

UNIVERSITY OF ILLINOIS  
DIGITAL COMPUTER

LIBRARY ROUTINE K 8 - 189

By Gene H. Golub

TITLE Product Moment Correlations, Variance-Covariances,  
Means and Standard Deviations for Use with Magnetic Drum  
(SADOI Only)

TYPE Entire program

METHOD OF USE 1) Read in the master program. A sum check is performed.  
If the program is read correctly, the machine will stop  
on 34 01K; otherwise on an FF 017 order.  
2) Read in the parameter tape. The computer stops on 24 0J9.  
3) Read in the data tape.  
4) After all data have been read into the computer, the  
desired information will be printed out. The program stops  
on 24 01K.  
5) Another problem can be begun by reading in new parameters.

CAPACITY The maximum number of variables is 144; there is no limit on  
the number of observations.

PUNCHING OF THE TAPE For every problem four parameters are necessary. They are  
as follows and may be punched in any order on the tapes:  
1) Let "f" be the number of decimal places to which the  
correlation matrix is to be printed. Put fF on the parameter  
tape. If no print out is desired, f = 0.  
2) Let "l" be the number of decimal places to which the  
variance covariance matrix is to be printed. Put lL on the  
parameter tape. If no print out is desired, l = 0.  
3) Let "j" be the number of decimal places to which the  
means and standard deviations are to be printed. Put jJ  
on the parameter tape. If no printout is desired, j = 0.  
4) Let "s" be the size of the sample. Put sS on the  
parameter tape.

This must be followed by either a "0" or "1". A "0" indicates that only a triangular matrix is to be punched row by row, while a 1 indicates that the square matrix is to be punched.

Each observation (which must lie in the range  $-1 < x < 1$ ) is 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.

#### THE PRINT OUT

The correlation matrix, scaled by one-tenth, is printed in the first column. The covariances appear in the second column. If the full matrix is printed out, then an N appears after each column of the matrix. Following this the means and standard deviations are printed in two parallel columns.

#### NOTES

- 1) Correlations with constants are assumed to be zero. In order to avoid a division hangup the correlation between a constant and itself will be zero.
- 2) If the incorrect number of variables has been punched in a row, then the machine will hangup on an FF 015 order at location  $(04N)_{16}$ .
- 3) If the variance is negative and outside the tolerance limits, then the machine will hangup on an FF 016 order at  $(088)_{16}$ , otherwise it is set equal to zero.
- 4) An FFO23 stop in location  $(081)_{16}$  indicates an arithmetic error, possible from scaling.

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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

LOCATION	ORDER	NOTES	PAGE 1 K 8
0	00 3K		
	00 F		
	00 (S3)		
1	00 F		
	00 217F		
2	00 F		
	00 2560F		
3	00 F		
	00 (F2)		
4	00 F		
	00 (R1)		
	00 12K		
0	50 OF		
	40 1024F		
1	06 11F		
	00 S5		
2	00 1F		
	00 1F		
3	50 OF		
	15 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
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	from 9	
2	81 4F	from 6	
	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	from 3	
7	L5 0F		
	40 F	by 6	
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	PAGE 3	K 8
14	40 7F		1/s		
	41 6F				
15	50 (S3)				
	50 15L		Read in first row		
16	24 (N12)				
	L0 (2)				
17	30 17L				
	L5 21S4	from 17			
18	40 11F		Count how many variables		
	L0 20F				
19	46 6F				
	10 20F				
20	42 6F				
	42 21F				
21	40 OF				
	L5 20F				
22	L4 6F				
	40 22F				
23	L4 6F				
	40 23F				
24	L4 6F				
	42 24F				
25	42 25F				
	L5 OF				
26	50 OF				
	74 OF				
27	S5 F				
	10 LF				
28	L4 OF				
	L4 OF				
29	40 OF				
	L5 24F				
30	40 32L				
	L5 22F				
31	42 32L				
	41 1F				

LOCATION	ORDER	NOTES	PAGE 4 K 8
32	J0 OF 40 F	from 38 by 30,31,33,35	
33	F5 32L 40 32L		Clear enough store for data
34	L0 12F 36 36L		
35	L4 13F 40 32L		
36	F5 1F 40 1F	from 34	
37	L0 OF 36 39L		
38	27 32L 23 161L		
39	L5 4F 00 20F	from 37	
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	from 97	Read in data
46	26 S4 L0 (2)		
47	30 47L L5 21S4	from 47	
48	L0 11F 40 OF		
49	L3 OF 32 50L		Are number variables the same?

LOCATION	ORDER	NOTES	PAGE 5	K 8
50	FF 21F			
	L5 22F	from 44, 49		
51	42 55L			
	46 55L			
52	L5 20F			
	42 54L			
53	46 76L			
	41 2F			
54	50 7F	from 60		
	7J F	by 52, 56		
55	L4 F	by 51, 58		
	40 F	by 51, 58	$\sum_{j=1}^p x_{ij}/s$	$p = 1, 2, \dots, s$
56	F5 54L			
	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	from 95		
	L5 20F			
64	42 76L			
	L5 23F			
65	42 70L			
	42 79L			
66	46 79L			
	42 87L			
67	F4 0F			
	42 133L			



LOCATION	ORDER	NOTES	PAGE 6 K 8
68	F5 OF 40 OF		Read row of matrix into working space
69	J0 OF L5 F	from 75 by 61, 71, 73	
70	J0 OF 40 F	by 65, 74, 130	
71	F5 69L 40 69L		
72	L0 15F 36 74L		
73	L4 16F 40 69L		
74	F5 70L 42 70L	from 72	
75	L0 133L 36 69L		
76	50 F 7J F	by 53,85; from 84 by 64, 80	
77	40 2F 50 2F		$\sum_{k=1}^p x_{ik} x_{jk} / s \quad p = 1, 2, \dots, x$ $i, j = 1, 2, \dots, n$
78	7J 7F 36 79L		
79	L4 F 40 F	by 66, 82 by 65, 82	
80	F5 76L 42 76L		
81	L5 79L L4 14F		
82	40 79L F5 1F		
83	40 1F L0 OF		
84	36 76L L5 76L		
85	L4 14F 46 76L		

LOCATION	ORDER	NOTES	PAGE 7	K 8
86	L5 87L L4 OF			
87	40 2F L5 F	by 66, 92; from 93		
88	J0 OF 40 F	by 62, 89, 91		
89	F5 88L 40 88L		Store row back into	
90	L0 12F 36 92L		matrix	
91	L4 13F 40 88L			
92	F5 87L 42 87L	from 90		
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 OF 41 11F			
102	J0 OF L5 F	from 119 by 98, 113, 115		

LOCATION	ORDER	NOTES	PAGE 8	K 8
103	36 104L			
	FF 35F			
104	40 1F	from 103		
	00 1F			
105	50 F	by 100, 117; from 114		
	79 F	by 100, 117		
106	L4 1F		$\sum_{k=1}^a x_{ik}^2 / s - \bar{x}_i^2$	
	40 1F			k=1
107	L3 1F			
	L4 9F			
108	36 109L			
	23 111L			
109	L5 1F	from 108		
	32 110L			
110	FF 22F			
	50 110L	from 109		
111	22 (R1)			
	40 F	by 99, 116; from 108		
112	F5 11F			
	F4 102L		Get standard deviation	
113	40 102L			
	L0 15F			
114	32 115L			
	L4 16F			
115	40 102L			
	F5 111L			
116	42 111L			
	L5 105L			
117	L4 14F			
	40 105L			
118	F5 11F			
	40 11F			
119	L0 21F			
	36 102L			
120	40 6F			
	L5 25F			

LOCATION	ORDER	NOTES	PAGE 9	K 8
121	40 7F			
	L5 20F			
122	46 156L			
	42 184L			
123	L5 22F			
	46 153L			
124	42 182L			
	L1 4F			
125	L0 5F			
	32 179L			
126	49 8F	from 179		
	41 11F			
127	L5 7F			
	40 132L			
128	F5 6F			
	40 6F			
129	42 11F			
	L4 23F			
130	42 70L			
	92 131F			
131	L5 23F			
	42 133L			
132	J0 0F	from 138; 147		
	L5 F	by 127,134,136,144,146		
133	50 0F			
	40 F	by 67, 137		
134	F5 132L		Read in row of matrix	
	40 132L		into working space	
135	L0 15F			
	36 137L			
136	L4 16F			
	40 132L			
137	F5 133L	from 135		
	42 133L			
138	L0 70L			
	36 132L			

LOCATION	ORDER	NOTES	PAGE 10 K 8
139	L3 8F 32 141L		
140	41 8F L5 132L		
141	40 7F L5 10F	from 139	
142	32 148L L5 132L		
143	L4 11F L0 17F		
144	40 132L L0 15F		
145	32 146L L4 16F		
146	40 132L F5 11F	from 145	
147	40 11F F0 21F		
148	36 132L L5 20F	from 142	
149	42 156L L5 23F		
150	46 154L 41 8F		
151	L5 22F 42 153L		
152	92 131F 92 515F	from 170; 173	
153	50 F 79 F	by 123, 178 by 151, 166	
154	L4 F 40 9F	by 149, 167	$\sum_{k=1}^s x_{ik} x_{jk} / s - \bar{x}_i \bar{x}_j$
155	L3 4F 32 162L		
156	50 F 7J F	by 122, 177 by 148, 168	Compute product of standard deviation

LOCATION	ORDER		NOTES	PAGE 11 K 8
157	40 OF L3 OF			
158	32 38L 50 9F			
159	75 18F 66 OF			
160	S5 OF 32 161L			
161	50 F 50 161L	by 40	Print out correlations	
162	26 (P2) L3 5F	from 155		
163	32 165L L3 9F			
164	50 F 50 164L	by 41	Print out variance	
165	26 (P2) F5 153L	from 163		
166	42 153L L5 154L			
167	L4 14F 46 154L			
168	F5 156L 42 156L			
169	F5 8F 40 8F			
170	L0 6F 36 152L			
171	L5 10F 32 174L			
172	L5 8F L0 21F			
173	36 152L 92 131F			
174	92 77OF L5 6F	from 171		

LOCATION	ORDER		NOTES	PAGE 12	K 8
175	L0 21F				
	32 179L				
176	L5 156L				
	L4 14F				
177	46 156L				
	L5 153L				
178	L4 14F				
	46 153L				
179	26 126L				
	L3 3F	from 125; 175			
180	32 190L				
	92 139F				
181	41 3F				
	92 131F		Print out means		
182	92 515F				
	L5 F	by 124, 187			
183	50 F	by 43			
	50 183L				
184	26 (P2)		Print out standard deviations		
	L5 F	by 122, 188			
185	50 F	by 43			
	50 185L				
186	26 (P2)				
	F5 182L				
187	42 182L				
	F5 184L				
188	42 184L				
	F5 3F				
189	40 3F				
	L0 21F				
190	32 181L				
	24 L	from 180			
(N12)	00 K				
	00 K(P2)				
	Routine P2 - 52		Print (A) with or without Sign to n Places as Determined by a Program Parameter		

LOCATION	ORDER		NOTES	PAGE 13	K 8
(R1)	00 K				
(2)	00 F				
	00 2F				
(S3)	00 F				
	00 F				
	00 800K				
0	80 40F		Sum Check		
	10 F				
1	40 F				
	L3 F				
2	34 26F				
	FF 23F				
	26 800N				
	78NO440NO70				