

# NAG Library Function Document

## nag\_tsa\_auto\_corr (g13abc)

### 1 Purpose

nag\_tsa\_auto\_corr (g13abc) computes the sample autocorrelation function of a time series. It also computes the sample mean, the sample variance and a statistic which may be used to test the hypothesis that the true autocorrelation function is zero.

### 2 Specification

```
#include <nag.h>
#include <nagg13.h>
void nag_tsa_auto_corr (const double x[], Integer nx, Integer nk,
    double *mean, double *var, double r[], double *stat, NagError *fail)
```

### 3 Description

The data consist of  $n$  observations  $x_i$ , for  $i = 1, 2, \dots, n$ , from a time series.

The quantities calculated are:

- (a) The sample mean

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$$

- (b) The sample variance (for  $n \geq 2$ )

$$s^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{(n - 1)}$$

- (c) The sample autocorrelation coefficients of lags  $k = 1, 2, \dots, K$ , where  $K$  is a user-specified maximum lag, and  $K < n$ ,  $n > 1$ .

- (d) The coefficient of lag  $k$  is defined as

$$r_k = \frac{\sum_{i=1}^{n-k} (x_i - \bar{x})(x_{i+k} - \bar{x})}{\sum_{i=1}^n (x_i - \bar{x})^2}$$

- (e) See page 496 *et seq.* of Box and Jenkins (1976) for further details.

- (f) A test statistic defined as

$$\mathbf{stat} = n \sum_{k=1}^K r_k^2,$$

which can be used to test the hypothesis that the true autocorrelation function is identically zero.

If  $n$  is large and  $K$  is much smaller than  $n$ , **stat** has a  $\chi_K^2$  distribution under the hypothesis of a zero autocorrelation function. Values of **stat** in the upper tail of the distribution provide evidence against the hypothesis.

Section 8.2.2 of Box and Jenkins (1976) provides further details of the use of **stat**.

## 4 References

Box G E P and Jenkins G M (1976) *Time Series Analysis: Forecasting and Control* (Revised Edition) Holden-Day

## 5 Arguments

- 1: **x[nx]** – const double *Input*  
*On entry:* the time series,  $x_i$ , for  $i = 1, 2, \dots, n$ .
- 2: **nx** – Integer *Input*  
*On entry:* the number of values,  $n$ , in the time series.  
*Constraint:* **nx** > 1.
- 3: **nk** – Integer *Input*  
*On entry:* the number of lags,  $K$ , for which the autocorrelations are required. The lags range from 1 to  $K$  and do not include zero.  
*Constraint:*  $0 < \mathbf{nk} < \mathbf{nx}$ .
- 4: **mean** – double \* *Output*  
*On exit:* the sample mean of the input time series.
- 5: **var** – double \* *Output*  
*On exit:* the sample variance of the input time series.
- 6: **r[nk]** – double *Output*  
*On exit:* the sample autocorrelation coefficient relating to lag  $k$ , for  $k = 1, 2, \dots, K$ .
- 7: **stat** – double \* *Output*  
*On exit:* the statistic used to test the hypothesis that the true autocorrelation function of the time series is identically zero.
- 8: **fail** – NagError \* *Input/Output*  
The NAG error argument (see Section 2.7 in How to Use the NAG Library and its Documentation).

## 6 Error Indicators and Warnings

### NE\_2\_INT\_ARG\_LE

On entry, **nx** =  $\langle value \rangle$  while **nk** =  $\langle value \rangle$ . These arguments must satisfy **nx** > **nk**.

### NE\_INT\_ARG\_LE

On entry, **nk** =  $\langle value \rangle$ .

Constraint: **nk** > 0.

On entry, **nx** =  $\langle value \rangle$ .

Constraint: **nx** > 1.

### NE\_TIME\_SERIES\_IDEN

On entry, all values of **x** are practically identical, giving zero variance. In this case **r** and **stat** are undefined on exit.

## 7 Accuracy

The computations are believed to be stable.

## 8 Parallelism and Performance

nag\_tsa\_auto\_corr (g13abc) is not threaded in any implementation.

## 9 Further Comments

The time taken by nag\_tsa\_auto\_corr (g13abc) is approximately proportional to  $\mathbf{nx} \times \mathbf{nk}$ .

## 10 Example

In the example below, a set of 50 values of sunspot counts is used as input. The first 10 autocorrelations are computed.

### 10.1 Program Text

```

/* nag_tsa_auto_corr (g13abc) Example Program.
 *
 * NAGPRODCODE Version.
 *
 * Copyright 2016 Numerical Algorithms Group.
 *
 * Mark 26, 2016.
 */

#include <nag.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nagg13.h>

int main(void)
{
    Integer exit_status = 0, i, nk, nx;
    NagError fail;
    double mean, *r = 0, stat, *x = 0, xv;

    INIT_FAIL(fail);

    printf("nag_tsa_auto_corr (g13abc) Example Program Results\n");
    /* Skip heading in data file */
#ifdef _WIN32
    scanf_s("%*[\n]");
#else
    scanf("%*[\n]");
#endif
#ifdef _WIN32
    scanf_s("%" NAG_IFMT " %" NAG_IFMT "", &nx, &nk);
#else
    scanf("%" NAG_IFMT " %" NAG_IFMT "", &nx, &nk);
#endif

    if (nk > 0 && nx > 1 && nk < nx) {
        if (!(r = NAG_ALLOC(nk, double)) || !(x = NAG_ALLOC(nx, double)))
        {
            printf("Allocation failure\n");
            exit_status = -1;
            goto END;
        }
    }
    else {
        printf("Invalid nx or nk.\n");
    }
}

```

```

        exit_status = 1;
        return exit_status;
    }
    for (i = 0; i < nx; ++i)
#ifdef _WIN32
        scanf_s("%lf", &x[i]);
#else
        scanf("%lf", &x[i]);
#endif
    printf("\nThe first %2" NAG_IFMT " coefficients are required\n", nk);

    /* nag_tsa_auto_corr (g13abc).
     * Sample autocorrelation function
     */
    nag_tsa_auto_corr(x, nx, nk, &mean, &xv, r, &stat, &fail);
    if (fail.code != NE_NOERROR) {
        printf("Error from nag_tsa_auto_corr (g13abc).\n%s\n", fail.message);
        exit_status = 1;
        goto END;
    }

    printf("The input array has sample mean %12.4f\n", mean);
    printf("The input array has sample variance %12.4f\n", xv);
    printf("The sample autocorrelation coefficients are\n\n");
    printf("   Lag      Coeff\n");
    for (i = 0; i < 10; ++i)
        printf("%6" NAG_IFMT "%10.4f\n", i + 1, r[i]);
    printf("\nThe value of stat is %12.4f\n", stat);
END:
    NAG_FREE(r);
    NAG_FREE(x);
    return exit_status;
}

```

## 10.2 Program Data

```

nag_tsa_auto_corr (g13abc) Example Program Data
50 10
 5.0  11.0  16.0  23.0  36.0
58.0  29.0  20.0  10.0   8.0
 3.0   0.0   0.0   2.0  11.0
27.0  47.0  63.0  60.0  39.0
28.0  26.0  22.0  11.0  21.0
40.0  78.0 122.0 103.0  73.0
47.0  35.0  11.0   5.0  16.0
34.0  70.0  81.0 111.0 101.0
73.0  40.0  20.0  16.0   5.0
11.0  22.0  40.0  60.0  80.9

```

## 10.3 Program Results

```
nag_tsa_auto_corr (g13abc) Example Program Results
```

```

The first 10 coefficients are required
The input array has sample mean      37.4180
The input array has sample variance  1002.0301
The sample autocorrelation coefficients are

```

Lag	Coeff
1	0.8004
2	0.4355
3	0.0328
4	-0.2835
5	-0.4505
6	-0.4242
7	-0.2419

8	0.0550
9	0.3783
10	0.5857

The value of stat is           92.1231

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