UNIVERSITY OF ILLINOIS

DIGITAL COMPUTER

LIBRARY ROUTINE K 17 - 309

TITLE: Product moment correlations, variance-covariances, means, and standard deviations (SADOI Only)

TYPE: Entire program

CAPACITY: $n \leq 144$; n is the number of variables. There is no practical limit on s, the sample size.

DESCRIPTION: This routine is a modification of K 8. It differs from K 8 in that a problem can be completed in two or more distinct machine runs.

A problem may be interrupted before completion by the user, by the machine operator, or automatically when an incorrect number of variables in a row of the data tape is read. In each of these cases the machine will stop on FF015. By moving the white switch up and down, the contents of the high speed memory and any drum locations being used will be punched on tape in sexadecimal characters.

Subsequently, the sexadecimal tape can be read which restores the memory to the conditions at the point of interruption. The problem can be continued by reading the proper remaining rows of the data tape. For details, see Methods of Use.

PARAMETER TAPE PREPARATION:

Parameters appear on tape as follows: rFcLjJsSX.

r: number of decimal places in the correlations. Put rF on tape. If no print out is desired, set r = 0.

c: number of decimal places in the covariances. Put cL on tape. If no print out is desired, set c = 0.

j: number of decimal places in the means and standard deviations. Put jJ on tape. If no print out is desired, set j = 0.

s: sample size, put sS on tape.

X: The last symbol on tape, X, is either a 0 or a 1.

If X = 0, the symmetric matrix of correlations and/or covariances will be punched in triangular form with an N at the end of the matrix. If X = 1, the results will be punched in square form with an N symbol at the end of each row or column. (See section on print out).

DATA TAPE PREPARATION:

The **data tape** consists of s rows of n elements each. The n variables are punched as signed fractions. Each row is terminated by an N symbol. If an F symbol terminates a row instead of an N, the computer will stop on 30049. To continue to read the next section of the data tape, raise the black switch.

Interrupted machine runs. Let the data tape be in i parts with s_1, s_2, ... and s_i rows each such that

$$s = s_1 + s_2 + \ldots + s_i.$$

At the end of each of the i parts, punch an extra N terminating symbol. When the extra N is read, the computer will stop on FF015. By moving the white switch up and down, the contents of the memory will be punched in sexadecimals. Subsequently, the sexadecimal tape is read which restores the memory. The problem is continued with the next part of the data tape. After s rows have been read, the results will be punched.

METHODS OF USE:

A. Machine runs without interruptions

1.	Master tape	2401K
2.	Parameter tape	240J9
3.	Data tape	2401K

At stop 2401K, an additional problem can be begun by reading a new set of parameters.

B. Machine run with one or more interruptions

First run

1.	Master tape	2401K
2.	Parameter tape	240J9
3.	Data tape, part 1, with extra N	FF015
4.	Move white switch up and down	0F

Subsequent runs

1.	Master tape	2401K
2.	Sexadecimal tape, move white up and down	24047
3.	Data tape, next part, with extra N	FF015
4.	Move white switch up and down	0F

After s rows have been read, the results will be punched, and the routine will end on 2401K.

THREE CASES OF INTERRUPTED MACHINE RUNS:

Case I: To avoid long machine runs, the user can separate the data tape into parts. When the extra N symbol is read at the end of a part, the computer will stop on FF015. If the white switch is moved up and down, the memory contents will be punched.

Case II: A reading error or error in the data tape will cause the computer to stop on FF015. The operator can preserve the previous calculations by marking the tape where the error occurred and by moving the white switch up and down. The data has to be started in part 2 at the beginning of the now corrected row.

Case III: The operator may desire to remove a problem before completion. He can cause a reading error to occur. Place white switch in mid-position, move the data tape forwards or backwards so that a sign is passed over (but not an N). When the white switch is placed in running position, the computer will stop on FF015. Mark the data tape where the error occurred and move the white switch up and down. The data has to be started in part 2 at the beginning of the interrupted row.

TIME USED BY INTERRUPTED MACHINE RUNS:

The user or operator is cautioned to consider the amount of time lost by each interruption. For example, if a reading error occurs near the beginning of a problem, it may be more efficient not to exercise the interrupted machine run option.

The amount of machine time used for each interruption (over and above the usual K 8 time - see Table, page 6), to punch the memory contents in sexadecimals and subsequently to read the sexadecimal tape, is as follows:

$n \leq 35$, 5 minutes	$n = 105$, 24 minutes
$n = 70$, 12 minutes	$n = 140$, 39 minutes

THE PRINT OUT:

When X = 0 (directive on parameter tape), the correlation matrix is printed by columns in triangular form. An extra carriage return is punched after each diagonal entry. After the final column sixteen delays and an N symbol are punched. This is followed by a title (MEANS AND ST DEV) and the means and standard deviations.

When X = 1, the correlation matrix is punched in square form by columns with an N symbol at the end of each column. This is followed by sixteen delays, an N, and the means and standard deviations.

If both correlations and covariances are specified by the parameter tape, the correlations appear in the first column and the covariances appear in the second column. The correlations are scaled by 10^{-1}. The scaling of the covariances depends upon the scaling of the variables punched on the data tape. If X_i is scaled by 10^{-i} and X_j by 10^{-j}, then Cov_{ij} is scaled by $10^{-(i+j)}$.

A three variable example punched in triangular form is shown below:

Parameter tape

4F6L4J45S0

Results

+1000 +001381
+0346 +000510
+1000 +001579
+0033 +000030
+0852 +000813
+1000 +000577 N

MEANS AND ST DEV
+0058 +0372
+0130 +0397
+0331 +0240 N

STOPS AND ERROR DIAGNOSIS:

Stop	Loc.	Meaning
2401K	3F5	Master tape has read correctly. Bl. sw. to read parameter tape. Wh. sw. to read sexadecimal tape and to restore memory.
240J9	02K	End of parameter tape; bl. sw. to read data.
3002S	02S	F terminating symbol after first row. Bl. sw. to continue reading data tape.
30049	11J	F terminating symbol after subsequent rows. Bl. sw. to continue reading data tape.
20047	155	Sexadecimal tape has been read correctly. Bl. sw. to continue with next part of data tape.
0F000	138	Sexadecimal tape has been punched.
FF001	152	Sum check on reading sexadecimal tape has failed.
FF015	04N	The user has intentionally punched an N symbol at the end of a part of the data tape for an interrupted machine run or else the number of variables in a row does not agree with the first row. To exercise the interrupted option, raise white switch up and down.
FF016	088	The variance is negative and outside the tolerance limits. Remove problem.
FF017	3F4	Sum check on reading master tape has failed. Reread.
FF023	081	Arithmetic error. This is possible from incorrect scaling on data tape.

NOTE:

1. If a constant appears on the data tape instead of a variable, correlations for this constant with the other variables will be punched on the tape as zeros. This avoids a division hangup since a constant has zero variance.
2. The memory cannot be punched out in sexadecimal after reading in only the first row of data.

DATE August 25, 1960
PROGRAMMED BY Freda Fischer
AND Kern Dickman
APPROVED BY

nj

TIME ESTIMATES FOR K-8 PROGRAM

The following times are estimates only. They are for use as a guide to help provide closer estimates in the time required to run K-8 programs through Illiac. In general, estimates based on these times should not be more than ± 10% in error.

The chart below gives the time for fixed intervals of variables in seconds per sample, i.e., for a 100 sample size problem, multiply the time in column two by 100 to obtain the time in seconds the problem is to run before output occurs. The remainder of the chart gives the time, in minutes, that a square or diagonal matrix would require to output. For convenience sake, these times are given for 3, 4, 5, and 6, decimal places of output.

NO. OF VARIABLES	READ-IN TIME SEC/SAMPLE	PRINT-OUT TIME IN MINUTES TRIANGULAR MATRIX				SQUARE MATRIX			
		3 dec.	4 dec.	5 dec.	6 dec.	3 dec.	4 dec.	5 dec.	6 dec.
5	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1
15	2	1	1	1	1	1	1	1	1
20	2	1	1	1	1	1	1	1	2
25	3	1	1	1	1	1	2	2	2
30	4	1	1.5	1.5	2	2	3	3	4
35	5	1.5	2	2	2.5	3	4	4	5
40	6	2	2.5	2.5	3	4	5	5	6
45	7	2.5	3	3	3.5	5	6	6	7
50	7.5	3	4	4	4.5	6	8	8	9
55	9	4	4.5	5	5.5	8	9	10	11
60	11	4.5	5.5	6	6.5	9	11	12	13
65	13	5.5	6.5	7	7.5	11	13	14	15
70	14	6.5	7.5	8	9	13	15	16	18
75	16	7.5	8.5	9.5	10.5	15	17	19	21
80	18	8.5	9.5	10.5	11.5	17	19	21	23
85	20	9.5	11	11.5	13	19	22	23	26
90	22	10.5	12	13	14.5	21	24	25	29
95	24.5	11.5	13.5	15	16	23	26	29	32
100	27	13	15	17	18	25	29	33	35
105	31	14	16.5	18	19.5	27	32	35	38
110	34	15.5	18	20	21.5	30	35	39	42
115	37	17	19.5	21.5	23.5	33	37	42	46
120	41	18.5	21	23.5	25.5	36	41	46	50
125	44	19.5	23	25.5	27.5	38	45	50	54
130	48	21	25	27.5	30.5	41	49	54	60
135	52	22.5	26.5	29.5	33	44	52	58	65
140	56	25	28.5	31.5	35	49	56	62	69
144	61	27.5	31	34	38	54	61	67	75

(M. Foster)

LOCATION	ORDER	NOTES	PAGE 1	K 17
	00 3K			
0	00 F			
	00 (S3)			
1	00 F			
	00 217F			
2	00 F			
	00 2560F			
3	00 F			
	00 (P2)			
4	00 F			
	00 (R1)			
	00 12K			
0	50 0F			
	40 1024F			
1	06 11F			
	00 S5			
2	00 1F			
	00 1F			
3	50 0F			
	L5 1024F			
4	05 11F			
	00 S5			
5	00 F			
	00 1F			
6	00 F			
	00 1000 0000 0000 J			
7	00 F			
	00 10F			
8	40 (S3)			
	00 (S3)			
9	80 F			
	00 F			
10	00 F			
	00 F			

LOCATION	ORDER	NOTES	PAGE 2	K 17
11	00 F			
	00 F			
12	J0 F			
	40 F			
13	J0 F			
	L5 F			
	00 26K			
0	19 3F			
	40 2F			
1	92 151F			
	41 F			
2	81 4F			
	L0 19F	Read in parameters and convert		
3	32 6L			
	L4 19F			
4	50 0F			
	74 19F			
5	S5 F			
	40 F			
6	26 2L			
	42 7L			
7	L5 0F			
	40 F			
8	L5 2F			
	L4 2F			
9	40 2F			
	32 1L			
10	L4 1F			
	40 9F			
11	81 4F			
	00 39F			
12	40 10F			
	19 38F			
13	66 1F			
	S5 F			

LOCATION	ORDER	NOTES
14	40 7F	
	41 6F	1/s
15	50 (S3)	
	50 15L	Read in first row
16	24 (N12)	
	L0 (2)	
17	30 17L	
	L5 21S4	
18	40 11F	
	L0 20F	Count how many variables
19	46 6F	
	10 20F	
20	42 6F	
	42 21F	
21	40 0F	
	L5 20F	
22	L4 6F	
	40 22F	
23	L4 6F	
	40 23F	
24	L4 6F	
	42 24F	
25	42 25F	
	L5 0F	
26	50 0F	
	74 0F	
27	S5 F	
	10 1F	
28	L4 0F	
	L4 0F	
29	40 0F	
	L5 24F	
30	40 32L	
	L5 22F	
31	42 32L	
	41 1F	
32	J0 0F	
	40 F	
33	F5 32L	
	40 32L	Clear enough store for data
34	L0 12F	
	36 36L	
35	L4 13F	
	40 32L	

LOCATION	ORDER	NOTES
36	F5 1F	
	40 1F	
37	L0 0F	
	36 39L	
38	27 32L	
	23 161L	
39	L5 4F	
	00 20F	
40	46 161L	
	L5 5F	
41	00 20F	
	46 164L	
42	L5 3F	
	00 20F	
43	46 183L	
	46 185L	
44	41 8F	
	22 50L	
45	50 (S3)	
	50 45L	Read in data
46	26 S4	
	L0 (2)	
47	30 47L	
	L5 21S4	
48	L0 11F	
	40 0F	
49	L3 0F	
	32 50L	Are number of variables the same
50	26 285F	
	L5 22F	to FF015 and dumping routine
51	42 55L	
	46 55L	
52	L5 20F	
	42 54L	

Location	ORDER	NOTES PAGE 5 K 17
53	46 76L	
	41 2F	
54	50 7F	
	7J F	
55	L4 F	
	40 F	$\sum_{j=1}^{p} x_{ij}/s$ $p = 1, 2, \ldots s$
56	F5 54L	$i = 1, 2, \ldots n$
	42 54L	
57	L5 55L	
	L4 14F	
58	40 55L	
	F5 2F	
59	40 2F	
	L0 21F	
60	36 54L	
	40 0F	
61	L5 25F	
	40 69L	
62	L5 24F	
	40 88L	
63	41 1F	
	L5 20F	
64	42 76L	
	L5 23F	
65	42 70L	
	42 79L	
66	46 79L	
	42 87L	
67	F4 0F	
	42 133L	
68	F5 0F	
	40 0F	Read row of matrix into working space
69	J0 0F	
	L5 F	

LOCATION	ORDER	NOTES
70	J0 0F	
	40 F	
71	F5 69L	
	40 69L	
72	L0 15F	
	36 74L	
73	L4 16F	
	40 69L	
74	F5 70L	
	42 70L	
75	L0 133L	
	36 69L	
76	50 F	
	7J F	
77	40 2F	$\sum_{k=1}^{p} x_{ik} x_{jk}/s \quad p = 1, 2, \ldots, x$
	50 2F	$i,j = 1, 2, \ldots, n$
78	7J 7F	
	36 79L	
79	L4 F	
	40 F	
80	F5 76L	
	42 76L	
81	L5 79L	
	L4 14F	
82	40 79L	
	F5 1F	
83	40 1F	
	L0 0F	
84	36 76L	
	L5 76L	
85	L4 14F	
	46 76L	
86	L5 87L	
	L4 0F	

LOCATION	ORDER	NOTES PAGE 7 K 17
87	40 2F	
	L5 F	
88	J0 F	
	40 F	
89	F5 88L	
	40 88L	
90	L0 12F	
	36 92L	
91	L4 13F	
	40 88L	Store row back into matrix
92	F5 87L	
	42 87L	
93	L0 2F	
	32 87L	
94	L5 1F	
	L0 21F	
95	36 63L	
	F5 8F	
96	40 8F	
	L0 9F	
97	36 45L	
	L5 25F	
98	40 102L	
	L5 20F	
99	42 111L	
	L5 22F	
100	42 105L	
	46 105L	
101	41 0F	
	41 11F	
102	J0 0F	
	L5 F	
103	36 104L	
	FF 35F	

LOCATION	ORDER	NOTES
104	40 1F	
	00 1F	
105	50 F	
	79 F	
106	L4 1F	$\sum_{k=1}^{a} x^2_{ik}/s - \bar{x}^2$
	40 1F	
107	L3 1F	
	L4 9F	
108	36 109L	
	23 111L	
109	L5 1F	
	32 110L	
110	FF 22F	
	50 110L	
112	22 (R1)	
	40 F	
113	F5 11F	
	F4 102L	Get standard deviation
114	40 102L	
	L0 15F	
115	32 115L	
	L4 16F	
116	40 102L	
	F5 111L	
117	42 111L	
	L5 105L	
118	L4 14F	
	40 105L	
119	F5 11F	
	40 11F	
120	L0 21F	
	36 102L	
121	40 6F	
	L5 25F	

LOCATION	ORDER	NOTES	PAGE 9	K 17
123	40 7F			
	L5 20F			
124	46 156L			
	42 184L			
125	L5 22F			
	46 153L			
126	42 182L			
	L1 4F			
127	L0 5F			
	32 179L			
128	49 8F			
	41 11F			
129	L5 7F			
	40 132L			
130	F5 6F			
	40 6F			
131	42 11F			
	L4 23F			
132	42 70L			
	92 131F			
133	L5 23F			
	42 133L			
134	J0 00F			
	L5 F			
135	50 0F			
	40 F			
136	F5 132L			
	40 132L	Read in row of matrix		
137	L0 15F			
	36 137L	into working space		
138	L4 16F			
	40 132L			
139	F5 133L			
	42 133L			

LOCATION	ORDER	NOTES PAGE 10 K 17
140	L0 70L	
	36 132L	
141	L3 8F	
	32 141L	
142	41 8F	
	L5 132L	
143	40 7F	
	L5 10F	
144	32 148L	
	L5 132L	
145	L4 11F	
	L0 17F	
146	40 132L	
	L0 15F	
147	32 146L	
	L4 16F	
148	40 132L	
	F5 11F	
149	40 11F	
	F0 21F	
150	36 132L	
	L5 20F	
151	42 156L	
	L5 23F	
152	46 154L	
	41 8F	
153	L5 22F	
	42 153L	
154	92 131F	
	92 515F	
155	50 F	
	79 F	
156	L4 F	$\sum_{k=1}^{s} \frac{x_{ik}\, x_{jk}}{s} - \bar{x}_i\, \bar{x}_j$
	40 9F	

LOCATION	ORDER	NOTES PAGE 11 K 17
157	L3 4F	
	32 162L	
158	50 F	
	7J F	Compute product of standard deviation
159	40 0F	
	L3 0F	
160	32 38L	
	50 9F	
161	75 18F	
	66 0F	
162	S5 0F	
	32 161L	
163	50 F	
	50 161L	Print out correlations
164	26 (P2)	
	L3 5F	
165	32 165L	
	L5 9F	
166	50 F	
	50 164L	Print out variance
167	26 (P2)	
	F5 153L	
168	42 153L	
	L5 154L	
169	L4 14F	
	46 154L	
170	F5 156L	
	42 156L	
171	F5 8F	
	40 8F	
172	L0 6F	
	36 152L	
172	L5 10F	
	32 174L	

LOCATION	ORDER	NOTES	PAGE 12	K 17
173	L5 8F			
	LO 21F			
174	36 152L			
	92 131F			
175	92 770F			
	L5 6F			
176	LO 21F			
	32 179L			
177	L5 156L			
	L4 14F			
178	46 156L			
	L5 153L			
179	L4 14F			
	46 153L			
180	26 126L			
	L3 3F			
181	32 190L			
	26 345F	Transfer to print title and N at end of matrix		
182	41 3F			
	92 131F			
183	92 515F			
	L5 F			
184	50 F			
	50 183L	Print out means		
185	26 (P2)			
	L5 F			
186	50 F			
	50 185L	Print out standard deviations		
187	26 (P2)			
	F5 182L			
188	42 182L			
	F5 184L			
189	42 184L			
	F5 3F			

LOCATION	ORDER	NOTES	PAGE 13	K 17
190	40 3F			
	L0 21F			
191	32 181L			
	22 358F			
	00 K(N12)			
	00 K(P2)	Print subroutine		
0	40 F			
	L1 16L			
1	S4 L			
	46 1L			
2	42 14L			
	36 6L			
3	L5 F			
	36 5L			
4	92 706F			
	22 5L			
5	92 642F			
	00 2F			
6	J0 8L			
	7J 17L			
7	42 8L			
	22 8L			
8	00 63F			
	19 F			
9	L6 F			
	10 39F			
10	75 15L			
	00 36F			
11	82 4F			
	10 40F			
12	L5 1L			
	L0 16L			
13	46 1L			
	36 10L			

LOCATION	ORDER	NOTES PAGE 14 K 17
14	92 963F	
	22 F	
15	00 F	
	00 10F	
16	S4 1F	
	00 1023F	
17	00 1F	
	K9 1000F	
	00 K(R1)	
0	(2)00 F	
	00 2F	
	00 284K	Routine for printing memory
0	(S6) 00 F	
	00 F	Sum check box
1	FF 21F	
	L5 95F	
2	40 (S7)	
	L5 F	Store end constant
3	40 (S8)	
	L5 1F	
4	40 (S9)	
	L5 2F	
5	40 (S10)	
	92 131F	
6	92 555F	
	41 (S6)	
7	J0 F	
	L5 (S7)	Start transfer at (S7)
8	82 40F	
	L5 (S7)	
9	L4 (S6)	
	40 (S6)	
10	92 131F	
	F5 292F	

LOCATION	ORDER	NOTES	PAGE 15	K 17
11	42 292F			
	F5 291F			
12	42 291F			
	L0 15F			
13	32 291F			
	L5 (S7)			
14	L0 (S4)			
	32 305F			
15	85 11F			
	00 2560F	Start drum data		
16	40 F			
	82 40F			
17	92 131F			
	L5 F			
18	L4 (S6)			
	40 (S6)			
19	F5 299F			
	40 299F			
20	L0 (S7)			
	32 305F			
21	26 299F			
	L5 3F			
22	40 F			
	82 40F			
23	L5 F			
	L4 (S6)			
24	40 (S6)			
	92 131F			
25	F5 305F			
	42 305F			
26	L0 (S5)			
	32 311F			
27	22 305F			
	L5 (S6)	Punch sum check		

LOCATION	ORDER	NOTES
28	82 40F	
	OF F	
29	(S4) J0 F	
	00 F	
30	(S5) 26 299F	
	L5 284F	
	00 315K	Restoring routine
0	00 F	
	00 F	Sum check box
1	41 315F	
	81 40F	
2	40 F	
	40 (S7)	Starts restoring with (S7)
3	L5 F	
	43 15F	
4	40 315F	
	F5 317F	
5	40 317F	
	L0 (S11)	
6	36 322F	
	22 316F	
7	L5 (S7)	
	L0 (S4)	
8	32 330F	
	81 40F	
9	40 F	
	26 325F	
10	86 11F	
	00 2560F	
11	L5 F	
	L4 315F	
12	40 315F	
	F5 325F	

LOCATION	ORDER	NOTES	PAGE 17	K 17
13	40 325F			
	LO (S7)			
14	LO (S12)			
	32 330F			
15	22 323F			
	81 40F			
16	40 F			
	40 3F			
17	L5 F			
	L4 315F			
18	40 315F			
	26 357F			
19	LO (S13)			
	32 335F			
20	22 330F			
	81 40F			
21	LO 315F			
	40 F			
22	L3 F			
	32 338F	Sum check		
23	FF 1F			
	L5 (S8)			
24	40 F			
	L5 (S9)			
25	40 1F			
	L5 (S10)			
26	40 2F			
	24 71F	Restarts routine at 71F		
27	(S11) 40 F			
	40 1024F			
28	(S12) 01 F			
	00 F			
29	(S13) 40 F			
	40 284F			

LOCATION	ORDER	NOTES	PAGE 18	K 17
	00 345K			
0	92 575F			
	92 770F			
1	92 139F			
	92 259F			
2	92 643F			
	92 194F			
3	92 387F			
	92 770F			
4	92 706F			
	92 963F			
5	92 387F			
	92 770F			
6	92 67F			
	92 963F			
7	92 706F			
	92 322F			
8	92 963F			
	92 67F			
9	92 194F			
	92 323F			
10	92 135F			
	92 707F			
11	92 575F			
	26 207F			
12	F5 331F			
	42 331F			
13	26 334F			
	92 575F			
14	92 770F			
	24 26F			
15	(S7) 00 F			
	00 F			
16	(S8) 00 F			
	00 F			

LOCATION	ORDER	NOTES	PAGE 19	K 17
17	(S9) 00 F			
	00 F			
18	(S10) 00 F			
	00 F			
19	(S3) 00 F			
	00 F			
	00 995K	Sum check		
0	L3 F			
	36 997F			
1	FF 23F			
	26 997F			
2	24 26F			
	26 316F			
3	J5 2173F			
	FN 0240F			
	26 L			
	26 1N			