Stochastic simulation of econometric models: installation procedures and user's instructions

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STOCHASTIC SIMULATION OF ECONOMETRIC MODELS: INSTALLATION PROCEDURES AND USER'S INSTRUCTIONS

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This manual describes the input requirements and the installation procedures of the program for stochastic simulation of econometric models, announced in Econometrica, volume 46, number 1, (January 1978). This program is available on magnetic tape, including samples (Klein-I and Klein-Goldberger models) and installation procedures under the operating system VM-370/CMS [5]; format and contents of the tape are briefly described. The input data sets and the final printed output of the stochastic simulation of the Klein-I model are displayed. References to the algorithms mentioned throughout this manual can be found in [2] and [3].

CONTENTS

1. INPUT REQUIREMENTS

Two files must be created to run stochastic simulation of each new econometric model: one is a FORTRAN subroutine, formalizing the model's equations and the second is a data set containing time series values and estimated structural coefficients.

When operating under VM-370/CMS these two files must be on the minidisk of the user's virtual machine; they must have the same arbitrary FILENAME; FILETYPE must be FORTRAN for the first (and TEXT for its corresponding object module after compilation) and DATA for the second. For example, for Klein-I model, the two files (10-th and 11-th on the tape) have been called KLEIN1 FORTRAN and KLEIN1 DATA.

An additional input file (15-th file on the tape) is required to contain the starting point for the pseudo-random numbers generator. Its CMS identifier must be INITIAL RANDOM; it is a one-card data set, containing an integer number with format (I10). Such a file, however, can be used for any model and does not need to be modified or duplicated unless experiments with different starting points for the pseudo-random disturbances are to be performed. The number in the file can be any integer between 1 and 2147483647 (=2**31-1).

1.1. The FORTRAN subroutine for the model

The following three statements are mandatory as heading lines of this subroutine for any model:

```
      SUBROUTINE MODEL (Y,X,NEXO,IREAD,I,YL,NEND,U,A)
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION Y(1),X(NEXO,IREAD),YL(NEND,IREAD),U(1),A(1)
```

It is recommended to use them "exactly" as they are listed above. The meaning of the involved variables is listed in the example below.

After these heading statements the model's equations must follow; normalization and ordering of the equations must be such as to guarantee convergence of the Gauss-Seidel solution algorithm (no automatic reordering is performed by this program); obviously in each equation a different endogenous variable must be made explicit on the left hand side.

The usual RETURN and END statements close the subroutine.

For example, for the Klein-I model this FORTRAN subroutine (10-th file on the tape; KLEIN1 FORTRAN is its CMS identifier when copied on disk) is as follows:

```
      SUBROUTINE MODEL (Y,X,NEXO,IREAD,I,YL,NEND,U,A)
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION Y(1),X(NEXO,IREAD),YL(NEND,IREAD),U(1),A(1)
C*********************************************************************
C MEANING OF THE VARIABLES
C X MATRIX OF EXOGENOUS VARIABLES; FOR EXAMPLE:
C X(2,I) IS THE SECOND EXOGENOUS AT CURRENT TIME I;
C X(2,I-1) IS THE SAME VARIABLE LAGGED ONE PERIOD, ETC.
C Y VECTOR OF CURRENT ENDOGENOUS VARIABLES.
C YL MATRIX OF LAGGED ENDOGENOUS VARIABLES; YL(5,I-1) IS THE 5-TH
C    ENDOGENOUS VARIABLE LAGGED ONE PERIOD, ETC.
C A IS THE VECTOR OF THE STRUCTURAL STOCHASTIC COEFFICIENTS.
C U IS THE VECTOR OF THE RANDOM DISTURBANCES.
```

```
C...FOR THE OTHER SYMBOLS, SEE THE MAIN PROGRAM...
C*********************************************************************
C   LIST OF ENDOGENOUS VARIABLES
C  Y(1)    = C        CONSUMPTION.
C  Y(2)    = I        INVESTMENT.
C  Y(3)    = W1       PRIVATE WAGES.
C  Y(4)    = Y        NATIONAL PRODUCT.
C  Y(5)    = P        PROFITS.
C  Y(6)    = K        END-OF-YEAR CAPITAL STOCK.
C   LIST OF EXOGENOUS VARIABLES
C  X(1,I)  = W2       GOVERNMENT WAGES.
C  X(2,I)  = T        INDIRECT TAXES.
C  X(3,I)  = TIME     1931=0.
C  X(4,I)  = G        GOVERNMENT EXPENDITURES.
C  X(5,I)  = 1.       CONSTANT TERM (INTERCEPT).
C   LIST OF EQUATIONS
C     CONSUMPTION
      Y(1) = A(1)*X(5,I)+ A(4) *(Y(3)+X(1,I)) + A(2) *Y(5) +
     +       A(3) *YL(5,I-1) +U(1)
C     INVESTMENT
      Y(2) = A(5)*X(5,I) + A(6)  *Y(5) + A(7) *YL(5,I-1) +
     +       A(8)*YL(6,I-1) +U(2)
C     PRIVATE WAGES
      Y(3) = A(9)*X(5,I)+A(10)*(Y(4)+X(2,I)-X(1,I))+A(12)*X(3,I)+
     +       A(11)*(YL(4,I-1)+X(2,I-1)-X(1,I-1)) +U(3)
C     NATIONAL PRODUCT
      Y(4) = Y(1) + Y(2) + X(4,I) - X(2,I)
C     PROFITS
      Y(5) = Y(4) - Y(3) - X(1,I)
C     CAPITAL
      Y(6) = YL(6,I-1) + Y(2)
C*********************************************************************
      RETURN
      END
```

Please note that each behavioural equation includes its stochastic error term U, while identities do not have stochastic terms. The numerical subscript of the stochastic term refers to the ordering in which residuals are read from the input data set (section 1.2.); thus U(1) corresponds to the first series of residuals in the input data set (and must not be necessarily related to the equation of Y(1)), U(2) to the second series of residuals, etc.

1.2. The input data set

It is a card-image file

1-st and 2-nd card: Comments (title) in free format.

3-rd card: The following list of integer numbers, each of which with format (I5).

col. 1- 5: NREP = number of replicated solutions to be performed for each year of the simulation period. If 0 is specified, only deterministic simulation is to be performed.

col. 6-10: NPRINT = number of replications to be summarized in a single printout (it can be equal to NREP if a single printout is desired, or it can be a submultiple of NREP).

col.11-15: NEND = number of endogenous variables.

col.16-20: NSTOCH = number of stochastic behavioural equations.

col.21-25: NEXO = number of exogenous variables.

col.26-30: NCOEFF = number of structural stochastic coefficients.

col.31-35: INYEAR = the starting date (year) for the time series; if all series do not start in the same year, the earliest starting date must be used.

col.36-40: NFINYR = the end date (year) of the time series; if all series do not end in the same year, the latest end date must be used here.

col.41-45: IFROM = initial year for the simulation experiment to be performed.

col.46-50: ITO = final year for the simulation experiment to be performed.

col.51-55: IVERIF = flag 0 or 1; if 1 residual check (verify) must be preliminarily performed: on the terminal (unit 6 for FORTRAN) and on the printer (unit 8) are printed for each year the absolute and the relative differences (in percentage form) between each endogenous variable and the right hand side of its equation, including residuals; these values are expected to be close to zeroes.

col.56-60: IDYNAM = flag 0 or 1; if 0 one-step simulation (total method) must be performed; if 1 dynamic simulation (final method) is performed.

The remaining cards will contain time series values.

4-th card: with format (2I5,1X,A8,1X,I1) must contain the following:

starting date (year) of the first endogenous variable (corresponding to Y(1) in the FORTRAN subroutine);

end date (year);

name (up to 8 characters) of the first endogenous variable;

flag: if 0 (or blank) all the results related to such a variable must be printed, if 1 they must be ignored in the printed output.

5-th card and following: time series values of the first endogenous variable, 4 per card, with format (4F15.6).

The same group of cards (4-th and following) are repeated for the second endogenous variable and so on (NEND times); the order of the variables must be the same in which they appear in the FORTRAN subroutine (as Y(1), Y(2), etc.).

The same group of cards, with the same format, must then be repeated NEXO times for the exogenous variables (X(1,I), X(2,I), etc.).

The time series of the structural residuals must now be introduced. Each series of the residuals of the single structural equations (NSTOCH in all) must be preceded by a heading card with initial and final year, with format (2I5); the residuals must be 5 per card, with format (5F15.6).

To finish, the structural coefficients must be introduced. They must be in the same order in which they appear in the FORTRAN subroutine, as elements of the vector A (NCOEFF is its length). They can be listed consecutively, 5 per card with format (5F15.6), preceded by a card indicating, in format (I5), the total number of structural coefficients of the model; otherwise they can be introduced equation by equation, with format (5F15.6), each time preceded by a card indicating, with format (I5), the number of coefficients of the equation itself.

In each heading line, for a group of data, everything exceeding the format is a comment.

It is important that the number of endogenous time series matches NEND, the number of exogenous time series matches NEXO and the number of residual vectors matches NSTOCH; finally the number of coefficients must be NCOEFF.

For example, for the Klein-I model this input data set (11-th file on the tape; KLEIN1 DATA is its CMS identifier when copied on disk) is as follows.

```
KLEIN-I MODEL. STOCHASTIC SIMULATION. 2SLS ESTIMATE AS IN
GOLDBERGER-NAGAR-ODEH'S PAPER (ECONOMETRICA 1961).
  100  100    6    3    5   12 1919 1941 1921 1941    0    0
 1920 1941 C                         ENDOGENOUS VARIABLES
    39.8000         41.9000         45.0000         49.2000
    50.6000         52.6000         55.1000         56.2000
    57.3000         57.8000         55.0000         50.9000
    45.6000         46.5000         48.7000         51.3000
    57.7000         58.7000         57.5000         61.6000
    65.0000         69.7000
 1920 1941 I
    2.70000        -.200000         1.90000         5.20000
    3.00000         5.10000         5.60000         4.20000
    3.00000         5.10000         1.00000        -3.40000
   -6.20000        -5.10000        -3.00000        -1.30000
    2.10000         2.00000        -1.90000         1.30000
    3.30000         4.90000
 1920 1941 W1
    28.8000         25.5000         29.3000         34.1000
    33.9000         35.4000         37.4000         37.9000
    39.2000         41.3000         37.9000         34.5000
    29.0000         28.5000         30.6000         33.2000
    36.8000         41.0000         38.2000         41.6000
    45.0000         53.3000
 1920 1941 Y
    43.7000         40.6000         49.1000         55.4000
    56.4000         58.7000         60.3000         61.3000
    64.0000         67.0000         57.7000         50.7000
    41.3000         45.3000         48.9000         53.3000
    61.8000         65.0000         61.2000         68.4000
    74.1000         85.3000
 1920 1941 P
    12.7000         12.4000         16.9000         18.4000
    19.4000         20.1000         19.6000         19.8000
    21.1000         21.7000         15.6000         11.4000
    7.00000         11.2000         12.3000         14.0000
```

```
   17.6000         17.3000         15.3000         19.0000
   21.1000         23.5000
1919 1941 K
   180.100         182.800         182.600         184.500
   189.700         192.700         197.800         203.400
   207.600         210.600         215.700         216.700
   213.300         207.100         202.000         199.000
   197.700         199.800         201.800         199.900
   201.200         204.500         209.400
1920 1941 W2                   EXOGENOUS VARIABLES
   2.20000         2.70000         2.90000         2.90000
   3.10000         3.20000         3.30000         3.60000
   3.70000         4.00000         4.20000         4.80000
   5.30000         5.60000         6.00000         6.10000
   7.40000         6.70000         7.70000         7.80000
   8.00000         8.50000
1920 1941 T
   3.40000         7.70000         3.90000         4.70000
   3.80000         5.50000         7.00000         6.70000
   4.20000         4.00000         7.70000         7.50000
   8.30000         5.40000         6.80000         7.20000
   8.30000         6.70000         7.40000         8.90000
   9.60000         11.6000
1921 1941 TIME
  -10.0000        -9.00000        -8.00000        -7.00000
  -6.00000        -5.00000        -4.00000        -3.00000
  -2.00000        -1.00000         .0              1.00000
   2.00000         3.00000         4.00000         5.00000
   6.00000         7.00000         8.00000         9.00000
   10.0000
1920 1941 G
   4.60000         6.60000         6.10000         5.70000
   6.60000         6.50000         6.60000         7.60000
   7.90000         8.10000         9.40000         10.7000
   10.2000         9.30000         10.0000         10.5000
   10.3000         11.0000         13.0000         14.4000
   15.4000         22.3000
1921 1941 CONSTANT
   1.00000         1.00000         1.00000         1.00000
   1.00000         1.00000         1.00000         1.00000
   1.00000         1.00000         1.00000         1.00000
   1.00000         1.00000         1.00000         1.00000
   1.00000         1.00000         1.00000         1.00000
   1.00000
1921 1941                    RESIDUALS
     -0.462706       -0.616492       -1.304310       -0.245888        0.229482
      0.885369        1.441840        1.341830       -0.394091       -0.625634
     -1.065610       -1.330430        0.610220       -0.142358        0.002885
      2.003070       -0.605754       -0.247928        1.384760        1.031770
     -1.893540
1921 1941
     -1.316770        0.260542        0.863514       -1.589980        0.262383
      1.211130        0.972715        0.117038        1.799650       -0.948889
     -0.803260       -0.892119        1.308640       -0.148140        0.145630
      1.752740       -0.188064       -3.287290        0.288949       -0.100161
      0.366706
```

```
1921 1941
    -1.296970      0.294890      1.188160     -0.139933     -0.467373
    -0.486607     -0.732667      0.334367      1.192050     -0.159485
     0.584402      0.092249      0.445699      0.279009      0.010945
    -0.851808      0.990709     -0.477612     -0.381070     -1.094280
     0.591751
   4        COEFFICIENTS OF EQUAT. C
    16.5548        0.0173024     0.216235      0.810182
   4        COEFFICIENTS OF EQUAT. I
    20.2782        0.150222      0.615944     -0.157788
   4        COEFFICIENTS OF EQUAT. W1
    1.5003         0.438859      0.146673      0.130396
```

Please note that the string ENDOGENOUS VARIABLES in the fourth card is only a comment, such as the strings EXOGENOUS VARIABLES, RESIDUALS and COEFFICIENTS OF EQUAT. C (I or W1); all of them, in fact, exceed the read format.

Note also that, for quarterly (monthly) models, quarters (months) must be numbered consecutively and not in terms of year and quarter (month).

2. MAIN PROGRAM AND SIZE OF THE MODEL

The main program (third file on the tape; STOCSIM FORTRAN is its CMS identifier when copied on disk) contains a list of the main variable names and the dimensions of the vectors and matrices used all over the program. It also contains the following comment lines, indicating the dimensions of the vectors and matrices:

```
C  MAXIMUM NUMBER OF DATA PER SERIES (IREAD) IS 0034
C  MAXIMUM NUMBER OF ENDOGENOUS (NEND) IS 0099
C  MAXIMUM NUMBER OF EXOGENOUS (NEXO) IS 0076
C  MAXIMUM NUMBER OF STRUCTURAL EQUATIONS (NSTOCH) IS 0051
C  MAXIMUM NUMBER OF STRUCTURAL COEFFICIENTS (NCOEFF) IS 0269
```

If these specified dimensions are insufficient for a given model, dimension statements must be modified all over the main program, not in the subroutines, where symbolic dimensions are always specified.

For example, before performing stochastic simulation experiments on a model with 135 endogenous variables, the following commands should be issued under VM-370/CMS environment:

```
edit stocsim fortran
EDIT:
change /0099/0135/ * *
C  MAXIMUM NUMBER OF ENDOGENOUS (NEND) IS 0135
      DIMENSION YOBS(0135,0034),YSTOC(0135,0034),YDET(0135,0034),
     ,YMEAN(0135,0034),
     ,SIGMA(0051,0051),AMAX(0135,0034),AMIN(0135,0034),
     ,VAR(0135,0034),
     ,INEND(0135),
     ,NFEND(0135),INEXO(0076),NFEXO(0076),INRES(0051),NFRES(0051),
     ,YSUM(0135,0034),
     ,VARSUM(0135,0034),TITLE1(10),TITLE2(10),ZLRES(0051),
     ,UMCO(0051),YY(0135),
     ,YMEANP(0034),ENDNAM(0135),EXONAM(0076),NVOUT(0135)
2     IF(NEND.LE.0135)GO TO 3
```

```
102    FORMAT(' MAXIMUM NUMBER OF ENDOGENOUS EXCEEDED (0135)')
EOF:
file
R; T=0.06/0.28 09:45:14

fortgi stocsim (print)
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = MAIN
*  NO DIAGNOSTICS GENERATED
R; T=0.41/0.64 09:46:33
```

3. THE PRINTED OUTPUT

For every year of the simulation period a table referred to all the endogenous variables is displayed. It includes:

1) The serial number of the variable and its name.
2) The observed (historical) value.
3) The deterministic solution value.
4) The sample mean computed across the replications of the stochastic solutions.
5) The minimum computed across the replications of the stochastic solutions.
6) The maximum computed across the replications of the stochastic solutions.
7) Range of the stochastic solutions (maximum - minimum).
8) The sample standard deviation computed across the replications of the stochastic solutions.
9) Standard deviation of the sample mean (the same as above, but divided by the square root of the number of replications).
10) Coefficient of variation (standard deviation divided by the mean, if non-zero, in percentage form).

In the second part of the printed output the same information are displayed for each variable, together with the first relative differences of the observed values, of the deterministic solutions and of the mean stochastic solutions.

On the right hand side of each output per variable two columns are indicated as DET and OBS.

In the first a - (+) appears if the deterministic solution is smaller (greater) than the mean stochastic solution minus (plus) its standard deviation; a -- (++) appears if the distance is greater than twice the standard deviation of the mean stochastic solution. This information can be useful when checking the existence of a bias in the deterministic simulation of non-linear models, as in [1].

In the second column the sign - (+) indicates that the observed value is smaller (greater) than the mean stochastic solution minus (plus) the standard deviation of the stochastic solutions (not of the mean, this time); -- (++) indicates that the distance is greater than the double of the standard deviation computed across the replications.

The following other statistics and goodness of fit indicators are finally displayed:

1) The means over the simulation period of the observed values, deterministic and mean stochastic solutions; on the right hand side the differences between the means of the deterministic (mean stochastic) solutions and the means of the observed values.
2) The coefficients and standard errors of the regression (with intercept) of the observed values of each endogenous variable on the deterministic or mean stochastic solutions; the t test is performed on the hypothesis of constant term equal to zero and slope equal to one [8].
3) The coefficient and standard error of the regression, without

intercept, of the first relative differences of the observed values of each endogenous variable on the first relative differences of the deterministic and mean stochastic solutions; the t test is performed on the hypothesis of coefficient equal to one (rejected for a large t value) [8].

4) The Root Mean Square Errors (RMSE), dimensionless [8] and dimensional [7], of the deterministic and mean stochastic solutions.
5) The Mean Absolute Percentage Errors (MAPE) of the deterministic and mean stochastic solutions [7].
6) Theil's inequality coefficients (U) of the deterministic and mean stochastic solutions, computed according to two different formulas as in [8].

If only deterministic simulation is performed (NREP must have been specified equal to zero on the third card of the input data set) the printed output, per year and per variable, contains observed values, deterministic simulation results, percentage error (year by year) and RMSE; in the output per variable, observed values and simulation results are also plotted over time.

The printed output of the stochastic simulation experiment on the Klein-I model, as it is on the tape, is displayed at the end of this manual.

4. THE TAPE FORMAT

The tape is 9 tracks; density is 1600 b.p.i. The tape is no-label and contains 15 files separated by tape marks.

The first file is in CMS DUMP format and should be used only for installation under the operating system VM-370/CMS; for installation under other operating systems some equivalent procedure must be used instead of it; this file is displayed in section (4.1.).

All the other files are card-image, record format is fixed blocked, logical record length is 80 8-bit characters and block-size is 800 characters; there is no difficulty in reading these files also under other operating systems.

File 2 is an EXEC procedure to run stochastic simulations; under operating systems different from VM-370/CMS it can be read and some equivalent procedure should be used instead of it; this file is displayed in section (4.2.).

Files 3, 4, 5, 6, 7 and 8 are FORTRAN-G programs.

File 9 is an ASSEMBLER-370 program.

Files 10 and 11 are respectively the FORTRAN code and the input data set for the Klein-I model.

Files 12 and 13 are respectively the FORTRAN code and the input data set for the Klein-Goldberger model.

File 14 is an EXEC procedure to be used under VM-370/CMS to compile the programs; under other operating systems this file can be read and some equivalent procedure should be used instead of it; it is displayed in section (4.3.).

File 15 is a one card data set.

4.1. Contents of the first file (EXEC procedure)

This file was dumped on tape directly by VM-370/CMS system; it is, therefore, in CMS DUMP format; it must be recalled that lines starting with * are comment lines and lines starting with &TYPE are messages which will be typed at the terminal. The CMS identifier of this file on disk is COPYTAPE EXEC.

```
*PROPRIETA' DELLA IBM ITALIA
*CENTRO SCIENTIFICO DI PISA.
*A PROGRAM FOR STOCHASTIC SIMULATION OF ECONOMETRIC MODELS
*REL. 1. JANUARY 1978.
TAPE REW (TAP1)
TAPE FSF 1 (TAP1)
FILEDEF IBMPISA TAP1 (DEN 1600 RECFM FB LRECL 80 BLOCK 800 PERM)
FILEDEF TWO DISK STOCSIM EXEC A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF THREE DISK STOCSIM FORTRAN A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF FOUR DISK STOCS1 FORTRAN A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF FIVE DISK RANDOM FORTRAN A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF SIX DISK INVERSE FORTRAN A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF SEVEN DISK MCALG FORTRAN A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF EIGHT DISK NAGAR FORTRAN A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF NINE DISK UNIFOR ASSEMBLE A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF TEN DISK KLEIN1 FORTRAN A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF ELEVEN DISK KLEIN1 DATA A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF TWELVE DISK KLEINGOL FORTRAN A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF THIRTEEN DISK KLEINGOL DATA A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF FOURTEEN DISK COMPILE EXEC A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF FIFTEEN DISK INITIAL RANDOM A1 (RECFM F LRECL 80 BLOCK 80)
MOVE IBMPISA TWO
MOVE IBMPISA THREE
MOVE IBMPISA FOUR
MOVE IBMPISA FIVE
MOVE IBMPISA SIX
MOVE IBMPISA SEVEN
MOVE IBMPISA EIGHT
MOVE IBMPISA NINE
MOVE IBMPISA TEN
MOVE IBMPISA ELEVEN
MOVE IBMPISA TWELVE
MOVE IBMPISA THIRTEEN
MOVE IBMPISA FOURTEEN
MOVE IBMPISA FIFTEEN
&TYPE THE TAPE HAS BEEN READ AND COPIED ON THE USER'S MINIDISK
&TYPE THE FORTRAN - ASSEMBL. PROGRAMS MUST NOW BE COMPILED
&TYPE USING THE COMMAND:
&TYPE COMPILE
&TYPE (I.E. ONE OF THE EXEC PROCED. JUST COPIED FROM TAPE)
```

4.2. Contents of the second file (EXEC procedure)

On tape this file is in card-image format; on disk, its CMS identifier is STOCSIM EXEC.

```
*PROPRIETA' DELLA IBM ITALIA
*CENTRO SCIENTIFICO DI PISA.
*A PROGRAM FOR STOCHASTIC SIMULATION OF ECONOMETRIC MODELS
*REL. 1. JANUARY 1978.
FILEDEF 01 DISK &1 DATA A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF 10 DISK INITIAL RANDOM A1 (RECFM F LRECL 80 BLOCK 80)
FILEDEF 08 PRINTER (LRECL 145 BLOCK 149 RECFM VA)
FILEDEF 06 TERM (LRECL 145 BLOCK 149 RECFM VA)
GLOBAL TXTLIB  FORTMOD2
CP SPOOL PRINTER CONT
PRINT &1 FORTRAN
PRINT &1 DATA
LOAD STOCSIM &1 &2 &3
START
CP SPOOL PRINTER CLOSE
```

Please note that FORTMOD2 is the name of the FORTRAN-G library on the computer IBM/370 model 168 installed at CNUCE (Pisa). Note also that the dummy argument &1 refers to the model's name (same FILENAME for the subroutine and the input data set); &2 and &3 refer to non-default options (see end of section 5.).

4.3. Contents of the 14-th file (EXEC procedure)

On tape this file is in card-image format; on disk, its CMS identifier is COMPILE EXEC.

```
*PROPRIETA' DELLA IBM ITALIA
*CENTRO SCIENTIFICO DI PISA.
*A PROGRAM FOR STOCHASTIC SIMULATION OF ECONOMETRIC MODELS
*REL. 1. JANUARY 1978.
CP SPOOL PRINTER CONT
FORTGI STOCSIM (PRINT)
FORTGI STOCS1 (PRINT)
FORTGI RANDOM (PRINT)
FORTGI INVERSE (PRINT)
FORTGI MCALG (PRINT)
FORTGI NAGAR (PRINT)
ASSEMBLE UNIFOR (PRINT)
FORTGI KLEIN1 (PRINT)
FORTGI KLEINGOL (PRINT)
CP SPOOL PRINTER CLOSE
```

Please note that FORTGI and ASSEMBLE are the names of the compilers on the computer IBM/370 model 168 installed at CNUCE (Pisa).

5. INSTALLATION AND EXECUTION PROCEDURES

Under VM-370/CMS the installation procedure could be as follows.

1) Log-on a virtual machine with at least 400 CMS records available on disk and at least 768K of virtual main storage.
2) Mount the tape on a 9 tracks, 1600 b.p.i. tape unit and attach it with virtual address 181 to the virtual machine.
3) Issue now the following commands (recall that command lines are typed in small letters, while capital letters are answers from the system; the following is an on-line installation session).

```
query disk a
A(200):0 FILES;5 REC IN USE,527 LEFT(of 532),1%FULL(2 CYL),3330,R/W
R; T=0.01/0.01 09:57:15
tape rew (tap1)
R; T=0.01/0.02 09:57:26
tape load
 LOADING.....
 COPYTAPE EXEC     A1
 END-OF-FILE OR END-OF-TAPE
R; T=0.01/0.03 09:57:31
copytape
TAPE REW ( TAP1 )
TAPE FSF 1 ( TAP1 )
FILEDEF IBMPISA TAP1 ( DEN 1600 RECFM FB LRECL 80 BLOCK 800 PERM )
FILEDEF TWO DISK STOCSIM EXEC A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF THREE DISK STOCSIM FORTRAN A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF FOUR DISK STOCS1 FORTRAN A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF FIVE DISK RANDOM FORTRAN A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF SIX DISK INVERSE FORTRAN A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF SEVEN DISK MCALG FORTRAN A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF EIGHT DISK NAGAR FORTRAN A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF NINE DISK UNIFOR ASSEMBLE A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF TEN DISK KLEIN1 FORTRAN A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF ELEVEN DISK KLEIN1 DATA A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF TWELVE DISK KLEINGOL FORTRAN A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF THIRTEEN DISK KLEINGOL DATA A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF FOURTEEN DISK COMPILE EXEC A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF FIFTEEN DISK INITIAL RANDOM A1 ( RECFM F LRECL 80 BLOCK 80 )
MOVE IBMPISA TWO
MOVE IBMPISA THREE
MOVE IBMPISA FOUR
```

```
MOVE IBMPISA FIVE
MOVE IBMPISA SIX
MOVE IBMPISA SEVEN
MOVE IBMPISA EIGHT
MOVE IBMPISA NINE
MOVE IBMPISA TEN
MOVE IBMPISA ELEVEN
MOVE IBMPISA TWELVE
MOVE IBMPISA THIRTEEN
MOVE IBMPISA FOURTEEN
MOVE IBMPISA FIFTEEN
THE TAPE HAS BEEN READ AND COPIED ON THE USER'S MINIDISK
THE FORTRAN - ASSEMBL. PROGRAMS MUST NOW BE COMPILED
USING THE COMMAND:
COMPILE
( I.E. ONE OF THE EXEC PROCED. JUST COPIED FROM TAPE )
R; T=0.74/1.42 09:57:56
query disk a
A(200):15 FILES;232 REC IN USE,300 LEFT(of 532),44%FULL(2 CYL),3330,R/W
R; T=0.01/0.02 09:58:04
detach 181
TAPE 181 DETACHED
R; T=0.01/0.01 09:58:09
```

4) To compile the programs issue now the following command.

```
compile
CP SPOOL PRINTER CONT
FORTGI STOCSIM ( PRINT )
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = MAIN
*  NO DIAGNOSTICS GENERATED
FORTGI STOCS1 ( PRINT )
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = STOCS1
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = GAUSSD
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = OUTDET
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = OUTPRD
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = OUTVAR
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = REGRSS
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
```

```
PROGRAM NAME = MEANSS
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = MAPESS
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = RMSESS
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = THEIL
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = VERIFY
*  NO DIAGNOSTICS GENERATED
    *STATISTICS*  NO DIAGNOSTICS THIS STEP
FORTGI RANDOM ( PRINT )
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = RANDOM
*  NO DIAGNOSTICS GENERATED
FORTGI INVERSE ( PRINT )
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = RANDOM
*  NO DIAGNOSTICS GENERATED
SOURCE ANALYZED
PROGRAM NAME = NDTRID
*  NO DIAGNOSTICS GENERATED
    *STATISTICS*  NO DIAGNOSTICS THIS STEP
FORTGI MCALG ( PRINT )
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = MCALG
*  NO DIAGNOSTICS GENERATED
FORTGI NAGAR ( PRINT )
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = MCALG
*  NO DIAGNOSTICS GENERATED
ASSEMBLE UNIFOR ( PRINT )
ASSEMBLER DONE
NO STATEMENTS FLAGGED IN THIS ASSEMBLY
FORTGI KLEIN1 ( PRINT )
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = MODEL
*  NO DIAGNOSTICS GENERATED
FORTGI KLEINGOL ( PRINT )
G1 COMPILER ENTERED
SOURCE ANALYZED
PROGRAM NAME = MODEL
*  NO DIAGNOSTICS GENERATED
CP SPOOL PRINTER CLOSE
COMPIL. HAS BEEN COMPLET.
R; T=8.51/11.40 10:01:05
```

5) To run stochastic simulation of the first sample (Klein-I model, estimated with Two Stage Least Squares as in [4]), with default options for the generation of the pseudo-random structural disturbances (Box-Muller and McCarthy's algorithms), issue the following command:

```
stocsim klein1
FILEDEF 01 DISK KLEIN1 DATA A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF 10 DISK INITIAL RANDOM A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF 08 PRINTER ( LRECL 145 BLOCK 149 RECFM VA )
FILEDEF 06 TERM ( LRECL 145 BLOCK 149 RECFM VA )
GLOBAL TXTLIB FORTMOD2
CP SPOOL PRINTER CONT
PRINT KLEIN1 FORTRAN
PRINT KLEIN1 DATA
LOAD STOCSIM KLEIN1
START
EXECUTION BEGINS...
R   10
R   20
R   30
R   40
R   50
R   60
R   70
R   80
R   90
R  100
CP SPOOL PRINTER CLOSE
R; T=10.17/11.41 10:05:07
```

100 replicated one-step solutions (total method) have been performed on the whole sample period (1921-1941). The number of replications performed is typed at the terminal at multiples of 10.

To use alternative pseudo-random disturbances generators (inverse method, Nagar algorithm) one of the following commands should be issued:

```
stocsim klein1 inverse
stocsim klein1 inverse nagar
stocsim klein1 nagar
```

Please note that the argument "klein1" refers to &1, while "inverse" and "nagar" refer to &2 and &3 (see section 4.2.).

6) To run stochastic simulation of the second sample (Klein-Goldberger revised model [6], estimated by 2SLS with 4 principal components; the corresponding CMS identifiers on disk are KLEINGOL FORTRAN -TEXT after compilation- and KLEINGOL DATA), with 100 replicated dynamic solutions (final method), issue the following command:

```
stocsim kleingol
FILEDEF 01 DISK KLEINGOL DATA A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF 10 DISK INITIAL RANDOM A1 ( RECFM F LRECL 80 BLOCK 80 )
FILEDEF 08 PRINTER ( LRECL 145 BLOCK 149 RECFM VA )
FILEDEF 06 TERM ( LRECL 145 BLOCK 149 RECFM VA )
GLOBAL TXTLIB FORTMOD2
CP SPOOL PRINTER CONT
PRINT KLEINGOL FORTRAN
PRINT KLEINGOL DATA
LOAD STOCSIM KLEINGOL
START
EXECUTION BEGINS...
R   10
R   20
R   30
R   40
R   50
R   60
R   70
R   80
R   90
R  100
CP SPOOL PRINTER CLOSE
R; T=12.24/13.80 10:15:56
```

or, alternatively:

```
stocsim kleingol inverse
stocsim kleingol inverse nagar
stocsim kleingol nagar
```

Please note that Nagar's algorithm for the generation of multivariate normal pseudo-random deviates cannot be used when the sample period length is smaller than the number of stochastic equations (NSTOCH).

REFERENCES

[1] Bianchi,C., G.Calzolari and P.Corsi, "Divergences in the Results of Stochastic and Deterministic Simulation of an Italian Non Linear Econometric Model", in L.Dekker, ed., "Simulation of Systems", North Holland, Amsterdam, (1976).

[2] Bianchi,C., G.Calzolari and P.Corsi, "A Program for Stochastic Simulation of Econometric Models", Econometrica, v.46, n.1 (1978).

[3] Calzolari,G., T.A.Ciriani and P.Corsi, "Generation and Testing of Pseudo-Random Numbers with Assigned Statistical Properties to be Used in the Stochastic Simulation of Econometric Models", IBM Technical Report CSP034/513-3544, Pisa, (1976).

[4] Goldberger,A.S., A.L.Nagar and H.S.Odeh, "The Covariance Matrices of Reduced-Form Coefficients and of Forecasts for a Structural Econometric Model", Econometrica, v.29, n.4, (1961).

[5] IBM, "Virtual Machine Facility/370: CMS Command and Macro Reference", GC20-1818, IBM, New York, (1976).

[6] Klein,L.R., "Estimation of Interdependent Systems in Macroeconometrics", Econometrica, v.37, n.2, (1969).

[7] Klein,L.R., "A Textbook of Econometrics", Prentice Hall, Englewood Cliffs, (1974).

[8] Sowey,E.R., "Stochastic Simulation of Macroeconometric Models: Methodology and Interpretation", in A.A.Powell and R.A.Williams, eds., "Econometric Studies of Macro and Monetary Relations", North Holland, Amsterdam, (1973).

```
               KLEIN-I MODEL. STOCHASTIC SIMULATION. 2SLS ESTIMATE AS IN
               GOLDBERGER-NAGAR-ODEH'S PAPER (ECONOMETRICA 1961).
OPTIONS ARE:    100  100    6    3    5   12 1919 1941 1921 1941    0    0
```

A PROGRAM FOR STOCHASTIC SIMULATION OF ECONOMETRIC MODELS
BY CARLO BIANCHI, GIORGIO CALZOLARI AND PAOLO CORSI
IBM PISA SCIENTIFIC CENTER

M C C A R T H Y   A L G O R I T H M

A PROGRAM FOR STOCHASTIC SIMULATION OF ECONOMETRIC MODELS
BY CARLO BIANCHI, GIORGIO CALZOLARI AND PAOLO CORSI
IBM PISA SCIENTIFIC CENTER

ONE-STEP SIMULATION

INITIAL VALUE OF PSEUDO-RANDOM NUMBERS 54829179

Y E A R 1921

NUMBER OF REPLICATIONS = 100

VARIABLE	OBSERVED	DETERMINIS.	MEAN STOC.	MINIMUM	MAXIMUM	RANGE	STD.DEV.	STD.DEV.MEAN	COEF.VAR.
Y(1)=C	41.9000	45.1232	45.1241	39.3309	49.4538	10.1229	1.98100	.198100	4.390
Y(2)=I	-.200000	1.32574	1.19755	-1.97945	3.68146	5.66091	1.27715	.127715	106.6
Y(3)=W1	25.5000	28.8781	28.9140	25.2887	31.8599	6.57124	1.48495	.148495	5.136
Y(4)=Y	40.6000	45.3490	45.2216	36.5154	51.9408	15.4254	3.16841	.316841	7.006
Y(5)=P	12.4000	13.7709	13.6076	8.37435	18.6411	10.2668	1.95947	.195947	14.40
Y(6)=K	182.600	184.126	183.998	180.821	186.481	5.66091	1.27715	.127715	.6941

******************** Similar tables will appear for the other years of the simulation period, 1922....1939 ********************

ONE-STEP SIMULATION

INITIAL VALUE OF PSEUDO-RANDOM NUMBERS 54829179

Y E A R 1940

NUMBER OF REPLICATIONS = 100

VARIABLE	OBSERVED	DETERMINIS.	MEAN STOC.	MINIMUM	MAXIMUM	RANGE	STD.DEV.	STD.DEV.MEAN	COEF.VAR.
Y(1)=C	65.0000	64.6803	65.2527	60.2497	71.8382	11.5885	2.07955	.207955	3.187
Y(2)=I	3.30000	3.20531	3.49047	-.506680	7.60625	8.11293	1.56000	.156000	44.69
Y(3)=W1	45.0000	45.9074	46.2640	42.1376	50.5898	8.45223	1.75672	.175672	3.797
Y(4)=Y	74.1000	73.6856	74.5432	65.5430	85.2444	19.7014	3.54679	.354679	4.758
Y(5)=P	21.1000	19.7782	20.2792	15.4055	26.6547	11.2492	2.08525	.208525	10.28
Y(6)=K	204.500	204.405	204.690	200.693	208.806	8.11293	1.56000	.156000	.7621

ONE-STEP SIMULATION

INITIAL VALUE OF PSEUDO-RANDOM NUMBERS 54829179

Y E A R 1941

NUMBER OF REPLICATIONS = 100

VARIABLE	OBSERVED	DETERMINIS.	MEAN STOC.	MINIMUM	MAXIMUM	RANGE	STD.DEV.	STD.DEV.MEAN	COEF.VAR.
Y(1)=C	69.7000	71.8803	72.3384	67.6945	78.5737	10.8793	2.03267	.203267	2.810
Y(2)=I	4.90000	4.80251	5.17354	2.19033	8.25755	6.06722	1.52822	.152822	29.54
Y(3)=W1	53.3000	53.6166	53.9557	50.2489	58.8172	8.56830	1.71190	.171190	3.173
Y(4)=Y	85.3000	87.3828	88.2119	80.9776	97.1678	16.1902	3.43699	.343699	3.896
Y(5)=P	23.5000	25.2662	25.7563	21.2265	31.3029	10.0764	1.97780	.197780	7.679
Y(6)=K	209.400	209.303	209.674	206.690	212.758	6.06722	1.52822	.152822	.7289

ONE-STEP SIMULATION

OUTPUT FOR VARIABLE Y(1)=C FROM YEAR 1921 TO YEAR 1941 WITH 100 REPLICATIONS

YEAR	ACTUAL VALUE	DETERM. VALUE	MEAN STOC. VALUE	STANDARD DEVIAT.	MINIMUM	MAXIMUM	ACTUAL %CHANGE	DETERM. %CHANGE	MEAN STOC. %CHANGE	ST.DEV. MEAN	CF.VAR.	DET	OBS
1921	41.9000	45.1232	45.1241	1.98100	39.3309	49.4538	.0	.0	.0	.198	4.39		-
1922	45.0000	45.4910	45.4306	1.96143	41.5492	51.6662	7.40	.815	.679	.196	4.32		
1923	49.2000	49.3458	48.9884	1.60667	45.0859	52.6031	9.33	8.47	7.83	.161	3.28	++	
1924	50.6000	52.2325	52.2075	1.99744	47.0400	57.9138	2.85	5.85	6.57	.200	3.83		
1925	52.6000	52.6116	52.9242	1.90871	48.4233	58.1609	3.95	.726	1.37	.191	3.61	-	
1926	55.1000	53.4141	53.6210	1.88728	49.2902	58.4636	4.75	1.53	1.32	.189	3.52	-	
1927	56.2000	54.0464	53.9117	1.92476	48.4863	58.1746	2.00	1.18	.542	.192	3.57		+
1928	57.3000	54.5795	54.3579	1.98732	48.6102	58.6233	1.96	.986	.828	.199	3.66	+	+
1929	57.8000	55.8050	55.8074	2.25649	50.7248	60.7865	.873	2.25	2.67	.226	4.04		
1930	55.0000	56.8623	56.5838	2.00285	51.8749	63.7999	-4.84	1.89	1.39	.200	3.54	+	
1931	50.9000	52.4906	52.3875	1.97465	47.0908	56.3672	-7.45	-7.69	-7.42	.197	3.77		
1932	45.6000	48.2906	48.4022	1.88910	43.6816	53.3822	-10.4	-8.00	-7.61	.189	3.90		-
1933	46.5000	44.0707	44.3533	1.85398	38.9543	49.9874	1.97	-8.74	-8.36	.185	4.18	-	+
1934	48.7000	48.6927	48.6497	1.94018	44.1013	53.2041	4.73	10.5	9.69	.194	3.99		
1935	51.3000	51.1826	51.1859	1.82479	45.5059	55.6235	5.34	5.11	5.21	.182	3.57		
1936	57.7000	54.2401	54.1821	1.88768	49.1663	58.9421	12.5	5.97	5.85	.189	3.48		+
1937	58.7000	58.6212	58.7707	1.84584	53.0747	64.0491	1.73	8.08	8.47	.185	3.14		
1938	57.5000	60.6730	60.8918	1.94557	56.0948	65.3053	-2.04	3.50	3.61	.195	3.20	-	-
1939	61.6000	59.5655	59.3692	1.98487	55.2825	63.8454	7.13	-1.83	-2.50	.198	3.34		+
1940	65.0000	64.6803	65.2527	2.07955	60.2497	71.8382	5.52	8.59	9.91	.208	3.19	--	
1941	69.7000	71.8803	72.3384	2.03267	67.6945	78.5737	7.23	11.1	10.9	.203	2.81	--	-

ONE-STEP SIMULATION

OUTPUT FOR VARIABLE Y(2)=I FROM YEAR 1921 TO YEAR 1941 WITH 100 REPLICATIONS

YEAR	ACTUAL VALUE	DETERM. VALUE	MEAN STOC. VALUE	STANDARD DEVIAT.	MINIMUM	MAXIMUM	ACTUAL %CHANGE	DETERM. %CHANGE	MEAN STOC. %CHANGE	ST.DEV. MEAN	CF.VAR.	DET	OBS
1921	-.200000	1.32574	1.19755	1.27715	-1.97945	3.68146	.0	.0	.0	.128	107.	+	-
1922	1.90000	1.71298	1.69506	1.22698	-.772324	5.47729	-.105D+04	29.2	41.5	.123	72.4		
1923	5.20000	4.46961	4.23809	1.39254	.705681	6.94366	174.	161.	150.	.139	32.9	+	
1924	3.00000	4.86814	4.90662	1.53389	.442030	8.12663	-42.3	8.92	15.8	.153	31.3		-
1925	5.10000	4.74246	4.99105	1.35147	2.18122	9.25059	70.0	-2.58	1.72	.135	27.1	-	
1926	5.60000	4.04708	4.13709	1.29624	.891482	7.79380	9.80	-14.7	-17.1	.130	31.3		+
1927	4.20000	2.82409	2.79365	1.46124	-.683879	6.10886	-25.0	-30.2	-32.5	.146	52.3		
1928	3.00000	2.68150	2.44753	1.43925	-.959866	6.43774	-28.6	-5.05	-12.4	.144	58.8	+	
1929	5.10000	3.15162	3.17753	1.60822	-.417903	7.42749	70.0	17.5	29.8	.161	50.6		+
1930	1.00000	2.18647	1.91229	1.61248	-2.08059	7.60631	-80.4	-30.6	-39.8	.161	84.3	+	
1931	-3.40000	-2.27601	-2.31377	1.37413	-5.07263	1.16275	-440.	-204.	-221.	.137	-59.4		
1932	-6.20000	-4.95889	-4.87974	1.32170	-8.36123	-1.10919	82.4	118.	111.	.132	-27.1		
1933	-5.10000	-6.67580	-6.56103	1.43101	-10.5280	-2.45076	-17.7	34.6	34.5	.143	-21.8		+
1934	-3.00000	-2.78911	-2.78633	1.46781	-6.84058	.698825	-41.2	-58.2	-57.5	.147	-52.7		
1935	-1.30000	-1.46392	-1.38601	1.27597	-4.54734	2.42417	-56.7	-47.5	-50.3	.128	-92.1		
1936	2.10000	-.267980	-.384034	1.36545	-3.76171	3.05796	-262.	-81.7	-72.3	.137	-356.		+
1937	2.00000	2.36524	2.52275	1.33639	-.568934	6.23540	-4.76	-983.	-757.	.134	53.0	-	
1938	-1.90000	1.90819	2.21134	1.39675	-1.36981	5.02615	-195.	-19.3	-12.3	.140	63.2	--	--
1939	1.30000	.739204	.636044	1.50187	-2.67147	4.17112	-168.	-61.3	-71.2	.150	236.		
1940	3.30000	3.20531	3.49047	1.56000	-.506680	7.60625	154.	334.	449.	.156	44.7	-	
1941	4.90000	4.80251	5.17354	1.52822	2.19033	8.25755	48.5	49.8	48.2	.153	29.5	--	

ONE-STEP SIMULATION

OUTPUT FOR VARIABLE Y(3)=W1 FROM YEAR 1921 TO YEAR 1941 WITH 100 REPLICATIONS

YEAR	ACTUAL VALUE	DETERM. VALUE	MEAN STOC. VALUE	STANDARD DEVIAT.	MINIMUM	MAXIMUM	ACTUAL %CHANGE	DETERM. %CHANGE	MEAN STOC. %CHANGE	ST.DEV. MEAN	CF.VAR.	DET	OBS
1921	25.5000	28.8781	28.9140	1.48495	25.2887	31.8599	.0	.0	.0	.148	5.14		--
1922	29.3000	29.1353	29.1752	1.47547	26.2209	33.7733	14.9	.891	.903	.148	5.06		
1923	34.1000	32.6516	32.4414	1.55448	28.7716	35.7748	16.4	12.1	11.2	.155	4.79	+	+
1924	33.9000	35.5723	35.6281	1.71734	31.4665	39.9218	-.587	8.95	9.82	.172	4.82		-
1925	35.4000	35.7115	36.0130	1.64683	32.5743	40.7463	4.42	.391	1.08	.165	4.57	-	
1926	37.4000	36.4609	36.5097	1.56634	32.2943	39.8827	5.65	2.10	1.38	.157	4.29		
1927	37.9000	37.0794	37.0310	1.64930	32.9679	40.6782	1.34	1.70	1.43	.165	4.45		
1928	39.2000	37.5276	37.3229	1.69577	32.4510	41.5242	3.43	1.21	.788	.170	4.54	+	+
1929	41.3000	38.3729	38.3646	1.87551	34.6479	43.2215	5.36	2.25	2.79	.188	4.89		+
1930	37.9000	39.3932	39.0755	1.93981	32.3654	44.7685	-8.23	2.66	1.85	.194	4.96	+	
1931	34.5000	35.1031	35.0830	1.65131	31.4731	38.8239	-8.97	-10.9	-10.2	.165	4.71		
1932	29.0000	30.6300	30.7559	1.54780	26.9437	34.5913	-15.9	-12.7	-12.3	.155	5.03		-
1933	28.5000	26.2936	26.5552	1.65405	22.5701	31.8406	-1.72	-14.2	-13.7	.165	6.23	-	+
1934	30.6000	30.4071	30.3822	1.68290	25.9782	34.2957	7.37	15.6	14.4	.168	5.54		
1935	33.2000	33.0620	33.0258	1.53993	29.7053	37.5389	8.50	8.73	8.70	.154	4.66		
1936	36.8000	35.0901	34.9399	1.61286	31.2347	38.8616	10.8	6.13	5.80	.161	4.62		+
1937	41.0000	40.1306	40.2206	1.69965	35.8353	44.9405	11.4	14.4	15.1	.170	4.23		
1938	38.2000	41.7371	41.9717	1.55038	38.2189	46.1444	-6.83	4.00	4.35	.155	3.69	-	--
1939	41.6000	40.8376	40.7013	1.70397	37.4216	44.3608	8.90	-2.16	-3.03	.170	4.19		
1940	45.0000	45.9074	46.2640	1.75672	42.1376	50.5898	8.17	12.4	13.7	.176	3.80	--	
1941	53.3000	53.6166	53.9557	1.71190	50.2489	58.8172	18.4	16.8	16.6	.171	3.17	--	

ONE-STEP SIMULATION

OUTPUT FOR VARIABLE Y(4)=Y FROM YEAR 1921 TO YEAR 1941 WITH 100 REPLICATIONS

YEAR	ACTUAL VALUE	DETERM. VALUE	MEAN STOC. VALUE	STANDARD DEVIAT.	MINIMUM	MAXIMUM	ACTUAL %CHANGE	DETERM. %CHANGE	MEAN STOC. %CHANGE	ST.DEV. MEAN	CF.VAR.	DET	OBS
1921	40.6000	45.3490	45.2216	3.16841	36.5154	51.9408	.0	.0	.0	.317	7.01		-
1922	49.1000	49.4040	49.3256	3.01619	43.8344	59.3435	20.9	8.94	9.08	.302	6.11		
1923	55.4000	54.8154	54.2265	2.87356	46.7915	60.2170	12.8	11.0	9.94	.287	5.30	++	
1924	56.4000	59.9006	59.9141	3.37095	50.2820	68.4098	1.81	9.28	10.5	.337	5.63		-
1925	58.7000	58.3540	58.9153	3.13194	51.8747	68.1118	4.08	-2.58	-1.67	.313	5.32	-	
1926	60.3000	57.0611	57.3581	3.04589	50.3718	65.8574	2.73	-2.22	-2.64	.305	5.31		
1927	61.3000	57.7705	57.6054	3.22885	48.9015	64.9134	1.66	1.24	.431	.323	5.61		+
1928	64.0000	60.9610	60.5055	3.29698	51.3503	68.7611	4.40	5.52	5.03	.330	5.45	+	+
1929	67.0000	63.0566	63.0850	3.75480	54.4069	72.2491	4.69	3.44	4.26	.375	5.95		+
1930	57.7000	60.7488	60.1961	3.48112	51.7320	73.1062	-13.9	-3.66	-4.58	.348	5.78	+	
1931	50.7000	53.4146	53.2737	3.22798	45.2182	59.6563	-12.1	-12.1	-11.5	.323	6.06		
1932	41.3000	45.2318	45.4224	3.07817	38.0330	54.1730	-18.5	-15.3	-14.7	.308	6.78		-
1933	45.3000	41.2949	41.6923	3.12829	33.1066	51.4366	9.69	-8.70	-8.21	.313	7.50	-	+
1934	48.9000	49.1035	49.0634	3.31196	40.4607	56.6724	7.95	18.9	17.7	.331	6.75		
1935	53.3000	53.0187	53.0999	2.98146	45.1260	61.0909	9.00	7.97	8.23	.298	5.61		
1936	61.8000	55.9721	55.7980	3.13608	47.8725	64.0001	15.9	5.57	5.08	.314	5.62		+
1937	65.0000	65.2864	65.5934	3.10120	56.8057	74.5845	5.18	16.6	17.6	.310	4.73		
1938	61.2000	68.1812	68.7031	3.20463	60.3250	75.3977	-5.85	4.43	4.74	.320	4.66	-	--
1939	68.4000	65.8047	65.5053	3.39073	59.3384	73.5165	11.8	-3.49	-4.65	.339	5.18		
1940	74.1000	73.6856	74.5432	3.54679	65.5430	85.2444	8.33	12.0	13.8	.355	4.76	--	
1941	85.3000	87.3828	88.2119	3.43699	80.9776	97.1678	15.1	18.6	18.3	.344	3.90	--	

ONE-STEP SIMULATION

OUTPUT FOR VARIABLE Y(5)=P FROM YEAR 1921 TO YEAR 1941 WITH 100 REPLICATIONS

YEAR	ACTUAL VALUE	DETERM. VALUE	MEAN STOC. VALUE	STANDARD DEVIAT.	MINIMUM	MAXIMUM	ACTUAL %CHANGE	DETERM. %CHANGE	MEAN STOC. %CHANGE	ST.DEV. MEAN	CF.VAR.	DET	OBS
1921	12.4000	13.7709	13.6076	1.95947	8.37435	18.6411	.0	.0	.0	.196	14.4		
1922	16.9000	17.3687	17.2504	1.82193	13.6693	22.6702	36.3	26.1	26.8	.182	10.6		
1923	18.4000	19.2638	18.8851	1.65722	14.9746	22.5374	8.88	10.9	9.48	.166	8.78	++	
1924	19.4000	21.2283	21.1859	1.88250	15.7155	26.3994	5.43	10.2	12.2	.188	8.89		
1925	20.1000	19.4425	19.7023	1.84304	15.2307	24.2807	3.61	-8.41	-7.00	.184	9.35	-	
1926	19.6000	17.3002	17.5484	1.73370	13.6958	22.6748	-2.49	-11.0	-10.9	.173	9.88	-	+
1927	19.8000	17.0911	16.9743	1.87667	10.9851	21.3625	1.02	-1.21	-3.27	.188	11.1		+
1928	21.1000	19.7335	19.4826	1.89937	15.1753	23.9115	6.57	15.5	14.8	.190	9.75	+	
1929	21.7000	20.6837	20.7203	2.14131	15.7590	26.0783	2.84	4.82	6.35	.214	10.3		
1930	15.6000	17.1556	16.9206	1.90764	12.8096	24.1377	-28.1	-17.1	-18.3	.191	11.3	+	
1931	11.4000	13.5115	13.3907	1.87477	7.39900	17.2398	-26.9	-21.2	-20.9	.187	14.0		-
1932	7.00000	9.30178	9.36657	1.79839	5.07901	14.2817	-38.6	-31.2	-30.1	.180	19.2		-
1933	11.2000	9.40134	9.53712	1.70459	4.93652	13.9960	60.0	1.07	1.82	.170	17.9		
1934	12.3000	12.6965	12.6811	1.84265	8.48259	17.5901	9.82	35.0	33.0	.184	14.5		
1935	14.0000	13.8567	13.9741	1.73786	9.32074	17.4542	13.8	9.14	10.2	.174	12.4		
1936	17.6000	13.4820	13.4581	1.80885	9.23781	17.7385	25.7	-2.70	-3.69	.181	13.4		++
1937	17.3000	18.4558	18.6728	1.66590	14.2704	22.9440	-1.70	36.9	38.7	.167	8.92	-	
1938	15.3000	18.7441	19.0314	1.95362	14.4061	22.6292	-11.6	1.56	1.92	.195	10.3	-	-
1939	19.0000	17.1671	17.0040	1.96564	12.8713	21.3561	24.2	-8.41	-10.7	.197	11.6		+
1940	21.1000	19.7782	20.2792	2.08525	15.4055	26.6547	11.1	15.2	19.3	.209	10.3	--	
1941	23.5000	25.2662	25.7563	1.97780	21.2265	31.3029	11.4	27.7	27.0	.198	7.68	--	-

ONE-STEP SIMULATION

OUTPUT FOR VARIABLE Y(6)=K FROM YEAR 1921 TO YEAR 1941 WITH 100 REPLICATIONS

YEAR	ACTUAL VALUE	DETERM. VALUE	MEAN STOC. VALUE	STANDARD DEVIAT.	MINIMUM	MAXIMUM	ACTUAL %CHANGE	DETERM. %CHANGE	MEAN STOC. %CHANGE	ST.DEV. MEAN	CF.VAR.	DET	OBS
1921	182.600	184.126	183.998	1.27715	180.821	186.481	.0	.0	.0	.128	.694	+	-
1922	184.500	184.313	184.295	1.22698	181.828	188.077	1.04	.102	.162	.123	.666		
1923	189.700	188.970	188.738	1.39254	185.206	191.444	2.82	2.53	2.41	.139	.738	+	
1924	192.700	194.568	194.607	1.53389	190.142	197.827	1.58	2.96	3.11	.153	.788		-
1925	197.800	197.442	197.691	1.35147	194.881	201.951	2.65	1.48	1.58	.135	.684	-	
1926	203.400	201.847	201.937	1.29624	198.691	205.594	2.83	2.23	2.15	.130	.642		+
1927	207.600	206.224	206.194	1.46124	202.716	209.509	2.06	2.17	2.11	.146	.709		
1928	210.600	210.282	210.048	1.43925	206.640	214.038	1.45	1.97	1.87	.144	.685	+	
1929	215.700	213.752	213.778	1.60822	210.182	218.027	2.42	1.65	1.78	.161	.752		+
1930	216.700	217.886	217.612	1.61248	213.619	223.306	.464	1.93	1.79	.161	.741	+	
1931	213.300	214.424	214.386	1.37413	211.627	217.863	-1.57	-1.59	-1.48	.137	.641		
1932	207.100	208.341	208.420	1.32170	204.939	212.191	-2.91	-2.84	-2.78	.132	.634		
1933	202.000	200.424	200.539	1.43101	196.572	204.649	-2.46	-3.80	-3.78	.143	.714		+
1934	199.000	199.211	199.214	1.46781	195.159	202.699	-1.49	-.605	-.661	.147	.737		
1935	197.700	197.536	197.614	1.27597	194.453	201.424	-.653	-.841	-.803	.128	.646		
1936	199.800	197.432	197.316	1.36545	193.938	200.758	1.06	-.527D-01	-.151	.137	.692		+
1937	201.800	202.165	202.323	1.33639	199.231	206.035	1.00	2.40	2.54	.134	.661	-	
1938	199.900	203.708	204.011	1.39675	200.430	206.826	-.942	.763	.835	.140	.685	--	--
1939	201.200	200.639	200.536	1.50187	197.229	204.071	.650	-1.51	-1.70	.150	.749		
1940	204.500	204.405	204.690	1.56000	200.693	208.806	1.64	1.88	2.07	.156	.762	-	
1941	209.400	209.303	209.674	1.52822	206.690	212.758	2.40	2.40	2.43	.153	.729	--	

ONE-STEP SIMULATION

	MEAN VALUES			DIFFERENCES	
	ACTUAL	DETERMINISTIC	STOCHASTIC	DET.	STOCH.
Y(1)=C	53.995238	53.995188	54.035236	-.49913256D-04	.39997904D-01
Y(2)=I	1.2666667	1.2665915	1.2961758	-.75184287D-04	.29509105D-01
Y(3)=W1	36.361905	36.361801	36.396704	-.10333906D-03	.34799724D-01
Y(4)=Y	58.371429	58.371303	58.440936	-.12509754D-03	.69507009D-01
Y(5)=P	16.890476	16.890454	16.925183	-.21758479D-04	.34707285D-01
Y(6)=K	201.76190	201.76183	201.79141	-.75184287D-04	.29509105D-01

ONE-STEP SIMULATION

REGRESSION OF ACTUAL ON SIMULATED VALUES

	DETERMINISTIC			STOCHASTIC		
	EST.COEFF.	STD.ERROR	T.VALUE	EST.COEFF.	STD.ERROR	T.VALUE
VARIABLE Y(1)=C						
B0	.94760713	3.7888479	.25010429	1.7993561	3.8091622	.47237580
B1	.98245108	.69665410D-01	-.25190291	.96596010	.69972483D-01	-.48647550
VARIABLE Y(2)=I						
B0	.19088799D-02	.34963988	.54595599D-02	-.12881017D-01	.36042201	-.35738709D-01
B1	.99855226	.10245440	-.14130582D-01	.98717143	.10476014	-.12245664
VARIABLE Y(3)=W1						
B0	.85093402	2.2911596	.37139884	1.1944779	2.3448459	.50940570
B1	.97660098	.62149880D-01	-.37649348	.96622558	.63532485D-01	-.53160868
VARIABLE Y(4)=Y						
B0	1.3957306	4.3532177	.32062044	2.4070196	4.3762836	.55001453
B1	.97609090	.73464275D-01	-.32545210	.95762343	.73730784D-01	-.57474736
VARIABLE Y(5)=P						
B0	.85505855	1.9539421	.43760691	1.1085492	1.9414179	.57099976
B1	.94937751	.11278703	-.44883251	.93245234	.11175539	-.60442416
VARIABLE Y(6)=K						
B0	.32830813	7.3670170	.44564594D-01	.76637896	7.5659629	.10129298
B1	.99837317	.36477961D-01	-.44597715D-01	.99605589	.37457449D-01	-.10529582

ONE-STEP SIMULATION

REGRESSION OF ACTUAL ON SIMULATED VALUES
(FIRST RELATIVE DIFFERENCES)

	DETERMINISTIC			STOCHASTIC		
	EST.COEFF.	STD.ERROR	T.VALUE	EST.COEFF.	STD.ERROR	T.VALUE
VARIABLE Y(1)=C						
B1	.65620172	.16607602	-2.0701260	.64691997	.16924604	-2.0861937
VARIABLE Y(2)=I						
B1	.16841473	.25718712	-3.2333861	.23474844	.29588722	-2.5862947
VARIABLE Y(3)=W1						
B1	.75730186	.16385796	-1.4811496	.75431362	.16770306	-1.4650083
VARIABLE Y(4)=Y						
B1	.71730150	.18130533	-1.5592399	.70532160	.18324767	-1.6080881
VARIABLE Y(5)=P						
B1	.60463702	.24081597	-1.6417640	.58988579	.23897845	-1.7161138
VARIABLE Y(6)=K						
B1	.80375267	.10770210	-1.8221310	.79102789	.10951699	-1.9081250

ONE-STEP SIMULATION

	R M S E (DIMENSIONLESS)		R M S E	
	DETERMINISTIC	STOCHASTIC	DETERMINISTIC	STOCHASTIC
Y(1)=C	.36400641D-01	.37290285D-01	1.9805146	2.0289190
Y(2)=I	.38346704	.39456588	1.4151960	1.4561566
Y(3)=W1	.44759960D-01	.46314882D-01	1.6506906	1.7080342
Y(4)=Y	.55243781D-01	.56728484D-01	3.2762284	3.3642786
Y(5)=P	.10950986	.11075850	1.9038659	1.9255740
Y(6)=K	.70072245D-02	.72100372D-02	1.4151960	1.4561566

ONE-STEP SIMULATION

	MAPE	
	DETERMINISTIC	STOCHASTIC
Y(1)=C	3.0414699	3.0958798
Y(3)=W1	3.8317069	4.0005606
Y(4)=Y	4.7593991	4.8549657
Y(5)=P	10.737764	10.489180
Y(6)=K	.53516554	.54918843

ONE-STEP SIMULATION

T H E I L INEQUALITY COEFFICIENTS

	DET1	STOC1	DET2	STOC2
Y(1)=C	.82021588	.83354043	.95635784	.97189404
Y(2)=I	1.2312745	1.1439815	.85425125	.79368788
Y(3)=W1	.72465021	.73417706	.66535526	.67410257
Y(4)=Y	.78642365	.79897241	.71598868	.72741353
Y(5)=P	.92595269	.93517634	.68817005	.69502510
Y(6)=K	.54665112	.56402565	.81740207	.84338204