

nag_shapiro_wilk_test (g01ddc)

1. Purpose

nag_shapiro_wilk_test (g01ddc) calculates Shapiro and Wilk's W statistic and its significance level for testing Normality.

2. Specification

```
#include <nag.h>
#include <nagg01.h>

void nag_shapiro_wilk_test(Integer n, double x[], Boolean calc_wts,
                           double a[], double *w, double *pw, NagError *fail)
```

3. Description

This routine calculates Shapiro and Wilk's W statistic and its significance level for any sample size between 3 and 2000. It is an adaptation of the Applied Statistics Algorithm AS 181, see Royston (1982a). The full description of the theory behind this algorithm is given in Royston (1982b).

Given a set of observations x_1, x_2, \dots, x_n sorted into either ascending or descending order (**nag_double_sort (m01cac)** may be used to sort the data), **nag_shapiro_wilk_test** calculates the value of Shapiro and Wilk's W statistic defined as:

$$W = \frac{\left(\sum_{i=1}^n a_i x_i \right)^2}{\sum_{i=1}^n (x_i - \bar{x})^2}$$

where $\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$ is the sample mean and a_i , for $i = 1, 2, \dots, n$ are a set of 'weights' whose values depend only on the sample size n .

On exit, the values of a_i , for $i = 1, 2, \dots, n$ are only of interest should the user wish to call the routine again to calculate W and its significance level for a different sample of the same size.

4. Parameters

n

Input: the sample size, n .
Constraint: $3 \leq \mathbf{n} \leq 2000$.

x[n]

Input: the ordered sample values, x_i ; for $i = 1, 2, \dots, n$.

calc_wts

Input: **calc_wts** must be set to **TRUE** if the user wishes **nag_shapiro_wilk_test** to calculate the elements of **a**.

calc_wts should be set to **FALSE** if the user has saved the values in **a** from a previous call to **nag_shapiro_wilk_test**.

If in doubt, set **calc_wts** equal to **TRUE**.

a[n]

Input: if **calc_wts** has been set to **FALSE** then before entry **a** must contain the n weights as calculated in a previous call to **nag_shapiro_wilk_test**, otherwise **a** need not be set.

Output: the n weights required to calculate W .

w

Output: the value of the statistic, W .

pwOutput: the significance level of W .**fail**

The NAG error parameter, see the Essential Introduction to the NAG C Library.

5. Error Indications and Warnings

NE_INT_ARG_LTOn entry, **n** must not be less than 3: **n** = $\langle value \rangle$.**NE_INT_ARG_GT**On entry, **n** must not be greater than 2000: **n** = $\langle value \rangle$.**NE_NON_MONOTONIC**On entry, the sequence in array **x** is non-monotonic. First anomaly detected at **x**[$\langle value \rangle$] = $\langle value \rangle$.**NE_ALL_ELEMENTS_EQUAL**On entry, all the values in the array **x** must not be equal.**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 consult NAG for assistance.

6. Further Comments

The time taken by the routine depends roughly linearly on the value of n .

For very small samples the power of the test may not be very high.

The contents of the array **A** should not be modified between calls to `nag_shapiro_wilk_test` for a given sample size, unless **calc_wts** is reset to **TRUE** before each call of `nag_shapiro_wilk_test`.The Shapiro and Wilk W test is very sensitive to ties. If the data has been rounded the test can be improved by using Sheppard's correction to adjust the sum of squares about the mean. This produces an adjusted value of W ,

$$WA = W \frac{\sum (x_{(i)} - \bar{x})^2}{\left\{ \sum_{i=1}^n (x_{(i)} - \bar{x})^2 - \frac{n-1}{12} \omega^2 \right\}}$$

where ω is the rounding width. WA can be compared with a standard normal distribution, but a further approximation is given by Royston (1986).

6.1. Accuracy

There may be a loss of significant figures for large n .

6.2. References

Royston J P (1982a) Algorithm AS181: The W Test for Normality *Appl. Statist.* **31** 176–180.Royston J P (1982b) An extension of Shapiro and Wilk's W Test for Normality to large samples *Appl. Statist.* **31** 115–124.Royston J P (1986) A Remark on AS181: The W Test for Normality *Appl. Statist.* **35** 232–234.

7. See Also

`nag_ranks_and_scores` (g01dhc)

8. Example

A program to test the following 2 samples (each of size 20) for Normality.

Sample Number	Data
(1)	0.11, 7.87, 4.61, 10.14, 7.95, 3.14, 0.46, 4.43, 0.21, 4.75, 0.71, 1.52, 3.24, 0.93, 0.42, 4.97, 9.53, 4.55, 0.47, 6.66
(2)	1.36, 1.14, 2.92, 2.55, 1.46, 1.06, 5.27, -1.11, 3.48, 1.10, 0.88, -0.51, 1.46, 0.52, 6.20, 1.69, 0.08, 3.67, 2.81, 3.49

The elements of **a** are calculated only in the first call of nag_shapiro_wilk_test and are re-used in the second call.

8.1. Program Text

```

/* nag_shapiro_wilk_test(g01ddc) Example Program.
 *
 * Copyright 1996 Numerical Algorithms Group.
 *
 * Mark 4, 1996.
 *
 */

#include <nag.h>
#include <nag_stdlib.h>
#include <stdio.h>
#include <nagg01.h>
#include <nagm01.h>

main()
{

#define NMAX 20

    /* Local variables */
    double a[NMAX];
    Integer i, j, n;
    double w, x[NMAX], pw;
    Boolean calwts;

    Vprintf("g01ddc Example Program Results\n");

    /*      Skip heading in data file */
    Vscanf("%*[^\\n] ");

    calwts = TRUE;
    Vscanf("%ld ", &n);
    if (n > 0 && n <= NMAX)
    {
        for (j = 1; j <= 2; ++j)
        {
            for (i = 1; i <= n; ++i)
                Vscanf("%lf ", &x[i - 1]);

            m01cac(x, (size_t)n, Nag_Ascending, NAGERR_DEFAULT);
            g01ddc(n, x, calwts, a, &w, &pw, NAGERR_DEFAULT);

            Vprintf("\n For sample number %2ld, value of W statistic = %7.4f\n",
                    j, w);
            Vprintf("                                Significance level is %8.4f\n", pw);
            calwts = FALSE;
        }
    }
    exit(EXIT_SUCCESS);
}

```

8.2. Program Data

g01ddc Example Program Data

20

0.11	7.87	4.61	10.14	7.95	3.14	0.46	4.43	0.21	4.75
0.71	1.52	3.24	0.93	0.42	4.97	9.53	4.55	0.47	6.66
1.36	1.14	2.92	2.55	1.46	1.06	5.27	-1.11	3.48	1.10
0.88	-0.51	1.46	0.52	6.20	1.69	0.08	3.67	2.81	3.49

8.3. Program Results

g01ddc Example Program Results

For sample number 1, value of W statistic = 0.8992
Significance level is 0.0408

For sample number 2, value of W statistic = 0.9583
Significance level is 0.5171
