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DIGITAL COMPUTER LABORATORY
STATISTICAL LIBRARY

KSL 2.61 - 249

TITLE: Chi-square for r by c Frequency Tables (SADOI Only)
TYPE: Entire program
DESCRIPTION: This routine will calculate a set of chi-square values,

$$\chi^2 = \sum_{i=1}^r \sum_{j=1}^c (f_{ij} - e_{ij})^2 / e_{ij}$$

where the f_{ij} are cell frequencies for a table of r rows and c columns. The e_{ij} are expected values for the cells and can be found by multiplying the i^{th} row sum by the j^{th} column sum and dividing this product by the total frequency of the table. For each table a chi-square value and the degrees of freedom will be punched onto tape. The expected values may also be punched if desired.

DURATION:

A. Chi-square and degrees of freedom:	(.033rc + 1.2) seconds per table
B. With expected values:	(.210rc + 1.8) seconds per table

METHOD OF USE:

	Stops
A. Chi-square and degrees of freedom:	
1. Master tape	2408K
2. Data tape, <u>raise black switch</u>	OF
B. Chi-square, degrees of freedom, and expected values:	
1. Master tape	2408K
2. Data tape, <u>raise white switch</u>	OF

Additional data tapes can be read at OF stop by raising white switch and then either white or black depending upon output desired.

DATA TAPE: The cell frequencies are punched on tape as positive signed integers. Each row of the table is terminated by an N, and the last row of the table is terminated by an NJ. After the last table in the set, an L is also punched; otherwise the machine will end on a read order.

CAPACITY: $2rc + r + c < 680$

$$N = \sum_i \sum_j f_{ij} < 1,000,000,000$$

SUM CHECK: The program tape is sum-checked during input. A failure to input the program correctly will result in an FF error stop from location 125₁₆.

Chi-square

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DATA TAPE ERRORS:

I. If the number of elements in successive rows of a frequency table does not agree with the number in the first row of the table, the machine will stop on 2009K after printing:

ERROR: ELEMENTS IN ROW XX

To continue with remaining tables, raise black switch.

II. If the frequency is negative due to an error in the data tape, the machine will stop on 2408S after printing:

ERROR: NEGATIVE SIGN IN ROW XX

To continue with remaining tables, raise the black switch.

III. If any row or column sum equals zero or if for any other reason the chi-square value becomes indeterminate, the machine will stop on 2408S after printing:

ERROR: INDETERMINATE

To continue with remaining tables, raise the black switch.

DATE	December 5, 1958
SUBMITTED BY	<i>Lem W. Dickman</i>
APPROVED BY	<i>J. Snyder</i>

lgr

LOCATION			ORDER	NOTES	PAGE 1	KSL 2.61
Abs.	Rel.	Sym.				
			003K			
3		(N1)	40(S) L521(NL2)		Initial store for (NL2)	
4		(N)	00F 00F		t.s. on input/ total frequency	
5		(NS)	00F 00F		$1000 \times (N) \times 2^{-39}$	
6		(R)	00F 00F		Rows	
7		(C)	00F 00F		Columns	
8		(F)	00F 00(S)		Initial store of frequencies at (S)	
9		(P)	00F 00F		Problem number	
10		(O)	00F 00F		Always zero	
11		(2)	00F 002F			
12		(1-1)	001F 001F			
13		(1000)	00F 001000F			
14		(RS)	00F 00F	by 4(D)	Store of row sums	
15		(CS)	00F 00F	by 6(D)	Store of column sums	
16		(E)	00F 00F	by 3(D)	Store of expected values	
17		(X)	00F 00F		Temporary storage	
18		(Y)	00F 00F		Temporary storage	
19		(Z)	00F 00F		Temporary storage	
20		(L)	00F 00F		Temporary storage	
21		(7)	00F 007F		Number of expected values per line	
22		(M)	00F 00F		Partial chi-square	
23		(NL2)	00K			
62		(P16)	00K			
			00K		<u>Begin here:</u>	
118	0	(A)	92135F 9259F			
	1		92259F 92835F		Print: CHI-SQUARE	
	2		92771F 92514F			
	3		92707F 92706F			
	4		92259F 92706F			
	5		9266F 92450F			
	6		92387F 92258F			
	7		92194F 41(X)			

LOCATION			ORDER	NOTES	PAGE 2
Abs.	Rel.	Sym.			
	8		2420L L5(2)		
	9		40(X) 92965F		Stop: insert data tape
	10		92387F 92770F		Black for chi-square only
	11		9267F 92961F		White for expected values.
	12		92194F 92451F		
	13		922F 92194F		If white, print:
	14		92835F 92322F		AND EXPECTED VALUES
	15		92194F 9267F		
	16		92961F 92323F		
	17		92387F 92962F		
	18		92450F 92194F		
	19		92706F 92961F		
	20		92135F 92707F		
	21		52(S) 5021L from 6(Q)		Read 1st line of table or
	22		26(NL2) L0(2)		test for end of set
	23		3624L 26(B)		
	24		OFF 41(P)		If end of set, stop on OF
	25		92139F 26L		To begin another set, raise white
			00K		
144	0	(B)	9259F 92135F from 23(A)		
	1		92770F 922F		
	2		92643F F5(P)		
	3		J23F 503L		
	4		26(P16) F5(P)		Print problem number
	5		42(P) 92323F		
	6		92961F 92961F		
	7		L5(NL) 40(N)		
	8		41(R) 41(C)		
	9		L521(NL2) L0(N)		
	10		40(C) L521(NL2)		Store number of columns
	11		40(N) 4613L		
	12		F5(R) 42(R)		Tally row number

LOCATION			ORDER	NOTES	PAGE 3
Abs.	Rel.	Sym.			
	13		52F 5013L		
	14		26(NL2) 40F	Read successive rows of table	
	15		L3F 3216L	Test for J	
	16		26(D) L521(NL2)	Test for same number elements each row	
	17		L0(N) L0(C)		
	18		401F L31F		
	19		3210L 5019L		
	20		26(ER) 50F	If error, print	
	21		92194F 92962F		
	22		92194F 92643F	ERROR: ELEMENTS IN ROW XX	
	23		92194F 92770F		
	24		92322F 92706F		
	25		92961F 92514F		
	26		92770F 92961F		
	27		92258F 92578F		
	28		92130F 92707F		
	29		F5(R) 50F		
	30		J23F 5030L		
	31		26(P16) 92135F		
	32		927F 2010L	Stop: black to continue with remaining problems	
			00K		
177	0	(ER)	K5F 425L	from 20(B), 5(H)	
	1		92259F 92194F		
	2		92262F 92578F		
	3		92258F 92707F		
	4		92835F 92259F		
	5		92965F 22F		
			00K		
183	0	(D)	L5(C) 1020F	from 16(B)	Store frequencies at (F)
	1		40(C) 50(R)		Expected values at (E) = $R \times C + F$
	2		75(C) L5(F)		Row sums at (RS) = $(2) R \times C + F$
	3		S4F 40(E)		Columns sums at (CS) = (RS) + R

LOCATION			ORDER	NOTES	PAGE 4
Abs.	Rel.	Sym.			
	4		S4F 40(RS)		
	5		427L 14(R)		
	6		40(CS) 14(C)		
	7		4211L 41F	by 5L	Clear previous columns sums
	8		F57L 427L		
	9		L011L 327L		
	10		26(G) 00F		
	11		N211L 41F	by 7L	
			00K		Form row and column sums
195	0	(G)	L5(F) 426L	from 10(G)	
	1		41(N) 15(RS)		
	2		4215L 41(Y)		
	3		50(Y) 15(CS)		
	4		429L 0020F		
	5		469L 41(Z)		
	6		41F 15F	by 0L	
	7		401F 14F		
	8		40F 151F		
	9		14F 40F	by 9L	
	10		F56L 426L		
	11		L59L 14(1-1)		
	12		409L F5(Z)		
	13		42(Z) 10 (C)		
	14		3615L 226L		
	15		L5F 40F	by 2L	
	16		14(N) 40(N)		Total frequency at (N)
	17		F515L 4215L		
	18		F5(Y) 42(Y)		
	19		L0(R) 36(H)		
	20		223L 00F		
			00K		
216	0	(H)	L5(F) 423L	from 19(G)	Convert frequencies to proportions, f_{ij}/N
	1		4219L 41(Y)		
	2		41(Z) 41F		
	3		50(O) 15F	by 3L	

LOCATION			ORDER	NOTES	PAGE 5	KSL 2.61
Abs.	Rel.	Sym.				
	4		3218L 504L			
	5		26(ER) 92770F		Test for negative frequencies	
	6		92194F 92579F			
	7		92707F 92643F		If negative, print:	
	8		92259F 92961F			
	9		92706F 92514F		ERROR: NEGATIVE SIGN IN ROW XX	
	10		92579F 92770F			
	11		92961F 92514F			
	12		92770F 92961F			
	13		92258F 92578F			
	14		92130F 92707F			
	15		92961F F5(Y)			
	16		J23F 5016L			
	17		26(F16) 92135F			
	18		2421(A) 66(N) from 4L			
	19		S5F 40F	by 1L	Stop: black to remaining problems	
	20		F53L 423L			
	21		4219L F5(Z)			
	22		42(Z) 10(C)			
	23		3624L 263L			
	24		F5(Y) 42(Y)			
	25		10(R) 36(I)			
	26		262L 00F			
			00K			
243	0	(I)	L5(RS) 424L	from 25(H)	Convert row and column sums to proportions,	
	1		426L L5(CS)		$f_{i.} / N$ and	
	2		4211L 4213L		$f_{.j} / N$	
	3		41(Y) 41(Z)			
	4		50(O) L5F	by 0L		
	5		66(N) S5F			
	6		40F 40F	by 1L		
	7		F54L 424L			
	8		426L F5(Y)			
	9		42(Y) 10(R)			

LOCATION			ORDER	NOTES	PAGE 6	KSL 2.61
Abs.	Rel.	Sym.				
	10		3611L 264L			
	11		50(O) L5F			
	12		66(N) S5F			
	13		40F 40F			
	14		F511L 4211L			
	15		4213L F5(Z)			
	16		42(Z) LO(C)			
	17		36(J) 2611L			
			00K			
261	0	(J)	41(Y) L5(RS)	from 17(I)	Form expected proportions, $f_{i.f.j} / N^2$	
	1		0020F 465L			
	2		L5(E) 425L			
	3		L5(CS) 424L			
	4		41(Z) 50F			
	5		75F 40F	by 1L, 2L		
	6		F54L 424L			
	7		F55L 425L			
	8		F5(Z) 42(Z)			
	9		LO(C) 3210L			
	10		224L L55L			
	11		L4(1-1) 465L			
	12		F5(Y) 42(Y)			
	13		LO(R) 36(K)			
	14		263L 00F			
			00K			
228	0	(K)	92259F 92965F	from 13(J)	Print: DF = (R-1)(C-1)	
	1		9267F 92898F			
	2		92961F 92707F			
	3		92579F 50(R)			
	4		75(C) S5F			
	5		40(L) K5F			
	6		LO(R) LO(C)			
	7		J23F 507L			
	8		26(F16) 92131F			

LOCATION			ORDER	NOTES	PAGE 7
Abs.	Rel.	Sym.			
	9		92259F 92835F		
	10		92771F 92514F		
	11		92707F 92706F		Print: CHI-SQUARE:
	12		92259F 92706F		
	13		9266F 92707F		
	14		92643F 92835F		
	15		L5(E) 4218L		
	16		L5(F) 4219L		
	17		41(M) 41(Y)		
	18		41(Z) L5F	by 15L	
	19		401F L5F	by 16L	
	20		L01F 40F		
	21		50F 75F		
	22		L01F 3630L		
	23		L41F 661F		
	24		S5F 14(M)		Form $\frac{\text{Chi-square}}{N}$ at (M)
	25		40(M) F518L		
	26		4218L F519L		
	27		4219L F5(Z)		
	28		42(Z) L0(L)		
	29		36(Q) 2218L		
	30		92965F 92259F		If Chi-square is indeterminate because
	31		92514F 92770F		a row or column sum is equal to zero, or for
	32		9267F 92194F		any other reason, print:
	33		92322F 92194F		INDETERMINATE
	34		92258F 92643F		
	35		92322F 92194F		
	36		92258F 92643F		
	37		92514F 92770F		
	38		92387F 92322F		
	39		92194F 92131F		
	40		92707F 2421(A)		Stop: Black to remaining problems
			OOK		
269	0	(Q)	50(N) 75(1000) from 29(K)		
	1		S5F 40(NS)		

LOCATION			ORDER	NOTES
Abs.	Rel.	Sym.		
	2		50(M) 7J (NS)	
	3		56407F 503L	Print Chi-square value
	4		26(P16) 92135F	
	5		92515F L3(X)	
	6		3621(A) L5(E)	Test if expected values
	7		429L 41(Y)	
	8		41(Z) 41(L)	
	9		50(NS) 7JF by 7L	Print expected values
	10		56407F 5010L	
	11		26(P16) F59L	
	12		429L F5(Z)	
	13		42(Z) L0(C)	
	14		3218L F5(L)	
	15		42(L) L0(7)	
	16		3617L 269L	
	17		92131F 92519F	
	18		228L 92131F	
	19		41(Z) F5(Y)	
	20		42(Y) L0(R)	
	21		366L 2617L	
			OOK	
291	0	(S)	00F 00F	Store of frequencies
			OOK	
292	0		L3F 36(A)	Sum Check
	1		FFF 26(A)	
	2		K32425F J70235F	
			26L 261N	