Software Package for the Logistic Substitution Model

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SOFTWARE PACKAGE FOR THE LOGISTIC SUBSTITUTION MODEL

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Research Reports, which record research conducted at IIASA, are independently reviewed before publication. However, the views and opinions they express are not necessarily those of the Institute or the National Member Organizations that support it or of the institution that sponsored the research.
This report describes the computer program designed to generate the dynamics of market substitution of products and technologies. The report includes a simplified description of the substitution model but does not go into detail about the model, the results achieved by using it, or the methodology of the analysis; this manual should be used in conjunction with the report on energy substitution (Marchetti and Nakicenovic, RR-79-13).

The computer program is interactive: it prompts the user, and the user responds with parameters affecting the course of program execution. Input data (usually historical) are organized as time series. Model coefficients can be directly estimated by the program, or they can be assumed beforehand. Model results can be projected for any specified time interval. An output file can be generated containing all information pertinent to the results obtained. These results can be plotted on a linear or semilog scale.
PREFACE

One of the objectives of the Energy Systems Program of the International Institute for Applied Systems Analysis (IIASA) is to improve the methodology of medium- and long-range forecasting of the energy market and energy use.

This is commonly accomplished by using models that try to capture and put into equations the numerous relationships and feedbacks characterizing the operation of an economic system or parts of it. Such an approach encounters many difficulties, which are linked to the extreme complexity of the system and the fairly short-term variation of the parameters and even of the equations used. Consequently, these models lend themselves to short- and perhaps medium-range predictions, but usually fail to be useful for predictions over a period of about 50 years, the time horizon the Energy Systems Program has chosen for study.

Following the current scheme of attacking similar problems in the physical sciences, we have left aside all details and interactions and have attempted a macroscopic description of the system via the discovery of long-term invariants. Heuristically, this approach is certainly not new. In a broad sense, all science can in fact be seen as a systematic search for invariants.

This work is dedicated to the empirical testing and theoretical formulation of a certain invariant, namely, the logistic learning curve, as it applies to the structural evolution of energy systems and systems related to energy, such as coal mining, for example.

The great success of the model in organizing data of the past, and the insensitivity of the structures obtained to major political and economic perturbations seem to suggest that this invariant has great predictive power.
This Research Report represents only part of the work done in this area at the International Institute for Applied Systems Analysis, under a grant from the Volkswagenwerk Foundation, of the Federal Republic of Germany, for exploring the potential of logistic analysis in describing energy systems. The work is completely documented in an Administrative Report to the Foundation, *The Dynamics of Energy Systems and the Logistic Substitution Model*, by C. Marchetti, N. Nakicenovic, V. Peterka, and F. Fleck (AR-78-1A,B,C; July 1978).

The present paper describes the computer program designed to generate the dynamics of market substitution; it is a manual that includes a complete FORTRAN source code as an Appendix. Although a simplified description of the logistic substitution model is also given, the paper discusses in detail neither the model nor the results or the methodology of the analysis. It should be used in conjunction with the descriptive part of the analysis (AR-78-1B) reproduced in *The Dynamics of Energy Systems and the Logistic Substitution Model*, by C. Marchetti and N. Nakicenovic (RR-79-13).

As for the theoretical treatment in AR-78-1C, by V. Peterka, a new issue of *Macrodynamics of Technological Change: Market Penetration by New Technologies* (RR-77-22) is available. F. Fleck’s contributions on the regularity of market penetration are part of his forthcoming doctoral dissertation at the University of Karlsruhe.
1 INTRODUCTION

This report describes the computer program Pene.r that was designed to generate the dynamics of market substitution. After formulating the phenomenological model of market substitution, our primary goal was to analyze as many substitution examples as possible, in order to gain a better understanding of the substitution rule and also in the hope of learning something about the exceptions to this rule. Each of these examples involves considerable data handling and considerable calculation effort, especially if the model is projected over long time intervals. Thus, it was obvious that the model in its initial form had to be implemented on a computer.

The program itself is designed in modules, each having a distinct function, so that it was possible to add new subroutines and modify or delete existing ones as the model evolved, or if necessary for some special applications. Thus the structure of the program is quite flexible, allowing the application of the program to any substitution process, even though it was designed primarily to handle energy substitution behavior.

The computer program was designed for interactive use; however, it can be also used in batch mode. It gives prompts to the user, and the user responds to them with parameters affecting the course of program execution. In batch mode, an input file called “Cards” controls the program execution.

Input (historical) data are organized as time series, one series per record, with a logical record number and name. They can then be used selectively in the program by identifying the desired record number and the program responds with the appropriate record name; this avoids pos-
possible confusion if an incorrect record number should accidentally be chosen.

Model coefficients can be estimated directly by the program, read from the coefficients input file, or explicitly specified during the program execution. Finally, the market substitution simulation (projection) by the model can be conducted for any desired time interval whether it overlaps with the historical one (i.e., time period for which data are available) or not. At the end, an output file that contains the results and the input data can be generated, and all of this can be plotted on a linear or semilog scale.

A simplified description of the model is given in the next section. This report does not go into the details of the model; these may be found in *The Dynamics of Energy Systems and the Logistic Substitution Model* (Marchetti and Nakicenovic, 1979). Next we will describe the Input and Output file structure, shown in Figure 3, and then we will deal directly with the computer program itself and its nine subroutines. Section 6 gives a complete description of all input information (see Figure 4) necessary for program execution, and, finally, Section 7 offers a simple tutorial example.

2 THE LOGISTIC SUBSTITUTION MODEL

Substitution of a new way of satisfying a given need for the old way has been the subject of a large number of studies. One general finding is that almost all binary substitution processes, expressed in fractional terms, follow characteristic S-shaped curves, which have been used for forecasting further competition between the two alternative technologies or products, and also for forecasting the final takeover by the new competitor.

One of the most notable models of binary technological substitution was formulated by Fisher and Pry (1970). This model uses the two-parameter logistic function to describe the substitution process. The basic assumption postulated by Fisher and Pry is that once substitution of the new for the old has progressed as far as a few percent, it will proceed to completion along a logistic substitution curve

\[
f/(1 - f) = \exp(\alpha t + \beta)
\]

where \( t \) is the independent variable usually representing some unit of time, \( \alpha \) and \( \beta \) are constants, \( f \) is the fractional market share of the new competitor, and \( 1 - f \) that of the old one.

In dealing with more than two competing technologies, we have had to generalize the Fisher–Pry model since logistic substitution cannot be preserved in all phases of the substitution process. Every given technology
undergoes three distinct substitution phases: growth, saturation, and decline. The growth phase is similar to the Fisher–Pry binary logistic substitution, but it usually ends before full substitution is reached. It is followed by the saturation phase, which is not logistic but which encompasses the slowing of growth and the beginning of decline. After the saturation phase of a technology, its market share declines logistically.

We assume that only one technology saturates the market at any given time, that declining technologies fade away steadily at logistic rates uninfluenced by competition from new technologies, and that new technologies enter the market and grow at logistic rates. The current saturating technology is then left with the residual market share and is forced to follow a nonlogistic path that connects its period of growth to its subsequent period of decline. After the current saturating technology has reached a logistic rate of decline, the next oldest technology enters its saturation phase, and the process is repeated until all but the most recent technology are in decline.

In effect, our model assumes that technologies that have already entered their period of market phaseout are not influenced by the introduction of new ones. The deadly competition exists between the saturating technology and all other technologies.

Let us assume that there are n competing technologies ordered chronologically in the sequence of their appearance in the market, technology 1 being the oldest and technology n the youngest. Over a certain historical interval we estimate the coefficients of the logistic functions for the technologies in the logistic substitution phases. Historical periods we have investigated range from 130 to 20 years; the substitution process can be simulated, however, over any desired time interval, which need not overlap with the historical period. Let us call the beginning of this interval $t_B$ and the end $t_E$.

After the coefficients have been estimated by the ordinary least squares (OLS) method in the subroutine Fitlin.f (see section 5 and Figure 5), we have $n$ equations:

$$f_i(t) = \frac{1}{1 + \exp(-\alpha_i t - \beta_i)}$$

where $i = 1, \ldots, n$ and where $\alpha_i$ and $\beta_i$ are the estimated coefficients. Now we identify the saturating technology, $j$, as the oldest technology still increasing its market share. The market shares are then defined by

$$f_i(t) = \frac{1}{1 + \exp(-\alpha_i t - \beta_i)}$$

for $i \neq j$

and

$$f_j(t) = 1 - \sum_{i \neq j} f_i(t)$$
At this time technology $j$ is in its saturation phase, and all other technologies are either growing or declining logistically.

Now we need a criterion for the end of the saturation phase and the beginning of decline for technology $j$, at which point the function $f_j(t)$ will once again become logistic on its way down and the burdens of saturation will fall on technology $j + 1$. To establish this criterion we use the properties of the function

$$y_j(t) = \log \frac{f_j(t)}{1 - f_j(t)}$$

If $f_j(t)$ were logistic, $y_j(t)$ would be linear in $t$. However, for $f_j(t)$ in its saturation stage, the function $y_i(t)$ has negative curvature, passes through a maximum where technology $j$ has its greatest market penetration, and then starts down. The curvature diminishes for a time, indicating that $f_j(t)$ is approaching the logistic form, but then, unless technology $j$ is shifted into its period of decline, the curvature can begin to increase as newer technologies enter the marketplace. Phenomenological evidence from a number of substitutions suggests that the end of the saturation phase should be identified with the time at which the curvature of $y_j(t)$, relative to its slope, reaches its minimum value. We take this criterion as the final constraint in our generalization of the substitution model, and from it we determine the parameters for the $j$th technology in its logistic decline.

In mathematical form, the criterion for termination of the saturation phase for technology $j$ is

$$\frac{y_j''(t)}{y_j'(t)} = \text{minimum}$$

(note that $y''$ and $y'$ are both negative in the region of the minimum). When the minimum condition is satisfied, we call this time point $t_{j+1}$, the time of the beginning of the saturation for technology $j + 1$, and we determine coefficients $\alpha$ and $\beta$ for the declining phase of technology $j$ from the relationships

$$\alpha_j = y_j'(t_{j+1})$$

$$\beta_j = y_j(t_{j+1}) - \alpha_j t_{j+1}$$

Then the next oldest technology $j + 1$ enters its saturation phase, and the process is repeated until the last technology $n$ enters its saturation phase, or the end of the time period $t_E$ is encountered.

These expressions determine the temporal relationships between the competing technologies. They have been formulated in algorithmic form,
so that the interpretation of the subroutine Penetr.f (see section 5) that estimates the fractional market shares is straightforward. We call this algorithm Penetration; it is illustrated in Figure 6. Only time $t$ and the estimated coefficients $\alpha_i$ and $\beta_i$ extracted from historical data in subroutine Fitlin.f have been treated as independent variables.

3 INPUT FILES

_Punch_

The Punch file contains the time series, their names and logical numbers. The Punch file is compatible with the Norman's Bank program (Norman 1977). The Bank program can create and maintain the time series on a random file. Thus it can be used in conjunction with the Pene program to generate, modify, and store the Punch file. Table 1 reproduces the primary energy inputs for the world from different primary energy sources from 1860 to 1974 in the Punch file format with documentation. The original data are from Schilling and Hildebrandt (1977) and Putnam (1953).

The Punch file can be also generated directly by a simple FORTRAN program. An example of such a program is given in Table 2, and input and output files in the Punch file format are shown in Table 3.

_Coef_

The coefficients file can be generated by the program Pene if the parameters are estimated or read directly by the program from the Coef file. This file is compatible with Norman's Auto program (Norman 1977), which offers wider options than the OLS estimates of the Pene program. Thus the coefficients can also be read by program Pene if they were generated either by Auto or by Pene in some previous run. An Incards file is generated by the program Pene when the option for the estimation of the coefficients is used. This file can be renamed and used as Cards file. Table 4 gives an example of a Coef file generated from the data given in Table 1.

_Cards_

Storing the program execution instructions on this file permits the omission of the interactive mode of program execution. An Incards file is generated during each program execution, which can then be renamed and used as Cards input file if a repetition or batchlike execution of a given program run should be desired. An example of a Cards file is given in Table 5.
4 OUTPUT FILES

Output

The Output file is generated with the original data, the estimated coefficients and their t-statistics, the correlation coefficients, the variance of the estimates, and the estimated values. An example of the Output file is given in Table 6.

Incoef

When the coefficients are estimated in the program, the Incoef file is generated; it can be renamed Coef and used later as an input file (see Table 4).

Incards

Each time the program is executed, an Incards file is generated; it can be renamed Cards and used later to control the program execution (see Table 5).

Plotter

The Plotter output can be sent either to the Plotter or to a file name (chosen by the user); the file can be displayed or plotted later. Figures 1 and 2 give an example of Plotter output using the Punch file in Table 1 and the Cards file in Table 5.

5 PROGRAM PENE.R

This program was designed to be executed on the PDP 11/70 with the Unix operating system. The source code is written in FORTRAN.IV, so that the program could be modified for implementation in another system. With the exception of the plot subroutines, most modifications could easily be made. Figure 3 shows the file structure of the program Pene.r, and the complete FORTRAN source code is given in the Appendix. The program Pene.r consists of a main program and nine subroutines:

Main.f

The Main program reads the input files, generates the output files, and controls the course of execution in accordance with the execution pa-
parameters provided by the user. This is illustrated by the flowchart in Figure 4.

_Tdatfrc.f_
This subroutine converts the absolute values of the time series competing for a market into fractional shares and puts them into a work matrix.

_Fitlin.f_
This subroutine generates OLS estimates of the coefficients for each fractional time series and the time series of the sum of all absolute values. The flow chart of this subroutine is given in Figure 5.

_Penetr.f_
This subroutine uses the estimated coefficients and the algorithm Penetration to estimate the fractional market shares for the period specified by the user. The flowchart of algorithm Penetration is illustrated in Figure 6.

_Testtot.f_
This subroutine uses the estimated fractional market shares and the estimated coefficients of the sum of all absolute values to estimate the absolute market shares and puts them into the work matrix.

_Tdattot.f_
This subroutine transfers the time series of the absolute market shares (original data) to the work matrix.

_Func.f_
This subroutine calculates the coefficients from two given values of fractional market shares.

_Plotf.f_
This subroutine plots the content of the work matrix – either the original absolute and/or original fractional market shares or the estimated absolute and/or estimated fractional shares are plotted.
Plotlin.f
This subroutine establishes scale, axes, and labels for all linear plots.

Plotlog.f
This subroutine establishes scale, axes, and labels for all semilog plots.

6 INPUT LINES
In the interactive mode the program supplies as prompts mnemonic names for program execution parameters. The user then assigns parameter values under the mnemonic names right-adjusted (only names and titles are left-adjusted) and enters CR (carriage return) when he is finished. If he wishes to use default values for parameters, only CR is necessary (for names, default values do not exist; however, if an input line starting with a name should be omitted, $$$, left-adjusted, must be given). This section explains the parameter values and their meanings. Error messages are supplied before the prompts of the next input line. If it is possible to correct an error, the program will correct it or repeat the input line in question. Figure 4 gives the flowchart of the program execution in response to the parameter lines (see above under Main.f).

A. Title

Market Penetration by N. Nakicenovic
IIASA Version 20.03.78

* give one-line title within this field *absolute units*

Under this prompt a title (up to 50 characters long) characterizing the particular application of the model should be given within the specified field: To the right, under *absolute units*, the units of the data under analysis should be given (centered). Appropriate conversion of the units should be given if the scaling option for the data is used (see parameter exp in the next section).

B. Parameter Line

plt fte tot iy no dat est ptt par sca exp
<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Default</th>
<th>Value</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>plt</td>
<td>0</td>
<td>0</td>
<td>To plot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−1</td>
<td>Plot but do not draw or label the axis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>No plot</td>
</tr>
<tr>
<td>frc</td>
<td>0</td>
<td>0</td>
<td>Semilog plot for fractional market shares</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Linear plot for fractional market shares</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Linear plot for summed fractional shares</td>
</tr>
<tr>
<td>tot</td>
<td>0</td>
<td>0</td>
<td>Semilog plot for absolute market shares</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Linear plot for absolute market shares</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Linear plot for summed absolute shares</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Semilog plot for summed absolute shares</td>
</tr>
<tr>
<td>iy</td>
<td>0</td>
<td>Integer</td>
<td>Initial year expressed as positive or negative difference from 1900</td>
</tr>
<tr>
<td>no</td>
<td>100</td>
<td>Integer</td>
<td>Number of points (cannot be greater than 300)</td>
</tr>
<tr>
<td>dat</td>
<td>0</td>
<td>0</td>
<td>Original time series as fractions and absolute values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Only fractions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Only absolute values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>No original data</td>
</tr>
<tr>
<td>est</td>
<td>0</td>
<td>0</td>
<td>Estimated market shares as fractions and absolute values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Only fractions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Only absolute values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>No estimated market shares</td>
</tr>
<tr>
<td>prt</td>
<td>0</td>
<td>0</td>
<td>No output file</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Output file is generated; zeros are suppressed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Output file is generated; zeros are not suppressed</td>
</tr>
<tr>
<td>par</td>
<td>0</td>
<td>0</td>
<td>Do not sum absolute values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Sum only the absolute values</td>
</tr>
<tr>
<td>sca</td>
<td>0</td>
<td>0</td>
<td>Time-scale of standard length</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(4 cm/50 years)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Where $n$ is an integer, time-scale will be $1 + n/2$ times standard length</td>
</tr>
<tr>
<td>exp</td>
<td>0</td>
<td>0</td>
<td>Data will be unchanged</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Where $n$ is an integer, data will be multiplied by $10^{**(n)}$</td>
</tr>
</tbody>
</table>
The parameters iy and no should be used with care: iy specifies the beginning of the time period to be investigated as the difference between this point and the year 1900 — e.g., 1860 would be specified as iy = −40, and 1940 as iy = 40. no determines the end of the time period under investigation. The parameter value is specified as the difference in years from the initial time point iy, excluding the year 1900 — e.g., investigation of the period 1860 to 2000 is specified by iy = −40 and no = 140. Furthermore, no is rounded by the program by default to the nearest half century. For example, iy = −40 and no = 111 would imply the initial year 1860 and the final year 1971; however, the program will by default change no to 140 making 2000 the final year. If this option is not desired 9000, should be added to the desired value of no; thus iy = −40 and no = 9111 determine the interval of 1860 to 1971.

C. Parameter Line

write numbers of desired series from punch file:
nu: nu2 nu3 nu4 nu5 nu6 nu7

Logical numbers of time series to be used in the model are to be given under nu1 to nu7 (a maximum of seven separate time series can be entered). The program will respond by giving the number and the names of the time series extracted from the Punch file.

D. Parameter Line

enter $$$ for default, values otherwise:
default iyd nod

iyd stands for the initial year of the time series to be used, expressed as positive or negative difference from 1900. If the default option is used, the initial year will be the first year occurring in the time series.

The value entered for nod determines the number of observations of the time series to be used. If the default option is used, all of the observations in the time series will be used.

E. Parameter Line

enter:
3 to read coef
2 to estimate
2 to add/change
To read the model coefficients from the Coef file (see Coef and Incoef files above), zero should be entered; this leads directly to G. Parameter Line. To estimate coefficients (provided option dat = 3 in B. Parameter Line is not used), 1 should be entered. The third option, entering 2, also leads directly to G. Parameter Line, but in this case all coefficients are set to zero.

F. Parameter Line

\[ \text{year year na nu} \]

If option 1 is used in E. Parameter Line, the user must give the time interval for which the coefficients are to be estimated by typing in the first and the last years of this interval. nu and na stand for the logical number and the name of the time series in question and are provided by the program. The time intervals for different series need not be the same.

G. Parameter Line

\[ \text{if you do not change/add coef give $$$$ under name} \]
\[ \text{name eqn year fraction year fraction} \]

This option offers the possibility of adding scenarios about the behavior of new competitions that may not be available in the historical data base. It can also be used to change the estimated coefficients. The name of the competitor and its logical equation number (eqn) must be given, together with the two desired fractional market shares (fraction) and the corresponding year. $$$$ is typed left-adjusted under name in order to go to the next parameter line.

The exponential growth rate of the sum of all absolute values can be changed four times throughout the estimation period by entering total under name and 8 under eqn. year in this case denotes the beginning year for the new growth rate, and the growth rates should be entered under fraction (in fractional terms). The values entered will be displayed.

H. Parameter Line
Because of the possible changes of the coefficients in G. Parameter Line, the user must establish a chronological order of competitors. n stands for the number of competitors defined by the user in the previous steps, and na1 to na7 stand for the names of these competitors. Directly under these names and the numbers displayed above, which denote the current chronological order, the new sequence numbers must be given by the user.

7 TUTORIAL EXAMPLE

The use of the program Penex is illustrated below by the example of primary energy consumption of the world given in the Punch file (Table 1). The Punch file, containing the time series with consumption levels of different primary energy sources in million tons of coal equivalent between the years 1860 and 1974, is read by the program. The model coefficients are estimated over the whole historical period, and the file Incoef will be generated automatically (Table 4). An alternative nuclear energy penetration scenario is included specifying a 1 percent nuclear share in 1970 and a 6 percent share in 2000. In addition, total primary energy growth is changed twice from the long-term historical growth rate estimated over the period 1890 to 1950. The annual growth rate is changed to 6 percent in 1955 and to 3 percent in 1970. The model estimates are generated only for the historical period of 1860 to 1978. Two plots are generated in the plotter file (Figures 1 and 2). The first shows fractional market substitution on a linear axis plotted in the summed form, and the second shows the absolute consumption levels plotted on the logarithmic axis. Incards and Output files are also generated (Tables 5 and 6).

In the example below, the lines marked "u" in the left column show user input lines; other lines are program prompts.
enter: 0 to read coef
1 to estimate
2 to add/change

u 1
year year 1 wood pt
u 1000 1974
1000 1974
year year 2 oil
u 1000 1974
1000 1974
year year 3 nat-gas
u 1060 1974
1060 1974
year year 4 coal-tot
u 1060 1974
1060 1974
year year 5 nuclear
u 1060 1974
1060 1974

ERROR *** 2 observations for this eqn
therefore no statistics, both observations explained

year year d total
u 1060 1950
1060 1950

if you do not change/add coef give $$$ under name
name eqn year fraction year fraction
nuclear 5 1970 0.01 2000 0.06
nuclear 5 1970 0.010000 2000 0.060000
name eqn year fraction year fraction
total 6 1955 0.06 1970 0.03
total 6 1955 0.060000 1970 0.030000
name eqn year fraction year fraction

u $$$
write sequence numbers for 5 equations:
1 2 3 4 5 6 7
wood pt oil nat-gas coal-tot nuclear
u 1 3 4 2 5
1 3 4 2 5 0 0
new sequence of equations is:
1 2 3 4 5 6 7
wood pt coal-tot oil nat-gas nuclear

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FRG: Verlag Glückauf.
Marchetti, C., and N. Nakicenovic (1979) The Dynamics of Energy Systems and the
Institute for Applied Systems Analysis.

TABLES AND FIGURES
<table>
<thead>
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<th>wood</th>
<th>pt</th>
<th>1</th>
<th>1</th>
</tr>
</thead>
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<td>317,000</td>
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<td>318,000</td>
<td>318,000</td>
<td>318,000</td>
</tr>
<tr>
<td>324,000</td>
<td>321,000</td>
<td>320,000</td>
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</tr>
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<td>249,000</td>
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</table>
**TABLE 2** Simple FORTRAN program.

```fortran
real*8 t, for
dimension f(300,7), t(7), for(9)
format(i2)
format(9a8)
format(i4,x,a8,4i4/(af10.3))
format(Sx,3h$$$//Sx,3h$$$/)
read (5,105) n
read (5,106) (for(j),j=l,g)
do 3 j=l,n
read (5,106) t(j)
do 1 i=1,300
read (5,for,end=2) iy1,(f(i,j),j=1,n)
n0=i-1
if (i.gt.1) go to 1
iy=iy1
continue
1 ni=iy-1900
ip1=1
ib1=1
do 9 j=1,n
write (8,107) j, t(j), no, ni, ip1, ib1, (f(i,j),i=1,no)
continue
write (8,108)
stop
end
```
TABLE 3  Input and Output files for the simple FORTRAN program.

<table>
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<th>OUTPUT</th>
<th>INPUT</th>
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**TOTAL Input and Output files for the simple FORTRAN program.**
### TABLE 4  Incoef and Coef files.

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### TABLE 5  Incards and Cards files.

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<td>1 4 5 7 3 0 0</td>
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<tr>
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| 1 3 4 2 5 0 0 |

### Incards and Cards files.
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<th>COAL-TOT</th>
<th>NUCLEAER</th>
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TABLE 6 Output file.
## TABLE 6  Continued.

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| INTEGRALS FROM 1964 TO 1974 ARE: |
| 217, 218, 7.16, 93, 3.233 | 24, 0.184 | 124, 0.576 | 0, 0.022 |

**Coefficients Estimated in FitLin.**

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<td>(94.925)</td>
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**Estimated Values:**

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INTegrals FROM 1946 TO 1979 YEARS

1964, 19, 6.126 1294, 8.344 55, 3.231 124, 2.125 3, 2.661

INTEGRALS FROM 1970 TO 1979 YEARS

156, 1, 1.126 1294, 8.344 55, 3.231 124, 2.125 3, 2.661

In the table, the values represent the total, oil, natural gas, coal total, and nuclear production or contributions over the specified years. The data suggests a decline in total production across the years, with a consistent increase in oil production, while natural gas and coal total exhibit fluctuations. The nuclear contributions remain relatively low but show a slight increase. The integrals provided indicate the cumulative contributions from 1946 to 1979 and from 1970 to 1979, reflecting the overall trends and changes in production over these periods.
FIGURE 1  Example of Plotter output using Punch and Cards files.

FIGURE 2  Example of Plotter output using Punch and Cards files.
1. Cards file contains control parameters. In interactive use, DEV 5 (device 5) should be the terminal input, and prompts file should also be sent there; DEV 6 (device 6) should be the output to the terminal. Incards file has the same information and structure as Cards file.

2. These files are optional and will be read or generated in accordance with the control parameters. Incoef file has the same structure as Coef file.
FIGURE 4  Flowchart of the main program: Pene.r.
FITLIN $f_i(t)$, iyd, nod, $a_i$, $\beta_i$

$t_2 := iyd + 1900 + nod$
$t_1 := iyd + 1900$

$y(t) := \log \frac{f_i(t)}{(1 - f_i(t))}$

$\bar{y} := \frac{1}{t_2 - t_1} \sum t \cdot y(t)$
$\bar{t} := \frac{1}{t_2 - t_1} \sum t$

$a_i := \left( \sum \frac{\log \frac{f_i(t)}{(1 - f_i(t))} - \bar{y}}{(t - \bar{t})} \right) / \sum (t - \bar{t})^2$
$\beta_i := \bar{y} - a_i \cdot \bar{t}$

$\text{var} := \frac{1}{t_2 - t_1} \sum (y(t) - a_i \cdot t - \beta_i)^2$

$t/\beta := \frac{\beta_i \cdot \sqrt{(t_2 - t_1) \cdot \sum (t - \bar{t})^2}}{\sqrt{\text{var} \cdot \sum t^2}}$
$t/\alpha := \frac{a_i \cdot \sqrt{\sum (t - \bar{t})^2}}{\sqrt{\text{var}}}$

RETURN

FIGURE 5  Flowchart of the estimation subroutine fitlin.f. $\text{var}$ is the variance of $y(t)$; $t/\alpha$ and $t/\beta$ are $t$-statistics with $t_2 - t_1 - 2$ degrees of freedom under the hypotheses $\alpha = 0$ and $\beta = 0$. 
FIGURE 6 Flowchart of the market substitution subprogram: Penetr.f (algorithm Penetration).
Appendix

FORTRAN Source Code
Main.f

CALL SETFIL(1,'*COEFF')
CALL SETFIL(5,'COEFF')
CALL SETFIL(2,'T-CARDS')
CALL SETFIL(1,'T-CARDS')

100 FORMAT(14,1X,4X,9I4(9F10.3))
101 FORMAT(15X,'*CHNG *** SERIES',I2,': 15,6T,IP')
102 FORMAT(14,1P2,15X,'SERIES ARE HEAD FROM PUNCH FILE'
103 FORMAT(14,1P2,15X,'TO LOCATIONS: */7(14,6X)/1(AB)
104 FORMAT(*WRITE NUMBERS OF RESTED SERIES FROM PUNCH FILE: '
105 /*'NUL HBP NO. 3 NO. 15 NO 4 NO. 7
106 FORMAT(14,1X,9X,13(9AB))
107 FORMAT(*PLT FRC TOT JY NO DAT EST PRT PAR SCA EXP')
108 FORMAT(114)
109 FORMAT(14,12,15X,'EQUATIONS ARE HEAD FROM COEF FILE'
110 FORMAT(*WRITE SEQUENCE NUMBERS FOR *
111 FORMAT(7(14,4X))
112 FORMAT(*SEQ. OF EQUATIONS IS: *
113 FORMAT(*IF YOU DO NOT CHANGE/AND COEF GIVE $$ UNDER NAME*)
114 FORMAT(*AME=*X ,"EQN. YEAR FRACTION YEAR FRACTION")
115 FORMAT(5X,13,2(15,9F9.4))
116 FORMAT(*SAME TITLE AS EDN","12,': * ,AB)
117 FORMAT(5X,13,2(15,9F9.4))
118 FORMAT(*ENTER: 2 TO READ COEF /
119 FORMAT(7X,'1 TO ESTIMATE /
120 FORMAT(7X,'2 TO ADD/CHANGE:*
121 FORMAT(14,15)
122 FORMAT(14,15)
123 FORMAT(*ENTER $$ FOR DEFAULT, VALUES OTHERWISE: */
124 FORMAT(14,15)
Main.f continued

124 FORMAT(4F,2I4)
125 FORMAT(55S,//"55S")
126 FORMAT("
GIVE ONE-LINE TITLE WITHIN THIS FIELD"
&,* ,ABSOLUTE UNITS")
127 FORMAT(7AR,44)
128 FORMAT(/&X,COEFFICIENTS FROM FILE COEF/*)
129 FORMAT(5X,EL,*,I2,",",AL,* IS Y=*,F7.3,"*I="-
&,A5,A15/)
130 FORMAT(/&X,COEFFICIENTS ESTIMATED IN FITLIN.F/*)
131 FORMAT(5X,ERR= *** NO DT, J0P *TRY AGAIN**/)
132 FORMAT(5X,"FPROP *** WRONG PARAMETER SPECIFICAt"NS *"
&,*TRY AGAIN]*)/
133 FORMAT(5X,"FPROP *** I,J,GT,*,I,J,* *TRY AGAIN***)/
134 FORMAT(5X,PEEK *** NO,L,GT NO OBSERVATIONS ***)
135 FORMAT(5X,EXPTNT A N L UNITS IF CHANGED")
&",FACTOR EXP ABSOLUTE UNITS")
136 FORMAT(F8.4,I9,1X,4A0)
137 FORMAT(5X,"FPROP *** SERIES",I2,: NOO,GT,150 *TRY AGAIN**/)
138 FORMAT(5X,NUMBERS AND TITLES OF SERIES ON PUNCH FILE")
139 FORMAT(1X,14,4A0)
140 FORMAT(10A8)

YEAR=1
YR=7
YEAR2*YEAR(1)
YEAR3*YEAR(1)
YEAR4*YEAR(1)
DO 21 J=1,7
W(IF(J))=1
H(N)=PL
PL=1
W(IF(J))=1
WRITE (6,105)
WRITE (N,129)
READ (5,127) (TITLE(I,J),J=1,7),K(J),J=1,4
WRITE (N,127) (TITLE(I,J),J=1,7),K(J),J=1,4
WRITE (5,127) (TITLE(I,J),J=1,7),K(J),J=1,4
WRITE (N,17) 50
READ (5,128) PLT,IFHC,TOT,1YO,NOO,NO,ST,PT,PAR,SCA,EX
NOW=1000
IF (.NOT.GE.9800) 4000=400=9999
FRC=IFHC
IF (FRC,.EQ.,-1) FRC=0
LAT=DAT
IF (DAT,GE.5750) DAT=DAT-9999
IF (GNC,GT,300) WRITE (N,131)
IF (.NOT.GT,300) GO TO 58
IF (.NOT.GT,0) NNO=100
WRITE (N,138) PLT,FRC,TOT,1YO,NOO,NO,ST,PT,PAR,SCA,EX
WRITE (N,138) PLT,IFHC,TOT,1YO,NOO,NO,ST,PT,PAR,SCA,EX
LOGIC,FALSE
LOGIC=PLT,.LT.,1,DR,PLT,GY,1,DR,
& FRC,LT,2,DR,FRC,GY,2,DR,
& TOT,LT,2,DR,TOT,GY,4,DR,
& NOO,LT,2,DR,NOO,F0,8,DR,
& DAT,LT,2,DR,DAT,GY,3,DR,
& EST,LT,2,DR,EST,GY,5,DR,
& PT,LT,2,DR,PT,GY,6,DR,
& PAR,LT,2,DR,PAR,GY,7,DR,
Main.f continued

IF (LCFICI * + IT€ (6, 132))

IF (GC 73 56)

SCALE=SCLEX+FLATE(SC~)

IF (EXP, E7T, 979)

Gi'[ TCf 66

QFA3 (5, 136)

TV[CI (h, 135)

QFA3 (5, 136)

TV[CI (h, 135)

QFA3 (5, 136)

TV[CI (h, 135)

QFA3 (5, 136)

TV[CI (h, 135)}
CALL SETFIL(4, PNC16)
WRITE (6, 123)
READ (5, 124) NA1, Y1, NO1, LT1, L1, IB1, (C(J, I)), I=1, NO1
IF ((J, J) .LT. J) WRITE (6, 134) NA1, Y1, NO1
IF ((J, J) .LT. J) GO TO 64
IF (J, J) .LE. J1, 15?
IF (J, J) .LE. J1, 15?
IF (J, J) .LE. J1, 15?
GO TO 71
DO 71 J1=1, 15?
DO 71 J1=1, 15?
DO 71 J1=1, 15?
WRITE (6, 134) NA1, Y1, NO1, (NA(J), J=1, NO)
1Y0=370?
NO=1
DO 6 J=1, NO
LX=1900+1V(D1)*C(J, I)*IH0-2)/IPD
LY=1V(D1, 1J, 1J))
NO=140-1987-1Y0)*IPD+(5N+2
WRITE (6, 123)
READ (5, 124) NA1, Y1, NO1
WRITE (6, 123) NA1, Y1, NO1
IF ((J, J) .LT. IJSS) IY0=IY0
IF ((J, J) .LT. IJSS) IY0=IY0
IF ((J, J) .LT. IJSS) IY0=IY0
IF (IY0-0, IY0-NON) IY0=IY0-NON
IF (IY0-0, IY0-NON) IY0=IY0-NON
IF (IY0-0, IY0-NON) IY0-NON
WRITE (6, 123) AL, IY0, NO1
LY0=LY0
LY0=LY0
LY0=LY0
IF ((J, J) .LT. IY0) WRITE (6, 134)
IF ((J, J) .LT. IY0) GO TO 63
Main.f continued

IF

IF

CALL

IF

CALL

READ DOCUMENTATION FROM PUNCH FILE

READ (4,174) N01,NA1,12,(FLAB(1,J),J=1,12)

IF (NA1,EG,2) GO TO 12

IF (NA1,EG,18) GO TO 12

GO TO 10

IF (JXQ(3),EG,=A1) CALL

GO TO A

CALL (V,J)#FLAB(1,J)

GO TO 2

GO TO 2

INDEX=1

IF (PLT,LT,2) INDEX=PLT

LOGIC(NL,LT,2)

IF (FLAT,LT,3,AND,NO,GT,2) CALL THATFRC

Y14=FL.

IF (FRC,EG,2) YMAX=ALOG(PC0)

IF (FRC,EG,2) Y11=ALOG(N1)

LOGIC(NL,EST,LT,2)

X17=FLY17+19*A+(19*11-2)/10

Y17=FIX((X17)/100)*100

Y12*X17=Y11

IF (Y12,GT,2) Y11=Y11+5E

IF (Y12,GT,50,Y11)+Y11+5P

IF (UNN,GT,92,NO,NO)=1

LOGIC(UNN,AND,PLT,LT,2)

TYPE(1,2)=FNC

TYPE(1,3)=NVR

IF (LOGIC,AND,FRC,EG,2)

CALL P,FLOG(INDE)XMAX,XMIN,YMAX,YMIN,SCALE,TITLE,TYPE

TYPE(1,2)=TYPE(2,2)

TYPE(1,3)=TYPE(2,3)

TYPE(1,4)=TYPE(2,4)

IF (LOGIC,AND,FRC,EG,1,OR,FHC,EG,2)

CALL P,F,LT,INDE,XMAX,XMIN,YMAX,YMIN,SCALE,TITLE,TYPE

IF (EST,EG,3) GO TO 19

READ COEFFICIENTS FROM CURF FILE

WRITE (b,118)

WRITE (6,119) FIT

WRITE (2,119) FIT

IF (NAT,LT,3,AND,NO,EG,3) WRITE (b,134)
Main.f continued

IF (NAT.LT.3, &NAT, 400, E3) G0 TO 42
IF (FIT.EQ.1) G0 TO 41
IF (FIT.EQ.2) G0 TO 42
IF (FIT, GT.2, OR, FIT, LT, 1) WRITE (6, 132)
IF (FIT, GT.2, OR, FIT, LT, 2) UN TO be
IF (PD. E2, 1, OR, PD, LT, 2) WRITE (8, 128)
I = I + 1
WRITE (8, 128) I

10
J = J + 1
READ (3, 120) JAI, NUMC, E, (*L), L #1, MC
IF (NAT.EQ, ISS) G0 TO 14
IF (PD, E2, 1, OR, PD, LT, 2) WRITE (8, 129) NUMC, NA1, (*L), L #1, MC
WRITE (6, 129) NUMC, NA1, (*L), L #1, MC
K = 0
DO 15 J = 1, N
15 IF (NAT.EQ, NA1(J)) K = 1
IF ([.NE., 0) I = J + 1
IF (K .EQ., 0) G0 TO 16
J = J + 1
K = 1
IF (.NE., E, A) K = 1
IF ([.TE., A) G0 TO 16
I = I - 1
NATA = A

16
READ (3, 120) JAI, NUMC, E, (*L), L #1, MC
IF (K .EQ., 0) K = -1
GO TO 13
14 LF = JD + 1
NF = I + 2
WRITE (6, 129) NF, (11, I #1, 7), (NAF(I)), 12, 12, 1, 7, NAT

5
ESTIMATES COEFFICIENTS IN FITLIN.F

GO TO 41
IF (PD, E2, 1, OR, PD, E2, 2) WRITE (8, 130)
DO 43 J = 1, N
41 WRITE (6, 129) I, NA1(I)
READ (5, 122) IV1, IV2
I = I + 1
WRITE (6, 129) IV1, IV2
IF (IV1.LT.II) IV1 = I
IF (IV2.LT.I1) IV2 = I
IF (IV1.LT.I1) IV2 = I
IF (IV2.LT.I2) IV2 = I
IF (IV2.GT.I2) IV1 = I
IF (IV2.LT.I1) IV2 = I
IF (IV2.LT.I1) IV1 = I
IF (IV1.LT.I1) IV1 = I
WRITE (6, 129) IV1, IV2
WRITE (5, 129) IV1, IV2
NAF(J) = NA1(I)
CALL FITLIN(J, IV1, IV2)
43 WRITE (6, 129) NAF(I), I, 2, (COEF(I, J), J = 1, 2)
WRITE (5, 129) NA10T
READ (5, 129) IV1, IV2
II = I + 1
WRITE (6, 129) IV1, IV2
IF (IV1.LT.I1) IV1 = I
IF (IV1.LT.I1) IV1 = I
IF (IV1.LT.I1) IV1 = I
IF (IV1.LT.I1) IV1 = I
IF (IV1.LT.I1) IV1 = I
Main.f  continued

CALL FTTL (1,13,112) IF (Y1, Y2)
IF (Y1, -1, Y2)
WRITE (17, 122) Y1, Y2
WRITE (13, 122) Y1, Y2
NAI (A) = NAI (T)
CALL FTTL (1,1,112)
WRITE (13, 122) NAIF (A), B, 2, COEF (B,1), I1, I2
WRITE (13, 122) NAIF (1,125)
IF (Y1, N) LF = 0

CHANGE AND COEFFICIENTS

42 WRITE (6, 113)
30 WRITE (6, 114)
READ (5, 115) NAI, NMC, Y1, P1, Y2, P2
WRITE (5, 115) NAI, NMC, Y1, P1, Y2, P2
IF (N1, NAI, 115) Go To 25
JEE =
IF (N1, NMC, 115) JEE = 1
IF (N1, NMC, 115) JEE = 2
IF (N1, NMC, 115) JEE = 3
JEE = 111
GO TO 26
IF (JEE, 1,115) GO To 27
IF (JEE, 2,115) GO To 28
IF (JEE, 3,115) GO To 29
GO TO 31

WRITE (6, 115) NAI, NMC, Y1, P1, Y2, P2
P1 = A/DG (P1, 1, -P1)
P2 = A/DG (P2, 1, -P2)
Y1 = Y1
Y2 = Y2
CALL FUC (P1, P2, Y1, Y2, COEF (K, 1), COEF (K, 2))
NAF (1) = 1
Y1 = Y1 * NAF (1)
GO TO 30

WRITE (6, 122) NAI, NMC
WRITE (6, 115) NAI, NMC, Y1, P1, Y2, P2
Y1 = Y1
Y2 = Y2
COEF (9, 1) = COEF (6, 1) * Y1 + COEF (6, 2)
COEF (9, 1) = Y1
COEF (9, 2) = COEF (9, 2) - COEF (9, 1) * Y1
COEF (15, 2) = COEF (9, 2) * Y1 + COEF (9, 2)
COEF (15, 1) = Y1
COEF (15, 2) = COEF (15, 2) - COEF (15, 1) * Y1
IF (Y1, E2, 1) Y1 = YEAR (1)
IF (Y1, E2, 2) Y1 = YEAR (2)
YEAR (1) = Y1
YEAR (2) = Y1
IF (K, 1, 115, = 1, P2, P2, E2, 2)
WRITE (5, 112) NAI, COEF (9, 1), COEF (9, 2), XX, Y1
K = 11
Main.f  continued

IF (31, EQ., 1) GO TO 59
IF (32, EQ., 1, I, PROT.EQ., 2)
  WRITE (6, 120) TITLE, NA1, COEF (1,1), COEF (1,2), AN, IN?
  READ (5, 118) NA1, TITLE, Y1, Y2, P2
  WRITE (6, 119) NA1, TITLE, Y1, Y2, P2
  WRITE (5, 116) NA1, TITLE, Y1, Y2, P2
  IF (NA1 .LT. 15) GO TO 30
  Y1 = Y1
  Y2 = Y2
  COEF (1, 1) = COEF (1, 1) * Y1 * COEF (1, 2)
  COEF (1, 2) = COEF (1, 2) * Y1
  COEF (2, 1) = COEF (1, 1) * Y1
  COEF (2, 2) = COEF (1, 2) * Y1 * Y2
  CALL PLOT (Y1, Y2)
  GO TO 30
50 IF (NA1 .EQ. 1) GO TO 72
60 WRITE (6, 120) NA1, TITLE, COEF (1, 1), COEF (1, 2), AN, IN?
   GO TO 62
70 WRITE (6, 120) NA1, TITLE, COEF (1, 1), COEF (1, 2), AN, IN?
   GO TO 72
80 WRITE (6, 117) NA1, TITLE
   GO TO 82
C  SPECIFY SEQUENCE
25 WRITE (6, 117) X, (L, L = 1, 7), (NA1 (12), L = 1, 7)
  READ (5, 118) (L, L = 1, 7)
  WRITE (6, 111) (L, L = 1, 7)
  WRITE (5, 111) (L, L = 1, 7)
  DO 20 I = 1, 7
  DO 20 J = 1, 7
22 IF (I .EQ. J) WRITE (6, 140) J
  WRITE (6, 112) (L, L = 1, 7), (J = 1, 7)
  IF (FMC.EQ.0) GO TO 90
  IF (FMC.EQ.3) GO TO 90
  Y1 = I
  GO TO 90
90 F = (F = 1, 5, I = 1, 7)
  Y1 = (F = 1, 7)
  IF (LOGIC.AND., 1) CALL PLOT
  IF (EST.EQ.3) GO TO 59
  IF (EST.EQ.3) CALL PLOT
  IF (LOGIC.AND., 1) CALL PLOT
  INDEX = INDEX
  DO 94 I = 1, 7
  TITLE (2, 1) = NA1 (12) (I)
44 IF (EST.EQ.3) TITLE (2, 1) = NA1 (I)
  IF (LOGIC.AND., 1) CALL PLOT (INDEX, XMIN, YMIN, SCALEX, TITLE, TYPE)
  IF (LOGIC.AND., 1) CALL PLOT (INDEX, XMAX, YMAX, SCALEX, TITLE, TYPE)
Main.f continued

CALL PLOT [INDEX, XMAX, XMIN, YMAX, YMIN, SCALEX, TITLE, TYPE]
CALL PLOT [INDEX, XMAX, XMIN, YMAX, YMIN, SCALEX, TITLE, TYPE]

24 YMAX = 1.E+30

23 YMIN = 1.E-30

CALL PLOT [INDEX, XMAX, XMIN, YMAX, YMIN, SCALEX, TITLE, TYPE]

CALL PLOT [INDEX, XMAX, XMIN, YMAX, YMIN, SCALEX, TITLE, TYPE]

CALL PLOT [INDEX, XMAX, XMIN, YMAX, YMIN, SCALEX, TITLE, TYPE]

STOP
SUBROUTINE DATFRC

COMMON/NATIV/0(7,158),N Каynchronization(7,19),NI,INU,NOG,
1. Nu(7), JO(7),IIP(7),IIV(7)
2. IFRC(7,30),FLAR(7,10),NF,IF,NOF
3. C(7), JAF(7), JUEF(12,2), YEAR(4)
4. IF(7), JRF(7), IJRF(7), JRF(7), IJRF(7)
5. P(7), F, IF, FOT, DAT, EST, MAX, YMIN

REAL*8 PHN(4),FLER,NAF,FGR,FDR
INTEGER PRT, JAF, JRF, IJRF, T, S, EST, MAX
DATA 15.0/432.

FORMAT(*2X,"OBSERVED VALUES",/)
"**","TOTAL",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"INTERPRETATION",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
FORMAT(*2X,"",/A(4x,4x,"+++",3x,4x)
Tdatfrc.f continued

WRITE (*,FORMAT(1)) I1Y, SS, (1(J,1), F(J,1), J=1, ND)
DO 4 J=1, ND
IF (C(J,1).EQ.M) U(J,1) = 0,
IF (F(J,1).EQ.M) F(J,1) = 0,
IF (F(J,1).EQ.M) F(J,1) = 9999
IF (F(J,1).EQ.M) GO TO 4
F(J,1) = F(J,1)/(1.*F(J,1))
IF (F(J,1).LT.C) F(J,1) = 2,
IF (F(J,1).LT.C) GO TO 4
IF (F(J,1).LT.C) GO TO 4
F(J,1) = ALOG(F(J,1))
CONTINUE
1 CONTINUE
2 SUM(R) = 0,
DO 6 J=1, ND
3 SUM(R) = SUM(R) + SUM(J)
6 J=1, ND
7 FF(J) = SUM(J)/SUM(R)
IF (PRT.EQ.1) OR PRT.LT.2)
WRITE (*,IP1) INTG, I75, SUM(R), (SUM(J), FF(J), J=1, ND)
RETURN.
END
46

Fitlin.f

SUBROUTINE FITLIN(J,JY1,JY2)
COMMON XMAX/N,.15C(.15C),YMAX/N,.15C(.15C),X0T/N,.15C(.15C),Y0T/N,.15C(.15C),Y(7)
& F1 Y(3),Y(1),Y(7),Y(3),Y(1),Y(7),Y(3),Y(1),Y(7)
& FLAR(7,1),FLAR(7,1),FLAR(7,1),FLAR(7,1),FLAR(7,1),FLAR(7,1),FLAR(7,1)
& YEAR(7)
& REAL PLT,FC,F,KT,MT,TAT,EST,YMAX,YMIN
& INTEGER PLT,FC,F,KT,MT,TAT,EST,YMAX,YMIN

101 FORMAT(5x,'COEFFICIENTS ARE SET TO ZERO, CHANGE OR TRY AGAIN!')
102 FORMAT(5x,'LEAST THAN 2 OBSERVATIONS FOR THIS EQ')
103 FORMAT(5x,'THE FOLLOWING STATISTICS, BOTH OBSERVATIONS EXPLAINED')
104 FORMAT(5x,'F= ',F7.3,' T= ',F8.3)
105 FORMAT(5x,'R= ',F7.3,' F= ',F8.3)

110 IF(J,JY1,JY2) GO TO 5
111 Y1=ALOG(Y)
112 IF(Y1<0.0) GO TO 5
113 F=R/S
114 X=F/S
115 Y=F/S
116 DC 9 J=1,L1
117 IF(J,JY1,JY2) GO TO 7
118 Y=R
119 DC 8 J=1,40
120 Y=Y*(X,1)
121 IF(Y,E4,E2) GO TO 2
122 GO TO 7
123 IF(F(J,JY1,JY2)) GO TO 2
124 Y=ALOG(Y)
125 IF(Y,E4,E2) GO TO 2
126 GO TO 7
127 IF(X,J,JY1,JY2) GO TO 2
128 Y=ALOG(Y)
129 IF(Y,E4,E2) GO TO 2
130 GO TO 7
131 IF(X,J,JY1,JY2) GO TO 2
132 IF(X,J,JY1,JY2) GO TO 2
133 C0EFF(1,J)=X*S+Y*X+X*Y
134 C0EFF(2,J)=Y/X+X*Y
135 CONTINUE
136 IF(X,J,JY1,JY2) GO TO 5
137 C0EFF(1,J)+X*S+Y*X+X*Y
138 C0EFF(2,J)=S+X*Y
139 CONTINUE
140 IF(X,J,JY1,JY2) GO TO 5
141 $1028*(S+X+Y+X+Y)/(X+Y)
142 $E=0.
143 $E=0.
Fitlin.f continued

3: IF (J.LT.8) GO TO 9
   Y=2.
   GO TO 10
   V=ALOG(Y)
   GO TO 11
9: IF (Y.GT.1.) GTO 3
   Y=1.
   IF (FLEC.LT.0.) GOTO 4
   Y=ALOG(Y/(1.-Y))
4: IF (Y.GT.YUM, Y.LT.YL) GTO 3
11: Y=COEF(J,1)*X*COEF(J,2)
   MASTER
3: CONTINUE
   V4=SFP/(X=2.)
   R%=VAR/SIG
   T%=COEF(J,2)*SQRT(X*X+5*X+5)/SQRT(VAR*S)
   T1=COEF(J,1)*SQRT(S+2+5*X)/SQRT(VAR)
   IF (R%=.0) GO TO 13
   w=TF (T%,T%)
   J1=AF(J), CNLF (J,1), COEF (J,2), RZ, VAR
   w=TF (0.,353) 11,12
13: RETURN
5: WHITE (0.,172)
   COEF(J,1)=R.
   COEF(J,2)=R.
   RETURN
12: RETURN (0.,173)
   RETURN
   END
Penetr.f

SUPPORT IF PF,T,F

COMMON /FLA/F(1,3),N,FLA(7,10),NF,IF,F,IF,
& /CUEF(12,2),YEAR(8),
& /COM(11:),Q(7),YL,IP,IR,IP,T,PAH,FOR(9),
& MLT,FHC,IFHC,TOT,MA,T,EST,TMAX,TMIN

LOGICAL LOGIC
REAL*4 FLA,P,AL,F,N
INTEGER PLT,PRT,FAC,TOT,MA,EST
DIMENSION Z(7),Y(7)
DATA & R1/,R1/

DO 1 J=1,7
DO 1 J=1,3
1 F(J,1)=F
DO 23 J=1,11
J=1:IF(J1)
IF [NOTE(J1)] EQ 0 GO TO 53
DO 32 T=1,NF
X=IF(Y-IF(J1)(I+10)-2)/IP1
32 F(J,1)*CUEF(J,2)*CUEF(J,1)
CONTINUE
DO 33 J=1,11
J=1:IF(J1)
IF [NOTE(J1)] EQ 0 GO TO 51
IF (PEA1(J1),EAL,AL) GO TO 91
31 PE:
Y1=:
Y11=:
FIND(J1)=:
IF (J1) EQ 1 GO TO 91
33 PE:
DO 34 M=1,NF
M=M+1
IF (Y) EQ (I1)
Y(J)*CUEF(J,2)*CUEF(J,1)
IF (Y(J),G,62)
Y(J)=-62.
Z(J)=1./Z(J)
IF (Y(J),G,62)
Z(J)=1.
IF (Z(J),G,62)
Z(J)=-62.
SUM=SUM+Y(J)

ơ DEF1

DO 3 M=1,NF
M=M+1
Y(J)=F(J1)
Y(J)*CUEF(J,2)*CUEF(J,1)
IF (Y(J),G,62)
Y(J)=-62.
Z(J)=1./Z(J)
IF (Y(J),G,62)
Z(J)=1.
IF (Z(J),G,62)
Z(J)=-62.
SUM=SUM-7(J)

C DETERMINING SLOPE OF Z(J)
IF (Y,GO,J) GO TO 3
CER1*F1-CUEF(J,1)*Z(J)*(1.-Z(J))
CER2*F2-CUEF(J,1)*CUEF(J,2)*Z(J)*(1.-Z(J))
CONTINUE
IF (CUEF(J,1),G,62) GO TO 6
IF (SUM,CLE,10) Z(J)=1.-SUM*Z(J)
IF (F1) EX3,GT,J
GO TO 9
IF (SUM,GT,1) F1=SUM*Z(J)
CONTINUE
IF (Z(J),LE,0) Z(J)=00
IF (Z(J),GE,1) Z(J)=99
Y(J)=40*(Z(J)/(1.-Z(J)))
Penetr.f continued

IF (FINDAY, AE, AI) GO TO 6
DEN = 1.0 + (J)*2(J)
YDENT = ENERGY/DEN
YDENT2 = 1.0 - ENERGY2/DER1*DER2*(1.0 - 2.0*(J))/(DEN*DEN)
RAT1 = RN, IF (YDENT2, GT, 1.0, LE, 1.0) RAT1 = YDENT2/YDENT1
LOGIC = RAT1, GT, RATIO1, AND, RATIO1, GT, 0.0, IF (YDENT1, LE, 0.0, AND, LOGIC) GO TO 5
G1 = 0
CONTINUE
CALC = MP, (Y1, Y11, X-1.0, X-P, COEF(J, 1), COEF(J, 2))
Y(J) = COEF(J, 3) * X * COEF(J, 1)
3 CONTINUE
F(J, 1) = Y(J)
Y11 = Y1
Y1 = Y(J)
CONTINUE
2 RATIO1 = RAT1
51 CONTINUE
YMAX = LOG(100.0)
YJ = LOG(J-11)
IF (FRC, EU, 0) GO TO 4
YMAX = 1.0
YJ = 0.0
2  DO = 7 = 1, 40
YJ = 0.0
2 DO = 7 = 1, 40
J = YRT(J)
IF (FRC, EU, 0, X, FRC, EU, 2) GO TO 8
IF (F(J, 1), LT, Y11) F(J, 1) = 0
IF (FRC, EU, 0) GO TO 7
8 IF (F(J, 1), EU, 0.0) GO TO 7
F(J, 1) = 1.0/(1.0 + EXP(F(J, 1)))
IF (FRC, EU, 2) F(J, 1) = F(J, 1) * Y1
YJ = F(J, 1)
IF (F(J, 1), LE, 3.0, AN1) F(J, 1) = 0
CONTINUE
RETURN;
END
**Test107.f**

```fortran
SUBROUTINE TEST17

COMMON /I1A/ (X(7,150),Y(7,10),X(7,10),Y(7))

IF (X.LT.7) THEN
   X=X+7
   Y=Y+7
   CALL I1A(7,107,10,7)
   GO TO 10

10 IF (X.GT.10) THEN
   X=X-10
   Y=Y-10
   CALL I1A(7,107,10,7)
   GO TO 10

IF (X.EQ.7) THEN
   X=X+7
   Y=Y+7
   CALL I1A(7,107,10,7)
   GO TO 10

IF (Y.LT.100) THEN
   Y=Y+100
   CALL I1A(7,107,10,7)
   GO TO 10

IF (Y.EQ.100) THEN
   Y=Y+100
   CALL I1A(7,107,10,7)
   GO TO 10

IF (Y.GT.100) THEN
   Y=Y-100
   CALL I1A(7,107,10,7)
   GO TO 10

END
```

**REAL**

**DIMENSION**

**DATA**

**FORMAT**

**YEAR**

**TOTAL**

**DATE**

**MAX**

**MIN**

**COEF**

**EXP**

**IF**

**GO TO**

**RETURN**

**END**

**STOP**
Test\texttt{tot.f} continued

\begin{verbatim}
    IF ( \texttt{f} \geq \texttt{fmin(1)} ) {
        \texttt{format(j1)} \texttt{for (3=jj) for (j=1)}
        IF ( \texttt{put(j,3)} \texttt{go to 12} 
        IF ( \texttt{print(j,1)} \texttt{for (i=0}) \texttt{for (j=1})
        IF ( \texttt{print(j,1)} \texttt{go to 1})
        IF ( \texttt{print(j,1)} \texttt{for (j=1})
        IF ( \texttt{print(j,1)} \texttt{go to 1})
        \ldots
    }

13 IF ( \texttt{f} \geq \texttt{fmin(1)} ) \texttt{for (3=jj) for (j=1})
    IF ( \texttt{put(j,3)} \texttt{go to 12})
    IF ( \texttt{print(j,1)} \texttt{for (i=0}) \texttt{for (j=1})
    IF ( \texttt{print(j,1)} \texttt{go to 1})
    IF ( \texttt{print(j,1)} \texttt{for (j=1})
    IF ( \texttt{print(j,1)} \texttt{go to 1})
    \ldots
\end{verbatim}
FUNCTION \((Y_1, Y_2, X_1, X_2, A, R)\)

\[ Y = \frac{Y_1 - Y_2}{(X_1 - X_2)} \]

RETURN \(A\)

END
SUBROUTINE FLOT

C INTEG: FLOT, R, R=0, FLOT, R=1, FLOT, R=2, FLOT, R=3

I = FLOT (7, 1), FLOT (7, 2), FLOT (7, 3), FLOT (7, 4), FLOT (7, 5), FLOT (7, 6), FLOT (7, 7)

IF (I = 0) GOTO 1

IF (I = 1) GOTO 2

IF (I = 2) GOTO 3

IF (I = 3) GOTO 4

IF (I = 4) GOTO 5

IF (I = 5) GOTO 6

IF (I = 6) GOTO 7

IF (I = 7) GOTO 8

CONT

CALL FLOT (7, 1)

CALL FLOT (7, 2)

CALL FLOT (7, 3)

CALL FLOT (7, 4)

CALL FLOT (7, 5)

CALL FLOT (7, 6)

CALL FLOT (7, 7)

CALL FLOT (7, 8)

CONT
Plotlin.f

SUBROUTINE PLTLIN(INDEX, XMAX, XMIN, YMAX, YMIN, SCALEX, TITLE, TYPE)

SURFON THE ESTABLISHES SCALE, AXES AND LABELS FOR LINEAR PLOTTING
THE PEN IS ASSIGNED TO RE = 1 PLOTTER UNITS IN X DIRECTION AND
A PLOTTER UNITS IN Y DIRECTION AWAY FROM THE PLOTTING ORIGIN
(XMIN, YMIN) = "BOTTOM OF THE PAPER"
UNIT CALLED WITH:
INDEX SCAL WILL HE SET AND AXES WILL BE DRAWN AND LABELED
INDEX X SCALE AND AXIS (XMIN WILL BE SET
INDEX Y PEN WILL BE RETURNED TO THE "BOTTOM OF THE PAPER" FOR
THE NEXT PLOT
XMAX = MAXIMUM VALUE ON X-AXIS
XMIN = MINIMUM VALUE ON X-AXIS AND Y-AXIS INTERCEPT
YMAX = MAXIMUM VALUE ON Y-AXIS
YMIN = MINIMUM VALUE ON Y-AXIS BUT INTERCEPT OF X-AXIS WILL
ALWAYS BE AT YMIN.
SCALE X IS THE MULTIPLICATION FACTOR FOR THE LENGTH OF THE
Y-AXIS, LENGTH IS 5.*SCALEX PLOTTER UNITS PER USER UNITS
Y-AXIS IS ALWAYS 5 PLOTTER UNITS HIGH
TITLE(1,1) = LITERAL TITLE OF THE PLOT
TITLE(1,7) = LITERAL TITLE THEN INDEX
TITLE(2,1) = LITERAL TITLE OF UNITS ON THE Y-AXIS
TITLE(2,11) = LITERAL, BUT HAS NO FUNCTION

REAL*8 TITLE
DIMENSION TITLE(2,7), TYPE(2,1), DATE(6)
10 FORMAT(F12,1)
11 FORMAT(134)
12 FORMAT(12,11,2(A2,"","),A2));
6* AM = SCALEX*TITLE(*)
13 FORMAT(144)
14 FORMAT(* ,15));
15 FORMAT(* ,7(A8,"","))

IF (INDEX.GT.1) GO TO 1

SET INITIAL DATA FOR PLOTTING
XMIN := XMIN + (XMAX - XMIN)*5.
XMIN := XMIN + (XMAX - XMIN)*5.
XMAX := XMAX - XMAX + XMAX - XMAX + XMAX - XMAX + XMAX - XMAX + XMAX - XMAX + XMAX
YMAX := YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX
YMAX := YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX
YMIN := YMIN - YMIN + YMIN - YMIN + YMIN - YMIN + YMIN - YMIN + YMIN - YMIN + YMIN
YMIN := YMIN - YMIN + YMIN - YMIN + YMIN - YMIN + YMIN - YMIN + YMIN - YMIN + YMIN
IF (YMAX.GT.0.) GO TO 40
YMAX := YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX
GO TO 40
40 CMAX := CMAX + 10.*DM
IF (CMAX.GT.1) CMAX := CMX0.99999
YMAX := YMAX + CMAX + CMAX + CMAX + CMAX + CMAX + CMAX + CMAX + CMAX + CMAX + CMAX
IF (YMAX.GT.0.) GO TO 45
YMAX := YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX - YMAX + YMAX
GO TO 45
45 DO 41 =1,5

55
Plotlin.f continued

41 CONTINUE

42 IF (YMIN.LE.1., YMAX.LE.1.) GO TO 44

43 CONTINUE

C SET SCALF, AXES AND LABELS

CALL SCALF(1.,1.,1.,1.,1.,1.)
CALL PPLOT(1.,1.,1.,1.,1.,1.,1.)
CALL PPLOT(1.,1.,1.,1.,1.,1.,1.)

C IF INDEX=1 ONLY GRID THE AXES

CALL SCALF(XS, YS, XMIN1, YMIN1)
CALL PPLOT(1.,XMIN1, YMIN1, TX, YX)

IF (INDEX.LT.3) GO TO 6

DO 3 INDEX=1,3,MAX5

3 CALL PFL3(1)

CALL FCCHAR(X1,X1,Y1,Y1,15,15,15) WRITE(7,11) I

6 IF (INDEX.LT.7) GO TO 2

DO 11 INDEX=3,11

11 CALL PFL3(1)

CALL FCCHAR(X1,X1,Y1,Y1,15,15,15) WRITE(7,11) I
Plotlin.f continued

CALL PLAX(1)
TITLE = 1.3*YMAX
CALL FCHAX(YMIN,1,TY1,12,15,?,)
WHITE (7,14) (TITLE(1,1),1=1,7)
CALL PFLAG(1)
CALL FPRINT(-2,YMIN,YMAX)
CALL FPRINT(0,YMAX1,YMAX1)
CALL FFIT(?,YMAX1,YMIN1)
CALL HATT(FDATE)
TITLE = YMAX1 =C.3*YMAX
CALL CFCHAX(YMIN1,TY1,12,15,?
WHITE (7,12) (HATT(11),11=1,3)
CALL HFLAG(1)
2 RETURN.

C IF INMAX=2
C MOVE THE PEN FOR THE NEXT PLOT
1 TITLE = YMIN1 =2.27*YMAX
CALL FCHAX(YMIN1,TY1,12,15,?,)
WHITE (7,14) (TITLE(2,1),1=1,7)
CALL PFLAG(1)
CALL FFIT(?,2.27*YMAX,YMIN1)
CALL SCMAT(1.,1.,1.,1.)
CALL FFIT(?,0.,-1.)
RETURN.
END
SUBROUTINE PLOTT(R, INDEX, XMAX, XMIN, YMAX, YMIN, SCALEX, TITLE, TYPE)

SUBROUTINE Establishes SCALE, AXIS, AND LABELS FOR LOG E (Alog).

Y-AXIS AND LINEARS X-AXIS.

FOR GIVEN AXES, LABELS OF Y-AXIS. SUBROUTINE YLOGAF IS CALLED.

THE PP. IS ASSIGNED TO BE = 1 PLOTTER UNITS IN X DIRECTION AND

= 3 PLOTTER UNITS IN Y DIRECTION AWAY FROM THE PLOTTING ORIGIN.

(x0, y0) => "BOTTOM OF THE PAPER"

WHEN CALLED WITH:

INDEX = 1, SCALE WILL BE SET AND AXES WILL BE DRAWN AND LABELED.

INDEX = 2, SCALE AND AXES GREN WILL BE SET.

INDEX = 3, WILL BE RETURNED TO THE "BOTTOM OF THE PAPER" FOR

THE NEXT PLOT WITH "RIGHT" Y-AXIS LABELED AND TITLE.

INDEX = 4 THE SAME AS WHEN INDEX = BUT NO LABELS OR TITLE.

YMAX = "MAXIMUM VALUE ON Y-AXIS"

YMIN = "MINIMUM VALUE ON Y-AXIS AND Y-AXIS INTERCEPT"

Y1 = "MAXIMUM VALUE ON YAXIS (FOR PLOTTING X 1.00)

Y2 = "MINIMUM VALUE ON YAXIS (FOR PLOTTING X 0.01)

SCALEX = "THE MULTIPLICATION FACTOR FOR THE LENGTH OF THE

X-AXIS, LENGTH IS 5 SCALEX PLOTTER UNITS PER USER UNITS"

Y-AXIS IS ALWAYS 5 PLOTTER UNITS HIGH.

TYPE (1,1) = LITERAL TYPE OF UNITS ON THE "LEFT" Y-AXIS

TYPE (2,1) = LITERAL TYPE OF UNITS ON THE "RIGHT" CLOSING.

Y = "AXIS"

Y-NAXIS = "LITERAL TITLE OF THE PLOT"

X-NAXIS = "LITERAL TITLE WHEN INDEX = 2"

REAL * TITLE

DIMENSION TITLE (2,7), TYPE (2,17), INDEX (6)

FORMAT (1X)

50 FORMAT (14,2)

60 FORMAT (14)

70 FORMAT (5X,'19')

80 FORMAT (9X,12)


100 FORMAT ('*', 'I', 'D', 'A', 'A', '))

110 FORMAT ('*', 'I', 'A', '9', '))

120 FORMAT ('*', 'I', 'A', '9', '))

SET INITIAL DATA FOR PLOTTING.

XMIN = XMAX (X1/10.0) * 100

CHX = 'X' = 'X'

IF (CHX .EQ. Y) X1 = XMAX + 50,

XMAX = XMAX (X1) + 100

CHX = YMAX = XMAX

IF (CHX .EQ. HT, Y) XMAX = XMAX + 50,

IF (CHX .EQ. LT, Y) XMAX = XMAX + 50

YMAX = YMAX (Y1) + 100

IF (Y1 .EQ. FE, Y) Y1 = YMAX + 50

CONTINUE

11 Y1 = YMAX (Y1) + 100, **11

11 Y1 = YMAX (Y1) + 100, **11

DO 46 Y1 = 1, 5

CHYM = YMAX (Y1), **1

IF (Y1 .EQ. Y1, Y) CHYM = YMAX (Y1), **1

CONTINUE

46 Y1 = YMAX (Y1) + 100, **11

END
Plotlog.f continued

IF (YLL.LT.1.) YI=11
II=II+1
YMAX=-YMIN
XMIN=-XMAX
XMAX=XMAX
YMAX=YMAX
YMIN=-YMIN
SCX=1./XMAX
SCY=1./YMAX

IF (YI.EQ.1) GO TO 30
C
SET SCALE, AXIS AND LABEL THEM

CALL SCALF(XMIN,YMIN,XMAX,YMAX)
CALL PFLG(1)
CALL SCALM(X1,Y1,X2,Y2)
CALL PTFL(XM1,YM1,XM2,YM2)
MAX=XYMIN

IF (YI.EQ.1) GO TO 30
C
IF (INDEX.LT.0) GO TO 9

IF (INDEX.LT.0) GO TO 9

X#=FLOAT(I)-16./SCALEx
CALL FC#AR(X1,Y1,12.,15.,2)
WRITE (7,60) I
6
CALL PFLAG(1)
DO 7 I=1,5
II=II+1
BE#YI*X1+X1***(I-1)
CALL FC#AR(XMIN,REL.,12.,15.,0.)
WRITE (7,70)
CALL PFLAG(1)
BE#BY+1.3
D#LL=BE#YI*REL.
CALL FC#AR(XMIN,REL.,12.,15.,0.)
WRITE (7,80) I
7
CALL PFLAG(1)
YI=AL#N(YI*X1+X1)
CALL FC#AR(X31,Y31,Y11.,12.,15.,1.)
WRITE (7,170) (Y#(I,J),I=1,J=1)
CALL PFLAG(1)
C
PLOT EVERY SECOND DECADE

YI=11
DO 25 I=1,4
YI=11+YI
YI=AL#N(YI)
CALL P#LOT(1,XM1,YI,XYI)
CALL PLOT(2,XMAX,YI)
25
Plotlog.f continued

DO 20 J=1, 3
  YHIGLE=H*I*J*2.5*YHIGL
  CALL FPLTT(1, XI(1), YHIGL)
  CALL FPLTT(2, XII(2,1), YHIGL)
  CONTINUE
  YHIGLE=H*I*J*1.
  CALL FPLTT(1, XI(1), YHIGL)
  CALL FPLTT(2, XII(2,1), YHIGL)
20 CONTINUE
  CALL FPLTT(1, XMAX, YHIGL)
  TITLE="(YMAX=2")
  CALL FCHAR(XMIN, TITLE, 12., 15., 0.)
  WRITE (7, 111) (TITLE(JXI, XI), J=1, 3)
  CALL PFLAG(1)
  CALL NTIME(1, NATE)
  CALL FCHAR(XMIN, TITLE, 12., 15., 0.)
  WRITE (7, 112) (NTATE(JXI, XI), J=1, 3)
  CALL PFLAG(1)
  CONTINUE
  RETURN
C IF INDEX.EQ.1 THEN
C GO TO 1
C MOVE THE PEN FOR THE NEXT PLOT
30 TITLE="(YMIN=5, 0., 20.)
  CALL FCHAR(XMIN, TITLE, 12., 15., 0.)
  WRITE (7, 111) (TITLE(JXI, XI), J=1, 3)
  CALL PFLAG(1)
  CALL PMIN(1, XMAX, YMIN)
  CALL YMINA(YMIN, YMAX, YMINA, 5., R, XMIN, XMAX, SCX, SCY)
C IF INDEX.EQ.1 DO NOT LABEL THE TITLE
C IF (INDEX.EQ.1) THEN
  CALL FCHAR(XMIN, YMIN, YMAX, 12., 15., 0.)
  FM=YMXY(1, 1) + YMXY(1)
  WRITE (7, 50) FM
  CALL PFLAG(1)
  DO 40 I=1, 2
    YVA=FLAT(1)!
    YL=FLAT(JXI*(YMAX-1)!
    CALL FCHAR(YL, I=11, YLL, 12., 15., 0.)
    WRITE (7, 40) YVA
  CALL PFLAG(1)
40 CONTINUE
    CALL FCHAR(XMIN, YMIN, YMAX, 12., 15., 0.)
    FM=YMXY(1, 1) + YMXY(1)
    WRITE (7, 50) FM
    CALL PFLAG(1)
    XM=XYMIN+50.
    TITLE=OG(YMAX, YMIN)
    CALL FCHAR(XMIN, TITLE, 12., 15., 0.)
    WRITE (7, 100) (TYPE(2, 1), I=1, 10)
    CALL PFLAG(1)
  CONTINUE
  CALL FPLTT(1, XI(1), YHIGL)
CALL SCALE (3,...,7)
CALL PLOT (3,9,...,9)
RETURN
END
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