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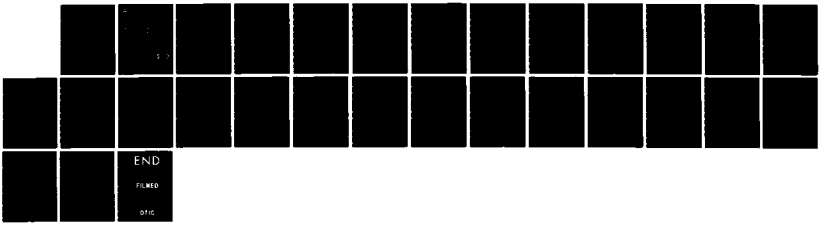

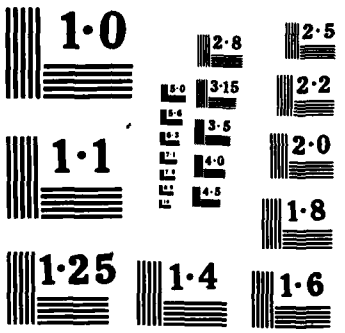
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US Army Corps
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A Guide to the Use of the IWR Interactive Ratio Forecasting Program

(PC-DOS PERSONAL COMPUTER VERSION)

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)* This report provides instruction for using the personal computer version of an interactive ratio forecasting program which can be used for developing forecasts of socioeconomic variables for small areas. Four commonly used methods are available in the program: basic ratio, average annual ratio, ratio difference, and shift share. These methods and their appropriate uses are described in the report.	

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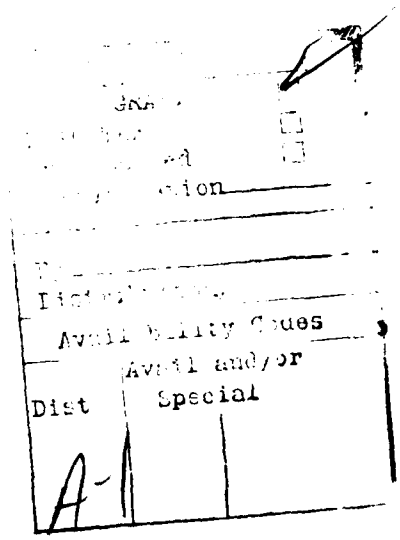
by

C. Mark Dunning, Ph.D.



Institute for Water Resources
Casey Building
Fort Belvoir, VA 22060-5586

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Table of Contents

1. Introduction

This user manual describes the IBM Personal Computer version of a ratio forecasting program developed at IWR. Several common ratio forecasting methods are available to the analyst in the program. These methods and their uses are described in section 2 of this manual. A presentation of the procedures involved in running the program is provided in section 3.

The development of this program proceeded from the observation that many Corps study areas are too small to have forecasts available for them. Since many plan formulation and evaluation tasks require forecasts of study area variables such as population, income, and employment the Corps analyst often faces a dilemma in obtaining or generating such forecasts for small study areas.

The ratio methods described in this manual and available in the program offer a means to generate forecasts of socio-economic variables for small areas. The methods are widely used to generate population and employment forecasts (see for example, Shyrock, et al 1972; Hammond, 1973; Greenberg, et al, 1978; U.S. Bureau of the Census, 1972). It should be noted that other variables of interest to Corps planners (e.g. income, price levels, etc.) can be forecast using the ratio methods described in this manual. Essentially, these methods produce forecasts for small areas by allocating an independently derived forecast of the variable(s) for a larger area (state, SMSA) among smaller subcomponent areas on the basis of past ratios of these smaller areas to the larger area for the variable being forecast.

These methods can thus be used to "step-down" forecasts for larger areas to study areas using a definable analytic structure and framework. Ratio techniques are premised on the assumption that a small area will continue to have a similar relationship to a larger area. The methods, thus, are wholly "top-down" in the way in which small area forcecasts are derived. They do not take into account plans, expectations and developments in the small area which may affect the historical relationship between small and large areas combined in the ratio(s) being used to generate forecasts. Judgment, on the part of the analyst, is thus necessary in using these techniques to generate forecasts just as it is necessary in adequately using any other forecasting method.

The central focuses of this manual are on the description of the ratio methods and on providing instruction on the use of a forecasting program. The manual is not intended to address the issue of the use and misuse of forecasts.

Several sources provide detailed discussion of this topic (see for example, Armstrong, 1978; Pittenger, 1978; Robinson, 1982; Delli Priscoli, 1979; Oak Ridge Associated Universities, 1977). Nevertheless, it is important to emphasize that judgments on the analysts' part are important. In the case of ratio methods assumptions are important in reaching decisions about the change in the ratio of a smaller area to the larger area -- is the recent past likely to be more important than the distant past, are there major changes occurring in the small area which may affect the past trend? These and other issues must be addressed, and assumptions shaping the small area forecast clearly stated in the projection.

2. Ratio Methods

The IWR Program offers four ratio forecasting methods: basic ratio, average annual ratio, ratio trend, and OBERs shift share. These methods are described in greater detail below.

2.1 Basic Ratio. This method uses the relationship between a small area and a larger parent area at one point in time to generate forecasts for the smaller area. This relationship is expressed as the ratio of the small area to the larger area:

(1) $r_t = S_t/P_t$

where:

S = small area population

P = parent area population

t = time

r = ratio

Generally, the ratio is computed for the most recent time period for which data for the small area and parent area are available. However, more distant data can be employed, if the analyst judges that the ratio from the most recent data available is not suitable.

Forecasts for the small area are computed by applying the ratio obtained in equation (1) to a forecast of the parent area:

(2) $S_{t+j} = r_t * P_{t+j}$

As noted previously the parent area forecast is externally derived. This forecast is obtained from other forecasting procedures at the local or national level (e.g. state or local planning agencies, OBERs).

The chief advantage of the basic ratio method is its ease of use. Only one data value for the small area and parent area is needed in combination with the parent area forecast in order to obtain a small area forecast. The primary potential disadvantage of the basic ratio method in comparison with the other methods described in this manual, however, is that it permits no use of information concerning how the relationship between the small area and parent area has changed over time. In periods of rapid change, when fundamental changes may be occurring in the small area, historical patterns of relationship may not be important. However, as a general rule, historical information about the past relationship of small to large areas can aid the analyst in making judgments about the future of the small area.

Example: Computation for population St. Clair County, Illinois using Basic Ratio Method

$r_{80} = S_{80}/P_{80}$

S_{80} = St. Clair County, 1980 (265,469)

P_{80} = Illinois, 1980 (11,418,461)

$r_{80} = .02325$

$S_{90} = r_{80} * P_{90}$

$= .02325 * 11,804,539$

$= 274,456$

2.2 Average Annual Ratio. The concept of an annual average rate of change is frequently used by Corps economists in computing benefits and costs. In the average annual ratio method for deriving small area forecasts, information about the ratio of the small to large area at two points of time is used to create an annual average change in the ratio. In this way a greater amount of information is employed in the forecasting process. The average annual method used in the IWR program has been derived from a method presented in White, et al 1953. The process is presented below:

(3) $y = r_t / r_{t-n}$

where:

y = ratio of ratios

r_t = ratio of small to large area at time t

r_{t-n} = ratio of small to large area at some previous time

(4) $i = t-(t-n)$ time interval between data points

(5) $A = \frac{1}{y^{\frac{1}{i}} - 1}$ average annual rate of change in ratio of small to large area

(6) $r_{t+j} = r_t * (1+j(A))$ ratio extrapolated j years into future on basis of annual average change

(7) $S_{t+j} = r_{t+j} * P_{t+j}$ forecast for small area at t+j

Example: Computation for St. Clair County, Illinois using average annual ratio method

$$y = r_{80}/r_{50}$$

$$r_{80} = .02325$$

$$r_{50} = .02357$$

$$= .98642$$

$$i = t - (t-n)$$

$$= 80-50$$

$$= 30$$

$$A = \frac{1}{.98642^{30} - 1}$$

$$= (\text{antilog } (\log .98642)/30) - 1$$

$$= -.000456 \text{ (average annual change = (-0.0456 percent)}$$

$$r_{80} = r_{90} (1 + 10 (-.000456))$$

$$= .02325 (.999544)$$

$$= .02314$$

$$S_{90} = r_{90} * P_{90}$$

$$= .02314 * 11,804,539$$

$$= 273,204$$

2.3. Ratio Difference Method. The ratio difference method inspects the change in ratios over time expressed as differences in ratios and projects on

the basis of these changes. Thus, like the average annual method, this method offers the advantage of incorporating historical information. However, where the average annual change method assumes a continuous slope in the historical change in ratios, the ratio difference method allows the use of information about fluctuations in the ratios over time. The ratio difference method presented in the IWR program was developed on the basis of a description of this technique in Pickard (1980).

The method allows past ratios to be weighted according to the judgment of the analyst. In the IWR program the user has two choices for weighing past ratios. In the first option the most recent ratios are weighted more heavily as an inverse proportion of this time from the period to be forecast. The second option allows the user to choose weighting factors (e.g. weight all ratios equally, weight past more heavily, etc.).

The ratio difference method is presented below:

(8) $D_t = r_t - r_{t-i}$ Difference of ratios where

r_{t-i} = ratio at some previous interval

(9) $$\bar{D} = \sum_{t}^{t-n} W(D)$$ Weighted average of differences; where weighting factors (w) are chosen by the user or are computed as below

(10) $w_j = \frac{1}{t+n - t_j} * 100$ factors weighted in inverse proportions to their distance in time from the period to be forecast.

(11) $S_{t+n} = (r_t + N(D)) * P_{t+n}$ Forecast for small area.

For example, for St. Clair County, Illinois:

$r_{50} = .02357$

$r_{60} = .02553$

$r_{70} = .02561$

$r_{80} = .02325$

$D_t = r_t - r_{t-i}$

$D_{50-60} = .00196$

$D_{60-70} = .00008$

$D_{70-80} = -.00236$

Weighting Factors:

For 1990 forecast

$W_{50-60} = \frac{1}{1990-1960} * 100 = 3.3$

$W_{60-70} = \frac{1}{1990-1970} * 100 = 5$

forecasts for each of the small areas as described in section 3.2.4. Examples include forecasts for SIC categories comprising a parent area employment forecast, forecasts for townships comprising a county for which an external forecast is available. It is unlikely that the small area forecasts will exactly total the value of the parent area. The reconciliation subroutine scales the small area forecasts so that they sum to the value of the parent area forecast. The scaling factor used is the ratio of the summed small area forecasts to the parent area forecast. Each small area forecast is then multiplied by this scaling factor to generate the reconciled small area forecasts. If the small areas do not entirely encompass the parent area a "Balance" is automatically computed representing that portion of the parent area not included in the small areas. A forecasted "Balance" is computed on the basis of the most recent ratio of the "Balance" to the parent area. This balance is then treated just like a small area in the scaling routine.

The reconciled summary table is then produced:

Reconciled Summary Table of Forecast Values

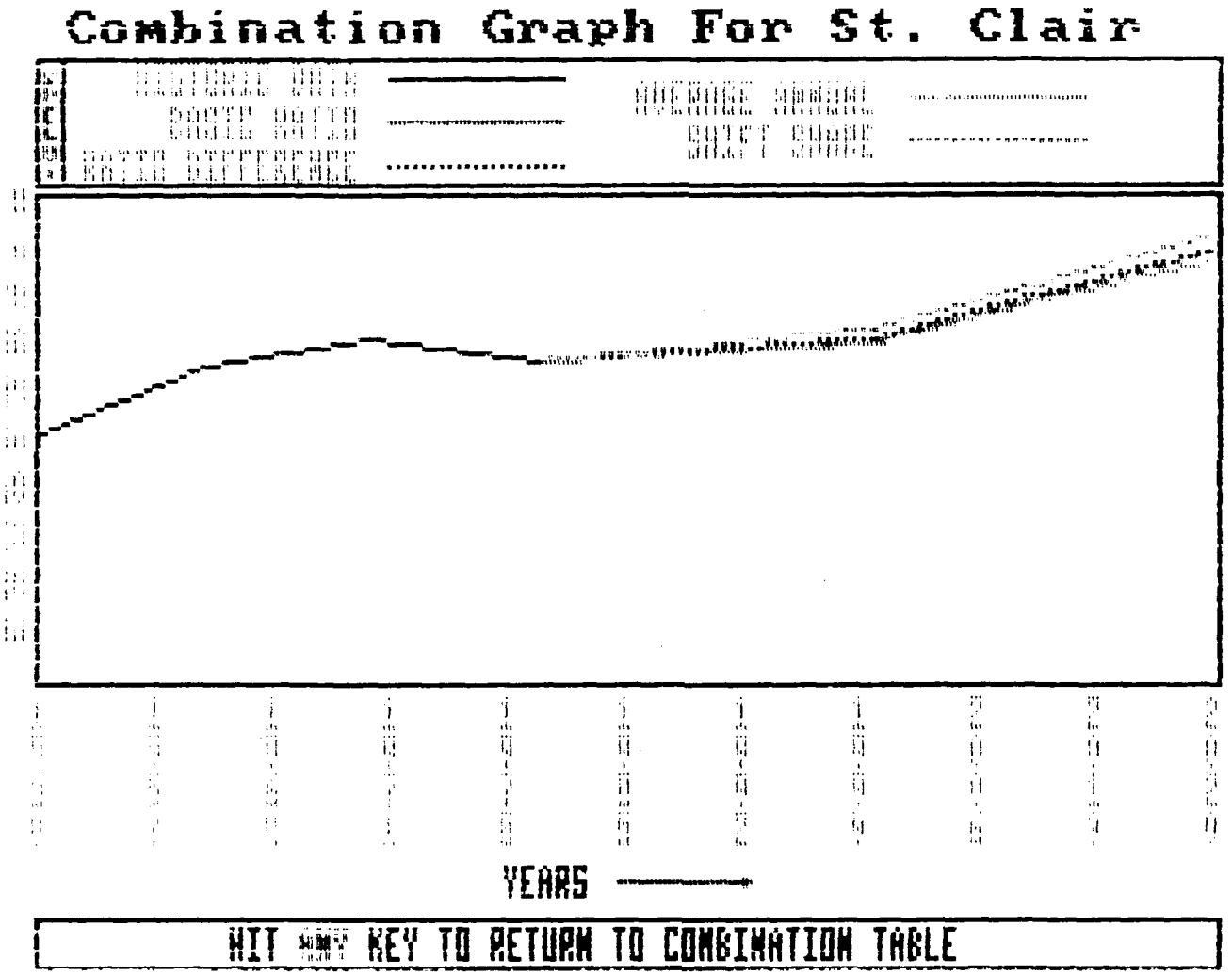
Forecast Year	1990	2000	2010
Parent Area			
Illinois	11804539	12263810	13877000
Division Area			
St. Clair	279489	291959	331424
Calhoun	8901	9454	10838
Balance	11516149	11962397	13534738

Press ESCAPE to return to main menu Press <- to scroll table to left
Press the G key to see a graph

Once again the table can be graphed by pressing the "G" key.

Figure 1.

Sample Graph of Small Area Forecasts



Combination Table for St. Clair, Illinois

Forecast Year	1990	2000	2010
Parent Area Illinois	11804539	12263810	13877000
Forecast Methods			
Basic Ratio	274444	285122	322627
Average Annual	273173	282480	318143
Ratio Difference	274337	285084	322605
Shift Share	279627	292147	331667

Press 1, 2, 3, or 4 to load the ata from the corresponding forecast mentod into the overall forecast:

1-Basic Ratio Method 3-Ratio Difference Method
2-Average Annual Method 4-Shift Share Method

Press ESCAPE to return to main menu Press <- to scroll table to left
Press the G key to see a graph

A graph of the forecasts can be created by pressing the "G" key. Figure 1 illustrates the graph which is produced.

If the user wants to use a particular forecast it can be extracted and placed in a seperate array for later use by following the instructions at the bottom of the table. That is, if the user feels that the shift share method has provided the best forecast, this forecast can be saved into an array for later display by pressing the "4" key.

The "ESC" key is used to select another small area for forecasting or to exit to the main menu .

3.2.5. (Option 5) Parent Area Reconciled Forecast. This option of the program can be called into operation when the analyst has generated forecasts for several small areas which encompass a parent area and has saved individual

3.2.4. (Option 4) Small Area Forecast. Forecasts for small areas are made individually, one at a time. Results of these forecasts can then be stored away for combining into a joint table (see section 3.2.5). Upon selecting option 4 the computer first prompts the user to identify the small area for which a forecast is to be generated. Then the user is given the option of invoking a default method of generating forecasts for the area or of providing input paramenters to the ratio forecast routines. For the default method of computation the following conventions are employed:

o Basic ratio	Most recent ratio
o Average Annual	Difference of first and last historical ratios
o Ratio Difference	Proportional weighting
o Shift Share	Most recent ratio as starting point for extrapolation of historical change in ratios

For the user controlled method of computation, the user has the following choices:

o Basic ratio	Any historic ratio
o Average Annual	Same as default
o Ratio Difference	User supplies weighting factors for historical differences
o Shift Share	Choice of most recent ratio or average ratio as starting point for extrapolation of historical change in ratios

After selecting the method of computation and entering the appropriate choices if the user supplied method of computation was selected a table like the below is produced. This table presents the parent area forecast and the derived forecasts for the small area using the four ratio methods. The table can be examined using the "<- ->" keys.

Example:

Forecast Data Display

Forecast Year	1990	2000	2010
Illinois Forecast Data	11804539	12263810	13877000
Historic Year	1950	1960	1970
Illinois Historic Data	8738000	10280000	11137000
St. Clair Historic Data	205995	262509	285176
Calhoun Historic Data	5600	6500	6700

Press ESCAPE to return to main menu Press <-to scroll table to left
Press the E key to edit data

Pressing the "E" key allows the user to access an edit menu.

Example:

Edit Menu

1-Change Parent Area Name

2-Change or Add Small Area Names

3-Change or Add Years of Historic Data

4-Change Historic Data

5-Change or Add Years to be Forecast

6-Change Forecast Data

Detailed instructions accompany each of the options which can be selected. For example, if or more historical data items had been entered incorrectly, the user would access option 3, and follow instructions which appear on the screen.

The final data entry element to be provided is the forecast for the parent area for the dates identified.

Example: "Enter the forecast for Illinois for 1990"

------- "11804539"

For experienced PC users, basic data entry can also be accomplished outside the IRFP/PC by using an editor to create a data file with the same format as the program creates when it stores the input data. Interested users can create a data file using the IRFP/PC prompts, save the data file (see section 3.2.6.), and then examine the structure of the file using an editor on the PC.

3.2.3. (Option 3) Examine/Change Forecast Data. Selecting option 3 displays a formatted screen of data which has been entered into the program. At the bottom of the table are instructions enabling the user to return to the main menu, to enter an edit mode to make changes in data, and to operate the right or left "arrow" keys on the PC to scroll the table to the right or left in order to inspect all the data.

Data entry for the specified historical time periods is then accomplished by cycling through the particular time period for each of the areas chosen.

Example: "Enter data for Illinois for 1950"

------- "8738000"

"Enter data for St. Clair for 1950"

------- "205995"

"Enter data for Calhoun for 1950"

------- "5600"

Next, the user is prompted to enter the dates for which an independent forecast for the parent area are available. In the current version of the IRFP/PC a total of ten dates can be input.

Example: "Enter year for which forecast is available for Illinois"
enter a 0 to stop"

------- "1990"

------- "2000"

------- "0"

instances where this number of small areas is not sufficient for user needs areas can be aggregated and then disaggregated.

Example: "Enter the name of the division area #1"

-------- "St. Clair"

"Enter the name of the division area #2"

-------- "Calhoun"

"Enter the name of the division area #3"

-------- "return"

The user is then prompted to enter the years for which historical data for both the parent area and small areas are available. In the current version of the IRFP/PC the user can input up to 14 dates for which historical data are available.

Example: "Enter the years for which historical data is available, enter a 0 to end"

------- "1950"

------- "1960"

------- "1970"

------- "1980"

------- "0"

3.2.1. (Option 1) Load Forecast Data From File. Data for small areas previously entered into the IRFP/PC program can be saved in a file and accessed later. When the user enters a "1" in response to the main menu prompt the computer will respond with:

"Enter the name of the file that contains the data"

The user should enter the appropriate file name and disk drive following standard DOS format. For example, if the data file has been named "area.dat" and is in drive B, the user should type "b:area.dat" in response to the prompt.

After loading data the program returns to the main menu.

3.2.2. (Option 2) Enter New Forecast Data. To load data into the IRFP/PC the user is prompted to first provide the name of the larger unit (called the parent area). This is the unit for which an independent forecast is available which will drive the ratio forecasts the IRFP/PC program will compute.

For example: "Enter the name of the parent area"

-------- "Illinois"

The user is then prompted to enter the names of the small areas for which forecasts are sought. These areas are entered one by one. When there are no more small areas to enter, the user presses the "return" key. In the current version of the IRFP/PC a maximum of eight small areas can be entered. In

System Requirements

The IRFP/PC program requires that the PC have at least 128K memory and one disk drive. A color monitor is also desireable. In order to produce graphics the PC must have at least 256K memory and a graphics monitor.

3.1. Accessing the Program. The IRFP/PC is started by typing in "RFP" beside the DOS A> prompt.

The program will then display a sign-on message, and prompt to press any key in order to continue. Upon entering any key the program's main menu will be displayed.

3.2. Main Menu. The main menu offers the following options:

Main Menu

1-Load Forecast Data From File

2-Enter New Forecast Data

3-Examine/Change Forecast Data

4-Small Area Forecast

5-Parent Area Reconciled Forecast

6-Save Forecast Data

7-End Program Execution

These options are described in detail below.

3. Using the Interactive Ratio Forecast Program

The interactive ratio forecast program, PC version,(IRFP/PC) performs the following functions:

- o generates forecasts for small areas using any of the four ratio methods
- o generates a "composite table" of the four ratio methods so that values can be compared
- o makes revisions to data erroneously entered
- o generates forecasts for multiple small areas which are subcomponents of the same parent area.
- o provides a graphic representation of the forecasts
- o reconciles forecasts of multiple small areas so that they sum to the value of parent forecast.
- o stores data to a file
- o reads data from a file

$$= \frac{-8.8900 + 8.88965}{2.7228 - 1.9049}$$

$$= \frac{.0065}{.8179}$$

= .0079 (1.008 expressed as natural number)

$$S90 = (\text{antilog } (r_{80} + b*\log 10)) * P_{90}$$

$$= (\text{antilog } (-1.6336 + .0079 * 1)) * 11{,}804{,}539$$

$$= \text{antilog } (-1.6257) * 11{,}804{,}539$$

$$= .0237 * 11{,}804{,}539$$

$$= 279{,}479$$

2.5 Summary. Four methods employing ratios to derive forecasts have been described in this section. It has been established that each method has different data requirements, makes different assumptions about the distribution of historical information used to derive forecasts, and employs different mathematical procedures to generate forecasts. These differences in the methods are summarized in the table below. Having discussed the ratio methods in detail, the next section describes how to use the IWR ratio forecast program.

Table 1. Summary of Ratio Forecast Methods

	Basic Ratio	Average Annual	Ratio Differences	Shift Share
Minimum No. of Historical Data Needed	1	2	3	10*
Mathematical procedure to forecast	Simple ratio	Rate of Change	Weighted Average	OLS
Weight of Historical Data	NA	Equal	Variable	Equal

between small and parent areas has changed over time. This information is used to modify the current ratio (or an average ratio) r_t. The approach uses logarithms to compute the shift factor. Logarithms smooth the curve when rapid fluctuations in ratios have occurred. The computation of the shift factor b is shown below.

$$(13)\quad b = \frac{N \Sigma (\log t) * (\log r_t) - \Sigma (\log t) * \Sigma (\log r_t)}{N \Sigma (\log t)^2 - (\Sigma (\log t)^2}$$

As can be seen, equation 13 is the familiar ordinary least squares formula for computing the slope of a regression. This approach requires the use of a series of historical data. Generally, at least 10 historical data points should be used.

For example: for St. Clair County, Illinois:

Data:

Year	t	logt	$(\log t)^2$	r_t	$\log r_t$	logt * $\log r_t$
1950	1	.0000	.0000	.02357	-1.6276	0
1960	2	.3010	.0906	.02553	-1.5929	-0.4795
1970	3	.4771	.2276	.02561	-1.5916	-0.7594
1980	4	.6021	.3625	.02325	-1.6336	0.9836
		1.3802	.6807	-6.4458	-2.2225	

$$b = \frac{4 \Sigma (-2.2225) - (1.3802)(-6.4458)}{4 \Sigma (.6807) - (1.3802)^2}$$

$$W_{70-80} = \frac{1}{1990-1980} * 100 = 10$$

$$W_{50-60} = W_{50-60/EW} = .18$$

$$W_{60-70} = W_{60-70/EW} = .27$$

$$W_{70-80} = W_{70-80/EW} = .54$$

$$\bar{D} = W_{70-80} (D_{70-8-}) + W_{60-70} (D_{60-70}) + W_{50-60} (D_{50-60})$$

$$= .54 (-.236) + .27 (.008) + .18 (.196)$$

$$= -.09$$

$$S_{90} = r_t + 1 (D) * P_{90}$$

$$= .02325 - .0009 * 11,804,539$$

$$= 263,831$$

2.4. *OBERs Shift Share*. This procedure was developed by the Bureau of Economic Analysis. It combines a ratio component with a trend extrapolation of historical changes in the small area. This latter component is termed a shift factor and measures the difference in the small area's change accounted for by the simple ratio between the small area and the parent area, and the actual change observed. The method presented below was derived from Greenberg, et al, 1978.

The approach is presented as follows:

$$(12)\ S_{t+m} = (r_t + b (t+m)) * P_{t+m}$$

In equation 12, the term r_t represents the ratio factor, while the b coefficient represents the "shift" component, showing how the relationship

3.2.6. (Option 6) Save Forecast Data. The user is prompted to enter the name for the file for storing the data, and is asked to insert the diskette into the appropriate drive. Normal DOS protocol in naming files and drives should be followed.

3.2.7. (Option 7) End Program. This option ends the program and returns the user to DOS.

3.3. Hard Copy of Results. Printed copy of forecasts can be produced by pressing the "Shift" and "PrtSc" keys simultaneously. This key sequence is a normal DOS command which dumps the screen image to the printer. In order to print images of the graphs it is necessary to have a printer with a graphics capability, and to invoke this capability by typing in the DOS command "graphics" BEFORE running the IRFP/PC. See the IBM PC DOS manual for further information about the "graphics" command.

4. Summary

This user manual has described four ratio methods which can be used to generate forecasts for socio-economic variables in small areas. It is felt that these methods offer a means for providing Corps planners with a way to generate forecasts of population, income, and employment for small study areas. The IWR program presented offers a way to relieve the computational tedium associated with using these methods. While the methods are easy to use and conceptually straightforward, it should again be emphasized that the role of professional judgment on the part of the analyst is just as essential in the use of these methods as it is in using any other forecasting techniques.

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