

# NAG Library Function Document

## nag\_sign\_test (g08aac)

### 1 Purpose

nag\_sign\_test (g08aac) performs the Sign test on two related samples of size  $n$ .

### 2 Specification

```
#include <nag.h>
#include <nagg08.h>
```

```
void nag_sign_test (Integer n, const double x[], const double y[], Integer *s,
                   double *p, Integer *non_tied, NagError *fail)
```

### 3 Description

The Sign test investigates the median difference between pairs of scores from two matched samples of size  $n$ , denoted by  $\{x_i, y_i\}$ , for  $i = 1, 2, \dots, n$ . The hypothesis under test,  $H_0$ , often called the null hypothesis, is that the medians are the same, and this is to be tested against a one- or two-sided alternative  $H_1$  (see below).

nag\_sign\_test (g08aac) computes:

- the test statistic  $S$ , which is the number of pairs for which  $x_i < y_i$ ;
- the number  $n_1$  of non-tied pairs ( $x_i \neq y_i$ );
- the lower tail probability  $p$  corresponding to  $S$  (adjusted to allow the complement  $(1 - p)$  to be used in an upper one tailed or a two tailed test).  $p$  is the probability of observing a value  $\leq S$  if  $S < \frac{1}{2}n_1$ , or of observing a value  $< S$  if  $S > \frac{1}{2}n_1$ , given that  $H_0$  is true. If  $S = \frac{1}{2}n_1$ ,  $p$  is set to 0.5.

Suppose that a significance test of a chosen size  $\alpha$  is to be performed (i.e.,  $\alpha$  is the probability of rejecting  $H_0$  when  $H_0$  is true; typically  $\alpha$  is a small quantity such as 0.05 or 0.01). The returned value of  $p$  can be used to perform a significance test on the median difference, against various alternative hypotheses  $H_1$ , as follows

- $H_1$ : median of  $x \neq$  median of  $y$ .  $H_0$  is rejected if  $2 \times \min(p, 1 - p) < \alpha$ .
- $H_1$ : median of  $x >$  median of  $y$ .  $H_0$  is rejected if  $p < \alpha$ .
- $H_1$ : median of  $x <$  median of  $y$ .  $H_0$  is rejected if  $1 - p < \alpha$ .

### 4 References

Siegel S (1956) *Non-parametric Statistics for the Behavioral Sciences* McGraw–Hill

### 5 Arguments

- n** – Integer *Input*  
*On entry:*  $n$ , the size of each sample.  
*Constraint:*  $n \geq 1$ .
- x[n]** – const double *Input*
- y[n]** – const double *Input*  
*On entry:*  $x[i - 1]$  and  $y[i - 1]$  must be set to the  $i$ th pair of data values,  $\{x_i, y_i\}$ , for  $i = 1, 2, \dots, n$ .

- 4: **s** – Integer \* *Output*  
*On exit:* the Sign test statistic,  $S$ .
- 5: **p** – double \* *Output*  
*On exit:* the lower tail probability,  $p$ , corresponding to  $S$ .
- 6: **non\_tied** – Integer \* *Output*  
*On exit:* the number of non-tied pairs,  $n_1$ .
- 7: **fail** – NagError \* *Input/Output*  
The NAG error argument (see Section 3.6 in the Essential Introduction).

## 6 Error Indicators and Warnings

### NE\_G08AA\_NON\_TIED

On exit, the number of **non\_tied** pairs, **non\_tied** = 0, i.e., the samples are identical.

### NE\_INT\_ARG\_LT

On entry, **n** =  $\langle value \rangle$ .  
Constraint: **n**  $\geq 1$ .

### 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

The tail probability,  $p$ , is computed using the relationship between the binomial and beta distributions. For  $n_1 < 120$ ,  $p$  should be accurate to at least 4 significant figures, assuming that the machine has a precision of 7 or more digits. For  $n_1 \geq 120$ ,  $p$  should be computed with an absolute error of less than 0.005. For further details see `nag_prob_beta_dist` (g01eec).

## 8 Further Comments

The time taken by `nag_sign_test` (g08aac) is small, and increases with  $n$ .

## 9 Example

This example is taken from page 69 of Siegel (1956). The data relates to ratings of ‘insight into paternal discipline’ for 17 sets of parents, recorded on a scale from 1 to 5.

### 9.1 Program Text

```
/* nag_sign_test (g08aac) Example Program.
 *
 * Copyright 2000 Numerical Algorithms Group.
 *
 * Mark 6, 2000.
 */

#include <stdio.h>
#include <nag.h>
#include <nagx04.h>
#include <nag_stdlib.h>
#include <nagg08.h>
```

```

int main(int argc, char *argv[])
{
    FILE      *fpin, *fpout;
    Integer    exit_status = 0, i, n, non_tied, s;
    NagError  fail;
    double     p, *x = 0, *y = 0;

    INIT_FAIL(fail);

    /* Check for command-line IO options */
    fpin = nag_example_file_io(argc, argv, "-data", NULL);
    fpout = nag_example_file_io(argc, argv, "-results", NULL);
    fprintf(fpout, "nag_sign_test (g08aac) Example Program Results\n");

    /* Skip heading in data file */
    fscanf(fpin, "%*[\n]");

    n = 17;
    if (!(x = NAG_ALLOC(n, double))
        || !(y = NAG_ALLOC(n, double)))
    {
        fprintf(fpout, "Allocation failure\n");
        exit_status = -1;
        goto END;
    }

    for (i = 1; i <= n; i++)
        fscanf(fpin, "%lf", &x[i-1]);

    for (i = 1; i <= n; i++)
        fscanf(fpin, "%lf", &y[i-1]);

    fprintf(fpout, "\n%s\n\n", "Sign test");
    fprintf(fpout, "%s\n\n", "Data values");
    for (i = 1; i <= n; i++)
        fprintf(fpout, "%3.0f%s", x[i-1], i%n?" ":"\n");
    fprintf(fpout, "\n");

    for (i = 1; i <= n; i++)
        fprintf(fpout, "%3.0f%s", y[i-1], i%n?" ":"\n");
    fprintf(fpout, "\n");

    /* nag_sign_test (g08aac).
     * Sign test on two paired samples
     */
    nag_sign_test(n, x, y, &s, &p, &non_tied, &fail);
    if (fail.code != NE_NOERROR)
    {
        fprintf(fpout, "Error from nag_sign_test (g08aac).\n%s\n", fail.message);
        exit_status = 1;
        goto END;
    }

    fprintf(fpout, "%s%5ld\n", "Test statistic", s);
    fprintf(fpout, "%s%5ld\n", "Observations", non_tied);
    fprintf(fpout, "%s%5.3f\n", "Lower tail prob.", p);
END:
    if (fpin != stdin) fclose(fpin);
    if (fpout != stdout) fclose(fpout);
    if (x) NAG_FREE(x);
    if (y) NAG_FREE(y);
    return exit_status;
}

```

## 9.2 Program Data

```
nag_sign_test (g08aac) Example Program Data
 4 4 5 5 3 2 5 3 1 5 5 5 4 5 5 5
 2 3 3 3 3 3 3 3 2 3 2 2 5 2 5 3 1
```

## 9.3 Program Results

```
nag_sign_test (g08aac) Example Program Results
```

```
Sign test
```

```
Data values
```

```
 4 4 5 5 3 2 5 3 1 5 5 5 4 5 5 5
 2 3 3 3 3 3 3 3 2 3 2 2 5 2 5 3 1
```

```
Test statistic      3
Observations       14
Lower tail prob. 0.029
```

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