FULL-INFORMATION MAXIMUM LIKELIHOOD PROGRAM: USER'S GUIDE

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I. INTRODUCTION

The present program (denoted as FIML) is designed to compute full-information maximum likelihood estimates of the coefficients of a linear econometric model. The model can be a simultaneous equations model and can have auto-regressive residuals of up to second order. It can also have identity equations and linear coefficient restrictions both within and across equations. The computational method used by the program is described in Chow [1] and Chow and Fair [2]. The model can be as large as the user's computer memory will hold; while there are "default" limits, the size of the model can be specified by control cards to be as large as necessary. There are no absolute size restrictions built into the program.

II. THE BASIC PROGRAM

Consider the estimation of the following simple model:[1]

$$y_1 = y_3 \beta_{13} + \gamma_{11} + z_2 \gamma_{12} + z_3 \gamma_{13} + u_1 \quad ,$$
$$y_2 = y_3 \beta_{23} + \gamma_{21} + z_2 \gamma_{22} + u_2 \quad ,$$
$$y_3 = \gamma_{31} + z_3 \gamma_{33} + z_4 \gamma_{34} + u_3 \quad ,$$

[1] It should be noted that in the Chow [1] and Chow and Fair [2] papers the model is written in matrix notation as $YB' = Z\Gamma' + U$, whereas the present program expects the model to be in the form $0 = YB' + Z\Gamma' + U$.

where the β's and γ's are coefficients to be estimated, the y's and z's are vectors of observations, and the u's are vectors of unobserved error terms. Only three groups of data cards are required to estimate this model:

1) Cards listing the initial values for the coefficients,
2) A card describing the format of the data,
3) Cards listing the data on y_1, y_2, y_3, z_1 (=1.0), z_2, z_3 and z_4.

The cards needed for the above model are (assuming the data to be read in by observation in format 7F10.0):

column 1	column 15	column 20	columns 21-40
BETA	1	3	0.783
GAMMA	1	1	16.68
GAMMA	1	2	0.219
GAMMA	1	3	0.076
BETA	2	3	-0.229
GAMMA	2	1	34.33
GAMMA	2	2	0.874
GAMMA	3	1	1.23
GAMMA	3	3	0.186
GAMMA	3	4	0.157
YZOBS			columns 41-80: 7F10.0

{data: y_1, y_2, y_3, 1.0, z_2, z_3, z_4}

The order of the BETA and GAMMA cards does not matter. If the data are to be read in by variable, then the YZOBS card must be replaced by the following two cards:

column 1	column 15	columns 41-80
NOBS	25	
YZVAR		3(8F10.0/), F10.0

where the NOBS card indicates the number of observations on each variable. The data are then to be read in by variable, 25 observations for each variable, in the order y_1, y_2, y_3, 1.0, z_2, z_3, z_4. The format specifies that for each variable there are three cards with eight observations followed by a fourth card with one observation.

If one wants to estimate a model over only a subset of the data that have been read in, this can be done by including a SELECT card anywhere before the YZOBS or NOBS card. The card is:

```
column 1    column 15   column 20
SELECT      4           23
```

This card says that only observations 4 through 23 are to be used to compute the coefficient estimates. The program does not allow for there to be gaps in the sample period. If no SELECT card is specified, the coefficients are estimated using all of the observations that have been read in. A NOBS card does not have to be specified when data are read in by observation (although it can be) because the program merely continues to read data until a /* card is encountered.

Users with data on tape or disk may specify a unit number in columns 11-15 (right justified) of the YZOBS or YZVAR card from which data records are to be read.

III. CALLING FIML OFF OF THE DISK AT PRINCETON

The following cards are needed to call the FIML program off of the disk at Princeton:

```
column 1
//_ JOB _ .... (see Section IV.4 for T=  and  REG=)
//FIML_EXEC_PGM=FIML
//STEPLIB_DD_DISP=SHR,DSN=U.FIML.PROGRAM
//FTϕ6Fϕϕ1_DD_SYSOUT=A
//FTϕ5Fϕϕ1_DD_*
{BETA  1  3   0.783 }
 etc.
/*
```

("_" indicates at least one blank. ϕ means the number zero. O means the letter o .)

IV. OTHER OPTIONS OF THE PROGRAM

The discussion of the basic program in Section II will now be extended to demonstrate the following features:

1) Identity equations,
2) Auto-regressive residuals in the model,
3) Linear restrictions on the coefficients,
4) Expanding the capacity of the program,
5) Convergence control cards,
6) Optional output,
7) Punching out computed coefficients,
8) Increasing execution efficiency.

1. Identity equations

Any equation in the model may be specified as an identity equation. For example, to replace the third equation of the above model with the identity,

$$y_3 = y_1 + y_2 + .5z_4 \quad ,$$

the last three GAMMA cards would be replaced with

column 1	column 15	column 20	columns 21-40
IDENTITY	3		
BETA	3	1	1.0
BETA	3	2	1.0
GAMMA	3	4	0.5

2. Auto-regressive residuals in the model

Assume that the residuals of the above model obey the following second-order auto-regressive process:

$$u_1 = r_{11}^{(1)} u_{1_{-1}} + r_{13}^{(1)} u_{3_{-1}} + r_{11}^{(2)} u_{1_{-2}} + r_{12}^{(2)} u_{2_{-2}} + e_1 \quad ,$$

$$u_2 = r_{21}^{(1)} u_{1_{-1}} + r_{22}^{(1)} u_{2_{-1}} + r_{23}^{(2)} u_{3_{-1}} + e_2 \quad ,$$

$$u_3 = r_{33}^{(1)} u_{3_{-1}} + r_{33}^{(2)} u_{3_{-2}} + e_3 \quad ,$$

where the r coefficients are auto-regressive coefficients to be estimated and the minus subscripts on the u's denote lagged values.

The following extra cards are necessary to estimate the model with auto-regressive residuals:

1) An ND card specifying the order of the autoregressive process (one or two),

2) An NR card specifying the maximum number of auto-regressive coefficients to be estimated (nine in the above example),

3) Cards listing the initial values for the auto-regressive coefficients.

For the above example the cards are:

↓column 1	↓column 15	↓column 20	↓columns 21-40
ND	2		
NR	9		
R1	1	1	0.40
R1	1	3	0.0
R2	1	1	0.0
R2	1	2	0.0
R1	2	1	0.0
R1	2	2	0.20
R2	2	3	0.0
R1	3	3	0.05
R2	3	3	0.0

The ND and NR cards must be placed in front of any coefficient cards (BETA, GAMMA, R1, or R2) and all coefficient cards must precede the YZOBS card.

For a model with first-order auto-regressive residuals, the first sample observation is used for the lagged values. For a model with second-orderauto-regressive residuals, the first two sample observations are used for the lagged values. If a SELECT card is specified, say, SELECT 4 23 , and the auto-regressive process is, say, second order, then observations 4 and 5 will be used for the lagged values (not observations 2 and 3), and so only observations

6 through 23 will actually be used to compute the estimates. If no SELECT card is specified, then observations 2 through the end will be used for the first-order case and observations 3 through the end will be used for the second-order case.

3. Linear restrictions on the coefficients

The program can handle general linear restrictions on the coefficients. For example, assume that in the above model there is the following linear restrictions on the coefficients:

$$3 = 2\beta_{13} + 4\gamma_{12} + 3\beta_{23} + 5\gamma_{31} .$$

This restriction is specified as follows:

column 1 ↓	column 15 ↓	column 20 ↓	columns 21-40 ↓
RESTRICT			3.0
BETA	1	3	2.0
GAMMA	1	2	4.0
BETA	2	3	3.0
GAMMA	3	1	5.0

These cards must be placed after the cards specifying the initial values for the coefficients and before the YZOBS card. The first coefficient listed after the RESTRICT card is the coefficient that the program restricts. This means that an initial value for this coefficient does not have to be specified. If a restriction takes the form, say, $\gamma_{13} = \beta_{23}$, then the restriction can be put in the form $0 = -1\gamma_{13} + 1\beta_{23}$, and the appropriate cards are:

RESTRICT			0.0
GAMMA	1	3	-1.0
BETA	2	3	1.0

Restricting a coefficient to a constant, say $\gamma_{34} = 5.72$, can be accomplished by:

```
RESTRICT
GAMMA        3        4        5.72
                               1.0
```

It should be noted that the same coefficient cannot be restricted twice (i.e., the same coefficient cannot be placed first after more than one RESTRICT card). Also, once a coefficient such as β_{13} has been restricted in terms of other coefficients such as γ_{12}, the other coefficients may not be subsequently restricted in terms of the first coefficient (β_{13}). For example, for the following two restrictions:

$$3 = 2\beta_{13} + 4\gamma_{12} + 3\beta_{23} + 5\gamma_{31} ,$$
$$4 = 3\beta_{13} + 3\gamma_{12} + 6\beta_{23} + 4\gamma_{31} ,$$

one must solve the second as

$$4 = 3\left[\frac{3-4\gamma_{12} - 3\beta_{23} - 5\gamma_{31}}{2}\right] + 3\gamma_{12} + 6\beta_{23} + 4\gamma_{31}$$

or

$$-.5 = -3\gamma_{12} + 1.5\beta_{23} - 3.5\gamma_{31} .$$

The first restriction should then be interpreted as restricting β_{13} in terms of γ_{12}, β_{23}, and γ_{31}, and the derived second restriction should be interpreted as restricting γ_{12} in terms of β_{23} and γ_{31}. If initial values are not specified for coefficients to be restricted, these coefficients should not be used in

restrictions prior to the one in which they become restricted. (These rules only specify an input order such that the restrictions can be checked as they are read; they do not limit the ability to apply restrictions.) In the above example, therefore, if no initial value is specified for γ_{12}, the second restriction (the one restricting γ_{12}) should be placed before the first restriction. The appropriate RESTRICT commands are:

```
RESTRICT                    -0.5
GAMMA       1   2           -3.0
BETA        2   3            1.5
GAMMA       3   1           -3.5
RESTRICT                     3.0
BETA        1   3            2.0
GAMMA       1   2            4.0
BETA        2   3            3.0
GAMMA       3   1            5.0
```

Restrictions can also be placed on the auto-regressive coefficients in the same manner. For example, $3 = 4\ r_{11}^{(1)} + 2\ r_{33}^{(2)}$, becomes

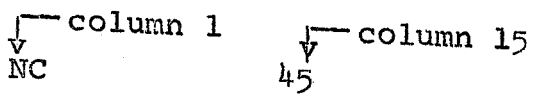
```
RESTRICT                     3.0
R1          1   1            4.0
R2          3   3            2.0
```

No restriction can involve both the beta and gamma coefficients and the auto-regressive coefficients. For example, the following restriction is not allowed: $2 = 5\ r_{11}^{(1)} + 3\ \beta_{23}$.

If restrictions involving more than two coefficients are used or if both auto-regressive residuals and restrictions are used, see the next section, Section IV.4, for suggestions using the 'NM' and 'NMR' cards.

4. Expanding the capacity of the program

So far no mention has been made regarding the capacity of the program. Capacity limitations do exist (at default levels), but they can be extended indefinitely, bounded only by the REGION specified on the JOB card. There are eight control cards that affect capacity limitations. All eight cards have a name starting in the first column and a number (integer) ending in column 15, so that, for example, "NC = 45" is specified as



These control cards must be placed ahead of the cards listing the initial coefficient values.

The maximum dimensions of the basic model are defined by the NY, NZ, and NC cards. NY and NZ are the maximum number of endogenous and predetermined variables respectively. If not specified, they default to NY = 10 and NZ = 20 . NC is the maximum number of coefficients in the model, including the β_{ii} coefficients, which are inserted automatically by the program (as restricted coefficients equal to -1). The default is NC = 50 .

The maximum dimensions of the model with auto-regressive residuals are defined by the ND and NR cards, which have already been discussed. ND is the order of the auto-regressive process, and NR is the maximum number of auto-regressive coefficients to be estimated. If neither ND nor NR is specified, they both default

to zero (the basic model). If only ND is specified, NR defaults to ND times NY. If only NR is specified, ND defaults to one. For the model with auto-regressive errors, the NC value must be at least as large as the NC value for the basic model times the ND value. See the last paragraph of this section.

The NM card allows for "extended restrictions" involving the β and γ coefficients and is difficult to set. See the last paragraph. NMR is similar for restrictions involving auto-regressive coefficients. Both default to zero.

The NOBS card is only required when reading data by the YZVAR control card or when using the PLOT optional output. (The PLOT optional output is discussed in Section IV.6.) The NOBS card sets the maximum number of observations allowed and defaults to 100.

As several of the above values are difficult to estimate, the program will compute the minimum values required, but only after successfully reading all control cards and data (without finding any errors). You thus need a "trial run" with:

REGION = 150K
T = 0.1 } on the JOB card

NY, NZ, ND, and NOBS values are usually well known
NC = NY * NZ * (ND+1) to be perfectly safe
NR = NY^2 * ND
NM = try 100
NMR = try 50 if any restricted auto-regressive coefficients

Only the NM and NMR values above can possibly be exceeded. After the program prints the Y and Z data, it will print a table

of the specified and required values of each of the above parameters, followed by the number of words or "K" of REGION that your over-estimates necessitate. Finally it will print the amount (in "K") by which your REGION can be reduced at Princeton (or elsewhere if you are using the 360/ASSEMBLER version) providing you change all the listed parameters to their minimum required values.

5. Convergence Control Cards

Convergence in the basic model is controlled by two cards, EPS and ITLIM . They default as:

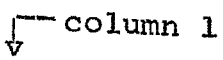
column 1	column 15	columns 21-40
EPS		0.0001
ITLIM	10	

ITLIM controls the maximum number of iterations before stopping. EPS is the convergence criterion. If the largest $\left|\frac{\alpha_i^{(n)} - \alpha_i^{(n-1)}}{\alpha_i^{(n-1)}}\right|$ is less than or equal to EPS, where $\alpha_i^{(n-1)}$ is the value of a coefficient on the $(n-1)^{st}$ iteration and $\alpha_i^{(n)}$ is the value of the coefficient on the n^{th} iteration, then convergence is reached.

Convergence in the model with auto-regressive residuals is controlled by two cards, either DELR and ITLIMR or EPSR and ITLIMR. DELR refers to absolute changes in the auto-regressive coefficients ($|\alpha_i^{(n)} - \alpha_i^{(n-1)}|$), while EPSR refers to percentage

changes in both the basic (β and γ) and auto-regressive coefficients. They default as DELR = 0.0001 and ITLIMR = 10 . As the solution of the model with auto-regressive residuals proceeds, by alternately solving for the β and γ coefficients and then for the auto-regressive coefficients (see Chow and Fair [2]), EPS controls only partial convergence (and reaching ITLIM is like reaching EPS convergence). Final convergence is reached when the estimates of the auto-regressive coefficients on the m^{th} "pass" are all within DELR of the respective coefficients estimates on the $m\text{-}1^{st}$ pass or when the estimates of all coefficients change by less than EPSR percent between two successive passes. (Only one of DELR and EPSR should be specified; if both are specified, only EPSR is used.) ITLIMR specifies the maximum number of passes the program will undertake before stopping.

The program can be forced to estimate the auto-regressive coefficients first by including the following card anywhere before the YZOBS card:



In this case the DELR test will not be applied until the second set of estimates of the auto-regressive coefficients is made.

6. Optional Output

Two additional sets of output can add considerably to the usefulness of the program. The first is a one or two page summary

and index of the complete output. This is obtained by inserting the following card anywhere before the YZOBS card:

```
column 1        column 15
SUMMARY         8
```

and the following JCL card immediately before the //FTϕ8Fϕϕ1 card:

```
// FTϕ8Fϕϕ1_DD_SYSOUT = A
```

The second additional set of output is an equation-by-equation analysis of the results. Using the FIML coefficient estimates, each equation is treated as if it were estimated by a single-equation technique, and single-equation summary statistics are presented. Plots of the actual and fitted values for each endogenous variable are also presented. To get this set of output, include the following card anywhere before the YZOBS card:

```
column 1
PLOT
```

7. Punching out computed coefficients

If a card specifying FILEOUT = 7 is put anywhere ahead of the YZOBS card and

```
// FTϕ7Fϕϕ1_DD_SYSOUT = B
```

is inserted immediately after the // FTϕ6Fϕϕ1 card in the JCL, every time a new set of coefficient estimates is computed, the values will be punched out as BETA, GAMMA, R1, or R2 control cards, which can be used as input for subsequent runs. A "set number" will be punched in columns 41-44 to provide correspondence with the printed coefficients. Only unrestricted coefficient values are punched.

Users familiar with disk or tape usage will find it easier to direct the FILEOUT records to a sequential dataset (LRECL = 44, unblocked if you need the last set in case of abends). An entire set may then be retrieved by a FILEIN card, on which the unit number is spedified in column 11-15 and the set number is specified in column 16-20. The FILEIN card thus replaces all BETA and GAMMA (or R1 and R2) initial-value cards. If the FILEOUT specifies the same unit as the FILEIN , the new coefficient sets will replace the old ones (this could cause recovery problems).

8. Increasing execution efficiency

Two additional control cards may be used to increase execution efficiency. If the auto-regressive coefficient matrices are completely unrestricted (no zero restrictions or other kinds of restrictions), then maximum likelihood estimates of the auto-regressive coefficients are merely ordinary least squares estimates. In the case of completely unrestricted auto-regressive coefficient matrices, one should specify the card

```
OLSQR
```

which causes the auto-regressive coefficients to be estimated by ordinary least squares. In this case initial estimates of the auto-regressive coefficients need not be supplied.

The second way in which execution efficiency might be increased is by specifying

```
                    ↓-- column 21
HLIM                1.0
```

This command avoids trying larger values of h (see Chow [1] and Chow and Fair [2] for the definition of h) if h=1 results in an improved likelihood ratio from the previous iteration value. General rules on the use and avoidance of this feature have not been formulated, but in several cases it hastened convergence considerably. (Note: do not try to specify a maximum h-value this way -- values other than one are treated as a limit which if reached causes termination.)

V. SUMMARY OF CONTROL CARDS

In Table 1 the control cards that have been discussed are listed. The control cards must be punched as follows:

cols. 1-8 : control card, starting in column 1.
cols. 11-15: "i" value, no decimal point, last digit in column 15
cols. 16-20: "j" value, no decimal point, last digit in column 20
cols. 21-40: "value" with a decimal point
cols. 41-80: may contain any comments, which will be printed.

TABLE 1. List of Control Cards

Type / Column 1	8	15	20	21	40	41	80	Default	Description
*		-	-	-		any comments			comment card
NY		i	-	-		"		10	max.# of Y vars.
NZ		i	-	-		"		20	max.# of Z vars.
NC		i	-	-		"		50	max.# of β and γ coeffs.
ND		i	-	-		"		0 or 1	order of auto-regressive process
NR		i	-	-		"		0 or ND·NY	max.# auto-regressive coeffs.
NM		i	-	-		"		0	max.# of extended β and γ restrictions
NMR		i	-	-		"		0	max.# of extended auto-regressive coeff. restrictions
PLOT		-	-	-		"		-	print eq.-by-eq. output at end
SUMMARY		i	-	-		"		-	unit used for printing summary output
EPS		-	-	value		"		0.0001	convergence criterion within an iteration
ITLIM		i	-	-		"		10	max.# of iterations allowed
DELR		-	-	value		"		0.0001	convergence criterion between passes (absol.)
EPSR		-	-	value		"		-	" " " " (%)
ITLIMR		i	-	-		"		10	max.# of passes allowed
STARTR		-	-	-		"		-	starts by estimating auto-regressive coeffs. first
OLSQR		-	-	-		"		-	OLS for auto-regressive coeffs.
HLIM		-	-	1.0		"		1000.0	limit of 1 on h if improvement
BETA		i	j	value		"		-	initial value of β_{ij}
GAMMA		i	j	value		"		-	initial value of γ_{ij}
R1		i	j	value		"		-	initial value of $r_{ij}^{(1)}$
R2		i	j	value		"		-	" " " $r_{ij}^{(2)}$
IDENTITY		i	-	-		"		-	specifies an identity eq.
FILEOUT		i	-	-		"		-	unit used for coeff. output
FILEIN		i	j	-		"		-	unit used for coeff. input
RESTRICT		-	-	value		"		-	beg.of a linear restr.
NOBS		i	-	-		"		100	# of obs.or max.# obs.
SELECT		i	j	-		"		i=1, j=NOBS	subset of obs.to be used to estimate coeffs.
YZOBS		(i)	-	-		format specifi-cation		-	read data by obs.
YZVAR		(i)	-	-				-	read data by variable

VI. A SAMPLE PROGRAM

The computer input with all the features described above (except FILEIN and OLSQR) would look like:

```
//_JOB_ ... P=250, T=0.10, REG=150K
//FIML_EXEC_PGM=FIML
//STEPLIB_DD_DISP=SHR,DSN=U.FIML.PROGRAM
//FT08F001_DD_SYSOUT=A
//FT06F001_DD_SYSOUT=A
//FT07F001_DD_SYSOUT=B
//FT05F001_DD_*
*
                                SAMPLE PROGRAM.
NY          3
NZ          4
ND          2
NC         36                   INITIAL OVERESTIMATE
NR          9
NM         50                   INITIAL OVERESTIMATE
SUMMARY     8
PLOT
FILEOUT     7
EPS                     0.0025
ITLIM      15
DELR                    0.001
ITLIMR     20
STARTR
HLIM                    1.0
BETA        1   3       0.783
GAMMA       1   1      16.68
GAMMA       1   2       0.219
BETA        2   3      -0.229
```

```
GAMMA       2       1   34.33
GAMMA       2       2   0.874
IDENTITY    3
BETA        3       1   1.0
BETA        3       2   1.0
GAMMA       3       4   0.5
R1          1       1   0.40
  :
R2          3       3   0.0
RESTRICT
GAMMA       1       3   -1.0
BETA        2       3   1.0
SELECT      4      23
NOBS       25
YZVAR
```

3(8F10.0/), F10.0

{ data for y_1
data for y_2
data for y_3
data for z_1 = 1.0
data for z_2
data for z_3
data for z_4 }

/*

VII. ERROR MESSAGES

Ordinary input errors do not cause the program to terminate immediately; instead, all input is read up to the control card that causes data to be read, at which point the program will terminate. In examining the output, the user should remember that the occurance of an error causes part of his input to be ignored. Thus a single error can generate a situation in which correct input appears erroneous. For example, if a card specifying NY=25 is punched inproperly so that the default of NY = 10 is used, all cards specifying coefficients in rows 11 to 25 will be flagged as errors. To prevent error "snowballing" of this sort, the program will terminate after 20 errors.

A "STOP nn" statement usually appears on the system output page and gives a quick indication of the way in which a run terminated:

STOP 18

Insufficient NM or NMR value detected too late. Report to program author.

STOP 19

Method failure (HLIM exceeded).

STOP 24

A matrix is singular or nearly singular.

STOP 26

Insufficient array space.

STOP 29

Input errors.

STOP 30

Normal termination after final convergence is reached.

STOP 31

Iteration limit reached.

The following is a list in alphabetical order of the major error messages in the program:

*** 'BETA/GAMMA' AND 'R*' IN SAME EQUATION

A restriction equation contains both β or γ coefficients and auto-regressive coefficients. This type of restriction cannot be handled by the current method of solution.

*** COEFFICIENT HAS ALREADY BEEN RESTRICTED

The coefficient to be restricted in a restriction equation has been restricted previously. See Section IV.3.

*** COEFFICIENT IS IN AN IDENTITY EQUATION

The coefficient to be restricted in a restriction equation is in an equation previously specified as an identity.

*** COEFFICIENT PREVIOUSLY RESTRICTED TO A CONSTANT

The coefficient to be restricted in a restriction equation has been restricted to a constant by a previous restriction.

*** COEFFICIENT PREVIOUSLY SPECIFIED

1) A BETA, GAMMA, R1, or R2 control card specifies a coefficient for which a value has already been given.
2) Coefficients in a set being read by a FILEIN card have already been specified.

*** COEFFICIENT SPECIFIED FOR IDENTITY EQUATION

An R1 or R2 coefficient has been specified in an identity equation (for which there should be no residual).

*** CONTROL CARD PARAMETER PREVIOUSLY SPECIFIED

A control card has already appeared and may not appear more than once.

*** DETERMINANT OVERFLOW

In taking the determinant of S or W as used in computing the likelihood ratio, the determinant was greater than e^{172}. The determinant is set to e^{172} and the program continues.

*** END-OF-FILE ON CONTROL CARD FILE

This is not an error but simply a note that all control cards and data have been read.

*** END OF 'FILEIN' COEFFICIENT SET

This is not an error.

*** EQUATION SUMS TO: ccc = bbb

All coefficients in a restriction equation have initial values, but they are not consistent with the restriction. ccc is the number on the RESTRICT card and bbb is the number implied by the initial values. Because of the format used, ccc and bbb may print the same but they are not the same to 7 digits (single precision accuracy). This and other problems can be avoided by not specifying initial estimates for coefficients to be restricted. See Section IV.3.

*** EQUATION NUMBER NOT WITHIN ALLOWABLE RANGE

An IDENTITY control card specifies a row number greater than the NY parameter. See Section IV.4.

*** EXCEEDS 'ND' LIMIT OF aaa

An R1 or R2 coefficient has been read when ND has been specified (or defaulted) to 0 or 1 respectively. See Section IV.2.

*** EXCEEDS PROGRAM LIMIT OF 2

ND has been specified greater than 2. The program currently limits the model to second-order auto-regression.

EXCESS SPACE REQUIREMENT = aaaaa WORDS
CORE REQUIREMENT COULD BE CUT BY bbbbb WORDS (ccc K)

"aaaaa" is the excess array space required by specifying NY, NZ, etc. larger than actually used. If these were changed to the values indicated in the "SPECIFIED-USED" table printed just before this message, the core requirement could be reduced as indicated in the second line.

*** EXECUTION INHIBITED DUE TO THE ABOVE nn ERROR(S)

Too many errors to continue processing. Correct them and resubmit.

*** 'F' MATRIX IS SINGULAR

*** 'F' MATRIX IS NEARLY SINGULAR

The matrix of second derivatives required for Newton's method is singular or nearly singular. This means that the model is poorly identified, has too little data or too many parameters, or some other malady such as an input error.
The program terminates with a STOP 24.

*** IDENTITY ALREADY SPECIFIED

A second IDENTITY control card specifies the same equation.

*** INCORRECT CONTROL CARD FORMAT

Either a field (e.g. i, j, value) contains data and should not or vice versa. Check Table 1.

*** INCORRECT CONTROL CARD PARAMETER

The value of i, j, or value is not acceptable (e.g. negative or zero). This will also occur if an input or output unit is designated which conflicts with other unit usage.

*** INSUFFICIENT MEMORY AREA TO ALLOCATE WORK ARRAYS

aaaaa WORDS ALLOCATED TO STORAGE BY MAIN PROGRAM

bbbbb WORDS REQUIRED SO FAR INCLUDING THE FOLLOWING

ccccc WORDS CURRENTLY REQUESTED AT THE POINT INDICATED BELOW

ddddd WORDS MINIMUM TO

eeeee WORDS MAXIMUM COULD BE REQUIRED

(followed by FORTRAN error traceback)

The space available for arrays is insufficient for the size of the problem. The minimum and maximum required are based on information available at that point in the input stream. After all data have been read, the minimum and maximum values will be equal and give an exact figure on which increases can be based.

1) At Princeton (or elsewhere using 360/ASSEMBLER version): increase the REGION size on the JOB card. The largest possible increase required is given (in "K") by (eeeee-aaaaa)/256 rounded up to an even integer.

2) Other installations (using FORTRAN only): the value aaaaa is the dimension of the vector MAINAR as well as the value of the variable NAR in the main program. These must be increased and the main program recompiled and linked to the rest of the program. The largest possible required value for the dimension is given by eeeee . The REGION size on the JOB card will also have to be increased, similar to 1) above.

*** INSUFFICIENT OBSERVATIONS

No observations remain for estimating the coeffients.

*** INVALID 'FILEIN' FILE

The unit specified on the FILEIN card does not contain parameter value sets as it should. Check the system control cards (DD cards) for this run and the run on which the old values were written.

ITERATION LIMIT OF aaa REACHED

The number of iterations for either a basic solution (B/Γ or R1/R2) or an auto-regressive solution (two-step procedure) has reached the user specified limit. If this is the limit for one step of the two-step auto-regressive solution, the next step is initiated as if convergence had been reached in this step.

*** LAST SET ON FILE aa IS NUMBER bbb

A FILEIN specifies a "set number" (j field) larger than the last set written on the specified file. Check which dataset the system control cards (DD cards) reference both for this run and the run on which the old values were written.

*** NO STOCHASTIC EQUATIONS LEFT

Every equation has been set as an identity.

*** NO 'Y' DATA READ

*** NO 'Z' DATA READ

Either or both of these will appear if after reading all control cards, no data has been read for Y or Z variables. This would indicate a missing or erroneous YZOBS or YZVAR card.

*** NUMBER OF COEFFICIENTS REQUIRED EXCEEDS SPECIFIED MAXIMUM OF aaaa

The NC or NR parameter is insufficient. See Section IV.4.

*** NUMBER OF TRANSORMATION COEFFICIENTS REQUIRED EXCEEDS SPECIFIED MAXIMUM OF aaaa

The NM or NMR parameter is insufficient. See Section IV.4.

*** 'R*' COEFFICIENTS PREVIOUSLY SPECIFIED IN THIS EQUATION

An IDENTITY control card specifies a row in which R1 or R2 coefficients have been specified.

*** RESTRICTION COEFFICIENT IGNORED DUE TO ABOVE ERROR

In reading a restriction equation, an error will cause subsequent coefficients in the equation to be ignored, with this message printed to indicate that no action is taken for that control card. This is not included in the error count.

*** RESTRICTIONS ARE CIRCULAR

A coefficient in this restriction equation has previously been restricted using (perhaps indirectly) the coefficient to be restricted by this equation.

*** ROW aaa IS EMPTY

The specified row contains no coefficients (other than the main diagonal of β).

*** 'S' MATRIX IS NEARLY SINGULAR
*** 'S' MATRIX IS SINGULAR
*** 'W' MATRIX IS NEARLY SINGULAR
*** 'W' MATRIX IS SINGULAR

The indicated matrix cannot be inverted to compute the derivatives of the likelihood ratio (which is either zero or infinity). The program terminates with a STOP 24.

*** SECOND PARAMETER EXCEEDS SPECIFIED 'NOBS'

The SELECT card's "last" observation is greater than the NOBS value.

*** SECOND UNDEFINED COEFFICIENT: FIRST WAS aaaaa (bb,cc)

A second coefficient has been read in a restriction equation which does not have an initial value. The first such coefficient is indicated. See Section IV.3.

*** SPECIFIED INPUT DATA HAS ALREADY BEEN READ

Attempt to read Y or Z data when it has already been read.

STEP SIZE OF aaaaa EXCEEDS LIMIT OF bbbbb

In the search for an optimum step size, successive step sizes of $1.0, 1.25, 1.25^2, 1.25^3, \ldots,$ aaaaa were tried and each gave a higher likelihood ratio than the last. The method will not work and the program terminates.

*** SUBSCRIPT NOT WITHIN ALLOWABLE RANGE

The $\underline{i}$ or $\underline{j}$ subscript for a BETA, GAMMA, R1, or R2 coefficient exceeds the limits given by the NY and NZ parameters or a BETA card has $\underline{i} = \underline{j}$ (the main diagonal elements of β are inserted automatically by the program as all -1.0). See Section IV.4.

*** UNRECOGNIZABLE CONTROL CARD

Control word (cc. 1-8) is not valid. Check the spelling; make sure the word starts in column 1.

*** aaaaa OBSERVATIONS READ FROM UNIT bbb

This is not generally an error. The observation count will be taken from the number of observations read before an end-of-file unless limited by a SELECT card.

*** aaaaa VARIABLES REQUIRED, END-OF-FILE AFTER bbbbb

While reading data by variable, not as many variables could be read as were required. Check the format specification in columns 41-80 of the YZVAR card.

REFERENCES

[1] Chow, Gregory C.: "Two Methods of Computing Full-Information Maximum Likelihood Estimates in Simultaneous Equations," International Economic Review IX (February, 1968), 100-112.

[2] Chow, Gregory C. and Ray C. Fair: "Maximum Likelihood Estimation of Linear Equation Systems with Auto-Regressive Residuals," Research Memorandum No. 118, Econometric Research Program, Princeton University, September 1971.