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## ANNUAL SHELF

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The Demand for Non Urban
Outdoor Recreation in Texas:
1968-2000

Volume II
by
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Texas Agricultural Experiment Station
Texas A\&M University

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THE DEMAND FOR NON URBAN
OUTDOOR RECREATION IN TEXAS:
1968-2000
VOLUME II
GRAVITY MODEL ESTIMATION
FOR
TEXAS OUTDOOR RECREATION
by
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Texas A\&M University

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to the
Texas Parks and Wildlife Department

## 1. Introduction

A simple "gravity" model ${ }^{1 /}$ for estimating the flow of travel for a particular outdoor recreation activity among geographical regions can be written as follows:

$$
Y_{i j}=\frac{k A_{j} P_{i}}{B_{i} d_{i j}^{2}}
$$

where
$y_{i j}=$ no. of days of activity participation by individuals in (origin) region $i$ spent in (destination) region $j$,
$k=$ constant,
$P_{i}=$ population in origin region $i$,
$A_{j}=$ "attraction" of region $j$ for participators in the activity,
$B_{i}=$ "availability" in region $i$ for participators in the activity, and $d_{i j}=$ distance from region $i$ to region $j$.
It should be noted that this model is intended to describe the gravitational attraction of one body (the destination region $f$ ) on an originating body (region i). The $B_{i}$ and $P_{i}$ are the gravitational pull of the originating body while $A_{j}$ is the gravitational pull of the destination body; $d_{i j}^{2}$ in the denominator illustrates the pull of gravity which is proportional to the square of the distance.

1/For a more comprehensive statement and bibliography see "Operations Research in Outdoor Recreation" by Frank J. Cesario, Jr., Journal of Leisure Research, Vol I, No. 1, Winter 1969, pp. 33-52.

The simple gravity model as stated above can easily be generalized to allow for wider applications. Specifically in the estimation of recreation participation the following generalizations have been implemented in this model:

1. An allowance for several components of attraction. Each component is given a weight to indicate its relative importance.
2. The provision for several components of availability, likewise with provisions for different degrees of importance.
3. Provisions for an exponent different from " 2 " for distance since the desire to travel a certain distance for recreation does not necessarily diminish by the square of the distance.
4. The use of more than one aspect of origin population for determining the magnitude of flow from an origin.

The more general model as used in this application can be written as follows:
where the $\beta, \gamma$, $\delta$ are coefficients indicating the importance of attraction population, and availability variables and $\alpha$ is the "distance decay" coefficient.

It is of interest to note that the coefficients of this model are elasticities. That is, each coefficient indicates the percent change in participation associated with a one percent change in the relevant variable: attraction, population, etc.

Thirty-Seven Regions of Texas


Given a set of sample data points on participation at specific origin destination combinations and observed values of the $A_{j}, P_{i}$, and $d_{i j}$, estimates of the coefficients for the gravity model can be estimated by least squares using the log-linear model:

$$
\begin{aligned}
\log y_{i j} & =\log k+\beta_{1} \log A_{l j}+\ldots \\
& +\beta_{p} \log A_{p j}+\gamma_{1} \log P_{1 i}+\ldots+\gamma_{q} \log P_{q i} \\
& +\delta_{1} \log B_{l i}+\ldots+\delta_{r} \log B_{r i}+\alpha \log d_{i j} .
\end{aligned}
$$

For this particular study the recreation participation flows are estimated for seven major outdoor activities as follows:

1. Boating for pleasure in rural environments only.
2. Outdoor camping in rural environments only.
3. Fresh water fishing in rural environments only.
4. Fresh and salt water fishing rural environments only.
5. Hunting, all types, in rural environment only.
6. Picnicking in rural environments only.
7. Swimming, fresh and salt water, in rural environments only.

The recreational participation flows are studied for a 37 region subdivision of the state of Texas. A map of the 37 regions is given in Figure 1. Recreational flows from and to other states are not included in this study.

After obtaining a set of suitable equation estirates, recreation flow projections are obtained for specific future conditions by applying these equations to projection data provided by TP\&W. Finally, these projections except for fresh and salt water fishing are compared to TP\&W estimates of regional capacities for cther activities.

## 2. Data Specifications

In this section are specified the variables to be used in this attempt to estimate a gravity model for outdoor recreation in Texas.
2.1. Activity participation - The variable to be analyzed and subsequently estimated for planning and policy purposes is the number of "people days" of participation for each of the activities in each of the 37 regions on trips whose total length is one, (not including overnight), two or three, and four or more days duration by individuals residing in each of the 37 aforementioned regions. The number of days of activity participation are obtained directly from the 1968 household survey using expansion factors appropriate for each region. It should be noted that the distinction between trips and vacations as specified in the schedule are not adhered to since for this type of analysis the total duration of the trip is seen to be of greater importance than the fact that annual leave may or may not have been used for the particular trip or vacation.
2.2 Demographic and socio-economic characteristics - Previous studies have indicated that socio-economic characteristics of individual households have a relatively small effect on the recreation participation of families. Since this particular model uses regional aggregations of data, the potential effects of such factors will be further dampened. Therefore, the only characteristics of the originating regions used in this model are:

1. The total region population according to the 1970 census,
2. Percent of the population of the region living in cities of 10,000 population or greater, and
3. The per capita buying power in dollars as obtained from the survey of buying power, 1969. This was used since recent regional data on income were not available during the estimation phase of this project. 2.3. The potential attraction of regions - Attraction is the pulling power of a particular region for individuals who want to participate in recreation activity. Attraction includes:
4. Environmental characteristics of the region, and
5. Facilities available for recreation.

Data on environment was obtained by Texas Parks and Wildife staff from general descriptions of counties within a region as obtainable in any standard reference on Texas counties and by special measurement from large scale maps. Data on facilities available for recreation were obtained from the 1969 T.P.\& W. inventory of recreational facilities. In Table 1 are given the 50 environment and facility variables used in this estimation of the model.
2.4. Availability - This factor is intended to indicate the attraction for an activity in and near the originating region. Often it is defined as a sum of "distance decayed" attractions for each region. Using the same notation as in section 1 , it can be defined:

$$
B_{i}=\sum_{j=1}^{37} d_{i j}^{\alpha} A_{j}
$$

Since $\alpha$ is a quantity to be estimated, a preliminary estimate is usually used to compute availability.

Preliminary studies indicated that this availability quantity tended to measure total statewide rather than local recreation availability hence its use did not provide the desired results. For this reason availability was defined simply to be origin attraction. A further modification of the use of the

TABLE 1
REGIONAL ATTRACTION VARIABLES

| $\begin{gathered} \hline \text { Variable } \\ \text { No. } \\ \hline \end{gathered}$ | Content | Scale |
| :---: | :---: | :---: |
| 1 | Miles River | 100 |
| 2 | Growing Season | 2 |
| 3 | Relief | 2 |
| 4 | Annual Rainfall | 2 |
| 5 | Acres of Hill Country | 100,000 |
| 6 | Acres of Piney Woods | 100,000 |
| 7 | Growing Season, Ratio of Destination to Origin | 1 |
| 8 | Mileage of Ocean Frontage | 1 |
| 9 | Mileage of Bay Frontage | 10 |
| 10 | Freshwater Boat Ramps | 1 |
| 11 | Saltwater Boat Ramps | 1 |
| 12 | Acres of Freshwater Lakes | 10;000 |
| 13 | Number of Freshwater Lakes | 1 |
| 14 | Miles Accessible Ocean Frontage | 1 |
| 15 | Miles Accessible Bay Frontage | 10 |
| 16 | Freshwater Slips and Stalls | 100 |
| 17 | Saltwater Slips and Stalls | 10 |
| 18 | Inland Campsites | 1,000 |
| 19 | Campsites on a Bay | 10 |
| 20 | Campsites on the Ocean | 10 |
| 21 | Fishing Quality Index | 1 |
| 22 | Yards of Freshwater Fishing | 100 |
| 23 | Yards of Bay Fishing | 100 |
| 24 | Yards of Ocean Fishing | 100 |
| 25 | Deer Index | 10 |
| 26 | Acres in Region | 1,000,000 |
| 27 | Leased Hunting Acres | 1,000,000 |
| 28 | Wildife Management Acres | 10,000 |
| 29 | Inland Picnic Sites | 1,000 |
| 30 | Bay Picnic Sites | 10 |
| 31 | Ocean Picnic Sites | 10 |
| 32 | Yards of Swimming Pools | 1,000 |
| 33 | Yards of Freshwater Swimming | 10,000 |
| 34 | Yards of Bay Swimming | 1 |
| 35 | Yards of Ocean Swimming | 100 |
| 36 | Population Density | 100 |
| 37 | Waterfowl Rating | 1 |
| 38 | Quail Rating | 1 |
| 39 | Dove Rating | 1 |
| 40 | Turkey Rating | 1 |
| 41 | Squirrel Rating | 1 |
| 42 | Javelin Rating |  |
| 43 | Total No. Deer | 10 |

Continued

| Variable No. | Content | Scale |
| :---: | :---: | :---: |
| 44 | Total Small Game Index | 1 |
| 45 | Proportional Total Region Leased for Hunting | 1 |
| 46 | All Yards Swimming | 1,000 |
| 47 | All Yards Fishing | 100 |
| 48 | All Campsites | 10 |
| 49 | All Picnic Sites | 10 |
| 50 | Al1 Boatramps | 1 |

availability variable is given in Section 3.3.
2.5. Distance - A preliminary estimate of distance between centers of each pair of regions was computed by obtaining airline distances between the major population centers of the region and adding a 15 percent adjustment to obtain estimates of road mileage. This estimate was updated for each activity by obtaining, where available, the average distance traveled among origin - destination combinations obtained from household survey data. *

## 3. Estimation

As previously indicated, the coefficients for the gravity model were estimated by using least squares on the logarithms of all variables. Obviously it was impossible to use all variables in the estimation process; a concensus of the various individuals involved in this project, personal opinions, examination of some simple correlations, and actual experimentation with various variable combinations were used to obtain a reasonably sized set of variables. A "stepdown" or "backward elimination" selection procedure was then used to delete; from each equation, variables which did not contribute materially to the estimating power of the equation. The final equation to be used for projections was chosen on the basis of statistical significances (not necessarily 5\%), a "logical" subset of factors, and a minimum of "incorrect" coefficient signs. In addition it was found necessary to make some revisions and/or redefinitions of variables so as to make the model more reasonable. These are discussed in the following sections.
3.1. Participation - The 37 by 37 matrix of origins and destinations provides a possible 1,369 pairs of origins and destinations; this includes within region trips. Obviously, for any one activity and length of trip, only a relatively small number of these pairs actually show recreation participation. For some activities, the number of non-zero pairs is as little as 100 while.
for others it may be over 500. The question remains how should the model estimation use the information from those origin destination pairs from which there was no participation. If none of these zero participation pairs are used, the model estimates may not reflect the reason for the absence of participation. On the other hand, the use of all combinations with zero participation will tend to dilute the effect of the non-zero participation data on the estimation procedure.

The solution used in this estimation procedure was to say that any origin-destination combination less than 100,200 and 300 miles for one day, two or three day, or four and over day trips, respectively, was a "relevant" zero and data from such combinations were used in the estimation prodedure. All other origin-distination combinations with no participation were ignored. The computational procedure used to accomplish this was to define each "relevant zero participation combination" as having had 50 people days (a number sufficiently small to be able to be missed by the sampling procedure) and then to eliminate data from all pairs having actual zeroes in the estimation procedure.

A limited number of estimation runs were made using this scheme as well as the schemes where all or no zeroes were omitted. A comparison of the results of these runs indicated that this particular method of handling zero participation did result in better estimates of participation rates.
3.2. Distance - Distance is, of course, used to estimate the distance decay coefficient. This coefficient indicates how much recreation participation decreases as the distance from the origin increases. This would, for example, mean that with a unity distance decay coefficient, participation at a distance of 20 miles would be one-half that of 10 miles. It is intuitive that participation does not drop off that rapidly for low mileage trips. In other words, a family is normally indifferent, even in one day trips, among
trips of 10,20 or possibly even 30 miles. On longer trips, this range of indifference may be even wider. To reflect this phenomenon all distances (as obtained in the previous section) were modified so that the minimum distance for 1 , 2 or 3 , and 4 or longer day trips were defined as being 20, 40 and 60 miles, respectively. These specific minimum values were obtained by preliminary studies and, in addition, have the advantage of appearing to be quite reasonable.
3.3. Availability - The basic gravity model implies that availability depresses recreational travel. The basic idea is that availability of recreational facilities near the origin will tend to make people participate in recreational activity at that origin. However, this particular application of the model is also intended to estimate participation within the originating region and the inclusion of availability would tend to provide a depressed estimate of such recreation as well. It is therefore reasonable to modify the model such that only the distance decay is increased by availability. This would then allow rather large participation in the originating region but would discourage travel of longer distances.

This is accomplished by including an interaction term. Substituting for the coefficient of distance and (one) availability variable, insert the following elements into the equation:

$$
\ldots \alpha \log d_{i j}+\delta_{1} B_{1 i} \log d_{i j}+\ldots
$$

The effect of these elements can be seen by recombining as follows:

$$
\ldots+\left(\alpha+\delta_{1} B_{1 i}\right) \log d_{i j}+\ldots,
$$

and rewriting in the multiplicative format produces

$$
\ldots d_{i j}^{\alpha+\delta_{1} B_{1 j}} \ldots
$$

It should be noted that in this expression $\alpha$ and $\delta_{1}$ would both be expected to be negative. It can, therefore, be seen that the absolute value of the distance decay function, that is, the rate at which travel decreases with distance is increased by a larger availability factor $\mathrm{B}_{1 i}$.

In this model, the above principle was applied using two factors as follows:
(1) The origin region quantity of the most relevant (see below) single facility for each activity, and
(2) The ratio of origin region over destination region quantity of this facility.

The use of (1) is self explanatory. Factor (2) exemplifies the idea that relative availability may be important, thus the corresponding coefficient would also be expected to be negative. The "most relevant" factors for the various activities are defined as follows:
(1) Boating and all boat ramps
(2) Camping: all campsites
(3) Freshwater Fishing: all yards fresh-water fishing
(4) All Fishing: all yards fishing
(5) Hunting: leased hunting acreage
(6) Picnicking: all picnic sites
(7) Swimming: all yards swimming.

It should be noted that preliminary analyses indicated that in some cases this second variable did not contribute significantly to the predictability of the equation hence it was not included.

From the above lists of population characteristics, attraction and availability variables, and distances, selections of variables for use in the prediction of specific recreational activities were made on the basis of previous studies (see reports distributed June and October, 1971) as well as several other trial runs on different variable subsets.

The estimates of the coefficients and associated tests for statistical significance of the estimates for the seven types of recreation and three types of trips are given in Tables 2 through 8. Zero valued coefficients correspond to variables deleted. The statistical significance of remaining coefficients is provided by the "Students $t$ " and statistical significance is indicated by (+) at $10 \%$ significance (*) at $5 \%$ significance and (**) at $1 \%$ or less significance. Other statistics such as $\mathrm{R}^{2}$ or the residual mean square are provided but since these are measured in logarithmic terms they are extremely difficult to interpret.

In general the resulting estimating equations appear quite reasonable with respect to both the magnitudes and the directions of various effects. The major disturbing factor is that in many cases some of the "package" factors, that is, associated attractions turn out not to be statistically significant and/or the associated activity facilities are significant whereas the main facilities variables are not. This is due to the often encountered high correlation among these attraction factors, that is, they often appear together in roughly proportional quantities.

Individual equation sets will be briefly described below with particular reference to those factors which are not exactly as one would expect.
4.1. Boating - The equations for boating are pretty much as one would expect. It should be noted that boat ramps are not included in the variable set; this is due to the fact that slips and stalls are highly correlated with them and, if a choice has to be made, these tend to predict boating better. Even then, freshwater slips and stalls are never statistically significant due to the high correlation with acreages of freshwater lakes. Total population and percent urban population are correlated; this is the reason why the relative magnitude of the total population factor changes as percent urban population is included in the longer trips. The very high coefficients for purchasing power are probably to be expected but will cause a very large increase in projected boating where projected data imply a marked increase in purchasing power.
2.2. Camping - Since one-day trips do not include overnight stays no equation can, by definition, be estimated for such trips. In general the equations are pretty much as one would expect with physical characteristics of the destination regions being more important for the longer trips. The negative signs for freshwater boatramps and all yards fishing are somewhat unexpected. This is again due to the high correlation between these and various other factors that are included such as, for example, freshwater lakes, ocean frontage, and campsites. It is also quite possible that to some degree camping may be preferred on lakes where there are fewer boats and somewhat less fishing. Again the high positive coefficients for purchasing power will provide a rather large increase in projected camping as real income increases.

TABLE 2
GRAVITY MODEL ESTIMATES

| No. | Index | Description | 1-Day |  | 2/3 Days |  | 4+ Days |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Coeff. | t | Coeff. | t | Coeff. | t |
| 0 |  | Intercept | -17.3435 |  | -10.1403 |  | -11.1465 |  |
|  |  | Destination Attractions |  |  |  |  |  |  |
| 1 | 7 | Growing Season, Dest./Orig. | . 0 | . 0 | . 0 | . 0 | 2.0612 | 4.1311 |
| 2 | 12 | Acres of Freshwater Lakes | . 3174 | 1.9765 | . 4358 | 4.5813 | . 3867 | 6.4740 |
| 3 | 16 | Freshwater Slips and Stalls | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 |
| 4 | 17 | Saltwater Slips and Stalls | . 0 | . 0 | . 1336 | 2.3576 | . 0944 | 2.6810 |
| 5 | 48 | All Campsites | . 5333 | 3.6418 | . 3871 | 4.3161 | . 2254 | 3.9853 |
| 6 | 49 | All Picnic Sites | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 |
| 7 | 36 | Population Density | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 |
|  |  | Origin Characteristics |  |  |  |  |  |  |
| 8 | 201 | Total Population | . 7819 | 3.6552 | . 2288 | 1.5490 | . 2664 | 2.7684 |
| 9 | 202 | \% Urban Population | . 0 | . 0 | . 2304 | 1.7216 | . 1575 | 1.9178 |
| . 10 | 203 | Purchasing Power | 2.4939 | 3.1179 | 2.1270 | 4.5731 | 1.8252 | 5.7370 |
|  |  | Distance Functions |  |  |  |  |  |  |
| 11 | 211 | Distance (Adj.) | - 1.6514 | -6.4412 | - 1.1665 | -6.9309 | . 4506 | -4.2679 |
| 12. | 306 | Interaction, Total Boat R. | - . 0056 | -3.4222 | - . 0042 | -5.5067 | - . 0040 | -8.8565 |
|  |  | $\mathrm{R}^{2}$ | . 3676 |  | . 2787 |  | . 2814 |  |
|  |  | EMS = | 5.5049 |  | 4.5581 |  | 2.8000 |  |

TABLE 3
GRAVITY MODEL ESTIMATES

2.3. Freshwater Fishing - As in most other equations the coefficients are generally what one would expect with some exceptions. The negative effect of growing season for one day trips is most likely a proxy for purchasing power which is known to be less in southern regions and, in the case of one day trips, is largely affected by those regions near the origin. This is further supported by the relatively low coefficient for purchasing power for one day trips. Various attempts at trying to eliminate this factor were unsuccessfu1.

Also disturbing is the negative sign for yards of freshwater fishing for one day trips. However, the positive factor for lakes and picnic sites, many of which are near fishing piers and barges, will probably overcome this problem.

The sign of the origin over destination interaction term with distance appears to be of the wrong sign in the longer trips; of course it may very well be that people with heavy local availability also like to travel farther distances for similar activities.
2.4. All Fishing - Again some of the signs are unexpected but in general the equations seem to be moderately satisfactory. Yards of freshwater fishing again has a negative sign for short trips but is compensated for a rather large coefficient for freshwater lakes. Ocean fishing for two and three day trips is probably compensated for by bay fishing and the high coefficient for miles of accessible ocean frontage. It is of interest to note that on the long trips picnic sites replace campsites as the auxiliary facilities variable; this is certainly not expected but again the rather large correlation between campsites and picnic sites should make the equation quite useful for prediction purposes.

TABLE 4
GRAVITY MODEL ESTIMATES


TABLE 5
GRAVITY MODEL ESTIMATES

| No. | Index | Description | 1-Day |  | 2/3 Days |  | 4+ Days |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Coeff. | t | Coeff. | t | Coeff. | t |
| 0 |  | Intercept | -12.1558 |  | -16.1095 |  | -18.7374 |  |
|  |  | Destination Attractions |  |  |  |  |  |  |
| 1 | 7 | Growing Season, Dest./Orig. | . 0 | . 0 | . 0 | . 0 | 1.3905 | 2.6966 |
| 2 | 12 | Acres of Freshwater Lakes | . 6323 | 3.6772 | . 5245 | 4.9206 | . 3756 | 4.7121 |
| 3 | 14 | Miles Accessible Ocean Frontage | . 0 | . 0 | . 7312 | 2.5868 | . 9202 | 5.4413 |
| 4 | 22 | Yards of Freshwater Fishing | - . 5123 | -3.4579 | . 0 | . 0 | . 0 | . 0 |
| 5 | 23 | Yards of Bay Fishing | . 5738 | 5.6433 | . 3056 | 3.4429 | . 0 | . 0 |
| 6 | 24 | Yards of Ocean Fishing | . 0 | . 0 | - . 7501 | -2.2251 | . 8112 | -3.9800 |
| 7 | 36 | Population Density | . 0 | . 0 | - . 3798 | -3.2715 | - . 1673 | -2.3660 |
| 8 | 48 | All Campsites | . 8595 | 5.1801 | . 4071 | 4.1050 | . 0 | . 0 |
| 9 | 49 | All Picnic Sites. | . 0 | . 0 | . 0 | . 0 | . 2915 | 3.3943 |
| 10 | 50 | A11 Boat Ramps | . 0 | . 0 | . 0 | . 0 | . 1028 | 1.8747 |
|  |  | Origin Characteristics |  |  |  |  |  |  |
| 11 | 201 | Total Population | . 6805 | 3.7218 | . 6130 | 4.5773 | . 4262 | 4.1652 |
| 12 | 202 | \% Urban Population | . 0 | . 0 | . 0 | . 0 | . 2123 | 2.3506 |
| 13 | 203 | Purchasing Power | 2.2450 | 3.1506 | 3.1313 | 6.5182 | 2.7420 | 7.8814 |
|  |  | Distance FunctionsDistance (Adj.) |  |  |  |  |  |  |
| 14 | 211 |  | - 1.9187 | -10.5384 | - 1.5412 | -9.4861 | - . 56.54 | -5.0803 |
| 15 | 306 | Interaction, All Yards Fishing | . 0 | . 0 | . 0 | . 0 | - . 0021 | -2.4346 |
| 16 | 309 | Interaction, A. F., Orig./Dest. | - . 0025 | -1.8217 | . 0 | . 0 | . 0 | . 0 |
|  |  | $\mathrm{R}^{2}=$ | .4567 |  | . 3346 |  | . 3326 |  |
| EMS = |  |  | 4.8702 |  | 5.5497 |  | 3.6284 |  |

4.5. Hunting - This set of equations makes large use of the environmental characteristics. This necessitated a somewhat unusual approach in that a different basic set of variables was used for selection for the one day trips than for the longer trips.

The resulting equations are generally quite reasonable. In this case, all coefficients can readily be explained although it is certainly true that the appearance and/or disappearance of variables as one goes to the longer trips is somewhat puzzling. It is also interesting to note that purchasing power has a lower coefficient in this activity than in most others.
4.6. Picnicking - The equations for picnicking for longer trips seem to fit much more poorly than those for the shorter trips. This could certainly be expected since picnicking is essentially a secondary activity, particularly for the longer trips. The negative coefficient for boatramps is somewhat unfortunate although it is normally offset by other factors. In general, although most other coefficients are of the appropriate sign, the equation may not be extremely useful for the reasons stated above.
4.7. Swimming - Swimming is another activity which is often secondary in nature, particularly for longer trips. It is of interest to note the interplay between the actual swimming variables and the associated activity variables. An attempt was made to estimate the equations using only associated variables as well as total swimming or using only the incividual swimming variables. Neither equations fit the data as well but, on the other hand, the use of all variables does produce some rather confusing substitutions. It is of interest to note that the number of statistically significant coefficients increases markedly as the trips get longer which again reinforces the idea

TABLE 6
GRAVITY MODEL ESTIMATES


TABLE 7
GRAVITY MODEL ESTIMATES


TABLE . 8
GRAVITY MODEL ESTIMATES

| No. | Index | Description | 1-Day |  | 2/3 Days |  | 4+ Days |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Coeff. | t | Coeff. | t | Coeff. | t |
| 0 |  | Intercept | -20.8232 |  | -14.0722 |  | -14.2774 |  |
|  | 7 | Destination Attractions Growing Season, Dest./Orig. | - 3.9608 | -1.8755 | . 0 | . 0 | 1.0257 | 1.8310 |
| 2 | 8 | Mileage of Ocean Frontage | . 1554 | . 1.5885 | . 1238 | 2.3120 | . 1392 | 3.8535 |
| 3 | 12 | Acres of Freshwater Lakes | . 0 | . 0 | . 2515 | 2.5086 | . 2789 | 3.7424 |
| 4 | 32 | Yards of Swimming Pools | . 0 | . 0 | . 0 | . 0 | . 1014 | 2.2831 |
| 5 | 33 | Yards of Freshwater Swimming | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 |
| 6 | 35 | Yards of Ocean Swimming | . 3331 | 1.7414 | . 4287 | 4.8304 | . 2573 | 4.1180 |
| 7 | 36 | Population Density | . 3388 | -1.4530 | . 0 | . 0 | . 1236 | -1.6404 |
| 8 | 48 | All Campsites | . 0 | . 0 | . 2897 | 3.0722 | . 2810 | 4.0855 |
| 9 | 49 | All Picnic Sites | . 6986 | 3.7375 | . 0 | . 0 | . 0 | . 0 |
|  |  | Origin Characteristics |  |  |  |  |  |  |
| 10 | 201 | Total Population | . 8023 | 3.1126 | . 3405 | 2.2548 | . 4400 | 4.0105 |
| 11 | 202 | \% Urban Population | . 0 | . 0 | . 2601 | 1.9173 | . 2024 | 2.0740 |
| . 12 | 203 | Purchasing Power | 3.1949 | 3.4129 | 2.5215 | 5.2344 | 2.0137 | 5.3839 |
|  | 211 | Distance Functions Distance (Adj.) | -1.5631 | -6.0509 | - 1.1057 | -6.5140 | -. 3007 | -2.5017 |
| 14 | 306 | Interaction, Yards Swimming | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 |
| 15 | 309 | Yards Swimming, Dest./Orig. | . 0001 | 1.7166 | . 0001 | 3.5302 | . 0 . | . 0 |
|  |  | $\mathrm{R}^{2}=$ |  |  |  |  |  | 82 |
|  |  | EMS = | 6.5 |  | 4.7 |  |  | 31 |

that swimming is a secondary activity and is more dependent on other facilities and activities.

## 5. Projections

The projections resulting from the application of the gravity model are obtained by applying the estimated gravity model coefficients to data sets which comprise projected values for population and attraction variables. The computer program which accomplishes this, provides as a* by-product the current participation rates as well as participation rate estimates for current values of population and attraction; these can be used to compare projected versus current participation rates. This program is documented more formally in a separate report. This section deals entirely with a description of the output of the program; no comments on interpretation will be made since this requires intimate knowledge on Texas outdoor recreation.

The output of the computer program comes in four major sections as follows:
(1) Coefficients for the gravity model; these are printed so that they can be checked with the output of the estimation program to insure the appropriate coefficients have been used.
(2) A listing of the first 12 data sets labeled "data listing 0 ". This will normally be the data for origin region number one to the first twelve destination regions.
(3) Current data and estimates. This portion of the output consists first of a listing of the "adjustment factors" which are necessary to adjust for the multiplicative bias introduced by the use of least square on logarithms as well as the fact that projections using the
gravity model are provided for all origin-destination combinations (i.e. including those for which there was no participation observed in the household survey) which were not included in the estimation process. The listing of adjustment factors is followed by tables of current participation rate estimates as obtained by the 1968 household survey, and the current gravity model estimates.

All estimation and projection tables are in the form of a 37 by 37 table covering all origins/destination combinations with marginal totals for origin and destination totals and a grand total participation. Each table is completely documented with respect to the activity and the nature of the table. All participation rates are given in thousands of "people days". One table is provided respectively for one day trips, 2 or 3 day trips, 4 and up day trips, and total of all trips.
(4) Data listing for projections. This is labeled "Data listing 1 " and is a listing of the first 12 observations of a particular projection; format is the same as given in Item 2 above; there is a title to indicate the type of projection data listed.
(5) Projections and comparisons. The projections and comparisons with current participation is provided in two sets of tables as described under Item 3 above. These are as follows:
a. Direct estimation. This set of tables is obtained by a direct application of the gravity model to a projection population and attraction data. They are adjusted by the adjustment factors described in Item 2 above.
b. The ratio of estimated projected participation to estimated current participation (two decimals assumed). A negative ratio indicates that there was a zero estimate for current participation hence the ratio is meaningless.

These tables are followed by a one page summary which compares the total destination recreation estimates with the TP\&W supplied "Standards" and also provides a summary of origin total and per capita recreation participation estimates.

Thus the proper usage of the projections provided by this model must be tempered by the knowledge that these projections are the result of extrapolations using a regression model. Most standard references on regression warn against the use of extrapolations; these warnings are particularly relevant when one projects for situations that are completely different from the data used to estimate the parameters of the model. Thus, for example, a drastic change in the relative frequency of boatramps to the number and size of lakes, would provide highly unreliable estimates. Thus the projections are useful for generalized projections but are of more limited use, for example, for the projected effect of a single large new facility.

## A RATIO CALIBRATION

AND
A. "CASCADE" ESTIMATION PROCEDURE

FOR

TEXAS OUTDOOR RECREATION

REPORT TO
TEXAS DEPARTMENT OF PARKS AND WILDLIFE

TEXAS AGRICULTURAL EXPERIMENT STATION

JUNE 1, 1972

1. A "Cascading" Procedure

As a part of the work performed by Texas A\&M in support of the state plan for outdoor recreation, two models for the prediction of rural outdoor recreation have been proposed and implemented. These are:
(1) The "econometric model" which uses individual household data to estimate the total participation in various recreation activities by individuals residing in each of the 37 regions, and
(2) The "gravity model" which uses aggregated data for recreation participation to estimate such travel among regions for recreation purposes.

The first model is expected, by definition, to provide more precise estimates of the recreation that "originates" in any one of the 37 regions but provides no method for allocating this recreational demand to the various "destinations", that is, regions in which the recreation actually occurs. The gravity model, on the other hand, estimates the amount of recreation involved in travel within and among regions. Total regional recreation, either origin or destination is simply obtained by summing the estimates of all origin-destination trave1. Since each of these particular estimates is subject to some degree of variation, the resulting variance of the estimate of total recreation for any region may be quite large.

It seems intuitively reasonable to combine the better features of both methods by using the econometric model to estimate total origin recreation and then use the gravity model to allocate this recreation to the various destination regions. This particular procedure has been named "cascading"
the two models and has been implemented for this study.
Denote the econometric estimate for the number of "people days" of participation in an activity by individuals in region $i$ by $\hat{y}_{i}$. Denote by $\tilde{y}_{i j}$ the number of people days participation in region $j$ by individuals residing in region $i$ as estimated by the gravity model. The gravity model estimate for the total participation by individuals residing in region $i$ is thus

$$
\tilde{y}_{i .}=\sum_{j=1}^{37} \tilde{y}_{i j}
$$

It is assumed that $\hat{y}_{i}$ is a better estimate than $\tilde{y}_{i}$, but there are no corresponding estimates $\hat{y}_{i j}$. The cascade estimate is then defined

$$
\hat{y}_{i j}^{*}=\frac{\hat{y}_{i \cdot}}{\tilde{y}_{i}}\left(\tilde{y}_{i j}\right)
$$

In other words, each origin/destination estimate is corrected or adjusted so that the total origin recreation:

$$
\varepsilon \hat{y}_{i j}^{*}=\hat{y}_{i}
$$

the econometric estimate.
This particular procedure was implemented for the short trips (labeled two or three day trips) and long trips and vacations, (labeled four and over day trips). Due to the nature of the data, an econometric estimate was not made for one day trips and thus a cascading adjustment could obviously not be made for these trips. However, in order to make all estimates more internally consistent with the cascaded estimates, a parallel adjustment was made.

Denote the total econometric state-wide estimate for participation in all trips of longer than one day by y .., and the corresponding gravity estimate by $\tilde{y} .$. . The "cascaded" estimates for one day trips is then calculated

$$
\hat{y}_{i j}^{*}=\frac{\hat{y}}{\tilde{y}} \ldots \tilde{y}_{i j},
$$

where the $\tilde{y}_{i j}$ are the gravity estimates.
The resulting cascaded estimates are presented in a manner essentially identical to the presentation of the gravity estimates. A first page contains the econometric estimates and the TP\&W supplied "standards". These are provided as a check to make certain that the correct cards have been provided. Then follow sets of origin destination participation tables for one day, 2-3 day, 4 and over day trips, as well as total of all trips. Then for all projections follow the table indicating percent change from current estimates of the various items in the table. The final page contains a comparison of the destination estimates with the TP\&W supplied "standards" as well as a summary of origin total participation and per capita participation estimates.

## 2. A "Ratio" Calibration

It has been pointed out in the report describing the "cascading" process for calibrating the gravity estimates with the econometric model estimates, that estimates of recreation participation of individuals residing in a particular region as obtained by the gravity model are likely to have quite large variances. The cascade procedure is one attempt of reducing this variance by using, as a calibrating tool, the presumably better estimates from the econometric model.

The 1968 sample survey data provides another estimate of current recreation participation. Although these estimates are subject to sampling error, it can be supposed that these are better estimates than those obtained by the gravity model. Thus it is possible to calibrate the gravity estimates by using the ratio of 1968 survey estimates to 1968 gravity estimates for future projections for recreation participation. This procedure which will be referred to as the "Ratio" estimates, has been implemented and is presented to the Texas Department of Parks and Wildife as an alternate method for their consideration.

It must be emphasized that no one of the three projections schemes can be absolutely preferred over the others. Each is subject to some uncertainties and each must be interpreted with care. For example, the ratio estimate cannot project recreation for any origin region showing non recreation in the 1968 household survey. A useful procedure is to compare the three estimates and make subjective judgements based on other knowledge of outdoor recreation to make adjustments where they are indicated.

The computer output for the ratio estimate projection is identical to that of the cascade projections; the unadjusted gravity model estimates included and are identical for both reports.
GRAVITY MODELANDEXTENSIONSFORESTIMATION OF TEXAS OUTDOOR RECREATIONCOMPUTER PROGRAM DOCUNENTATION
REPORT TO
TEXAS DEPARTMENT OF PAPKS AND WILDLIFE
SUBMITTED BY
TEXAS AGRICULTURAL EXPERIMENT STATION

JUNE 1, 1972

## 1. Introduction

The Procedures for implementing the gravity model estimates for Texas Recreation Participation are performed by two programs as follows:
(1) The Estimation Program which uses various data generated by the Texas Department of Parks and Wildlife in Cooperation with other agencies to provide estimates for the gravity model, and
(2) The Projections Program which utilizes the estimated parameters for the gravity model together with projections data to forecast recreation participation. The projections program comes in two versions, one which calibrates forecasts by using Econometric Model estimates and one which uses an internal ratio estimate for a similar calibration. Details of the model concepts and description of statistical and forecasting procedures are discussed in other reports.

Several other programs we re used in the development of the gravity model but in general these are concerned with the preparation of data or have been superseded by these two programs. Listings of the three programs are attached to this report; it should be noted that these are listings for specific runs of the model and minor changes in programs (as noted below) must be made for estimation and projection for different activities and/or different versions of the model which may be used. Data formats for the various input cards are reproduced in appendix 4 to this report.

## 2. The Estimation Program

The estimation program uses various input data regarding region characteristics, attractions, distances, and participation to estimate, by least squares
on logarithms, coefficients for a regression relating participation to various of these characteristics. Basically, the first part of the program develops a "variable pool" from which are selected, by a selection control card, the variables to be used in a particular regression. A "stepdown" or "backward selection" procedure is used to delete independent variables until all remaining coefficients are statistically significant at some predetermined level. One "run" of the program is required for each activity but a number of alternate models can be obtained in one "run" of the program. Regression parameter estimates are printed as well as punched, with the punched cards being directly usable for the projections program. It should be noted, however, that these punched cards have no model identification and must be kept in the appropriate order.

There are a considerable number of comments cards throughout the program which should be helpful in case the program aborts. Also there are checks to see that most data cards are in the appropriate order and the program aborts with an error message if this happens.

The required input for the estimation program is as follows:
(1) The "Master Distance Deck" containing initial estimates of distances among all 37 regions.
(2) The "POP" deck containing the population and income characteristics of the 37 regions. Only four of the variables of this card are normally read by the program; these are (1) total region population, (2) percent of population living in cities of 10,000 population or greater, (3) the percapita buying power, (4) population density.
(3) The "AT" deck containing, for each region, the various attraction variables as given on page 6 of the report describing the gravity
model. Fifty spaces are available in the array for attractions allowing for the generation of special attraction variables. Some of these variables are generated within the program.
(4) The "DD" deck, containing distance decay factors which are used to generate availabilities. Provisions are made for reading these factors even though they were not used in the latest version of the gravity model.
(5) The next two cards are control cards for the first selection of variables and performing the regression; necessary information and formats are given after line 90 on the attached listing. Selection indices refer to numbers (indices) of the particular desired variables from the variable pool; the identification of variables is given in a set of comments statements after line 165 on the attached listing. "IT" is the value of the "t" statistic, which if exceeded for all coefficients, stops the variable selection process.
(6) At this point follows the origin/destination deck for estimated participation followed by a "end card", a card with the letters "END" punched in columns 78, 79, and 80.
(7) Finally there may be additional sets of two cards (as in 5, above) specifying different variable selections and conditions for additional regression models.

Several modifications need to be made to the program for specific realizations of the model. These are as follows:
(1) If availabilities are to be generated as distance decayed attractions, statements performing this operation must be inserted after the comments card indicating "generate availabilities" (line 122).
(2) For most activities only rural participation is needed and this is implemented in the version of the program attached. If rural and urban participation is required, lines 157-159 must be changed since items $\mathrm{ZZ}(4), \mathrm{ZZ}(5)$, and $\mathrm{ZZ}(6)$ contain urban participation.
(3) Lines 230-239 provide for the generation of the interaction of distances with an attraction variable as specified in the final report. The specific variable to be used must be programmed to be "AT1" for the origin and "AT2" for the destination quantity (lines 230 and 231) statement 133.
Finally it should be noted that a large number of executable statements are given in the program as comments. These are generally optional output statements which were used in debugging the program and may yet be useful for this purpose when other models are tried.
3. The Projections Program - Cascade

The projections program produces a set of projected origin-destination tables for the gravity model and cascade adjusted gravity estimates as described in other reports. A complete set of projections is supplied for any given set of population, attraction, standards, and econometric data. All of these must be present or the program aborts. Sets of projections data may be "stacked" so as to provide a large number of projections in one run of the program, however, separate runs of the' program are required for each activity. The general nature of inputs to the program is very similar to that of the estimation program as the "head end" of the program is based on the equivalent portion of the estimation program. Description of equivalent data decks will not be repeated here.

The required input for the projections program is as follows:
(1) The "Master Distance Deck".
(2) The distance decay coefficients (equivalent to item 4 in the estimation deck).
(3) A specification of the number of independent variables and title information, format given after line 60 in the attached listing.
(4) The gravity model coefficient estimates; these are automatically available as punched output from the estimation program. If coefficients from other estimation procedures are to be used, they must be punched in the appropriate format which is described after line 76 and format statement 117. It should be noted that three sets of coefficients are read, one for each of the trip lengths. All three equations must have the same number of variables, although if a smaller number of variables are needed, coefficients can be entered with zero values. However, the intercept coefficient must always be the last coefficient.
(5) The data for current population, attraction, econometric estimates and standards, preceeded by a card containing 24 characters of desired identification. These decks are read by the REAT and ECRD subroutines.
(6) The origin-destination deck for estimated participation followed by an "END" card.
(7) Any number of population, attraction, econometric estimates and standards decks for desired projection; each must be preceeded by a card containing 24 characters of appropriate identification. The program will automatically terminate on an end of file.
4. The Projections Program - Ratio

This program is almost identical to the previous program except that it does not use the econometric estimates. Hence for steps 5 and 7 above, submit only the Population, Attraction, and Standards decks, preceeded by the identification card.

## APPENDIX 1

## LISTING OF GRAVITY ESTIMATION PROGRAM

```
    , ,wwm!=
```



```
C PROGRAM DEVELDPS UP TO BO VAOIARLES USING POP, AT, AV,MASTER
C DISTANCE AND PAPTICIPATICN DECKS. THEN, USING INFORMATION FROM A
C NUMBER DF VARIABLES (ETC) CARD, FORMAT 1O) AND
C A SELECTION CARD ( FORMAT 351) CARD,
C WITH DEPENDENT VARIABLE LAST, IT RUNS MAXI-MLR WITH STEPDOWN
C TO ESTIMATE GRAVITY COEFFICIENTS
C*********亲*********
C COEFFICIENTS ARE PIJINCHED TO BE USED WITH THE PROJECTIONS
    AND CASCADE PROGRAM
```



```
            IMPLICIT REAL*& (A-H,O-Z)
            DIMENSION T(20), T4(20)
            DIMENSION AQ(3)
            DIMENSION DP(3,37,37), [S (37,37), POP (37,10), AT(37,50),.
            2 AV (3,37,50 ), 2(350),
            1 ID(20),ZZ(6),AVT( 7), DD(10,3)
            DIMENSION R(20,21)
            DIMENSION X(20),XPAR(20),XPX(21,21),XPY(2O)
            DATA AYT/'BCAT','CAMP','AFSH','FFSH','HUNT','SWI决','PICN'/
            DATA END/3HEND/
            DATA AQ/'10AY','2/30','4+D 1/
            ALOG (YYY).= DLOG ( YYY)
            EXP ( YYY) = DEYP (YYY)
            DEC = DLOG (1CC.ODO)
            DO 360 K=1,3
            DO 86.) I= 1,37
            DO 860 J=1,50
            AV ( K,I,J ) = 0.0DO
        860 CONTINUF
C% READ MASTEP DISTANCES
            DO 934 I=1,37
            READ (5,932) II, (DS(I,J),J=1,37)
    032 FOPMAT (I2,2X, 19F4.?/ 4X,18F4.0)
            IF (I.NE.II)GO Tत 933
            GO TO 934
    933 WPITE (6,935) II,I
    9 3 5 ~ F O R M A T ~ ( ' D I S T A N C E ~ C A R D S ~ N U T ~ O F ~ D R D E R ' , 2 I O ́ )
            STOP
    934 CONTINUE
    D\cap 9045 I = 1.37
    READ (5,9028) II, (POP(I,J),J=1, 4)
    9028 FORIMAT (4X, I4, 8X, F8.0, F8.3, F..0,. 24X, F8.01
    IF (I.NE.II ) GO TO 9134
    GO TO \045
    9134 WRITE (6,9334) II,!
```

```
    9334 FORMAT (' POP CARDS OUT OF ORDFR ',2I4)
            STOP
    9045 CONT INUE
        DO 9016 I = 1,37
        Dत 9015 K=1,5
        JJ=(10*K)-9
        JJJ=10%K
        READ(5,9010)II,KK,(AT(I,JK),JK=JJ,JJJ)
        9010 FORMAT (I 3,3X,I 4,1OF7.3)
        IF(II.NE.I.OR.KK.NE.K) GO TO 9011
        GO TO 9C15
        9011 WRITE (6,9012)I,II,K,KK
        9012 FORMATI ' AT CAPOS OUT OF ORDER',4141
        STOP
        9015 CONT INUE
C **:* P\capP I4 IS PODP DENSITY PUT IN AT 36
        AT (I, 36) = POP (I,4)
C %** AT 44 IS TOTAL SMALL GAME INDEX
    AT (I,44)=0.
    DO 9116 KK=1,6
    AT(I,44)=AT(I,44) + AT(I,KK+36)
    9116 CONTINUE
C *** AT 45IS PROPORTION ACRES LEEASEO
    AT (I,45)=AT(I,27) / AT(I,26)
C *** AT 46 IS ALL SUIMMING
        AT (I,46)=AT(I,32) + . I*AT(I,33) + 1000.*AT(I,34) + 10.*\DeltaT(I,35,
C %** AT47 IS ALL YDS FISHING
            AT (I,47)=AT(I,22) + AT (I,23) + AT(I,24)
C %*** AT(4ß) ARE ALL CNMPSITES
            AT (I,48) = 1r0.*AT(I,13) + AT(I,19) + AT(I,20)
C. %*% AT 49 IS ALL PICNIC
            AT. (I,4O)=1CO.* AT(I,29) + AT (I,31)
C AT 50 IS ALL ROATRAMPS
            \DeltaT (I,50) = 4T(I,10) + AT(I,11)
    9016 CONT INIUE
```



```
C 3. READ DISTANCE DECAY COEFFICIENTS, TACTIVITIES AND 3 DAYS TRIP
C FROMAT IS 3X,I2,3F6.3, THREE COEFFS PER CARD
```



```
            DO 352 II = 1,8
            READ (5,345) I,(DD(I,J),J=1,3)
    345 FDRMAT ( }3\times,I2,3F6.3
    352 CONT INUE
```



```
C 1. READ NO IMD VARIABLES,ACTIVITY NO, ANO MIN T, 2 DEC ASSIJUED
C ALSO A 'I' IF MULTIPLE SELECTIONS FROM SAME DATA,
C FORMAT IS 4I3I
C 2.READ SELECTION INDICES, FORMAT I3, MAXIMUM 20. DEPENDENT LAST
```



```
    1111 CONTINUE
            READ. (5,10, END=1112) NV,IAC,IT,IREP
        10 FJFMAT (4I3)
            AVX = AVT(IAC)
            REAO (5,351) ([0(I),I=1,20)
        351 FORMAT (2CI3)
```



```
            ZERD ARRAYS FOR REGRESSION MNALYSIS
```



```
            NCT = 0
            YBAP=0.000
```



167 C. 201-210 APF POR CHAR

168 C 211-2-3 ARE DISTANCES, MIN=26,40,63 RESP
167 C 214-5-5 ARE PAPTICIPATIGA ADJ FOR MIN=50 FOR DIST LT 1OO*IAD
17 C 217-8-9 ARE ACTUAL PARTICIPATION
171 C 220-1-2 ARE PARTICIPATICN - NOT LIJG
17 ? C 223 IS TOTAL NON LOG PARTICIPATIUN
173 C. $\%$.

17511.50 COntinue
$176 \quad A Q X=A Q(3)$
$177 \quad$ IS $=10(M)$
178
179
180
181
182
183
184
185
186
187
188
189
190
191
102
193
104
195
$196 \mathrm{C} \quad 7(50 \div I R+I 口)=A V(I R, I, I Q)$
197 C. 948 continue
199949 CONTINUE

$200 \quad Z(223)=0.0$
201
202
203
204
205
206
207
2C. 8
207
210
211
$z Z X=$ D.CDO
D 947 IP $9.1,3$
$Z Y=D P(I R, I, J)$
$Z(216+I Q)=$ OLOG $(Z Y+1.0)$
$Z(217+I R)=Z Y$
$Z(223)=Z(223)+Z Y$
XID $=12+100$
IF ( ZY.EQ.?.r.AND.ZZY •LE.XIDIZY $=50$.
$Z(213+I P)=\operatorname{OLOG}(Z Y+1 . r D ?)$
$Z Z X=Z Z X+Z Y$
947 CONTINUE

IF ( ZZX.E日.C.OD?) GC TO 940
OO 950 IR $=1,50$
Z (IR) $=A T(J, I P)$
950 continue
DO $951 \quad[R=1,10$
$2(I P+200)=00 p(I, I P)$
951 CONT INUF

C END OF VARIABLE PORL GENGOATIGN

ANY RECOYRINATIDNS MAY BEPROGRAMMED HERE
USE Z(300 - 350)

226
$Z 7$ IS FATIO DF GROWIMG SEASCN, DESTINATIJN OVER ORIGIN

227
228 22.9 230 231 232 233 234
235
236
2.37

238
239
240
241
242
243 C
244
245
246
247
248
249
250
251
252
253
254
2.55

256
257
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283
284
285 286

C VARIABLFS FOP DISTANCE INTERACTION,
C FV IS ORIGIN, FW IS ORIGIN DIVIDED BY DESTINATION
$A T 1=A T(I, 46)$
$A T 2=A T(J, 46)$
$F V=\operatorname{DEXP}$ (AT1)
$F W=\operatorname{DEXP}(A T 1-A T 2)$
$Z(306)=Z(211) \% F V$
$Z(307)=Z(212) * F V$
$z(308)=7(213) \% 5 \mathrm{~V}$
$7(309)=2(211) * \mathrm{FW}$
$Z(310)=Z(212) * F N$
$Z(311)=2(213) * F W$

C. MULTIPLE LINEAR REGRESSION

C SELECT

$451 \times(I I)=7(I O(I I))$
$X X X=X(M)$
IF (xxx.EQ.O.ODO) G $\cap$ Tח 940
DO $40 \mathrm{~L}=1$, 4
XBAR $(L)=X B A R(L)+X(L)$
$\mathrm{DO} 40 \mathrm{~K}=1$, NV
$X P X(K, L)=X P X(K, L)+X(K) * X(L)$
40 COntinuse
$Y S Q=Y S Q+X X X * X X X$
NCT $=1+$ NCT

IF (NCT.GE. 50) GO TO 42
WRITE $(6,41)$ NCT, $(X(K), K=1, M)$
41 FORMAT (' $\cdot, 14,1 /, 1$, 10F8.4)
4? CONTINUE
940 CONT INUE
YBAR $=$ XBAR (M)

C START REGRESSION CALCULATIONS HERE
 $50 \quad Z N=N C T$

DO $60 \mathrm{I}=1$, NV
$0060 \mathrm{~J}=1, \mathrm{M}$
$X P Y(I)=X P X(I, 4)-X B A D(I) * X B A R(J) / Z N$
$\operatorname{XPX}(I, J)=X P X(I, J)-X B A P(I) * X B A R(J) / Z N$
60 CONTINUE
WRITE $(6,67)$
67 FIPRMAT('1',1CX,'XPX MATRIX \& XPY')
DO 70 I $=1, N V$
$\operatorname{WRITE}(6,65)(X P X(I, J), J=1, M)$
70 CONTINUE

C CORRELATIONS

SST = YSO - YBAR*YBAR/ZN
$\operatorname{XPX}(M, M)=S S T$
WOITE (6,61C)
610 FORMAT ('r CORRELATICNS *********)
DO $61 \mathrm{I}=1$, NV
$\times D G=X P X(I, I)$
D! $62 \mathrm{~J}=1, \mathrm{M}$

```
    R(I,J ) = XPX (I,J) / DSOPT ( XDG*XPX(J,J))
    62 CONTINUE
        WRITE (6,&5) (R(I,K),K=1,:G)
    61 CONTIMUE
        CALL INVERT(XPX, Y!,:4,PET)
        DO 6b I=1,!
        XBA?(I) = XBAR (I) / ZN
    6G CONTIINUF
        YPAR = XBAR(IA)
        WPITE(6,68)
        63 CJRYAT (/////' ',1rX,' DETERMINANT OF XPX, MEANS OF X S AND Y'/)
        W?ITE(6,65) DET,(XEAR(J),J=1,M)
    6 8 1 ~ W श I T E ( 6 , 6 7 ) ~
69 FJFMAT('O',1OX,'XPX INVEFSF')
        DO 75 I = 1,NV
        WOITE(6,65) (XPX(I,J),J=1,NV)
    75 CONTINUE
        65 FOPMAT (/ (5x, 8%14.7) )
        SSD=0.OOC
        PSUM = &.%NO
        OD 9? I = 1,NV
        BSUM= RSUM + XPX(I,4) =XRAR(I)
        SSR = SSR + XPX(I,&) %XPY(I)
90 CNINTIMUF
        RO = YBAR - BSUM
        SSE = SST - SSO
        DFTOT = NST - 1
        DFQEG = I:4X
        DFERR = DFTRT - DFREG
        RFGUS = SSR/DFRE:G
        ERDMS = SSE/DFFDR
        FTST = PEGYS/EROUS
```



```
C CALCUlatF T STATISTICS FOF COEFFICIENTS
C OUTPUT STARTS HERE
```



```
        WRITE (G,1כG) \VX,A门X ,ID(:1)
    1OG FDRMAT ('l ACTIVITY = ',A4,', ',A4,' TRIPS'//
        1 1OX,' DEPFNOENT VARIARLE IS ',I4,///1
        WRITE(6,105) NV,VICT
    105 FOPYAT!' ', 10X,'MULTIPLE LINEAR REGRESSION'/
        116X,I2,' VARIARLFS',2X,I3,' DBSERVATIONS'////
        21Ox,'ANALYSIS OF vARIANCE'//1
            N! = DFTOT
            N2 = DFERR
            NA = IMX
            WRITE(G,11\cap) NI,SST,NA,SSR,DESMS,FTST,N2,SSF,ERP.MS
11@ FORYAT(' SOURCE',IOX,'OOF',1OX,'SS',16X,'MS',16X,'F'//
    1' TOTAL',12X,[3,5X,G13.7/
    2' REG.',13X,I 3,6X,G13.7,6X,G13.7,6X,G13.7/
    3' ERROR',12X,I3,6X,013.7,6x,r13.7////1
            R2 = SSP/SST
            NPITE (6,112) Q2
    112 FOPHAT (////'R-SOIARE = ',F6.4///)
            D~ 1OO I = 1,NY
            T(I) = XPX(I, :I)/DSOPT(XPX(I,I)*FFOMS)
                    100 CNIITIN!IE
            WDITE(6,115)
115 FOR\becauseAT (33x,'COEFFICIENTS',ICX,'T-STATISTICS'/)
            HRITE (6,116) AVX,AOX, BO,(AVX,AQX,I,IO(I),XPX(I ,M),T(I),
```

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$4 C 1$
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```
            1 I=1,NV)
    116 FORMATI' ',2X, 2A4 ,14X,F16.7/
    12\(3X,2\Delta4 ,2X,2I4,4X,2(Fl6.7,6X)/)//////)
    117 FORMAT ( 3I3, F12.6)
        DO 120 I = 1,NV
    120 HRITE (7,117) [AC, I, ID(I); XPX(I,M)
        WRITE (7,117) IAC, M, ID(M),BO
        IF(IMX.LE.I) GO TO 1111
        IMX = IMX - 1
        IX = O
        TMIN = IT*IT
        TMIN = TMIN/10000. n00
        0丁 300 I=1,NV
        TI = T(I)*T(I)
        IF ( TI.EQ.O.ODO) GO TO 300
        IF ( TI.GE.TMIN , GO TO 300
        IX = I
        TYIN = TI
    30@ CONTINUE
    WRITE (6,118) IX, TMIN
    118 FORMAT ('O DELETE VARIABLE ',I6,' T-SQUARE = ',FIC.5.)
        IF (IX.EQ.O) GO TO 1111
        DO 3l@ I= ,M
        TM(I) = XDX (IX,I)
    31: CONTINIJE
        DO 320 I=1,NV
        DO 320 J=1,M
    320 XPX (I,J)= XPX(I,J)-TM(I)*TM(J)/TM(IX)
        D) 325 I=1, NV
        XPX(I,IX)= U.CDO
        XPX(IX,I)=0.0DO
    325 CONTINUE
        XfX (IX,IX)=1.000
        XPX.(IX,M)= 0. ODO
        IMY = NV - IMX
        WRITE (6,330) IMY
    330 FORMAT (11','STFDDOWN, STEDNO.',I4,///1
        GO TO 681
    1112 STOP
        END
        SIJBROUT INE INVERT(X,N,M,D)
        IMPLICIT REAL*& (A-H,O-Z)
        DIMENSION X (21,21)
        DATA ZEOO/O.ODO/
        DAT^ JNE/1.COO/
        D = ONE
        DO }3\textrm{L}=1,
        P}=X(L,L
        D = D*P
        X(L,L) = ONE
        OO 1 J = 1,M
    1 X(L,J) = X(L,J)/P
        D) 3 I = 1,N
        IF(I.EQ.L) GO TO 3
        P}=\textrm{X}(I,L
        X(I,L) = ZERO
        Oח 2 J = 1,M
        X(I,J)=X(I,J)-P*X(L,J.)
        3. CDNTINUF
        RETUR:N
        END
```


## APPENDIX 2

## LISTING OF CASCADE PROGRAM

```
    //*11A!!
```

```
    //*11A!!
```








```
    C MASTFQ OISTAYES
```

    C MASTFQ OISTAYES
        OISTA\:` P-CAY COEFF FO? AVAILARILITIFS
    ```
        OISTA\:` P-CAY COEFF FO? AVAILARILITIFS
```




```
        GQAVIVY UrOEL ROF=E[CIROT ESTIMATFS
```

        GQAVIVY UrOEL ROF=E[CIROT ESTIMATFS
        CUFPEMT O!P AMQ AT DOECEDEN rY ?4 CHAR TITLE CARO
        CUFPEMT O!P AMQ AT DOECEDEN rY ?4 CHAR TITLE CARO
            FOLLNYES PY & SET UF 197? CAPACITIES CARNS ( STAVIARDS)
            FOLLNYES PY & SET UF 197? CAPACITIES CARNS ( STAVIARDS)
        CHODEMT DADTICIPATICY( NIN FABLFS )
        CHODEMT DADTICIPATICY( NIN FABLFS )
        FND CAPO
        FND CAPO
        DRGJECTFO D.OM AVO AT DFCRS, DRCCENED OY 2G CHARACTER TITLE CARN,
    ```
        DRGJECTFO D.OM AVO AT DFCRS, DRCCENED OY 2G CHARACTER TITLE CARN,
```




```
                THIS UAY R= DFPFATED & S AFTEi: \triangleS OfSIPFD
```

```
                THIS UAY R= DFPFATED & S AFTEi: \triangleS OfSIPFD
```










```
        TAPLF. FOP", ANJIS*S ( CASCAFFS) FOD ECOVRAETFIC UROEL NIO
```

```
        TAPLF. FOP", ANJIS*S ( CASCAFFS) FOD ECOVRAETFIC UROEL NIO
```










```
            #TuFUSTri: SCALE(4) , マTAS(?)
```

            #TuFUSTri: SCALE(4) , マTAS(?)
            QEAL*& L\I, LEMTH
            QEAL*& L\I, LEMTH
            DIMEP!SITM חP(3,37,37), חS (37,37), DOP (37,1C), AT(37,50),
    ```
            DIMEP!SITM חP(3,37,37), חS (37,37), DOP (37,1C), AT(37,50),
```




```
            3 1V(3,27,59), 7(25`), [X (?,?1), 77(5), AXT(7), חO(10, 3)
```

            3 1V(3,27,59), 7(25`), [X (?,?1), 77(5), AXT(7), חO(10, 3)
            DI:ENSTR:U ESr:% (4,20,30), XX`(4)
    ```
            DI:ENSTR:U ESr:% (4,20,30), XX`(4)
```




```
            DIAFN!SIOA! EC'F (2,42), S:O (37)
```

            DIAFN!SIOA! EC'F (2,42), S:O (37)
            \MTEGED C'
    ```
            \MTEGED C'
```




```
            DATA TYOF /'ART ','GST ','C^SC','*EST','&CAS'/
```

```
            DATA TYOF /'ART ','GST ','C^SC','*EST','&CAS'/
```






```
            DATA EA!n/3HEy!/
```

            DATA EA!n/3HEy!/
            OCG = AL:O ( 1O?.)
            OCG = AL:O ( 1O?.)
            NTT = r
    ```
            NTT = r
```




```
            \cap!? 024 ! = 1,??
```

            \cap!? 024 ! = 1,??
            PEAO (5,7??) II, (\capC(I,J),J=1,37)
    ```
            PEAO (5,7??) II, (\capC(I,J),J=1,37)
```






```
            @า Tn 2つ4
```

```
            @า Tn 2つ4
```

47
48

```
    033 WQITE (4,O35) II,I
    0.35 FOQAAT ('i)ISTANGE CARMS NUT OF OROER', \IG)
            ST门o
    034 C.\MT [u|F
C **********************
C 3. D=AT MIS AMCE MECAY COEFFICIEVTS, TACTIVITIES AND 2 OAYS TPIP
C FORQAT IS 2X,I?,3FB.2, THREF CDEFFS PER CARD
```




```
            PEAn (5,345) [,(n)(I,J),J=1,3)
    345 FORA: (2x, I 2, 2=f.3)
    352 CONT TMIF
```



```
C 1. 2EAN MR INO VIRIABLES,ATTIVITY NO., SIX RLANKS, AND START IN
C. IN COILI? A 2B CHADAOTEO INENTIFICATION
                    FORMAT IS 2I3,6x,7:4
```



```
        1111 COMTIMOE
            REAN (5,I`) NV,IAC, (AVT(I), I=1,3)
        1? FORMAT (2I3, 6x, SA4 )
            B=M + 1
C ***%*************
C MFAO GOAYITY COEFFICIFVT FSTINATFS *******
        THFDF AFE rHCEE SF:S NF CMFFFICIENTS
            ?O IS QEAT LASE TV PLACF OF THE OEDENNENT VARIABLE
        #\cap 36.8 k=1,?
        n\ 3SR ICC= = 1,:
        RF,O (.5,117) TA,I,rXT, XR (K,ICR)
        117 FOQMAT ( 3I?, F1?.6.).
            IF (IA.NE.[AC) GOTO 36?
            IF (I.AE.ICRO fO TO 3&0
            IX (K,Y) = IXT
            Gח TO 263
    36O NOITE (t, 2t&) I,ICC,IAC,IC
    364 FGP`AT (' CARDS FOP COEFF OUT CF OROEQ 1,4I41
        STOP
    363 CNNTINMJF
        0\cap 365 T=1,4
        WPITE (E,355) \DeltaXİIAC), [, 1 TX(J,I), X3(J,I), J=1,3)
        366 FNOWAT ( , CNEFF, \triangleCT=',A4,I4, 3( [6,FI\cap.4))
        365 COMT TMUE
```



```
C READ 1OT: FOD AND AT DATA
    READ (5,1165) AIC
    1165 FNGMAT ( 644)
            IOD=?
            CALL RFAN ( POD,AT,TPD )
```



```
C ** FEAO CURQEVT ECHT AVD STANOARDS
            WOITE(S,117%)\DeltaYT, \IT
            CALL FCRD (ECMT,STD)
            On 9\27 K=1,3
            กก วr.27 r=1,37
            กก Э:27 J=1,37
            DD (K,I,J)= \because, C
        9027 COMT!r!IE
            0ก 25 !=1,4
            \squareก 25 J=1,38
            @ก 25 K=1, ? %
```




115
$11 \theta$
117
112
110
12 ？
$1 ? 1$
$12 ?$
1？？
124
$1 ? 5$
12.5

127
129
129
$13 \%$
131
$12 ?$
123
134
$\operatorname{Ar}(!, J, Y)=r . r$
EST $(I, J,<)=\therefore$







חo（ 1，I，J）＝ 77 （1）

no $(?, 1,1)=27(2)$
DO（2．1，1）$=7.2(3)$
DS $1 \quad[, J 1=x \square$
G？－ 9034
C．
115 「 「ゾリソリニ

C GFAEVIFF AVAIIMEILITTES

C．חก $1071 \quad 1=1,37$




（ALL－EAS（SY，AV，ORO）
กา $1155 \quad[=1,4$
$1155 \mathrm{~F}(\mathrm{I})=1 . \square$
$I N=r$
MPITF 1\＆，11571 IN


กา $55^{\circ}!=1$ ， 4
$F(I)=1 C T(I, 33,39) i=c^{-}(1,33,38)$
$55 \mathrm{5COMTM}=$
NRITE（ヒ，55！）（ ᄃ（I），！＝1，千 ）


กก $5 \because 1 \quad J=?, 20$
กา $5 \ldots 1 \mathrm{~K}=1,33$
FST（ $ム, J,<)=$ ．
กา $5 \mathrm{~T}!\mathrm{I}=1$ ，
$E S=F(I): F S \because(I, J, K)$
EST：（I，J，K）$=E S=$
$E S T(L, J, k)=E S *(4, J, K)+E S E$
561 CONTIUE
กา $55 \quad \mathrm{I}=1,4$
กค $5=J=?, 3$ ？
［त $55 \mathrm{k}=$ ？， 3 ？

55 くかいT！い！

「TVO＝！
ICC＝！

D？©S $I=1,4$

```
            D~ 56 J=1,35
            D) 50́ K=1,35
C. ** ACT GILL rrATAIY CURQEVT CASCADED EST, EST WILL HAVE GRAV EST
    XET= EST(I,J,K)
    \triangleCT(I,J,K)=XET
```



```
        5 5 ~ C O N T ~ I N U E ~
        ITYD= ?
        ISC= = 1
        CALL WRITE ( CD,ITYP, TR, NVT, LENTH, TYOF, SCALE, ISC,AIDI
        WRITE ( f,l21r.) TVDE(?)
        CALL XNFCOS (AVT, AIN, EST, STO, IOX, POP)
C CurafMt CASC
            CALL CASO ( ECMT,NCT)
            D\cap 571 I =1,4
            D\cap 57! J=1,?,9
            D\cap 57! K=1,3Q
            C\cap(I,J,k)=(ACT(I,J,k) + 5!C.) / lrnn.
            571 COyTyM!e
            ITYD=3
            CALI WRITE (CR,ITYP, IB, AYT, LENTH, TYOF, SCALE, ISC,AIDI
```



```
C 197' NFFO.S
            IOX = ]
1210 FחRMAT ('1 ', 14)
            WOITE (6,1210) TYOE(3)
            CALL XNEEOS ( AVT, AIT, ACT , STC, IOX, POPI
    1170 CONTIMIJF
            חก l1Q: I= 1,4
            O 119.*J=1,3R
            Oก ll&~ K=1,3%
            ESTM (I,J,K ) = r.
    11RA CNMTINUE
C STADT DOOJ=CTIDNS
            REAN (5,1165, EN!N=1\capNF) AIO
                IPD = 1
            CALL PEAD ( OnD^,AT:Y, IPP)
            CALL \triangleVL (AVA,ATM,OD,DS,IAC )
            C\triangleLL TRANS (ATH,AVM,DOPY)
            WO!TE (6,117昗 AVE,ATO
    1178 FחP"AT!'! FCMT FSTIMATES (1975 ANO LATERI AND STANOARDS' /
        l /2nx,14A4)
            CALL ECRO ( ECMT,STD)
            IN = !
            WPITE (Ó,l160) [4
            WRITF (6,1135) AID
    1125.FORMAT (1, 人A4)
```



```
C GRAVITY 「STIUATES
            CAIL EXT( DS,7M,ATM,DODM,AV ,ESTM, ACT,XB,IX,DO, NV ,IA:,F. I
            0n 62 ! = 1,4
            DO K? J = 1,3Q
            7? 62 K = 1,39
    6? C\cap(I,J,K)=1=STH(I,J,<) + 5NO.)/10\capO.?
            ITYO =?
            ISC= = 1
            CALL WPITC ( CD,TTYP, IR, AVT, LENTH, TYPF, SCALE, ISC,AIDI
```



```
C PERCFA:TANF INCPFASFS
            Di 刀r I = 1,4
```

```
        0% ?? J = 1,32
        n) 90 K=1,32
        ACX = ACO (T,J,K)
        \DeltarX=EC+
        IF(Arx.LT.L.r ) ACX = -FSTM(I,J,K)+ O.l
```



```
        ITYD=4
        ISr=?
        CALL MRTGC(CO,ITYD, IP, AVT, LCNTH, TYPF, SCALF, ISC,AID)
```



```
C MEENS EMO RQAVITY AODE JNADJMSTEN, IDX=I IN ROL ? IN CARDS
        InY = ].
        WRITF (S,121!) TYFE(2)
        CALI. XOFEOS ( AVT, AIO, ESTM, STD, IPY , PNOM)
        CALI. RASO ( Fr`MT, FSSTM
        n! 25: I=1,4
        #\cap 25? J=1,38
        0^ 35: K=1,33
        CO(I,J.K) = (FST:: (I,J,k) + 500. )/ 10OO.
        850 c)-1:MJ5
            ITYO = ?
            ISC= = 1
            CALL UETTE ( CO,ITYP, IN, AVT, LENTH, TYPE, SCALF, ISC,AID)
            ก\cap }37\textrm{I}=1,
            \squareก 0,7 J=1,3?
            ก\cap 87 K=1,39
            xrn = FS-4 (I,J,K)
            \Deltary = Ar- (I,J,k)
            IF (Ary:LT.l.r) Arx = - xCD + O.l
            Cn (I,J,x) = (xrn/\Deltarx ) =!rre + 0.5
        87 CNツIM!F
            TTVO=5
            ISC= ?
            CALL WニITE (CD,ITYO, [J, AVT, LFNTH, TVOE, SCALE, ISC,AIO)
C %********
C NFFOS
C#%% IPX=? INFMTIFI=C CASCANES PPOJECTIGNS AND NFGDS, CTL 2 IN CADOS
            IPX= ?
            MPTTF (f,!2l`?) TYPE(3)
            COLL XNEENS (AVT, AIN, EST:, STD, !OX, DODM)
            G\cap-п 1!7%
    10ne sTod
            EN!
            SURROUTIYE ESAE (DOD,NT, IPD)
            DI:4EN:S!7, PRO(27,13), AT(27,57)
            n\ 0.4.4 I = 1, 27
            READ (5,0,22) IT, (OMP(I,J),J=1, 4)
```



```
            IF (I.NE.TI ) Gr: T!O O134
            GO T? O:45
    0134 H:TT= (6,03?4) II.I
    Q334 F\capP&AT (' POD CAMOS CIT OF MQDER ', \I<)
            STMO
    O<45 CONTIM|=
    O\cap c,16 ! = 1,37
    กด 0)1% <=1,5
    JJ=(1) %K)-7
    JJJ=1^#K.
```



```
9C1? FOQ4AT (I3,.2X,I4,1OF7.3)
```


$343 \mathrm{C} \quad I J=12$
344
345
346

GO TO C!15
sTOP
0015 CONTINUE

9216 CNivT IM!
C.

9116 CONTINUE

9016 CONTINIJ.
PETURA
EMIO


86․ CONTINUE
$C$ D $9025 \quad I=1.37$
$C \quad D I S=$ DS $(I, J)$

DIX $=$ DIS


C IJ $=12$

346 CON25 CRNTTNUE

QO11 WRITE (6, On) 2.)I,IT,K,KK
QO12 FORMAT ' 1 CT CARDS DUT OF CRDER', 4J4)

C $\%$ POD I4 IS POP DFNSITY PUT IN AT 35
$\Delta T(I, ? 6)=P \cap P([, 4)$
C SCALF $\triangle$ OJUST FOR PROJFCTITN AT
IF (IPF ) 9110,9215,011:
9110 AT (I,15) = $\Delta T(I, 15) / 10$
$\Delta T(I, 16)=\Lambda T(I, 16) /$ IC
$\Lambda^{\top}(I, 17)=A T(I, 17) / 10$

C W** $\triangle$ T 44 IS TOTAL SMALL GAME IMOEX
$A^{T}(I, 44)=$ ?
חण 911t KK=1, 5
$\Delta T(I, 44)=4 T(I, 44)+\Delta T(I, K K+36)$

$A T(I, 45)=\Lambda T(I, 27) / \Delta T(I, 2 \in)$
C $\%$ AT 46 IS ALL SWTMMIMG
$\Delta T(I, 4 t)=A T(I, 32)+.1 * \Delta T(I, 32)+10 \cap 0 . * \Delta T(I, 34)+10 . * \Delta T(I, 3$

$\Delta \bar{T}(I, 4.7)=A^{\top}(I, ? 2)+\Delta T(I, 23)+\Delta T(I, 24)$

$\Delta T(I, 4 . \hat{\prime})=1 r, \ldots \Delta T(I ; 12)+\Delta T(I, 19)+\Lambda T(T, 2 C)$
C *** AT $4 \cap$ IS 1 LI PICAIC
$\Delta T(I, 4 C)=10 O_{0} * A T(I, 29)+\Delta T(I, 31)$
C AT SO IS ALL BOATPANPS
$\Delta T(I, 5 C)=\Delta T(I, 1 r)+\Delta T(I, 11)$

SURPRUTINE $\triangle V L$ (AV,AT,Oח, חS,IAC)
DI4ENSICY $A V(3,37,5 n), ~ A T(37,5 C), \quad$ OD $(1 \cap, 3), \operatorname{DS}(37,37)$
C. $\Delta V=S U M$ (AT) (DS**RD)

C \#
$0 \cap$ S $6(J=1,50$
$\Delta V(K, I, J)=$ O. C

Dก 9025 $J=1,37$
$C$ Dn כr. 25 ! $\triangle \cap=1,2$
$\sigma M N=2 R . * I A D$
IF (DIS.LE.DMNI OIS =ONM

SOECIFY HERE OYLY THOSF AV VEEDED (IJ RANGE)

$\Delta V(I \Delta D, I, I J)=\Delta V(I \Delta \Pi, I, I J)+A T(J, I J) \neq$

```
            FPT!!%N
            FO!
            SIROMJTlUF OPANS (AT,AV,DID)
            CIMSNSTG! AT(37,5r), av(3,?7,5C), ono(37,10)
                    C %2%******
            DO APORODPIATE TRANSFODMATIONS
            C 4%%*************
            07 O?% I= 1,37
            00 0?1 J=1,5r
            AT ([,J) = ALOC, (AT(I,J)+r.I)
```



```
            C IF (\DeltaV(l,I, 
            C AV K,I,J)= 人L?(听(K,I,J)+C.l)
                    C 97.5 cmivTra!ue
    0?1 Conitynys
            ก\cap 92? J= 1,4
            F\capD (I,J)=\DeltaL!G (D\capP(I,J) +1.O )
    922 COMT IN!JF
    20% CONTIM|F
            &5T|ra:
            F\IO
            SURERUTIUGEXTPDS,Z,AT,NMP,AV,FST,NTT, XB, IX, ND, NV ,IN,FI
            C OS= OISTANCES
            C Z = VAR OC:L
                    C. AT = ATTOPRTIMNS
```



```
                            AV IS MVAILLABILITIFS -- CJREFMTLYY NOTT USEN
                            FST IS AEDAY EIR OFVEL ODIYG ROAVITY EST
            ACT IS APOAY FOP ACTIJAL PAZT
            X3 IS ANOF:Y EOR SHAYITY ROEOFICIENTS
            IX IS AFOAY HF IMNEXING GOFFFICIENTS
            DO IS AOOLV \capE ACTUNL DAFTICIDATITN
            NV IS NO VARS IV r,HRAVITY 4OCfL
            IN =? CIIPFENT, =1 ALL ITHFR CUN:S
            F ISARRAY OF LOG RIAS GMRPEOTIMMS
            CFNERATE VARIAELE OOGL
        VARIABLES l-5n ARF ATTQACTIONS
                    51 - ح`G ARE`AVAILAPIIITIES (ISETS)
                    ?N1 - 2!S ARF DOD CHAD
                    211-2-3 ARE TISTANCFS, HTH=2`,4C,6R 2ESP + 15
                    ?14-5-5 ADE D\PTICIPATTON AD.J FOD MIN=5O FDR DIST LY 1OS*IAD
                    217-8-g A2F ACTUAL PARTICIPATICN
                220-1-2 ADE 口ARTICIDATTOA! - NOT LOG
                ?>2 IS TOTAL जnM LOGG つAFTIC[DATICN
```




```
            1 X(3,2!). 5ST(4,30,30) , A!T(4,33,38)
            DIMENSI\capN XR(3,?1), IX(3,21), DO(3, 27,37),XX(4) ,F(4)
            DEXD(WW)= EXO(NiN)
            M=NY+1
            NCT= = 
            O? 94%, I=1,37
            Dก 94-}J=1,3
            z 1222)=?.0
            #ก@ Q4? !?=1,2
            OMN= [F:?)
            ZY = n¢ (I,J)
            IE ( ZY.LE.)MNi ) 7Y = ONN
                    C\quadZZY = ZY + 15.
                            7.7Y = 7.Y
```

497
4 4.8
409
41 ?
411
412
413
414
415
416
417
418
41 ?
420
421
427
4? 3
424
425
426
427
423
429
430
431
432
433
434
435
436
437
$43^{\circ} 8$
430
44 ?
441
$44 ?$
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
45 ?
450
460
461
462
463
464
465 466

```
    7 ( 2l? + (2) = ALПG (7ZY)
    ZY=np (IO,I,j)
    IF (TN.50.1) GO TO 24%
    2. (?1n + [0. ) = ALOG ( ZY + 1.n )
    Z (210}+10)=7
    Z (2?3) = Z (223) + ZY
    XIO = I?*1nr.
    IF (ZY.FO.O.r.AND.7.YY .LF.XIDIZY=50.
    Z (213+[P)=ALOGY (ZY + 1.n )
C กก 94? 10=1,50
C 2 (50*IF+IO ) = \! (IP,IT,IO)
C }943\mathrm{ COnTIN!IE
    749 CONT INUE
    Dก Q50 [! =1,50
        7 (IR) = \T (J,IR)
    95? CONTIMUS
        0n 55! IR=1,10
    Z (IR + 2OO ) = POP(I,IR)
    951 CONTIM1J5
```



```
C FNO OF VARIABLE POOL SENEOATION
```



```
C ANY RECOMZINATIONS MAY REOOOGRAMMED HERE
C USE Z13O- - 35Cl
    XPO = FYO(POP(I,1))/ lOP..
C 27 IS RATIOU !F RPOMING SFASOM
    7(7) = AT(J,2) - \DeltaT(I, 2)
C * * * LEASFN HIIMTIMG ACRFS
    ATL=AT ( !,27)
    \DeltaT2 = ^T(J,27)
    FV = חEXD ( ATI)
    FW = OEXP( AT 1 - AT? )
    Z(3n6)=2(21!)*FV
    Z(3:7) = 7(212) %FV
    Z(3.O.) = Z.(213)*FV
    Z (3:5) = Z (21!) *FW
    7 (210)=7 (212)*F*
    Z (311)= Z (?13) & FW
```



```
C SFLECT
```



```
            OO 45? K=1,3
            DO 45? II = 1,NV.
            X (K,II) = Z (IX(K,II))
    452 COMT INUF
            NCT = 1 +NCT
C $%%%*******
    IF (NCT.GF. 13) GOTO 42
    WRITE (S,41) NCO, ( X (l,K), K=1,NV)
    41 FOूQ^AT (' ',[4,( /,' 1,1CF3.4))
    42 CONTINUE
        IF (I\because.F?.1) GO T\cap 206
        D0 ?05 II = 1,4
        x^ = Z (210 + IT)
        [C ( XA.50.\therefore.0) Gח T0 2:05
        \DeltaCT (II,I,J)= XA
    ACT}(II,3Q,J ) = ACT (II,39, J) + XA
    ACT (IT,I,3\Omega) = ACT (II, I,39) + XA
    ACT ([I,3.,33) = NCT (II,38,38) + XA
    205 CONTINJE
```

467
$4+6 ?$
$450 \quad C$
47：C
471
47 ？
473
474
475
476
477
478
470
429
$48!$
4 ？？
432
424
4.85

435
497
48.3

480
$49:$
4？！
$40 ?$
493
494
405
40.5

407
4の？
$40 ?$
$51!$
501
5：？
5？？
5こ4
$5 r .5$
516
5.77
$5 \div 8$
5へロ
$51 ?$
511
512
513
514
515
$51 ヶ$
517
519
519
5？？
72．
5？？
5？？
$5 ? 4$
52う
525

```
    206 crav:IMuF
```



```
        OGE!口「T
            \cap% !? K=1,3
            xx(k) =x? ( K, !)
            n@143 1N = 1,:!V
            XX(K) { = XX (K) +KD (K,IA) * X (K,IN)
            4. CMNTTNUE
            Y=(EXD (XX(K)))*F(以)
            FST (K,I,J)=Y
            FST (K,I,2,) = EST (K,I,2,O) + Y
            EST (K,3?,J)= rST (K,2<,J) + Y
            SST (K;3{,3\Omega)= :5%.(k,3?,34)+Y
            EST (4,I,J)= EST
            EST (4,?子,J)= r.ST (4,3?,J)+Y
            EST (4,I,3?)= 5ST (4, !,32)+Y
            EST (4,33,32)=E\T (4,3.2,3.3)+Y
            4% CONTIN!!
                    94n}\mathrm{ CONM IN!IE
                            RET!IR:U
            FVO
```



```
            INFEOEF CO
```



```
C. ***********
            Dח अ:O I= 1,4
```




```
            1 ESTIM,Tに FOQ` ',\14)
            VRITE (A,2.ר1) LENTH(I),TYOE(ITYP),SCALF(TSR )
```



```
            *1-^RLE r!iyTATNS ',AL,l又,A!/1
        WRITG(f,2`21)
```



```
            ARIT=(&,?\because?)(IJ,I, J=1,?系)
    2)?F乌R\becauseAT(/' חP[GIN', 34[5,/ )
        DO ?O! J=1,37
```



```
    203 FO?:14T (?X, I?,2X,24 !5)
    2031 FOUYAT1/' TOTNL 1,24!51
    200 CTVTIM!JE
        WRIT= (*,? 2l)(rn (I, 37,k),K=1,24)
        WQITF (G,?.,N) (NGT(IO), IO=1, S) , (AID(IO),IO=1,G)
        WOTTE (S,?RI) LFNTH(I),TYOF(ITYP),SCALE(ISC)
        WR!TE(*,?N?1)
        WPITE(&,?)G)([J,[J=25,?7)
```



```
        ロก 25% J=1,37
        WRITF (\leq,2)7)J,(CO (I,J,K. ),K=25,2Q1
```



```
    28? COMT I!!UF
```





```
        RET!JE*:
        EN?
        SIQROITIMF YNEFNS (AVT, AIN, EST, STO, IPX ,POP)
        \capI!!SSIn! p\capp (27,1O)
        DIME*SIGN &YT(B), AIN.(f), FST(4, 2%,3%), STC(?7)
```

WPTTE (R,71) AVT, AID
71 FORAAT (M NEECS $1, ~ \Omega A 4,1,9,6 \Delta 4$ )
WRITE $(6,72)$
7 ? FOOMAT ('? RESION
PPRJ CAPACITY
0IFF
P.ATIO

IחRIGIA TRT DCAP POP',// I
$S T T=0$.
DO $7: I=1,37$
XORIG $=\operatorname{EST}(4, I, 38) /$ 100O.
ᄃXS = FST (4,30, ! ) / 1000.
$X D D=\operatorname{EXP}(P O D(I, 1)) / 1 O \operatorname{On}$.
$X D C=X \cap D T G / X P D$
$S T C=S T T(I) /$ IODC.
STT $=$ STT + STC.
XNT $=$ XNT + STR.
$V A C=E X S-S T C$
PVAC = STC / EXS
WRITE (6, 73) I, EXS, STC, VAC, RVAC, XOPIT, XPC, XDP

C STATEMENTS FOR DUNOCHING CARDS
WRITE (7,75) IPX, AVT(1), AVT(2), $\triangle I D(1), ~ A I D(2), ~ I, ~ E X S, ~ S T C, ~$
] VAC, PVAC, XIRIG
75 FRRMAT (I?, 4A4, I4, 3FIn。O, FIO.3, Flo.n)
79 COVTIMUE
EXS = ECT (4, 20, 3R) / lnno.
$V A C=E X S-S T T$
RVAC $=$ STT / FXS
WRTTE (6,74) FXC, STT,VAC,RVAC
74 FODAAT (IO TOTAI. ' , ?Fli.?, FlJ.3)
PETIVQ\%
En!
SIIRROUTIME FCPD (ECAT; STRI
DIMEMSIחY =CAT (2,42), STD(37)
DATA nSY/'S'/ , nI.Y/'L'/:

C. QEAT =CDMOMETDIT UODEL PROJFCTIONS

Oก 5? $I=1$, 7
$I V=6 *(I-1)+1$
$I M=5 \div(I-1)+5$
IF ( $\because \cdot G \mathrm{Co} 33)$ TM=33
$\operatorname{RFAO}(5,1131) \Delta X, \Delta \cap D, A Y, A 7, I C O, \quad(E C M T(1, J), J=I M, I!)$

11?1 FOPMAT ( $44,41,1 X, 4 \neq 1 X, 14,4 X$, I $1,6 F 10.0$ )
IFI OSY.EQ.AND.ANO.ITN.EO.I I GO TO 57
GOT? 1176
57 CONT VIJE
П $52 \quad I=1,7$
$I N=5 *(I-1)+1$
$I M=6 *(I-1)+6$

$\operatorname{REA} \cap(5,1191) \Delta X, \Delta \Pi \Pi, \Delta Y, \Delta Z, I C \cap,(\operatorname{FCMT}(2, J), J=[N, I M)$

GO TO 1175
53 CON TNMIE
ดา $50 \quad 1=1$ ?
WRITE (6, !192) $\therefore X, A Y, 1 \geq,(F C \cdots T(I, J), J=1,38)$
$1132 \operatorname{crpa17}(1,1,314,1,(2510.7))$
59 COyTTMy5

C REAN STANOARDS DOOJERTIONS

ラ\＆7
$58 \%$
529
$50 \%$
50！
50？
593
594
595
595
597
593
509
6？
6？1
50？
hr． 3
A： 4
$6 \cap 5$
6n6
$65 \cdot 7$
698
6．9
$61 \%$
か！1
612
613
614
615
616
$61 ?$
613
610
6つ？
621
62 ？
67． 3
ト24
万25
626
6？7 628

RFA？（5，118？）ivI，IYI，STO


```
    wRIT ( 6,1134\()\) MYI, IYI, S-n
    1184 FORMAT (1M1, 14, I5, 7F12.の/ (1rX, 7F12.n))
        OFTURN
    1175 HRTTS \((6,1172) A X, \cap S Y, A \cap O, I C D, I\)
```



```
        stip
        FNO
        SUBRTUTIUE CASD (FC,MT, ESTY)
        DIMEMSINツ FCA \((2,42)\), ESTM1 4, 38,391
C rascank puric=nige --------
C CNE DAY IS ADJISTED OY RATID OF ECONONFTRIC MODEL AND
C GRAVITY ODEL FSTIUATES FRR \(2 / 3\) ANO \(4+\) DAY TRIPN. THE LATTER
```




```
C DNF DAY A NJISTMENT
            RATID \(=(\) FCMT 11,39\()+E C 4 T(2,38)) /(E S T M(2,38,38)+\)
            ! EST4 (?, 30, 38) )
```



```
C1190 FAPUAT (1 , F1? . F)
    กก \(3 \Omega \mathrm{~J}=1,3\) ?
```



```
    FST! (1,J,K) \(=\) PAT[O * ESTM (1, J,K)
    ES: \(1(4, J, K)=E S^{-M}(1, J, K)\)
    99 COUTIM1F
```



```
C CASTADE 2/3 An! \(4+\) ? \(4 Y\)
            กก \(92, I=2,3\)
            \(I ?=I-1\)
            กา \(85 k=1,30\)
            EST:A (I, フ2, k) \(=\) ○。
            ก!? 2:3 \(J=1,37\)
            Far \(=\) FCrr (I2,J) / ESTM (I, J, 28)
            EXS = FAC * ESTM (I,J,K.)
            EST:! \((I, J, K)=F X S\)
            FST:1 (L, J, K) = FSTM(4,J, ! ) + FXS
            FSTA \((T, 32, K)=E S T A(T, 30, K)+E X S\)
```



```
        39 CTV: TVUE
            RFTUPV
            FN!
```

CORE USASE GQJECT CODE= $\quad 4 \angle 0$ RYTESGARRAY ADEA= O RYTESGTOTAL AE

COMOILETIMF= T.RA SEC,EXFCUTIOMTIMF= 3.99SEC, TAMM/WATFIV - VER !

## APPENDIX 3

## PROGRAM FOR GRAVITY PROJECTION WITH RATIO CALIBRATION

## ／\＄DATA

C
C米米米米 $=$ AUD NEEDS ＊＊$* *$ DATA PRESTENTATION

MASTER DISTANCFS
CISTANCF DECAY COEFF FOR AVAILABILITIES MIO．INDEPENDENT，VARIARLES，ACTIVITY NO， 6 BLANKS， 28 CHAR IDENT GRAVITY MODEL CCFFFICIENT ESTIMATES
CURRENT POD AND AT POECEDED BY 24 CHAR TITLE CARD
FOLLI：UET BY $A$ SET OF $1 G 7 ?$ CAPACITIES CARDS（ STANDARDS） CUFRENT PARTICIPATION 1 O／D TABLES 1
END CARD PROJECTEO POP．AND AT DECKS，PRECEDED BY 24 CHARACTER TITLE CAFD， FOLLOWED BY STANDAFOS

THIS YAY BE FEPEATEJ AS OFTEN AS DESIRED
PFOGQAM DFVELOPS UP TO 3OCVARIABLES USING POP，AT，AV，NASTER OISTANCE AND PARTICTOATION DECKS．THEN，USING INFORMATICN FPCM A A．NIJBER OF VARIABLES CARD AND THE COEFFICIENT DUTPUTS TF THE FSTIMATIOM PROGRAY，IT PFRFORMS A FEEDBACK，PRINT THIS IN O／O
－TABLE FORY，ADJUSTS（ CASCADES）FOR ECONGMETRIC MODEL ANO
C PROVIDES NARKET VACUMM USING GIVEN CAPACITY INFJRMATION

CIMENSICN TYPE（5），LENTH（4），F（4），AVT（ 8 ）
$\qquad$ CIMEMSION ACT（4，39，3？），FST（4，38，38），CD（4，38，38），XX（4） DIMENSION SCNLE（4），RIAS（3） RFAL $\because 4$ LDG，LENTH
DIMENSIDN DP $(3,37,37), \operatorname{DS}(37,37), \operatorname{POP}(37,10), \operatorname{AT}(37,50)$ ，
$2 \times(3,21), ~ \triangle I D(5), \quad X R(3,21)$ ，
3 AV（3，37，5i），Z（35＾），IX（3，21），ZZ（6），AXT（7），DO（10，3） DIMENSION EST：$(4,33,38), ~ X X M(4)$
DIMEVSICN POP4（ 37，10），ATM（37，50），ZM（350）
DIMENSION ECMT（3．39），STD（37）
INTEGER CD
DATA SCALE／＇THOU＇，＇xICG＇，＇xIOD＇，THS＇／

DATA LENTH／＇IDAY＇，12－30＇，＇4－1JP＇，＇ALL＇／
DATA $A X T /$＇RCAT＇，＇CAMP＇，＇AFSH＇，＇FFSH＇，＇HUNT＇，SWIM＇，＇PICN＇／
DATA END／3HEND／
$D E C=\Delta L O G(10 n$.
$\mathrm{NCT}=0$
$C=\% \quad$ FSAD MASTFP DISTANCES
$0] \quad 934 \quad I=1,37$
READ $(5,932)$ II，（DS（I，J），J $=1,37)$
93？FRRMAT（I2，2X，ICF4．0／4X，18F4．0）
IF（I．NE．II）GO Tn 933

```
            TOO}03
    933 42.1TE (6,0.35) II,I
    Q35 FORMAT ('OISTANCF CARDS OUT OF CRDER',216)
        STOP
    034 CTINTIMIIE
C %*******************
C 3. QEAD DISTINICF MECAY COFFFICIENTS, TACTIVITIES AND 3 DAYS TPIP
C FOPMAT IS 3X,I?,3FG.3, THREE CIJEFFS PER CARD
```



```
            7] 352 [I=1,8
            RFAD (5,345) I, (DO(I,J),J=1,3)
    345 FOR:4AT (3X,I2,3F6.?)
    352 CONTIAUE
C #******,**********
C. 1. PEAO NO INO VARIASLES,ACTIVITY NG., SIX BLANKS, AN! START IN
C. IN COL. 13 A 29 CHAOACTEQ IDENTIFICATION *
                    FOR"AT IS 2I3,6X,7A4
```



```
    1.111 CONTTMUE
            QEAD (5,1S) NV,IAC, (AVT(I), I=1,C)
        10 FIRMAT (2I3, 6X, &AK )
            N = VV + 1
```



```
C PEAD GPAVITY COEFFICIFNT rSTIMATES **********
C THERE ARE THREF SETS OF COEFFICIENTS
                    BO IS CEAO LAST IN PLACE OF THE DEPENDENT VADIABLE
            DO 363 K=1,3
            D] 36% [C.C = 1,4
            READ ( 5,117) IA,I,IXT, XB (K,ICC)
    117 FORMAT ( 3I3, F12.6)
            IF (IA.NE.IAC) G? T? 369
            IF (I.AE.ICr.) GO TO 367
            IX ( K,I) = IXT
            GO T] 368
    369 WRITE (6,364) I,ICC,IAC,IA
    364 FORNAT (' CAPNS EOR COEFF NIJT OF ORDER 1,4I4)
            STOD
    363 CJNTINUE
            07 365 I =1,4
            M2ITE (G,3t6) \triangleXT(IAC), I, ( IX(J,I), XB(J,I), J=1,3)
    366 FORMAT ( ' COEFF, ACT = ', 44,I4, 3( [6,FIC.4))
    365 CONTTIVIJE
```



```
    C RFAD 197U PNO ANO AT DATA
            READ (5,1165) AID
    1165 FORMAT ( GA4)
            IFP=0
            CALL READ ( POP,AT,IFP )
```



```
    C ** READ CURPFIIT ECMT AYN STANOARDS
    WRITE(6,1178)\VT,.1I?
    CALL FCRD (EOMT,STO)
    On 9「:27 K=1,3
    #O @%27 T=1,37
    0! 0r27 J=1,37
    DN (K,!,J) = .n
    9027 CNNTIU|F
    DO 25 I= 1,4
    DO 25 J=1,38
```

$107 \quad D O 25 \mathrm{~K}=1,38$
108 ACT $(I, J, K)=$ O．0
$109 \ldots$ EST $(I, J, K)=0.0$
$110 \quad 25$ CDNTINUE

112 C READ ACTIJAL PART AND DIST
113 C READ SIY PART－ $1,2 / 2, ~ A N D ~ 4+~ D A Y S ~ F O R ~ R U R A L ~ T H E N ~ U R B A N ~$
114 C ALL OUT OF STATE PARTICIPATION IS IGNORED

116 9340 READ（5，0040）I，J，（Z7（K），K＝1，6），XD，CHK
117 111．IF（CHK。EQ．ENO）GO TO 1150
118 ［F（J．GE．38）GO TO 9340
119.9049 FORMAT（ $3 \mathrm{X}, 2 \mathrm{I} 4,2 \mathrm{X}, 6 \mathrm{FB}$ ．O，T64，F8．O，T78，A3）

120 C WRITE（6，904ก）I；J，（ZZ（K），K＝1，6），XD，CHK
121 （ 1.1 .5$)=Z 2(1)$
122 C＊क\％RURAL INLY
123 DD $(2, I, J)=2 Z(2)$
$124 \quad D P(3, I, J)=22(3)$
$125 \quad D S(I ; J)=X D$
126 GO TO 9349

128 115n CONTINIS

130 C GENERATE AVAILABILITIFS
$131 \ldots$ CALL AVL（AV，AT，DD，DS，IAC）
$132 \mathrm{C} \quad$ O $1971 \quad \mathrm{I}=1.37$
$132 \mathrm{C} \quad$ WRITE $(6,736) \mathrm{I},(P$ PP（I，J），$J=1,10)$
$134 \mathrm{C} \quad \operatorname{WRITE}(6,936)[,(\Lambda T(1, J), J=1 ; 50)$
135．Cl971 WRITE（6．936）I，（ヘV（T，J），J＝1，5C）
136 C 935 FORMAT（＇O1，I3／5（1X，1活9．3／））
137 CALL TRANS（AT，AY，POP）
138 D $1155 \mathrm{I}=1,4$
139 1155 F（I）$=1.0$
$140 \quad I N=0$
141 WRITE $(6,1160)$ IN
1421160 FOFMAT 1：DATA LISTING $1.16, / / / / 1$
143 CALL EXT（DS，Z，AT，POP，AV，EST，ACT，XE，IX，DP，NV IN ，F ）
144 DO $550 \quad I=1,4$
$145 \cdots \quad E(I)=\operatorname{ACT}(I, 38,38) / E S T(I, 38,33)$
146
550 CONTINUE
147 WRITE $(6,551)($ F（I），$I=1,4)$
148551 FIRMAT（10．ADJ FACT 1／1／／／4F12．4）
149 C ADJIJST CUPRENT FSTIYATES FOR LOG BIAS
$150 \quad$ DO $561 \mathrm{~J}=1,39$
$151 \quad$ CO $561 \mathrm{~K}=1,33$
$152 \operatorname{EST}(4, J, K)=0.0$
$153 \quad$ D $561 \mathrm{I}=1,3$

154
155
$156 \quad \operatorname{EST}(4, J, K)=\operatorname{EST}(4, \mathrm{~J}, K)+\operatorname{ESF}$
$157 \quad 561$ CONTINUE
158
DO $55 \quad \mathrm{I}=1,4$
07 $55 \mathrm{~J}=1,38$
D0 $55 \mathrm{~K}=1,38$
$\operatorname{CD}(I, J, K)=(A C T(I, J, K)+500.1 / 1000.0$
55 CONTINUE
C $* * L$ ISTING OF CURRENT，ACT ND LONGER NEEDED
ITYP $=1$
ISC $=1$
CALL WRITE（CD，ITYO，IB，AVT，LENTH，TYPE，SCALE，ISC，AIDI

```
    D\cap 562 I =1,3
    D\cap 562 J=1,37
    ESTX = EST (I,J,39)
    IF:( ESTX.LT.LCO.)ESTX=100.
    562. ECMT (I,J) = ACT(I,J,39)/ ESTX
        D] 56 I=1,4
        D0) 56 J=1,38
        DO 5h K=1,38
    C.*** ACT WILL CONTAIN CMRPENT CASCADED EST, EST WILL HAVE GPAV EST
        XET= FST(I,J,K)
        ACT(I,J,K)=XET
        CD(I,J,K)=(XET + 500.) / 1000.
        56 CMNTINUE
        ITYP = 2
        ISC = 1
        CALL WRITE ( CN,ITYD, IB, AVT, LENTH, TYPE, SCALE, ISC,AIDI
        HRITE ( b,l2lO) TVPE(2)
        CALL XNEENS ( AVT, AIT, EST, STD, IPX , POPI
    C CIJRRENT CASC
        CALL CASD ( FCMT,ACT)
        D] 571 I=1,4
        D) 571 J=1,3R
        D:) 5? 1 K=1,38
        CD(I,J,K)=(ACT(I,J,K) + 500.) / 1000.
    571 CONT INUEE
        ITYP = 3
    CALL wRITE ( CD,ITYP, IB, AVT, LFNTH, TYPE, SCALE, ISC.,AID)
```



```
C 1970 NEEDS
            IPX=1
    1210 FORMAT ('1 ', 14)
    WRITS (6,1210) TYPE(3)
    CALL YNEENS ( AVT, AID, ACT , STD, IPX, POP)
    1170 CONT INUE
                DO 118: I= 1,4
                00 1180 J=1,38
                DO 1135 K=1,38
            ESTM (I,J,K ) = ?.
    118% CTNTINUF
    C START PROJECTIDNS
            READ (5,1165, END=1COO) AID
                IPP = 1
            CALL PEAD ( PODN, ATM, IPP)
            CALL AVL (AVM, \triangleTA,DD,DS,IAC )
            CALL TRAN:S (ATM,AVM,?DOM)
            WRITE (6,1178) AVT,AIO
    1178 FORMATI'1 FCYT ESTIYATES (1975 ANO LATER) AND STANDARDS' /
            1 /2(x,!4A/4)
                CALL ECRD ( ECHT,STOI
            IN = 1
            WRITE (6,11GR) IN
            1185.FORMAT (.1, 614)
```



```
    C GRAYITY FSTIMATES
            CALL EXT( \capS,Z\because, \TM,DOPM,AV ,ESTM,ACT,XB,IX,DP, NV ,IN,F )
            DO 62 I = 1,4
            [] 62 J = 1,38
            D} 62 K = 1,38
    62 CD(I,J,K)=(ESTM(I,J,K) + 500.1/1000.0
```

```
    ITYP =2
    ISC = 1
    CALL WRITE ( CD,ITYD, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
    C ##%%%###%っ%%%%%####%
    C PERCENTAGE INCREASES
        0ก 90 I = 1,4
        00 9ij J = 1,38
        0? 90 K = 1,39
        ACX = ACT (I,J,K)
        ACX = EST (I,J,K)
        IF (ACX.LT.1.0 ) ACX = -ESTM(I,J,K) + 0.1
        90 CD(I,J,K) = ((ESTM(I,J,K) / ACX)*100. ) +C.5
        ITYP = 4.
        ISC = 2
        CALL WFITE ( CD,ITYO, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
    C %%******%*%*****
    C. NESDS FOR GRAVITY MODF IMADJUSTED, IPX=1 IN COL 2 IN CADDS
        IPX = 1
        WRITE (6,121O) TYPE(2)
            CALL XNEEDS (AVT, NID, ESTH, STD, IPX, POPMM)
            CALL CASD ( ECMT, FSTM)
            DO 850 I=1,4
            [0 850 J=1,3?
            On 850 K=1,38
            CO(I,J,K)=1ESTM (I,J,K) + 500.)/1000.
    85% CONTINUE
        ITYP=3
        ISC = 1
        CALL WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
        DO }87\textrm{I}=1,
        07 87 J=1,38
        D) 87 K=1,38
        xCn = ESTM (I,J,K)
        ACX = ACT(I,J,K)
        IF (ACX.LT.1.O) ACX = -XCD + O.1
        CD (I,J,K) = (XCD/ACX)*10C. + 0.5
        87 CONTINUE
        ITYP = 5
        ISC = 2
        CALL WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AIDI
        C #%%%%%%%
        C NEEOS
        C *** IDX=2 IDENTIFIES CASCADED PROJECTIONS AND NEEDS, CDL 2 IN CARDS
        IDX=2
        WRITE (6,1210) TYPE(3)
        CALL XNEEDS ( AVT, AID, ESTM, STD, IPX, POPM)
        60 T2 117%
        1000 STMP
        EvD
            SUBROUTINE READ (OOD,AT, IPP)
        DIMENSION POP(37,1C), AT 37,50)
        DO 9045 I = 1,37
        READ (5,0)28) II, (ODP(I,J),J=1, 4)
    902\Omega FTRMAT (4X, I4, 8X,F8.C, F8.3, F8.0, 24X, F8.0)
        IF (I.NE.TI ) GO TO Ol34
        GO TO 9045
        9134 URITE (6,9334) II,I 
            STDD
        9045 CONTINUS
```

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238 299 200 291 292 293 294 295 296
207 298
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301
$3 r ?$
$3: 3$
3.4

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306
3)7

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311
$31 ?$
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318
310.
$32 ?$
32.1

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325
$320^{\circ}$
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330
331

```
    0016 I = 1,37
    D? gr. 15 K=1,5
    JJ=(1r*k)-9
    JJJ=1%*K
    READ(5,901C)II,KK,(4T(I,JK),JK=JJ,JJJ)
    O010 FORMAT (I3,3X,I4,1\capF7.3)
    IF(II.NE.I.OP.KK.NE.K) GO TO 9011
    GO T! 9r.15
    Q\cap1] WPITE (6,9\cap12)I,II,K,KK
    9012 FOFMAT( ' AT CAROS OUT OF OROER',4I4.
    STOP
    9015 CONT INUE
C #** POP I4 IS DOP DENSITY D!JT IN AT 35
    AT ( I, 36) = PMF (I,4)
C. SCALE AOJUST FOR PROJECTIDN AT
            IF (IPP ) G110,0216,9110
    9110 AT (I,15)= ^T (I,15)/10
    AT (I,16)=AT (I,15)/ 1n0
    \DeltaT (I,17)=AT (I,17)/10
C *%%%%%*%%*******
    9216 COMTIMMJE
```



```
C *** AT 44 IS TOTAL SMALL GAME INDEX
    AT (I,44)=?.
    Dr) 9116 KK=1;6
    \DeltaT(I,44)=AT(I,44) + AT(I, KK+36)
    9116 CJNT INUE
C %%* AT 45IS PFOPDRTION ACRES LEASED
    AT (I,45)= AT(I,27) / AT(I,26)
C*** AT 46 IS ALL SUIMYINO
    AT (I,46)=AT(I,32)+.1*AT(I,33) +.100J.*AT(I,34) + 10.*AT(I,3
C %** AT47 IS ALL YDS FISHIVG
    AT (I,47)=AT(I,?2) + AT(I,?3) + AT(I,24)
C **:* AT(48) ADF ALL CA:IDSITES
            AT (I,4E)=10n.*AT(I,1.3)+AT(I,13) + AT(I,20)
C *** AT 49 IS ALL PICNIC
            AT (I,42)= 1rn.*AT(I,29) + AT (I,31)
C AT 50 IS ALL PIOATPAMOS
            AT(I,5O)=AT(I,10)+\DeltaT(I,11)
        901% CONTINUE
            RETURM
            END
            SURROUTINE AVL (AV,AT,RD,DS,IAC)
            DIMENSION AV (3,37,50), AT(37,50), DO(10,3), DS(37,37)
C DV = SUQ (AT) (DS**[D)
```



```
333 C DO 86^ K=1,3
334 C On 860 I=1,37
335 C DO 36? J=1,50
336 C AV (K,I,J) = ?.?
343 C ......IF (DIS.LF.DMN) DIS=DMN
344 C DIX = OIS
345 C 积%%%%%%%
346 C SPECIFY HERE ONLY THDSE.AV NEEDED (IJ RANGE)
```

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338
339
34 C
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342

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452
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454
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456
457
459 C
$46 ?$
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465

```
435 C ANY RECOMBINATIONS IIAY BEPROGRAMMED HERE
436 C USE Z(30n-350)
437 XPP = EXP(P\capP(I,1))/ 1ONO.
4 3 3 ~ C ~ 7 7 ~ I S ~ R A T I O Y ~ O F ~ G F O N I N I S ~ S E A S O N ! ~
439 ....Z(7) = 4T(J,?) - 4T(I,2)
44? C * % % SWIMMING
    D! 949 [0=1,3
    DMN = IN*2%
    7.Y = חS (I,J)
    IF ( ZY.LF.OMN ) ZY= DMN
C ZTY = ZY + 15.
    7ZY = ZY
    Z (21C+IP)= ALOG (ZTY)
    ZY = DP (IP,I,J)
    IF (IN.EO.1) GOT Tก 949
    Z (2.16 + IR ) = AL\capC ( ZY + 1.0)
    7. (21O+IR)= ZY
    ? (223) = Z (223) + 7.Y
    XIO = IR*1!?
    IF (ZY.EO.R.D.ANO.TZY .LE.XIDIZY=50.
    Z(213+IR)=\DeltaIOG(ZY+1.n)
C Oח 948 IO=1,50
C 2 (50%IR + IO ) = AV (IR,I,IQ)
    C 948 CONTIMUE
    949 COMTINUE
    DO G50 IR = 1,50
    Z (IR)=AT (J,IR)
    950 CONT INUE
    DO 951 IR=1,10
    Z. (IP + 20\cap ) = POP (I,IR)
    951 CCNTINUE
```



```
    END नF VAPIARLF DCOL GFNFRATION
```



```
    AT1 = AT ( I, 46)
    AT2 = AT(J,46)
    FV = DEXP (AT1)
    FW = DEXP(AT1 - AT2)
    Z(306)=Z(211)*FV
    Z(3こ7)= Z(212)*FV
    Z(3r3)= ?(213)*FV
    7. (3.99)= ? (211)*FN
    Z (31%)= Z (2.1?)*FW
    Z (311)=Z (213) % FW
```



```
    SELECT
```



```
            D) 452 K=1,3
            DO 45? II =1,NV
            X (K,II) = Z (IX(K,II))
        45? CONTINUE
            NCT = 1+NCT
```



```
            IF (NCT.rE. 13) GOTO 4?
            WITF (6,41) NCT, (x(1,K),K=1,NV)
        4 FJR|^T (' ',I4,(/,'. ',ICF9.4))
        4. 42 CDNTIVUC
    IF (IN.EO.1) GO TO 2%6
            O\cap 205 II = 1,4
            XA = Z (219 + II)
```

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47 ?
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476 C
$477 \quad$ DD $40 K=1,3$
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49.7

IF ( XA.EV.O.O) GO TO 205
ACT (II,I,J) = XA

205 CONTINUE
206 CDNTINUE

C PREDICT
$X X(K)=X B \quad(K, M)$
DG $48 I A=1, N V$
43 CONTIM!JE
$Y=(E X P(X X(K))) * F(K)$
EST $(K, I, J)=Y$

49 CONTINUE
940 CTNTINUE
RETURN
ENT
INTEGER CD

DO. $30 \cap \quad I=1,4$

1 ' ESTIHATE FDP 1,6A4)

WRITE(6,2021)
20?1. FORMAT (50X, 'DESTINATION!)
WRITE(6,222)(IJ,IJ=1,24)
202 FORMAT(/' DRIGIN', 24I5.1)
DO 290 $J=1,37$
2 O3 FORMAT $(3 x, 12,2 x, 24$ I5)
2031 FחRMAT(/' TOTAL ..,24I5)
200 CONTINUF

WPITE(5,2021)
WRITE $(6,276)(I J, I J=25,37)$
DC 2g: $J=1,37$
$2 \cap 7$ FORMAT ( $3 \mathrm{X}, \mathrm{I} 2,2 \mathrm{X}, 1315,17,4 \mathrm{x}, \mathrm{I} 2)$
280 CONTINUE

ACT (II, 38,J) =ACT (II, 38, J) + XA
$A C T(I I, I, 3 S)=\triangle C T(I I, I, 38)+X A$
$A C T(I I, 33,38)=A C T(I I, 38,38)+X A$
$X X(K)=X X 1 K 1+X B(K, I A) \neq X(K, I A)$

FST $(K, I, 38)=E S T(K, I, 38)+Y$
EST $(K, 38, J)=E S T(K, 38, J)+Y$
EST $(K, 38,38)=$ EST $(K, 33,38)+Y$
FST $(4, I, J)=E S T \quad(4, I, J)+Y$
EST $(4,33, J)=E S T \quad(4,39, J)+Y$
EST $(4, I, 33)=$ EST $\quad(4, I, 39)+Y$
EST $\quad(4,39,38)=$ EST $\quad(4,39,38)+Y$

SIJRPחITTIUE WRITE (CD,ITYP,I $A, A C T, L E N T H, T Y P E, S C A L E, I S C, A I D)$
DIMENSIDN CD (4, 38,38), TYPE(5), LENTH(4),ACT (8), SCALE(4),AID'

WRITE (6,2OQ) (ACT(IQ), IQ=1,8) , ( $\triangle$ ID(IO), IQ=1,6)
20! FIJRMAT ( 11 GRAVITY MODEL , ACTIVITYIS, 3A4,
WRITE $(6,2 C 1)$, LENTH(I),TYPE(ITYP),SCALE(ISC )
2)1 FORMAT: QFIGIN/DESTINATION', 4 X , TRIPS=1, A4, 4 \%!TABLE CONTAINS ... ', 14, IX, A4/1

WRITE $(6,203)$ J,CD (I,J,K),K=1,24)

WRITE $(6,2 C 31)(C D(I, 38, K), K=1,24)$
WRITE $(6,20 C)(A C T(I O), I Q=1,8),(A I D(I Q), I Q=1,5)$
WPITE $(6,201)$ LENTH(I), TYPE(ITYP),SCALEIISC )

2r.6 FITRMAT(/' ORIGIN', 13 I5,4X,'TOTAL'/)
WRITE (S, 2C7)J, (C) (I,J,K),K=25,38)

WRITE $(6,209)(C O(I, 39, K), K=25,38)$
209 FORMAT(/' TOTAL. , 13I5, [7////)

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30？CTNTTOUE
RETURM
FNO
SUEODUTINE YNEEOS（ AVT，NJO，EST，STO，IPX，POPI
DIMENSION POP $(37,10)$
DIMENSIGN AVT（3），AID（6），EST（4，38，38），STD（37）
URITE $(6,71) \triangle V T, A I O$
71 FORMAT（19 NFEDS＇， $8 \triangle 4,1,1,6 \Delta 4$ ）
WRITF（6，72）
72 FORMAT（＇？REGION PROJ CAPACITY DIFF PATIO IORIGIN TOT PCAP POP＇，／／I
$S T T=0$ ．
ロา $70 \quad[=1,37$
XORIG $=$ EST（ $4, I, 23) / 1$ Cr．．
EXS $=$ EST $(4,33,1) / 1000$ ．
$X P P=F X P(\operatorname{POP}(1,1)) / 1000$.
$X P C=X O R I G / X P P$
STC $=$ STD（I）／lCON．
$S T T=S T T+S T C$
YNT $=$ YNT＋STC
$V A C=E X S-S T C$
RVAC $=S T C / E X S$
WRITE $(6,73) I, ~ E X S, ~ S T C, ~ V A C, ~ R V A C, ~ X O Q I G, X P C, X D P$
C STATEMENTS FOQ PUNCHING CAROS WPITE（7，75）IPX，AVT（1），AVT（2），AIO（1），AID（2），I，EXS，STC，
1 VAC，$\because V A C, ~ X \cap R I G$
75 FIRUAT（I？，4A4，［4，2FIr．n，FIO．3，F1O．J）
70 CTHTINUE．
$E X S=F S T \quad(4,38,39) / 1 \div 00$.
VAC $=E X S-S T T$
RVAC $=S T T / E X S$
WRITE（ $G, 74)$ EXS ，STT，VAC，PRVAC
74 FORMAT（＇O TOTAL ，3F10．0，F1U．31
RETUR $\because 1$
ENID
SURPDUTINE ECRO（ECMT，STD）
DIMENSION SCMT（ 2，33），STD（37）
CATA DSY／＇S＇／，DLY／＇L＇／

C PEAD STAVDARDS PROJFCTIONS READ（5，1183）AYI，IVI，STD
1183 FOOMAT（ $44,[4,2 X, 7 F 3.0 /(19 X, 7 F 3.0) 1$
WNITF（ 6，1184）AYI，IYI，STD
1184 FORMAT（1～1，A4，I5，7F12．7／（ $10 \times$ ，7F12．01）
DETIJRN
END
SUBROUTINE CASD（ ECMT，ESTM）
DIMENSICN FCMT $(3,38)$ ，ESTM $4,38,38)$
C＂それ RATIO AOJUST：AENT DROCEDURE
D0 $9 \mathrm{~J}=1,39$
DO $9 \mathrm{~K}=1,38$
FSTM $(4, J, K)=2.0$
ก？ $9[=1,3$
ESTM（I，J，39）＝C．$\quad$ ）
ESTA（ $I, 38, K)=$ ．？
9 CONTINIS
กิ i）$I=1,3$
กา $12 \mathrm{~J}=1,37$
（ר） 1 i？$K=1,37$

CDRE USAGE

DIAGNOSTICS
COMPILE TIME=


$$
\text { OB.JECT CODE }=\quad 44 \cap \text { BYTES, ARRAY AREA }=
$$

? BYTES, TDTAL APE
ESTX = ESTM(I,J,K) * ECMT(I,J)
ESTM (I,J,K) = ESTX
ESTM (I, J,39) = ESTH ( I, J,38) + ESTX
ESTM ( $1,38, K$ ) $=$ FSTM $(1,38, K)+$ ESTX
ESTM $(1,38,38)=$ ESTM $(1,38,38)+$ ESTX
ESTM ( $4, \mathrm{~J}, \mathrm{~K})=\operatorname{ESTM}(4, \mathrm{~J}, \mathrm{~K})+$ ESTX
ESTM $(4, J, 38)=$ ESTM $(4, J, 38)+E S T X$
ESTM $(4,38, K)=E S T: 1(4,38, K)+E S T X$
ESTM $(4,38,38)=$ ESTM $(4,38,38)+$ ESTX
CONTINIUE
RETURN
END

NUMBER OF ERFORS =
©, NUMBER OF WARNINGS=

$$
\because, ~ N U N E
$$

O.OR SEC, EXFCUTIOU TIME=
3.55 SEC,


Data Format

> "PøP" Deck

| Co1's | FMT | Description |
| :--- | :--- | :--- |
| 1-8 | I8 | Region |
| 9-16 | F8.0 | Year |
| 17-24 | F8.0 | Pop., adj. to base used for grav. |
| $25-32$ | F8.3 | \% Urban |
| $33-40$ | F8.0 | Purch. pover, per capita |
| $41-48$ | F8.3 | Pop. density, new |
| $49-56$ | F8.0 | P.C. Income |
| $57-64$ | F8-0 | Family Income |
| $65-72$ | F9.3 | Pop. dens. ; adj to gravity |
| $73-80$ | F8.0 | Pop., new |

NOTE: (1) The population figures used in gravity estimation are somewhat different from data provided in August by TPV. Thus all projections are based on an "adjusted" population obtained by multiplying the TPW projections by the ratio of the two population estimates. (2) Projected per capita purchasing power is projected income multiplied by ratio of current purchasing power to current income. (3) Only the first: four ficlds are used by the gravity programs.

Data Format

> "AT" Decks

| Col's | FMT | Description |
| :---: | :---: | :---: |
| 1-3 | I3 | Region |
| 4 | I1 | $0=1970,1=1975,2=1980$, |
|  |  | $3=1990,4=2000$ |
| 5 | I1 | 1 Low, $2=$ Med, $3=$ High, $(1970=0)$ |
| 6-9 | 3 x |  |
| 10 | I1 | Card No. (1-5) |
| 11-80. | -10F7.3 | Ten attraction variables per card, in order given in Table 1 of Final Report |

Data Format
Econometric Model Estimates

| Col's | FMT | Description |
| :---: | :---: | :---: |
| 1-4 | A4 | Activity designation |
| 5 | A1 | S = Short ( $2 / 3$ day) trips |
|  |  | $L=$ Long (4+ day) trips |
| 7-10 | 14 | Year |
| 12-19 | A8 | High, Medium, Low |
| 20 | I1 | Card No. (1-7) |
| 21-80 | 6110 | Econometric estimates, six per card; |
|  |  | regions 1-37, followed by total state- |
|  |  | wide estimate; last four fields of |
|  |  | card 7 contain trash. |

NOTE: No econometric estimates exist for all fishing.

Data Format
Coefficient Decks

| Col's | FMT | Description |
| :---: | :---: | :---: |
| 1-3 | I3 | Activity No. |
|  |  | 1 Boating |
|  |  | 2 Camping |
|  |  | 3 All Fishing |
|  |  | 4 Freshwater Fishing |
|  |  | 5 Hunting |
|  |  | 6 Swimming |
|  |  | 7 Picnicking |
| 4-6 | I3 | Coefficient No. (1 to M) |
| 7-9 | I3 | Coefficient index as picked from |
|  |  | variable pool, last coefficient is |
|  |  | $B_{o}$ and has index of dependent variable |
| 10-21 | F12.6 | Coefficient |

Standards Deck

| Col's | FMI | Description |
| :--- | :--- | :--- |
| $1-4$ | A4 | Date and level |
| $7-8$ | I2 | Activity identification, coded as in |
|  |  | household survey |
| 10 | I1 | Card No. (1-6) <br> $11-66$ |
|  |  | Standards (Capacities), last card has <br> only two entries |

Note: Standards used for fishing were not supplied by TP\&W and have col's 1-8 different. This does not affect programming.

