UNIVERSITY OF ILLINOIS

DIGITAL COMPUTER

LIBRARY ROUTINE K 14 - 233

By Gene H. Golub

TITLE — Multiple Regression Analysis with Transformations

TYPE — Entire Program

METHOD OF USE

1) Read in master program. A sum check is performed, and if the program is read correctly the machine will stop on 24 $(012)_{16}$; otherwise it will stop on an FF order.

2) Read in the parameter tape. The computer stops on 20 $(ONL)_{16}$.

3) Read in the data tape.

4) After all data have been read into the computer, the desired information will be printed out. The computer stops on 24 $(012)_{16}$.

5) Another problem can be begun by reading in new parameters.

CAPACITY

The maximum number of non-eliminated variables is twenty-two. The total number of variables must be ≤ 50. The number of observation is unlimited.

This program hangs up unless $s > n + 1$.

DURATION — [See Note 3]

PUNCHING OF THE TAPES

For each problem six parameters are necessary. They are as follows:

(1) Let "s" be the sample size. Put sS on the tape.

(2) Let "n" be the number of non-eliminated variables. Put nN on the tape.

(3) Let "f" be the number of decimal places to which correlations are to be printed. Put fF on the tape.

(4) Let "ℓ" be the number of decimal places to which covariances are to be printed. Put ℓL on the tape.

(5) Let "k" be the number of decimal places to which standardized regression weights, their standard errors, and multiple correlations are to be printed. Put kK on the tape.

(6) Let "j" be the number of decimal places to which unstandardized regressions weights, their standard errors and standard errors of estimate are to be printed. Put jJ on the tape.

Any of the four parameters f, j, k, or ℓ may be set to zero. The parameters are followed by a sequence of 1's and 0's! The 1's indicate which of the non-eliminated variables are to be considered successively independent. (e.g., if this sequence is a single 1 the first variable will be considered dependent, if it consist of 1001 the first variable and then the fourth variable will be considered dependent). 0's following the last 1 in the sequence should be omitted. If more than one variable is to be considered dependent no delays, spaces, line feeds or other characters with the fifth hole punched may be inserted between the first 1 and the last 1 in this sequence. The first character after the last 1 in the sequence must be a character with the fifth hole punched, (e.g., delay, space, line feed, etc). The portion of the input tape between this character and a character which consists of a single fifth hole on the tape will be exactly reproduced on the output tape. In this interval some identification may be punched. The identification can be a number, a name, or any combination of characters which does not include a character consisting a single fifth hole on the tape. It must, however, be followed by such a character. If no identification is desired, two fifth hole characters must be punched immediately after the last 1 in the sequence. The second of these must consist of a single fifth hole on the tape. No fifth hole character may be punched following the S, N, F, L, J, K parameters in the section where the successive dependent variables are indicated. If one is punched, characters between the fifth hole character the single fifth hole delay will be reproduced as identification.

Next, a sequence of signed integers, followed by an N, is punched on the tape. These integers take on the values 0, 1, 2, 3, 4, 5, 6. Corresponding to each integer, the following transformations are made:

n	transformation on x
+0	eliminate variable
+1	x
+2	x^2
+3	x^3
+4	$\sqrt{x}$, $x \geq 0$
+5	$\log x/10$, $x \geq 10^{-10}$
+6	$\frac{1}{x}$ arc sin x

The number of digits in this sequence must be equal to the total number of variables.

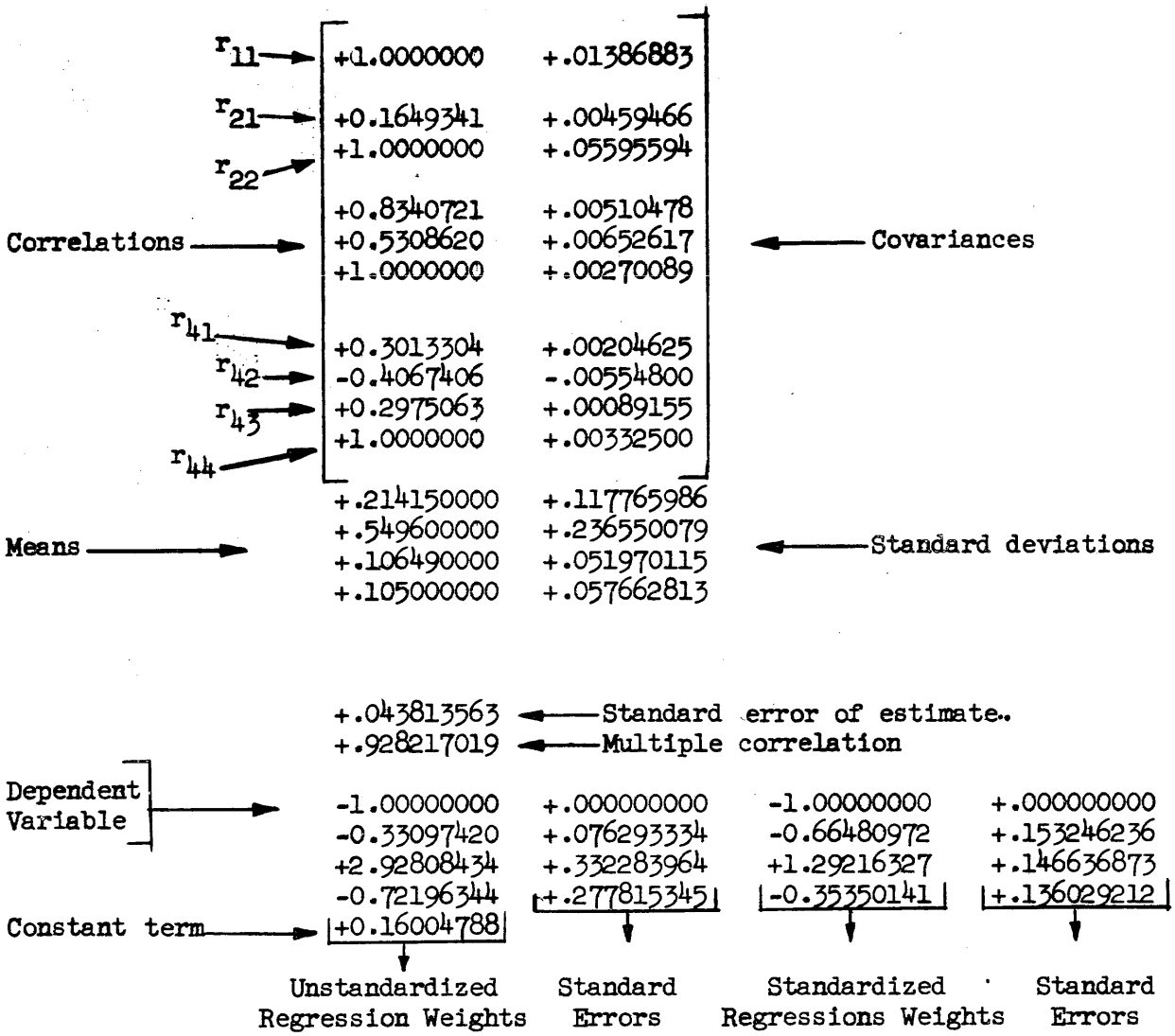
Each element of an observation vector must be punched as a sign followed by up to 12 decimal digits. The character N must be punched after each row. If an F follows a row, then the machine will stop, and another part of the data tape may be placed in the reader.

SCALING OF THE DATA

Each observation must be scaled so that it is less than one in absolute value before it can be punched. Each element should be scaled by the same value if the constant term is to be easily interpreted. If each element is scaled by a constant c, then the correlation coefficients, multiple correlation, regression coefficients and standard error of the regression coefficients will be unaffected. The means, standard deviations, standard estimate of error and constant term will all be scaled by c. The variances and covariances will be scaled by c^2.

THE PRINT OUT

This is best illustrated by a typical example. For a problem with four variables, the print out could appear as follows on the next page. The means and standard deviations are always printed to nine places.



SUM CHECK

Throughout this program, there are a number of checks on the tapes and magnetic drum storage. They are as follows:

1.) If the master tape has been read in incorrectly, the machine will stop on an FF 011 order at $(378)_{16}$.

2.) If the data tape does not have the same number of variables in each row, the machine stops on an FF 012 order at $(0J4)_{16}$.

3.) If a drum error has been made, the machine will stop on an FF 013 order at $(06N)_{16}$.

MATHEMATICAL MODEL

Let x_{ij} be the jth observation on the ith variable. As each observation vector is read in,

$$\sum_{j=1}^{p} \frac{x_{ij}\, x_{kj}}{s} \quad \text{and} \quad \sum_{j=1}^{p} \frac{x_{ij}}{s} \qquad \begin{array}{l} p = 1, 2, \ldots s \\ k \leq i \\ i = 1, 2, \ldots n \\ k = 1, \ldots, n \end{array}$$

are computed. After all the observations have been read in, the correlation matrix is calculated and then inverted using a modified version of M 14. The formulas used for calculation are as follows:

The mean: $$\bar{x}_i = \sum_{j=1}^{s} \frac{x_{ij}}{s}$$

The Covariance: $$c_{ik} = \sum_{j=1}^{s} \frac{x_{ij}\, x_{kj}}{s} - \bar{x}_i\, \bar{x}_k$$

The Correlation Coefficient: $$r_{ik} = \frac{c_{ik}}{\sqrt{c_{ii}\, c_{kk}}}$$

The Standardized Regression Weight:

$$b^*_{ik} = \frac{-r^{ik}}{r^{ii}}, \quad k = 1, \ldots, n$$

where r^{ik} is the (i,k) element of the inverse of the correlation matrix.

The Standard Error of the Standardized Regression Weights:

$$S_{b^*_{ik}} = \sqrt{\frac{r^{ii}\, r^{kk} - (r^{ik})^2}{(s - n)\,(r^{ii})^2}}$$

The Multiple Correlation Coefficient:

$$R_i = \sqrt{1 - \frac{1}{r^{ii}}}$$

The Standard Error of Estimate:

$$S_i = \sqrt{c_{ii}\ (1 - R_i^2)}$$

The Unstandardized Regression Weights:

$$b_{ik} = \sqrt{\frac{c_{ii}}{c_{kk}}}\ b^*_{ik}$$

The Standard Error of the Unstandardized Regression Weights:

$$S_{b_{ik}} = \sqrt{\frac{c_{ii}}{c_{kk}}}\ S_{b^*_{ik}}$$

NOTE 1 Beginning at drum location 2560, the subroutines necessary for this program are stored.

NOTE 2 Beginning at drum location 3584, the means, standard deviations, correlation matrix and its inverse are stored.

NOTE 3

A TABLE OF TYPICAL TIMES

Number of Variables	Read in 100 Observations of 8 digits	Print Correlations and Covariance Matrix to 8 Places	Invert Correlation Matrix	Print Standardized and Unstandardized Regression Weights and their Standard Error to 8 Places
5	45 sec.	10 sec.	4 sec.	6 sec.
10	95 sec.	32 sec.	10 sec.	12 sec.
15	150 sec.	68 sec.	18 sec.	18 sec.
20	218 sec.	120 sec.	35 sec.	23 sec.

In addition, it requires about 35 seconds to read the master tape into the machine.

Rt: 7/1/60

DATE March 20, 1957

PROGRAMMED BY G Golub

APPROVED BY D E Muller

LOCATION	ORDER	NOTES
Decimal Order Input- X-1		
	00 3K	
3	00 F	Location of data, means and matrix
	00 500F	of cross-products
4	00 F	Location of Library Routine N 12
	00 960F	
5	00 F	Location of List of Constants
	00 58F	
6	00 F	Location of Library Routine R-1
	00 116F	
7	00 F	
	00 3584F	First location of Data Stored on Drum
8	00 F	Location of Diagonal Elements of Inverse
	00 982F	and Scaling Factors.
9	00 F	Location of Library Routine Y-1
	00 76F	
10	00 F	Location of Library Routine P-1 (modified)
	00 125F	
11	00 F	
	00 2560F	First Location of Subroutines on Drum
12	00 F	
	00 700F	
13	00 F	
	00 400F	Location of directory
14	00 F	
	00 275F	Location of transformation routine
	00 76K	
Library Routine Y-1		Transfer Blocks of Words from the Memory to the Drum or from the Drum to the Memory Change FF order in Y-1 here to read FF 19F
Subroutine A		
This subroutine clears the memory, inputs the parameters, and translates the identification.		
	00 200K	
0	K5 F	
	42 40L	Plant link

LOCATION	ORDER	NOTES	PAGE 2
1	L5 43L		
	40 2L		
2	00 11F	from 4	
	41 ( )F	by 1,3	Clear memory
3	F5 2L		
	40 2L		
4	L0 41L		
	36 2L		
5	92 135F		
	41 7F	from 13	
6	81 4F	from 10	
	L0 13S5		
7	32 10L		
	L4 13S5		Read in parameters and
8	50 7F		convert
	74 13S5		
9	S5 F		
	40 7F		
10	26 6L		
	42 11L	from 7	
11	L5 7F		
	40 ( )F	by 10	
12	F5 8F		
	40 8F		
13	L0 42L		
	32 5L		
14	40 8F		
	81 4F		
15	F0 5S5	from 19	
	32 17L		Read in sequence of 1's and 0's
16	L5 9F		to determine dependent variables
	L6 8F		
17	40 9F		
	L5 8F	from 15	
18	10 1F		
	40 8F		

LOCATION	ORDER	NOTES	PAGE 3
19	91 4F		
	36 15L		
20	26 25L		
	L5 7F	from 26	
21	32 22L		
	50 24L		read in identification and print out
22	26 23L		
	50 23L	from 21	
23	04 6F		
	42 24L		
24	02 1F		
	92 ( )F	by 23	
25	91 4F		
	40 7F	from 20	
26	L7 7F		
	32 20L		
27	92 707F		
	92 131F		
28	92 515F		
	L5 2F		
29	42 0S5		
	42 6S5		Set parameters
30	42 16S5		
	00 20F		
31	46 S5		
	L5 S5		
32	L4 1S5		
	40 2S5		
33	L4 S5		
	40 3S5		
34	L5 4F		
	42 8S5		
35	L5 5F		
	42 9S5		

LOCATION	ORDER	NOTES	PAGE 4
36	L5 0F		
	42 10S5		
37	L5 3F		
	42 11S5		
38	L5 1F		
	40 15S5		
39	L5 9F		
	40 14S5		
40	00 1F		
	22 ( )F	by 0	
41	80 11F		
	41 1034F		
42	80 F		
	00 6F		
43	00 11F		
	41 S3		
	00 800K		
0	J0 200F		
	50 L		
1	26 S9		Store subroutine A
	00 SS		on drum
2	00 44F		[This is an interlude which is
	L5 0F		later overwritten.]
3	40 4L		
	26 999F		
	26 800N		

Subroutine B

This subroutine computes the means and sum of cross-products divided by s.

	00 200K		
0	S5 50F		
	40 0L		
1	52 SJ		Read in integers determining
	50 1L		transformations
2	26 S4		
	L5 21S4		

LOCATION	ORDER		NOTES PAGE 5
3	40 56L		
	L0 6L		
4	10 20F		
	42 53SF		
5	50 L		
	24 7L		
6	40 SJ		
	L5 21S4		
7	50 8L		
	26 999F		
8	00 F		
	00 7L		
9	00 F		
	26 7L		
	26 1N		
0	L5 15S5		
	L4 5S5		
1	40 4F		
	K5 F		Plant link
2	42 48L		
	19 38F		
3	66 15S5		
	S5 F		1/s
4	40 5F		
	L5 49L		
5	40 6F		
	L4 7L		
6	46 6F		
	41 9F		
7	50 49F	from 39	Read in and transform
	50 7L		observation row
8	26 SF		
	L0 12S5		
9	30 9L		
	L5 21S4		

LOCATION	ORDER	NOTES	
10	L0 6F		
	40 0F		
11	L3 0F		
	32 12L		Have n observations been
12	FF 18F		read in?
	L5 1S5		
13	42 15L		
	L5 2S5		
14	42 16L		
	46 16L		
15	50 5F	from 21	
	7J ( )F	by 13,17	
16	L4 ( )F	by 14,19	$\sum_{k=1}^{p} \frac{x_{1k}}{s}$
	40 ( )F	by 14,19	
17	F5 15L		
	42 15L		p = 1, 2, ... s
18	L5 16L		
	L4 4S5		
19	40 16L		
	F5 0F		
20	40 0F		
	L0 6S5		
21	36 15L		
	F5 5S5		
22	40 2F		
	L5 1S5		
23	42 26L		
	L5 3S5		
24	42 29L		
	46 29L		
25	L5 1S5	from 36	
	42 28L		
26	41 1F		
	50 ( )F	by 23,35;from 34	

LOCATION	ORDER	NOTES	PAGE 7
27	7J 5F		
	40 0F		
28	50 0F		$\sum_{k=1}^{p} \frac{x_{ik}\, x_{jk}}{s}$
	7J ( )F	by 25,30	
29	L4 ( )F	by 24,32	
	40 ( )F	by 24,32	
30	F5 28L		p = 1, 2, ... s
	42 28L		
31	L5 29L		
	L4 4S5		
32	40 29L		
	F5 1F		
33	40 1F		
	L0 2F		
34	32 26L		
	F5 26L		
35	42 26L		
	F5 2F		
36	40 2F		
	L5 1F		
37	L0 6S5		
	36 25L		
38	F5 9F		
	40 9F		
39	L0 4F		
	36 7L		Have s observations been read in?
40	41 0F		
	L5 3S5		
41	42 42L		
	L5 1S5		
42	42 43L		
	L5 ( )F	by 41,46;from 48	
43	22 43L		
	40 ( )F	by 42,44	Store diagonal elements
44	F5 43L		consecutively
	42 43L		

LOCATION	ORDER		NOTES
45	F5 42L		
	F4 0F		
46	42 42L		
	F5 0F		
47	40 0F		
	L0 6S5		
48	32 42L		
	22 ( )F	by 2	
49	40 S3		
	L5 21S4		
50	00 F		
	00 52L		
51	50 50L		
	26 999F		
52	00 1F		
	26 51L		
	26 1N		
Subroutine C			
This subroutine computes the standard deviations			
0	K5 F		
	42 14L		Plant link
1	L5 2S5		
	42 5L		
2	46 5L		
	L5 1S5		
3	42 8L		
	46 6L		
4	41 0F		
	41 3F		
5	50 ( )F	by 1,10; from 13	
	79 ( )F	by 1,10	$\frac{\sum_{k=1}^{s} x_{ik}^2}{s}$
6	L4 ( )F	by 3,11	$= \left(\frac{\sum x_{ik}}{s}\right)^2$
	32 7L		

LOCATION	ORDER		NOTES
7	23 8L		If the variance is negative, replace
	50 7L	from 6	by zero.
8	26 S6		Compute standard deviation
	40 ( )F	by 3,11; from 7	
9	L5 5L		
	L5 4S5		
10	40 5L		
	L0 S5		
11	46 6L		
	42 8L		
12	F5 3F		
	40 3F		
13	L0 6S5		
	36 5L		
14	00 1F		
	22 ( )F	by 0	
Routine H			
Read in data and perform transformations			
	00 275K		
0	50 50SJ		
	50 0L		
1	26 S4		
	40 13F		
2	41 10F		Read in data
	L5 17L		
3	42 9L		
	L5 49L		
4	42 7L		
	00 1F		
5	L5 21L		
	42 6L		
6	L5 16L	from 14	
	L4 SJ	by 5,12	
7	42 8L		
	L5 50SJ	by 4,11	

LOCATION	ORDER	NOTES	
8	40 1F		
	26 ( )F	by 7	Determine transformation
9	7J 1F	from 8,42	
	40 S3	by 3,10;from 17,44,49,35,36	
10	F5 9L		
	42 9L		
11	F5 7L	from 16	
	42 7L		
12	F5 6L		
	42 6L		
13	F5 10F		
	40 10F		
14	L0 53L		
	36 6L		
15	L5 13F		
	22 215F		Jump to subroutine B
16	26 11L		eliminate x
	00 16L		
17	22 9L		x
	00 S3		
18	50 1F		
	26 9L		x^2
19	50 1F		
	26 41L		x^3
20	41 0F		
	22 43L		$\sqrt{x}$
21	22 45L		
	00 SJ		$\log_{10} x/10$
22	40 3F		
	50 3F		$\frac{1}{\pi}$ arc sin x
23	7J 3F		
	40 12F		$x^2 \rightarrow 12$
24	L4 54L		80 F00F
	40 1F		
25	41 0F		
	L1 1F		

LOCATION	ORDER	NOTES	
26	32 26L		
	50 26L		
27	26 S6		$\sqrt{1-x^2}$
	50 54L		
28	LJ 12F		
	36 37L		
29	L5 2F		
	66 3F		
30	S7 F		
	50 30L		arc tan
31	26 366F		
	40 0F		
32	50 0F		
	79 51L		1/x
33	L4 50L		1/2
	40 1F		
34	L5 3F		
	36 36L		
35	L1 1F		
	22 9L		
36	L5 1F	from 34	
	22 9L		
37	L5 3F	from 28	
	66 2F		
38	S5 F		
	50 38L		
39	26 366F		arc tan
	40 1F		
40	50 51L		
	26 9L		
41	7J 1F	from 19	
	40 0F		
42	50 0F		x^3
	26 9L		
43	00 1F		
	50 43L	from 20	

LOCATION	ORDER	NOTES	PAGE 12
44	22 S6		$\sqrt{x}$
	22 9L		
45	32 45L		
	50 45L		
46	26 330F		$\frac{\log_e x}{32}$
	40 0F		
47	19 5F		
	50 0F		
48	74 52L		$\frac{1}{10} \log_{10} x$
	00 5F		
49	22 9L		
	00 50SJ		
50	40 F		
	00 F		
51	00 F		
	00 3183 0988 6184J		$= \frac{1}{\pi}$
52	00 F		
	00 0434 2944 8195J		
53	80 F		
	00 ( )F	by word 4, Routine B	
54	80 F		
	00 F		
	00 330K		
Routine S-5 - 1/32 Natural Logarithm			
	00 366K		
Routine T-4 - New arc Tan			
	00 810K		
0	J0 200F		
	50 L		Store subroutines
1	26 S9		B, C, and H on drum.
	00 700SS		
2	00 191F		[This is an interlude which is later overwritten.]
	L5 0F		
3	40 4L		
	26 999F		

LOCATION	ORDER	NOTES
	26 810N	
Subroutine D		
This subroutine computes and prints correlations, covariances means, and standard deviations.		
	00 200K	
0	K5 29L	
	42 56L	Plant link
1	L3 8S5	
	36 6L	Should correlations be printed?
2	50 8S5	
	75 13S5	
3	K5 F	
	L4 4S5	
4	00 20F	
	46 28L	
5	L5 26L	
	22 6L	
6	L5 0L	from 1
	46 27L	from 5
7	L3 9S5	Should covariances be printed?
	32 11L	
8	50 9S5	
	75 13S5	
9	K5 F	
	00 20F	
10	46 31L	
	L5 32L	
11	26 12L	
	L5 59L	from 7
12	42 29L	from 11
	F5 5S5	
13	40 5F	
	L5 3S5	
14	42 20L	
	42 26L	

LOCATION	ORDER		NOTES	PAGE 14	K 14
15	L5 2S5				
	46 20L				
16	L5 1S5				
	46 22L				
17	41 6F	from 44			
	L5 2S5				
18	42 19L				
	L5 1S5				
19	42 21L				
	L5 (0)F	by 18,34; from 39			
20	79 ( )F	by 15, 42			
	L4 ( )F	by 14, 37			
21	40 3F				
	50 ( )F	by 19, 35			
22	7J ( )F	by 16, 41			
	40 0F				
23	L3 0F				
	32 27L				
24	50 3F				
	75 57L		Compute correlations coefficient		
25	66 0F				
	S5 F				
26	50 28L				
	40 ( )F	by 14, 36			
27	22 ( )F	by 6			
	23 26L	from 23			
28	52 ( )F	by 4			
	50 28L		Print correlations		
29	26 SK				
	26 ( )F	by 12			
30	92 963F				
	L5 3F				
31	52 ( )F	by 10	Print covariances		
	50 31L				
32	26 SK				
	50 30L		Waste		

LOCATION	ORDER	NOTES
33	92 131F	
	92 515F	
34	F5 19L	
	42 19L	
35	F5 21L	
	42 21L	
36	F5 26L	
	42 26L	
37	42 20L	
	F5 6F	
38	40 6F	
	L0 5F	
39	32 19L	
	92 131F	
40	L5 22L	
	L4 4S5	
41	46 22L	
	L4 S5	
42	46 20L	
	F5 5F	
43	40 5F	
	L5 6F	
44	L0 6S5	
	36 17L	
45	L5 2S5	
	42 47L	
46	L5 1S5	
	42 49L	
47	41 3F	
	L5 ( )F	by 45, 52; from 56
48	52 91F	Print means
	50 48L	
49	26 SK	
	L5 ( )F	by 46, 53

LOCATION	ORDER		NOTES
50	52 91F		
	50 50L		
51	26 SK		Print standard deviations
	F5 47L		
52	42 47L		
	F5 49L		
53	42 49L		
	92 131F		
54	92 515F		
	F5 3F		
55	40 3F		
	L0 6S5		
56	32 47L		
	22 ( )F	by 0	
57	00 F		
	00 1000 000 0000J		
58	L3 8S5		
	36 34L		
59	26 33L		
	00 58L		
	00 820K		
0	J0 200F		
	50 L		
1	26 S9		Store subroutine
	00 179SS		
2	00 60F		D on drum.
	L5 0F		
3	40 4L		[This is an interlude which is
	26 999F		later overwritten.]
	26 820N		

Subroutine E

This subroutine stores the standard deviations, means and entire correlation matrix on the drum.

LOCATION	ORDER	NOTES	PAGE 17	K 14
	00 200K			
0	K5 F			
	42 28L		Plant link	
1	L5 S5			
	46 22L			
2	L4 S5			
	46 7L			
3	L4 4S5			
	10 20F			
4	L4 6L			
	40 21L			
5	J0 S3		Store standard deviations and	
	50 5L		means on drum	
6	26 S9			
	00 S7			
7	00 ( )F	by 2		
	L5 3S5			
8	40 6F			
	42 11L			
9	F5 5S5			
	40 5F			
10	L5 1S5	from		
	42 12L			
11	41 3F			
	L5 ( )F	by 8,14,17,24;from 19		
12	32 12L			
	40 ( )F	by 10, 13		
13	F5 12L			
	42 12L		Square matrix	
14	F5 11L			
	42 11L			
15	F5 3F			
	L0 5F			
16	36 18L			
	L5 3F			

LOCATION	ORDER	NOTES	
17	L4 11L		
	42 11L		
18	F5 3F	from 16	
	40 3F		
19	L0 6S5		
	32 11L		
20	J0 S3		
	50 20L		
21	26 S9		Store successive rows of correlation
	00 ( )F	by 4, 25	matrix on drum
22	00 ( )F	by 1	
	L5 6F		
23	L4 5F		
	40 6F		
24	42 11L		
	F5 21L		
25	L4 3F		
	40 21L		
26	F5 5F		
	40 5F		
27	L4 5S5		
	F0 6S5		
28	36 10L		
	22 ( )F	by 0	
	00 830K		
0	J0 200F		
	50 L		
1	26 S9		
	00 240SS		Store subroutine E on drum
2	00 29F		
	L5 0F		[This is an interlude which is
3	40 4L		later overwritten.]
	26 999F		
	26 830N		

LOCATION	ORDER	NOTES	PAGE 19
Subroutine F			
This subroutine reads in rows of the correlation matrix off the drum, computes the inverse and stores the rows of the inverse matrix on the drum.			
	00 116K		
0	K5 F		
	42 16L		Plant link
1	41 8F		
	L5 S5		
2	42 15L		
	46 14L		
3	46 19L		
	L4 4S5		
4	46 26L		
	L4 S5		
5	42 8F		
	L5 32L		
6	L4 8F		
	40 18L		
7	50 16S5		
	L5 16S5		
8	74 16S5		
	S5 F		
9	L4 18L		
	40 25L		
10	40 8F		
	L5 33L		
11	40 22L		
	F5 33L		
12	42 23L		
	L4 S5		
13	46 23L		
	00 1F		
14	J0 ( )F	by 2	
	L5 L4L		

LOCATION	ORDER	NOTES	PAGE 20
15	26 35L		
	00 ( )F	by 2	
16	00 1F		
	22 ( )F	by 0	
17	50 150L		Read in successive rows of
	50 17L		correlation matrix from drum.
18	26 S9	by 6,20	
	00 F	by 6,20	
19	00 ( )F	by 3	
	F5 18L		
20	L4 16S5		
	40 18L		
21	22 56L		
	00 1F		
22	L5 ( )F	by 11,29	Store successive rows of inverted
	40 ( )F	by 11,27	correlation matrix on drum.
23	L5 ( )F	by 13	
	40 ( )F	by 12,28	
24	J0 150L		
	50 24L		
25	26 S9	by 9,30	
	00 F	by 9,30	
26	00 ( )F	by 4	
	F5 23L		
27	42 22L		
	F5 22L		
28	42 23L		
	L4 4S5		
29	46 22L		
	F5 25L		
30	F4 16S5		
	40 25L		
31	26 141L		
	00 F		

LOCATION	ORDER		NOTES PAGE 21 K 14
32	26 S9		
	00 S7		
33	L5 150L		
	40 S8		
34	00 F		
	00 35L		
35	50 34L		
	26 999F		
36	00 F		
	26 35L		
	26 1N		
Routine M-14 (modified)			[Note: M-14 has been modified so that
	00 840K		the columns of the inverted matrix are
0	J0 116F		scaled by powers of 2 rather than by
	50 L		powers of 10.]
1	26 S9		Store subroutine F on drum
	00 270SS		[This is an interlude which is later
2	00 150F		overwritten.]
	L5 0F		
3	40 4L		
	26 999F		
	26 840N		
Subroutine G.			
This program computes and prints out the standard error of regression, the multiple correlation, the standardized and unstandardized regression weights and their standard errors.			
	00 200K		
0	K5 ( )F	by 3	
	42 154L		Plant link
1	50 10S5		
	75 13S5		

LOCATION	ORDER	NOTES	PAGE 22
2	K5 ( )F		Compute print parameters for
	00 20F		standardized regression weights and
3	46 0L		standard errors.
	46 123L		
4	L4 4S5		
	46 2L		
5	50 11S5		Compute print parameters for
	75 13S5		unstandardized regression weights
6	K5 ( )F	by 7	and standard errors.
	00 20F		
7	46 6L		
	46 119L		
8	L4 4S5		
	46 12L		
9	00 1F		
	L5 15S5		
10	L0 16S5		
	40 0F		
11	19 38F		
	66 0F		
12	S5 ( )F	by 8	1/s-n
	40 14F		
13	L5 S5		
	L4 S5		
14	46 19L		
	L0 S5		
15	L4 4S5		
	46 31L		
16	L5 8F		
	40 30L		
17	50 SN		Read means and standard deviations
	50 17L		from drum.
18	26 S9		
	00 S7		

LOCATION	ORDER		NOTES	PAGE 23	K 14
19	00 ( )F	by 14			
	L5 17S5				
20	42 23L				
	F5 17S5				
21	42 25L				
	L5 56L				
22	42 24L				
	L5 14S5	from 155	Dependent variable?		
23	36 148L				
	L5 (t_{ii})F	by 20,148	Diagonal element of inverse		
24	40 9F				
	L5 (s_i)F	by 22,150	Standard deviation		
25	40 10F				
	L5 (c_i)F	by 21,149	Scaling factor		
26	40 11F				
	L5 156L		1/10		
27	40 7F				
	L5 5S5		-1		
28	40 8F				
	32 29L		Waste		
29	50 50SN		Read first row of inverse matrix		
	50 29L		from drum		
30	26 S9				
	00 S7	by 16,152			
31	00 ( )F	by 15			
	L5 0L		Set print parameters		
32	46 136L				
	L5 2L				
33	46 134L				
	L5 6L				
34	46 130L				
	L5 12L				
35	46 128L				
	46 146L				
36	41 15F	from 162,166			
	L5 56L				

LOCATION	ORDER	NOTES	PAGE 24
37	42 49L		
	L4 S5		
38	42 85L		
	L5 168L		
39	42 48L		
	L4 155L		
40	42 84L		
	42 127L		
41	L4 155L		
	42 95L		
42	42 129L		
	L4 155L		
43	42 57L		
	42 133L		
44	L4 155L		
	42 77L		
45	42 135L		
	L5 17S5		
46	42 50L		
	F5 17S5		
47	42 51L		
	41 17F		
48	41 16F		Waste
	L5 (t_{ij})F	by 39,96;from 106	
49	40 3F		
	L5 (s_j)F	by 37,97	
50	40 4F		
	L5 (t_{jj})F	by 46,98	
51	40 5F		
	L5 (c_j)F	by 47,99	
52	40 6F		
	50 7F		
53	71 3F		
	40 0F		
54	L3 9F		
	L6 0F		

LOCATION	ORDER		NOTES PAGE 25
55	36 158L		Change scale
	L5 0F		Compute standardized regression weight
56	66 9F		and store
	S5 SN		
57	40 12F		
	40 (b^*_{ij})F		
58	L5 4F		
	L0 10F		
59	40 0F		
	L3 0F		
60	32 77L		
	50 3F		
61	79 3F		
	40 0F		
62	50 0F		
	7J 6F		Compute standard error of standardized
63	40 0F		regression weights
	50 5F		
64	7J 9F		
	40 1F		
65	50 1F		
	7J 11F		
66	L4 0F		
	40 0F		
67	50 0F		
	7J 14F		
68	40 0F		
	50 9F		
69	7J 9F		
	40 1F		
70	50 1F		
	7J 6F		
71	40 1F		
	50 0F		
72	71 8F		
	40 2F		

LOCATION	ORDER	NOTES	
73	L7 2F		
	L2 1F		
74	32 163L		
	L5 2F		
75	66 1F		
	41 0F		
76	S5 F		
	50 76L		
77	26 S6		
	40 $(S_{b_{ij}}^{*})$F	by 44,101	
78	40 13F		
	L3 11S5		
79	36 96L		
	50 12F		
80	75 10F		
	40 0F		
81	L7 0F		
	L2 4F		
82	36 158L		
	L5 0F		
83	66 4F		Compute unstandardized regression
	S5 F		weight
84	32 84L		
	40 (b_{ij})F	by 40,102	
85	L5 16F		
	74 (x_i)F	by 38,103	
86	40 0F		
	LL 0F		Compute constant term
87	36 88L		
	26 158L		Change scale
88	L5 0F		
	L4 15F		
89	40 15F		
	S5 F		

LOCATION	ORDER	NOTES	PAGE 27
90	40 16F		
	50 13F		
91	75 10F		
	40 0F		
92	L7 0F		
	L2 4F		
93	32 163L		Change scale
	L5 0F		
94	66 4F		Standard error of unstandardized re-
	S5 F		gression weight
95	32 95L		Waste
	40 ($S_{b_{ij}}$)	by 41,104	
96	F5 48L		
	42 48L		
97	F5 49L		
	42 49L		
98	F5 51L		
	42 50L		
99	F5 50L		
	42 51L		
100	F5 57L		
	42 57L		
101	F5 77L		
	42 77L		
102	F5 84L		
	42 84L		
103	F5 85L		
	42 85L		
104	F5 95L		
	42 95L		
105	F5 17F		
	40 17F		
106	L0 6S5		
	32 48L		

LOCATION	ORDER	NOTES	
107	41 0F		
	L5 9F		
108	L0 11F		
	50 12S5		Multiple correlation
109	66 9F		coefficient
	S5 F		
110	40 3F		
	50 110L		
111	26 S6		
	40 5F		
112	L5 5S5		
	L4 3F		
113	40 1F		Standard error of estimate
	L1 1F		
114	32 114L		Waste
	50 114L		
115	26 S6		
	50 2F		
116	7J 10F		
	40 4F		
117	92 139F		
	L3 11S5		
118	32 121L		
	L5 4F		
119	52 ( )F	by 7	Print standard error of
	50 119L		estimate
120	26 SK		
	92 131F		
121	92 515F		
	L3 10S5	from 118	
122	32 124L		
	L5 5F		Print multiple correlation
123	52 ( )F	by 3	
	50 123L		
124	26 SK		
	92 131F		

LOCATION	ORDER	NOTES	PAGE 29
125	41 3F		
	92 131F	from 143	
126	92 515F		
	L3 11S5		
127	32 132L		Print b_{ij}
	L5 ( )F	by 40, 138	
128	52 ( )F	by 35, 161	
	50 128L		
129	26 SK		
	L5 ( )F	by 42, 139	Print $S_{b_{ij}}$
130	52 ( )F	by 34, 165	
	50 130L		
131	26 SK		
	92 965F		
132	32 132L		
	L3 10S5	by 127	
133	32 137L		Print b^*_{ij}
	L5 ( )F	by 43,140	
134	52 ( )F	by 33	
	50 134L		
135	26 SK		Print $S_{b_{ij}}{}^*$
	L5 ( )F	by 44, 141	
136	52 ( )F	by 32, 165	
	50 136L		
137	26 SK		
	F5 127L		
138	42 127L		
	F5 129L		
139	42 129L		
	F5 133L		
140	42 133L		
	F5 135L		
141	42 135L		
	F5 3F		
142	40 3F		
	L0 6S5		

LOCATION	ORDER	NOTES	
143	32 125L		
	L3 11S5		
144	32 147L		
	92 131F		
145	92 515F		
	L1 15F		
146	52 ( )F	by 35,160	
	50 146L		Print constant term
147	26 SK		
	92 135F	from 144	
148	F5 25L	from 23	
	42 23L		
149	F5 23L		
	42 25L		
150	F5 24L		
	42 24L		
151	F5 30L		
	F4 16S5		
152	40 30L		
	L5 14S5		
153	L4 14S5		
	40 14S5		
154	L3 14S5		
	32 ( )F	by 0	
155	22 22L		
	00 25F		
156	00 F		
	00 1000 0000 0000J		
157	00 F		
	00 0100 0000 0000J		
158	50 7F	from 55,82,87	
	7J 156L		
159	40 7F		
	L5 146L		

LOCATION	ORDER	NOTES	PAGE 31
160	L4 4S5		
	42 146L		
161	46 128L		
	L5 134L		
162	L4 4S5		
	46 134L		
163	26 36L		
	L5 130L	from 73,93	
164	L4 4S5		
	46 130L		
165	L5 136L		
	L4 4S5		
166	46 136L		
	50 8F		
167	7J 157L		
	40 8F		
168	26 36L		
	00 50SN		
	00 850K		
0	J0 200F		
	50 L		
1	26 S9		
	00 421SS		Store subroutine G on drum
2	00 169F		[This is a interlude which is
	L5 0F		later overwritten.]
3	40 4L		
	26 999F		
	26 850N		
Master Routine			
	00 18K		
0	50 200F		
	50 L		Read subroutine A
1	26 S9		from drum
	00 SS		

LOCATION	ORDER	NOTES
2	00 44F	
	50 2L	
3	26 200F	Enter subroutine A
	22 4L	
4	50 200F	
	50 4L	Read subroutine B and C and H
5	26 S9	from drum
	00 700SS	
6	00 191F	
	22 7L	
7	50 S4	Read N-12 from drum
	50 7L	
8	26 S9	
	00 900SS	
9	00 39F	
	22 10L	
10	50 S6	Read R-1 from drum
	50 10L	
11	26 S9	
	00 140SS	
12	00 9F	
	50 12L	
13	26 200F	Enter subroutine B
	50 13L	
14	26 259F	Enter subroutine C
	22 15L	
15	50 SK	Read P-1 from drum
	50 15L	
16	26 S9	
	00 150SS	
17	00 28F	
	22 18L	
18	50 200F	Read subroutine D
	50 18L	from drum

LOCATION	ORDER	NOTES
19	26 S9	
	00 179SS	
20	00 60F	
	50 20L	Enter subroutine D
21	26 200F	
	22 22L	
22	50 200F	Read subroutine E
	50 22L	from drum
23	26 S9	
	00 240SS	
24	00 29F	
	50 24L	Enter subroutine E
25	26 200F	
	22 26L	
26	50 116F	
	50 26L	Read subroutine F
27	26 S9	from drum
	00 270SS	
28	00 150F	
	50 28L	
29	26 116F	Enter subroutine F
	22 30L	
30	50 S6	Read R-1 from drum
	50 30L	
31	26 S9	
	00 140SS	
32	00 9F	
	22 33L	
33	50 SK	Read P-1 from drum
	50 33L	
34	26 S9	
	00 150SS	
35	00 28F	
	22 36L	

LOCATION	ORDER	NOTES
36	50 200F	Read subroutine G
	50 36L	from drum
37	26 S9	
	00 421SS	Enter subroutine G
38	00 169F	
	50 38L	
39	26 200F	
	24 L	Stop; Begin program again.
List of Constants		
	00 58K	
0	00 (n)F	
	00 (n)F	
1	00 S3	location of observation row
	00 S3	
2	00 F	location of means
	00 F	
3	00 F	location of sum of cross products
	00 F	
4	00 1F	
	00 1F	
5	80 F	
	00 F	
6	80 F	
	00 (n)F	
7	00 F	
	00 S7	
8	00 F	
	00 ( )F	Print parameter for correlations
9	00 F	
	00 ( )F	Print parameter for covariances
10	00 F	Print parameter for standardized
	00 ( )F	regression weights
11	00 F	Print parameter for unstandardized
	00 F	regression weights

LOCATION	ORDER	NOTES	PAGE 35
12	00 F		
	00 1F		
13	00 F		
	00 10F		
14	00 F		Dependent variables
	00 F		
15	00 F		
	00 (s)F		
16	00 F		
	00 (n)F		
17	00 S8		
	00 S8		
	00 116K		
Library Routine R-1		Square Root	
	00 125K		
Library Routine P-1 (modified)			Print One Number Fractional or Integer in a Manner Determined by a Program Parameter
	00 960K		
Library Routine N-12		Input a Sequence of Decimal Fractions	
	00 860K		
0	J0 S6		
	50 L		Store R-1 on drum
1	26 S9		
	00 140SS		
2	00 9F		
	L5 0F		[This is an interlude which is later
3	40 12L		overwritten.]
	00 1F		
4	J0 SK		
	50 4L		Store P-1 on Drum
5	26 S9		
	00 150SS		

LOCATION	ORDER	NOTES	PAGE 36
6	00 28F		
	L5 0F		
7	40 13L		
	00 1F		
8	J0 S4		
	50 8L		Store N-12 on Drum
9	26 S9		
	00 900SS		
10	00 0039F		
	L5 0F		
11	40 14L		
	26 999F		
	26 860N		
	00 880K		
Library Routine X-7		Sum Check	Change FF order in X-7 here to read FF 17F
	24 18N		