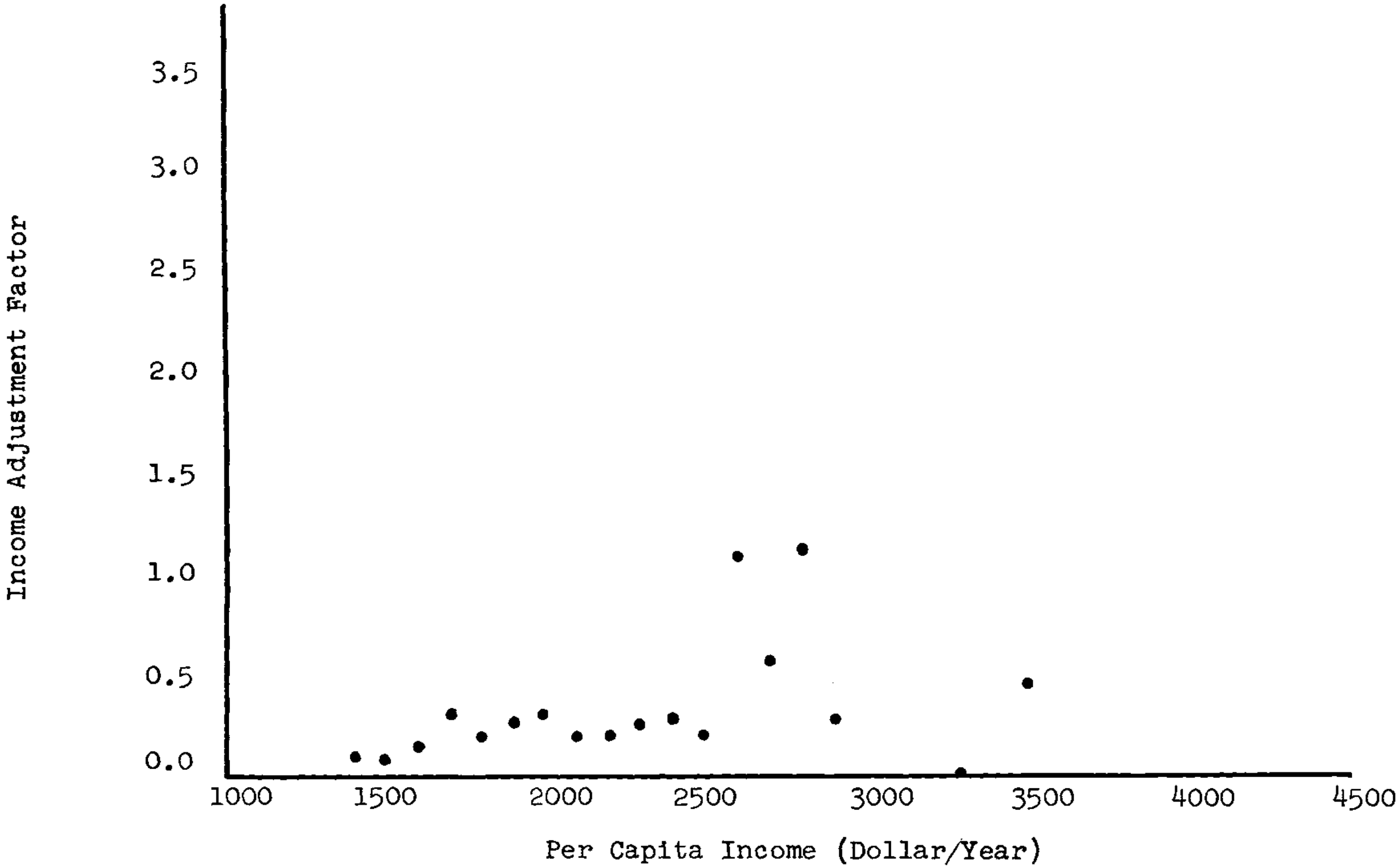

Figure 8. Income Adjustment Factors Calculated Using Zones 1-50, Adjusted for the Low Georgia Response

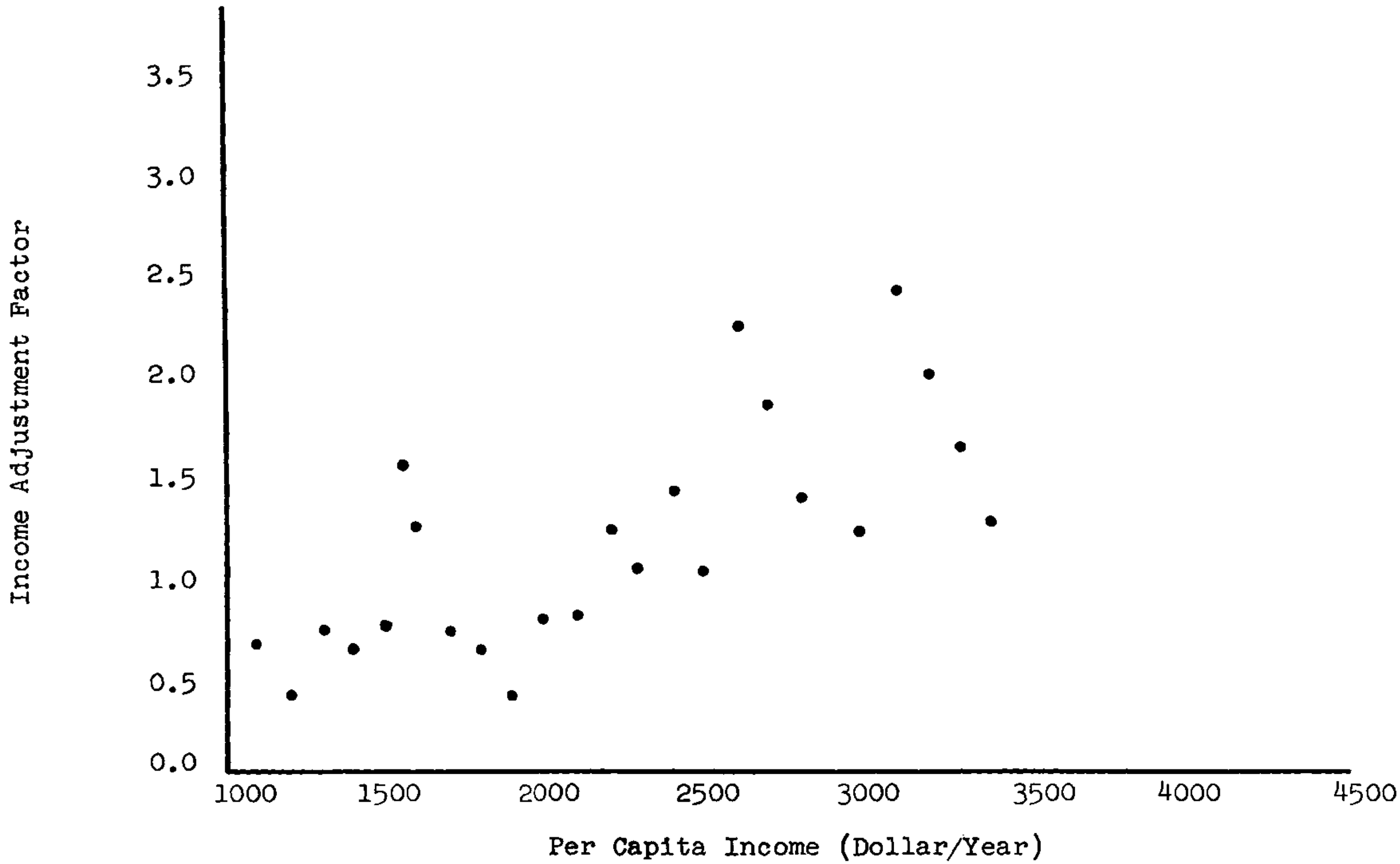

Figure 9. Income Adjustment Factors Calculated Using Zones 51-176, Adjusted for the Low Georgia Response

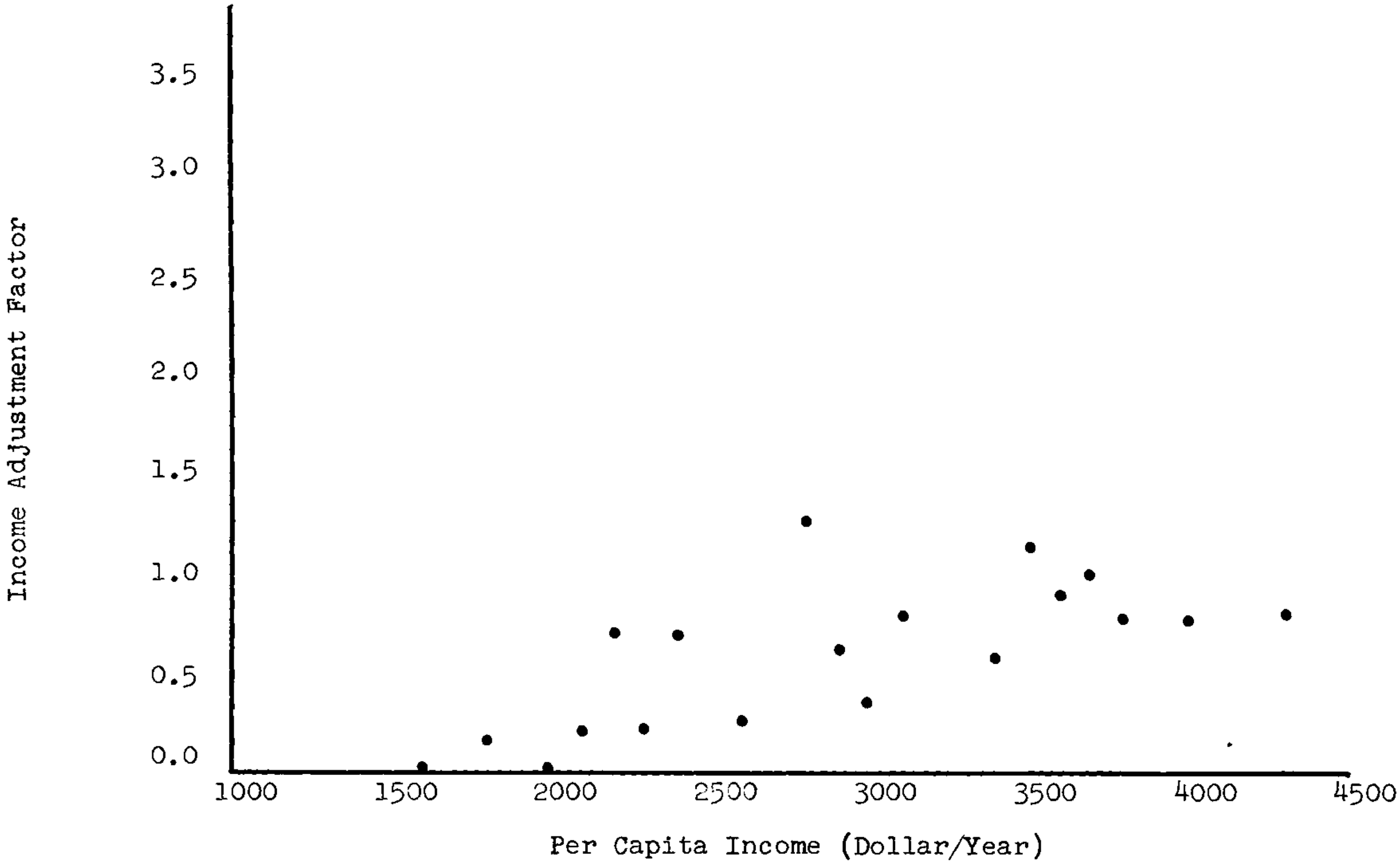

Figure 10. Income Adjustment Factors Calculated Using Zones 177-208, Adjusted for the Low Georgia Response

Table 5. Comparison of Values of Reported Trips and Predicted Trips

Zone Number	Reported Trips	Predicted Trips
1	89	451.5
2	11	81.7
3	24	144.6
4	82	293.3
5	46	237.2
6	11	65.2
7	69	250.0
8	53	175.0
9	48	179.7
10	92	447.9
11	33	120.7
12	3390	7081.3
13	92	417.0
14	81	336.4
15	99	184.7
16	6	55.5
17	25	86.4
18	33	246.6
19	71	330.6
20	26	137.4
21	9	86.3
22	17	236.4
23	27	121.7
24	2	67.3
25	96	293.1
26	148	517.3
27	21	100.8
28	19	70.5
29	23	60.9
30	36	43.8
31	327	396.5
32	1	44.9
33	6	44.5
34	28	53.2
35	18	88.7
36	4	36.0
37	24	63.2
38	20	41.8
39	145	128.9
40	9	53.5
41	71	136.3
42	29	92.5
43	21	50.9

Table 5. Comparison of Values of Reported Trips and Predicted Trips (Continued)

Zone Number	Reported Trips	Predicted Trips
44	28	77.5
45	24	85.0
46	33	66.7
47	11	40.2
48	3	11.2
49	26	24.8
50	250	215.1
51	515	394.8
52	1129	659.1
53	44	46.7
54	139	176.6
55	37	31.0
56	245	200.4
57	143	122.9
58	405	156.1
59	385	260.3
60	79	65.7
61	14	64.3
62	27	65.0
63	48	96.2
64	54	58.5
65	78	68.2
66	37	38.4
67	19	33.0
68	35	30.3
69	14	20.6
70	362	96.5
71	149	93.6
72	56	53.9
73	9	13.8
74	9	46.4
75	44	25.8
76	7	10.4
77	92	53.4
78	71	80.5
79	476	202.9
80	2	7.7
81	36	44.4
82	38	45.9
83	20	9.9
84	29	36.9
85	59	28.5
86	289	103.6

Table 5. Comparison of Values of Reported Trips and Predicted Trips (Continued)

Zone Number	Reported Trips	Predicted Trips
87	287	148.7
88	54	36.1
89	3	3.7
90	52	19.6
91	8	8.8
92	8	13.1
93	20	8.8
94	71	35.9
95	99	53.8
96	111	80.6
97	284	138.4
98	674	247.7
99	193	263.1
100	34	46.3
101	111	93.3
102	93	78.1
103	344	292.6
104	22	54.0
105	148	128.6
106	1756	1392.9
107	525	530.7
108	60	95.1
109	79	79.3
110	63	75.1
111	143	190.2
112	259	286.6
113	58	81.7
114	14	32.9
115	26	74.4
116	383	309.7
117	51	106.9
118	7	15.7
119	78	89.9
120	75	63.8
121	145	75.8
122	227	138.0
123	172	119.3
124	8	19.7
125	21	39.5
126	14	15.7
127	15	65.1
128	37	57.3
129	601	314.7

Table 5. Comparison of Values of Reported Trips and Predicted Trips (Continued)

Zone Number	Reported Trips	Predicted Trips
130	117	134.2
131	81	78.7
132	123	167.9
133	82	160.7
134	26	80.7
135	366	289.8
136	28	101.2
137	675	593.8
138	93	195.1
139	137	138.1
140	31	55.9
141	102	127.6
142	27	106.0
143	18	49.2
144	201	120.5
145	167	153.9
146	135	119.1
147	33	76.5
148	501	316.8
149	289	138.8
150	1318	414.3
151	61	111.1
152	397	237.3
153	36	83.3
154	61	98.3
155	46	66.4
156	30	48.7
157	20	48.3
158	163	83.2
159	51	55.6
160	39	28.3
161	15	23.1
162	14	3.7
163	12	29.6
164	11	27.3
165	37	54.4
166	15	20.7
167	7	21.8
168	10	23.1
169	76	64.3
170	17	18.4
171	42	70.8
172	27	60.0
173	77	53.1

Table 5. Comparison of Values of Reported Trips and Predicted Trips (Continued)

Zone Number	Reported Trips	Predicted Trips
174	18	23.4
175	10	31.2
176	35	50.0
177	13	86.3
178	33	179.2
179	6	28.8
180	4	25.7
181	34	33.8
182	3	14.0
183	45	33.3
184	18	35.8
185	44	66.5
186	0	1.4
187	12	7.0
188	120	135.9
189	235	242.6
190	248	467.6
191	363	460.3
192	24	80.6
193	41	169.8
194	8	32.1
195	5	138.5
196	29	244.9
197	2	57.1
198	70	91.7
199	300	171.6
200	134	176.2
201	86	107.9
202	160	146.3
203	34	42.7
204	82	60.7
205	183	130.0
206	35	37.1
207	136	127.0
208	33	31.0

Note: The Predicted Trips in Table 5 were calculated with the use of impedance factors which were estimated based on an adjustment for the low Georgia response but no adjustment for the overall percentage response to the questionnaires.

APPENDIX III

DESCRIPTION OF COMPUTER PROGRAMS

Two computer programs were written specially for use in this research. These are referred to in this thesis as the impedance factor program and the income factor program. A brief description of these programs is included as well as a copy of the programs. The descriptions are meant primarily to supplement the main text of this report by providing a brief, informative outline of the programs. Those persons interested in greater detail are referred to the copies of the programs included in this Appendix. Both programs were written in ALGOL (programming language) for operation on the Burroughs B-5500 computer at the Georgia Institute of Technology.

Impedance Factor Program

This program performs the following operations:

(1) For each zone, reads the zone number, the number of reported trips, the population, the total personal income, and the traveltime.

(2) For each traveltime value used, reads the input impedance factors.

(3) For each income level, reads the income adjustment factor.

(4) For each zone, replaces the calculated value of traveltime (as read from the data cards) with the nearest value used in the program.

(5) For each zone, calculates the per capita income by dividing the total personal income by the population.

(6) For each zone, calculates the number of predicted trips by multiplying the zone population by the appropriate impedance factor and income adjustment factor.

(7) For each traveltime value used in the program, computes an adjusted impedance factor by multiplying the input impedance factor by the ratio of reported trips to predicted trips for zones with that traveltime.

(8) Computes the average length (in minutes) of reported trips and of predicted trips.

In order to accomplish the above operations, some "counter" variables are used in the impedance factor program. These include the number of reported trips from zones having various traveltimes, the number of predicted trips from zones having various traveltimes, certain variables used in calculating the average length of reported and predicted trips, and a variable (TOTALZONES) equal to the number of zones for which the above operations have been performed. This last variable is useful in determining whether any logic errors resulted in some zones being omitted from any calculations.

Income Factor Program

This program performs the following operations:

(1) For each zone, reads the zone number, the number of reported trips, the population, the total personal income, and the traveltime.

(2) For each traveltime value used, reads the input impedance factors.

(3) For each zone, replaces the calculated traveltime value (as read from the data cards) with the nearest value used in the program.

(4) For each zone, computes a predicted number of trips (without any adjustment for per capita income) by multiplying the zone population by the appropriate impedance factor.

(5) For each zone, calculates the per capita income by dividing the total personal income by the population.

(6) For each zone, calculates the ratio of reported trips to predicted trips, calculated in Step 4 above.

(7) For each income level, computes an adjustment factor by dividing the number of reported trips by the number of predicted trips computed in Step 4 above.

As in the impedance factor program, some "counter" variables are used in the income factor program. These include the number of reported trips from all zones in each income level, the number of predicted trips from all zones in each income level, two variables (TOTALZONES AND ZONESUSED) that indicate the number of zones for which various calculations have been made. These two variables are useful in determining whether any logic error resulted in some zones being omitted from any calculations.

```
     BURROUGHS B-5500 ALGOL COMPILER LEVEL   4      MONDAY,   9/29/69,   9:46 PM.
?COMPILE BIN0909/TIMGRAV*ALGOL         .115800007    *0909 DYER C D
?PROCESS=        00000005;ID=    00000002.
?DATA.
?DATA CDDIN.
?
          BEGIN
FILE IN CUDIN (2,10);
FILE OUT CDDOUT 16 (2,15);
FORMAT IN       FMT1 (I3,X6,I4,X5,I8,X3,I8,X22,I4);
FORMAT IN       FMT2 (F9.7);
FORMAT OUT      FMT3 (X5,"ZONE",X10,"ACTUAL NO OF TRIPS",X10,
                    "PREDICTED NO OF TRIPS",X10,"PER CAPITA INCOME"//);
FORMAT OUT      FMT4 (X5,I3,X19,I4,X24,F6.1,X24,I4/);
FORMAT OUT      FMT5 (X2,"TRAVELTIME",X2,"ACTUAL TRIPS",X3,
                    "PREDICTED TRIPS",X3,"TF USED",X3,"ADJUSTED TF"//);
FORMAT OUT      FMT6 (X5,I4,X9,I4,X13,I4,X6,F9.7,X3,F9.7/);
FORMAT OUT      FMT7 (X5,"AVERAGE LENGTH OF ACTUAL TRIPS =",X2,F5.1//);
FORMAT OUT      FMT8 (X5,"AVERAGE LENGTH OF PREDICTED TRIPS =",X2,
                    F5.1////);
FORMAT OUT      FMT9 (X5,"TOTAL NUMBER OF ZONES USED =",X2,I3);
FORMAT IN       FMT10 (F4.2);
FORMAT OUT      FMT11 ("BELOW ARE LISTED THE INCOME LEVELS");
FORMAT OUT      FMT12("AND THE K_FACTORS USED IN THIS RUN:"///);
FORMAT OUT      FMT13 ("PER CAPITA INCOME",X10,"K-FACTOR"//);
FORMAT OUT      FMT14 (X7,I4,X18,F4.2);
REAL ARRAY      GMTRP, AVGINCOME[1:250], GM, TF, TFADJ[0:200],
                    KFINCLEVEL[0:4,3];
INTEGER ARRAY   ZONE, TRIPS, INCOME, POP, TIME[1:250], ODTOT[200];
REAL            AVGOD, TOTGM, AVGGM, NUMERGM;
INTEGER         I, J, K, TOTOD, NUMEROD, TOTALZONES, Z;
                WRITE (CDDOUT[NO],<" ">);
```

```
        FOR I ← 1 STEP 1 UNTIL 208 DO
        READ (CDDIN, FMT1, ZONE[I], TRIPS[I], POP[I],
            INCOME[I], TIME[I]);
        FOR J ← 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20,
            22, 24, 26, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64,
            68, 72, 76, 80, 88, 96, 104, 112, 120, 128, 136,
            144, 152, 160, 168, 176, 184, 192, 200 DO
        READ (CDDIN, FMT2, TF[J]);
        FOR K ← 10 STEP 1 UNTIL 43 DO
        READ (CDDIN, FMT10, KFINCLEV[K]);
        TOTALZONES ← 0;
        FOR I ← 1 STEP 1 UNTIL 208 DO
BEGIN
        IF TIME[I] < 37.5 THEN TIME [I] ← 30;
        FOR Z ← 45 STEP 15 UNTIL 105 DO
        IF TIME[I] ≥ Z-7.5 AND TIME[I] < Z+7.5 THEN
            TIME[I] ← Z;
        IF TIME[I] ≥ 112.5 AND TIME[I] < 135 THEN
            TIME[I] ← 120;
        FOR Z ← 150 STEP 30 UNTIL 390 DO
        IF TIME[I] ≥ Z-15 AND TIME[I] < Z+15 THEN
            TIME[I] ← Z;
        IF TIME[I] ≥ 405 AND TIME[I] < 450 THEN
            TIME[I] ← 420;
        FOR Z ← 480 STEP 60 UNTIL 1140 DO
        IF TIME[I] ≥ Z-30 AND TIME[I] < Z+30 THEN
            TIME[I] ← Z;
        IF TIME[I] ≥ 1170 AND TIME[I] < 1260 THEN
            TIME[I] ← 1200;
        FOR Z ← 1320 STEP 120 UNTIL 3000 DO
        IF TIME[I] ≥ Z-60 AND TIME[I] < Z+60 THEN
            TIME[I] ← Z;
        IF TIME[I] ≥ 3060 THEN TIME[I] ← 3000;
END;
        FOR J ← 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20,
            22, 24, 26, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64,
            68, 72, 76, 80, 88, 96, 104, 112, 120, 128, 136,
            144, 152, 160, 168, 176, 184, 192, 200 DO
BEGIN
        OD[J] ← 0;
        GM[J] ← 0
END;
        FOR I ← 1 STEP 1 UNTIL 208 DO
BEGIN
        AVGINCOME[I] ← 1000×INCOME[I]/POP[I];
        FOR J ← 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20,
            22, 24, 26, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64,
            68, 72, 76, 80, 88, 96, 104, 112, 120, 128, 136,
            144, 152, 160, 168, 176, 184, 192, 200 DO
        FOR K ← 10 STEP 1 UNTIL 43 DO
        IF TIME[I] = 15×J AND AVGINCOME[I] > 100×K-50
            AND AVGINCOME[I] ≤ 100×K+50 THEN
BEGIN
        TOTALZONES ← TOTALZONES + 1;
        GMTRP[I] ← POP[I] × TF[J] × KFINCLEV[K];
        OD[J] ← OD[J] + TRIPS[I];
        GM[J] ← GM[J] + GMTRP[I]
END;
END;
        TOTOD ← TOTGM ← NUMEROD ← NUMERGM ← 0;
        FOR J ← 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20,
```

```
          22, 24, 26, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64,
          68, 72, 76, 80, 88, 96, 104, 112, 120, 128, 136,
          144, 152, 160, 168, 176, 184, 192, 200 DO
   BEGIN
      TOTOD ← TOTOD + OD[J];
      TOTGM ← TOTGM + GM[J];
      NUMEROD ← NUMEROD + 15×J × OD[J];
      NUMERGM ← NUMERGM + 15×J × GM[J];
      IF GM[J] = 0 THEN GM[J] ← 1;
      TFAD[J] ← TF[J] × OD[J]/GM[J]
   END;
      AVGOD ← NUMEROD/TOTOD;
      AVGGM ← NUMERGM/TOTGM;
      WRITE (CDDOUT, FMT3);
      FOR I ← 1 STEP 1 UNTIL 208 DO
      WRITE (CDDOUT, FMT4, ZONE[I], TRIPS[I], GMTRP[I],
          AVGINCOME[I]);
      WRITE (CDDOUT[PAGE]);
      WRITE (CDDOUT, FMT5);
      FOR J ← 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20,
          22, 24, 26, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64,
          68, 72, 76, 80, 88, 96, 104, 112, 120, 128, 136,
          144, 152, 160, 168, 176, 184, 192, 200 DO
      WRITE (CDDOUT, FMT6, 15×J, OD[J], GM[J], TF[J], TFAD[J]);
      WRITE (CDDOUT, FMT7, AVGOD);
      WRITE (CDDOUT, FMT8, AVGGM);
      WRITE (CDDOUT[PAGE]);
      WRITE (CDDOUT, FMT11);
      WRITE (CDDOUT, FMT12);
      WRITE (CDDOUT, FMT13);
      FOR K ← 10 STEP 1 UNTIL 43 DO
      WRITE (CDDOUT, FMT14, 100×K, KFINCLEV[K]);
      WRITE (CDDOUT, FMT9, TOTALZONES);
   END.

OUTPUT(W) IS SEGMENT NUMBER 0018,PRT ADDRESS IS 0076
BLOCK CONTROL IS SEGMENT NUMBER 0019,PRT ADDRESS IS 0005
INPUT(W) IS SEGMENT NUMBER 0020,PRT ADDRESS IS 0102
ALGOL WRITE   IS SEGMENT NUMBER 0021,PRT ADDRESS IS 0014
ALGOL READ    IS SEGMENT NUMBER 0022,PRT ADDRESS IS 0015
ALGOL SELECT  IS SEGMENT NUMBER 0023,PRT ADDRESS IS 0016

NUMBER OF SYNTAX ERRORS DETECTED =    0. NUMBER OF SEQUENCE ERRORS DETECTED =     0
COMPILER TIMES: PROCESSOR =   14 SECONDS; IO =   17 SECONDS; ELAPSED =   68 SECONDS.
PRT SIZE =  96; TOTAL SEGMENT SIZE =  1049 WORDS; DISK SIZE =  53 SEGS; NO. PGM. SEGS =  24
ESTIMATED CORE STORAGE REQUIREMENT =  6752 WORDS.
```

```
      BURROUGHS B-5500 ALGOL COMPILER LEVEL   4    THURSDAY,   9/25/69, 12:10 PM.
?COMPILE BIN1005/INCOMET+ALGOL           .115800007   *1005 DYER C D
?PROCESS*       00000005;10*    00000002.
?DATA.
?DATA CDDIN.
?
          BEGIN

FILE IN CDDIN (2,10);
FILE OUT CDDOUT 16 (2,15);
FORMAT IN       FMT1 (I3,X6,I4,X5,I8,X3,I8,X22,I4);

FORMAT IN       FMT2 (F9.7);

FORMAT OUT      FMT3 (X11,"ACTUAL",X5,"PREDICTED",X4,"TRAVEL",X4,
                   "PER CAPITA",X6,"ZONAL");
FORMAT OUT      FMT4 ("ZONE",X7,"TRIPS",X8,"TRIPS",X7,"TIME",X7,
                   "INCOME",X7,"K-FACTOR"//);
FORMAT OUT      FMT5 (I3,X9,I4,X8,I4,X8,I4,X8,I4,X9,F5.2/);

FORMAT OUT      FMT6 (X5,"MEDIAN",X8,"ACTUAL",X5,"PREDICTED",
                   X5,"INCOME LEVEL");
FORMAT OUT      FMT7 (X5,"INCOME",X8,"TRIPS",X8,"TRIPS",X9,"K-FACTOR"//);
FORMAT OUT      FMT8 (X6,I4,X10,I4,X9,I4,X10,F5.2/);

FORMAT OUT      FMT9 ("TOTAL NUMBER OF ZONES USED =",X2,I3/);

FORMAT OUT      FMT10 ("ZONES USED IN INCOME PORTION =",X2,I3);

FORMAT OUT      FMT11 ("THE TRAVEL-TIME FACTORS USED IN THIS RUN ");

FORMAT OUT      FMT12 ("ARE GIVEN BELOW:"////);

FORMAT OUT      FMT13 ("TRAVEL-TIME",X10,"TRAVEL-TIME FACTOR"//);

FORMAT OUT      FMT14 (X3,I4,X20,F9.7/);

REAL ARRAY      GMTRP, KFZONE, AVGINCOME[1:250], TF[0:200], GMTRP1,
                   KFINCLEV[10:43];
INTEGER ARRAY  ZONE, TRIPS, POP, TIME, INCOME[1:250],
                   TRIPS1[10:43];
INTEGER         I, J, K, TOTALZONES, ZONESUSED, Z;
                FOR I ← 1 STEP 1 UNTIL 208 DO
```

```
        READ (CDDIN, FMT1, ZONE[I], TRIPS[I], POP[I],
            INCOME[I], TIME[I]);
        FOR J ← 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20,
            22, 24, 26, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64,
            68, 72, 76, 80, 88, 96, 104, 112, 120, 128, 136,
            144, 152, 160, 168, 176, 184, 192, 200 DO
        READ (CDDIN, FMT2, TF[J]);
        TOTALZONES ← ZONESUSED ← 0;
        FOR I ← 1 STEP 1 UNTIL 208 DO
  BEGIN
        IF TIME[I] < 37.5 THEN TIME [I] ← 30;
        FOR Z ← 45 STEP 15 UNTIL 105 DO
        IF TIME[I] ≥ Z-7.5 AND TIME[I] < Z+7.5 THEN
            TIME[I] ← Z;
        IF TIME[I] ≥ 112.5 AND TIME[I] < 135 THEN
            TIME[I] ← 120;
        FOR Z ← 150 STEP 30 UNTIL 390 DO
        IF TIME[I] ≥ Z-15 AND TIME[I] < Z+15 THEN
            TIME[I] ← Z;
        IF TIME[I] ≥ 405 AND TIME[I] < 450 THEN
            TIME[I] ← 420;
        FOR Z ← 480 STEP 60 UNTIL 1140 DO
        IF TIME[I] ≥ Z-30 AND TIME[I] < Z+30 THEN
            TIME[I] ← Z;
        IF TIME[I] ≥ 1170 AND TIME[I] < 1260 THEN
            TIME[I] ← 1200;
        FOR Z ← 1320 STEP 120 UNTIL 3000 DO
        IF TIME[I] ≥ Z-60 AND TIME[I] < Z+60 THEN
            TIME[I] ← Z;
        IF TIME[I] ≥ 3060 THEN TIME[I] ← 3000;
  END;
        FOR K ← 10 STEP 1 UNTIL 43 DO
        TRIPS1[K] ← GMTRP1[K] ← 0;
        FOR I ← 1 STEP 1 UNTIL 208 DO
        FOR J ← 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20,
            22, 24, 26, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64,
            68, 72, 76, 80, 88, 96, 104, 112, 120, 128, 136,
            144, 152, 160, 168, 176, 184, 192, 200 DO
        IF TIME[I] = 15×J THEN
  BEGIN
        GMTRP[I] ← POP[I] × TF[J];
        TOTALZONES ← TOTALZONES + 1
  END;
        FOR I ← 51 STEP 1 UNTIL 176 DO
  BEGIN
        AVGINCOME[I] ← 1000×INCOME[I]/POP[I];
        IF GMTRP[I] = 0 THEN GMTRP[I] ← 1;
        KFZONE[I] ← TRIPS[I]/GMTRP[I];
        FOR K ← 10 STEP 1 UNTIL 43 DO
  BEGIN
     IF AVGINCOME[I] > 100×K-50 AND AVGINCOME[I] ≤ 100×K+50 THEN
  BEGIN
        TRIPS1[K] ← TRIPS1[K] + TRIPS[I];
        GMTRP1[K] ← GMTRP1[K] + GMTRP[I];
        ZONESUSED ← ZONESUSED + 1;
  END;
  END;
  END;
        FOR K ← 10 STEP 1 UNTIL 43 DO
  BEGIN
        IF GMTRP1[K] = 0 THEN GMTRP1[K] ← 1;
        KFINCLEV[K] ← TRIPS1[K]/GMTRP1[K];
```

```
END;
    WRITE (CDDOUT, FMT3);
    WRITE (CDDOUT, FMT4);
    FOR I ← 51 STEP 1 UNTIL 176 DO
    WRITE (CDDOUT, FMT5, ZONE[I], TRIPS[I], GMTRP[I],
        TIME[I], AVGINCOME[I], KFZONE[I]);
    WRITE (CDDOUT[PAGE]);
    WRITE (CDDOUT, FMT6);
    WRITE (CDDOUT, FMT7);
    FOR K ← 10 STEP 1 UNTIL 43 DO
    WRITE (CDDOUT, FMT8, 100×K, TRIPS1[K], GMTRP1[K],
        KFINCLEV[K]);
    WRITE (CDDOUT[PAGE]);
    WRITE (CDDOUT, FMT11);
    WRITE (CDDOUT, FMT12);
    WRITE (CDDOUT, FMT13);
    FOR J ← 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20,
        22, 24, 26, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64,
        68, 72, 76, 80, 88, 96, 104, 112, 120, 128, 136,
        144, 152, 160, 168, 176, 184, 192, 200 DO
    WRITE (CDDOUT, FMT14, 15×J, TF[J]);
    WRITE (CDDOUT, FMT9, TOTALZONES);
    WRITE (CDDOUT, FMT10, ZONESUSED);
END.

OUTPUT(W) IS SEGMENT NUMBER 0017,PRT ADDRESS IS 0101
BLOCK CONTROL IS SEGMENT NUMBER 0018,PRT ADDRESS IS 0005
INPUT(W) IS SEGMENT NUMBER 0019,PRT ADDRESS IS 0073
ALGOL WRITE   IS SEGMENT NUMBER 0020,PRT ADDRESS IS 0014
ALGOL READ    IS SEGMENT NUMBER 0021,PRT ADDRESS IS 0015
ALGOL SELECT  IS SEGMENT NUMBER 0022,PRT ADDRESS IS 0016

NUMBER OF SYNTAX ERRORS DETECTED =   0. NUMBER OF SEQUENCE ERRORS DETECTED =    0
COMPILER TIMES: PROCESSOR =   16 SECONDS; IO =   42 SECONDS; ELAPSED =  104 SECONDS.
PRT SIZE =  82; TOTAL SEGMENT SIZE =   833 WORDS; DISK SIZE =  44 SEGS; NO. PGM. SEGS =  23
ESTIMATED CORE STORAGE REQUIREMENT =  6570 WORDS.
```

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