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IMPLEMENTATION OF ZELLNER'S "SEEMINGLY UNRELATED REGRESSION" TECHNIQUE USING REGRESSION ANALYSIS OF TIME SERIES (RATS)

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RATS (Regression Analysis of Time Series) can be executed in both interactive or batch modes. In most cases, the batch mode is more convenient and will be demonstrated in the following application of Zellner's SUR method.

RATS SETUP ON HARD DISK

When using RATS on a hard disk, the program should be installed (run RATSINST and follow instructions) with a default subdirectory for all data (*.DAT) and program (*.PGM) files. It is recommended that the subdirectory be specified as:

[d]:\RATS\DATA

CREATION OF THE GRUNFELD DATA SET

Using the RATS batch mode, there are three ways to supply the necessary data set to the RATS compiler:

1. Enter the data directly into a word-processed file that is submitted to RATS as a program. Although this method is straightforward, it is also tedious. Values must be separated by either commas or spaces. It is more convenient for editing and proofreading to enter the data in columnar alignment, which is difficult with a word processor.

2. Read a PRN data file from a Lotus worksheet into the word-processed program file. This method requires three steps: prepare worksheet, print data to a file (*.PRN), then read PRN file into the program file. This procedure may seem overly complicated, but it allows more convenient editing of data at the time of entry, and reduces data format and alignment problems.

3. Prepare the word-processed program file with an "OPEN DATA" call for an existing data file, usually carrying the "DAT" suffix. Although this method is encouraged by RATS because it speeds implementation of a batch job, the procedures for creating a RATS data file are likely to be too formidable for the beginner. RATS includes several example data files, including GRUNDFELD.DAT, which have been prepared in ASCII code by word processors operating in a "non-document" or unformatted mode. Data files created under other formats, such as Lotus, can be translated to RATS data formats.

Each of these methods will be demonstrated in the following section on preparation of the program file.

PREPARATION OF THE SUR PROGRAM FILE

To run Zellner's model with the original Grunfeld data set in RATS batch mode, an unformatted text file was created with Wordstar 2000. The file, SUR.PGM, is presented as Figure 1. The program lines ("cards") are explained as follows:

CAL	1935	1	1
(defines calendar)	(first year)	(first period)	(annual data)

ALL	0	1954:1
(Allocate, set bounds on observations)	(series parameter, usually 0)	(date upper bound)

DATA(UNIT=INPUT,ORG=OBS) / GI GF GC WI WF WC
(options) (series or variable names)

UNIT=[INPUT] (from terminal)
[DATA] (from input file)

ORG=[OBS] (by row of all variables per period)
[VAR] (by row of each variable for all periods)

Series: GI - General Electric (GE) Gross Investment
GF - GE Value of Outstanding Shares Lagged
GC - GE Capital Stock Lagged
WI - Westinghouse (WEST) Gross Investment
WF - WEST Value of Outstanding Shares Lagged
WC - WEST Capital Stock Lagged

Since the DATA card specifies the data to be input directly, the next 20 lines must list values for the six variables, one row per year, for 20 years. The data could have been entered directly into the text, but alignment and editing would have been time-consuming. Instead, the second data method from above was used. A Lotus worksheet, GRUNFELD.WK1, was created (See Figure 2.) and its six variables printed to the file, GRUNFELD.PRN. With the cursor set at the line following the DATA line, the Wordstar command, ^BI (block, insert file) was used to insert GRUNFELD.PRN, as shown in Figure 1.

Immediately following the data, and prior to executing the SUR command, the equation system must be specified, by number (1, 2) and name (GI, WI). Next, OLS is called to estimate each equation.

Finally, SUR is called to include variance-covariance matrices (VCV) for a (2)-equation system. (A supplemental card [#] is required for each equation.) Following the estimation of the model, restrictions are applied to test whether the share (GF, WF) and stock (GC, WC) coefficients differ across equations.

Figure 1. Listing of the Text File, SUR.PGM

```
CAL 1935 1 1
ALL 0 1954:1
DATA(UNIT=INPUT,ORG=OBS) /  GI GF GC WI WF WC
 33.1    1170.6     97.8    12.93    191.5      1.8
 45.0    2015.8    104.4    25.90    516.0      0.8
 77.2    2803.3    118.0    35.05    729.0      7.4
 44.6    2039.7    156.2    22.89    560.4     18.1
 48.1    2256.2    172.6    18.84    519.9     23.5
 74.4    2132.2    186.6    28.57    628.5     26.5
113.0    1834.1    220.9    48.51    537.1     36.2
 91.9    1588.0    287.8    43.34    561.2     60.8
 61.3    1749.4    319.9    37.02    617.2     84.4
 56.8    1687.2    321.3    37.81    626.7     91.2
 93.6    2007.7    319.6    39.27    737.2     92.4
159.9    2208.3    346.0    53.46    760.5     86.0
147.2    1656.7    456.4    55.56    581.4    111.1
146.3    1604.4    543.4    49.56    662.3    130.6
 98.3    1431.8    618.3    32.04    583.8    141.8
 93.5    1610.5    647.4    32.24    635.2    136.7
135.2    1819.4    671.3    54.38    723.8    129.7
157.3    2079.7    726.1    71.78    864.1    145.5
179.5    2371.6    800.3    90.08   1193.5    174.8
189.6    2759.9    888.9    68.60   1186.9    213.5
EQUATION 1 GI
# CONSTANT GF GC
EQUATION 2 WI
# CONSTANT WF WC
OLS(EQUATION=1) GI
OLS(EQUATION=2) WI
SUR(VCV) 2
# 1
# 2
RESTRICT 2
#    2      5
# 1.0   -1.0   0.0
#    3      6
#  1.0   -1.0   0.0
END
```

Figure 2. Lotus Worksheet File, GRUNFELD.WK1

	A	B	C	D	E	F	G
1	GRUNFELD DATA, USED FOR ZELLNER'S SUR TECHNIQUE						
2							
3	YEAR	GI	GF	GC	WI	WF	WC
4	1935	33.1	1170.6	97.8	12.93	191.5	1.8
5	1936	45.0	2015.8	104.4	25.90	516.0	0.8
6	1937	77.2	2803.3	118.0	35.05	729.0	7.4
7	1938	44.6	2039.7	156.2	22.89	560.4	18.1
8	1939	48.1	2256.2	172.6	18.84	519.9	23.5
9	1940	74.4	2132.2	186.6	28.57	628.5	26.5
10	1941	113.0	1834.1	220.9	48.51	537.1	36.2
11	1942	91.9	1588.0	287.8	43.34	561.2	60.8
12	1943	61.3	1749.4	319.9	37.02	617.2	84.4
13	1944	56.8	1687.2	321.3	37.81	626.7	91.2
14	1945	93.6	2007.7	319.6	39.27	737.2	92.4
15	1946	159.9	2208.3	346.0	53.46	760.5	86.0
16	1947	147.2	1656.7	456.4	55.56	581.4	111.1
17	1948	146.3	1604.4	543.4	49.56	662.3	130.6
18	1949	98.3	1431.8	618.3	32.04	583.8	141.8
19	1950	93.5	1610.5	647.4	32.24	635.2	136.7
20	1951	135.2	1819.4	671.3	54.38	723.8	129.7
21	1952	157.3	2079.7	726.1	71.78	864.1	145.5
22	1953	179.5	2371.6	800.3	90.08	1193.5	174.8
23	1954	189.6	2759.9	888.9	68.60	1188.9	213.5

Since the Grunfeld data are already stored in a RATS data file, GRUNFELD.DAT, Figure 3. shows a simpler SUR.PGM file.

Figure 3. Alternative Text File, SUR.PGM, Reading GRUNFELD.DAT

```
OPEN DATA GRUNFELD.DAT
CAL 1935 1 1
ALL 0 1954:1
DATA /  GI GF GC WI WF WC
EQUATION 1 GI
# CONSTANT GF GC
EQUATION 2 WI
# CONSTANT WF WC
OLS(EQUATION=1) GI
OLS(EQUATION=2) WI
SUR(VCV) 2
# 1
# 2
RESTRICT 2
#   2     5
# 1.0   -1.0   0.0
#   3     6
#  1.0  -1.0   0.0
END
```

EXECUTING A RATS PROGRAM IN BATCH MODE

The Wordstar file, SUR.PGM was saved in the RATS default data subdirectory:

\RATS\DATA\SUR.PGM

The program was then run by the following procedure:

1. Exit to DOS

2. Make the RATS directory current:

   CD\RATS

3. Execute the program with the following command:

   RATS SUR.PGM,SUR.OUT

   This statement instructs the compiler to execute a list of RATS-compatible instructions (cards) in a special program file (SUR.PGM) and send the output to the text file, SUR.OUT. Because the output of most RATS procedures exceeds the length of the monitor screen, it is advisable to send the results to a text file, which can then be reviewed via a word processor. The output of SUR.PGM is shown in Figure 4.

Figure 4. Results of SUR.PGM, as Text File, SUR.OUT

```
RATS Version 2.02.  08/06/86
  Copyright (C) 1986,1985,1984 by VAR Econometrics
CAL 1935 1 1
ALL 0 1954:1
DATA(UNIT=INPUT,ORG=OBS) /  GI GF GC WI WF WC
 33.1   1170.6    97.8   12.93   191.5    1.8
 45.0   2015.8   104.4   25.90   516.0    0.8
 77.2   2803.3   118.0   35.05   729.0    7.4
 44.6   2039.7   156.2   22.89   560.4   18.1
 48.1   2256.2   172.6   18.84   519.9   23.5
 74.4   2132.2   186.6   28.57   628.5   26.5
113.0   1834.1   220.9   48.51   537.1   36.2
 91.9   1588.0   287.8   43.34   561.2   60.8
 61.3   1749.4   319.9   37.02   617.2   84.4
 56.8   1687.2   321.3   37.81   626.7   91.2
 93.6   2007.7   319.6   39.27   737.2   92.4
159.9   2208.3   346.0   53.46   760.5   86.0
147.2   1656.7   456.4   55.56   581.4  111.1
146.3   1604.4   543.4   49.56   662.3  130.6
 98.3   1431.8   618.3   32.04   583.8  141.8
 93.5   1610.5   647.4   32.24   635.2  136.7
135.2   1819.4   671.3   54.38   723.8  129.7
157.3   2079.7   726.1   71.78   864.1  145.5
179.5   2371.6   800.3   90.08  1193.5  174.8
189.6   2759.9   888.9   68.60  1188.9  213.5
EQUATION 1 GI
# CONSTANT GF GC
VAR    0     CONSTANT
VAR    2     GF
VAR    3     GC
EQUATION 2 WI
# CONSTANT WF WC
VAR    0     CONSTANT
VAR    5     WF
VAR    6     WC
```

Figure 4. Continued

```
OLS(EQUATION=1) GI

EQUATION     1
DEPENDENT VARIABLE     1      GI
FROM  1935:  1  UNTIL  1954:  1
OBSERVATIONS            20      DEGREES OF FREEDOM      17
R**2              .70530669     RBAR**2          .67063689
SSR           13216.588         SEE           27.882725
DURBIN-WATSON  1.07209856
Q(  10)=   30.7177        SIGNIFICANCE LEVEL  .653123E-03
NO.      LABEL     VAR  LAG    COEFFICIENT    STAND. ERROR     T-STATISTIC
***     *******    ***  ***   ************   ************    ************
  1      CONSTANT   0    0   -9.956306       31.37425       -.3173401
  2      GF         2    0    .2655119E-01   .1556610E-01    1.705705
  3      GC         3    0    .1516939       .2570408E-01    5.901548

OLS(EQUATION=2) WI

EQUATION     2
DEPENDENT VARIABLE     4      WI
FROM  1935:  1  UNTIL  1954:  1
OBSERVATIONS            20      DEGREES OF FREEDOM      17
R**2              .74444612     RBAR**2          .71438095
SSR           1773.2339         SEE           10.213123
DURBIN-WATSON  1.41302068
Q(  10)=   36.2147        SIGNIFICANCE LEVEL  .773163E-04
NO.      LABEL     VAR  LAG    COEFFICIENT    STAND. ERROR     T-STATISTIC
***     *******    ***  ***   ************   ************    ************
  1      CONSTANT   0    0   -.5093902       8.015289       -.6355232E-01
  2      WF         5    0    .5289413E-01   .1570650E-01    3.367658
  3      WC         6    0    .9240649E-01   .5609897E-01    1.647205

SUR(VCV) 2
# 1
# 2

EQUATION     1
DEPENDENT VARIABLE     1      GI
FROM  1935:  1  UNTIL  1954:  1
OBSERVATIONS            20      DEGREES OF FREEDOM      17
R**2              .69255740     RBAR**2          .65638768
SSR           13788.376         SEE           28.479483
DURBIN-WATSON   .98560311
Q(  10)=   30.1065        SIGNIFICANCE LEVEL  .822943E-03
NO.      LABEL     VAR  LAG    COEFFICIENT    STAND. ERROR     T-STATISTIC
***     *******    ***  ***   ************   ************    ************
  1      CONSTANT   0    0   -27.71932       27.03283       -1.025395
  2      GF         2    0    .3831021E-01   .1329011E-01    2.882609
  3      GC         3    0    .1390363       .2303559E-01    6.035716
```

Figure 4. Continued

```
EQUATION     2
DEPENDENT VARIABLE     4      WI
FROM  1935:  1  UNTIL  1954:  1
OBSERVATIONS            20      DEGREES OF FREEDOM      17
R**2              .74040118      RBAR**2          .70986014
SSR          1801.3009           SEE          10.293633
DURBIN-WATSON  1.36467022
Q(  10)=    30.7589        SIGNIFICANCE LEVEL  .642992E-03
NO.      LABEL     VAR  LAG    COEFFICIENT   STAND. ERROR    T-STATISTIC
***    *******     ***  ***   ************   ************   ************
  4      CONSTANT    0    0   -1.251988       6.956347       -.1799778
  5      WF          5    0    .5762980E-01   .1341101E-01    4.297200
  6      WC          6    0    .6397807E-01   .4890100E-01    1.308318
```

COVARIANCE/CORRELATION MATRIX OF COEFFICIENTS

VARIABLE	SERIES	LAG	CONSTANT 0 0	GF 2 0	GC 3 0	CONSTANT 0 0
CONSTANT	0	0	730.77	-.91649	-.23484	.67515
GF	2	0	-.32927	.17663E-03	-.11122	-.56991
GC	3	0	-.14624	-.34048E-04	.53064E-03	-.24726
CONSTANT	0	0	126.96	-.52688E-01	-.39621E-01	48.391
WF	5	0	-.22619	.11999E-03	-.16872E-04	-.80023E-01
WC	6	0	.39251	-.32480E-03	.59483E-03	.11362

VARIABLE	SERIES	LAG	WF 5 0	WC 6 0
CONSTANT	0	0	-.62392	.29693
GF	2	0	.67323	-.49977
GC	3	0	-.54616E-01	.52805
CONSTANT	0	0	-.85777	.33400
WF	5	0	.17986E-03	-.72367
WC	6	0	-.47459E-03	.23913E-02

COVARIANCE/CORRELATION MATRIX

VARIABLE	SERIES	LAG	GI 1 0	WI 4 0
GI	1	0	689.42	.76504
WI	4	0	190.64	90.065

```
RESTRICT 2
#   2     5
# 1.0   -1.0   0.0
#   3     6
#  1.0  -1.0   0.0
CHI-SQUARE(   2) =    4.706791        SIGNIFICANCE LEVEL    .9504590E-01
```

Figure 4. Continued

```
END

          NORMAL COMPLETION OF JOB
                    HALT AT    0
                        0 ERRORS        0 WARNINGS
```

REFERENCES

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