NAG Library Function Document

nag_friedman_test (g08aec)

1 Purpose

nag_friedman_test (g08aec) performs the Friedman two-way analysis of variance by ranks on \(k\) related samples of size \(n\).

2 Specification

```c
#include <nag.h>
#include <nagg08.h>
void nag_friedman_test (Integer k, Integer n, const double x[], Integer tdx, 
double *fr, double *p, NagError *fail)
```

3 Description

The Friedman test investigates the score differences between \(k\) matched samples of size \(n\), the scores in the \(i\)th sample being denoted by:

\[
x_{i1}, x_{i2}, \ldots, x_{in}.
\]

(Thus the sample scores may be regarded as a two-way table with \(k\) rows and \(n\) columns.) The hypothesis under test, \(H_0\), often called the null hypothesis, is that the samples come from the same population, and this is to be tested against the alternative hypothesis \(H_1\) that they come from different populations.

The test is based on the observed distribution of score rankings between the matched observations in different samples.

The test proceeds as follows:

(a) The scores in each column are ranked, \(r_{ij}\) denoting the rank within column \(j\) of the observation in row \(i\). Average ranks are assigned to tied scores.

(b) The ranks are summed over each row to give rank sums \(t_i = \sum_{j=1}^{n} r_{ij}\), for \(i = 1, 2, \ldots, k\).

(c) The Friedman test statistic \(FR\) is computed, where

\[
FR = \frac{12}{nk(k+1)} \sum_{i=1}^{k} \left( t_i - \frac{n}{2} \right)^2.
\]

nag_friedman_test (g08aec) returns the value of \(FR\), and also an approximation, \(p\), to the significance of this value. \((FR\) approximately follows a \(\chi^2_{k-1}\) distribution, so large values of \(FR\) imply rejection of \(H_0\)). \(H_0\) is rejected by a test of chosen size \(\alpha\) if \(p < \alpha\). The approximation \(p\) is acceptable unless \(k = 4\) and \(n < 5\), or \(k = 3\) and \(n < 10\), or \(k = 2\) and \(n < 20\); for \(k = 3\) or \(4\), tables should be consulted (e.g., \(n\) of Siegel (1956)); for \(k = 2\) the Sign test (see nag_sign_test (g08aac)) or Wilcoxon test (see nag_wilcoxon_test (g08agc)) is in any case more appropriate.

4 References

5 Arguments

1:  \textbf{k} – Integer \hspace{1cm} \textit{Input}
    \textit{On entry:} k, the number of samples.
    \textit{Constraint:} \(k \geq 2\).

2:  \textbf{n} – Integer \hspace{1cm} \textit{Input}
    \textit{On entry:} the size of each sample, n.
    \textit{Constraint:} \(n \geq 1\).

3:  \textbf{x}[k \times \textbf{tdx}] – const double \hspace{1cm} \textit{Input}
    \textit{On entry:} \(x[i-1] \times \textbf{tdx} + j-1\) must be set to the value, \(x_{ij}\), of observation \(j\) in sample \(i\), for \(i = 1, 2, \ldots, k\) and \(j = 1, 2, \ldots, n\).

4:  \textbf{tdx} – Integer \hspace{1cm} \textit{Input}
    \textit{On entry:} the stride separating matrix column elements in the array \textbf{x}.
    \textit{Constraint:} \(\textbf{tdx} \geq n\).

5:  \textbf{fr} – double * \hspace{1cm} \textit{Output}
    \textit{On exit:} the value of the Friedman test statistic, \(FR\).

6:  \textbf{p} – double * \hspace{1cm} \textit{Output}
    \textit{On exit:} the approximate significance, \(p\), of the Friedman test statistic.

7:  \textbf{fail} – NagError * \hspace{1cm} \textit{Input/Output}
    The NAG error argument (see Section 3.6 in the Essential Introduction).

6 Error Indicators and Warnings

\textbf{NE_2_INT_ARG_LT}

\textit{On entry,} \(\textbf{tdx} = \langle\text{value}\rangle\) while \(n = \langle\text{value}\rangle\). These arguments must satisfy \(\textbf{tdx} \geq n\).

\textbf{NE_ALLOC_FAIL}

Dynamic memory allocation failed.

\textbf{NE_INT_ARG_LE}

\textit{On entry,} \(k = \langle\text{value}\rangle\).
\textit{Constraint:} \(k \geq 2\).

\textbf{NE_INT_ARG_LT}

\textit{On entry,} \(n = \langle\text{value}\rangle\).
\textit{Constraint:} \(n \geq 1\).

\textbf{NE_INTERNAL_ERROR}

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please contact NAG for assistance.
7 Accuracy
For estimates of the accuracy of the significance $p$, see nag_prob_chi_sq (g01ecc). The $\chi^2$ approximation is acceptable unless $k = 4$ and $n < 5$, or $k = 3$ and $n < 10$, or $k = 2$ and $n < 20$.

8 Parallelism and Performance
Not applicable.

9 Further Comments
The time taken by nag_friedman_test (g08aec) is approximately proportional to the product $nk$.
If $k = 2$, the Sign test (see nag_sign_test (g08aac)) or Wilcoxon test (see nag_wilcoxon_test (g08agc)) is more appropriate.

10 Example
This example is taken from page 169 of Siegel (1956). The data relate to training scores of three matched samples of 18 rats, trained under three different patterns of reinforcement.

10.1 Program Text
/* nag_friedman_test (g08aec) Example Program. */
/* Copyright 2014 Numerical Algorithms Group. */
/* Mark 6, 2000. */
#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nag8.h>

int main(void)
{ 
  Integer exit_status = 0, i, ix, j, k, n;
  NagError fail;
  double fr, sig, *x = 0;
  #define X(I, J) x[((I)-1)*n+(J)-1]

  INIT_FAIL(fail);

  printf("nag_friedman_test (g08aec) Example Program Results\n");

  /* Skip heading in data file */
  else
    scanf("%*[\n]");
  endif

  n = 18;
  k = 3;
  if(!(x = NAG_ALLOC(ix*n, double)))
  { 
    printf("Allocation failure\n");
    exit_status = -1;
    goto END;
  }
  for (i = 1; i <= ix; ++i)
    for (j = 1; j <= n; ++j)
```c
scanf_s("%lf", &X(i, j));
#else
    scanf("%lf", &X(i, j));
#endif

printf("\nFriedman test\n");
printf("\nData values\n");
printf("\n  Group Group Group\n");
for (j = 1; j <= 18; ++j)
{
    for (i = 1; i <= 3; ++i)
        printf("%7.1f", X(i, j));
    printf("\n");
}

nag_friedman_test(k, n, x, n, &fr, &sig, &fail);
if (fail.code != NE_NOERROR)
{
    printf("Error from nag_friedman_test (g08aec).\n%s\n", fail.message);
    exit_status = 1;
    goto END;
}
printf("\n");
printf("%s%6.3f\n", "Test statistic ", fr);
printf("%s%6\nAG_IFMT\n", "Degrees of freedom ", k-1);
printf("%s%6.3f\n", "Significance ", sig);
END:
NAG_FREE(x);
return exit_status;
```

10.2 Program Data

nag_friedman_test (g08aec) Example Program Data

<table>
<thead>
<tr>
<th>Group</th>
<th>Group</th>
<th>Group</th>
</tr>
</thead>
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<tr>
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<td>2.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

10.3 Program Results

nag_friedman_test (g08aec) Example Program Results

Friedman test

Data values
<table>
<thead>
<tr>
<th>Value</th>
<th>2.0</th>
<th>3.0</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test statistic</td>
<td>8.583</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degrees of freedom</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Significance</td>
<td>0.014</td>
<td></td>
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</tbody>
</table>