MULTICOLLINEARITY IN TRANSPORTATION MODELS

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ABSTRACT

This thesis explores some of the limitations and implications of using multiple regression analysis in transportation models. Specifically it investigates how the problem of multicollinearity, which results from using intercorrelated variables in trip generation models, adversely affects the validation of hypotheses, discovery of underlying relationships and prediction.

The research methodology consists of a review of the literature on trip generation analysis and a theoretical exposition on multicollinearity. Secondly, trip generation data for Greater Vancouver (1968) is used for empirical analysis. Factor analysis and multiple regression techniques are employed.

The results demonstrate that multicollinearity is both an explanatory and prediction problem which can be overcome by a combined factor analytic and regression method. This method is also capable of identifying and incorporating causal relationships between land use and trip generation into a single model. It is concluded that the distinction between the explanatory, analytic and predictive abilities of a regression model is artificial, and that greater emphasis on theorizing in model-construction is needed.

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CHAPTER I

INTRODUCTION

Multiple regression is one of the most widely used techniques in data analysis and model building; it is often abused due to a lack of understanding of its basic assumptions. This chapter introduces the problem of multicollinearity which results from violation of the assumption that predictors in the regression equation are independent. The discussion is conducted within the context of transportation models.

1.1 Justification for Research

Estimation of travel demand is an important and integral part of the transportation planning process. Among its various phases, trip generation and modal split procedures have generally relied heavily on statistical methodology such as multiple regression. These procedures require a sound knowledge of the structural relationship contained in the basic data set. Yet a survey of the literature in this field indicates that major effort has so far been in the direction of statistical efficiency and selection of optimal relationships between variables. Little effort has been devoted to understanding the inferences concerning travel behaviour that are implicit in these procedures.[1] Stated simply, most model-builders are overly concerned with obtaining a high correlation coefficient, and hence a good fit of data, and less attention has been paid to the analytical and explanatory powers of the model. The general view held is that prediction is not necessarily dependent on explanation. To the extent that the function of a model is purely predictive, as opposed to those models that seek to explain certain phenomena or to establish causal relationship, a high correlation is seen as an end in itself.

Reacting to the above attitude, Muller and Robertson[2] cautioned that multiple regression equations with a high correlation coefficient, but containing illogical relationships,are statistically unstable. This is self-evident as regression, and other mathematical models for that matter, is only as accurate and as useful as the validity of the assumptions that are made and the statistical significance of the result obtained. It is entirely possible to produce results meeting all of the various statistical criteria and yet offer no explanation of the causative relationships. In order to forecast, such a causal relationship is essential.[3]

The use of intercorrelated variables in regression is increasingly being recognized, by Alonso[4] and Harris[5] among others, as a problem obscuring the causative relationships. Unfortunately variables in the urban context used for transportation models are more often than not spatially distributed in a correlated fashion, e.g. car ownership is correlated with income, income with density, density with distance from C.B.D., etc. Thus, if all these intercorrelated variables were used in the model, it becomes extremely difficult to determine which are the causal factors related to urban travel. In other words, it is not known then whether trips are a function of all these variables working independently or whether they are interacting and in effect overlapping. Moreover, the existence of collinearity among variables casts many doubts on conventional statistical analyses and creates severe operating problems.[6] It is felt therefore, that as transportation planners are more and more relying on regression as a tool for planning, it is perhaps timely to place in perspective this issue which bears on the reliability of the model as an explanatory and predictive device.

1.2 The Problem and General Hypothesis

The multiple regression model usually takes the form of

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + \dots\dots\dots\dots\dots\dots + b_mx_m$$

In specifying the model in this form, it is assumed that the various independent variables make <u>independent</u> and <u>additive</u> contributions to the prediction of the variances observed in the dependent variable Y. If the assumption of independence is violated, then the problem of collinearity is introduced[7] (in the case of two correlated independent variables), or multicollinearity (in the case of three or more correlated variables).

The term multicollinearity is the name given to the general problem which arises when some or all of the explanatory variables in an equation are so highly correlated that it becomes very difficult, if not impossible, to separate their individual influences and obtain a reasonably precise estimate of their effects.[8] Secondly, since the variables are highly correlated, they reinforce each other's relationship with the criterion, or suppress the true contribution of other variables in the equation. In the former case, the tendency is towards distorting the value of the multiple correlation coefficient beyond its true proportion; in the latter, some variables of explanatory value may never be able to enter the equation due to the predominance of collinear sets.

As previously stated, this problem is particularly prevalent in transportation models due to the type of variables employed. The objective of this study, therefore, is to investigate how multicollinearity affects the performance of transportation models, in respect to validation of hypotheses, discovery of underlying relationships and prediction. Methods for overcoming the problem will be suggested in the course of investigation. Moreover, the implications of prediction versus explanation in model-building will be discussed.

The following general hypothesis is developed as a focus for the research:

> "When collinearity exists in a regression model, explanatory and analytical powers are decreased, despite the apparently good predictive power shown by a high multiple correlation coefficient."

1.3 Postulates

The investigation is based on the following assumptions:

1) A good statistical fit does not assure a good predictive model.[9] A model's strength lies essentially in the soundness of its theoretical base.

2) Only variables that can be supported by intuitively sound arguments should be used in regression analysis. It makes little sense to throw all possible variables into the pot in a shotgun approach merely to obtain a high correlation coefficient.[10]

3) Multiple regression models are basically concerned with postulates of cause and effect. Hence their validity as forecasting tools must rely on causative relationships.[11]

1.4 Methodology

A twofold strategy is adopted. Firstly, a theoretical exposition on collinearity or multicollinearity based on literature research is given. Hopefully this will throw light on why and how collinearity affects the validity and utility of the model. Secondly, the general hypothesis is to be verified empirically by:

1) Using multiple regression analysis to examine, in depth, a typical example of transportation models on trip generation, with special emphasis on the undesirable properties associated with collinearity.

2) Factor analysis of the data to extract underlying dimensions, and to see if the model has incorporated the significant factors into the equation.

3) Formulating a new multiple regression model to eliminate collinear sets and compare results.

Data analysis is carried out by UBC IBM 360 digital computer. The computer programs used are the TRIP[12] and FACTO[13] packages, the former for regression analysis and the latter for factor analysis.

1.5 Source of Data

The trip generation model studied here and its associated data has been obtained through the courtesy of N. D. Lea & Associates, Vancouver. The data was collected for thirty-two traffic districts of Greater Vancouver in 1968, partly through a telephone survey and partly from census information (See Figure 1). A total of twenty-nine variables are used for computation in this thesis and all variables are measured on interval scales.[14]

It should be pointed out that the original data from N. D. Lea & Associates consisted of ten dependent variables and sixty-nine independent variables. The former is a finer breakdown of the nature of trips.[15] The sixty-nine independent variables include the twenty-nine variables[16] selected in this study, the rest being complex or transgenerated variables.[17] By step regression, a total of about forty equations were developed and finally nine were selected, one for each

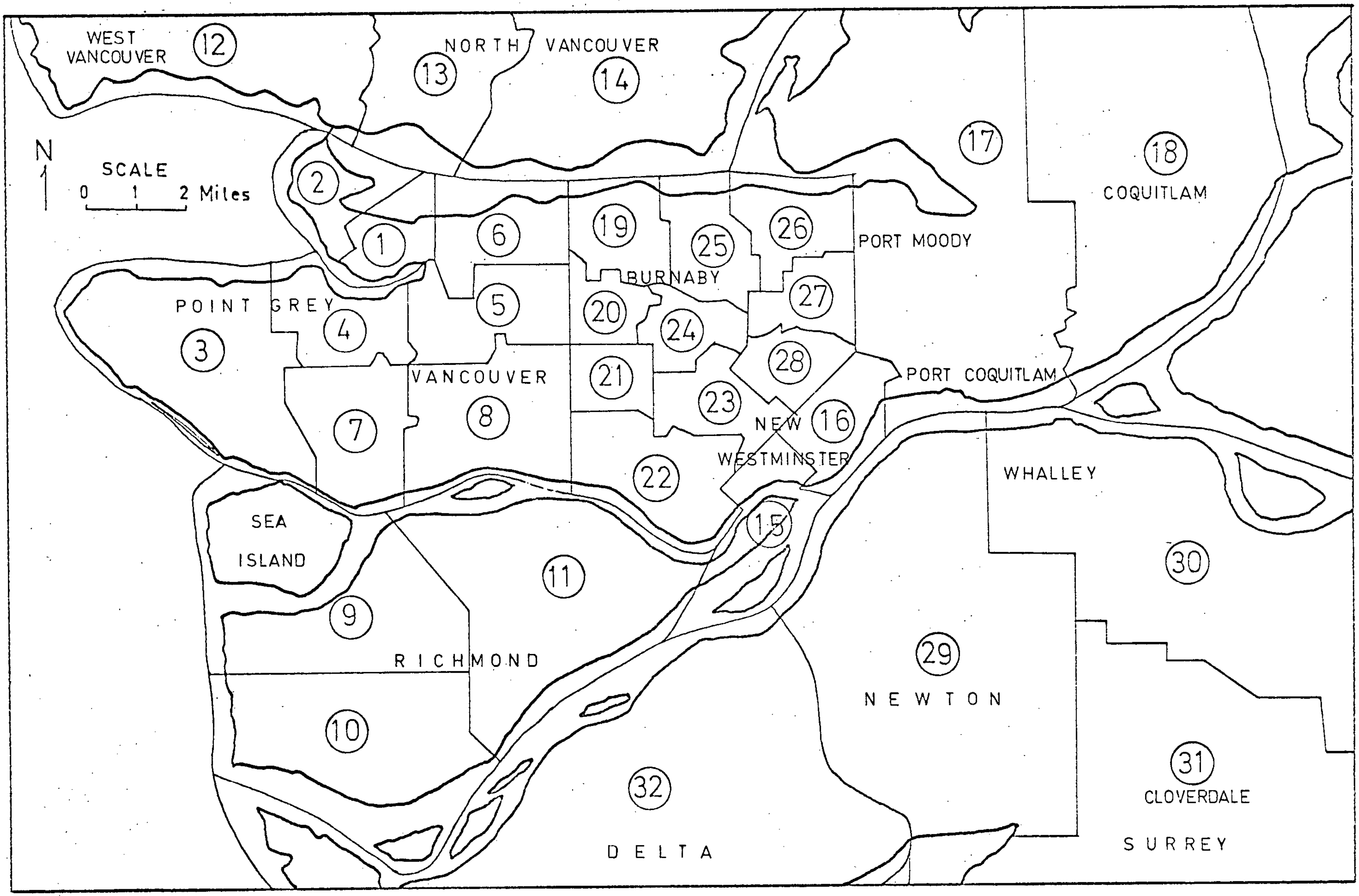

FIG. 1 TRAFFIC DISTRICTS OF GREATER VANCOUVER

dependent variable except total trip production. The model developed for total trip generation (total persons trips excluding walk trips per day) is selected for detailed examination here for two reasons:

1) It is representative of transportation models for trip generation. Hence findings will generally be applicable to other models in the field.
2) It is a convenient example because data is available locally. Familiarity with local conditions facilitates interpretation and visualization of the issues involved.

1.6 Limitation of the Data

Since this is areal data, i.e. all information is grouped on the basis of geographical units, three limitations are recognized:

a) The problem of autocorrelation, i.e. measurements obtained in one area are not entirely independent of those obtained in other areas. Certain population and land use characteristics between contiguous areas may exhibit greater similarity than non-contiguous areas. If this is indeed so, then one of the assumptions of correlation analysis, that residuals from regression are mutually independent random variables will be violated. Statistical tests are carried out on the residual distribution of Model 2 (See Figure 12) using the "contiguity measures for k-colour maps technique".[18] The result reveals that there is no significant autocorrelation in this set of data. Computations can be found in Appendix B.

b) The traffic districts are not uniform in size. This gives rise to the problem in identifying or eliminating differences in parameters which may be attributed merely to differences in size of areal units from those differences which are owing to "truly different" relationships.[19] For example, when comparing two districts of equal size, the absolute number of people residing within them reflects the intensity of residential use. However, for districts of unequal sizes, there is no real basis for comparison unless rate variables are used. As can be seen later on in this set of data, the variable "Area" is found to explain a significant amount of variation in trip generation (See page 67). This reveals that the analysis units for this study are divided in such a way that the small districts are found within the urban areas with the large districts at the metropolitan fringe; "Area" in effect becomes a proxy for distance from C.B.D. and to some extent reflects degree of urbanization of the district. Hence additional care must be exercised in interpreting outputs under these circumstances.

c) The highly aggregated data on a district basis for this set poses some problems of interpretation and application. In general, geographical aggregation of data is not as efficient as it may be. As Fleet and Robertson[20] pointed out, the underlying assumption of areal aggregation is that contiguous households exhibit some similarity in family and travel characteristics. The degree to which these units are not homogenous results in a loss of disaggregated detail. An example of a detailed household characteristic that does not "show up" in explaining the zonal trip generation is family income, which intuitively would directly reflect differences in household characteristics and in particular, differences in trip-making. However, when this information is averaged for an areal unit composed of a number of households and related to the number of trips generated by that unit, almost all these differences are lost. This has resulted in the seemingly "weak" relationships. Therefore there is an inherent danger in making statistical inference from highly aggregated data concerning disaggregated relationships.

Similarly, because trip generation data for this study has been collected at the traffic district level, the apparently good results of analysis (the extremely high correlation coefficients obtained) are misleading. This is intuitively obvious since the larger the unit, the more total variation will be lost <u>within</u> the units. Little of the total variation is actually left to explain <u>between</u> the units, thus allowing a high proportion of the between-group-variance to be unaccounted for. As such it is statistically incorrect to use equations developed at the district level to calculate trips generated at the smaller zonal level because another set of variables may do a better job at this level.

Since the primary interest of this study is to investigate trip generation characteristics at an areal level, the inferences drawn will not be applicable to individual and household travel behaviour.

1.7 Organization of the Chapters to Follow

Chapter II presents an overview of current practices and developments in trip generation analysis based on literature research. Chapter III contains a discussion on model attributes and a statistical exposition on the problem of multicollinearity. Chapter IV attempts to validate, empirically, the general hypothesis through the testing of three operational hypotheses and the development of an alternative model. Finally, Chapter V deals with the planning implications of the findings and concludes with a summary and suggestions for future research.

1.8 Definitions

The following is a brief resume of the terms used in the text. More rigorous and technical expositions on regression and factor analysis can be found in standard textbooks on these subjects.

Linear Multiple Regression Analysis[21]

Using the least-squares principle, multiple regression is a technique for measuring the influence of some independent variables (predictors) on a dependent variable (criterion). In the context of this study, the aim of linear multiple regression is to obtain from land use, traffic and population data an equation of the form:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 \quad . . . . + b_nx_n$$

where Y is the zonal measure of travel. All the x's are the independent zonal land use and population factors, each of which has a separate influence on Y with per unit effects given by b_1, b_2, b_3, etc. Since not all of the numbers of trips per zone may be explained by the x's in the equation, 'a' is a number put in to represent the unexplained part of the value of Y. It is often referred to as the 'constant' of the equation. A large constant for this reason is undesirable as it indicates the possibility of presence of other explanatory variables not taken into account. The b-coefficients are called regression coefficients which in the case of standardized variables are called β coefficients. Beta coefficients indicate the relative weights of the different independent variables.

Standardized Variables

Variable values are transformed into standard or Z scores rather than in raw scores. The Z score expresses the measurement of a variable for an individual in terms of its deviation from the mean value of the distribution. The formula is $Z = \frac{x_i - \bar{x}}{\sigma}$

F Probability

A measure of whether the regression coefficient is significant to the regression equation. Generally when the F Probability is greater than 0.05 the regression coefficient is not significant at the 5% level.

Standard Error of Estimate (Residual Standard Deviation or Root Mean Square Error)

It is usually denoted by $S_{y.x}$. It is a summary of all the squared discrepencies of actual measurements from the predicted measurements. A general measure of the value of a regression equation is the standard error of estimate as a percentage of the mean value of the dependent variable; a good equation has a small standard error of estimate which is a small percentage of the mean, and vice versa.

Correlation Coefficient

It is possible to measure the degree of association between two variables by means of a statistic known as coefficient of simple correlation. It is generally represented by 'r', which can assume values in the range ± 1 only. The closer 'r' is to ± 1, the stronger the relationship between the two variables. As a measure of correlation between one dependent variable and more than one independent variable, the statistic is known as coefficient of multiple correlation or 'R'.

There is a further property of the coefficient of correlation which is useful in interpreting the results given by the regression equation. The percentage of the total variation in the dependent variable which is 'explained' by an independent variable is approximately equal to one hundred times the square of 'r'. This statistic is known as the coefficient of determination or r^2 in case of simple correlation, and R^2 for multiple correlation. It should be noted that the tendency for one variable to vary with another, as shown by its 'r', is no evidence of any causal relationship, since it may be that both variables are influenced by other variable(s) not examined.

Fisher's Transformation

A method to transform the value of the correlation coefficient of a regression equation into a statistic known as Fisher's 'z' so that the testing of whether 'r' is significantly different from zero or to compare the difference between two r's can be carried out by 't' test. The principle involves approximating 'r' into a normal sampling population regardless of the size of sample and population.

Partial and Simple Correlations[22]

A simple correlation expresses the relationship between two variables under consideration, not holding constant any other variables. Therefore, if there is any collinearity between the explanatory variable and other independent variables, then the simple 'r' will incorporate this relationship also. The partial 'r' expresses the relationship between the independent variable under consideration and the dependent variable, holding the effect of other independent variables constant.

Factor Analysis

A generic term for a variety of procedures developed for the analysis of intercorrelations within a set of variables. The most common type of factor analysis is principal component analysis; it collapses large masses of data into basic underlying dimensions, and is capable of eliminating collinear sets of variables within a set of data to produce an underlying set of independent or orthogonal factors.

Factor Loading

The square root of the total variance of a variable accounted for by the factors. In other words, it is the correlation coefficient between the variable under consideration and the factors.

Communality

The proportion of common variance of a variable accounted for by a factor. It can be regarded as the R^2 between the variable under consideration and a factor.

Factor Score

The score that an individual obtains for a particular factor. It is calculated from the scores the individual gets in a set of variables contributing to that factor by regression. Usually it is standardized and orthogonalized. (See Appendix C)

Model

An experimental design based on a theory. Being a simplified representation of reality, it is frequently truncated theories, sacrificing richness and completeness for operational purposes.[23]

Trip Generation

A term commonly used to describe the number of trips starting or ending in a particular area in relation to the land use and/or socio-economic characteristics of that area.

Total Trips Generated in a Zone

It is the number of person or vehicle trips, by all modes of transport, made by residents to and from a zone. It does not include walk trips and trips by taxi and trucks.

Total Trips Attracted to a Zone

Refers to the number of person or vehicle trips, by all modes of transport, but excluding walk trips and trips by taxi and trucks, ending in a zone.

Prediction

Conditional statements about future developments - statements which are conditioned by varying assumptions of policy and external conditions.[24]

Measurement and Specification Errors[25]

Two general categories of error can be distinguished in any experimental design. The first is measurement error. It includes data collection errors, errors of scaling and sampling errors. For the most part, the model-builder is unable to control these errors unless he is responsible for the design of the data collection survey. Specification error arises from a misunderstanding or a purposeful simplification in the model of the phenomenon we are trying to represent e.g. the representation of a non-linear relation by a linear expression, omission of significant variables, inclusion of inter-correlated variables as well as the failure to correctly evaluate a model.[25] These can be more easily controlled with a good research design.

Footnotes

[1]Christopher R. Fleet and Sydney R. Robertson, "Trip Generation In The Transportation Planning Process", Highway Research Record, No. 240 (1968), p.11.

[2]U.S. Department of Transportation/Federal Highway Administration, Bureau of Public Roads, Guidelines for Trip Generation Analysis, (June 1967), p.109.

[3]Ibid, p.25.

[4]William Alonso, "Predicting Best With Imperfect Data", Journal of The American Institute of Planners, Vol. 34, No. 3, (1968), p.249.

[5]Britton Harris, "New Tools for Planning", Journal of The American Institute of Planners, Vol. 31, No. 2 (1965), p.95.

[6]Ibid, p.95.

[7]N. d. Cherukupalle,"Regression Analysis - Interpretation of Computer Outputs, Etc.", Planning 508 Course Notes, October 1969, School of Community & Regional Planning, U.B.C., p.1.

[8]J. Johnston, Econometric Methods, New York, McGraw Hill Inc., (1963), p.201.

[9]K. Rask Overgaard, "Urban Transportation Planning: Traffic Estimation", Traffic Quarterly, (April 1967), p.202.

[10]Jeffrey M. Zupan, "Mode Choise: Implications for Planning", Highway Research Record, No. 251 (1969), p.14.

[11]K. Rask Overgaard, op. cit., p.202.

[12]James H. Bjerring, J. R. H. Dempster and Ronald H. Hall, U.B.C. TRIP (Triangular Regression Package), (The University of British Columbia Computing Centre, January 1968).

[13]James H. Bjerring, U.B.C. FACTO - Factor Analysis Program, (The University of British Columbia Computing Centre, May 1969).

[14] An interval-scale deals with quantative measurements in equality of units, which means the same numerical distance is associated with the same empirical distance on some real continuum such as length and weight.

[15] The ten dependent variables for the N. D. Lea Burnaby Transportation Study are: home-based work attraction, home-based other attraction, non-home-based destinations, total attraction, home-based work production, home-based other production, non-home-based production, non-home-based origins, total production and total trip generation.

[16] See Appendix A.

[17] Basic Variables are variables collected in the survey. Complex and transgenerated variables are those obtained by combining basic variables in various manner, e.g. addition, subtraction, multiplication and division, logarithm, cosine, and sine, etc., e.g. ln density is derived from ln (total population/area).

[18] For details on this method, see Michael F. Dacey, "A Review on Measures of Contiguity for Two and k-colour Maps", Spatial Analysis (New York: Prentice Hall Inc., 1968), Ed. by Brian J. Berry and D. F. Marble, pp.479-490.

[19] E. N. Thomas and D. L. Anderson, "Additional Comments on Weighting Values in Correlation Analysis of Areal Data", loc. cit., pp.431-445.

[20] Christopher R. Fleet and Sydney R. Robertson, op. cit., p.13.

[21] Adapted from: M. A. Taylor, Studies of Travel in Gloucester, Northampton & Reading, Road Research Laboratory Report, L.R. 141 (Ministry of Transport, Great Britain, 1968), pp.142-149.

[22] N. d. Cherukupalle, op. cit., pp.4-5.

[23] Britton Harris, "The Use of Theory In The Simulation of Urban Phenomena", Journal of the American Institute of Planners, Vol. 32, No. 5 (September 1966), p.265.

[24] Britton Harris, "New Tools for Planning", <u>op. cit.</u>, p.91.

[25] William Alonso, <u>op. cit.</u>, p.248.

CHAPTER II

TRIP GENERATION ANALYSIS - AN OVERVIEW

This chapter provides an overview of current practices and developments in trip generation analysis. Particular reference is being made to consideration and limitations in using the multiple regression technique.

2.1 Trip Generation In The Transportation Planning Process

Decisions on transportation facilities in urban areas are made everyday. Each decision has complex implications for the entire urban community. To aid in making these decisions, effective and accurate forecasts of travel demands are necessary. These forecasts are generally made within the framework of an urban transportation study which is a systematic process serving as a basis on which to plan, design and evaluate transportation systems. The transportation planning process is generally considered to consist of the following: population and economic studies, land use studies, trip generation, trip distribution, modal split, traffic assignment and system evaluation.[1]

Trip generation is the term commonly used to denote the study of amounts of person and vehicular travel. This phase is intended to prepare forecasts of travel demand, usually by small areas called traffic zones. The result is, in essence, a spatial distribution on frequency of trip-making, defined at one end of the trip and stratified by the types of trips being made.[2] The traditional linkage between land use and travel is introduced in this phase when the number of trips that begin or end in a given zone can be related to the activities and socio-economic characteristics of that zone. The generated trip ends form the measure of 'trip production' and 'trip attraction' used in trip distribution and modal split models. The resulting travel patterns are then assigned to the highway or transit network in the traffic assignment stage. Many alternative plans of both land use and transportation systems can then be evaluated in the system analysis phase.[3]

It can be seen that the trip generation phase is a crucial step in bridging the gap between land use and travel. Also, apart from producing the number of trips per zone as inputs for subsequent analysis in the transportation planning process, it holds the key to an understanding of the varied interacting relationship between travel and the surrounding environment. An insight is a prerequisite to the determination of transportation and land use policies.

2.2 Factors Influencing Trip Generation

Travel is uniquely human and subject to all the complexities and variations in human behaviour. The basic trip-making unit is the individual, whose behaviour is conditioned by his own characteristics and by those of the household in which he lives. Therefore, trip-making on a person or household basis is governed by the socio-economic factors of the home. Throughout the years, many transportation studies have consistently found that variables such as car ownership per household, family size, income per dwelling unit and occupation of the head of household are capable of explaining trip generation satisfactorily. The general conclusion is that high income families, who are also often multi-car families, make more trips than low income families, which, on the other hand, often own no car and must rely on public transportation and thus generate fewer automobile trips.[4] S. T. Wong[5] in a trip generation analysis of Chicago data, found that total daily residential trips per occupied dwelling unit are dependent on such household characteristics as car ownership, choice of mode, trip purpose, age of trip-maker and distance from C.B.D. M. A. Taylor[6] came to similar conclusion in his analysis of Gloucester, Northampton and Reading data. He found that the trip rate per person, or per household, is related to the socio-economic index, as well as travel time to the town centre. Recent studies have indicated that household size is emerging as a more important variable than car ownership.[7] This is highly probable in view of the fact that automobile ownership is becoming more ubiquitous in North America.

More often than not, trip generation estimates are conducted at an areal level. The geographic level of aggregation is generally the traffic zone, or the traffic district. This is necessary for the trip distribution and assignment processes. Due to the process of aggregation, household characteristics are no longer the significant variables in explaining total trips generated from a zone, as much of the variation is lost by grouping heterogeneous households together. The higher the level of aggregation, the less likelihood of detailed information at the individual or household level being significant (see earlier discussion on pp.9-10). Taylor[8] further asserted that measures of trip generation in the form of total number of trips produced per zone or per district cannot be expected to be correlated with socio-economic characteristics of the household since they are not dimensionally compatible. They are more logically dependent on population and land use factors which measure the gross amount of human activity within the analysis unit. In the main, three factors are considered important in determining the total number of trips generated at the zonal or district level:

a) All measures relative to the size of population in the tract, e.g. total population, total number of cars, total labour force, total number of dwelling units, etc.

b) Characteristics and intensity of land use - the amount of activities to be found in a unit is also an explanatory factor for trip generation. It is usually stated in terms of density variables such as dwelling units per acre or employees per acre. Variations in intensity have distinct impact on the number and type of trips that are produced. In addition, the type of land use activity, be it residential, commercial, industrial or institutional, gives rise to different trip rates, e.g. it was found in Chicago that residential use accounted for over 50% of all trips generated, followed by commercial and manufacturing uses.[9] The number of employees in each activity or commercial floor area are typical measures of this factor.

c) Location of land use activities:

This factor refers to the spatial distribution of land uses within the study area, e.g. an area of mixed land uses will generate more walking trips and less vehicle trips, whereas a predominantly residential area with no shopping facilities nearby will generate more vehicle trips. A study of traffic characteristics in suburban residential areas in Washington[10] found that areas with extensive shopping facilities nearby generated four times more pedestrian trips than a strictly residential neighbourhood. However, the latter generates slightly more vehicle trips than the former area. Distance from C.B.D. is one of the measures of this factor.

In conducting comparative studies between cities, which is an even higher level of aggregation than the traffic district, factors such as size of population and area, urban form and density, and the economic level of the average resident, as manifested by car ownership, are the major explanatory variables. Findings from O.D. data in thirteen cities (Chicago, Detroit, Washington, Pittsburg, St. Louis, Houston, Kansas City, Phoenix, Nashville, St. Landerdale, Chattanooga, Charlotte and Reno) substantiated this.[11] The result also revealed that as density increases there is an increase in total person-trips, a decrease in person-trips in vehicles and an increase in transit trips. Compactness of an urban area could therefore be construed as a means of minimizing urban travel.

In conclusion, trip generation is dependent on population, land use and socio-economic factors. However, it is emphasized that the relationships developed from grouped data are sensitive to the size of the zones and the degree of internal homogeneity achieved in drawing their boundaries. Undoubtedly this is an important factor in explaining why different variables become significant at various level of zonal aggregation.

2.3 Approaches to Trip Generation Analysis

Throughout the history of transportation planning, various techniques, each with increasing sophistication, have been employed to quantify and analyze travel patterns of urban dwellers. All the techniques developed are essentially based on the assumption that people are predictable, i.e. there is a logical and orderly pattern such that mathematical formulae can be developed to express travel behaviour. Another important concept inherent in these procedures is that travel occurs only as the consequence of persons being unable to fulfill all desires at a common location, i.e. when all functions cannot be incorporated into a single location. Different functions, or land uses, which are spatially separated initiate person trips.[12] A third assumption is that the relationship between trips and land use and socio-economic variables is stable over time. Below is a brief resume of the techniques used in this field:

1) <u>Growth Factor Method</u>

   It was much used prior to 1950 to obtain an estimate of the future trip generation of a zone. The present number of trips is multiplied by a growth factor, representing the product of the ratios between the future and the present population, car density and car utilization.[13] In essence it is an extrapolation technique.

2) <u>Land Area Trip Rate Analysis</u>

   Since early 1950, analytical techniques have been used in an attempt to quantify urban trip volumes in terms of the land uses associated with trip ends. Existing land uses are categorized by type of activity, location and intensity of use, such as residential, manufacturing, commercial, transportation, public building and public open space, etc. Trip rates are calculated relating observed number of trips per acre of land to the land use categories. In other words, land use classifications are used as an 'end' or classifactory variable. Another set of generation figures may be obtained by relating the number of trips to the floor area. Many European studies have estimated future trip generation from the number of residents and employees in the zones. This may be regarded as a special case of the land use method with only two land use categories being considered, namely residential and employment activities. Projections for the future are obtained by applying these trip generation rates per unit of area in a given period of time to the future land use pattern.[14]

3) <u>Cross Classification Analysis</u>[15]

Much of the early work on this was undertaken by the Puget Sound Regional Transportation Study. It is a non-parametric or distribution-free technique. Essentially, 'n' number of variables are stratified into two or more appropriate groups, creating an 'n' dimensional matrix. Observations on the dependent variable are then allocated to the various cells of the matrix, based on the values of the several independent variables, and then averaged to obtain the trip rate per dwelling unit with certain socio-economic characteristics. The following table is produced by this technique.

TABLE I

TRIPS PER DWELLING UNIT CROSS-CLASSIFIED WITH HOUSEHOLD SIZE AND AUTO OWNERSHIP

No. of Persons Per d.u.	Average Total Person Trips Per d.u.				
	No. of autos owned per d.u.				Weighted Average
	0	1	2	3 & Over	
1	1.03	2.68	4.37	--	1.72
2	1.52	5.13	7.04	2.00	4.38
3	3.08	7.16	9.26	10.47	7.46
4	3.16	7.98	11.56	12.75	9.10
5	3.46	8.54	12.36	17.73	10.16
6 - 7	7.11	9.82	12.62	16.77	11.00
8 & Over	7.00	9.66	17.29	22.00	12.24
Weighted Average	1.60	6.62	10.53	13.68	6.58

Source: 1962 O.D. data by the Madison Area Transportation Study, Madison, Wisconsin.

Similarly, trips per dwelling unit may be cross-classified with other variables considered by the analyst to be possible indicators of travel demand, e.g. family income, stage in family life-cycle, etc. Once the important indicators of household travel are isolated, forecasts of dwelling units by car ownership and family size characteristics are applied to the base year trip rate matrix above. A straightforward approach would involve estimating percentages of the total future number of dwelling units, by zone, that are expected to fall into each cell in the matrix. Total trip production for a zone would then be determined by applying the appropriate trip rate to the number of dwelling units and summing individual trip estimates. For example, if a zone is expected to contain 500 dwelling units in the design year with 50% having a family of three and owning one automobile, their share of the total person trip production estimate would be:

$$7.16 \text{ trips/d.u.} \times 250 \text{ d.u.} = 1{,}790 \text{ trips}$$

The remaining 50% of households would be apportioned among the appropriate trip rate cells of the matrix in a similar way. The grand total would give the design year estimate of zonal trip productions. The same technique could be used for trip production estimates by purpose.

This method has the advantage of being able to detect curvilinear relationship. Since it need not assume normality in the data, nominal and ordinal data can be handled as well. The approach is somewhat tedious and more detailed than the reliability of the data or the statistical validity of the relationship would warrant. Moreover, the finer the stratification, the larger the sample required. Further, there is no simple way of measuring the amount of variation in the dependent variable explained by the independent variable under consideration.

4) Multiple Regression Analysis

Multiple regression is by far the most popular technique currently employed in trip generation analysis. With the aid of computers, the development of trip generation models becomes a relatively fast 'pre-packaged' process. By this process future trip generation is determined from a regression equation using such explanatory variables as car density, distance from C.B.D., residential density, income, etc. With a proper combination of variables, it is often possible to develop from the survey data an expression for trip generation which is correlated significantly, in a statistical sense, with the observed number of trips.[16] In most applications of regression analysis, the assumptions of linearity, normality and homogeneity of variance of a given set of data are accepted without statistical verification.[17] The different procedures used to develop an estimating equation are enumerated below:

a) Earlier model-builders attempted to search for independent variables that were individually correlated with the dependent variable. Multiple regression equations were then established consisting of various combinations and permeations of these variables. Those finally selected were more often than not those having the highest correlation coefficient. Another method is the manual "tear-down" method where all variables and combinations of variables are included initially and then eliminated by inspection of their simple correlation coefficients. One of the variables in a highly correlated pair is eliminated and the regression calculations are then repeated; the F-ratios with and without the eliminated variable are compared as a check on the variable's significance.

b) The former methods are now replaced by step regression. Two types of step regression programs are available. The first is the 'build-up' method, i.e. a battery of independent variables, whether basic, complex or trans-generated, are fed into the computer which selects the variable best correlated with the criterion, one at a time, and adds it to the equation, with the object of obtaining the highest R. The stepwise addition of variables continues until the specified F-ratio of remaining variables is no longer significant for inclusion.

The second method which is less widely used is called the 'tear-down' method, it successively deletes variables from an equation that at first contains all possible variables. The specified F ratio is the criterion used at each step for dropping out a variable.

2.4 Some Considerations in Using Multiple Regression Analysis

Due to the fact that multiple regression analysis is invariably performed with the computer using prepacked programs, there is an inherent danger for the analyst to become more and more dissociated from the data he is analyzing. Consequently it is emphasized that the first task in analysis must be to establish a theoretical framework through conceptualization of the relationships to be investigated. Careful formulation of the problem and hypothesis enables the analyst to completely control the process, instead of leaving the job of finding relationships entirely in the hands of the computer. Identifying and defining relationships between travel demand and the urban environment not only assists in the selection of independent variables consistent with the hypothesis put foward, but also helps eliminate those associated with the dependent variable simply by chance. The use of intercorrelated independent variables should be reviewed critically prior to computation. The implication of this will be dealt with at length in Chapters III and IV.

Another point worthy of note is that the analyst should have an idea before-hand of the degree to which the equation produced can be expected to fit the data. In other words, the amount of accuracy achievable by improving the multiple R and the standard error of estimate ($S_{y.x}$) is governed by the standard error of the mean ($S_{\bar{x}} = \frac{S_x}{\sqrt{N}}$) of the criterion. This statistic which indicates the sampling accuracy of the data being 'fitted' sets an upper limit to which the analyst should attempt to improve the $S_{y.x}$ of the regression equation. For $S_{y.x}$ to be pushed to greater accuracy than $S_{\bar{x}}$ is spurious. Therefore, when $S_{y.x}$ is approaching or equal to the value of $S_{\bar{x}}$, the regression analysis can be terminated as further 'fine tuning' only results in false precision.[18]

When computation is completed, the models developed should be evaluated both statistically and analytically. The former involves examining statistical measures of reliability and validity of the equation such as coefficient of multiple correlation and determination, standard error of estimate, standard error of the regression coefficients and the distribution of residuals. Section 1.8 in Chapter I gives a detailed non-mathematical account of the meaning of these terms. Note that all four should be used simultaneously as each provides a measure of different aspects of the estimating equation. The traditional over-emphasis on the coefficient of multiple correlation should be avoided.

The satisfaction of all these statistical tests does not eliminate the need to evaluate the equation for reasonableness. As mentioned before, equations are likely to be valid if formulated on a reasoned hypothesis.[19] Those exhibiting no causal or an illogical relationship should be discarded in favour of the ones with good explanatory and analytical powers. The supporting arguments for this are:

1) Multiple regression models are essentially predictive in function. Therefore, they must be capable of reflecting both real world phenomena and to specify a causal sequence among variables. The very form of the equation (e.g. one unit of change in X will cause say, two units of change in Y) dictates causality as a necessary condition for it to have any validity.
2) Regression models assume stability of relationship over time. The model is a valid forecasting tool only if the relationship on which it is based can be shown to be stable. Whether or not these parameters can be expected to exhibit secular stability depends largely on the extent to which the model includes structural relationships.[20] Put in another way, the relationships are more likely to be stable if the variables cover those basic motivating factors of urban travel that are not likely to change with time or from one city to another.[21]

In the process of predicting the value of the dependent variable in some design year, the forecasting of independent variables, usually from other sources, is a pre-requisite. The model should be evaluated in terms of whether the variables used are easy to project. Those whose future estimates are not available or cannot be forecasted should be omitted.

A common dilemma facing the analyst is the question of whether the improvement to the equation by adding another variable is enough to offset the additional effort in forecasting it. This is largely a trade-off situation. On the one hand, over-simplified models, though operationally feasible, may be theoretically so crude that they have little validity. On the other hand, over-complicated models based on obscure variables can be equally hazardous. What strategy to adopt will have to be resolved on an individual basis, although it is often advisable to choose somewhere between the two extremes.

Footnotes

[1]Christopher R. Fleet and Sydney R. Robertson, "Trip Generation in The Transportation Planning Process", Highway Research Record, No. 240 (1968), p.12.

[2]Ibid.

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[4]Loc. cit., p.8.

[5]S. T. Wong, "A Multivariate Analysis of Urban Travel Behaviour in Chicago", Transportation Research, Volume 3 (1969), p.36.

[6]M. A. Taylor, Studies of Travel in Gloucester, Northampton and Reading, Road Research Laboratory Report, LR 141, (Ministry of Transport, Great Britain, 1968), pp.153-155.

[7]K. Rask Overgaard, "Urban Transportation Planning: Traffic Estimation", Traffic Quarterly (April 1967), p.203.

[8]M. A. Taylor, op. cit., pp.153-155.

[9]U. S. Department of Transportation/Federal Highway Administration, Bureau of Public Roads, op. cit., p.17.

[10]W. L. Mertz, "A Study of Traffic Characteristics in Suburban Residential Areas", Public Roads, Volume 29 (August 1957), p.210.

[11]Herbert S. Levinson and F. Houston Wynn, "Some Aspects of Future Transportation in Urban Areas", Highway Research Board Bulletin, No. 326 (1962), p.16.

[12]Louis E. Keefer, Pittsburg Transportation Research Letter, Volumes 2-4 (May 1960), pp.12-13.

[13]K. Rask Overgaard, op. cit., p.201.

[14]U. S. Department of Transportation/Federal Highway Administration, Bureau of Public Roads: op. cit., p.1.

[15]Ibid, p.19. Data of Table I is based on 1962 O.D. survey data supplied by the Madison Area Transportation Study, Madison, Wisconsin.

[16]K. Rask Overgaard, op. cit., p.202.

[17]W. R. Jefferies and E. C. Carter, "Simplified Techniques for Developing Transportation Plans - Trip Generation in Small Urban Areas", Highway Research Record, No. 240 (1968), p.73.

[18]Christopher R. Fleet and Sydney R. Robertson, op. cit., p.19.

[19]M. A. Taylor, op. cit., p.165.

[20]J. H. Niedercorn and J. F. Kain, "Suburbanization of Employment and Population 1948-1975", Highway Research Record, No. 38 (1963), p.37.

[21]T. B. Deen, W. L. Mertz and N. A. Irwin, "Application of a Modal Split Model to Travel Time Estimates for the Washington Area", Highway Research Record, No. 38 (1963), p.98.

CHAPTER III

THEORETICAL EXPOSITION OF MULTICOLLINEARITY AS AN EXPLANATORY AND ANALYTICAL PROBLEM

This chapter puts foward the idea that a regression model should have three necessary attributes. Within the framework of these attributes the theoretical implications of multicollinearity to model-building is examined. Due to the mathematical nature of the exposition, a brief summary is provided in Section 3.2 for the non-mathematical reader. Those interested in pursuing the statistical proofs and theories can turn to Section 3.3 for details. Empirical examples will be represented in Chapter IV.

3.1 Model Attributes

Before proceeding onto the verification of the general hypothesis, it is necessary to discuss the meaning of analytical, explanatory and predictive power of the model.

Christ[1] enumerated several desirable properties which a model should possess. They are: relevance, simplicity, accuracy of coefficients, theoretical plausibility, explanatory ability and forecasting ability. In fact relevance and accuracy are implied in its explanatory and forecasting abilities. In sum, a model should possess three attributes: explanatory, analytical and predictive powers.

Explanatory ability means that a model should be able to explain the behaviour of variables under examination. Consistency and relevancy are the main ingredients in this because they aim at eliminating redundant variables that do not contribute to the explanation of a given phenomenon, but are included only because of high correlation to the criterion. An equation is considered better, other things being equal, the wider the range of data it can explain.[2] Therefore, a model is a better explanatory model if it is able to extract the pertinent underlying dimensionalities of the available data.

Analytical power means that a model should be able to establish causal relationships, where possible, and enable the testing of specific hypothesis through deductive reasoning. A model after all is no more than a formal statement of the outcome of analysis by which theories can be conceptualized and formulated.

Planning is future-oriented, therefore, the analyst wants models that can forecast the future. The predictive ability of a regression model is a function of:

1) Its ability to fit the data (as shown by R and $S_{y.x}$),

2) Its theoretical plausibility,

3) Ease in obtaining reliable forecast of independent variables.

The principle of theoretical plausibility may urge the analyst to build a model based on a comprehensive theory, thus more often than not resulting in a complex model. On the other hand, the last principle calls for simple models. Simplicity may refer either to the functional form or the number of explanatory variables included in the relationship. Although simplicity itself is a desirable feature, the model must also be a plausible one.[3] Bearing in mind that a complex model minimizes specification error due to omission of variables, but increases measurement error, and that a simple model does the exact opposite,[4] an optimal combination must exist. It is possible, up to a point, to gain advantage of specification without substantially increasing the measurement error. Therefore, in determining the projection implication of the model, the analyst must scrupulously examine not merely the statistical measures applied to calibration, but also the model structure itself to discover possible inconsistencies and contradictions. It is possible that, by reformulating a model, its R^2 may be lowered for the period of calibration, but that this, for theoretical reasons, will increase the confidence in its predictive accuracy.[5]

3.2 A Non-Mathematical Summary of the Theoretical Implications of Multicollinearity.

Multicollinearity has the following undesirable effects on the regression model:

1) Collinearity causes deterioration in the least-square estimating procedure in the regression system. When two independent variables are intercorrelated, one of them is superfluous. (See Sections 4.3 and 4.4). Such redundancy is contrary to the properties of consistency and relevancy in the model construct.
2) Collinearity is a source for compounding errors of the data set, both during the sampling and forecasting periods. Large standard errors of the beta coefficients usually result. Since the values of the beta coefficients become extremely unstable and highly susceptible to sampling error, conflicting conclusions regarding the behaviour of a variable from different samples of the same population can be drawn. This is hazardous to hypothesis testing. This is demonstrated empirically in Section 4.3.
3) Collinearity tends to make the value of R and R^2 very unreliable and indeterminate. Hence, a degree of fit obtained under this

condition often amounts to false precision and self-delusion. (See Section 4.4)

3.3 Problem of Multicollinearity - A Statistical Exposition

Using the three attributes as criteria for assessing the utility of models, a discussion on the theoretical implications underlying the problem of multicollinearity is in order here. The following will show how and why multicollinearity violates the properties of a good model construct.

1) Fitting A Line Instead of A Plane

In the case of simple regression, statistical fitting of data points amounts to drawing a least-square line through the scatter. For multiple regression models of 'n' variables, this amounts to fitting a n-dimensional regression surface to all the data points. Geometrically, in the three variable case, $Y = f(X_1, X_2)$ and when X_1 and X_2 are not correlated, the data points will be widely scattered on the X_1X_2 plane. A 99% equiprobability ellipse will then become a circle. The resultant regression surface will be a three dimensional plane through the scatter. (See Figure 2). However, when X_1 and X_2 are correlated, then the regression plane becomes an ellipse, flattened in one of its dimensions. (See Figure 3). When X_1

FIG. 2 GEOMETRIC INTERPRETATION OF MULTIPLE REGRESSION IN A THREE VARIABLE PROBLEM WITH NO INTERCORRELATION BETWEEN INDEPENDENT VARIABLES

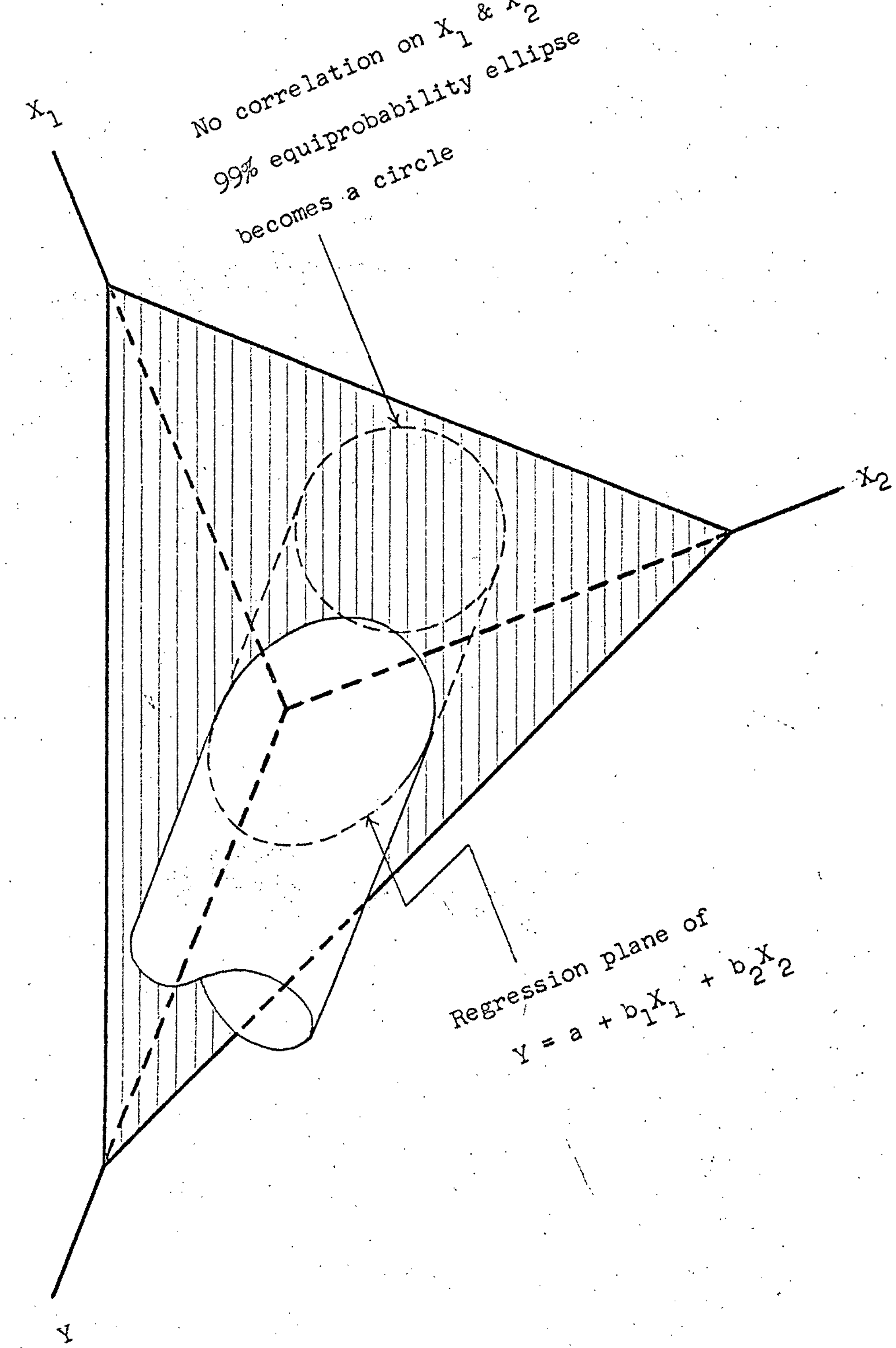
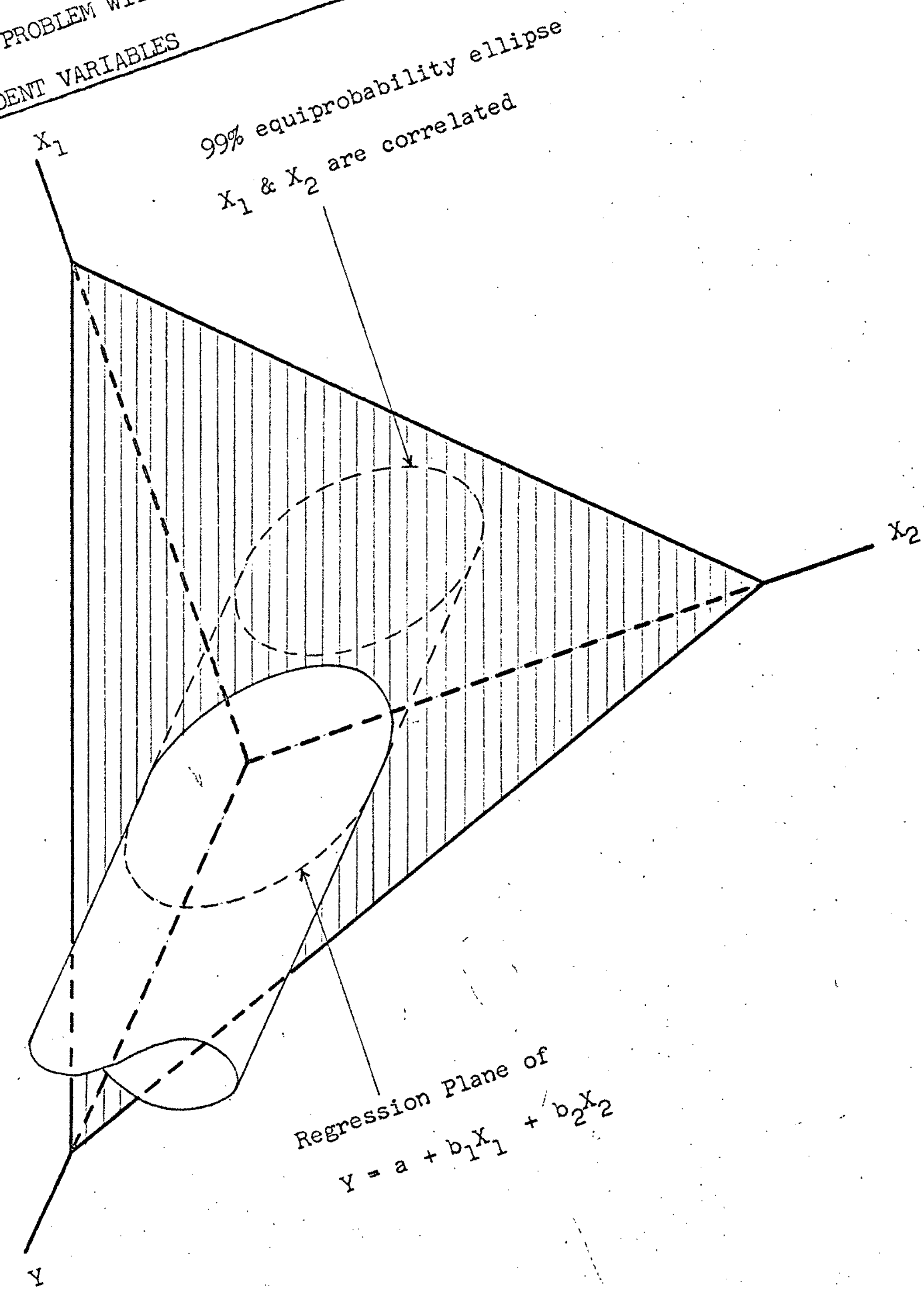


FIG. 3 GEOMETRIC INTERPRETATION OF MULTIPLE REGRESSION IN A THREE VARIABLE PROBLEM WITH INTERCORRELATION BETWEEN INDEPENDENT VARIABLES



and X_2 are near perfectly correlated, i.e. a linear function exists between them. Therefore,

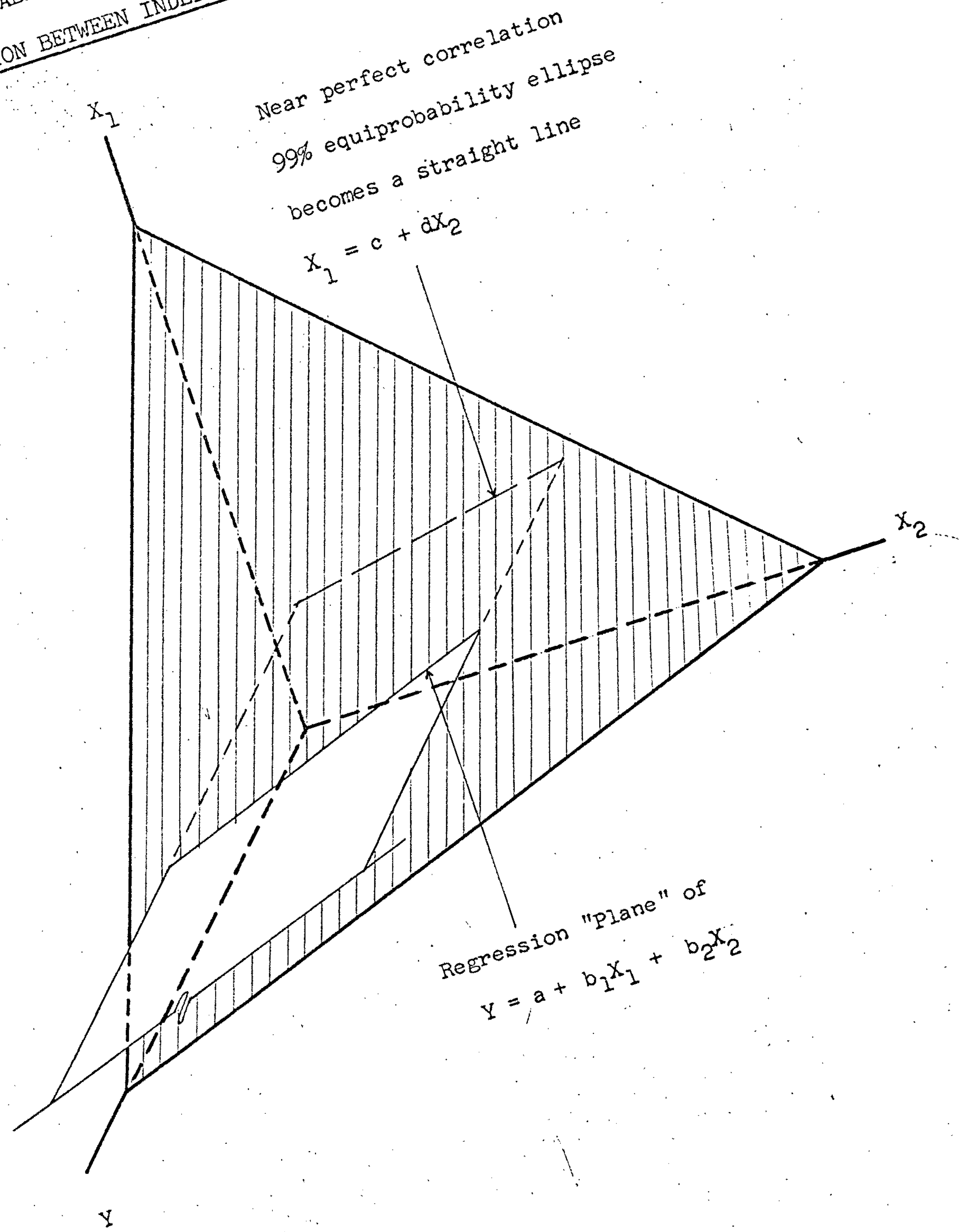
$$Y = a + b_1x_1 + b_2x_2$$

$$X_1 = c + dX_2$$

The geometric interpretation of least square fitting in this case is interesting and revealing. It means that the scatter of points in the X_1X_2 plane must lie exclusively on the straight line $X_1 = c + dX_2$; the Y value then gives rise merely to a vertical scatter of points (i.e. in the Y direction) above and below a single straight line in a three dimensional space. An attempt to fit an equation to the data involves inserting a plane in a three dimensional scatter of points, but in this case, the scatter is really only two dimensional, for the complete lack of scatter in the X_1X_2 plane means that all the sample points lie in a plane parallel to the Y-axis and which contains the line $X_1 = c + dX_2$. The regression plane then becomes a line. (See Figure 4)

Frisch[6] termed this phenomenon as "p-fold flattened" regression when such clustering occurs in a n-dimensional regression surface ($n > 2$). In the case quoted above, $n = 3$, $p = 1$. Therefore, the regression is "one-fold flattened". It is not a true three variable multiple regression problem but should be a two variable or simple regression problem. The variable X_1 has nothing to

FIG. 4 GEOMETRIC INTERPRETATION OF MULTIPLE REGRESSION IN A THREE VARIABLE PROBLEM WITH NEAR PERFECT INTERCORRELATION BETWEEN INDEPENDENT VARIABLES



do in the linear regression system. From the standpoint of linear regression it is a superfluous variable drawn into observation and the whole system of regression coefficients can in fact be considered artificial.

The significance of this lies in that inclusion of collinear sets is contrary to the properties of consistency and relevancy that are desirable in the model construct. This is obvious as the resulting model includes redundant variables that do not 'explain' variation in the criterion. Moreover, their presence may preclude the inclusion of relevant variables that have been overlooked.

2) Indeterminacy of Beta Coefficients Usually Accompanied by a Large Standard Error

When the correlation between the independent variables is high, the sampling error of the partial slopes and partial correlations will be quite large. As a result there will be a number of different combinations of regression coefficients, and hence partial correlations, which gives almost equally good fits to the empirical data. The following example will serve to indicate the problem involved.[7]

Let $$Y = a + b_1X + b_2Z + e_1$$

Suppose X and Z are perfectly related according to the equation

$$X = c + dZ$$

Putting in numerical values for the coefficients, for a = 6, $b_1 = 5$, $b_2 = 3$, c = 1 and d = 2, we have

$$Y = 6 + 5X + 3Z + e_1 \quad \ldots\ldots\ldots \quad (1)$$

$$X = 1 + 2Z \quad \ldots\ldots\ldots \quad (2)$$

$$(2) \times 3 \quad 3X = 3 + 6Z \quad \ldots\ldots\ldots \quad (3)$$

$$(1) - (3) \quad Y = 3 + 8X - 3Z + e_1 \quad \ldots\ldots\ldots \quad (1')$$

Eqn. (1') is therefore mathematically the same as eqn. (1). But there are obviously an infinitely large number of such equations that gives equally good fitting to the data. Therefore there is no way of determining the coefficients uniquely. However, if an error term e_2 were to be added to eqn. (2), a unique solution with least squares can then be obtained as eqn. (4) now is mathematically distinct from eqn. (1):

$$Y = 6 + 5X + 3Z + e_1 \quad \ldots\ldots\ldots \quad (1)$$

$$X = 1 + 2Z + e_2 \quad \ldots\ldots\ldots \quad (2')$$

$$(2') \times 3 \quad 3X = 3 + 6Z + 3e_2 \quad \ldots\ldots\ldots \quad (3')$$

$$(1) - (3') \quad Y = 3 + 8X - 3Z + e_1 - 3e_2 \quad \ldots\ldots \quad (4)$$

But such a solution will not render the regression model desirable properties. This is intuitively obvious as the entire estimate of parameters hinges on the error term e_2 which means that with slight modifications of the magnitude that could easily be due to sampling or measurement error, one might obtain estimates which differ considerably from the original set.[8] This may lead to erroneous conclusions about the hypotheses to be tested.

Examination of the formula for standard error of beta coefficients shows that the higher the correlation between independent variables, the greater the standard error of the coefficient.

$$\sigma^2 B_{12.23\ldots\ldots m} = \frac{1 - R^2_{1.234\ldots\ldots m}}{(1-R^2_{2.34\ldots m})\ (N - m)}$$

where m = number of variables in the equation

N = number of observations

R^2 = multiple coefficient of determination

In the three variable case:

$$\sigma^2 B_{12.23} = \frac{1-R^2_{1.23}}{(1-R^2_{2.3})\ (N - m)}$$

When variable 2 and 3 are highly correlated the denominator of the equation becomes very small and hence the standard error will increase considerably.

When one considers the correlation matrix of variables, one can in fact think of them as variances and covariances matrix for the same set of variables when they are standardized. The intercorrelation of independent variables is none other than their covariance. The covariance indicates the degree to which two variables are likely to err in the same or different directions because of sampling fluctuations. If covariance of two variables is positive, this means that an overestimate of one will lead to an overestimate of the other, and the same for underestimates. If their covariance is negative, the overestimate of one will be accompanied by an underestimate of another, and vice versa. If their covariance is near zero, then there is no correlation between the variables, the over-estimate or underestimate of one bears no reflection on the other.

The importance of this concept is that if X_1 and X_2 are two correlated variables that have been included in the model, the change in X_1 in the sampling period is always accompanied by the change in X_2. This being so, one could never discover the coefficient of either X_1 or X_2, and all we could tell is when X_1 (and hence X_2) changes by one unit, Y usually changes, say, by 0.8 unit in the same direction. We could not rule out the possibility that b_1 (the b coefficient for X_1) is 0 and b_2 (the b coefficient for X_2) is 0.8, or that their beta values are respectively 0.8 and 0; or 0.4 and 0.4. This problem cannot be overcome even by taking large samples. The only recourse is to choose the correct model to begin with.[9]

One could argue that if the aim is not primarily to estimate parameters in the regression equation, but instead to forecast the value of the dependent variable, then the inability to determine the true separate value for beta coefficients will not be problematic. The answer is both yes and no. One must realize that the whole basis for prediction is the assumption that the relationship observed between independent and dependent variables will remain constant. If the joint distribution of the independent variables between themselves and also with the dependent variable stays the same in the forecasting period, then there is no disadvantage in multicollinearity. This is, however, subject to the following qualifications;

1) That the standard error of the beta coefficient will be great. This means that there is less faith in the prediction.
2) That the high correlation may yield a higher multiple R^2 than warranted. This will render the estimate unrealistic.

If the sampling relationship of the independent variables with the criterion is much altered during the forecasting period, variation of one necessitates the variation of the other. Hence the predicted value will have a greater margin of error. However, if the independent variables are not significantly correlated, the change in the relationship of one with the criterion need not affect the others. In this way, the margin of error is minimized and a more reliable prediction can be obtained.

3) Effect on Multiple Coefficient of Determination

There are two conflicting effects that multicollinearity has on the multiple R^2, namely:

a) Multiple R^2 increases as the size of intercorrelation of independent variables decreases.

b) Multiple R^2 increases when the intercorrelation of independent variables is high.

This can be better understood by looking at the formula for multiple coefficient of determination in a three variable case.

$$R^2_{1.23} = \frac{r^2_{12} + r^2_{13} - 2r_{12}r_{13}r_{23}}{1 - r^2_{23}} \quad . \quad . \quad . \quad . \quad (5)$$

or $R^2_{1.23} = r^2_{12} + r^2_{13}$, if the intercorrelation of two independent variables is zero. . . . . (6)

If the correlation r_{23} is zero, the third term in the numerator of eqn. (5) is zero, which has a tendency to make $R^2_{1.23}$ larger. On the other hand, there is a distinct gain in having r_{23} very large, because of its role in the denominator. If r_{23} approaches 1.0, the denominator approaches zero. Even though the numerator may become small, under these conditions R^2 can be quite large. A large R^2 is thus obtained by having r_{23} either very small or very large. This is because its role in the numerator only decreases R^2 in a linear manner, but its role in the denominator increases R^2 exponentially.[10]

In order to visualize the effect of intercorrelation of the predictors on multiple R^2, Figure 5 is plotted based on the following table.

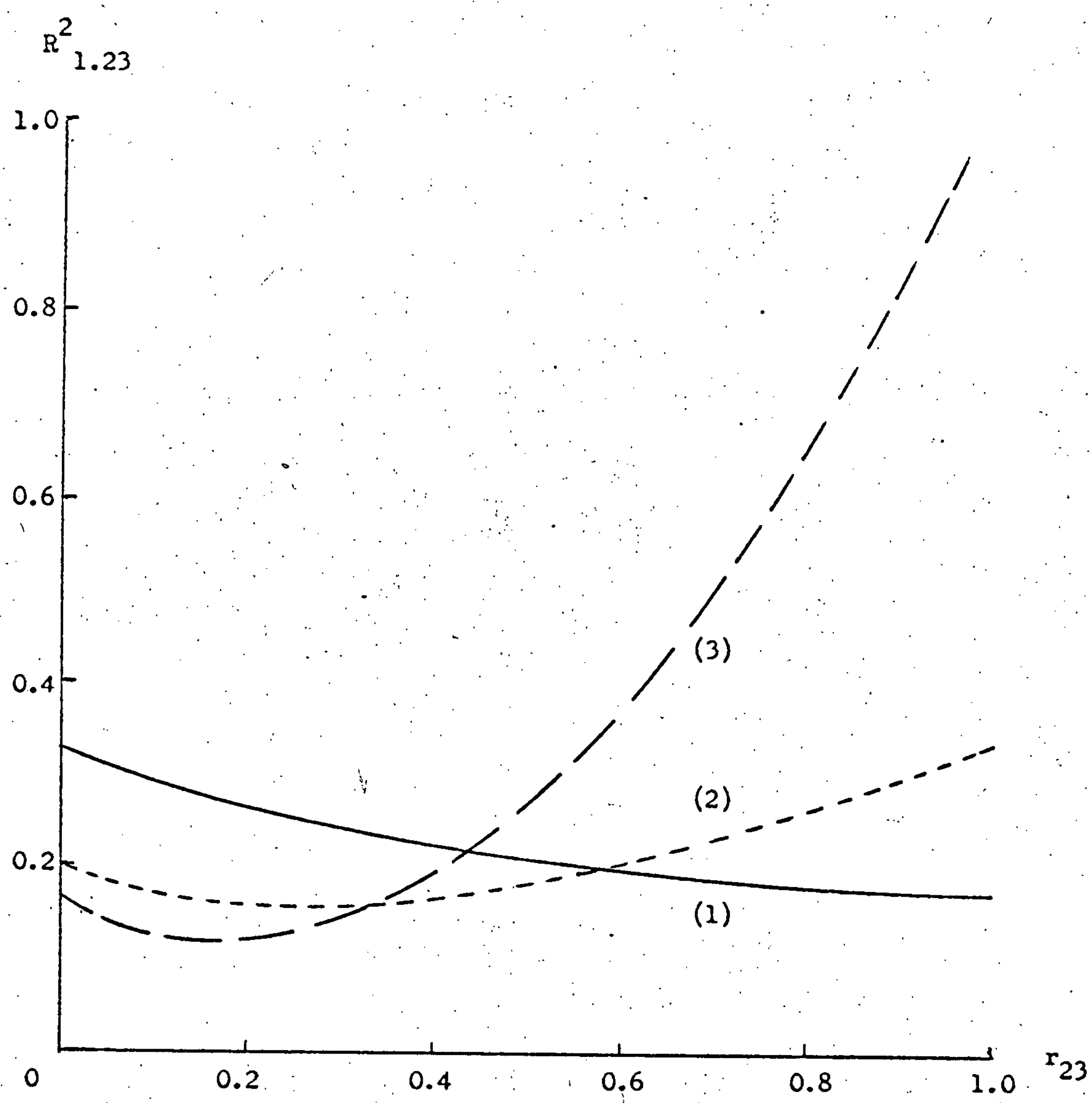
TABLE II

EXAMPLES OF MULTIPLE CORRELATIONS IN A THREE VARIABLE PROBLEM WHEN INTERCORRELATIONS VARY

Example	r_{12}	r_{13}	r_{23}	$R^2_{1.23}$	$R_{1.23}$
1	0.4	0.4	0.0	0.3200	0.57
2	0.4	0.4	0.4	0.2286	0.48
3	0.4	0.4	0.9	0.1684	0.41
4	0.4	0.2	0.0	0.2000	0.45
5	0.4	0.2	0.4	0.1619	0.40
6	0.4	0.2	0.9	0.2947	0.54
7	0.4	0.0	0.0	0.1600	0.40
8	0.4	0.0	0.4	0.1905	0.44
9	0.4	0.0	0.9	0.8421	0.92

Source: J. R. Guilford, "Fundamental Statistics in Psychology and Education, (New York: McGraw Hill Inc., 1965), p.404.

FIG. 5 GRAPH SHOWING MULTIPLE $R^2_{1.23}$ AS A FUNCTION OF r_{23}



(1) $R^2_{1.23}$ as a function of r_{23} when r_{12} & r_{13} are the same (0.4).

(2) $R^2_{1.23}$ as a function of r_{23} when r_{12}(0.4) and r_{13}(0.2) are unequal.

(3) $R^2_{1.23}$ as a function of r_{23} when one variable is not correlated with the dependent variable, $r_{12} = 0.4$, $r_{13} = 0.0$

From the graph it can be seen that

1) When r_{12} and r_{13} are the same, increase in r_{23} will decrease multiple $R^2_{1.23}$.
2) When r_{12} and r_{13} are unequal, increase in r_{23} will decrease multiple $R^2_{1.23}$ up to a point, but once r_{23} is above 0.6, then multiple $R^2_{1.23}$ increases steadily.
3) When r_{12} and r_{13} are very unequal, especially if one of them has no correlation with the criterion, then increase in r_{23} up to 0.24 will decrease multiple $R^2_{1.23}$, once above that, $R^2_{1.23}$ increases very rapidly towards unity.

Therefore, there is a distinct disadvantage in having correlated independent variables because it tends to make the value of R^2 highly unreliable and indeterminate. By the same token,a large R^2 obtained by having r_{23} very small is a more reliable estimate, than having r_{23} very large because of the foregoing explanation.

3.4 Conclusion

The preceding attempts to show that prediction is not independent of other model attributes. Explanatory and analytical ability can only be attained by a consistent and logical model construct. Harris uncompromisingly favors the analytic approach of theorizing in model construction, enlightened by an adequate inductive understanding[11] and Blalock asserts that "understanding" of the phenomenon under examination is the key to accurate prediction.[12] Both positions are well founded.

Footnotes

[1] C. F. Christ, Econometric Models and Methods, (New York: John Wiley & Sons Inc., 1966), p.4.

[2] Ibid, p.5.

[3] Walter Y. Oi and Paul W. Shouldiner, "An Analysis of Urban Travel Demands", (Transportation Centre, Northwestern University, 1962), p.73.

[4] William Alonso, "Predicting Best With Imperfect Data", Journal of the American Institute of Planners, Volume 34, No. 3. (1968), pp.248-251.

[5] Britton Harris, "Quantitative Models of Urban Development: Their Role in Metropolitan Policy-Making", Issues in Urban Economics, Edited by Harvey S. Perloff & Lowdon Wingo Jr., (Johns Hopkins Press, 1968), p.383.

[6] R. Frisch, Correlation and Scatter in Statistical Variables, (University of Oslo, 1934), p.57.

[7] H. M. Blalock Jr., "Correlated Independent Variables: The Problem of Multicollinearity", Social Forces, Volume 42 (December 1963), pp.233-234.

[8] Ibid.

[9] C. F. Christ, op. cit., p.389.

[10] J. P. Guilford, Fundamental Statistics in Psychology and Education, (New York: McGraw Hill Inc., 1965), p.404.

[11] Britton Harris, op. cit., p.381.

[12] H. M. Blalock Jr., Social Statistics, (New York: McGraw Hill Inc., 1960), p.274.

CHAPTER IV

EMPIRICAL VERIFICATION OF HYPOTHESES

4.1 Summary of Empirical Findings

This chapter verifies the general hypothesis through the testing of three operational hypotheses. By first examining a trip generation model with collinear variables (Model 1), it is shown that:

a) Within the collinear set, one variable is a linear transformation of the other and is redundant.

b) The large standard error of the constant confirms that collinearity is a source of compounding error.

c) Simple and partial correlation coefficients exhibit remarkable discrepancies in the equation. Conflicting conclusions can be reached for the relationships among variables.

d) The high R of this model implies greater accuracy than justified by the input data.

Secondly, the data is subjected to factor analysis with a view to obtaining a set of orthogonal factors. When the reinforcing effect of the collinear variables in Model 1 is eliminated, the R is significantly lowered,as in Model 2 which incorporates basically the same factors. Collinearity makes R very unreliable and it loses much of its value as a statistical measure of the strength of the model. It is also noted that the orthogonal factors are more efficient in detecting the traffic-land use relationships in the districts than are the original variables, which are subject to the subtle influence of many interacting factors.

Thirdly, it is discovered that the omission of land use dimensions have resulted in large residuals in Model 2. An alternate model is developed. It incorporates land use factors that not only give the model a better theoretical construct, but which are also capable of producing a good fit of data. This finding appears to indicate that there is no artificial distinction between a model's analytical, explanatory and predictive functions. All three, in fact, must go hand-in-hand in order to produce an operational model.

4.2 Formulation of Three Operational Hypotheses

This section attempts to test, empirically, the General Hypothesis:

> "When collinearity exists in a regression model, explanatory and analytical power are decreased, despite the apparently good predictive power shown by a high multiple correlation coefficient."

Three operational hypotheses are formulated for this purpose, namely:

H_1: When collinearity exists, the true contribution of some independent variables may be exaggerated, obscured or suppressed.

H_2: When highly correlated independent variables exist in a model, the multiple R^2 is an unreliable estimate of the true relationship between the predictors and the criterion.

H_3: When highly correlated independent variables are included in a model, other significant explanatory variables may be omitted due to the predominance of collinear sets.

4.3 Validation of Hypothesis 1

To verify hypothesis 1, multiple regression analysis is applied to the trip generation model derived by step regression for Greater Vancouver. This will henceforth be referred as Model 1. (Details of this computer output appear in Appendix E) The equation takes the form:

$$\text{Total Trips Generated} = \underset{(594.0954)}{338.7013} - \underset{(0.1574)}{0.651} \times (\text{Labour Force}) + \underset{(0.2666)}{2.5415} \times (\text{Dwelling Units with Car}) - \underset{(26.5996)}{79.4897} \times (\text{Area})$$

$$R^2 = 0.9647, \qquad R = 0.9822, \qquad S_{y.x} = 1842$$

(The figures in parentheses denote standard errors of regression coefficients.)

The regression analysis reveals that 96% of the variance in "Total Trips Generated" is explained by "Labour Force", "Dwelling Units with Car" and "Area". The intercorrelation between "Labour Force" and "Dwelling Units with Car" is 0.975, but there is no significant correlation between Area and the other two independent variables.

In view of the presence of a collinear set in the model, a simple regression is performed which indicates that the second variable is merely a linear transformation of the first, as follows,

$$\text{Labour Force} = 1.6571\ (\text{D.U.W.C.}) - 668.6074$$
$$r = 0.975$$

The explanation is obvious as both variables describe aggregated characteristics of the household, and both are stable proportions of the size of zonal inhabitants. This anticipates the result of the factor analysis.

A point worthy of note is that large standard error (594.0954) of the constant (338.7013). The confidence interval for the value of the intercept at 95% level is 338.7013 ± 664.24. Therefore, the value of the constant can be anywhere between -325.5387 and 1,002.9413. The error is considered unusually large for an equation with a R^2 of 0.9647. In fact it would be of interest to compare the difference in results if the regression line is forced through zero, i.e. with the constant eliminated.

Another point of interest is that the standard error of estimate for "Total Trips Generated" in this model is 1842, which is even less than the standard error of the mean of the sample. (The sample size is 32, and the standard deviation is 9314. Therefore, $S_{\bar{x}} = \frac{\sigma}{\sqrt{N}} = \frac{9314}{\sqrt{32}} = 1892$). As previously pointed out in Section 2.4 (p.34), when the estimating equation is pushed to greater accuracy than justified by the input data, this results in false precision. Hence the very high R^2 obtained can be considered spurious because the degree of "fit" is closer to the tolerance limits than those associated with the input data. Although the difference in magnitude is not big, it demonstrates that this phenomenon can occur by the inclusion of collinear variables.

A comparison of the simple and partical correlation coefficients of the dependent and independent variables is revealing. (See Table III)

TABLE III

SIMPLE AND PARTIAL CORRELATIONS OF MODEL 1.

Variables	Simple Correlation		Partial Correlation		Remarks
	r	r^2	r	r^2	
Labour Force	0.9209	0.8481	-0.6158	0.3792	Partial r changes sign*
DUWC	0.9700	0.9409	0.8744	0.7645	Partial r lower*
Area	-0.0242	0.00059	-0.4917	0.2419	Partial r higher*

* Their differences are significant at 0.01 level.

The simple correlation coefficients represent the effects of one independent variable on the dependent variable, with the effects of other variables allowed to vary at the same time. Partial correlation coefficients represent the effects of one independent variable on the dependent variable, holding constant the effects of other variables. The conclusion to be drawn from the simple correlation coefficients are:

1) "Labour Force" is very highly correlated with "Total Trips Generated" in a positive direction. It explains about 85% of the latter's variance.
2) "Dwelling unit with Car" is also very highly correlated with "Total Trips Generated" in a positive direction. It explains 94% of the latter's variance. (Column 3 of Table III)
3) "Area" is slightly correlated with "Total Trips Generated" in a positive direction. It explains practically nothing of the latter's variance.

However, when the influence of other variables is being partialled out, the conclusion to be drawn from the partial correlation coefficients are:

1) "Labour Force" is moderately correlated with "Total Trips Generated" in a negative direction. In other words, the larger the Labour Force, the fewer the trips generated. The explanation seems to lie in the fact that in this set of data, "Labour Force" is negatively correlated with: "Cars per Dwelling Unit", "Population per Dwelling Unit", "Percentage of Dwelling Units with Car", "Time to C.B.D.", "Area" and "Income per Dwelling Unit".

This suggests that districts with a large labour force tend to have lower car ownership, lower income per dwelling unit, and fewer persons per household. These districts are also close to the C.B.D. and have small areas. These characteristics point to districts with higher density dwellings, lower socio-economic status, single person households and areas of mixed land uses. Area of mixed land uses and high density usually generates fewer vehicle trips because of availability of employment, shopping and entertainment facilities nearby.[1] Thus, the negative relationship between "Total Trips Generated" and "Labour Force" appears plausible. In addition, "Labour Force" really does not explain very much of the variance of the criterion - only 37.92% as opposed to the somewhat exaggerated estimate shown by the simple correlation coefficient. The reason for the discrepancy between the simple and the partial correlation coefficients is that the strong positive relationship between "Labour Force" and "Dwelling Unit with Cars", which is positively correlated with "Total Trips Generated", obscures the true negative relationship cited. Hence highly misleading conclusions can be drawn by examining simple correlation coefficients alone in a model with collinear sets.

2) Correlation of "Dwelling Units with Car" and "Total Trips Generated" is lowered when the reinforcing effect of "Labour Force" is removed.

3) "Area" is shown to explain a much larger portion of the variance of "Total Trips Generated" than warranted by the simple correlation coefficients. This indicates that its true effect on the criterion has earlier been suppressed due to the dominance of the collinear set. At first glance the outcome appears unreasonable because the absolute area of a district has no bearing on the number of trips generated. Boundaries are but arbitrary lines on the map. However, close examination reveals that the traffic districts are set up in such a way that all large tracts happen to be rural areas outside the City of Vancouver. Therefore, "Area" becomes a proxy for distance from C.B.D. and to some extent represents the degree of urbanization of the tract. In the light of this, the higher partial r^2 then appears plausible.

Results of the multiple regression analysis indicates that Model 1 has a few undesirable properties:

1) It does not explain the underlying relationships among variables in their true perspective, as evidenced by the discrepancies in the simple and partial correlation coefficients. This makes the testing of hypotheses a difficult task.

2) The high intercorrelation of "Labour Force" with "Dwelling Units with Car" produces a 'one-fold flattened' regression system. One of the two variables appears superfluous.

3) There is a possibility that other important dimensions that could explain trip generation have not been entered into the model due to the predominance of the collinear set.

This analysis, therefore, supports Hypothesis 1 which states that:

> "When collinearity exists, the true contribution of some independent variables may be exaggerated, obscured or suppressed."

Under such circumstances, it is difficult to decide from the model which are the causal factors for trip generation.

4.4 Validation of Hypothesis 2

A. Factor Analysis

In view of the above findings, the set of data was subjected to factor analysis by the principal component method. Varimax rotation was employed to obtain a simple structure. Since trip generation is a function of land use and socio-economic characteristics of the population, it might be interesting to determine the underlying dimensions that explains it. Principal component analysis is ideal for handling such a problem, it eliminates all redundant factors within a set of variables and produces and underlying set of orthogonal factors.[2] Out of a total of twenty-nine variables, factor analysis only produces seven major factors. The loadings of variables on the factors are clear, i.e. each loads very highly on one major factor alone, with no variable loading half-and-half on two factors. A diagrammatic representation of the composition of these seven major factors is shown in Figure 6. (Detailed results of the factor analysis are shown in Appendix F).

Factor I (Size): This factor accounts for 43% of the variance, it is composed of variables descriptive of the size of population. As expected, "Labour Force" and "Dwelling Units with Car" are collapsed into this factor, meaning that they in fact explain the same dimension in the data. All variables load positively on this factor. One point of interest is that variables for single family dwellings are picked up here whereas those for multiple family dwellings are picked up in Factor III (Density). This shows that single family dwelling variables are good approximations of the total population since this is the predominant North American way of life. The same may not apply to cities where apartment living is more prevalent, such as in Asiatic cities.

Factor II (Employment): All employment variables are collapsed into this dimension accounting for 25% of the variance. These variables load positively on the factor with two exceptions: "Cars per Dwelling Unit" and "Percentage of Dwelling Unit with Car". The explanation lies in that commercial and industrial areas have lower car ownership as a result of lack of residential units.

Fig. 6 COMPOSITION OF SEVEN MAJOR FACTORS OUT OF 29 VARIABLES

Factor I	Factor II	F. III	F. IV	F. V	F. VI	F. VII
Size	Employment	Density	Income	Area	Student	Household Size
Variance explained 43 %	25 %	12 %	5 %	4 %	3 %	2.7%

Percentage of trace: 94.7 %

Factor I	Factor II	F. III	F. IV	F. V	F. VI	F. VII
1.total population	14.car per d.u.*	3.pop. multi. fam.*	22.income per d.u.	18.time to C.B.D.	17.student 4-6 pm.	15.popul. per d.u.
2.pop. single family	16.% d.u. with car*	6.lab. force, m.f.*				
4.labour force total	23.total employment	9.multi.fam. d.u.*				
5.labour force,sing.fam.	24.employ. public	12.m.f.d.u. with car*				
7.dwelling unit, total	25.emp. industry	29.population density*				
8.single family d.u.	26.emp. service					
10.d.u. with car	27.emp. entertainment					
11.s.f.d.u. with car	28.emp. density					
13.cars total						
19.gross income						
20.bus miles						

Note: * denotes negative factor loadings

Factor III (Density): This factor includes all variables for multiple family dwellings and "Population Density", and accounts for 12% of the variance. All variables load negatively on this factor, this means that tracts with positive loadings on it will be low density areas whereas those with negative loadings will have higher densities.

Factor IV (Income): This factor includes only one variable, "Income per Dwelling Unit", and accounts for 5% of the variance. Strangely enough "Gross Income" is not picked up in this factor but in Factor I, showing that it is a better measure of size than actual economic status of the tract.

Factor V (Area): This factor consists of "Time to C.B.D." and "Area". The former variable loads positively here because the larger the areal units, the longer time it takes to reach C.B.D. This factor accounts for 4% of the variance.

Factor VI (Student): It is composed of only one variable, "No. of Students" in the district at 4-6 p.m. This factor accounts for 3% of the variance.

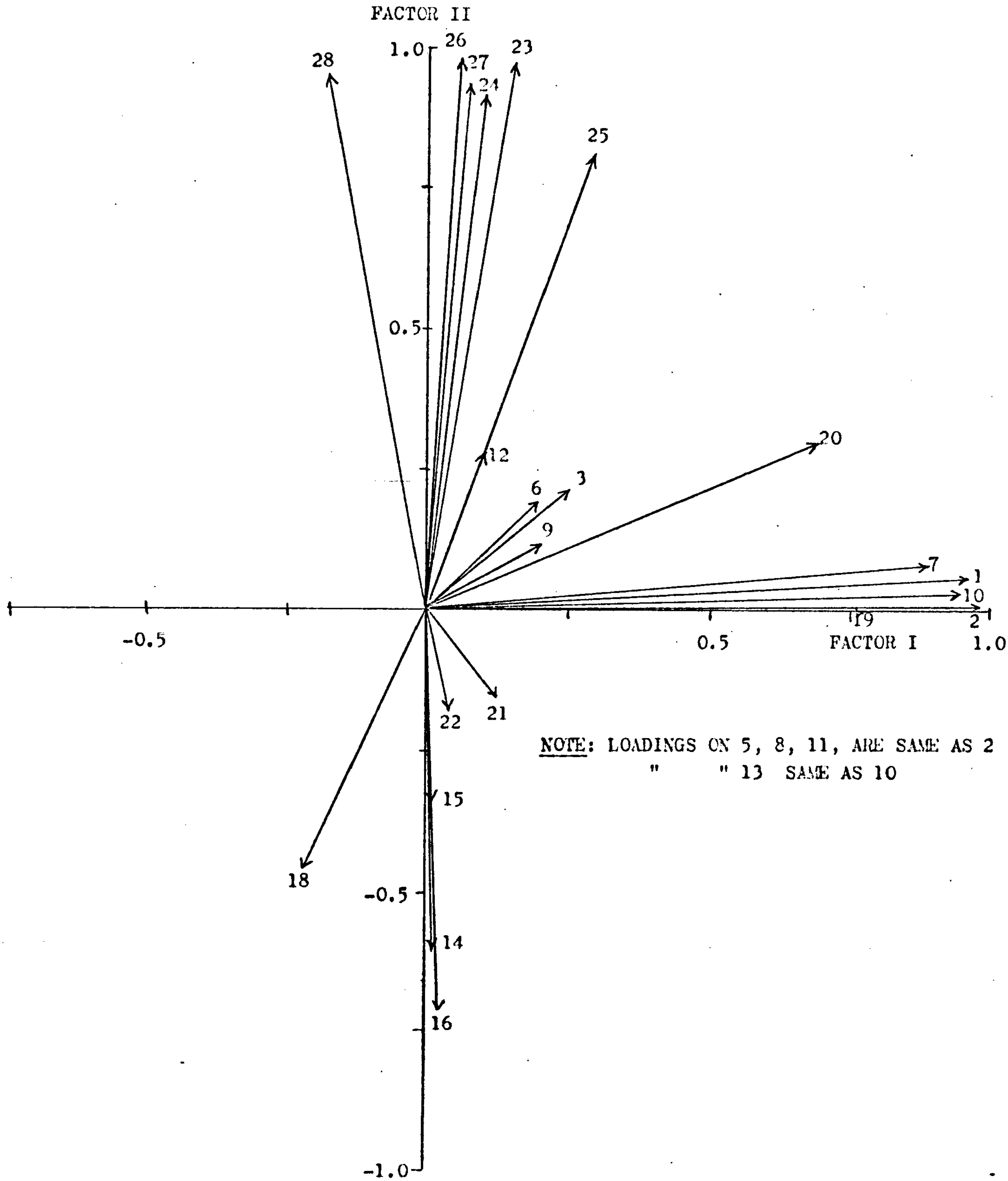
Factor VII (Household Size): The only variable that loads in this factor is "Population per Dwelling Unit". 2.7% of the variance is explained by this dimension.

Three graphs have been prepared to illustrate the behaviour of variables in one factor in justaposition with another. In doing so, it is hoped that relationships not otherwise revealed by multiple regression analysis can be discovered.

Figures 7, 8 and 9 show loadings of variables on Factor I versus Factor II, Factor II versus Factor III and Factor III versus Factor IV. Each arrow represents a vector for a particular variable in a two-dimensional space. The longer the arrow, the higher the loading. Variables contributing heavily to one factor will lie close to the axis of that factor. The closer the vectors are to one another, the more collinear the variables sets are. If the angle between two vectors approaches 90°, the correlation between them approaches zero, i.e. they are independent and orthogonal.

Figure 7 reveals that variables loading highly on Factor I load very little on Factor II, and vice versa. This means there is not much employment opportunity in residential areas. Variable 28 (Employment Density) further substantiates this fact because it loads negatively on Factor I but positively on Factor II. Variables 14 (Cars per Dwelling Unit) and 16 (% of Dwelling Unit with Car) loads negatively on Factor II, but positively on Factor I meaning that employment areas have low car ownership but residential areas have high car ownership. Variable 18 (Time to C.B.D.) loads negatively on both of the two factors showing that the further away from C.B.D., the lower the population and employment opportunities. This land use pattern is true for Vancouver but may not apply for cities such as Boston.

FIG. 7 LOCATION OF THE FIRST & SECOND COMPONENT VECTORS FOR THE VARIABLES IN TWO-DIMENSIONAL SPACE



NOTE: LOADINGS ON 5, 8, 11, ARE SAME AS 2
" " 13 SAME AS 10

Figure 8 shows the loading of variables on Factor II versus Factor III. Variables loading highly positive on Factor II load negatively on Factor III, meaning that in areas of high employment opportunities, there are more multiple family dwelling units. This factor manages to pick up areas of mixed land uses.

Figure 9 shows the loadings of variables on Factor III versus Factor IV. Note that variables loading negatively on Factor III also load negatively on Factor IV. This implies high density areas generally have lower income. Variable 19 (Gross Income) and 29 (Population Density) load negatively on Factor III but positively on Factor IV showing that gross income diminishes with lower density although Income per Dwelling Unit may likely be higher in the latter areas.

If the three graphs are superimposed, there is virtually no overlap in the position of component vectors in the factor space. This further confirms that the resultant factors are distinct and uncorrelated dimensions of the data.

B. Regression on Two Factors: Size & Area

Results of the factor analysis indicates that the inclusion of both "Labour Force" and "Dwelling Units with Car" in Model 1 is statistically and theoretically incorrect because they explain the same thing. A new regression model (Model 2) is formulated by regressing Factor I (Size) and Factor V (Area) on "Total Trips Generated". Now that these two factors are orthogonal, reinforcing

FIG. 8 LOCATION OF THE SECOND & THIRD COMPONENT VECTORS FOR THE VARIABLES IN TWO-DIMENSIONAL SPACE

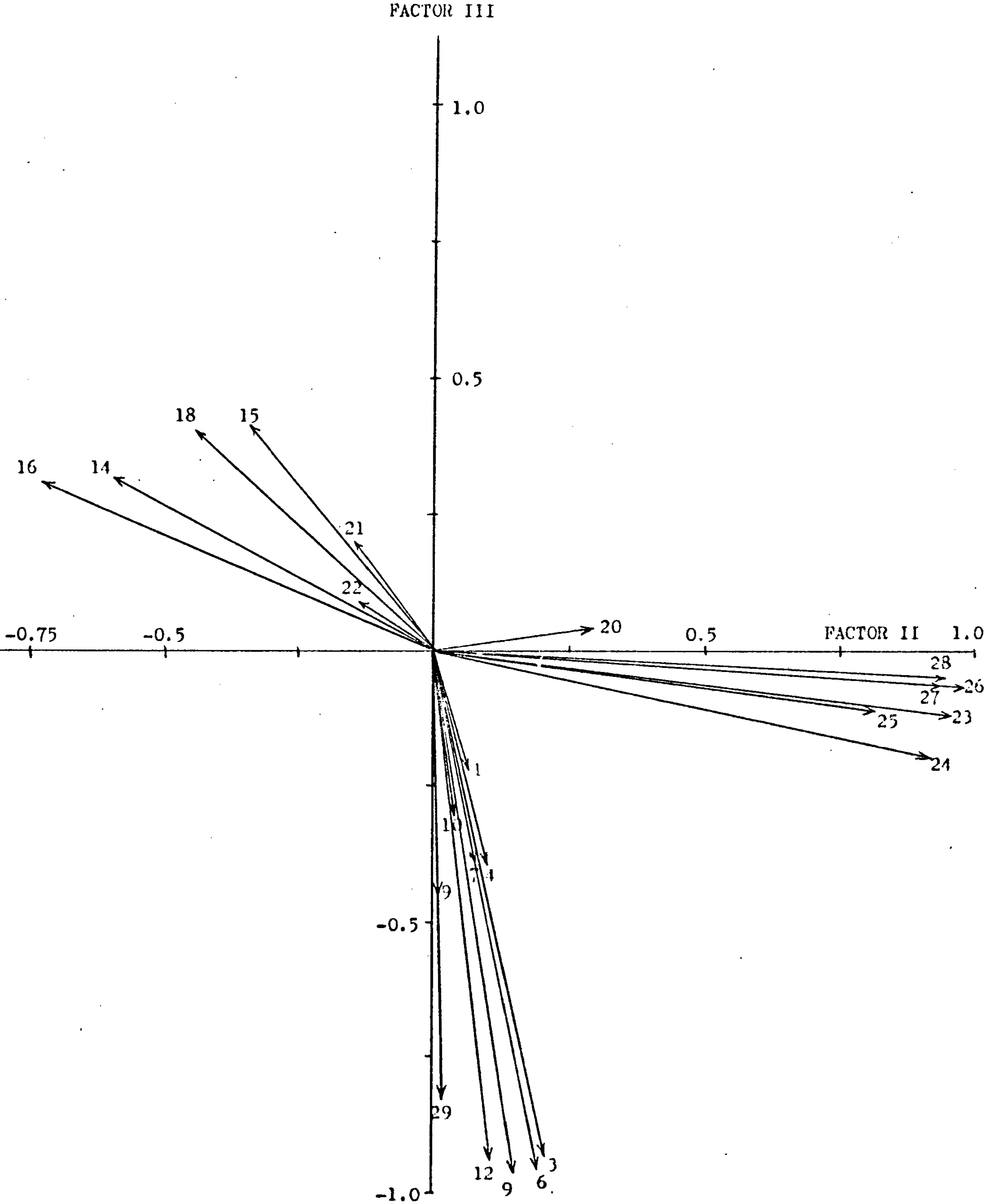
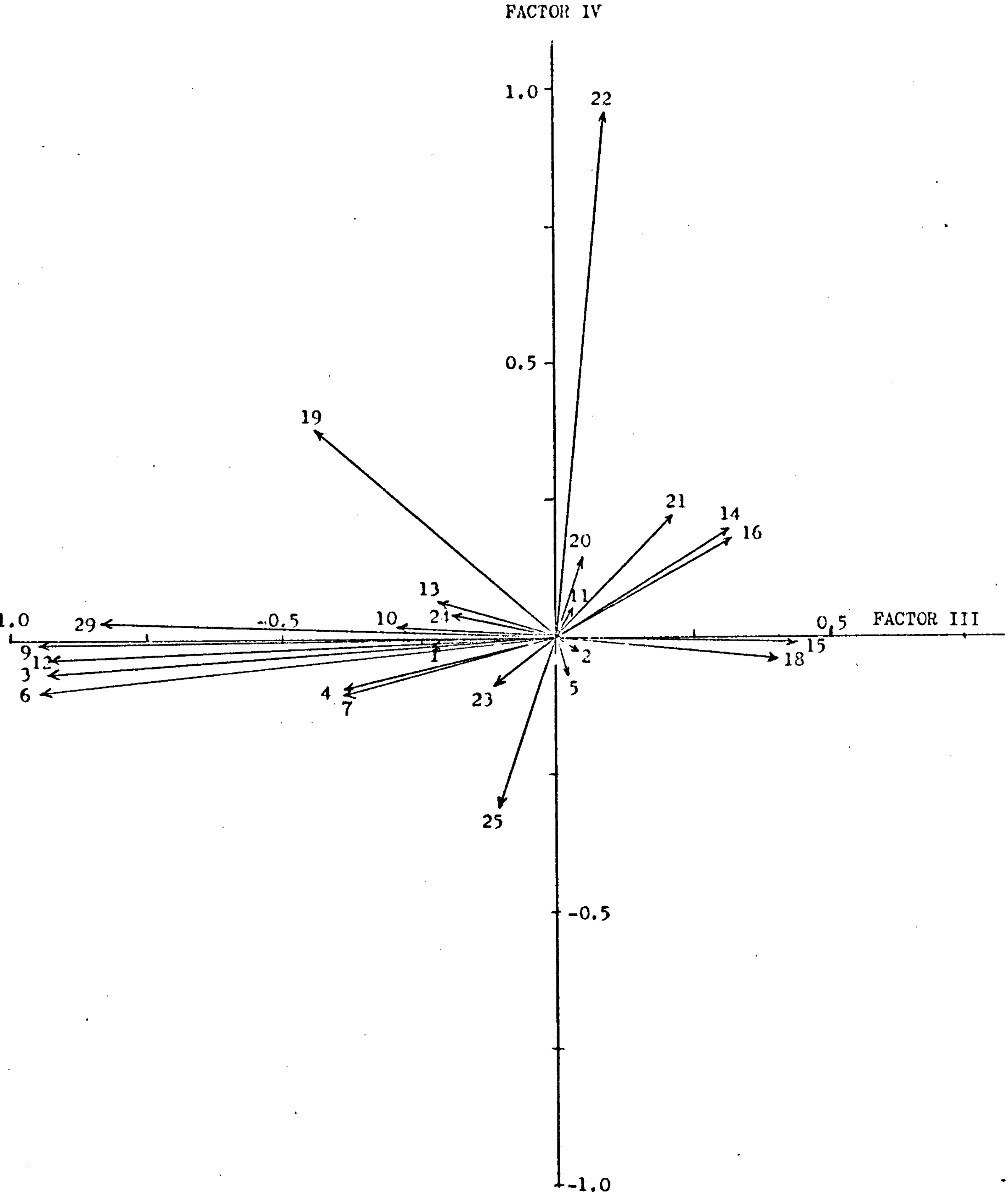


FIG. 9 LOCATION OF THE THIRD & FOURTH COMPONENT VECTORS FOR THE VARIABLES IN TWO-DIMENSIONAL SPACE



effect of collinear sets is eliminated and the resultant estimate is likely to be more realistic. This can be seen in the lack of significant difference between the simple and partial correlations shown in Table IV below. The new model takes the form of :

Total Trips Generated Per Day = 0.9157X(Size) - 0.0588X(Area)

R^2 = 0.8275 , R = 0.9097

TABLE IV

SIMPLE AND PARTIAL CORRELATIONS OF MODEL 2

Simple Correlation		Partial Correlation		Remarks
$r_{12} = 0.9078$	$r^2_{12} = 0.8241$	$r_{12.3} = 0.9095$	$r^2_{12.3} = 0.8272$	No significant difference between the simple and partial 'r's at 0.05 level
$r_{13} = -0.0431$	$r^2_{13} = 0.0016$	$r_{13.2} = -0.1399$	$r^2_{13.2} = 0.0195$	

Model 1 which essentially has only the same two dimensions as Model 2 yields a much higher R^2 of 0.9647 compared with 0.8275 for the latter. The lowering of R is significant at 0.01 level. However, one may argue that the lowering of R^2 is not attributed to elimination of collinearity, but due to loss of information in the process of factor analysis. A table is therefore computed to find out if this is true.

TABLE V

LOSS AND GAIN OF COMMUNALITIES IN MODEL 2 COMPARED WITH MODEL 1

Variables in Model 1	Factor I (Size)	Factor V (Area)	Commu - nalities R^2	Loss of Information $1 - R^2$
4.Labour Force	0.82	0.0025	0.8225	0.1775
10.D.U.W.C.	0.91	--	0.91	0.09
21.Area	0.015	0.866	0.881	0.119
Other Variables				Gain of Information*
1.Pop.Total	0.93	--	0.93	0.93
2.Pop.S.F.	0.99	0.0006	0.9906	0.9906
5.Lab.Force S.F.	0.98	0.0008	0.9808	0.9808
7.Dwelling Unit Total	0.82	--	0.82	0.82
8.S.F.D.U.	0.99	0.001	0.991	0.991
11.S.F.D.U. with Car	0.99	0.0016	0.9916	0.9916
13.Cars Total	0.91	0.0002	0.9102	0.9102
18.Time to C.B.D.	0.05	0.343	0.393	0.393
19.Gross Income	0.596	0.0006	0.5966	0.5966
20.Bus Miles	0.523	0.178	0.701	0.701

* Only those with high contributions are presented.

The above table shows that in fact the loss of information in Model 2 compared with Model 1 is more than compensated by the communalities contributed by other variables to the two factors in the equation. Therefore, the R^2 of 0.8275 is a liberal estimate of the two dimensions that are present in Model 1.

Hence Hypothesis 2 which states that "When highly correlated independent variables exist in a model, the multiple R^2 is an unreliable estimate of the true relationship between the predictors and the criterion", is validated by comparing the R^2 of Models 1 and 2. The significance of this finding is that the high R^2 in Model 1 is unreliable and implies a degree of fit not warranted by the data.

4.5 Validation of Hypothesis 3

A. Search for Missing Factors

To find out if there are any missing dimensions in Models 1 and 2, their residuals are plotted (See Figures 10 and 11). Residuals of Model 1 gives slightly better fit of the data than Model 2 (See Appendices E and G for residual values). This is attributable to the high R^2 in the former. Both models give poor estimate of District 3 (Point Grey) and 30 (North Surrey). In addition, while residuals for Districts 13 (North Vancouver City) and 29 (Newton) are relatively large for Model 1, the same applies to Districts 2 (West End), 4 (Kitsilano, Fairview and Shaughnessy), 8 (South Vancouver) and 16 (New Westminster) for Model 2.

FIG. 10 OBSERVED & CALCULATED VALUE OF Y FOR MODEL 1

(STANDARDIZED VARIABLES)

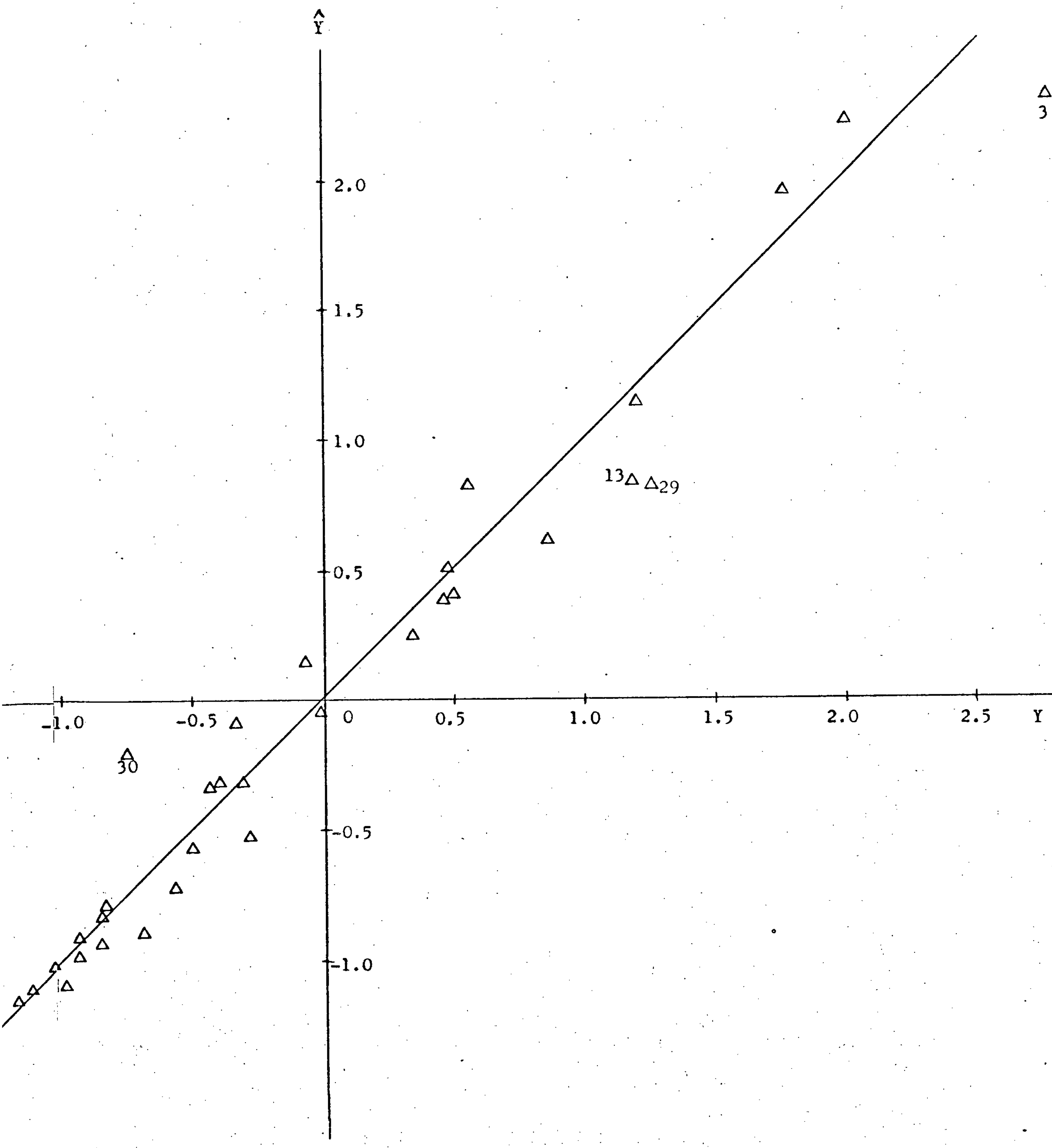
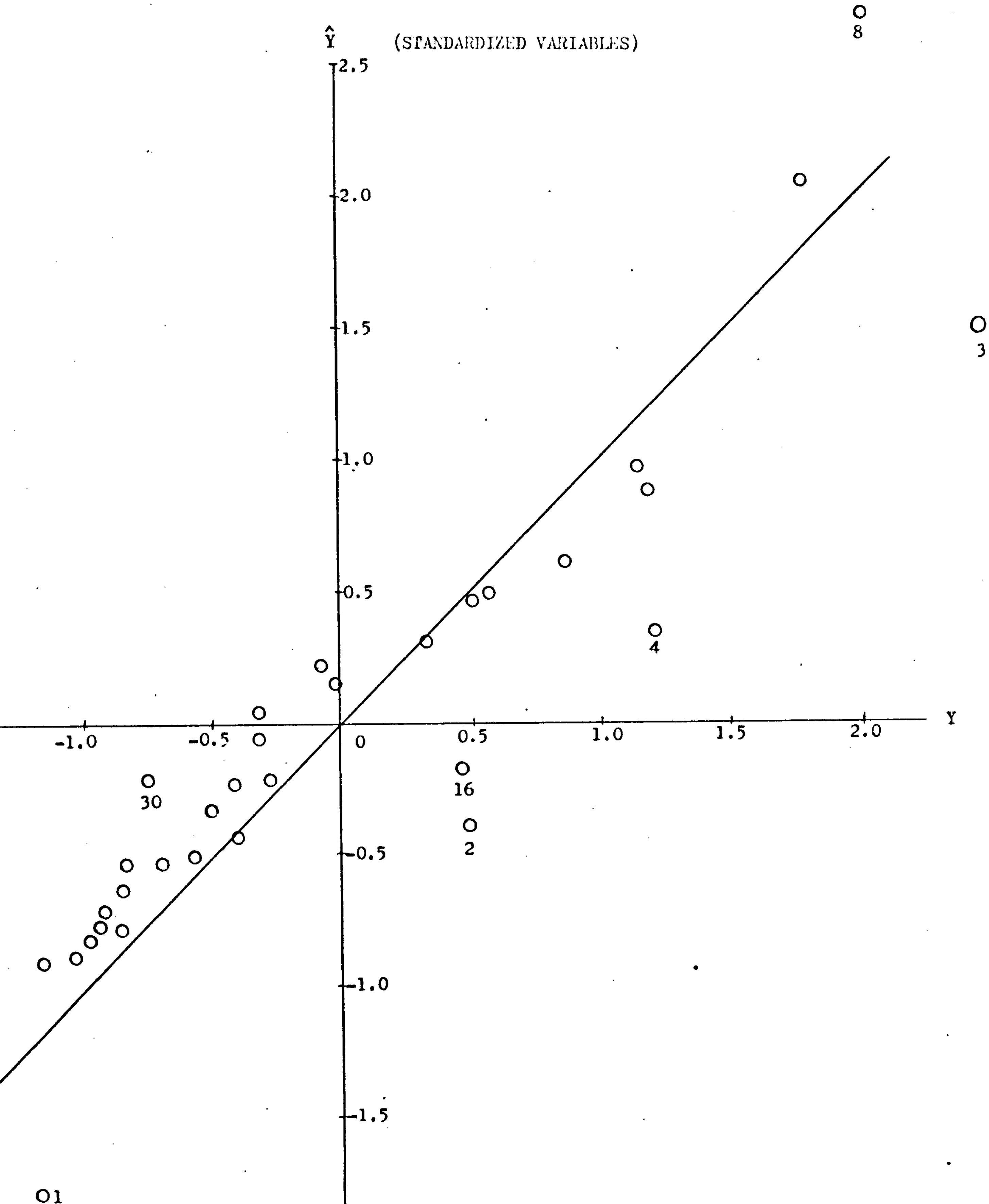


FIG. 11 OBSERVED & CALCULATED VALUE OF Y FOR MODEL 2

(STANDARDIZED VARIABLES)



The residuals for Model 2 are again plotted on a map (See Figure 12). Their distribution reveals an interesting pattern. The west side of Vancouver City (West of Cambie) and West Vancouver are consistently being over-estimated whereas the east and south portions of the metropolitan area are generally being underestimated, excepting New Westminster. The large positive residuals are found at District 1 (C.B.D.), District 2 (West End), District 3 (Point Grey), District 4 (Kitsilano, Fairview and Shaughnessy), and District 16 (New Westminster). A possible explanation is that these are areas of mixed land uses; the omission of Employment and Density Factors results in an over-estimate of vehicle trips generated based only on the Size and Area Factors. As previously pointed out, employment opportunities and higher density within the tracts decreases the number of trips generated because of the availability of jobs, shops and entertainment nearby. The largest negative residual occurs in District 30 (North Surrey). One suspects that an underestimate here can be explained by the omission of the Density and Household Size Factors. First, families further away from the city tend to be larger in size and hence the higher frequency in trip-making. Also, in areas of lower density, more trips per dwelling unit are generated because of more extensive travel requirements to satisfy employment, shopping and entertainment needs.

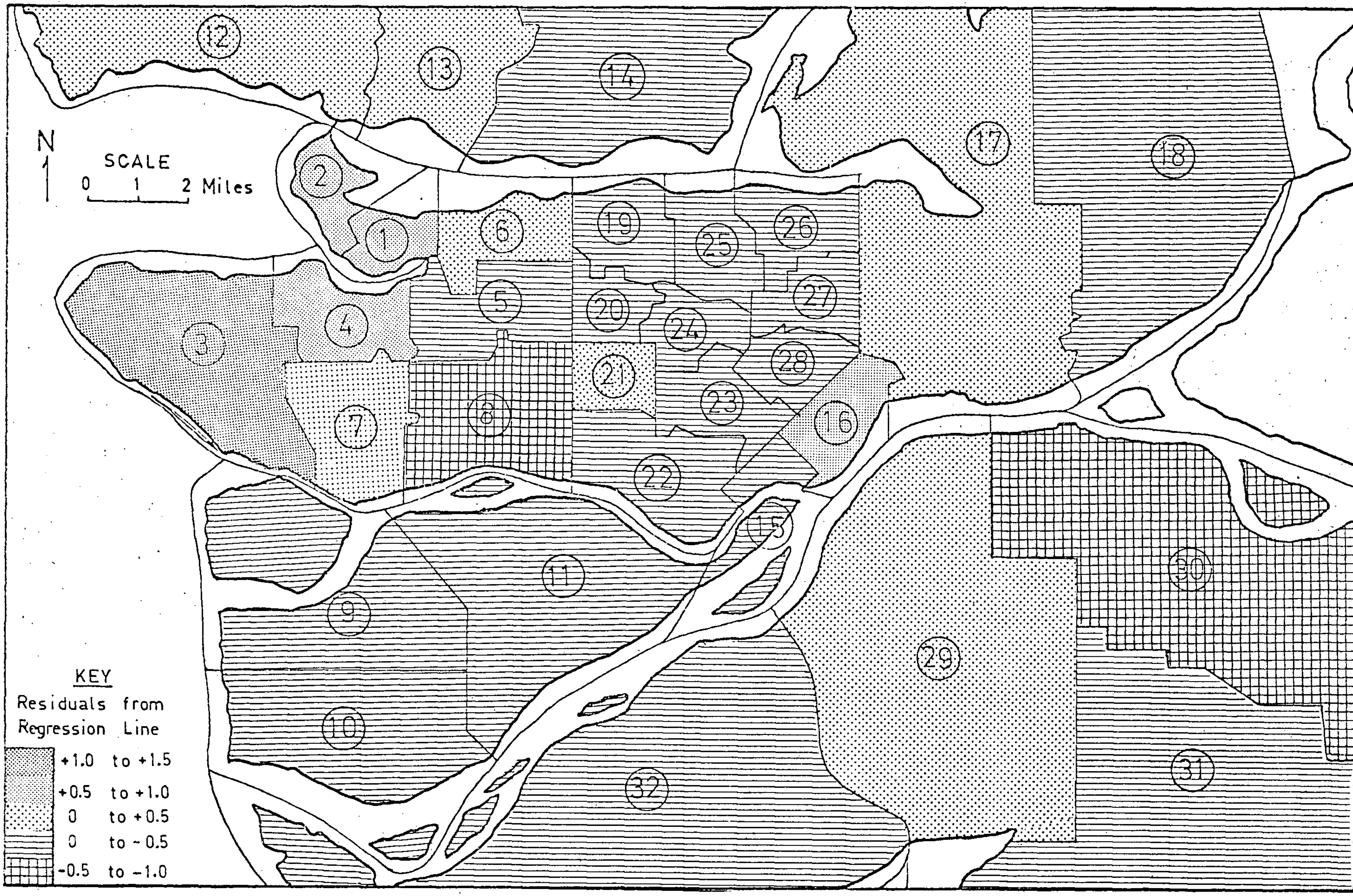


FIG. 12 MAP SHOWING DISTRIBUTION OF RESIDUALS FOR MODEL 2

Since it is suspected that the inclusion of land use factors such as employment and density will provide a better understanding and estimate of trip generation, the scores of these two factors have been mapped. (See Figures 13 and 14). The purpose is to see whether their factor score distribution coincides with areas of poor estimate. A rule of thumb in the search for additional explanatory factors is to look for the ones with low or negative scores for areas with large positive residuals, and the opposite for areas with large negative residuals. By doing so it was hoped that the value of the residuals of Model 2 could be minimized.

After detailed examination of the factor score distribution[3], the following table was arrived at:

TABLE VI

A LIST OF POSSIBLE EXPLANATORY FACTORS OMITTED BY MODEL 2

Area of Poor Estimate	Residuals	Possible Explanatory Factors	Factor Score
District 1	0.6645	VII VI	-0.39595 0.13083
District 2	0.8767	III	-4.20216
District 3	1.0566	II	-0.26562
District 4	0.8668	III IV	-2.82124 -0.41607
District 8	-0.6743	III	1.00236
District 16	0.6391	III	-0.5523
District 30	-0.5274	VII	2.97536

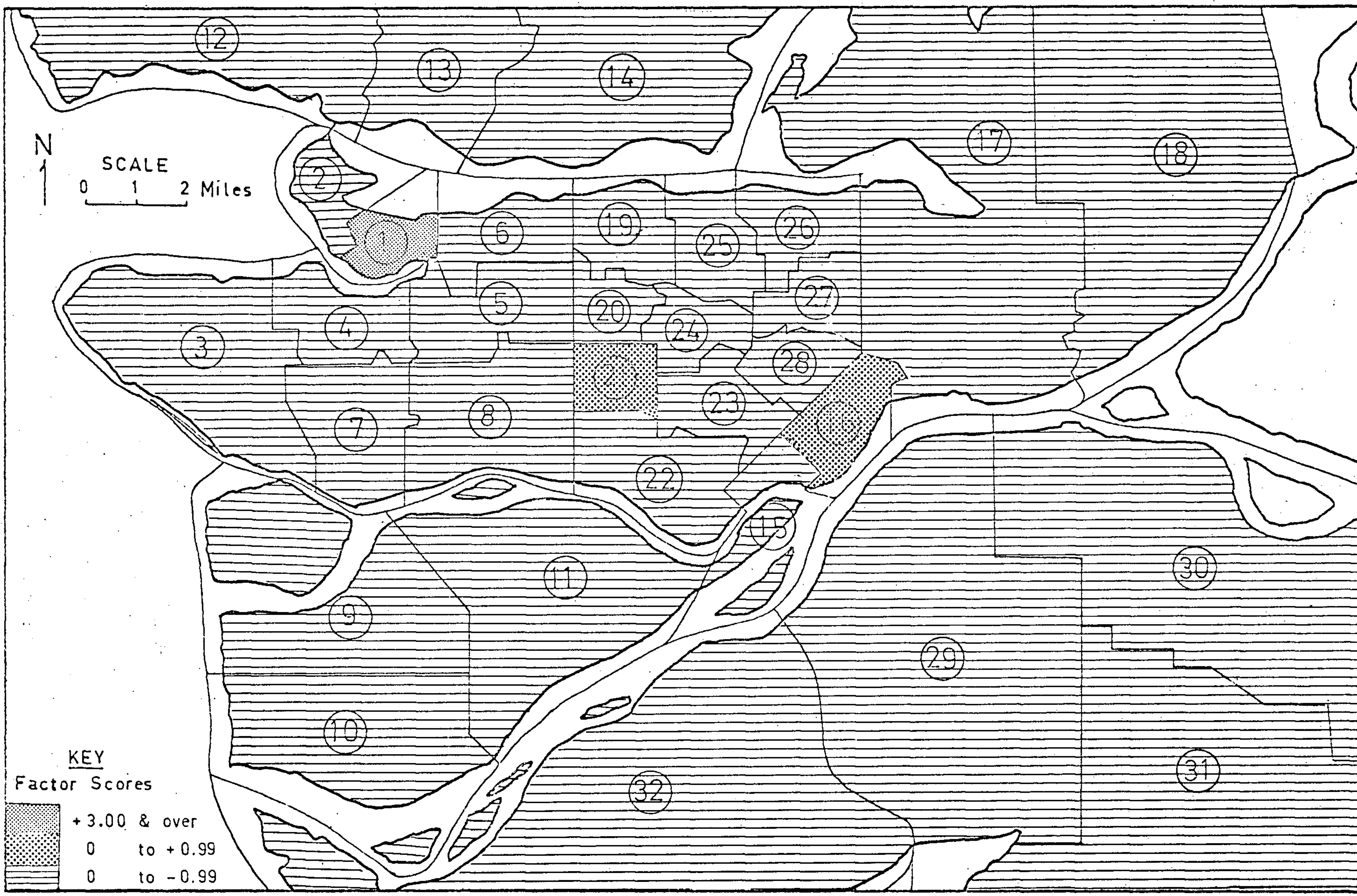


FIG. 13 FACTOR SCORE DISTRIBUTION FOR FACTOR II (EMPLOYMENT)

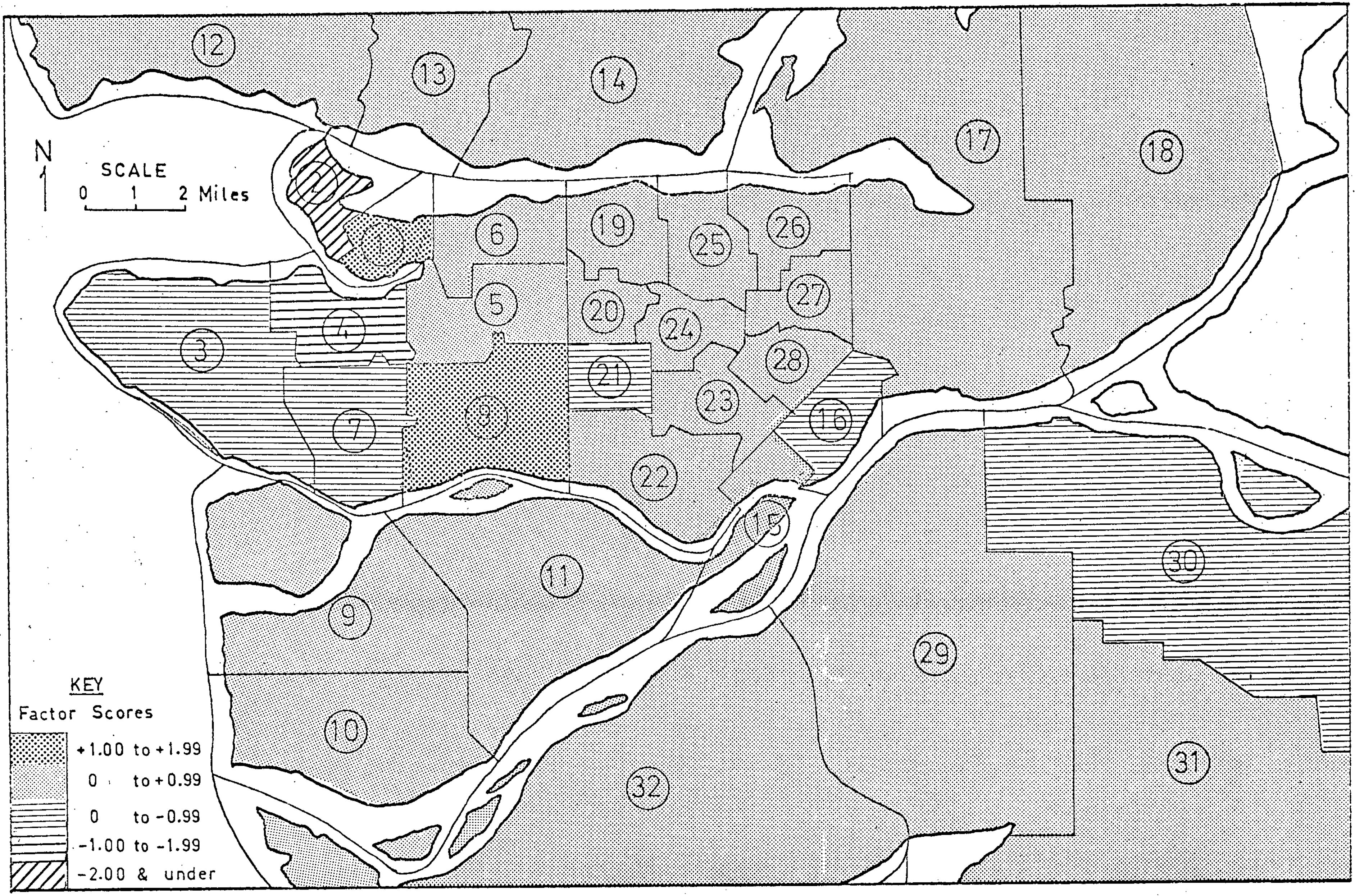


FIG. 14 FACTOR SCORE DISTRIBUTION FOR FACTOR III (DENSITY)

B. Development of an Alternate Model

Using the above results as a guide, a number of regression equations using both factors and variables were tried. The object was to develop an alternative model capable of incorporating causative factors of trip generation in addition to meeting all the statistical measures of predictive efficiency. It was found that while models developed by using variables only, in general, satisfied the statistical tests, they were incapable of explaining a wide range of data and to include the land use-travel relationships. Hence they were discarded in favour of models developed from factors.

The following model, designated Model 3, is considered the most satisfactory one. It shows that trip generation is a positive function of population size, intensity of land use activity (commercial, industrial, institutional and school) and a negative function of density, i.e.

$$\text{Total Trips Generated} = \underset{(0.0478)^*}{0.9904} \times (\text{Factor I - Size})$$

$$+ \underset{(0.0603)}{0.2675} \times (\text{Factor II - Employment})$$

$$- \underset{(0.0462)}{0.2718} \times (\text{Factor III - Density})$$

$$+ \underset{(0.0447)}{0.1776} \times (\text{Factor VI - Student})$$

$S_{y.x} = 0.2489$ $\quad$ $R = 0.973$ $\quad$ $R^2 = 0.946$

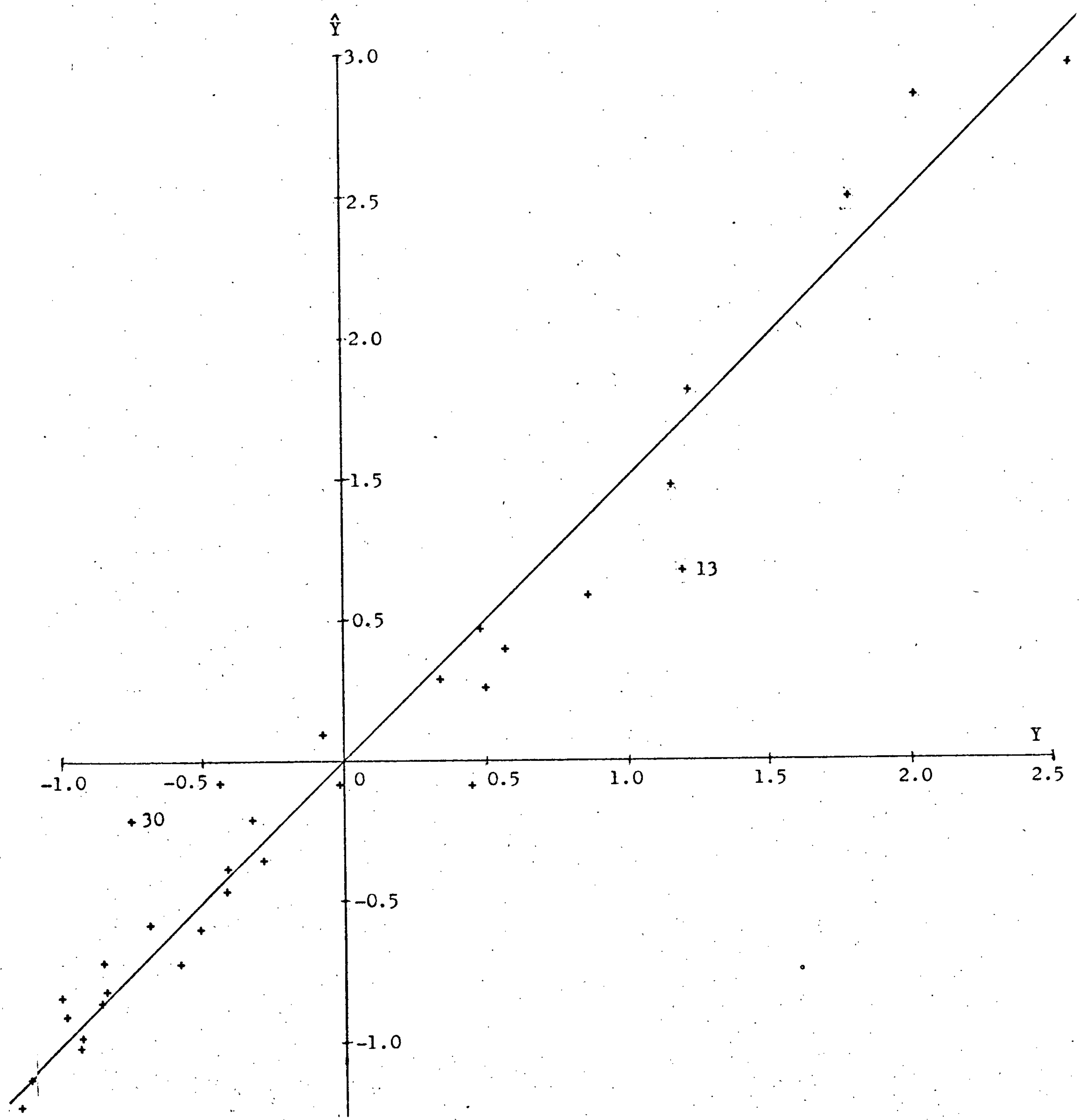
*Figures in parentheses denote the standard errors of regression coefficients.

Both the R and $S_{y.x}$ (See Figure 15 and Appendix H) are significant improvements over Model 2. Moreover, the relationship expressed is logical and causative. The method of using this model for prediction is in Appendix C.

Up to the present, many transportation studies have postulated that trip generation is a function of land use. Despite this, so far few regression models have been developed to incorporate this relationship in a comprehensive manner, apart from the land-area trip rate method which employs land use as "end" variables. One explanation being that model-builders are content with securing a high R using a minimum number of variables in order to make the model operational, so that the theoretical structure is sacrificed.

In using factor analysis to extract the "hidden dimensions" of the data, not only can a more intelligent selection of factors be made, but the danger of including collinear variables is also eliminated. Therefore, Model 3 can be considered as a step towards injecting a stronger structural relationship into the equation rather than being satisfied merely with its ability to fit the data. In addition, the land use factors are not used as 'end' or exogenous variables but has become endogenous. The model is, therefore, more dynamic and responsive to transportation-land use policy implications.

FIGURE 15 OBSERVED & CALCULATED VALUE OF Y FOR MODEL 3



In order to predict the future trip generation, forecasting independent variables such as car ownership for traditional regression models has to be derived in two steps. Firstly land use activities have to be projected to the design year based upon which population estimates and hence the number of cars in a zone can be estimated. By making land use factors endogenous in Model 3, one step in the forecasting process is eliminated as land use projections becomes the direct input, thus minimizing some measurement errors. Despite the fact that Model 3 has more variables, it is believed that it has gained sufficient advantage in specification without introducing significant additional measurement errors to the model. In addition, its better theoretical base coupled with statistical efficiency enables us to have more confidence in its predictive power. However, at this stage it is unable to demonstrate quantitatively the relative reduction or gain in the two types of errors introduced by the added complexity of factor analysis. It is felt that further research into this issue may be of interest.

A comparison of Models 1 and 3 demonstrates that the former has indeed omitted some significant land use explanatory variables (such as employment and density) in the estimating equation. Consequently Hypothesis 3 which states that 'When highly correlated variables are included in a model, other significant explanatory variables may be omitted due to the predominance of collinear set' is validated.

4.6 Conclusion

This chapter substantiates the theme of the preceding chapter, that multicollinearity is in fact an explanatory and analytical problem in model construction. By rigorous statistical analysis of the empirical data collected in Vancouver, it is shown that the presence of collinear set of variables has a number of undesirable effects on the performance of the model, such as exaggerating, obscuring and suppressing plausible relationships which make the testing of hypotheses difficult. In addition, one has less faith in such a model as a predictive tool because of the lack of logical theory in its construct. Through the validation of the three operational hypotheses, the general hypothesis: "When collinearity exists in a regression model, explanatory and analytical powers are decreased, despite the apparently good predictive powers shown by a high multiple correlation coefficient", can be accepted as generally applicable. Also, this finding bears truth on the philosophy that even for models that are built for prediction, they must also be concerned with explanation. The popularly-held view of the dichotomy between predictive and explanatory models appears fallacious.

Another outcome of the data analysis is the development of an alternate model as a step towards giving trip generation models a more solid theoretical framework. In this process, it is found that the total trips generated per areal unit is a direct function of measures of population size, intensity and characteristics of land use in the tract, whereas socio-economic characteristics do not come into play at the zonal level. The low correlation between "Total Trips

Generated" and variables such as "Car Ownership per Dwelling Unit" (-0.0382), "Persons per Dwelling Unit" (-0.1457), "% Dwelling Unit with Car" (-0.0393) and "Income per Household" (0.0697) supply ample proof of this statement. Hopefully this suggests where research efforts should be directed in building trip generation models at the zonal level.

Footnotes

[1] A. M. Voorhees, "Transportation Planning and Urban Development", Plan: Canada, Volume 4, No. 3. (1965), p.101.

[2] Shue Tuck Wong, "A Multivariate Statistical Model for Predicting Mean Annual Flood in New England", Annals, Association of American Geographers, Volume 53 (1963), pp.298-311.

[3] Factor scores for seven factors are in Appendix F.

CHAPTER V

TRANSPORTATION MODELS - A PERSPECTIVE VIEW

5.1 Summary of Research Findings

The foregoing investigation, based both on statistical theory and empirical results, has shown that in formulating multiple regression models for transportation planning purposes, the use of intercorrelated predictors not only gives rise to specification error, but also to spurious inferences and to spurious predictions. This renders the model less effective as a predictive and analytic tool. One of the possible ways to overcome this problem is by subjecting all input variables to a factor analysis to determine the underlying dimensions of the data set as well as to eliminate redundant or confounding variables. By experimenting with trip generation data for Vancouver, the result is sufficiently promising to warrant wider use in the transportation planning process. The more salient contributions of this approach can be summarized as:

1) Multicollinearity is eliminated.
2) The sharp reduction of variables into smaller number of factors assist in organizing huge masses of data into manageable size for further analysis.

3) The factors themselves form meaningful constructs that give further insight into the trip-generation-land use relationship.

4) The factor scores have more desirable statistical properties (e.g. greater reliability) than those of single variables in isolation. As the factors combine information from several variables, predictive accuracy tend to increase due to the gain in specification. In addition, the explanatory and analytic powers of the model are enhanced.

In the land area trip rate analysis, it is shown that different land uses adequately isolate attributes which result in different trip generation rates. Oi and Shouldiner, however, felt that the absence of any statistical significance tests suggests caution in accepting this assumption.[1] This method is incapable of handling the effects of the interaction among different arrangements of land uses on the number of trips generated, and its treatment of land use as a non-quantifiable explanatory variable is somewhat unsatisfactory. On the other hand, the regression technique thus far employed emphasizes on prediction, hence often use a simple explanatory variable, such as car ownership, in the equation. These simple regressions cannot be interpreted as neat causal relationships. The intercorrelations among alternative explanatory variables confound the parameter estimates. The neglect of all but a single explanatory variable tends to overstate its true effect because of its correlations with other variables. However, even when other variables are included, the overall goodness of fit will not be appreciably improved. This gives rise to the difficulty that even when the analyst wants to include more dimensions into the data, statistical test of significance will not justify their inclusion, although they may be valid on theoretical grounds.[2]

As a corollary to eliminate multicollinearity, this investigation indicates that the combined factor analytic and regression solution seems capable of overcoming the pitfalls of both approaches as evidenced in the result of Model 3. Unlike the trip rate method, land use variables are used as explanatory rather than classificatory variables. Interaction of different patterns of land use on trip generation is taken into account and tests of significance are attached to the results. Secondly, the pertinent causal relationships are included and the confounding effect of correlated variables is ironed out. All explanatory factors are found to be significant.

This analysis shows that in an attempt to isolate causal relationships which conform to some theoretical framework and yet satisfy statistical criteria, the model gains additional strength as a predictive tool. It also demonstrates that explanation and prediction can and should be combined in the same analysis because it yields more fruitful results.

The following sections will place the significance of the findings into the larger framework of model-building in the transportation planning process.

5.2 Utility of Transportation Models

In general, wide variation in the availability of resources and data have led to an almost equally wide variation in the scope, coverage and complexity of transportation studies. While a number of combinations of techniques have been tried, the general criticism appears to be the inability of transportation models to move away from the turgid empiricism of data-fitting. The Rand Report[3] observed that even under the best of execution and circumstances, most transportation studies have been remarkably mechanic in conception, especially in establishing the relationship between land use and trip generation. W. L. Garrison[4] also remarked that:

> "I have serious reservations in my own mind with respect to the role of these models in (transportation) studies. This is because I am unable to express a theory or even provide a simple description of the choice behaviour that these models represent."

Such shortcomings largely result from the strong emphasis on prediction of most transportation models. The transportation planner is often so engrossed with the number emerging from the model that his real objective - to find out the hows and whys of interaction between urban activities so that plans can be formulated and evaluated - tend to be lost sight of.

At this juncture, a clarification of the utility of transportation models in the planning process is in order. Essentially a transportation model is an experimental device to abstract travel demand and patterns so that the functioning of the urban system can be observed by varying transportation and land use inputs. The knowledge gained will form a systematic basis whereby alternative policies and plans can be proposed and evaluated.

To achieve this goal, the model should be capable of:

a) Predicting what effect will occur over time if the existing situation is allowed to run on unaltered. By showing what modifying effects can be produced by a particular decision or policy or by a new arrangement of the elements affecting movement, it enables us to judge between alternatives in the light of their future consequences.

   In order to predict, one of two kinds of knowledge is needed. We may understand the dynamics of an event, which are the theories that describe how it changes. Together with the initial conditions, a knowledge of the dynamics is sufficient to determine the future. This approach calls heavily on the planner's ability to understand urban development and to systematize his knowledge. A second avenue is to project from past events. In this case, due to the lack of a theory, the entire prediction rests on the quality of our knowledge of the past, thus making a scrutiny of this quality an important matter. The past must be representative of the present and the future for the purpose of prediction. No contingency can be covered unless it has already occurred and been recorded.[5] This method is often questioned because the rapid change that technology and economy has brought about render many past events irrelevant.

Of the two ways, the first is favoured because firstly, if prediction should succeed, we shall want to say why. Part of the payoff of a good prediction is the insight it provides into mechanism and relations.[6] Secondly, if we want to evaluate policy alternatives, it is essential that the model can adequately "explain" movements as they actually occur, and that the process employed for prediction takes proper account of all the major factors involved in determining future movements, including land use with which planners are particularly concerned.[7]

b) In addition to prediction, models are important educational and research devices. Their formulation reveals the importance of structural interrelationships which otherwise may pass unnoticed or may not be given their due emphasis. In the construction of a model, the analyst becomes aware of the sensitive linkages in the research scheme and he is therefore able to give attention to these areas as required. This sometimes results in reformulation of the problem as new thoughts are generated about fundamental factors which might have gone unnoticed except for their discovery in the model-building process.[8]

In transportation studies, engineers and planners are concerned with the behaviour of households and business establishments in making use of the transportation system and in making locational decisions. Such behaviour is the source of travel demand. If we understand thoroughly the whole constellation of decisions made by individuals and firms, we could understand at the same time the extent to which various urban arrangements satisfies their needs. Such an understanding is vital to producing plans and policies best to serve the public interest.[9] Sound analytic models facilitate analysis of the context of policy, by clarifying the areas within which decisions must be made, thus making possible more pointed criticisms of the postulates on which present policy is based. Also, good explanatory and analytical models are invaluable for basic research, even if they do not find practical application.[10]

It is sometimes argued that while planners are concerned with decisions, design and planning, 'academic' researchers are concerned with explanation and theory-building, and that these two sets of activities are rather different. From the above it is apparent that planners need all the knowledge supplied by researchers in order to plan. In fact it is the understanding of the planned systems which give planners techniques for prediction. Indeed, it can even be said that "understanding" can be substituted for "prediction" as being of more general application.[11]

5.3 Implications for Model Building in the Transportation Planning Process

In view of impending urban growth a decision to plan the arrangement and intensity of land use activities is an important one. The transportation element is not only a prime variable in the achievement of a desired plan, but is also a major cost component of urban growth, a cost which depends significantly on the form of the land use plan itself. However, the satisfactory integration of transportation into the land use plans will require much more technical expertise and understanding than has hitherto been demonstrated. In particular, a change in the attitude towards the development and refinement of transportation models in relationship to land use is called for. Forcing the construct of transportation models into some larger view of theory-building rather than using them purely for statistical prediction will most likely turn out to be an advantage.

The logic behind this is put forward most succintly by Alonso.[12] He felt that in an explanatory model, we are asking what are the relations among the measured variables, and whether they conform to what we would expect from various theories and prior empirical work. On the other hand, predictive models are concerned only with the numerical product that emerges. As these numbers become variables and feed into other models, they tend to have a large specification error when predicted for a future state of the system. From these considerations, it would seem that a model which seeks to increase our understanding by asking how certain variables relate to each other is in a sense less subject to some of the sources of error than identical models designed to predict the future. Therefore, a model with a sound theory will often result in better prediction, not through its direct use, but by shedding light on some facets of the structure we are considering; prediction itself proceeds in a fashion which he called "mulling over". By the same token, for a given quality of data, the explanatory model is more tolerant of complexity of formulation than a predictive model.

It is not surprising therefore to find that a significant trend is taking place. A decade ago, models were viewed primarily as predictors of the future. Somewhat later, stress was placed on their use as conditional predictors of the consequences of alternative policies, and efforts were made to incorporate into them policy variables which permit such experimentation. More recently, as experience has been gained, the practitioners of this craft have tended to play down the ability of models to predict, and to stress their value as educational instruments which serve to bring to the consciousness of those who make decisions the complex interrelations among the variables, including those which can be manipulated for normative purposes.[13] Thus the downgrading of the importance of the predictive function and the emphasis of the explanatory and analytical values of the model is in accord with the viewpoint being advanced here. Stegman,[14] in his examination of urban residential models asserted that for models that suffer from inadequate theoretical structures, better data would not necessarily improve performance. Therefore, manipulating and adjusting the parameters of equations in order to improve the 'fit' of the models to the data will not make the models better predictors. He put forward the view that predictive models may be more useful in providing policy-makers with a general understanding of the magnitudes, direction and interaction of the forces at play in the urban system, than in providing actual predictions. As transportation models have already reached a high level of sophistication in the data-fitting aspect, the planner's future contribution lies in the improvement of the quality and range of data and the theoretical basis of the model, particularly in the treatment of factors affecting travel demands which stem from land use characteristics. In other words, a theoretically sound and scientific approach to system simulation of transportation and land use is advocated here. In addition, a further and potentially more important trend suggested by W. D. Peters[15] - that of merging environmental studies with transportation studies - merits special consideration. Combined studies of this kind can have important effect in "humanizing" the transport study process, a point which has been stressed recently from the traffic engineering side by A. M. Voorhees.[16]

5.4 Conclusion

Mathematical models for both research and prediction have become established during the last few years in the planning profession, in particular in the transportation field, as indispensable analytic tools. The value and quality of these models are not really given adequate attention. It has been the object of this thesis to discuss some of the problems involved by using trip generation models as an example. It is demonstrated that in using linear predictive modelling techniques, such as multiple regression, the mathematical framework places severe demand on the model-builder because it is associated with a highly restrictive set of assumptions. It is, therefore, imperative that, where multiple regression models are used in planning, their limitations and the implications of statistical procedures are clearly understood. This study has shown that multicollinearity is an explanatory problem to model construction and hypothesis testing. Its statistical significance has also been demonstrated. It would be meaningful to investigate its practical significance in shaping actual transportation-land use policies.

A further objection to past uses of these models in transportation studies is their theoretical content, without which they are but extrapolation of significant statistical regularities. These extrapolation do not contribute very much to the theories of urban structure and development since they ignore the behaviour of the urban system. Moreover, the myopic concern with prediction has led to the formulation of some questionable models. In view of the large amounts of money, time and effort in data collection and analysis, the building of models for prediction only is unrewarding. In fact, it is argued that the distinction between explanatory and predictive abilities of the model is only artificial, not real. A suggestion is therefore made towards greater emphasis on theorizing in model-construction to lay firmer foundations upon which statistical analysis can be based; thus moving away from the realm of turgid empiricism of curve-fitting prevalent in most transportation studies.

The statistical techniques used in this study are largely designed to test hypotheses based on a desire to gain a better understanding of urban travel behaviour. It is found that by using the combined factor-analytic and regression method, it is capable of identifying and incorporating the causal relationship between land use and trip generation into a single model. It will be interesting to extend the work to modal split models which up to now has not yet established a well-defined set of causal factors. Research effort may also be directed to the effects introduced by the factor analytic model for prediction purposes in terms of gain and reduction in measurement and specification errors. Further, the idea of combining transportation and environmental studies to "humanize" the transportation planning process merits further exploration. These may well be new areas for further research.

Footnotes

[1] Walter Y. Oi and Paul W. Shouldiner, An Analysis of Urban Travel Demands,(Published for the Transportation Center at Northwestern University by Northwestern University Press, 1962), p.47.

[2] Ibid., p.51.

[3] The Rand Corporation, Transportation for Future Communities: A Study Prospectus, (Rm-2824-7F, The Rand Corporation, Santa Monica, California, August 10, 1961), p.11.

[4] W. L. Garrison, "Urban Transportation Planning Models in 1975", Journal of the American Institute of Planners, Volume 31, No. 2 (May 1965), p.12.

[5] Aaron Fleisher, "On Prediction and Urban Traffic", Papers and Proceedings of the Regional Science Association, Volume 7 (1961) p.45.

[6] Ibid.

[7] Paul Brenikov, "Land Use/Transportation Studies -- Methods and Limitations", Report of Proceedings, Town and Country Planning Summer School, (University of Nottingham 10-21 September 1969, published under the auspices of the Town Planning Institute, Britain), p.25.

[8] Louis A. Loewenstein, "On the Nature of Analytic Models", Urban Studies, Volume 3, No. 2 (1966), p.113.

[9] Britton Harris, "The Use of Theory in the Simulation of Urban Phenomena", Journal of the American Institute of Planners, Volume 32, No. 5 (September 1966), pp.269-270.

[10] Brian L. J. Berry, "The Retail Component of the Urban Model", Journal of the American Institute of Planners, Volume 31, No. 2 (May 1965), p.150.

[11] A. G. Wilson, "Models in Urban Planning, A Synoptic Review of Recent Literature", Urban Studies, Volume 5, No. 3 (November 1968) p.250.

[12] W. Alonso, "Predicting Best with Imperfect Data", Journal of the American Institute of Planners, Volume 34, No. 3 (1968), p.254.

[13] *Ibid.*

[14] Michael Allen Stegman, *An Analysis and Evaluation of Urban Residential Models and Their Potential Role in City Planning*, unpublished Ph.D. thesis, (University of Pennsylvania, 1966).

[15] W. D. Peters, "Planning Aspects of Land Use Transportation Studies", *Journal of the Town Planning Institute*, Volume 55, No. 2 (February 1969), pp.59-61.

[16] Paul Brenikov, *op. cit.*, p.27.

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APPENDIX A

A LIST OF THE VARIABLES USED IN THIS STUDY

The 29 independent variables are:

1. Population, Total
2. Population, Single Family
3. Population, Multiple Family
4. Labour Force, Total
5. Labour Force, Single Family
6. Labour Force, Multiple Family
7. Dwelling Units, Total
8. Single Family Dwelling Units
9. Multiple Family Dwelling Units
10. Dwelling Units with Car
11. Single Family Dwelling Units With Car
12. Multiple Family Dwelling Units With Car
13. Cars, Total
14. Cars Per Dwelling Unit
15. Population Per Dwelling Unit
16. % of Dwelling Units With Car
17. Students (4 - 6 p.m.)
18. Time to C.B.D. in Minutes
19. Gross Income X 10^{-5}
20. Bus Miles
21. Area (In Acres)
22. Income Per Dwelling Unit
23. Employment, Total
24. Employment: Public Utilities, Government and Institutional Services
25. Employment: Industrial, Wholesale and Unclassified
26. Employment: Service Industries
27. Employment: Entertainment
28. Employment Density Per Acre
29. Population Density Per Acre

The dependent variables is: Total Trips Generated per day (vehicle trips only).

APPENDIX B

STATISTICAL TEST OF AUTOCORRELATION OF MODEL 2 BY USING THE "CONTIGUITY MEASURE FOR k-COLOR MAPS" TECHNIQUE

NOTATION

B B Joins: Joins with positive residuals in contiguous zones.

W W Joins: Joins with negative residuals in contiguous zones.

B W Joins: Joins with positive residuals in continguity with negative residuals.

L_k : Number of contiguous zones of a typical zone k, k = 1 to N.

Two zones are considered contiguous if they had an edge and/or vertex in common.

K = total number of zones that are not common to a typical zone k, k = 1 to N.

Sum of B B Joins = z

Sum of B W Joins = y

Sum of W W Joins = x

x + y + z = L

Appendix B (cont'd). Page 2.

ZONES	L_k	L_k-1	$L_k\ (L_k-1)$
1	4	3	12
2	4	3	12
3	3	2	6
4	7	6	42
5	7	6	42
6	5	4	20
7	6	5	30
8	7	6	42
9	4	3	12
10	3	2	6
11	7	6	42
12	2	1	2
13	3	2	6
14	5	4	20
15	6	5	30
16	5	4	20
17	8	7	56
18	2	1	2
19	5	4	20
20	6	5	30
21	6	5	30
22	5	4	20
23	5	4	20
24	7	6	42
25	6	5	30
26	4	3	12
27	6	5	30
28	5	4	20
29	6	5	30
30	4	3	12
31	2	1	2
32	4	3	12

$$\sum_{k=1}^{N} L_k = 159 \qquad \sum_{k=1}^{N} L_k\ (L_k-1) = 712$$

Appendix B (cont'd). Page 3.

B B JOINS	B W JOINS	W W JOINS
12-13	13-14	14-19
12-2	6-14	14-25
13-2	6-19	14-26
2-1	6-20	19-25
2-4	6-5	19-20
1-4	1-5	19-24
3-4	4-5	20-5
3-7	7-8	20-24
4-7	7-11	25-24
1-6	7-9	28-24
17-16	3-9	25-27
29-16	21-20	25-26
17-29	21-5	26-27
	21-8	27-24
	21-22	27-28
	29-15	24-23
	21-23	23-22
	21-24	23-15
	16-28	22-15
	16-23	22-11
	16-15	22-8
	16-29	8-5
	17-18	8-11
	17-14	9-10
	17-26	9-11
	17-27	10-11
	17-28	11-32
	17-30	11-15
	29-30	15-32
	29-31	30-31
	29-32	30-18
z = 13	y = 31	x = 31

$$L = z + y + x = 13 + 31 + 31 = 75$$

Let p = probability for z
q = probability for x

$p + q = 100\%$

$p = 13/(x+z) = \frac{13}{44} = 29.5\%$

$q = 70.5\%$

Appendix B (cont'd). Page 4.

$$\mu(z) = p^2(L) = 0.295^2 \times 75$$
$$= 0.087 \times 75 = \underline{6.55}$$

$$\mu(x) = q^2(L) = 0.705^2 \times 75 = 0.497 \times 75$$
$$= \underline{37.3}$$

$$\mu(y) = 2pq\ (L) = 2 \times 0.705 \times 0.295 \times 75$$
$$= 1.51 \times 0.295 \times 75$$
$$= 0.445 \times 75$$
$$= \underline{33.4}$$

$$\sigma^2(z) = p^2L + p^3K - p^4(L+K)$$
$$= 6.55 + 0.295^3\ (712) - 0.295^4\ (75+712)$$
$$= 6.55 + 0.02567 \times 712 - 0.007573 \times 787$$
$$= 6.55 + 18.3 - 5.96 = \underline{18.89}$$

$$\sigma^2(x) = q^2L + q^3K - q^4\ (L+K)$$
$$= 37.3 + 0.705^3\ (712) - (0.705)^4\ (75+712)$$
$$= 37.3 + 0.35 \times 712 - 0.247 \times 787$$
$$= 37.3 + 249 - 194 = \underline{92.3}$$

$$\sigma^2(y) = 2pqL + pqK - 4\ p^2q^2\ (L+K)$$
$$= 33.4 + 0.445\ (712) - (4 \times 0.087 \times 0.497)(75+712)$$
$$= 33.4 + 0.445 \times 712 - 4 \times 0.087 \times 0.497 \times 787$$
$$= 33.4 + 317 - 136$$
$$= \underline{214.4}$$

To compute the Z scores for the three sets:

$$Z_x = \frac{31-37.3}{\sqrt{92.3}} = \frac{-6.3}{9.607} = \underline{-0.656}$$

$$Z_y = \frac{31-33.4}{\sqrt{214.4}} = \frac{-2.4}{14.64} = \underline{-0.164}$$

$$Z_z = \frac{13-6.55}{\sqrt{18.89}} = \frac{6.45}{4.346} = \underline{1.483}$$

Conclusion: Since all of the three test statistics are less than 1.96 at 5% level of significance, it is concluded that the residual distribution is random, i.e. there is no significant autocorrelation in this set of data.

APPENDIX C

METHOD OF USING MODEL 3 FOR PREDICTION

Model 3 takes the form of

$$\text{Total trips generated} = 0.9904 \times (\text{Factor I}) + 0.2675 \times (\text{Factor II}) - 0.2772 \times (\text{Factor III}) + 0.1776 \times (\text{Factor IV}).$$

Since the independent variables in this model are in the form of factor scores, the following steps are necessary in order to project them to some future year:

1) Project the variables that constitute the factors in question for each traffic district. Transform the variables into standard scores by using $Z = \frac{x_i - \bar{x}}{\sigma}$, $\bar{x}$ (the mean) and σ (standard deviation) have been calculated for the previous set of data, e.g. Factor VI consists of one variable, variable "Students". Its present mean is 1003, and standard deviation is 3490. District 1 now has 1,600 students. An estimate of the future number of students in District 1, say five years ahead, is, for the sake of illustration, 2,000. Transform this number into standard scores according to the formula:

$$Z = \frac{2{,}000 - 1{,}003}{3{,}490} = \frac{997}{3{,}490}$$

2) Convert the standard scores for the variables in the factors according to the formula:

$$F_{1i} = (a_{11}z_{1i} + a_{21}z_{2i} + \ldots a_{m1}z_{mi}) \; (1/\lambda_i)$$

a_{11} is the factor loading of variable 1 on factor 1.

z_{1i} is the standard score of individual i on variable 1.

a_{21} is the factor loading of variable 2 on factor 1.

z_{2i} is the standard score of individual i on variable 2.

a_{m1} is the factor loading of variable m on factor 1.

z_{mi} is the standard score of individual i on variable m.

λ_i is the eigenvalue of the factor under consideration.

Appendix C (cont'd). Page 2

Again, using Factor VI and District 1 as an example,

$F_{61} = (a_{17.6} z_{17.1}) \; (1/\lambda_i)$

F_{61} means the factor score of Factor VI for District 1.

$a_{17.6}$ means the factor loading of variable 17 (Students) on Factor VI.

$z_{17.1}$ means the standard score of variable 15 for District 1.

$$\therefore F_{61} = (0.64 \times \frac{997}{3490}) \; (1/1.53)$$
$$= 0.119$$

3) After obtaining the scores of all the four factors for District 1 in the model, direct substitution of these values into the equation would yield the total number of trips generated there five years from now.

MULTIPLE REGRESSION OUTPUTS OF MODEL I (STANDARDIZED VARIABLES)

```
$SIGNON PLAK TIME=5M PAGES=50 COPIES=36 PRIO=V
**LAST SIGNON WAS: 21:27:25   02-24-70
 USER "PLAK" SIGNED ON AT  15:11:35 ON 03-25-70
$RUN *WATFOR 5=*SOURCE* 6=*SINK* 4=-A
EXECUTION BEGINS
```

```
      $COMPILE
      C PROGRAM TO FIND RESIDUALS
      C
            DIMENSION X(32,4),F(32,2),BARX(4),STDX(4),STDSCO(32,4),
           1Y(32),RESY(32),YY(32),RESYY(32)
            READ(5,1) ((X(I,J),J=1,4),I=1,32)
        1   FORMAT (F10.5/3F10.3)
            WRITE(6,4)
            WRITE(6,3) ((X(I,J),J=1,4),I=1,32)
        4   FORMAT ('  TRIPGN     LABROR      DUWC        AREA')
        6   FORMAT (2F10.7)
            READ(5,3) (BARX(J),J=1,4)
            READ(5,3) (STDX(J),J=1,4)
        3   FORMAT (4F10.3)
            WRITE(6,7)
        7   FORMAT ('MEANS AND STANDARD DEVIATIONS')
            WRITE(6,8) (BARX(J),J=2,4)
            WRITE(6,8) (STDX(J),J=2,4)
        8   FORMAT (3F10.3)
            DO 20 J=2,4
            DO 25 I=1,32
       25   STDSCO(I,J)=(X(I,J)-BARX(J))/STDX(J)
       20   CONTINUE
            WRITE(6,9)
        9   FORMAT ('STANDARD SCORES OF THE VARIABLES')
            DO 30 I=1,32
            WRITE(6,10) X(I,1),(STDSCO(I,J),J=2,4)
       30   WRITE(4,10) X(I,1),(STDSCO(I,J),J=2,4)
       10   FORMAT (4F10.3)
            STOP
            END
```

```
    0    0  0  1  1  1  2  2 2 2 33   3    4    4    5    5    6    6    7    7    8
    1    6  9  2  5  8  1  4 6 8 01   5    0    5    0    5    0    5    0    5    0
CONTROL
CARDS

1.  INMSDC  4        5  1  1 1 1
2.  STPREG  3  1               1  2333
3.  STPREG  3     5  6             333
4.  PARCOR        6
5.  END
```

NOTE: OUTDATED *INVR* OR *MULREG* ROUTINES HAVE BEEN REPLACED BY THE EQUIVALENT *STPREG*

CONTROL CARD NO. 1 * INMSDC *

FORMAT CARDS
(F10.5/3F10.3)

INPUT DATA

TRIPGN	LABFOR	DUWC	AREA
288.0	2880.	864.0	1.229
0.1532D 05	0.2251D 05	0.1188D 05	0.6820
0.3486D 05	0.2753D 05	0.1995D 05	4.895
0.2216D 05	0.3487D 05	0.1727D 05	4.818
0.2739D 05	0.3745D 05	0.2118D 05	7.420
0.1392D 05	0.1753D 05	9743.	4.050
0.1602D 05	0.1471D 05	0.1111D 05	5.480
0.2966D 05	0.3821D 05	0.2245D 05	9.810
8190.	8190.	4809.	15.40
7717.	8395.	6353.	11.97
1553.	3364.	1551.	18.75
0.1545D 05	0.1274D 05	9464.	16.01
0.2193D 05	0.1597D 05	0.1164D 05	9.788
0.1022D 05	0.1272D 05	8674.	21.64
2862.	5406.	2225.	2.073
0.1510D 05	0.1286D 05	9057.	4.312
0.1889D 05	0.1682D 05	0.1162D 05	27.68
4388.	5081.	3001.	27.68
0.1066D 05	0.1110D 05	6910.	4.031
1997.	2238.	1425.	2.451
7074.	7638.	4965.	2.203
6111.	5653.	3677.	5.892
6955.	7816.	5119.	3.654
2038.	1634.	1139.	3.728
5449.	3778.	2530.	3.158
23.00	69.00	46.00	3.296
1095.	960.0	706.0	2.855
2976.	3254.	2178.	3.397
0.2145D 05	0.1844D 05	0.1302D 05	35.83
3807.	6772.	5925.	26.97
6728.	7505.	6469.	51.09
2862.	2864.	3436.	51.02

32 OBSERVATIONS
31 DEGREES OF FREEDOM

NAME	MEAN	S.D.
TRIPGN	0.1079D 05	9314.
LABFOR	0.1178D 05	0.1051D 05
DUWC	7512.	6185.
AREA	12.29	13.77

CORRELATION MATRIX

VARIABLE	TRIPGN	LABFOR	DUWC	AREA
TRIPGN	1.0000			
LABFOR	0.9211	1.0000		
DUWC	0.9700	0.9752	1.0000	
AREA	-0.0364	-0.0835	0.0117	1.0000

ARRAY WRITTEN IN AREA 5

CONTROL CARD NO. 2 * STPREG *

DEPENDENT VARIABLE IS TRIPGN

RSQ = 0.9647
FPROB. = 0.0000
STD ERR Y = 1841.7498

VAR	COEFF	STD ERR	F-RATIO	FPROB.
CONST.	338.7013	594.0954		
LABFOR	-0.6510	0.1574	17.1011	0.0003
DUWC	2.5415	0.2666	90.8980	0.0000
AREA	-79.4897	26.5996	8.9304	0.0057

NO.	OBSERVED	CALCULATED	RESIDUAL	NO.	OBSERVED	CALCULATED	RESIDUAL
1.	-1.1270	-1.0983	-0.28742E-01				
2.	0.48700	0.49451	-0.75117E-02				
3.	2.5840	2.4627	0.12125				
4.	1.2210	1.3269	-0.10593				
5.	1.7820	2.0342	-0.25224				
6.	0.33600	0.29604	0.39964E-01				
7.	0.56200	0.40358	0.15842				
8.	2.0260	2.3681	-0.34206				
9.	-0.27900	-0.35083	0.71834E-01				
10.	-0.32900	-0.19231	-0.13669				
11.	-0.99100	-0.88771	-0.10329				
12.	0.50100	0.25862	0.24238				
13.	1.1960	0.65623	0.53977				
14.	-0.60000E-01	0.10716	-0.16716				
15.	-0.85100	-0.82867	-0.22332E-01				
16.	0.46300	-0.94176E-01	0.55718				
17.	0.87000	0.59127	0.27873				
18.	-0.68700	-0.56298	-0.12402				
19.	-0.13000E-01	-0.81321E-01	0.68321E-01				
20.	-0.94400	-0.95528	0.11279E-01				
21.	-0.39800	-0.37340	-0.24604E-01				
22.	-0.50200	-0.58431	0.82306E-01				
23.	-0.41100	-0.45361	0.42615E-01				
24.	-0.93900	-1.0132	0.74238E-01				
25.	-0.57300	-0.72477	0.15177				
26.	-1.1560	-1.1762	0.20213E-01				
27.	-1.0400	-0.80554	-0.23446				
28.	-0.83800	-0.79665	-0.41347E-01				
29.	1.1450	0.93311	0.21189				
30.	-0.74900	-0.18437	-0.56463				
31.	-0.43600	-0.67188E-01	-0.36881				
32.	-0.85100	-0.70268	-0.14832				

* END OF CONTROL SET *

STOP 0
EXECUTION TERMINATED

$SIGNOFF

NO.	OBSERVED	CALCULATED	RESIDUAL	NO.	OBSERVED	CALCULATED	RESIDUAL
1.	288.00	562.13	-274.13				
2.	15318.	15816.	-497.81				
3.	34857.	32729.	2127.5				
4.	22162.	21149.	1013.1				
5.	27387.	29210.	-1823.1				
6.	13916.	13367.	548.51				
7.	16019.	18573.	-2554.3				
8.	29656.	31731.	-2075.4				
9.	8190.0	6005.7	2184.3				
10.	7717.0	10069.	-2351.7				
11.	1553.0	600.11	952.89				
12.	15448.	14823.	624.52				
13.	21928.	18745.	3183.0				
14.	10222.	12381.	-2158.7				
15.	2862.0	2309.7	552.27				
16.	15102.	14640.	462.12				
17.	18891.	16731.	2159.5				
18.	4388.0	2458.2	1929.8				
19.	10660.	10356.	303.52				
20.	1997.0	2308.7	-311.69				
21.	7074.0	7810.2	-736.20				
22.	6111.0	5535.6	575.36				
23.	6955.0	7970.4	-1015.4				
24.	2038.0	1873.5	164.52				
25.	5449.0	4058.4	1390.6				
26.	23.000	148.70	-125.70				
27.	1095.0	1281.1	-186.15				
28.	2976.0	3485.9	-509.88				
29.	21454.	18573.	2880.7				
30.	3807.0	8844.7	-5037.7				
31.	6728.0	7833.5	-1105.5				
32.	2862.0	3151.1	-289.11				

CONTROL CARD NO. 3 * STPREG *

ARRAY RESTORED FROM AREA 5

ARRAY WRITTEN IN AREA 6

CONTROL CARD NO. 4 * PARCOR *

ARRAY RESTORED FROM AREA 6

PARTIAL CORRELATIONS

VARIABLE	TRIPGN	LABFOR	DUWC	AREA
TRIPGN	1.000			
LABFOR	-0.6158	-1.000		
DUWC	0.8744	0.9797	-1.000	
AREA	-0.4917	-0.4289	0.4223	-1.000

* END OF CONTROL SET *

STOP 0
EXECUTION TERMINATED

APPENDIX E

MULTIPLE REGRESSION OUTPUTS OF MODEL I (UNSTANDARDIZED VARIABLES)

```
$SIGNON PLAK TIME=5M PAGES=50 COPIES=36 PRIO=V
**LAST SIGNON WAS: 16:04:29   03-25-70
 USER "PLAK" SIGNED ON AT  16:10:27 ON 03-25-70
$RUN *TRIP 4=*SOURCE*
EXECUTION BEGINS
TRIP/360 IMPLEMENTATION 3/18/70
```

21	0.7280	0.7016	0.7000	0.2312	0.6846	0.7302	0.1868	0.6816	0.7217	0.2092	0.7046
22	0.0242	0.0562	0.1450	-0.2643	-0.0489	0.0829	-0.2781	0.0094	0.1468	-0.2632	0.0590
23	0.0697	-0.0354	0.0146	-0.1814	-0.1229	-0.0418	-0.2089	-0.0449	0.0096	-0.1248	0.0168
24	0.1639	0.2218	0.1342	0.3692	0.2773	0.1585	0.3453	0.2473	0.1406	0.3118	0.1991
25	0.1893	0.1925	0.0874	0.4244	0.2608	0.1116	0.3984	0.2394	0.1027	0.3671	0.1977
26	0.2396	0.3655	0.2900	0.3783	0.4116	0.3131	0.3598	0.3493	0.2783	0.2852	0.3059
27	0.0753	0.1177	0.0420	0.2906	0.1664	0.0647	0.2670	0.1522	0.0539	0.2556	0.1041
28	0.0769	0.1111	0.0356	0.2875	0.1611	0.0573	0.2686	0.1555	0.0459	0.2792	0.0996
29	-0.1420	-0.1062	-0.1776	0.2008	-0.0511	-0.1590	0.1909	-0.0558	-0.1720	0.2026	-0.1187
30	0.2309	0.2318	0.0295	0.7552	0.3556	0.0323	0.7750	0.3928	0.0436	0.8452	0.2752

CORRELATION MATRIX

VARIABLE	12	13	14	15	16	17	18	19	20	21	22
12	1.0000										
13	0.2489	1.0000									
14	0.9579	0.4794	1.0000								
15	0.0319	-0.4124	-0.0118	1.0000							
16	0.0191	-0.5530	-0.1300	0.5949	1.0000						
17	0.0525	-0.3942	-0.0337	0.8222	0.6271	1.0000					
18	0.2838	0.2170	0.3063	-0.0785	-0.1111	-0.0909	1.0000				
19	-0.1975	-0.5575	-0.2979	0.5110	0.3438	0.4903	-0.2082	1.0000			
20	0.7880	0.6140	0.8942	-0.0655	-0.2742	-0.1074	0.3939	-0.3616	1.0000		
21	0.7094	0.2714	0.7004	-0.1871	-0.2037	-0.2169	0.3579	-0.5949	0.6075	1.0000	
22	0.1729	-0.2840	0.0918	0.2618	0.1005	0.2350	-0.0560	0.6541	0.1029	-0.3087	1.0000
23	0.0730	-0.1451	0.0798	0.3841	0.1042	0.3557	0.0334	0.1695	0.3378	0.0202	0.4107
24	0.1293	0.2691	0.1823	-0.6377	-0.3907	-0.7367	0.1075	-0.5900	0.1252	0.4197	-0.2434
25	0.1085	0.3212	0.1968	-0.5620	-0.4302	-0.6757	0.2180	-0.5675	0.1973	0.3714	-0.2064
26	0.2548	0.2619	0.2800	-0.5539	-0.2207	-0.6264	-0.0278	-0.5813	0.1107	0.4279	-0.2684
27	0.0424	0.2089	0.0905	-0.6471	-0.4228	-0.7494	0.1027	-0.5272	0.0724	0.3846	-0.2158
28	0.0332	0.2199	0.0718	-0.6886	-0.4483	-0.7813	0.1305	-0.5778	0.0894	0.3735	-0.2411
29	-0.1844	0.1298	-0.1448	-0.6936	-0.4389	-0.7998	0.0281	-0.4796	-0.0967	0.1840	-0.2379
30	0.0183	0.8057	0.1970	-0.4750	-0.4776	-0.4457	-0.0009	-0.5094	0.4335	0.0439	-0.3025

CORRELATION MATRIX

VARIABLE	23	24	25	26	27	28	29	30
23	1.0000							
24	-0.2650	1.0000						
25	-0.1336	0.9517	1.0000					
26	-0.4621	0.9004	0.7893	1.0000				
27	-0.1806	0.9726	0.9183	0.7970	1.0000			
28	-0.1957	0.9501	0.8940	0.7732	0.9690	1.0000		
29	-0.1989	0.8975	0.8336	0.7001	0.9459	0.9590	1.0000	
30	-0.0868	0.1041	0.0982	0.1050	0.0735	0.1818	0.1650	1.0000

* END OF CONTROL SET *

STOP 0
EXECUTION TERMINATED

$SIG

32.00	2.855	5710.	1362.	161.0	898.0	234.0	19.00	477.0	1140.
2976.	9102.	8902.	200.0	3254.	3152.	102.0	2502.	2425.	77.00
2178.	2127.	51.00	3021.	1.208	3.640	0.8690	0.0	23.60	97.58
60.00	3.397	5182.	828.0	255.0	243.0	283.0	47.00	244.0	2682.
0.2145D 05	0.5174D 05	0.5065D 05	1084.	0.1844D 05	0.1790D 05	542.0	0.1410D 05	0.1356D 05	542.0
0.1302D 05	0.1275D 05	271.0	0.2034D 05	1.440	3.670	0.9220	0.0	38.30	695.3
1.000	35.83	6301.	6208.	1341.	2942.	1635.	290.0	173.0	1442.
3807.	0.2793D 05	0.2581D 05	2115.	6772.	6349.	423.0	5925.	5502.	423.0
5925.	5502.	423.0	7616.	1.286	4.710	1.000	0.0	31.00	322.9
1.000	26.97	7467.	3532.	595.0	1076.	1620.	241.0	131.0	1035.
6728.	0.2716D 05	0.2639D 05	775.0	7505.	6987.	518.0	8538.	8021.	517.0
6469.	6469.	0.0	9315.	1.091	3.180	0.7590	0.0	42.00	465.3
1.000	51.09	6649.	2842.	551.0	621.0	1369.	301.0	56.00	531.0
2862.	9789.	9789.	0.0	2864.	2864.	0.0	3722.	3722.	0.0
3436.	3436.	0.0	4294.	1.152	2.630	0.9220	0.0	31.00	255.0
1.000	51.02	8563.	1796.	828.0	203.0	620.0	77.00	35.00	192.0

32 OBSERVATIONS
31 DEGREES OF FREEDOM

NAME	MEAN	S.D.	NAME	MEAN	S.D.	NAME	MEAN	S.D.
1	0.1079D 05	9314.	11	7512.	6185.	21	133.8	129.9
2	0.2939D 05	0.2449D 05	12	6303.	5381.	22	12.60	13.71
3	0.2565D 05	0.2226D 05	13	1209.	1990.	23	5885.	1806.
4	3834.	6599.	14	0.1047D 05	8460.	24	9695.	0.1402D 05
5	0.1178D 05	0.1051D 05	15	1.220	0.2574	25	2485.	3533.
6	9441.	8725.	16	3.408	0.5529	26	3378.	4313.
7	2338.	4438.	17	0.8661	0.1253	27	3067.	5611.
8	8877.	7599.	18	1003.	3490.	28	749.3	1369.
9	7092.	6247.	19	21.34	9.686	29	3452.	0.1070D 05
10	1783.	3210.	20	414.1	357.2	30	5453.	0.1037D 05

CORRELATION MATRIX

VARIABLE	1	2	3	4	5	6	7	8	9	10	11
1	1.0000										
2	0.9478	1.0000									
3	0.9147	0.9642	1.0000								
4	0.4442	0.4672	0.2170	1.0000							
5	0.9209	0.9705	0.8862	0.6191	1.0000						
6	0.9081	0.9575	0.9856	0.2396	0.9095	1.0000					
7	0.3960	0.4162	0.1621	0.9930	0.5800	0.1889	1.0000				
8	0.9439	0.9741	0.8891	0.6216	0.9858	0.8932	0.5783	1.0000			
9	0.9285	0.9687	0.9935	0.2528	0.9044	0.9885	0.1994	0.9108	1.0000		
10	0.4278	0.4211	0.1717	0.9800	0.5741	0.1911	0.9813	0.5952	0.2103	1.0000	
11	0.9700	0.9867	0.9362	0.5133	0.9751	0.9379	0.4654	0.9860	0.9517	0.4825	1.0000
12	0.9356	0.9592	0.9901	0.2316	0.8910	0.9838	0.1770	0.8966	0.9931	0.1900	0.9502
13	0.4844	0.4725	0.2319	0.9688	0.6211	0.2548	0.9677	0.6400	0.2722	0.9857	0.5384
14	0.9705	0.9704	0.9324	0.4655	0.9529	0.9353	0.4183	0.9593	0.9474	0.4276	0.9877
15	-0.0382	-0.1239	-0.0027	-0.4447	-0.1882	-0.0010	-0.4424	-0.2120	-0.0235	-0.4561	-0.1049
16	-0.1457	-0.0702	0.0735	-0.5023	-0.2005	0.0259	-0.5241	-0.2406	-0.0034	-0.5628	-0.1613
17	-0.0393	-0.0984	0.0292	-0.4532	-0.1770	0.0199	-0.4570	-0.1947	0.0005	-0.4619	-0.0811
18	0.4101	0.2702	0.2354	0.2043	0.2510	0.2273	0.1479	0.3191	0.2843	0.2024	0.3168
19	-0.3300	-0.3546	-0.2120	-0.5895	-0.4453	-0.2511	-0.5598	-0.4237	-0.2220	-0.5712	-0.3512
20	0.8915	0.8300	0.7431	0.5782	0.8264	0.7227	0.5355	0.8829	0.7678	0.5963	0.8832

348.0	16.01	0.1075D 05	5121.	1302.	624.0	2763.	432.0	320.0	2025.
0.2193D 05	0.4979D 05	0.4817D 05	1623.	0.1597D 05	0.1488D 05	1082.	0.1326D 05	0.1218D 05	1083.
0.1164D 05	0.1110D 05	542.0	0.1786D 05	1.347	3.760	0.8780	0.0	17.00	815.6
294.0	9.788	7743.	9806.	1996.	3229.	3770.	811.0	1003.	5090.
0.1022D 05	0.3239D 05	0.3046D 05	1930.	0.1272D 05	0.1176D 05	964.0	8867.	8096.	771.0
8674.	7903.	771.0	0.1214D 05	1.370	3.560	0.9780	0.0	18.00	437.1
168.0	21.64	6307.	4794.	1424.	2398.	782.0	190.0	221.0	1492.
2862.	9540.	7314.	2226.	5406.	2862.	2544.	3178.	2225.	953.0
2225.	1272.	953.0	3497.	1.002	3.000	0.7010	0.0	28.50	49.26
62.00	2.073	1891.	4187.	806.0	3512.	380.0	91.00	2022.	4610.
0.1510D 05	0.2602D 05	0.1953D 05	6484.	0.1286D 05	7625.	5240.	9532.	5720.	3813.
9057.	5720.	3337.	0.1191D 05	1.250	2.730	0.9500	0.0	27.00	371.7
219.0	4.312	4823.	0.1609D 05	4526.	4741.	5120.	1103.	3735.	6030.
0.1889D 05	0.4420D 05	0.4415D 05	3045.	0.1682D 05	0.1592D 05	895.0	0.1217D 05	0.1108D 05	1090.
0.1162D 05	0.1071D 05	908.0	0.1610D 05	1.323	3.640	0.9560	0.0	28.60	530.5
37.00	27.68	5777.	8757.	3682.	3505.	1283.	287.0	316.0	1595.
4388.	0.1224D 05	0.1224D 05	0.0	5081.	5081.	0.0	3463.	3463.	0.0
3001.	3001.	0.0	5541.	1.599	3.540	0.8670	0.0	38.50	161.9
1.000	27.68	6003.	2361.	1160.	465.0	586.0	150.0	85.00	441.0
0.1066D 05	0.2854D 05	0.2582D 05	2724.	0.1110D 05	9743.	1354.	8152.	7113.	1040.
6910.	6067.	843.0	9662.	1.183	3.500	0.8480	0.0	17.00	343.2
226.0	4.031	5888.	2940.	725.0	739.0	1309.	172.0	729.0	7070.
1997.	5146.	4742.	404.0	2238.	1951.	287.0	1536.	1359.	177.0
1425.	1248.	177.0	2013.	1.310	3.350	0.9280	0.0	16.00	65.89
66.00	2.451	5018.	7480.	2206.	1862.	1990.	1421.	3050.	2097.
7074.	0.1784D 05	0.1225D 05	5588.	7638.	4815.	2823.	5840.	3414.	2427.
4965.	3103.	1862.	6732.	1.153	3.060	0.8510	3500.	19.70	227.8
97.00	2.203	5156.	4371.	340.0	1958.	1836.	236.0	1986.	8110.
6111.	0.1445D 05	0.1401D 05	439.0	5653.	5454.	199.0	4119.	3900.	219.0
3677.	3506.	171.0	5616.	1.364	3.510	0.8920	0.0	25.60	146.2
114.0	5.892	4754.	2111.	202.0	1536.	310.0	63.00	358.0	2455.
6955.	0.1885D 05	0.1668D 05	2167.	7816.	6657.	1159.	6087.	5093.	944.0
5119.	4270.	849.0	7019.	1.153	3.100	0.8420	0.0	22.90	237.4
115.0	3.654	5005.	6997.	1644.	3301.	1816.	236.0	1919.	5160.
2038.	4607.	4465.	142.0	1634.	1615.	19.00	1289.	1256.	33.00
1139.	1120.	19.00	1678.	1.300	3.160	0.8840	0.0	17.40	51.69
40.00	3.728	5502.	3351.	2293.	659.0	252.0	147.0	898.0	1236.
5449.	0.1075D 05	0.1028D 05	475.0	3778.	3586.	192.0	2664.	2530.	134.0
2530.	2396.	134.0	3678.	1.370	4.040	0.9500	0.0	22.20	124.5
58.00	3.158	6295.	700.0	59.00	351.0	261.0	29.00	222.0	3405.
23.00	161.0	161.0	0.0	69.00	69.00	0.0	46.00	46.00	0.0
46.00	46.00	0.0	46.00	1.000	3.500	1.000	0.0	26.40	1.794
15.00	3.296	5050.	1554.	0.0	242.0	1300.	12.00	472.0	49.00
1095.	3254.	3254.	0.0	960.0	960.0	0.0	753.0	753.0	0.0
706.0	706.0	0.0	1133.	1.504	4.320	0.9480	5000.	25.20	35.20

CONTROL CARD NO. 1 * INMSDC *

ORMAT CARDS
(F10.5/8F9.3/8F9.3/8F9.3/5F9.3)

INPUT DATA

1 11 21	2 12 22	3 13 23	4 14 24	5 15 25	6 16 26	7 17 27	8 18 28	9 19 29	10 20 30
288.0	5472.	1152.	4320.	2880.	576.0	2304.	2304.	288.0	2016.
864.0	288.0	576.0	864.0	0.3750	2.370	0.3750	1600.	2.600	58.18
245.0	1.229	4555.	0.7469D 05	0.1761D 05	0.1812D 05	0.3132D 05	7634.	0.6075D 05	4550.
0.1532D 05	0.4031D 05	0.1437D 05	0.2594D 05	0.2261D 05	4690.	0.1782D 05	0.1906D 05	4376.	0.1469D 05
0.1188D 05	3126.	8750.	0.1250D 05	0.6560	2.120	0.6220	0.0	3.600	1039.
45.00	0.6820	5900.	7044.	1742.	1361.	2471.	1470.	0.1032D 05	0.5910D 05
0.3486D 05	0.7248D 05	0.6415D 05	8337.	0.2753D 05	0.2348D 05	4041.	0.2374D 05	0.1944D 05	4293.
0.1995D 05	0.1692D 05	3030.	0.2677D 05	1.128	3.060	0.8410	0.1900D 05	13.10	1288.
414.0	14.89	6735.	0.1208D 05	5287.	1058.	3828.	1313.	810.0	4860.
0.2216D 05	0.6485D 05	0.3682D 05	0.2803D 05	0.3487D 05	0.1629D 05	0.1858D 05	0.2281D 05	0.1140D 05	0.1140D 05
0.1727D 05	0.1043D 05	6843.	0.2574D 05	1.128	2.840	0.7570	3000.	6.300	988.9
190.0	4.818	4536.	0.3438D 05	0.1082D 05	0.1168D 05	0.1011D 05	1768.	7130.	0.1345D 05
0.2739D 05	0.9194D 05	0.8216D 05	9779.	0.3745D 05	0.3186D 05	5588.	0.2683D 05	0.2316D 05	3672.
0.2118D 05	0.1779D 05	3390.	0.2599D 05	0.9700	3.430	0.7890	0.0	10.40	626.5
408.0	7.420	2910.	0.2307D 05	3274.	0.1059D 05	7877.	1330.	3110.	2400.
0.1392D 05	0.4954D 05	0.4397D 05	5562.	0.1753D 05	0.1419D 05	3338.	0.1225D 05	0.1058D 05	1670.
9743.	8908.	835.0	0.1197D 05	0.9750	4.050	0.7950	0.0	8.500	362.5
189.0	4.050	3751.	0.2252D 05	4085.	0.1388D 05	3248.	1306.	5555.	0.1222D 05
0.1602D 05	0.3988D 05	0.3465D 05	5232.	0.1471D 05	0.1177D 05	2943.	0.1209D 05	9480.	2615.
0.1111D 05	9153.	1961.	0.1733D 05	1.433	3.300	0.9100	0.0	12.80	908.3
210.0	5.480	9294.	0.1134D 05	4257.	3269.	3397.	618.0	2070.	7275.
0.2966D 05	0.8871D 05	0.8684D 05	1869.	0.3821D 05	0.3714D 05	1069.	0.2565D 05	0.2458D 05	1069.
0.2245D 05	0.2164D 05	802.0	0.3099D 05	1.170	3.350	0.8750	0.0	15.20	965.8
416.0	9.810	4738.	0.1291D 05	1628.	6458.	3422.	1404.	1318.	9040.
8190.	0.2084D 05	0.2084D 05	0.0	8190.	8190.	0.0	5165.	5165.	0.0
4809.	4809.	0.0	6590.	1.273	4.030	0.9300	0.0	22.90	302.7
106.0	15.40	8482.	7742.	4148.	1164.	1885.	545.0	503.0	1354.
7717.	0.2405D 05	0.2360D 05	454.0	8395.	8168.	227.0	6807.	6580.	227.0
6353.	6126.	227.0	8849.	1.298	3.520	0.9340	0.0	28.10	349.9
76.00	11.97	7224.	2346.	495.0	1276.	476.0	99.00	196.0	2001.
1553.	6468.	6468.	0.0	3364.	3364.	0.0	1551.	1551.	0.0
1551.	1551.	0.0	2587.	1.668	4.170	1.000	0.0	24.10	48.24
28.00	18.75	4374.	4938.	76.00	4138.	589.0	135.0	263.0	345.0
0.1545D 05	0.3244D 05	0.3070D 05	1737.	0.1274D 05	0.1216D 05	579.0	0.1004D 05	8884.	1159.
9464.	8498.	966.0	0.1564D 05	1.556	3.230	0.9410	0.0	19.50	876.3

```
  0     0    0    1    1    1    2    2   2   2   3 3    3    4    4    5    5    6    6    7    7    8
  1     6    9    2    5    8    1    4   6   8   0 1    5    0    5    0    5    0    5    0    5    0
CONTROL
CARDS

1. INMSDC  30                       1       1
2. END
```

APPENDIX D

INPUT DATA AND THE CORRELATION MATRIX

```
$SIGNON PL08 TIME=5M PAGES=50 COPIES=36 PRIO=V
THE DISK SPACE ALLOTTED THIS USER ID HAS BEEN EXCEEDED.
**LAST SIGNON WAS: 14:53:52   03-25-70
 USER "PL08" SIGNED ON AT  16:03:22 ON 03-25-70
$RUN *TRIP 4=*SOURCE*
EXECUTION BEGINS
TRIP/360 IMPLEMENTATION 3/18/70
```

VARIABLE NAMES

1. Total Trip Generated
2. Population, Total
3. Population, Single Family
4. Population, Multiple Family
5. Labour Force, Total
6. Labour Force, Single Family
7. Labour Force, MUltiple Family
8. Dwelling Units, Total
9. Single Family Dwelling Units
10. Multiple Family Dwelling Units
11. Dwelling Units Per Car
12. Single Dwelling Units With Car
13. Multiple Family Dwelling Units With Car
14. Cars, Total
15. Cars, Per Dwelling Unit
16. Population Per Dwelling Unit
17. % of Dwelling Units With Car
18. Students (4 - 6 p.m.)
19. Time to CBD in Minutes
20. Gross Income (10.0 E -5)
21. Bus Miles
22. Area in Acre
23. Income Per Dwelling Unit
24. Employment, Total
25. Employment: Public Utilities, Government and Institutional Services
26. Employment: Industrial, Wholesale and Unclassified
27. Employment: Service Industries
28. Employment: Entertainment
29. Employment Density, Per Acre
30. Population Density, Per Acre

$DATA

TRIPGN	LABFOR	DUWC	AREA
-1.127	2880.000	864.000	1.229
0.487	22508.000	11876.000	0.682
2.584	27526.000	19948.000	4.895
1.221	34870.000	17270.000	4.818
1.782	37446.000	21183.000	7.420
0.336	17530.000	9743.000	4.050
0.562	14711.000	11114.000	5.480
2.026	38212.000	22446.000	9.810
-0.279	8190.000	4809.000	15.396
-0.329	8395.000	6353.000	11.970
-0.991	3364.000	1551.000	18.753
0.501	12744.000	9464.000	16.006
1.196	15967.000	11638.000	9.788
-0.060	12724.000	8674.000	21.642
-0.851	5406.000	2225.000	2.073
0.463	12865.000	9057.000	4.312
0.870	16817.000	11623.000	27.678
-0.687	5081.000	3001.000	27.678
-0.013	11097.000	6910.000	4.031
-0.944	2238.000	1425.000	2.451
-0.398	7638.000	4965.000	2.203
-0.502	5653.000	3677.000	5.892
-0.411	7816.000	5119.000	3.654
-0.939	1634.000	1139.000	3.728
-0.573	3778.000	2530.000	3.158
-1.156	69.000	46.000	3.296
-1.040	960.000	706.000	2.855
-0.838	3254.000	2178.000	3.397
1.145	18439.000	13018.000	35.827
-0.749	6772.000	5925.000	26.974
-0.436	7505.000	6469.000	51.086
-0.851	2864.000	3436.000	51.024

MEANS AND STANDARD DEVIATIONS

11779.780	7511.938	12.289
10509.600	6184.680	13.767

STANDARD SCORES OF THE VARIABLES

-1.127	-0.847	-1.075	-0.803
0.487	1.021	0.706	-0.843
2.584	1.498	2.011	-0.537
1.221	2.197	1.578	-0.543
1.782	2.442	2.210	-0.354
0.336	0.547	0.361	-0.598
0.562	0.279	0.582	-0.495
2.026	2.515	2.415	-0.180
-0.279	-0.342	-0.437	0.226
-0.329	-0.322	-0.187	-0.023
-0.991	-0.801	-0.964	0.470
0.501	0.092	0.316	0.270
1.196	0.398	0.667	-0.182
-0.060	0.090	0.188	0.679
-0.851	-0.606	-0.855	-0.742
0.463	0.103	0.250	-0.579
0.870	0.479	0.665	1.118
-0.687	-0.637	-0.729	1.118
-0.013	-0.065	-0.097	-0.600
-0.944	-0.908	-0.984	-0.715
-0.398	-0.394	-0.412	-0.733
-0.502	-0.583	-0.620	-0.465

-0.411	-0.377	-0.387	-0.627
-0.939	-0.965	-1.030	-0.622
-0.573	-0.761	-0.806	-0.663
-1.156	-1.114	-1.207	-0.653
-1.040	-1.030	-1.100	-0.685
-0.838	-0.811	-0.862	-0.646
1.145	0.634	0.890	1.710
-0.749	-0.476	-0.257	1.067
-0.436	-0.407	-0.169	2.818
-0.851	-0.848	-0.659	2.814

COMPILE TIME= 0.21 SEC,EXECUTION TIME= 0.50 SEC,OBJECT CODE= 1824 BYTES,ARRAY AREA= 1824 BYTES,UNUSED= 98752 BYTES

**************** END OF JOB ***

ENDFILE**   UN-1

```
        $STOP
EXECUTION TERMINATED


$RUN -LOAD#+*TRIP 4=-A 5=*SOURCE* 6=*SINK*
EXECUTION BEGINS
TRIP/360 IMPLEMENTATION 3/18/70
```

```
      0   0   0   1   1   1   2   2  2  2  3 3   3    4    4    5    5    6    6    7    7    8
      1   6   9   2   5   8   1   4  6  8  0 1   5    0    5    0    5    0    5    0    5    0
CONTROL
CARDS

 1. INMSDC   4               1   1  1  1
 2. STPREG   3   1                     1    2333
 3. END
```

NOTE: OUTDATED *INVR* OR *MULREG* ROUTINES HAVE BEEN REPLACED BY THE EQUIVALENT *STPREG*

CONTROL CARD NO. 1 * INMSDC *

FORMAT CARDS
(4F10.3)

INPUT DATA

TRIPGN	LABFOR	DUWC	AREA
-1.127	-0.8470	-1.075	-0.8030
0.4870	1.021	0.7060	-0.8430
2.584	1.498	2.011	-0.5370
1.221	2.197	1.578	-0.5430
1.782	2.442	2.210	-0.3540
0.3360	0.5470	0.3610	-0.5980
0.5620	0.2790	0.5820	-0.4950
2.026	2.515	2.415	-0.1800
-0.2790	-0.3420	-0.4370	0.2260
-0.3290	-0.3220	-0.1870	-0.2300D-01
-0.9910	-0.8010	-0.9640	0.4700
0.5010	0.9200D-01	0.3160	0.2700
1.196	0.3980	0.6670	-0.1820
-0.6000D-01	0.9000D-01	0.1880	0.6790
-0.8510	-0.6060	-0.8550	-0.7420
0.4630	0.1030	0.2500	-0.5790
0.8700	0.4790	0.6650	1.118
-0.6870	-0.6370	-0.7290	1.118
-0.1300D-01	-0.6500D-01	-0.9700D-01	-0.6000
-0.9440	-0.9080	-0.9840	-0.7150
-0.3980	-0.3940	-0.4120	-0.7330
-0.5020	-0.5830	-0.6200	-0.4650
-0.4110	-0.3770	-0.3870	-0.6270
-0.9390	-0.9650	-1.030	-0.6220
-0.5730	-0.7610	-0.8060	-0.6630
-1.156	-1.114	-1.207	-0.6530
-1.040	-1.030	-1.100	-0.6850
-0.8380	-0.8110	-0.8620	-0.6460
1.145	0.6340	0.8900	1.710
-0.7490	-0.4760	-0.2570	1.067
-0.4360	-0.4070	-0.1690	2.818
-0.8510	-0.8480	-0.6590	2.814

32 OBSERVATIONS
31 DEGREES OF FREEDOM

NAME	MEAN	S.D.
TRIPGN	-0.3125D-04	0.9999
LABFOR	0.3125D-04	0.9999
DUWC	0.6250D-04	1.000
AREA	0.6250D-04	1.000

CORRELATION MATRIX

VARIABLE	TRIPGN	LABFOR	DUWC	AREA
TRIPGN	1.0000			
LABFOR	0.9211	1.0000		
DUWC	0.9700	0.9752	1.0000	
AREA	-0.0366	-0.0836	0.0115	1.0000

CONTROL CARD NO. 2 * STPREG *

DEPENDENT VARIABLE IS TRIPGN

RSQ	=	0.9648
FPROB.	=	0.0000
STD ERR Y	=	0.1974

VAR	COEFF	STD ERR	F-RATIO	FPROB.
CONST.	-0.1064D-03	0.0349		
LABFOR	-0.7354	0.1773	17.1945	0.0003
DUWC	1.6883	0.1767	91.2683	0.0000
AREA	-0.1175	0.0392	8.9625	0.0056

NO.	OBSERVED	CALCULATED	RESIDUAL	NO.	OBSERVED	CALCULATED	RESIDUAL
1.	-1.1270	-1.0979	-0.29144E-01				
2.	0.48700	0.54008	-0.53082E-01				
3.	2.5840	2.3566	0.22737				
4.	1.2210	1.1123	0.10874				
5.	1.7820	1.9769	-0.19491				
6.	0.33600	0.27739	0.58610E-01				
7.	0.56200	0.83549	-0.27349				
8.	2.0260	2.2489	-0.22289				
9.	-0.27900	-0.51296	0.23396				
10.	-0.32900	-0.76331E-01	-0.25267				
11.	-0.99100	-1.0938	0.10284				
12.	0.50100	0.43403	0.66970E-01				
13.	1.1960	0.85472	0.34128				
14.	-0.60000E-01	0.17134	-0.23134				
15.	-0.85100	-0.91082	0.59815E-01				
16.	0.46300	0.41426	0.48740E-01				
17.	0.87000	0.63904	0.23096				
18.	-0.68700	-0.89382	0.20682				
19.	-0.13000E-01	-0.45581E-01	0.32581E-01				
20.	-0.94400	-0.90970	-0.34301E-01				
21.	-0.39800	-0.31984	-0.78159E-01				
22.	-0.50200	-0.56352	0.61515E-01				
23.	-0.41100	-0.30259	-0.10841				
24.	-0.93900	-0.95637	0.17372E-01				
25.	-0.57300	-0.72339	0.15039				
26.	-1.1560	-1.1420	-0.14006E-01				
27.	-1.0400	-1.0194	-0.20646E-01				
28.	-0.83800	-0.78316	-0.54840E-01				
29.	1.1450	0.83537	0.30963				
30.	-0.74900	-0.20933	-0.53967				
31.	-0.43600	-0.31722	-0.11878				
32.	-0.85100	-0.81974	-0.31263E-01				

* END OF CONTROL SET *

```
STOP      0
EXECUTION TERMINATED

$SIGNOFF
```

RFS NO. 019810 UNIVERSITY OF B C COMPUTING CENTRE MTS(AN059) JOB START: 14:53:37 03-25-70

APPENDIX F

FACTOR ANALYSIS OUTPUTS FOR THE TRIP GENERATION DATA

```
$SIGNON PL08 TIME=5M PAGES=50 COPIES=36 PRIO=V
THE DISK SPACE ALLOTTED THIS USER ID HAS BEEN EXCEEDED.
**LAST SIGNON WAS: 11:55:14   03-16-70
 USER "PL08" SIGNED ON AT  14:53:52 ON 03-25-70
$RUN *FACTO+*SSP 1=-A 2=-B 4=*SOURCE*
EXECUTION BEGINS
```

VARIABLE NAMES

1. Population, Total
2. Population, Single Family
3. Population, Multiple Family
4. Labour Force, Total
5. Labour Force, Single Family
6. Labour Force, Multiple Family
7. Dwelling Units, Total
8. Single Family Dwelling Units
9. Multiple Family Dwelling Units
10. Dwelling Units With Car
11. Single Family Dwelling Units With Car
12. Multiple Family Dwelling Units With Car
13. Cars, Total
14. Cars Per Dwelling Unit
15. Population Per Dwelling Unit
16. % of Dwelling Units With Car
17. Students (4 - 6 p.m.)
18. Time to CBD in Minutes
19. Gross Income (10.0 E -5)
20. Bus Miles
21. Area in Acre
22. Income Per Dwelling Unit
23. Employment, Total
24. Employment: Public Utilities, Government and Institutional Services
25. Employment: Industrial, Wholesale and Unclassified
26. Employment: Service Industries
27. Employment: Enterainment
28. Employment Density Per Acre
29. Population Density Per Acre

FACTOR ANALYSIS.....TRIPGEN2

NO. OF CASES 32
NO. OF VARIABLES 29

MEANS

29389.28125	25649.21875	3833.81250	11782.90625	9441.43750	2338.34375	8876.59375	7092.12500
1783.03125	7511.93750	6302.84375	1209.09375	10470.53125	1.21984	3.40843	0.86606
1003.12500	21.34370	414.07495	133.84375	12.60173	5885.34375	9695.43750	2485.15625
3378.18750	3067.12500	749.28125	3452.40625	5452.56250			

STANDARD DEVIATIONS

24488.33984	22260.67187	6598.98828	10512.91797	8724.85156	4438.44922	7599.47656	6247.10156
3209.49121	6184.67969	5381.29297	1990.07080	8460.46875	0.25744	0.55295	0.12532
3490.11816	9.68599	357.14966	129.91887	13.70711	1806.46021	14019.75391	3532.57666
4312.88281	5610.63672	1369.17456	10704.78125	10368.73047			

CORRELATION COEFFICIENTS

ROW 1

1.00000	0.96421	0.46717	0.97052	0.95753	0.41619	0.97406	0.96871	0.42106	0.98667
0.95925	0.47248	0.97036	-0.12388	-0.07017	-0.09844	0.27016	-0.35455	0.82999	0.70158
0.05621	-0.03540	0.22177	0.19247	0.36548	0.11773	0.11114	-0.10617	0.23183	

ROW 2

0.96421	1.00000	0.21696	0.88620	0.98556	0.16207	0.88914	0.99349	0.17174	0.93615
0.99015	0.23192	0.93236	-0.00271	0.07354	0.02918	0.23537	-0.21202	0.74307	0.70002
0.14496	0.01458	0.13422	0.08740	0.29002	0.04199	0.03557	-0.17758	0.02955	

ROW 3

0.46717	0.21696	1.00000	0.61909	0.23959	0.99295	0.62164	0.25279	0.98001	0.51326
0.23162	0.96876	0.46551	-0.44471	-0.50232	-0.45322	0.20434	-0.58950	0.57817	0.23116
-0.26425	-0.18142	0.36923	0.42439	0.37834	0.29059	0.28751	0.20075	0.75517	

ROW 4

0.97052	0.88620	0.61909	1.00000	0.90949	0.58002	0.98582	0.90438	0.57409	0.97511
0.89098	0.62114	0.95289	-0.18825	-0.20048	-0.17698	0.25101	-0.44528	0.82642	0.68464
-0.04889	-0.12287	0.27727	0.26078	0.41159	0.16639	0.16112	-0.05111	0.35555	

ROW 5

0.95753	0.98556	0.23959	0.90949	1.00000	0.18888	0.89319	0.98845	0.19108	0.93794
0.98376	0.25476	0.93531	-0.00096	0.02592	0.01994	0.22733	-0.25107	0.72274	0.73019
0.08289	-0.04176	0.15853	0.11165	0.31306	0.06473	0.05732	-0.15895	0.03227	

ROW 6

0.41619	0.16207	0.99295	0.58002	0.18888	1.00000	0.57827	0.19939	0.98126	0.46537
0.17698	0.96770	0.41827	-0.44240	-0.52412	-0.45699	0.14788	-0.55983	0.53547	0.18677
-0.27810	-0.20894	0.34526	0.39837	0.35983	0.26696	0.26859	0.19093	0.77497	

ROW 7

0.97406	0.88914	0.62164	0.98582	0.89319	0.57827	1.00000	0.91080	0.59516	0.98604
0.89656	0.64002	0.95931	-0.21200	-0.24062	-0.19470	0.31910	-0.42371	0.88286	0.68157
0.00941	-0.04492	0.24726	0.23939	0.34926	0.15223	0.15553	-0.05584	0.39276	

ROW 8

0.96871	0.99349	0.25279	0.90438	0.98845	0.19939	0.91080	1.00000	0.21032	0.95172
0.99313	0.27223	0.94738	-0.02353	-0.00345	0.00048	0.28429	-0.22203	0.76776	0.72169
0.14682	0.00960	0.14064	0.10268	0.27831	0.05393	0.04586	-0.17201	0.04360	

ROW 9

0.42106	0.17174	0.98001	0.57409	0.19108	0.98126	0.59516	0.21032	1.00000	0.48247
0.18999	0.98567	0.42765	-0.45607	-0.56278	-0.46186	0.20235	-0.57118	0.59630	0.20918
-0.26317	-0.12481	0.31179	0.36706	0.28524	0.25559	0.27919	0.20265	0.84516	

ROW 10

0.98667	0.93615	0.51326	0.97511	0.93794	0.46537	0.98604	0.95172	0.48247	1.00000
0.95020	0.53836	0.98773	-0.10492	-0.16131	-0.08114	0.31679	-0.35121	0.88319	0.70461
0.05905	0.01684	0.19910	0.19773	0.30595	0.10411	0.09963	-0.11871	0.27518	

ROW 11

0.95925	0.99015	0.23162	0.89098	0.98376	0.17698	0.89656	0.99313	0.18999	0.95020
1.00000	0.24892	0.95788	0.03192	0.01911	0.05252	0.28383	-0.19745	0.78797	0.70943
0.17289	0.07303	0.12930	0.10847	0.25478	0.04241	0.03319	-0.18443	0.01832	

ROW 12

0.47248	0.23192	0.96876	0.62114	0.25476	0.96770	0.64002	0.27223	0.98567	0.53836
0.24892	1.00000	0.47945	-0.41239	-0.55300	-0.39419	0.21701	-0.55755	0.61404	0.27140
-0.28399	-0.14514	0.26910	0.32118	0.26189	0.20889	0.21989	0.12978	0.80566	

ROW 13

0.97036	0.93236	0.46551	0.95289	0.93531	0.41827	0.95931	0.94738	0.42765	0.98773
0.95788	0.47945	1.00000	-0.01176	-0.13004	-0.03365	0.30629	-0.29792	0.89425	0.70037
0.09183	0.07984	0.18233	0.19680	0.27999	0.09050	0.07184	-0.14484	0.19696	

ROW 14

-0.12388	-0.00271	-0.44471	-0.18825	-0.00096	-0.44240	-0.21200	-0.02353	-0.45607	-0.10492
0.03192	-0.41239	-0.01176	1.00000	0.59487	0.82225	-0.07846	0.51103	-0.06547	-0.18714
0.26180	0.38410	-0.63767	-0.56198	-0.55392	-0.64713	-0.68859	-0.69365	-0.47498	

ROW 15

-0.07017	0.07354	-0.50232	-0.20048	0.02592	-0.52412	-0.24062	-0.00345	-0.56278	-0.16131
0.01911	-0.55300	-0.13004	0.59487	1.00000	0.62714	-0.11114	0.34379	-0.27420	-0.20370
0.10051	0.10420	-0.39073	-0.43024	-0.22067	-0.42280	-0.44825	-0.43887	-0.47758	

ROW 16

-0.09844	0.02918	-0.45322	-0.17698	0.01994	-0.45699	-0.19470	0.00048	-0.46186	-0.08114
0.05252	-0.39419	-0.03365	0.82225	0.62714	1.00000	-0.09087	0.49030	-0.10739	-0.21693
0.23498	0.35569	-0.73668	-0.67569	-0.62640	-0.74935	-0.78134	-0.79977	-0.44571	

ROW 17

0.27016	0.23537	0.20434	0.25101	0.22733	0.14788	0.31910	0.28429	0.20235	0.31679
0.28383	0.21701	0.30629	-0.07846	-0.11114	-0.09087	1.00000	-0.20824	0.39389	0.35792
-0.05604	0.03345	0.10748	0.21802	-0.02778	0.10268	0.13052	0.02806	-0.00087	

ROW 18

-0.35455	-0.21202	-0.58950	-0.44528	-0.25107	-0.55983	-0.42371	-0.22203	-0.57118	-0.35121
-0.19745	-0.55755	-0.29792	0.51103	0.34379	0.49030	-0.20824	1.00000	-0.36158	-0.59490
0.65409	0.16952	-0.58996	-0.56752	-0.58126	-0.52716	-0.57782	-0.47958	-0.50942	

ROW 19

0.82999	0.74307	0.57817	0.82642	0.72274	0.53547	0.88286	0.76776	0.59630	0.88319
0.78797	0.61404	0.89425	-0.06547	-0.27420	-0.10739	0.39389	-0.36158	1.00000	0.60755
0.10289	0.33779	0.12524	0.19734	0.11071	0.07242	0.08936	-0.09667	0.43346	

ROW 20

0.70158	0.70002	0.23116	0.68464	0.73019	0.18677	0.68157	0.72169	0.20918	0.70461
0.70943	0.27140	0.70037	-0.18714	-0.20370	-0.21693	0.35792	-0.59490	0.60755	1.00000
-0.30866	0.02019	0.41969	0.37144	0.42789	0.38458	0.37354	0.18402	0.04389	

ROW 21

0.05621	0.14496	-0.26425	-0.04889	0.08289	-0.27810	0.00941	0.14682	-0.26317	0.05905
0.17289	-0.28399	0.09183	0.26180	0.10051	0.23498	-0.05604	0.65409	0.10289	-0.30866
1.00000	0.41068	-0.24342	-0.20642	-0.26838	-0.21582	-0.24105	-0.23787	-0.30253	

ROW 22

-0.03540	0.01458	-0.18142	-0.12287	-0.04176	-0.20894	-0.04492	0.00960	-0.12481	0.01684
0.07303	-0.14514	0.07984	0.38410	0.10420	0.35569	0.03345	0.16952	0.33779	0.02019
0.41068	1.00000	-0.26495	-0.13360	-0.46210	-0.18059	-0.19573	-0.19888	-0.08684	

ROW 23

0.22177	0.13422	0.36923	0.27727	0.15853	0.34526	0.24726	0.14064	0.31179	0.19910
0.12930	0.26910	0.18233	-0.63767	-0.39073	-0.73668	0.10748	-0.58996	0.12524	0.41969
-0.24342	-0.26495	1.00000	0.95173	0.90045	0.97259	0.95007	0.89748	0.10408	

ROW 24

0.19247	0.08740	0.42439	0.26078	0.11165	0.39837	0.23939	0.10268	0.36706	0.19773
0.10847	0.32118	0.19680	-0.56198	-0.43024	-0.67569	0.21802	-0.56752	0.19734	0.37144
-0.20642	-0.13360	0.95173	1.00000	0.78928	0.91831	0.89397	0.83357	0.09824	

ROW 25

0.36548	0.29002	0.37834	0.41159	0.31306	0.35983	0.34926	0.27831	0.28524	0.30595
0.25478	0.26189	0.27999	-0.55392	-0.22067	-0.62640	-0.02778	-0.58126	0.11071	0.42789
-0.26838	-0.46210	0.90045	0.78928	1.00000	0.79698	0.77321	0.70013	0.10495	

ROW 26

0.11773	0.04199	0.29059	0.16639	0.06473	0.26696	0.15223	0.05393	0.25559	0.10411
0.04241	0.20889	0.09050	-0.64713	-0.42280	-0.74935	0.10268	-0.52716	0.07242	0.38458
-0.21582	-0.18059	0.97259	0.91831	0.79698	1.00000	0.96904	0.94589	0.07346	

ROW 27

0.11114	0.03557	0.28751	0.16112	0.05732	0.26859	0.15553	0.04586	0.27919	0.09963
0.03319	0.21989	0.07184	-0.68859	-0.44825	-0.78134	0.13052	-0.57782	0.08936	0.37354
-0.24105	-0.19573	0.95007	0.89397	0.77321	0.96904	1.00000	0.95903	0.18176	

ROW 28

-0.10617	-0.17758	0.20075	-0.05111	-0.15895	0.19093	-0.05584	-0.17201	0.20265	-0.11871
-0.18443	0.12978	-0.14484	-0.69365	-0.43887	-0.79977	0.02806	-0.47958	-0.09667	0.18402
-0.23787	-0.19888	0.89748	0.83357	0.70013	0.94589	0.95903	1.00000	0.16498	

ROW 29

0.23183	0.02955	0.75517	0.35555	0.03227	0.77497	0.39276	0.04360	0.84516	0.27518
0.01832	0.80566	0.19696	-0.47498	-0.47758	-0.44571	-0.00087	-0.50942	0.43346	0.04389
-0.30253	-0.08684	0.10408	0.09824	0.10495	0.07346	0.18176	0.16498	1.00000	

EIGENVALUES

12.38673	7.31579	3.63327	1.52941	1.23195	0.88700	0.77393	0.45769	0.20327	0.15438
0.13926	0.10893	0.06794	0.03440	0.03048	0.01884	0.01307	0.00457	0.00350	0.00203
0.00156	0.00086	0.00031	0.00011	0.00008	0.00000	0.00000			

CUMULATIVE PROPORTION OF EIGENVALUES

0.42714	0.67942	0.80470	0.85744	0.89993	0.93051	0.95720	0.97298	0.97999	0.98532
0.99012	0.99388	0.99622	0.99741	0.99846	0.99911	0.99956	0.99971	0.99983	0.99990
0.99996	0.99999	1.00000	1.00000	1.00000	1.00000	1.00000			

EIGENVECTORS

VECTOR 1

0.24842	0.21196	0.20757	0.26292	0.21695	0.19594	0.26418	0.21924	0.19885	0.25220
0.21422	0.20454	0.24249	-0.12817	-0.11785	-0.13284	0.09391	-0.18417	0.23050	0.20831
-0.04884	-0.03894	0.15754	0.15377	0.16811	0.13256	0.13454	0.08027	0.13472	

VECTOR 2

-0.16741	-0.21361	0.09524	-0.12432	-0.20314	0.10450	-0.12996	-0.20867	0.09840	-0.16761
-0.21844	0.06978	-0.18263	-0.24919	-0.17669	-0.27251	-0.03198	-0.15641	-0.14039	-0.05301
-0.14789	-0.12219	0.25185	0.24101	0.18858	0.26738	0.27403	0.31497	0.10091	

VECTOR 3

0.05551	0.15144	-0.30194	-0.01338	0.14891	-0.32285	-0.03086	0.13650	-0.33874	0.01606
0.14271	-0.33599	0.03773	0.00480	0.14629	-0.02893	0.01420	0.03283	-0.09247	0.18845
0.08019	-0.01267	0.22941	0.18155	0.22180	0.23565	0.21353	0.18983	-0.37520	

VECTOR 4

-0.04501	-0.04987	0.00597	-0.08045	-0.09265	-0.00877	0.00246	-0.02450	0.05374	0.01369
0.01192	0.01033	0.04890	0.00365	-0.26187	-0.07425	0.14369	0.23254	0.25619	-0.10614
0.56068	0.57454	0.04319	0.15173	-0.18703	0.12219	0.11331	0.12691	-0.00667	

VECTOR 5

0.08528	0.08733	0.03653	0.09158	0.07549	0.06820	0.06285	0.07203	0.00855	0.03785
0.04591	-0.00652	0.01485	-0.18192	-0.06248	-0.16107	-0.50514	0.36864	-0.15104	-0.35251
0.42497	-0.35275	0.02307	-0.07939	0.18825	-0.01741	-0.03750	0.00133	0.04336	

VECTOR 6

-0.01275	0.00743	-0.07567	-0.02543	0.01180	-0.08320	0.03506	0.06910	-0.05171	0.00969
0.02095	-0.02655	-0.03565	-0.28562	-0.29147	-0.22141	0.67500	0.20297	-0.06869	0.00316
0.07163	-0.42767	-0.11188	-0.10089	-0.17099	-0.08262	-0.04060	-0.04394	-0.08748	

VECTOR 7

0.00478	-0.06623	0.25487	0.03894	-0.06944	0.23002	-0.00643	-0.07274	0.12669	0.00124
-0.04223	0.11805	0.03874	0.32171	0.39220	0.21446	0.37342	0.14833	-0.05566	-0.27621
0.15361	-0.17481	0.16163	0.28303	0.20510	0.06577	-0.02577	-0.05580	-0.27937	

VECTOR 8

0.09751	0.11979	-0.04017	-0.04630	-0.01021	-0.09151	0.03057	0.03528	0.00423	-0.02132
0.01449	-0.10544	-0.10838	-0.32049	0.66177	-0.16813	0.20913	-0.12624	0.06380	-0.24183
0.10578	0.12852	-0.04874	-0.14588	-0.00886	-0.04431	0.10413	0.13569	0.40538	

VECTOR 9

-0.04118	-0.01155	-0.11955	0.00190	0.03287	-0.06142	0.00036	-0.01945	0.03875	0.00826
0.01382	-0.01169	0.12538	0.59574	0.06773	-0.37861	-0.00322	0.38689	0.18281	-0.01495
-0.24297	-0.15953	-0.01312	-0.07756	-0.13295	0.08426	0.17183	0.22902	0.27817	

VECTOR 10

-0.02965	-0.03009	-0.02558	-0.01979	-0.00920	-0.02913	-0.02568	-0.00583	-0.04931	-0.07943
-0.03895	-0.14153	-0.07646	0.41240	-0.15853	-0.22659	0.10684	-0.50146	0.01689	0.08186
0.43811	-0.11713	-0.01737	-0.10402	0.36436	-0.23757	-0.03777	-0.07471	0.17308	

VECTOR 11

0.05143	-0.00903	0.16491	-0.02921	-0.12333	0.17536	-0.00617	0.00429	-0.02356	-0.09459
-0.09355	-0.04098	0.00037	-0.08484	0.22311	-0.64810	-0.06961	0.13334	0.06211	0.28852
-0.05986	0.20093	-0.02587	0.00273	0.09538	-0.02457	-0.32775	-0.22216	-0.32464	

VECTOR 12

-0.01479	-0.04926	0.04198	-0.00190	-0.02680	0.04708	0.04476	-0.01117	0.12903	-0.01379
-0.11799	0.27623	-0.16046	0.03563	0.18718	0.16183	-0.00004	0.13065	-0.20500	0.58065
0.31871	-0.08035	0.00559	-0.43365	-0.04987	0.26037	0.13845	0.11517	0.00996	

VECTOR 13

-0.02864	0.00422	-0.13455	-0.17749	-0.19238	-0.04181	-0.07283	-0.07642	-0.02515	0.02866
0.02488	0.02186	0.05431	-0.14569	-0.07048	0.23173	0.11184	0.39626	0.24937	0.18062
-0.12159	0.07504	0.11649	-0.06095	0.62821	-0.15404	-0.10949	-0.08257	0.27386	

VECTOR 14

0.05895	-0.00093	0.15610	-0.07147	-0.07576	-0.01919	0.03321	0.04560	-0.01120	0.00802
0.02692	-0.04792	0.14812	0.03550	-0.13838	0.01067	0.07894	-0.13512	0.11454	-0.35132
-0.14794	0.10991	0.00155	-0.64046	0.20736	0.32384	-0.14255	0.24812	-0.27767	

VECTOR 15

0.05515	0.06101	-0.00097	0.17107	0.25262	-0.09206	0.08623	0.11843	-0.02825	0.03057
-0.03263	0.18293	-0.22423	0.13504	-0.13288	-0.10419	0.16786	0.14677	-0.63028	-0.12109
-0.14510	0.40484	0.05009	0.01180	0.19148	-0.02302	-0.15060	0.03208	0.16355	

VECTOR 16

-0.20314	-0.31819	0.15334	0.40970	0.32551	0.33177	-0.07930	-0.08624	-0.01943	-0.15289
0.02095	-0.53179	0.10864	-0.09445	-0.00305	0.07880	0.07341	0.12861	-0.02290	0.08280
-0.02082	0.09674	-0.02711	-0.15125	0.05565	-0.03859	0.16884	-0.01910	0.07886	

VECTOR 17

-0.14785	-0.10772	0.02817	0.10142	0.19074	-0.13496	-0.15994	-0.18568	-0.01944	0.06452
0.06089	0.03582	0.15925	-0.05742	0.07145	0.04139	0.00276	-0.05075	0.03519	0.12477
0.11995	-0.10325	-0.02444	0.17308	-0.05461	0.07592	-0.67667	0.48903	0.12245	

VECTOR 18

-0.25005	-0.17699	-0.28862	0.25035	0.37932	-0.15712	0.13307	0.11715	0.08365	-0.13895
-0.27987	0.32368	-0.29415	-0.05756	0.05964	-0.03206	-0.02274	-0.01775	0.42268	-0.12679
-0.01530	-0.01276	-0.01579	-0.01833	0.13441	0.00732	-0.00004	-0.06843	-0.19225	

VECTOR 19

-0.06490	-0.07539	0.14635	0.04671	0.08972	-0.06127	-0.28675	-0.22341	-0.23618	0.22516
0.11649	0.38483	0.19214	-0.06480	0.06241	-0.11258	-0.01617	-0.00450	-0.04264	-0.00298
0.00255	0.07617	-0.19389	-0.09097	0.10331	-0.45959	0.34425	0.22201	-0.23070	

VECTOR 20

-0.12220	-0.13614	-0.54989	0.02316	-0.25791	0.55864	0.17287	0.21446	0.00086	0.16649
0.18327	0.02490	-0.05577	0.00643	0.04545	-0.00684	-0.00082	-0.06000	-0.09395	-0.02418
-0.00951	0.04002	-0.06141	-0.00656	0.00801	-0.15182	-0.06975	0.29018	-0.10598	

VECTOR 21

0.01116	-0.02141	-0.38823	0.10852	0.05461	0.15866	-0.27361	-0.21523	-0.22314	0.02923
-0.05852	0.25059	0.41743	-0.03979	0.03196	-0.08840	0.06298	-0.11222	-0.10040	-0.09592
0.06822	0.01481	0.08089	-0.06188	-0.02327	0.37789	-0.02068	-0.40859	0.15553	

VECTOR 22

-0.40007	-0.51954	0.17195	-0.16710	-0.06468	-0.26141	0.20810	0.25566	-0.04710	0.29996
0.32929	0.04104	0.08720	-0.02168	0.09946	-0.08371	-0.04299	-0.03751	-0.08587	-0.01749
0.01096	-0.01390	0.11322	-0.00780	-0.00068	0.10846	0.00175	-0.24411	0.09241	

VECTOR 23

-0.18596	0.19123	-0.21427	0.00911	0.07377	-0.13489	-0.07768	-0.41726	0.66972	0.20914
0.29184	-0.14052	-0.06526	-0.01855	0.01375	-0.10029	-0.00065	-0.03085	-0.09136	-0.01794
-0.00914	0.04004	0.06602	-0.08622	0.03914	-0.01923	0.02297	-0.12262	-0.16261	

VECTOR 24

0.25035	-0.30252	-0.17321	-0.08715	0.00268	-0.21327	0.21757	0.09230	0.35289	-0.25584
-0.28831	-0.01380	0.55697	-0.05942	0.04085	0.00558	-0.00895	-0.01798	-0.18793	0.02307
0.01937	0.03349	0.07201	0.00708	0.01089	-0.24506	0.03718	0.09131	-0.07208	

VECTOR 25

0.68467	-0.52498	-0.09214	0.03504	0.05425	-0.03210	-0.12374	-0.18302	-0.00140	0.15279
0.19930	-0.01957	-0.32455	0.02532	-0.02346	-0.01482	-0.00725	0.01371	0.10408	-0.01233
-0.01243	-0.02250	0.07928	-0.01715	-0.03298	0.02970	-0.03648	-0.03067	-0.01389	

VECTOR 26

-0.00324	0.00683	-0.00054	0.50544	-0.41647	-0.20797	0.24600	-0.20785	-0.11104	0.46785
-0.41005	-0.14829	0.00133	-0.00021	-0.00009	-0.00077	0.00025	-0.00071	0.00159	-0.00077
0.00015	0.00016	0.04459	-0.01244	-0.01387	-0.01814	-0.00389	0.00055	-0.00133	

VECTOR 27

0.01354	-0.02160	0.00429	0.12127	-0.10351	-0.05728	-0.68273	0.56739	0.28325	0.23802
-0.19637	-0.07559	-0.00728	0.00080	-0.00008	0.00047	-0.00053	0.00103	0.00182	0.00022
-0.00047	-0.00125	-0.02924	0.00946	0.00899	0.01667	0.00075	-0.00358	0.00375	

ERROR BOUNDS FOR EIGENVALUES

0.0001435	0.0001326	0.0000978	0.0000938	0.0001085	0.0000592	0.0000529	0.0000182	0.0000237	0.0000409
0.0000361	0.0000314	0.0000381	0.0000218	0.0000615	0.0000124	0.0000111	0.0000172	0.0000157	0.0000121
0.0000170	0.0000151	0.0000583	0.0000294	0.0000060	0.0000181	0.0000136	0.0000108	0.0000235	

ERROR BOUNDS FOR EIGENVECTORS

0.0000566	0.0000720	0.0000930	0.0006304	0.0007294	0.0010477	0.0009358	0.0001429	0.0009697	0.0054044
0.0047718	0.0020713	0.0022746	0.0111186	0.0313656	0.0042888	0.0038515	0.0322166	0.0293792	0.0512877
0.0721269	0.0544068	0.5858514	2.1083441	0.4274132	26.2166748	19.6783905	9.3527594	20.3988953	

FACTOR MATRIX (27 FACTORS)

VARIABLE 1

0.87431	-0.45280	0.10580	-0.05566	0.09466	-0.01201	0.00420	0.06597	-0.01857	-0.01165
0.01919	-0.00488	-0.00746	0.01093	0.00963	-0.02788	-0.01690	-0.01690	-0.00384	-0.00551
0.00044	-0.01174	-0.00326	0.00261	0.00615	-0.00001	0.00001			

VARIABLE 2

0.74598	-0.57777	0.28866	-0.06167	0.09693	0.00700	-0.05826	0.08104	-0.00521	-0.01182
-0.00337	-0.01626	0.00110	-0.00017	0.01065	-0.04367	-0.01231	-0.01196	-0.00446	-0.00613
-0.00085	-0.01524	0.00335	-0.00315	-0.00471	0.00001	-0.00002			

VARIABLE 3

0.73054	0.25760	-0.57553	0.00738	0.04055	-0.07127	0.22421	-0.02718	-0.05390	-0.01005
0.06154	0.01385	-0.03507	0.02895	-0.00017	0.02105	0.00322	-0.01951	0.00866	-0.02478
-0.01532	0.00505	-0.00376	-0.00180	-0.00083	-0.00000	0.00000			

VARIABLE 4

0.92533	-0.33626	-0.02550	-0.09949	0.10165	-0.02395	0.03426	-0.03132	0.00086	-0.00777
-0.01090	-0.00063	-0.04626	-0.01325	0.02986	0.05623	0.01159	0.01692	0.00276	0.00104
0.00428	-0.00490	0.00016	-0.00091	0.00031	0.00081	0.00013			

VARIABLE 5

0.76356	-0.54946	0.28383	-0.11458	0.08379	0.01111	-0.06109	-0.00691	0.01482	-0.00362
-0.04602	-0.00885	-0.05014	-0.01405	0.04410	0.04468	0.02181	0.02564	0.00531	-0.01162
0.00216	-0.00190	0.00129	0.00003	0.00049	-0.00067	-0.00011			

VARIABLE 6

0.68961	0.28264	-0.61540	-0.01084	0.07570	-0.07836	0.20236	-0.06191	-0.02769	-0.01144
0.06544	0.01554	-0.01090	-0.00356	-0.01607	0.04554	-0.01543	-0.01062	-0.00362	0.02517
0.00626	-0.00767	-0.00237	-0.00222	-0.00029	-0.00033	-0.00006			

VARIABLE 7

0.92979	-0.35151	-0.05882	0.00304	0.06975	0.03302	-0.00565	0.02068	0.00016	-0.01009
-0.00230	0.01477	-0.01898	0.00616	0.01505	-0.01088	-0.01828	0.00899	-0.01696	0.00779
-0.01080	0.00611	-0.00136	0.00227	-0.00111	0.00040	-0.00075			
VARIABLE 8									
0.77160	-0.56441	0.26019	-0.03030	0.07995	0.06508	-0.06399	0.02387	-0.00877	-0.00229
0.00160	-0.00369	-0.01992	0.00846	0.02068	-0.01184	-0.02123	0.00792	-0.01321	0.00966
-0.00850	0.00750	-0.00732	0.00096	-0.00164	-0.00033	0.00062			
VARIABLE 9									
0.69984	0.26615	-0.64568	0.06646	0.00949	-0.04870	0.11145	0.00286	0.01747	-0.01937
-0.00879	0.04258	-0.00656	-0.00208	-0.00493	-0.00267	-0.00222	0.00565	-0.01397	0.00004
-0.00881	-0.00138	0.01174	0.00368	-0.00001	-0.00018	0.00031			
VARIABLE 10									
0.88763	-0.45335	0.03061	0.01694	0.04201	0.00912	0.00109	-0.01442	0.00373	-0.03121
-0.03530	-0.00455	0.00747	0.00149	0.00534	-0.02098	0.00738	-0.00939	0.01332	0.00750
0.00115	0.00880	0.00367	-0.00267	0.00137	0.00075	0.00026			
VARIABLE 11									
0.75393	-0.59083	0.27201	0.01474	0.05096	0.01973	-0.03715	0.00981	0.00623	-0.01530
-0.03491	-0.03894	0.00649	0.00499	-0.00570	0.00288	0.00696	-0.01892	0.00689	0.00826
-0.00231	0.00966	0.00512	-0.00300	0.00179	-0.00066	-0.00022			
VARIABLE 12									
0.71986	0.18874	-0.64043	0.01278	-0.00724	-0.02500	0.10385	-0.07134	-0.00527	-0.05561
-0.01529	0.09117	0.00570	-0.00889	0.03194	-0.07299	0.00409	0.02188	0.02276	0.00112
0.00989	0.00120	-0.00246	-0.00014	-0.00018	-0.00024	-0.00008			
VARIABLE 13									
0.85345	-0.49398	0.07192	0.06047	0.01648	-0.03358	0.03408	-0.07332	0.05653	-0.03004
0.00014	-0.05296	0.01416	0.02747	-0.03915	0.01491	0.01821	-0.01988	0.01137	-0.00251
0.01648	0.00256	-0.00114	0.00580	-0.00291	0.00000	-0.00001			
VARIABLE 14									
-0.45109	-0.67401	0.00916	0.00451	-0.20192	-0.26900	0.28302	-0.21682	0.26859	0.16204
-0.03166	0.01176	-0.03797	0.00658	0.02357	-0.01296	-0.00656	-0.00389	-0.00383	0.00029
-0.00157	-0.00064	-0.00033	-0.00062	0.00023	-0.00000	0.00000			
VARIABLE 15									
-0.41478	-0.47790	0.27885	-0.32386	-0.06935	-0.27450	0.34503	0.44770	0.03054	-0.06229
0.08326	0.06178	-0.01837	-0.02566	-0.02320	-0.00042	0.00817	0.00403	0.00369	0.00205
0.00126	0.00292	0.00024	0.00043	-0.00021	-0.00000	-0.00000			
VARIABLE 16									
-0.46752	-0.73709	-0.05514	-0.09182	-0.17878	-0.20853	0.18866	-0.11375	-0.17069	-0.08903
-0.24186	0.05341	0.06040	0.00198	-0.01819	0.01082	0.00473	-0.00217	-0.00666	-0.00031
-0.00349	-0.00246	-0.00176	0.00006	-0.00013	-0.00000	0.00000			
VARIABLE 17									
0.33052	-0.08649	0.02707	0.17770	-0.56067	0.63572	0.32851	0.14148	-0.00145	0.04198
-0.02598	-0.00001	0.02915	0.01464	0.02930	0.01008	0.00032	-0.00154	-0.00096	-0.00004
0.00249	-0.00126	-0.00001	-0.00009	-0.00007	0.00000	-0.00000			
VARIABLE 18									
-0.64819	-0.42305	0.06258	0.28758	0.40917	0.19115	0.13049	-0.08540	0.17443	-0.19703
0.04976	0.04312	0.10329	-0.02506	0.02562	0.01765	-0.00580	-0.00120	-0.00027	-0.00270
-0.00443	-0.00110	-0.00054	-0.00019	0.00012	-0.00000	0.00000			
VARIABLE 19									

0.81124	-0.37972	-0.17626	0.31683	-0.16765	-0.06469	-0.04897	0.04316	0.08242	0.00664
0.02318	-0.06766	0.06500	0.02124	-0.11003	-0.00314	0.00402	0.02857	-0.00252	-0.00423
-0.00396	-0.00252	-0.00160	-0.00196	0.00093	0.00000	0.00000			
VARIABLE 20									
0.73313	-0.14338	0.35921	-0.13126	-0.39126	0.00298	-0.24299	-0.16361	-0.00674	0.03216
0.10767	0.19164	0.04708	-0.06516	-0.02114	0.01137	0.01426	-0.00857	-0.00018	-0.00109
-0.00379	-0.00051	-0.00031	0.00024	-0.00011	-0.00000	0.00000			
VARIABLE 21									
-0.17188	-0.40000	0.15285	0.69339	0.47169	0.06747	0.13513	0.07157	-0.10954	0.17214
-0.02234	0.10519	-0.03169	-0.02744	-0.02533	-0.00286	0.01371	-0.00103	0.00015	-0.00043
0.00269	0.00032	-0.00016	0.00020	-0.00011	0.00000	-0.00000			
VARIABLE 22									
-0.13705	-0.33049	-0.02415	0.71053	-0.39152	-0.40279	-0.15378	0.08695	-0.07192	-0.04602
0.07498	-0.02652	0.01956	0.02038	0.07068	0.01328	-0.01180	-0.00086	0.00451	0.00180
0.00058	-0.00041	0.00070	0.00035	-0.00020	0.00000	-0.00000			
VARIABLE 23									
0.55445	0.68120	0.43728	0.05341	0.02561	-0.10537	0.14219	-0.03297	-0.00592	-0.00682
-0.00965	0.00185	0.03036	0.00029	0.00874	-0.00372	-0.00279	-0.00107	-0.01147	-0.00277
0.00319	0.00332	0.00116	0.00075	0.00071	0.00007	-0.00003			
VARIABLE 24									
0.54119	0.65188	0.34605	0.18764	-0.08811	-0.09502	0.24899	-0.09869	-0.03497	-0.04087
0.00102	-0.14312	-0.01589	-0.11879	0.00206	-0.02076	0.01979	-0.00124	-0.00538	-0.00030
-0.00244	-0.00023	-0.00151	0.00007	-0.00015	-0.00002	0.00001			
VARIABLE 25									
0.59167	0.51008	0.42278	-0.23130	0.20895	-0.16104	0.18043	-0.00600	-0.05994	0.14316
0.03560	-0.01646	0.16374	0.03846	0.03343	0.00764	-0.00624	0.00908	0.00611	0.00036
-0.00092	-0.00002	0.00069	0.00011	-0.00030	-0.00002	0.00001			
VARIABLE 26									
0.46655	0.72319	0.44918	0.15111	-0.01932	-0.07781	0.05786	-0.02998	0.03799	-0.09335
-0.00917	0.08593	-0.04015	0.06006	-0.00402	-0.00530	0.00868	0.00049	-0.02719	-0.00684
0.01492	0.00318	-0.00034	-0.00255	0.00027	-0.00003	0.00002			
VARIABLE 27									
0.47350	0.74118	0.40702	0.14013	-0.04162	-0.03824	-0.02267	0.07045	0.07747	-0.01484
-0.12231	0.04570	-0.02854	-0.02644	-0.02629	0.02317	-0.07736	-0.00000	0.02036	-0.00314
-0.00082	0.00005	0.00040	0.00039	-0.00033	-0.00001	0.00000			
VARIABLE 28									
0.28252	0.85191	0.36183	0.15694	0.00147	-0.04138	-0.04909	0.09180	0.10326	-0.02936
-0.08290	0.03801	-0.02152	0.04602	0.00560	-0.00262	0.05591	-0.00463	0.01313	0.01307
-0.01613	-0.00716	-0.00215	0.00095	-0.00028	0.00000	-0.00000			
VARIABLE 29									
0.47416	0.27294	-0.71518	-0.00824	0.04813	-0.08239	-0.24577	0.27425	0.12541	0.06801
-0.12115	0.00329	0.07138	-0.05150	0.02855	0.01082	0.01400	-0.01299	-0.01365	-0.00478
0.00614	0.00271	-0.00285	-0.00075	-0.00012	-0.00000	0.00000			

ITERATION CYCLE	VARIANCES
0	0.146480
1	0.460208
2	0.498346

3	0.501713
4	0.502589
5	0.502614
6	0.502614
7	0.502614
8	0.502614
9	0.502614

ROTATED FACTOR MATRIX (27 FACTORS)

VARIABLE 1

0.96682	0.06288	-0.22594	-0.02900	0.00165	0.02715	0.05941	0.03944	-0.01299	0.02688
0.01495	-0.00104	0.02656	0.00359	0.00820	-0.01283	-0.00636	-0.03118	-0.00758	-0.00450
-0.00200	-0.01467	-0.00164	0.00097	0.01116	-0.00000	0.00001			

VARIABLE 2

0.99344	0.00682	0.02852	-0.01585	0.02433	0.01164	0.07473	0.04100	0.01929	0.01827
0.01014	-0.00096	0.01791	-0.00219	0.00734	-0.02923	-0.00331	-0.03505	-0.00604	-0.00346
-0.00650	-0.02221	0.00166	-0.00117	-0.00155	-0.00002	0.00004			

VARIABLE 3

0.24727	0.20952	-0.93085	-0.05894	-0.05973	0.05619	-0.02784	0.00446	-0.10943	0.03783
0.00577	-0.02490	0.03023	-0.00395	0.00165	0.03144	0.00613	0.00340	0.00403	-0.03460
0.01113	-0.00024	-0.00340	-0.00002	0.00043	-0.00015	0.00011			

VARIABLE 4

0.90640	0.09730	-0.38689	-0.09119	-0.05006	0.00367	-0.00938	-0.01503	-0.03126	0.02681
-0.01042	0.00144	0.00260	-0.01406	0.03810	0.03523	-0.00336	0.05721	0.00152	0.00659
0.00154	-0.00063	-0.00249	0.00002	0.00046	0.00086	-0.00011			

VARIABLE 5

0.99234	0.02181	0.01690	-0.06575	-0.02861	-0.00055	0.01800	-0.01585	0.00906	0.02813
-0.01873	0.00505	-0.01498	-0.00417	0.05246	0.01563	0.00394	0.06436	0.00124	-0.00536
-0.00159	-0.00210	0.00162	-0.00007	0.00028	-0.00062	0.00011			

VARIABLE 6

0.19655	0.18782	-0.94657	-0.08709	-0.06226	0.01018	-0.05724	-0.00538	-0.09382	0.00802
0.01175	-0.00642	0.03627	-0.02537	-0.01294	0.05292	-0.01574	0.00894	0.00102	0.02601
0.00737	0.00282	-0.00931	0.00025	0.00052	-0.00032	0.00024			

VARIABLE 7

0.90526	0.07792	-0.40389	-0.01732	-0.00163	0.07326	-0.04273	0.03964	0.00614	0.01654
0.01812	0.00984	-0.00263	0.01191	0.01071	-0.00760	-0.00928	-0.00714	-0.00964	0.00485
-0.02804	0.00524	0.00194	0.00540	-0.00094	0.00001	-0.00100			

VARIABLE 8

0.99564	0.00738	-0.00194	-0.02060	0.03264	0.05740	-0.00110	0.03250	-0.00732	0.01878
0.01727	0.01308	0.00668	0.01240	0.02041	-0.00953	-0.01247	-0.00833	-0.00894	0.00530
-0.02617	0.00705	-0.00404	0.00716	-0.00080	-0.00017	0.00064			

VARIABLE 9

0.20568	0.17023	-0.95272	-0.00069	-0.06706	0.06184	-0.09857	0.03047	0.02888	0.00287
0.00912	-0.00193	-0.01971	0.00415	-0.01440	0.00066	0.00185	-0.00080	-0.00487	0.00192
-0.01496	-0.00245	0.01307	-0.00097	-0.00102	-0.00012	0.00008			

VARIABLE 10

0.95230	0.03798	-0.28686	0.02204	0.00369	0.07188	-0.03463	-0.00617	-0.00206	-0.00674
-0.03642	0.00152	0.00248	-0.00698	-0.00458	-0.01936	0.00575	-0.01441	0.00955	0.00081
0.00971	0.01023	0.00147	-0.00644	-0.00327	0.00090	0.00011			

VARIABLE 11

0.99530	0.00308	0.01510	0.03716	0.04342	0.05832	0.00778	-0.01325	0.00338	0.00090
-0.02782	-0.01446	0.01045	-0.01166	-0.01411	0.01045	0.00336	-0.01200	0.01045	-0.00088
0.01152	0.01170	0.00239	-0.00755	-0.00371	-0.00066	0.00016			

VARIABLE 12

0.26817	0.10967	-0.93233	-0.03201	-0.10595	0.06568	-0.12865	0.01665	-0.01555	-0.02340
-0.03796	0.04385	-0.02054	0.00984	0.02391	-0.08840	0.00880	-0.01241	0.00143	0.00503
-0.00093	0.00027	-0.00191	0.00018	0.00024	-0.00002	0.00007			

VARIABLE 13

0.95505	0.02941	-0.23467	0.07456	0.01308	0.06427	-0.04002	-0.09603	-0.04470	-0.03892
-0.01621	-0.02306	0.01264	-0.01191	-0.06418	0.02434	0.01534	-0.00355	0.00309	-0.00201
0.03949	0.00539	-0.00081	0.00323	-0.00065	-0.00003	-0.00017			

VARIABLE 14

0.00746	-0.60275	0.32194	0.20185	0.05985	-0.01273	0.21239	-0.65986	-0.05251	-0.02351
-0.06727	0.00301	0.00274	-0.00371	-0.00181	0.00045	0.00032	0.00026	-0.00008	0.00004
0.00035	0.00014	0.00002	-0.00012	-0.00004	0.00001	-0.00001			

VARIABLE 15

0.00794	-0.34124	0.44154	-0.00431	-0.02608	-0.03747	0.82019	-0.10823	-0.01394	-0.00022
-0.03766	-0.01477	0.00723	0.00091	0.00194	0.00005	0.00013	-0.00015	-0.00011	-0.00002
-0.00003	-0.00014	0.00004	-0.00003	-0.00004	-0.00001	-0.00000			

VARIABLE 16

0.02639	-0.72550	0.31821	0.17644	0.01599	-0.02447	0.23642	-0.24091	-0.09824	0.00987
-0.46447	-0.01079	0.00574	-0.00557	0.00364	-0.00042	-0.00010	0.00017	-0.00024	-0.00002
0.00017	0.00018	0.00001	-0.00004	0.00001	0.00000	0.00000			

VARIABLE 17

0.23090	0.06195	-0.08327	0.03194	-0.04473	0.96537	-0.02356	0.00417	-0.01048	0.00660
0.00259	0.00945	-0.00501	-0.00161	-0.00145	-0.00034	-0.00022	-0.00016	-0.00006	0.00001
-0.00001	0.00003	-0.00011	0.00003	-0.00006	0.00000	0.00000			

VARIABLE 18

-0.22401	-0.47492	0.41593	-0.04223	0.58644	-0.06405	0.00383	-0.07939	-0.05011	-0.43530
0.01114	-0.04429	-0.03092	0.00167	-0.00172	-0.00048	0.00080	-0.00034	0.00006	0.00009
0.00022	-0.00001	-0.00002	0.00003	0.00001	-0.00001	-0.00000			

VARIABLE 19

0.77195	0.00552	-0.43504	0.36336	0.02536	0.17298	-0.09599	-0.04037	0.07342	-0.01411
0.05341	-0.00836	0.00212	-0.01467	-0.18036	0.00291	-0.00134	-0.00227	0.00012	0.00007
-0.00026	-0.00009	0.00011	-0.00019	0.00002	0.00000	0.00000			

VARIABLE 20

0.72345	0.30221	0.04364	0.11550	-0.42231	0.15043	-0.15470	-0.01832	-0.04136	0.07267
0.01985	0.37013	0.01263	0.01262	0.00141	-0.00098	-0.00050	-0.00003	-0.00026	0.00012
-0.00022	0.00003	-0.00006	0.00001	0.00005	-0.00000	0.00000			

VARIABLE 21

0.12376	-0.15449	0.21036	0.21676	0.93064	-0.02470	-0.02808	-0.00967	-0.00875	0.04107
-0.00443	0.00866	0.00373	0.00098	-0.00036	0.00014	-0.00014	-0.00056	0.00021	0.00001
-0.00001	-0.00012	0.00010	0.00002	-0.00017	-0.00000	-0.00001			

VARIABLE 22

0.02662	-0.17250	0.09221	0.96364	0.16344	0.02336	0.00714	-0.06560	0.00070	0.00723
-0.02368	0.00854	-0.00395	-0.00038	0.00354	-0.00013	0.00030	-0.00036	0.00007	-0.00016
0.00031	0.00030	0.00019	0.00020	-0.00014	-0.00000	-0.00001			

VARIABLE 23

0.13351	0.97154	-0.12164	-0.08175	-0.07387	0.00490	-0.01423	-0.00736	-0.06630	0.01967
-0.02947	0.01561	0.06639	-0.02105	0.00359	0.00158	0.00427	-0.00545	-0.01230	-0.00042
-0.00271	0.00125	0.00163	0.00027	0.00059	0.00004	-0.00011			

VARIABLE 24

0.09701	0.92269	-0.19166	0.04211	-0.04850	0.12116	-0.05042	-0.07538	-0.15420	0.01091
-0.05385	-0.06967	0.02481	-0.20732	-0.00961	0.00137	0.00481	0.00080	-0.00036	0.00006
0.00054	0.00004	-0.00015	-0.00006	-0.00001	-0.00002	0.00002			

VARIABLE 25

0.27525	0.81557	-0.11678	-0.31218	-0.09761	-0.14828	0.11228	-0.02079	-0.05278	0.09938
-0.01944	0.02380	0.29936	-0.00972	-0.00093	0.00122	0.00132	-0.00031	-0.00000	-0.00013
0.00021	-0.00006	-0.00008	-0.00000	0.00003	0.00000	0.00002			

VARIABLE 26

0.04550	0.98168	-0.07000	0.00568	-0.06095	0.02059	-0.06671	0.03109	-0.06232	-0.03595
-0.00702	0.05041	-0.05911	0.08098	0.00877	-0.00249	0.03098	-0.00297	-0.02792	0.00077
-0.00221	-0.00117	-0.00192	0.00008	0.00005	-0.00000	0.00009			

VARIABLE 27

0.03525	0.96825	-0.08680	-0.00518	-0.08263	0.05160	-0.08534	0.06859	0.12138	0.02734
-0.00137	0.02383	-0.07981	0.03068	-0.00489	0.00813	-0.09304	0.00065	0.00188	0.00064
-0.00111	0.00001	-0.00027	0.00007	0.00002	-0.00001	-0.00000			

VARIABLE 28

-0.18063	0.95293	-0.05891	-0.00705	-0.05804	0.00212	-0.08895	0.09751	0.13039	-0.00562
0.05268	-0.00542	-0.06867	0.07401	0.00118	-0.00849	0.05301	0.00972	0.04284	-0.00174
0.00604	0.00128	-0.00072	-0.00017	-0.00018	-0.00000	0.00001			

VARIABLE 29

0.04659	0.02304	-0.83722	0.03761	-0.14708	-0.09260	-0.09046	0.21245	0.43992	0.04986
0.11873	-0.02854	-0.01632	0.00965	-0.00595	-0.00006	-0.00096	-0.00018	-0.00026	-0.00011
-0.00037	-0.00014	0.00002	-0.00001	-0.00005	-0.00002	0.00001			

CHECK ON COMMUNALITIES

VARIABLE	ORIGINAL	FINAL	DIFFERENCE
1	0.99994	0.99991	0.00003
2	0.99993	0.99991	0.00002
3	0.99993	0.99990	0.00003
4	0.99994	0.99991	0.00003
5	0.99993	0.99991	0.00002
6	0.99993	0.99990	0.00003
7	0.99994	0.99991	0.00003
8	0.99994	0.99991	0.00002
9	0.99993	0.99990	0.00003
10	0.99994	0.99992	0.00003
11	0.99994	0.99992	0.00002
12	0.99993	0.99990	0.00003
13	0.99995	0.99992	0.00003
14	0.99994	0.99989	0.00004
15	0.99993	0.99989	0.00004
16	0.99993	0.99989	0.00004
17	0.99993	0.99990	0.00003
18	0.99993	0.99988	0.00004
19	0.99994	0.99990	0.00003
20	0.99994	0.99990	0.00004
21	0.99992	0.99988	0.00004

22	0.99992	0.99989	0.00003
23	0.99994	0.99991	0.00003
24	0.99993	0.99990	0.00003
25	0.99993	0.99989	0.00004
26	0.99994	0.99991	0.00003
27	0.99994	0.99990	0.00003
28	0.99994	0.99991	0.00003
29	0.99994	0.99990	0.00004

THE PERCENTAGE OF THE TOTAL VARIANCE OF THE ORIGINAL STANDARDIZED VARIABLES WHICH IS ACCOUNTED FOR IN THE FACTOR SPACE IS 100.0

REGRESSION EQUATIONS FOR COMPUTING FACTOR SCORES

0.07219	0.17069	-0.02652	0.07970	0.17242	0.0	-0.20511	0.36826	0.0	0.07372
0.15848	0.0	0.10647	-0.00187	-0.01834	-0.01392	-0.04961	0.00603	0.06006	-0.00386
-0.03349	-0.00681	0.24045	-0.12154	-0.16050	-0.16493	-0.03642	0.01447	-0.01966	
0.02025	-0.01505	-0.03105	-0.05409	0.06013	0.0	-0.11079	-0.02963	0.0	-0.07170
0.06033	0.0	0.01572	0.03269	0.05494	-0.03043	-0.01256	0.02238	-0.01308	-0.03526
0.04616	0.03225	0.29179	0.13872	-0.00822	0.05037	0.21568	0.20395	-0.00218	
0.07991	-0.04028	-0.28488	-0.78101	0.64307	0.0	-0.43188	0.45117	0.0	-0.87964
0.84662	0.0	0.05431	-0.03116	-0.10455	-0.00995	0.02166	-0.02367	-0.02177	0.00604
-0.08414	-0.01363	-0.55664	0.20638	0.22806	0.27488	0.07788	0.01042	-0.12364	
0.09328	-0.11034	-0.02130	-0.19333	0.07823	0.0	0.47359	-0.33003	0.0	-0.16884
0.20608	0.0	0.02307	-0.10016	0.02217	-0.03235	-0.03302	0.01478	-0.04851	0.00028
-0.19801	1.12481	-1.33105	0.37016	0.44963	0.54715	0.15401	-0.00334	-0.02327	
0.00620	-0.06622	0.05339	0.04562	-0.09991	0.0	0.31030	-0.25706	0.0	0.11455
-0.12645	0.0	0.00220	0.01102	0.07936	0.01570	0.04489	0.11492	-0.04308	0.00505
1.09472	-0.22589	-0.42519	0.17365	0.16879	0.24411	0.08470	0.02290	0.07993	
-0.01212	-0.03719	-0.01271	-0.07245	0.00972	0.0	-0.00105	-0.03841	0.0	-0.09666
0.04399	0.0	-0.02174	0.00874	0.01242	0.01508	1.06727	0.02012	-0.02592	-0.02145
0.03662	-0.03471	-0.17839	0.03415	0.07495	0.05930	0.00956	-0.00924	0.02849	
-0.04706	-0.00124	0.14020	0.36888	-0.32385	0.0	0.19328	-0.19946	0.0	0.43932
-0.45932	0.0	-0.02098	-0.16946	1.38310	-0.07488	0.02011	0.03649	0.02332	0.04855
0.12001	0.03849	0.39445	-0.03437	-0.11432	-0.07157	0.02282	0.05626	0.07852	
-0.01422	0.01343	-0.02679	-0.01070	0.04578	0.0	-0.18872	0.13599	0.0	-0.03674
0.03429	0.0	-0.00110	-1.76923	0.33701	0.18130	-0.01923	0.06467	0.05563	0.03909
-0.05022	0.30533	0.22244	-0.19792	-0.17181	-0.30557	-0.19101	-0.14577	-0.16934	
-0.01303	0.02863	-0.42448	-0.98486	0.84869	0.0	-1.28345	1.04907	0.0	-1.25620
1.11394	0.0	-0.01054	0.56915	-0.12368	0.54657	0.34506	0.35671	-0.05872	0.23341
0.24023	-0.36977	0.63940	0.13022	0.08499	-0.02654	0.08539	0.16385	2.44150	

0.02828	-0.10487	-0.10400	-0.35498	0.21394	0.0	-0.12573	0.08643	0.0	-0.31487
0.23486	0.0	0.00584	0.25749	-0.09853	-0.14877	-0.10077	-2.38535	-0.01879	-0.30617
1.26761	-0.48918	-0.58669	0.00831	-0.16367	0.06459	-0.08503	-0.12123	-0.36517	
0.04572	-0.02252	0.01071	0.00021	0.03636	0.0	0.05162	0.00981	0.0	0.10396
-0.02798	0.0	0.01562	0.60637	0.38500	-2.40857	-0.07780	-0.19403	-0.02202	-0.08900
-0.13870	0.32770	-0.41187	-0.14163	-0.07265	-0.21359	-0.23720	-0.26451	-0.48566	
-0.28907	-0.22332	0.23942	0.45096	-0.76489	0.0	0.12724	-0.59070	0.0	0.43788
-0.93064	0.0	-0.24496	-0.16342	0.69624	0.25767	-0.24026	0.60383	-0.05602	2.88005
1.20183	-0.61234	0.65952	-0.03003	-0.32574	-0.37925	-0.15213	-0.07917	0.57092	
-0.15842	0.02742	-0.05449	0.00717	0.01503	0.0	-1.01799	0.61995	0.0	0.01584
-0.18970	0.0	-0.18793	-0.18030	-0.64891	0.01432	0.70028	0.72080	0.10091	-0.18240
-0.51666	1.19035	1.02413	-0.96177	2.84328	-1.14523	-0.62505	-0.48724	0.31840	
0.14230	-0.03024	0.23445	0.55887	-0.44688	0.0	1.69815	-1.26285	0.0	0.57310
-0.33685	0.0	0.16750	0.27442	-0.43454	0.02464	0.41281	-0.38802	0.20676	-1.24400
-0.52203	0.68515	-1.00744	-3.83030	1.27257	1.82009	0.90925	0.86334	-1.67235	
0.60412	0.45636	0.22086	0.98704	-0.25617	0.0	1.44470	-0.36914	0.0	0.41384
0.70544	0.0	0.35230	0.75290	-0.52123	-0.53521	0.80442	0.43513	-5.58346	0.04335
-0.27724	2.10050	-1.08292	0.57175	0.31780	0.27359	0.06326	-0.02834	1.18888	
-0.02536	1.34770	2.27674	10.51530	-10.27223	0.0	5.12517	-3.09556	0.0	-27.80121
24.82422	0.0	-0.14471	0.31948	-0.85211	1.50692	0.35356	0.92740	-1.85664	1.52595
-0.24989	0.00582	1.91804	-0.49861	-1.66717	-0.02443	-0.95509	1.16922	1.74444	
-0.00556	0.24859	-0.43675	-0.00717	-0.15646	0.0	-0.21755	0.45263	0.0	-4.42096
3.90921	0.0	-0.11521	0.25320	-0.09346	0.90007	0.22420	-0.52481	0.15404	0.60571
0.68951	-1.05270	2.30533	1.08576	-1.45187	3.11372	-7.99403	3.24147	2.29206	
-2.38597	-3.44337	-1.16840	-0.18010	12.17865	0.0	-3.72487	-0.77833	0.0	9.08600
-12.01273	0.0	-1.59580	-1.21335	0.74341	-0.64052	0.24750	0.14597	4.25171	-1.00413
0.21711	0.29124	-1.53169	-0.40945	1.88266	0.68227	0.51811	-1.18462	-1.34780	
1.05171	1.55669	1.72724	6.48324	-7.50906	0.0	6.38090	-2.93779	0.0	-0.94007
1.45645	0.0	-1.66828	-0.16651	0.06522	0.94988	-0.75642	1.28469	-0.66195	1.89542
-0.80698	1.00258	-6.00656	0.72807	1.74429	-12.85294	2.55054	14.14331	-5.87979	
0.27973	1.84016	-18.72362	33.47461	-27.41634	0.0	8.69985	-9.20554	0.0	5.99319
-5.60386	0.0	3.25682	-0.46437	0.57868	-0.82449	0.94973	-2.23624	-2.09246	-1.67023
0.40069	1.21242	4.09678	-2.18706	-1.02162	-1.50518	-2.02501	1.74904	-2.35797	
-0.31155	-0.23501	-3.18059	-3.67038	3.51379	0.0	-7.87424	-5.08703	0.0	14.67192
-14.82066	0.0	18.86780	-1.99484	1.35329	-2.25749	0.96409	-1.98754	-6.81715	-0.27040
1.70799	1.22496	-0.45810	-1.50892	0.32026	0.13366	2.90469	-3.80095	1.02761	

3.64147	-32.24710	-0.09271	-20.34119	10.09042	0.0	1.62492	13.68811	0.0	16.67035
5.44177	0.0	1.67473	-0.74603	3.37977	-2.38472	-1.63263	-1.22291	-2.25328	-0.57170
0.26876	-0.47861	5.62040	-0.41356	-0.85400	-0.44498	-0.66093	-4.05860	1.81474	
4.19171	-7.07571	-17.96086	-52.20502	42.24194	0.0	136.03285	-118.81073	0.0	-31.33025
23.85272	0.0	25.27940	-3.86004	2.75322	-4.01271	-0.63237	-1.94524	-14.83328	0.96982
0.51176	3.56608	-13.84796	1.98320	8.85872	-5.98815	5.27845	-0.95804	-11.53463	
-12.80019	1.32217	-2.40107	-32.18195	15.16525	0.0	46.04953	10.35435	0.0	-23.21570
-47.83936	0.0	58.22420	-5.00917	3.64468	4.16964	-0.20915	-1.05087	-16.41324	2.84299
2.21488	2.49503	-6.39455	5.30277	3.23445	-16.22427	4.31281	11.49642	-0.16918	
80.76552	-60.14397	-12.84580	-17.43996	20.08327	0.0	4.90721	-17.85847	0.0	-3.17453
4.31166	0.0	-10.05247	0.71019	-1.77684	0.93163	-0.63485	1.45739	4.75599	0.13819
-0.38718	-1.43669	3.38940	1.30542	-1.78994	-4.04492	-1.88269	3.24173	-1.91963	
5.43824	-7.34354	-2.12888	-13.30058	4.36546	0.0	28.51631	-18.78526	0.0	-12.25775
16.03757	0.0	1.87304	0.17861	0.03177	1.40572	0.37009	0.92817	-5.71616	1.87447
0.11487	0.38015	-107.37512	28.70490	33.24991	42.83047	10.93032	-1.26232	1.08614	
4.78634	-6.22551	2.20323	-5.36386	-0.57241	0.0	1.93889	2.12723	0.0	-5.40226
12.22506	0.0	-4.39195	0.90510	-0.48855	1.61445	0.28609	1.21148	-1.78743	1.38861
-0.08483	-0.42936	-84.34357	22.85645	25.41504	36.15402	7.90405	-1.60452	2.83226	

FACTOR SCORES ON ROTATED FACTORS

SUBJECT 1

-1.94836	4.23197	1.19204	0.21736	0.12526	0.13083	-0.39595	0.43787	0.70171	-0.12899
0.29055	-0.02780	-0.70894	0.45010	0.00770	-0.00782	0.52146	0.11744	0.32787	-0.01469
0.04704	0.01814	-0.00215	-0.06076	-0.01497	0.00332	0.00598			

SUBJECT 2

-0.43094	-0.46306	-4.20216	0.50086	-0.08356	-0.54531	-0.49937	1.28519	2.70557	0.26096
0.55258	-0.12938	-0.90011	0.36707	0.10359	-0.46229	0.01154	0.14902	0.14767	0.26290
-0.67112	-0.37202	0.14656	0.10408	0.05127	0.00600	-0.04634			

SUBJECT 3

1.66895	-0.26562	-0.03424	0.36849	0.01530	4.90682	-0.47860	0.41194	0.32877	0.18239
-0.09315	0.30442	-0.33670	-0.59181	-0.52207	-0.35482	-0.14241	-0.20248	0.18839	-0.16519
-0.59320	0.03829	-0.36248	0.06754	0.53134	-0.07489	0.01100			

SUBJECT 4

0.40769	0.52150	-2.82124	-0.41607	0.32570	0.09488	0.54153	-1.57583	-3.02919	0.15360
-0.21319	-0.64254	0.38119	-0.53443	-0.40492	2.19161	-0.15491	0.54664	0.05217	-0.14654
0.38737	0.32265	-0.09206	-0.27579	-0.14348	-0.01125	0.02666			

SUBJECT 5

2.24131	-0.09168	0.00180	-1.54206	-0.27070	-0.90410	0.29280	0.73394	-1.66717	0.66673
0.29153	0.89408	-0.62371	1.64400	1.99182	-2.14897	-0.10033	-0.28266	-0.48472	0.44344
-1.49993	-0.69719	-0.04345	0.72832	0.04696	0.05734	-0.03729			

SUBJECT 6

0.32435	0.32122	0.15838	-0.97357	-0.39081	-0.38327	1.71641	1.04535	1.26350	1.17680
0.18707	0.23149	3.98642	-1.13874	-0.14435	0.38463	-0.70169	-0.76478	0.39143	-0.65350

-0.00175	-0.36429	0.11268	0.70490	0.46557	-0.31236	-0.23635			
SUBJECT 7									
0.48085	-0.01115	-0.10351	2.14975	-1.10869	-0.55057	-0.34604	-0.92540	-0.38190	0.26049
0.33132	-1.49080	0.87046	-0.12910	-1.22924	-2.19880	0.39643	-0.07223	-0.77100	0.22914
-0.09988	1.68790	-1.43527	0.45087	0.20076	0.47100	0.58597			
SUBJECT 8									
2.90588	-0.27795	1.00236	-0.65831	-0.66914	-0.91881	-0.70686	0.20707	1.85862	-0.05585
-0.43369	-0.22560	-0.80654	0.03756	0.19991	1.94108	-0.61322	1.99757	-0.17520	0.16066
0.61940	1.11527	-0.34445	-1.33400	-0.13632	0.11239	0.21596			
SUBJECT 9									
-0.24890	0.15305	0.38103	1.52688	-0.14012	-0.23460	1.26433	0.76086	-0.37990	-0.24624
0.06660	0.03656	-0.42935	-2.91143	1.68948	-0.32461	-0.52676	1.98098	-1.22112	1.23819
0.24403	-0.37548	1.35347	0.46934	0.69541	0.20815	-0.12368			
SUBJECT 10									
0.02783	-0.28798	0.37201	0.75073	-0.36485	-0.23466	-0.18138	0.35071	-0.25006	-1.16958
-0.13477	-1.21262	0.90077	1.00502	0.90733	0.67938	-0.52530	-0.48972	2.61440	0.58330
-1.66663	0.04488	-0.36837	-1.54560	0.08738	0.20997	0.21177			
SUBJECT 11									
-0.84985	-0.08012	0.12764	-1.24906	0.73031	0.05727	1.21426	-2.32670	1.10049	1.53547
-0.72383	1.19566	0.11179	0.89626	-1.09151	-0.58663	0.82114	1.28628	-1.26601	0.23971
-1.11328	0.80818	0.03620	-0.83104	0.07707	-0.02010	0.03708			
SUBJECT 12									
0.48180	-0.20987	0.26604	2.75519	-0.61183	-0.50718	-0.77665	-1.07373	-0.39392	-0.25077
0.54197	1.98697	0.80980	1.08214	-0.63811	-0.21301	-0.37105	1.72274	1.17983	-1.16899
-0.16130	-1.12031	0.87820	0.61842	-0.27102	-0.49105	-0.51384			
SUBJECT 13									
0.90554	-0.08030	0.45135	1.14803	-0.70157	-0.54309	0.52775	-0.16138	0.20568	-0.02155
0.84448	0.75696	-0.31350	0.16935	-1.67103	1.09004	0.11165	-2.49011	-1.98446	1.27861
0.05270	-2.14677	0.13949	-1.50050	-0.83334	0.25738	0.14422			
SUBJECT 14									
0.29475	-0.25820	0.22335	0.00586	0.43534	-0.30938	-0.02134	-0.36526	-0.06668	1.96891
-0.96721	0.81079	-0.77564	-0.23064	-0.62782	-0.29788	1.28090	-0.14283	2.35322	1.05161
1.26358	0.00002	1.10957	0.39638	1.39561	0.09120	-0.21288			
SUBJECT 15									
-0.71481	-0.32854	0.08856	-2.21362	-0.32399	-0.04894	-1.01208	0.63524	-0.70686	-0.89427
2.05491	0.38482	0.44063	-0.77072	-1.72409	-1.23609	-0.15276	1.46460	1.12028	1.51810
1.30675	-1.04175	-1.40823	-0.48340	-0.32024	0.44326	0.38021			
SUBJECT 16									
-0.21071	0.10029	-0.55230	-0.56536	-0.28598	-0.35127	-1.32320	-0.91015	0.24014	-2.55721
-2.70556	1.99276	0.47797	-1.26476	0.46118	-0.93594	-0.41243	-1.59705	-0.17242	0.94773
0.46112	0.77298	0.36787	-0.19116	-0.09021	-0.14870	-0.23119			
SUBJECT 17									
0.74309	-0.04745	0.25145	-0.32405	1.10572	-0.35832	0.25592	-0.24526	0.26732	-0.02124
-1.05683	-1.65326	-0.54433	-1.67929	-0.27724	-1.32045	1.26844	0.04834	0.81265	-2.01817
-0.24113	-1.42831	0.62849	-0.52885	-3.14928	-0.00587	0.01277			
SUBJECT 18									
-0.49184	-0.05688	0.20369	-0.32538	1.23934	-0.02945	-0.11326	-2.03513	0.67642	-1.17038
1.30130	0.25131	-0.34260	-0.60590	1.59102	0.41472	-0.33734	0.26595	-0.50454	-1.31755

-0.66936	-1.61686	-1.78216	-0.03251	1.45805	-0.05928	0.29041			
SUBJECT 19									
0.12080	-0.38918	0.14312	0.07721	-0.87073	-0.32604	0.00757	0.61947	-0.16091	0.50671
0.91628	1.30978	-1.25220	-0.79408	0.52307	1.13491	1.48302	-1.15763	-0.00669	-1.24123
1.23834	0.84304	-1.77519	1.83305	-0.56200	-0.14027	0.19076			
SUBJECT 20									
-0.88155	0.13847	0.38862	-0.47148	-0.76116	-0.07629	-0.51148	-0.66534	0.08073	1.45330
-0.89406	-0.75782	-1.13053	0.12073	-0.48710	-0.29476	-4.29731	-0.51605	-0.03010	-0.73397
0.47777	-0.14513	-0.32339	1.02322	-0.54286	0.07749	0.09397			
SUBJECT 21									
-0.51993	-0.36708	-0.31847	-0.34616	-0.68738	0.86278	-0.78642	0.24472	-0.22137	-0.07389
0.10621	-0.64073	0.89994	1.91278	1.28605	-0.50140	0.37457	0.09793	-1.28181	-1.46871
3.05837	-0.72824	1.74634	-0.89823	0.29664	0.00450	-0.15003			
SUBJECT 22									
-0.39019	-0.32310	0.33321	-0.71828	-0.49477	-0.11715	-0.26200	-0.59870	0.21095	-0.33914
0.39311	0.57509	-0.24772	0.00450	0.03459	1.05925	0.53236	-0.92942	1.15139	-1.05089
-0.77780	0.17369	1.25582	0.65908	0.54509	0.57711	0.36304			
SUBJECT 23									
-0.29355	-0.21554	0.25096	-0.41433	-0.68668	-0.20811	-0.94279	0.30045	-0.07404	-0.54275
0.25539	-0.43028	0.96670	-0.22821	0.12932	-0.31536	0.94188	0.13534	-1.13386	-1.38236
-0.82299	1.94314	-0.22933	-0.35459	0.38380	-0.01197	0.21826			
SUBJECT 24									
-0.84599	-0.17746	0.42511	-0.21110	-0.82728	-0.06917	-1.06454	-0.40146	-0.57889	1.59448
0.37053	-1.47633	-0.57023	-1.11327	0.50630	0.01175	0.50898	-1.03001	-0.07828	0.49349
-1.17045	-0.66561	0.65677	-1.00022	1.61808	-0.40728	-0.39760			
SUBJECT 25									
-0.59536	-0.27759	0.16362	0.25432	-0.84493	-0.09198	1.03493	0.01929	-0.09015	-0.07884
0.07033	-0.33159	-0.56106	0.51588	0.63694	0.46594	0.18043	-0.28817	0.58380	0.57768
0.05747	0.98344	-0.35793	1.14546	-1.14475	-0.21136	-0.19195			
SUBJECT 26									
-1.02014	-0.31767	0.30760	-0.39827	-0.66524	0.01575	-0.08874	2.10721	-0.89604	-0.77978
-2.40190	-0.23273	-0.14927	0.78873	-1.63185	1.12444	0.68644	1.31369	-1.12328	-0.37844
-1.43370	-1.41567	-0.40343	1.28933	0.58221	-0.06582	0.01081			
SUBJECT 27									
-0.99673	-0.19326	0.14481	-0.18151	-0.61965	1.53558	1.67767	-0.84119	0.41900	-0.56311
0.37684	-0.12681	0.41847	1.02248	1.27792	0.38198	0.19158	0.33333	0.06949	1.74987
-0.12694	0.16105	0.20138	0.55832	-2.13812	0.28829	0.04571			
SUBJECT 28									
-0.62132	-0.31619	0.30300	-0.36541	-0.74167	-0.08048	0.16523	0.59325	-0.52843	-0.05155
0.74354	-0.30915	-0.74261	-0.06345	-0.22022	0.20271	0.03456	0.00260	-0.14032	0.12886
0.02470	1.38329	1.07703	-1.45248	-0.30761	-0.80002	-0.72422			
SUBJECT 29									
1.16062	-0.11056	0.43903	-0.15417	1.65128	-0.37988	0.16244	-0.81762	0.81133	-1.41117
-0.04879	-2.43765	0.00509	1.00679	-0.64405	0.13856	0.47795	-0.51427	-0.24526	1.19496
1.08558	-0.27747	0.35960	2.29142	1.27859	-0.35600	-0.49522			
SUBJECT 30									
-0.17354	-0.04042	-0.08539	0.73369	1.06481	-0.13989	2.97536	1.16998	-0.44010	-0.71751
-0.78634	0.39149	-0.95006	0.62168	-0.33191	-0.93247	-0.53960	-0.45681	0.61859	-1.10347

1.12551	0.46121	-1.35493	-1.84003	1.41563	0.15996	0.42890			

SUBJECT 31

0.05366	-0.11768	0.23303	-0.00553	2.91168	-0.14347	-0.42892	1.12365	-0.61530	-0.54517
1.78112	0.69122	-0.11333	0.03039	-1.07610	0.16593	-1.16468	-0.47819	-0.55170	-0.34734
-0.87873	1.66016	1.87290	0.47758	-0.55276	-0.14897	-0.32318			

SUBJECT 32

-0.58342	-0.16196	0.26544	1.04528	2.54606	-0.05251	-1.89633	0.89663	-0.38885	1.85882
-1.01744	0.31208	1.22912	0.38037	1.37436	0.74474	0.21694	-0.04994	-0.44000	1.09172
0.47574	-0.02392	-1.66498	-0.48928	-0.92118	0.29832	0.41139			

MEANS OF THE FACTORS

-0.00000	-0.00000	-0.00000	-0.00000	0.00000	0.00000	0.00001	-0.00001
0.00001	-0.00001	-0.00003	0.00001	-0.00000	0.00000	-0.00003	0.00001
0.00002	0.00000	0.00001	-0.00003	-0.00008	-0.00005	-0.00017	-0.00004
0.00004	0.00002	0.00003					

STANDARD DEVIATIONS OF THE FACTORS

0.99226	0.80052	0.98878	0.99850	0.99744	1.00011	0.99955	0.99982
0.99827	0.99994	1.00013	0.99979	0.99882	0.99988	1.00006	1.00082
0.99980	0.99993	1.00010	0.99804	1.00021	1.00676	0.98600	1.00034
0.99710	0.28552	0.30033					

CORRELATIONS OF THE FACTORS

ROW 1

1.00000	-0.32513	0.02183	0.02534	0.01714	0.00211	-0.00031	0.00244	0.02165	-0.00596
0.00714	-0.00456	-0.02453	0.00475	-0.00234	-0.00031	-0.00148	0.00163	0.00301	0.00036
0.00027	0.00016	-0.00062	0.00015	-0.00030	-0.00109	0.00061			

ROW 2

-0.32513	1.00000	0.18259	0.03740	0.06644	-0.01019	0.01750	-0.00997	0.03936	-0.00649
-0.00391	-0.01987	-0.03593	-0.02272	-0.00111	0.00377	-0.00810	0.00341	0.01263	-0.00185
0.00913	-0.00127	-0.00134	-0.00146	0.00108	-0.00153	0.00009			

ROW 3

0.02183	0.18259	1.00000	-0.01203	-0.01357	0.00242	-0.00266	-0.00010	-0.01212	0.00268
-0.00314	0.00230	0.01155	-0.00261	-0.00057	-0.00073	0.00108	-0.00106	-0.00194	0.00009
-0.00081	0.00018	0.00049	0.00041	0.00010	-0.00686	0.00465			

ROW 4

0.02534	0.03740	-0.01203	1.00000	-0.00360	0.00118	-0.00077	-0.00030	-0.00184	0.00084
0.00009	0.00035	0.00348	-0.00056	-0.00017	-0.00020	0.00012	-0.00033	-0.00041	0.00002
-0.00054	0.00006	-0.00009	-0.00003	-0.00025	0.00312	0.00217			

ROW 5

0.01714	0.06644	-0.01357	-0.00360	1.00000	0.00139	-0.00159	-0.00021	-0.00396	0.00087
-0.00088	0.00098	0.00352	-0.00086	-0.00033	-0.00021	0.00067	-0.00029	-0.00092	-0.00009
-0.00043	0.00007	-0.00018	0.00006	-0.00026	0.00310	0.00006			

ROW 6

0.00211	-0.01019	0.00242	0.00118	0.00139	1.00000	0.00014	-0.00010	0.00162	-0.00024
0.00025	-0.00043	-0.00118	-0.00026	-0.00001	0.00009	-0.00015	-0.00004	0.00023	0.00003
0.00005	-0.00023	-0.00017	0.00008	-0.00019	0.00010	0.00052			

ROW 7

-0.00031	0.01750	-0.00266	-0.00077	-0.00159	0.00014	1.00000	0.00050	-0.00107	0.00015
-0.00015	0.00058	0.00079	0.00075	-0.00005	-0.00005	0.00008	0.00005	-0.00038	-0.00016
-0.00018	0.00016	-0.00026	0.00021	0.00002	0.00421	-0.00164			

ROW 8

0.00244	-0.00997	-0.00010	-0.00030	-0.00021	-0.00010	0.00050	1.00000	-0.00006	0.00014
0.00012	-0.00013	0.00016	-0.00035	-0.00003	-0.00004	0.00003	-0.00006	-0.00004	0.00013
0.00011	0.00023	0.00060	0.00022	0.00003	-0.00399	-0.00197			

ROW 9

0.02165	0.03936	-0.01212	-0.00184	-0.00396	0.00162	-0.00107	-0.00006	1.00000	0.00065
-0.00041	0.00055	0.00277	-0.00059	-0.00019	-0.00013	0.00050	-0.00051	-0.00046	0.00060
-0.00044	0.00022	0.00056	0.00025	-0.00002	-0.01280	0.00624			

ROW 10

-0.00596	-0.00649	0.00268	0.00084	0.00087	-0.00024	0.00015	0.00014	0.00065	1.00000
-0.00008	-0.00004	-0.00039	-0.00002	-0.00006	0.00010	-0.00008	0.00006	0.00024	0.00013
0.00008	-0.00008	-0.00056	-0.00019	0.00006	-0.00356	0.00077			

ROW 11

0.00714	-0.00391	-0.00314	0.00009	-0.00088	0.00025	-0.00015	0.00012	-0.00041	-0.00008
1.00000	0.00014	0.00001	0.00053	0.00009	-0.00011	0.00019	-0.00005	-0.00018	-0.00005
-0.00023	0.00008	0.00008	-0.00014	-0.00003	0.00451	0.00318			

ROW 12

-0.00456	-0.01987	0.00230	0.00035	0.00098	-0.00043	0.00058	-0.00013	0.00055	-0.00004
0.00014	1.00000	-0.00051	-0.00033	-0.00008	-0.00010	-0.00005	0.00006	0.00017	0.00007
0.00039	-0.00008	0.00009	0.00063	-0.00014	0.00405	-0.00497			

ROW 13

-0.02453	-0.03593	0.01155	0.00348	0.00352	-0.00118	0.00079	0.00016	0.00277	-0.00039
0.00001	-0.00051	1.00000	0.00040	-0.00023	0.00026	-0.00060	0.00041	0.00046	0.00002
0.00052	-0.00017	0.00038	0.00009	-0.00002	-0.00108	0.00282			

ROW 14

0.00475	-0.02272	-0.00261	-0.00056	-0.00086	-0.00026	0.00075	-0.00035	-0.00059	-0.00002
0.00053	-0.00033	0.00040	1.00000	-0.00015	-0.00001	0.00016	-0.00026	0.00013	-0.00030
-0.00009	-0.00019	-0.00035	-0.00015	-0.00013	0.00457	-0.00912			

ROW 15

-0.00234	-0.00111	-0.00057	-0.00017	-0.00033	-0.00001	-0.00005	-0.00003	-0.00019	-0.00006
0.00009	-0.00008	-0.00023	-0.00015	1.00000	0.00016	0.00016	-0.00010	0.00030	0.00034
-0.00004	-0.00112	0.00102	-0.00001	0.00104	0.00932	-0.00114			

ROW 16

-0.00031	0.00377	-0.00073	-0.00020	-0.00021	0.00009	-0.00005	-0.00004	-0.00013	0.00010
-0.00011	-0.00010	0.00026	-0.00001	0.00016	1.00000	0.00018	-0.00096	0.00050	0.00383
-0.00005	-0.00131	-0.00300	-0.00039	-0.00706	-0.09505	-0.03318			

ROW 17

-0.00148	-0.00810	0.00108	0.00012	0.00067	-0.00015	0.00008	0.00003	0.00050	-0.00008
0.00019	-0.00005	-0.00060	0.00016	0.00016	0.00018	1.00000	0.00004	-0.00055	0.00053
0.00018	-0.00008	0.00032	-0.00050	-0.00108	-0.00924	0.01221			

ROW 18

0.00163	0.00341	-0.00106	-0.00033	-0.00029	-0.00004	0.00005	-0.00006	-0.00051	0.00006
-0.00005	0.00006	0.00041	-0.00026	-0.00010	-0.00096	0.00004	1.00000	-0.00036	-0.00216
-0.00028	-0.00015	-0.00030	-0.00118	0.00462	0.03582	0.01812			

ROW 19

0.00301	0.01263	-0.00194	-0.00041	-0.00092	0.00023	-0.00038	-0.00004	-0.00046	0.00024
-0.00018	0.00017	0.00046	0.00013	0.00030	0.00050	-0.00055	-0.00036	1.00000	-0.00056
0.00007	-0.00225	-0.00081	0.00068	-0.00207	0.04171	-0.02330			

```
ROW 20
   0.00036    -0.00185     0.00009     0.00002    -0.00009     0.00003    -0.00016     0.00013     0.00060     0.00013
  -0.00005     0.00007     0.00002    -0.00030     0.00034     0.00383     0.00053    -0.00216    -0.00056     1.00000
  -0.00167    -0.00385    -0.00641    -0.00359     0.00146     0.20000    -0.08801

ROW 21
   0.00027     0.00913    -0.00081    -0.00054    -0.00043     0.00005    -0.00018     0.00011    -0.00044     0.00008
  -0.00023     0.00039     0.00052    -0.00009    -0.00004    -0.00005     0.00018    -0.00028     0.00007    -0.00167
   1.00000    -0.00050     0.00118     0.00061     0.00497     0.05234    -0.00463

ROW 22
   0.00016    -0.00127     0.00018     0.00006     0.00007    -0.00023     0.00016     0.00023     0.00022    -0.00008
   0.00008    -0.00008    -0.00017    -0.00019    -0.00112    -0.00131    -0.00008    -0.00015    -0.00225    -0.00385
  -0.00050     1.00000    -0.00583     0.00005     0.00246    -0.06912     0.02735

ROW 23
  -0.00062    -0.00134     0.00049    -0.00009    -0.00018    -0.00017    -0.00026     0.00060     0.00056    -0.00056
   0.00008     0.00009     0.00038    -0.00035     0.00102    -0.00300     0.00032    -0.00030    -0.00081    -0.00641
   0.00118    -0.00583     1.00000    -0.00316    -0.02011    -0.28885    -0.67946

ROW 24
   0.00015    -0.00146     0.00041    -0.00003     0.00006     0.00008     0.00021     0.00022     0.00025    -0.00019
  -0.00014     0.00063     0.00009    -0.00015    -0.00001    -0.00039    -0.00050    -0.00118     0.00068    -0.00359
   0.00061     0.00005    -0.00316     1.00000     0.00733    -0.09976    -0.18123

ROW 25
  -0.00030     0.00108     0.00010    -0.00025    -0.00026    -0.00019     0.00002     0.00003    -0.00002     0.00006
  -0.00003    -0.00014    -0.00002    -0.00013     0.00104    -0.00706    -0.00108     0.00462    -0.00207     0.00146
   0.00497     0.00246    -0.02011     0.00733     1.00000    -0.11209    -0.05645

ROW 26
  -0.00109    -0.00153    -0.00686     0.00312     0.00310     0.00010     0.00421    -0.00399    -0.01280    -0.00356
   0.00451     0.00405    -0.00108     0.00457     0.00932    -0.09505    -0.00924     0.03582     0.04171     0.20000
   0.05234    -0.06912    -0.28885    -0.09976    -0.11209     1.00000     0.84306

ROW 27
   0.00061     0.00009     0.00465     0.00217     0.00006     0.00052    -0.00164    -0.00197     0.00624     0.00077
   0.00318    -0.00497     0.00282    -0.00912    -0.00114    -0.03318     0.01221     0.01812    -0.02330    -0.08801
  -0.00463     0.02735    -0.67946    -0.18123    -0.05645     0.84306     1.00000

 STOP      0
EXECUTION TERMINATED


$SIG
```

APPENDIX G

MULTIPLE REGRESSION OUTPUTS OF MODEL II

```
$SIGNON PLAK TIME=5M PAGES=50 COPIES=7 PRIO=V
**LAST SIGNON WAS: 16:12:38   03-25-70
 USER "PLAK" SIGNED ON AT  16:14:23 ON 03-25-70
$RUN *TRIP 4=*SOURCE*
EXECUTION BEGINS
TRIP/360 IMPLEMENTATION 3/18/70
```

```
     0  0  0  1  1  1  2  2 2 2 33  3  4  5  5  6  6  7  7  8
     1  6  9  2  5  8  1  4 6 8 01  5  0  5  0  5  0  5  0  5  0
CONTROL
CARDS

 1. INMSDC  3        5  1  1 1 1
 2. STPREG  2  1               1   233
 3. STPREG  2     5  6              33
 4. PARCOR        6
 5. END
```

NOTE: OUTDATED *INVR* OR *MULREG* ROUTINES HAVE BEEN REPLACED BY THE EQUIVALENT *STPREG*

CONTROL CARD NO. 1 * INMSDC *

FORMAT CARDS
(F10.5/F10.7,30X,F10.7)

INPUT DATA

TRIPGN	FACTO1	FACTO5
-1.127	-1.948	0.1253
0.4870	-0.4309	-0.8356D-01
2.584	1.669	0.1530D-01
1.221	0.4077	0.3257
1.782	2.241	-0.2707
0.3360	0.3243	-0.3908
0.5620	0.4808	-1.109
2.026	2.906	-0.6691
-0.2790	-0.2489	-0.1401
-0.3290	0.2783D-01	-0.3648
-0.9910	-0.8498	0.7303
0.5010	0.4818	-0.6118
1.196	0.9055	-0.7016
-0.6000D-01	0.2947	0.4353
-0.8510	-0.7148	-0.3240
0.4630	-0.2107	-0.2860
0.8700	0.7431	1.106
-0.6870	-0.4918	1.239
-0.1300D-01	0.1208	-0.8707
-0.9440	-0.8815	-0.7612
-0.3980	-0.5199	-0.6874
-0.5020	-0.3902	-0.4948
-0.4110	-0.2935	-0.6867
-0.9390	-0.8460	-0.8273
-0.5730	-0.5954	-0.8449
-1.156	-1.020	-0.6652
-1.040	-0.9967	-0.6196
-0.8380	-0.6213	-0.7417
1.145	1.161	1.651
-0.7490	-0.1735	1.065
-0.4360	0.5366D-01	2.912
-0.8510	-0.5834	2.546

32 OBSERVATIONS
31 DEGREES OF FREEDOM

NAME	MEAN	S.D.
TRIPGN	-0.3125D-04	0.9999
FACTO1	-0.3125D-06	0.9923
FACTO5	0.2188D-05	0.9974

CORRELATION MATRIX

VARIABLE	TRIPGN	FACTO1	FACTO5
TRIPGN	1.0000		
FACTO1	0.9078	1.0000	
FACTO5	-0.0431	0.0171	1.0000

ARRAY WRITTEN IN AREA 5

CONTROL CARD NO. 2 * STPREG *

DEPENDENT VARIABLE IS TRIPGN

RSQ = 0.8275
FPROB. = 0.0000
STD ERR Y = 0.4294

VAR	COEFF	STD ERR	F-RATIO	FPROB.
CONST.	-0.3084D-04	0.0759		
FACT01	0.9157	0.0777	138.7819	0.0000
FACT05	-0.0588	0.0773	0.5786	0.4590

NO.	OBSERVED	CALCULATED	RESIDUAL	NO.	OBSERVED	CALCULATED	RESIDUAL
1.	-1.1270	-1.7916	0.66459				
2.	0.48700	-0.38974	0.87674				
3.	2.5840	1.5274	1.0566				
4.	1.2210	0.35415	0.86685				
5.	1.7820	2.0683	-0.28634				
6.	0.33600	0.31998	0.16023E-01				
7.	0.56200	0.50552	0.56483E-01				
8.	2.0260	2.7004	-0.67435				
9.	-0.27900	-0.21972	-0.59284E-01				
10.	-0.32900	0.46916E-01	-0.37592				
11.	-0.99100	-0.82123	-0.16977				
12.	0.50100	0.47716	0.23839E-01				
13.	1.1960	0.87047	0.32553				
14.	-0.60000E-01	0.24427	-0.30427				
15.	-0.85100	-0.63555	-0.21545				
16.	0.46300	-0.17616	0.63916				
17.	0.87000	0.61540	0.25460				
18.	-0.68700	-0.52333	-0.16367				
19.	-0.13000E-01	0.16181	-0.17481				
20.	-0.94400	-0.76253	-0.18147				
21.	-0.39800	-0.43572	0.37717E-01				
22.	-0.50200	-0.32824	-0.17376				
23.	-0.41100	-0.22845	-0.18255				
24.	-0.93900	-0.72607	-0.21293				
25.	-0.57300	-0.49552	-0.77477E-01				
26.	-1.1560	-0.89508	-0.26092				
27.	-1.0400	-0.87632	-0.16368				
28.	-0.83800	-0.52537	-0.31263				
29.	1.1450	0.96566	0.17934				
30.	-0.74900	-0.22158	-0.52742				
31.	-0.43600	-0.12216	-0.31384				
32.	-0.85100	-0.68406	-0.16694				

CONTROL CARD NO. 3 * STPREG *

ARRAY RESTORED FROM AREA 5

ARRAY WRITTEN IN AREA 6

CONTROL CARD NO. 4 * PARCOR *

ARRAY RESTORED FROM AREA 6

PARTIAL CORRELATIONS

VARIABLE	TRIPGN	FACT01	FACT05
TRIPGN	1.000		
FACT01	0.9095	-1.000	
FACT05	-0.1399	0.1714D-01	-1.000

* END OF CONTROL SET *

STOP 0
EXECUTION TERMINATED

```
$SIGNON PLAK TIME=5M PAGES=50 COPIES=36 PRIO=V
**LAST SIGNON WAS: 16:04:29   03-25-70
 USER "PLAK" SIGNED ON AT  16:10:27 ON 03-25-70
$RUN *TRIP 4=*SOURCE*
EXECUTION BEGINS
TRIP/360 IMPLEMENTATION 3/18/70
```

APPENDIX H

MULTIPLE REGRESSION OUTPUTS OF MODEL III

```
$SIGNON PLAK TIME=5M PAGES=50 COPIES=7 PRIO=V
**LAST SIGNON WAS: 16:10:27   03-25-70
 USER "PLAK" SIGNED ON AT  16:12:38 ON 03-25-70
$RUN *TRIP 4=*SOURCE*
EXECUTION BEGINS
TRIP/360 IMPLEMENTATION 3/18/70
```

```
 0    0  0  1  1  1  2  2  2  2  3 3    3    4    4    5    5    6    6    7    7    8
 1    6  9  2  5  8  1  4  6  8  0 1    5    0    5    0    5    0    5    0    5    0
```

CONTROL
CARDS

```
1. INMSDC   5                1   1  1  1
2. STPREG   4   1                       1    23333
3. END
```

NOTE: OUTDATED *INVR* OR *MULREG* ROUTINES HAVE BEEN REPLACED BY THE EQUIVALENT *STPREG*

CONTROL CARD NO. 1 * INMSDC *

FORMAT CARDS
(F10.5/3F10.7,20X,F10.7)

INPUT DATA

TRIPGN	SIZE	EMPLOY	DENSI	STUD
-1.127	-1.948	4.232	1.192	0.1308
0.4870	-0.4309	-0.4631	-4.202	-0.5453
2.584	1.669	-0.2656	-0.3424D-01	4.907
1.221	0.4077	0.5215	-2.821	0.9488D-01
1.782	2.241	-0.9168D-01	0.1800D-02	-0.9041
0.3360	0.3243	0.3212	0.1584	-0.3833
0.5620	0.4808	-0.1115D-01	-0.1035	-0.5506
2.026	2.906	-0.2779	1.002	-0.9188
-0.2790	-0.2489	0.1530	0.3810	-0.2346
-0.3290	0.2783D-01	-0.2880	0.3720	-0.2347
-0.9910	-0.8498	-0.8012D-01	0.1276	0.5727D-01
0.5010	0.4818	-0.2099	0.2660	-0.5072
1.196	0.9055	-0.8030D-01	0.4513	-0.5431
-0.6000D-01	0.2947	-0.2582	0.2233	-0.3094
-0.8510	-0.7148	-0.3285	0.8856D-01	-0.4894D-01
0.4630	-0.2107	0.1003	-0.5523	-0.3513
0.8700	0.7431	-0.4745D-01	0.2514	-0.3583
-0.6870	-0.4918	-0.5688D-01	0.2037	-0.2945D-01
-0.1300D-01	0.1208	-0.3892	0.1431	-0.3260
-0.9440	-0.8815	0.1385	0.3886	-0.7629D-01
-0.3980	-0.5199	-0.3671	-0.3185	0.8628
-0.5020	-0.3902	-0.3231	0.3332	-0.1171
-0.4110	-0.2935	-0.2155	0.2510	-0.2081
-0.9390	-0.8460	-0.1775	0.4251	-0.6917D-01
-0.5730	-0.5954	-0.2776	0.1636	-0.9198D-01
-1.156	-1.020	-0.3177	0.3076	0.1575D-01
-1.040	-0.9967	-0.1933	0.1448	1.536
-0.8380	-0.6213	-0.3162	0.3030	-0.8048D-01
1.145	1.161	-0.1106	0.4390	-0.3799
-0.7490	-0.1735	-0.4042D-01	-0.8539D-01	-0.1399
-0.4360	0.5366D-01	-0.1177	0.2330	-0.1435
-0.8510	-0.5834	-0.1620	0.2654	-0.5251D-01

32 OBSERVATIONS
31 DEGREES OF FREEDOM

NAME	MEAN	S.D.
TRIPGN	-0.3125D-04	0.9999
SIZE	-0.3125D-06	0.9923
EMPLOY	0.3125D-06	0.8005
DENSI	-0.1875D-05	0.9888
STUD	-0.3125D-06	1.000

CORRELATION MATRIX

VARIABLE	TRIPGN	SIZE	EMPLOY	DENSI	STUD
TRIPGN	1.0000				
SIZE	0.9078	1.0000			
EMPLOY	-0.1562	-0.3251	1.0000		
DENSI	-0.2078	0.0218	0.1826	1.0000	
STUD	0.1769	0.0021	-0.0102	0.0024	1.0000

CONTROL CARD NO. 2 * STPREG *

DEPENDENT VARIABLE IS TRIPGN

RSQ = 0.9460
FPROB. = 0.0000
STD ERR Y = 0.2489

VAR	COEFF	STD ERR	F-RATIO	FPROB.
CONST.	-0.3148D-04	0.0440		
SIZE	0.9904	0.0478	429.0756	0.0000
EMPLOY	0.2675	0.0603	19.7063	0.0002
DENSI	-0.2718	0.0462	34.6809	0.0000
STUD	0.1776	0.0447	15.7943	0.0005