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MULTIPLE LINEAR REGRESSION AND LARGE SCALE INTEGRATION TECHNOLOGY APPLICATION TO THE TEXAS INSTRUMENT TI-59

William C. Croom
The University of Akron

The use of MLR as a general model-testing system has, over the last few years, provided the user with a powerful, flexible research tool (Newman, 1976' McNeil, K.; Kelly, F.; McNeil, J 1975). Except for the most simple cases (e.g. two or three variables), MLR has, unfortunately, been limited in application to those who have easy access to a large computer, or at least to those who are in contact with individuals who have such access. Thus, the smaller agencies, private practitioners, consultants, schools and the like may well have information which could be evaluated by MLR but is evaluated (if at all) by more traditional statistical procedures which may be inappropriate for the

research question being asked, or suffer from insufficient power to discriminate real differences (Roll, S.; Hoedt, K.; Newman, I. 1979).

The program below was written to allow the occasional user of MLR to take advantage of the features of the Texas Instrument TI-59 hand-held programmable calculator. The program may be recorded on magnetic cards which are supplied with the calculator; at the time of this writing, the instrument sells for approximately $225.00.

Once so equipped, the user may then perform up to seven-variable regression routines with unlimited replications - since all other regression routines for hand-held calculators manipulate at most two independent variables the gain may well be worth the cost.

Definitions: string - one ordered series of data (X_1, X_2. . .Y)

set - K strings, where K = number of replications or subjects

vector - K replications of each variable; e.g., all X_1 scores

Description of Program

This program takes ordered strings of data and 1) creates a raw-score sum-of-squares-and-cross-products matrix (SSCP), 2) provides a fast, efficient method of constructing a correlation matrix from the SSCP matrix, 3) computes means and standard deviations for all variables,

4) calculates slopes and intercepts for any combination of two vectors taken as a X-Y pair, 5) provides a least-squares solution for a multiple regression analysis, where predictor variables (N = 1-6) are regressed on one criterion, then computes regression coefficients (raw-score) for these predictors, and 6) computes R^2, the variance in the criterion accounted for by the linear combination of predictors. Input data may be any combination of discrete or continuous variables.

Limitation, Error Recovery, Notes

1. This program uses the matrix-inversion method of calculating the regression coefficients. If a singularity (determinant = 0) exists in the data, computation of the coefficients and R^2 will result in serious errors. Means, standard deviations, slopes, intercepts and individual correlations, among score vectors may be calculated without error. However, the user is encouraged to examine the data for "logical" perfect correlations (e.g. 1 if male, 0 otherwise, etc.). If the optional TI print cradle is used with this program, the determinant of the SSCP matrix will be printed and may then be easily examined.

2. Program execution of each string (X_1, X_2...Y) of raw data requires approximately 10 seconds per variable.

3. Error recovery before the final variable of a string is entered with the R/S Key merely involves pressing SBR Y^x

and re-entering the string beginning with the first variable. If an error is discovered after value Y is entered in the calculator with the R/S Key, the matter is considerably more complicated. Recovery now involves expanding that particular data string into its own SSCP matrix and subtracting each value from the corresponding memory location in the calculator. This process is so lengthy and error-prone, it is recommended that the user press E and start over. Note that the use of the optional printer greatly reduces the chance of key punch error.

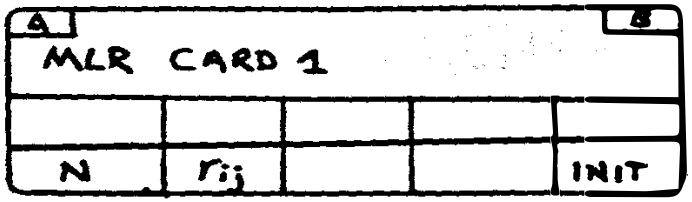
4. Note that it is not necessary to perform all steps if only regression coefficients are required - the user may jump directly from step 7 to step 19.

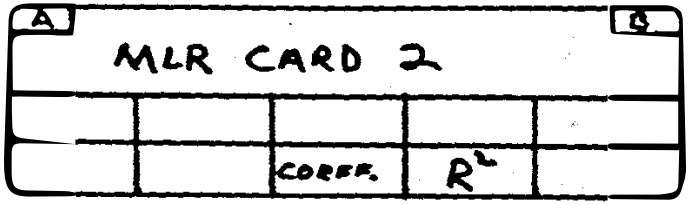
On the following pages appears the program. *TI-59 is a registered trademark of Texas Instruments, Inc.

STEP	ENTER	PRESS	DISPLAY	COMMENTS
STARTUP				
1. Repartition calculator	8	(2nd) OP 17	319.79	320 pgm steps/80 memories
2. Load side A/card 1 into Bank 1	1	RST	1	Bank 1 read from side A of card 1
3. Load side B/card 1 into Bank 2	2	—	2	Bank 2 read from side B of card 1
DATA LOAD				
4. initialize	—	E	(current)	clears memories and T-register, resets SBR counter
5. Enter # of predictors	N	A	0	$N \leq 6$
6. Enter predictor raw scores in order; e.g., X_1, X_2, $X_3 \ldots X_n$, then criterion score (Y) which is defined as X_{n+1}	X_1 X_2 ⋮ X_{n+1}	R/S R/S ⋮ R/S	— — — K	at X_{n+1}, calculator will process the set of scores. display will blank, then display K, the number of that data set (where K = 1, 2, 3,... K = number of sets of scores)
7. Repeat (6) until all replications are entered				
TO COMPUTE CORRELATIONS Perform steps 1-7 first. 8. initialize correlation sub-routine	—	B	0	r;j = correlation between variable i and j
9. compute r;j	i j	R/S R/S	i r;j	enter data so $i < j$; e.g. (1, 2) not (2, 1). note: $j \leq n+1$ where variable n+1 = y, the criterion variable, thus, with 2 predictors, 1,3 would calculate correlation between X_1 and Y
10. To compute additional correlations, repeat 8-9.				

STEP	ENTER	PRESS	DISPLAY	COMMENTS
MEANS, STD. DEVS., SLOPES, INTERCEPTS, $\hat{X}$, $\hat{Y}$				
11. Perform steps 8-9 first.				
12. Compute $\bar{X}_j$	—	R/S	$\bar{X}_j$	mean of 2nd variable entered
13. Compute $\bar{X}_i$	—	R/S	$\bar{X}_i$	mean of 1st variable entered
14. Compute SD_j	—	R/S	SD_j	standard deviation of 2nd variable entered
15. Compute SD_i	—	R/S	SD_i	standard deviation of 1st variable entered
16. To compute slope and intercept of ij pair - perform steps 8-9 first, then:	— —	(2nd) OP 12 $X \leq t$	a b	intercept, a slope, b
17. Compute $\hat{Y}$ from X	X	(2nd) OP 14	$\hat{Y}$	estimate of Y computed from X
18. Compute $\hat{X}$ from Y	Y	(2nd) OP 15	$\hat{X}$	estimate of X computed from Y
CALCULATE REGRESSION COEFFICIENTS				
19. Perform steps 1-7 first				
20. Save raw-data matrix on magnetic card 3 - insert side A	3	(2nd) write	3	Bank 3 written on side A of card 3
21. Insert Side B	4	(2nd) write	4	Bank 4 written on side B of card 3
22. Read side A of card 2 into Bank 1	1	RST	1	Bank 1 read from side A of card 2
23. Calculate regression coefficients:	—	C R/S ⋮ R/S	a_o a_1 ⋮ a_i	constant (a_o u) regression coefficients for X_1 ⋮ regression coefficient for X_n
CALCULATE R^2				
24. Calculate regression coefficients first				Note: press R/S until a "0" appears in the display—this insures all coefficients are calculated and stored in the calculator memory

STEP	ENTER	PRESS	DISPLAY	COMMENTS
25. Read side A of data card 3 into Bank 3	3	—	3	Bank 3 read from side A of card 3
26. Read side B of data card 3 into Bank 4	4	—	4	Bank 4 read from side B of card 3
27. Read side B of card 2 into Bank 1	1	—	1	Bank 1 read from side B of card 2
28. Calculate R^2	—	D	R^2	proportion of variance in Y accounted for by the linear combination of predictors





SIDES A & B, CARD 1

LOC	CODE	KEY	COMMENTS
00	76	LBL	
	11	A	
	42	STO	
	59	59	
	32	X⇄t	
	76	LBL	
	45	Y^x	
	00	0	
	42	STO	
	00	00	
10	06	6	
	00	0	
	42	STO	
	01	01	
	01	1	
	72	ST*	
	01	01	
	69	OP	
	21	21	
	43	RCL	
20	08	08	
	91	R/S	
	99	PRT	
	72	ST*	
	01	01	
	69	OP	
	20	20	
	69	OP	
	21	21	
	43	RCL	
30	00	00	
	67	EQ	
	22	INV	
	61	GTO	
	00	00	
	19	19	
	76	LBL	
	22	INV	
	91	R/S	
	99	PRT	
40	42	STO	
	70	70	
	06	6	
	00	0	
	42	STO	
	00	00	
	42	STO	
	01	01	
	00	0	
	42	STO	
50	02	02	
	42	STO	
	03	03	
	08	08	
	42	STO	

LOC	CODE	KEY	COMMENTS
	04	04	
	07	7	
	01	1	
	42	STO	
	05	05	
60	76	LBL	
	23	LNX	
	53	(	
	73	RC*	
	00	00	
	65	×	
	73	RC*	
	01	01	
	54	)	
	74	SM*	
70	04	04	
	43	RCL	
	02	02	
	67	EQ	
	24	CE	
	69	OP	
	20	20	
	69	OP	
	22	22	
	69	OP	
80	24	24	
	61	GTO	
	23	LNX	
	76	LBL	
	24	CE	
	69	OP	
	24	24	
	69	OP	
	20	20	
	53	(	
90	73	RC*	
	00	00	
	65	×	
	73	RC*	
	01	01	
	54	)	
	74	SM*	
	04	04	
	53	(	
	73	RC*	
100	01	01	
	65	×	
	43	RCL	
	70	70	
	54	)	
	74	SM*	
	05	05	
	43	RCL	
	03	03	
	67	EQ	

LOC	CODE	KEY	COMMENTS
110	34	√x	
	06	6	
	00	0	
	42	STO	
	00	00	
	69	OP	
	21	21	
	69	OP	
	23	23	
	69	OP	
120	25	25	
	00	0	
	42	STO	
	02	02	
	61	GTO	
	23	LNX	
	76	LBL	
	34	√x	
	69	OP	
	25	25	
130	43	RCL	
	70	70	
	33	X²	
	74	SM*	
	05	05	
	98	ADV	
	61	GTO	
	45	Y^x	
	76	LBL	
	15	E	
140	47	CMS	
	29	CP	
	92	RTN	
	76	LBL	
	12	B	
	98	ADV	
	99	ADV	
	00	0	
	42	STO	
	07	07	
150	42	STO	
	00	00	
	29	CP	
	91	R/S	
	99	PRT	
	42	STO	
	68	68	
	91	R/S	
	99	PRT	
	42	STO	

SIDES A & B, CARD 1 (cont.)

LOC	CODE	KEY	COMMENTS
160	69	69	
	43	RCL	
	68	68	
	42	STO	
	07	07	
	71	SBR	
	35	1/x	
	42	STO	
	04	04	
	43	RCL	
170	68	68	
	42	STO	
	00	00	
	71	SBR	
	35	1/x	
	42	STO	
	06	06	
	43	RCL	
	59	59	
	85	+	
180	01	1	
	54	)	
	32	X≠t	
	43	RCL	
	69	69	
	67	EQ	
	96	WRT	
	29	CP	
	00	0	
	42	STO	
190	07	07	
	43	RCL	
	69	69	
	42	STO	
	00	00	
	71	SBR	
	35	1/x	
	42	STO	
	01	01	
	43	RCL	
200	69	69	
	42	STO	
	07	07	
	71	SBR	
	35	1/x	
	42	STO	
	02	02	
	43	RCL	
	68	68	
	42	STO	
210	07	07	
	43	RCL	
	69	69	
	42	STO	
	00	00	

LOC	CODE	KEY	COMMENTS
	71	SBR	
	35	1/x	
	42	STO	
	06	06	
	43	RCL	
220	08	08	
	42	STO	
	03	03	
	61	GTO	
	78	Σ+	
	76	LBL	
	96	WRT	
	43	RCL	
	71	71	
	42	STO	
230	01	01	
	07	7	
	02	2	
	85	+	
	43	RCL	
	59	59	
	54	)	
	42	STO	
	00	00	
	73	RC*	
240	00	00	
	42	STO	
	02	02	
	07	7	
	01	1	
	85	+	
	43	RCL	
	68	68	
	54	)	
	42	STO	
250	00	00	
	73	RC*	
	00	00	
	42	STO	
	06	06	
	43	RCL	
	08	08	
	42	STO	
	03	03	
	61	GTO	
260	78	Σ+	
	76	LBL	
	78	Σ+	
	69	OP	
	13	13	
	99	PRT	
	91	R/S	
	79	∇	
	99	PRT	
	91	R/S	

LOC	CODE	KEY	COMMENTS
270	32	X≠t	
	99	PRT	
	91	R/S	
	22	INV	
	79	∇	
	99	PRT	
	91	R/S	
	32	X≠t	
	99	PRT	
	92	RTN	
280	76	LBL	
	35	1/x	
	43	RCL	
	07	07	
	65	×	
	53	(	
	43	RCL	
	59	59	
	85	+	
	01	1	
290	54	)	
	85	+	
	43	RCL	
	00	00	
	85	+	
	08	8	
	54	)	
	42	STO	
	67	67	
	73	RC*	
300	67	67	
	92	RTN	

END OF CARD 1.
Sides A and B

SIDE A, CARD 2

LOC	CODE	KEY	COMMENTS
000	76	LBL	
	13	C	
	25	CLR	
	48	EXC	
	59	59	
	32	X≷t	
	25	CLR	
	06	6	
	02	2	
	42	STO	
010	61	61	
	32	X≷t	
	85	+	
	01	(	
	54	)	
	42	STO	
	79	79	
	36	PGM	
	01	01	
	71	SBR	
020	25	CLR	
	01	1	
	32	X≷t	
	43	RCL	
	79	79	
	42	STO	
	07	07	
	36	PGM	
	02	02	
	13	C	
030	01	1	
	94	+/-	
	42	STO	
	79	79	
	07	7	
	01	1	
	42	STO	
	00	00	
	01	1	
	36	PGM	
040	02	02	
	14	D	
	76	LBL	
	52	EE	
	73	RC*	
	00	00	
	36	PGM	
	02	02	
	91	R/S	
	43	RCL	
050	07	07	
	75	−	
	01	1	
	54	)	
	32	X≷t	

LOC	CODE	KEY	COMMENTS
	01	1	
	44	SUM	
	79	79	
	69	OP	
	20	20	
060	43	RCL	
	79	79	
	67	EQ	
	44	SUM	
	61	GTO	
	52	EE	
	76	LBL	
	44	SUM	
	25	CLR	
	36	PGM	
070	02	02	
	15	E	
	01	1	
	36	PGM	
	02	02	
	16	A'	
	76	LBL	
	65	×	
	36	PGM	
	02	02	
080	91	R/S	
	91	R/S	
	72	ST*	
		61	
	01	1	
	44	SUM	
	61	61	
	61	GTO	
	65	×	
	92	RTN	
090			

END OF SIDE A
CMD 2

LOC	CODE	KEY	COMMENTS

SIDE B, CARD 2

LOC	CODE	KEY	COMMENTS
00	76	LBL	
	14	D	
	36	PGM	
	01	01	
	71	SBR	
	25	CLR	
	43	RCL	
	71	71	
	55	÷	
	43	RCL	
10	08	08	
	54	)	
	42	STO	
	01	01	
	07	7	
	02	2	
	42	STO	
	02	02	
	43	RCL	
	79	79	
20	42	STO	
	04	04	
	43	RCL	
	79	79	
	85	+	
	09	9	
	54	)	
	42	STO	
	03	03	
	76	LBL	
30	37	P/R	
	73	RC*	
	03	03	
	65	×	
	43	RCL	
	01	01	
	54	)	
	94	+/-	
	74	SM*	
	02	02	
40	69	OP	
	34	34	
	43	RCL	
	04	04	
	67	EQ	
	49	PRD	
	69	OP	
	22	22	
	43	RCL	
	79	79	
50	85	+	
	01	1	
	54	)	
	44	SUM	
	03	03	

LOC	CODE	KEY	COMMENTS
	61	GTO	
	37	P/R	
	76	LBL	
	49	PRD	
	43	RCL	
60	79	79	
	85	+	
	07	7	
	02	2	
	54	)	
	42	STO	
	00	00	
	43	RCL	
	71	71	
	23	X^2	
70	55	÷	
	43	RCL	
	08	08	
	54	)	
	94	+/-	
	85	+	
	73	RC*	
	00	00	
	54	)	
	42	STO	
80	00	00	
	36	PGM	
	01	01	
	71	SBR	
	25	CLR	
	43	RCL	
	79	79	
	42	STO	
	30	30	
	43	RCL	
90	00	00	
	35	1/X	
	42	STO	
	00	00	
	06	6	
	03	3	
	42	STO	
	61	61	
	07	7	
	02	2	
100	42	STO	
	71	71	
	01	1	
	36	PGM	
	03	03	
	11	A	
	43	RCL	
	79	79	
	36	PGM	
	03	03	

LOC	CODE	KEY	COMMENTS
110	11	A	
	01	1	
	36	PGM	
	03	03	
	12	B	
	76	LBL	
	38	SIN	
	73	RC*	
	61	61	
	36	PGM	
120	03	03	
	91	R/S	
	01	1	
	22	INV	
	44	SUM	
	30	30	
	25	CLR	
	32	X≠t	
	48	EXC	
	30	30	
130	67	EQ	
	50	|x|	
	48	EXC	
	30	30	
	32	X≠t	
	01	1	
	44	SUM	
	61	61	
	61	GTO	
	38	SIN	
140	76	LBL	
	50	|x|	
	43	RCL	
	79	79	
	42	STO	
	30	30	
	01	1	
	36	PGM	
	03	03	
	17	B'	
150	76	LBL	
	60	DEG	
	73	RC*	
	71	71	
	36	PGM	
	03	03	
	91	R/S	
	01	1	
	22	INV	
	44	SUM	

SIDE B, CARD 2 (cont.)

LOC	CODE	KEY	COMMENTS
160	30	30	
	25	CLR	
	32	Xt	
	48	EXC	
	30	30	
	67	EQ	
	80	GRD	
	48	EXC	
	30	30	
	32	Xt	
170	01	1	
	44	SUM	
	71	71	
	61	GTO	
	60	DEG	
	76	LBL	
	80	GRD	
	36	PGM	
	03	03	
	18	C'	
180	01	1	
	36	PGM	
	03	03	
	19	D'	
	36	PGM	
	03	03	
	91	R/S	
	65	X	
	43	RCL	
	00	00	
190	95	=	
	42	STO	
	00	00	
	00	0	
	00	0	
	03	3	
	05	5	
	07	7	
	00	0	
	00	0	
200	00	0	
	00	0	
	00	0	
	69	OP	
	04	04	
	43	RCL	
	00	00	
	69	OP	
	06	06	
	92	RTN	
210			
		END OF Side B CARD 2	

LOC	CODE	KEY	COMMENTS
220			

LOC	CODE	KEY	COMMENTS

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