nag arma time series (g05hac)

1. Purpose

*nag arma time series (g05hac)* generates an autoregressive moving average (ARMA) time series with normally distributed errors (or residuals). It initialises the series to a stationary position and sets up a reference vector enabling the function to be called repeatedly, adding terms to the previous series at each call.

2. Specification

```c
#include <nag.h>
#include <nagg05.h>

void nag_arma_time_series(Boolean start, Integer p, Integer q,
                          double phi[], double theta[], double mean, double vara,
                          Integer n, double w[], double ref[], NagError *fail)
```

3. Description

An ARMA model, denoted by ARMA$(p, q)$, is a mixture of an autoregressive process of order $p$ (AR) and a moving average (MA) process of order $q$ and can be written as

$$
(x_n - \mu) = \phi_1(x_{n-1} - \mu) + \ldots + \phi_p(x_{n-p} - \mu) + a_n - \theta_1a_{n-1} \ldots - \theta_qa_{n-q}
$$

where $x_n$ are the realization of the series, $\mu$ is the mean of the series and $a_n$ are the errors (or residuals, also often called the white noise) which are independently distributed as normal with mean zero and variance $\sigma^2$. The parameters $\phi_i$ are the autoregressive parameters and the parameters $\theta_i$ are the moving average parameters.

The function sets up initial values corresponding to a stationary position using the method described by Tunnicliffe-Wilson (1979). It generates $n$ terms of the time series by first calculating the next term in the autoregressive series and then applying the moving-average summation and storing the result.

4. Parameters

- **start**
  - Input: *start* must be **TRUE** if a new series is to begin, if *start* is **FALSE** a previously generated series will be continued. If start is **FALSE** then the scalar parameters $p$, $q$, **mean** and **vara** and the contents of the array parameters, **phi** and **theta** must not be changed.

- **p**
  - Input: the number of autoregressive coefficients supplied.
  - Constraint: $p \geq 0$.

- **q**
  - Input: the number of moving-average coefficients supplied.
  - Constraint: $q \geq 0$.

- **phi[p]**
  - Input: the autoregressive coefficients of the model, if any, **phi**[$i - 1$] must contain $\phi_i$ for $i = 1, 2, \ldots, p$.

- **theta[q]**
  - Input: the moving-average coefficients of the model, if any, **theta**[$i - 1$] must contain $\theta_i$ for $i = 1, 2, \ldots, q$.

- **mean**
  - Input: the mean of the time series.

- **vara**
  - Input: the variance of the errors, $\sigma^2$.
  - Constraint: **vara** $> 0.0$. 

[NP3275/5/pdf] 3.g05hac.1
### nag_arma_time_series

**n**

Input: the number of observations to be generated.

Constraint: \( n \geq 1 \).

**w[n]**

Output: the realization of the time series.

**ref \([5+\text{MAX}(p,q)+7] \)**

Output: the reference vector and the recent history of the series.

**fail**

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

### 5. Error Indications and Warnings

**NE_INT_ARG_LT**

On entry, \( p \) must not be less than 0: \( p = \langle \text{value} \rangle \).

On entry, \( q \) must not be less than 0: \( q = \langle \text{value} \rangle \).

On entry, \( n \) must not be less than 1: \( n = \langle \text{value} \rangle \).

**NE_REAL_ARG_LE**

On entry, \( vara \) must not be less than or equal to 0.0: \( vara = \langle \text{value} \rangle \).

**NE_STATIONARITY**

The input series does not constitute a stationary time-series model.

**NE_START_P_Q**

The function has been called either with \( \text{start} = \text{FALSE} \) the first time or at least one of \( p \) or \( q \) has been changed in a subsequent call with \( \text{start} = \text{FALSE} \).

**NE_REF_VEC**

The reference vector set up by the previous call of this function has become corrupt.

### 6. Further Comments

None.

### 6.1. References


### 7. See Also

None.

### 8. Example

The program below shows two calls of nag_arma_time_series. In the first call an ARMA series is generated. In the second call terms are added to the already existing series.

#### 8.1. Program Text

```c
#include <nag.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nagg05.h>
```

3.g05hac.2

[NP:275/5/pdf]
```c
#define NA 3
#define NB 2
#define NR 20
#define NW 10

main()
{
    Integer i, ip, iq, n;
    double phi[NA], theta[NB], w[NW];
    double mean, vara;
    double ref[NR];
    Boolean start;
    Integer seed = 0;

    Vprintf("g05hac Example Program Results\n\n");

    g05cbc(seed);
    ip = 2;
    iq = 0;
    n = NW;
    phi[0] = 0.4;
    phi[1] = 0.2;
    mean = 0.0;
    vara = 2.0;

    /* Generate an ARMA series with 5 terms */
    start = TRUE;
    g05hac(start, ip, iq, phi, theta, mean, vara, (Integer)5, w, ref,
           NAGERR_DEFAULT);

    /* Add further 5 terms to the previous series*/
    start = FALSE;
    g05hac(start, ip, iq, phi, theta, mean, vara, (Integer)5, &w[5], ref,
           NAGERR_DEFAULT);
    for (i = 0; i < n; ++i)
        Vprintf("%12.4f \n", w[i]);
    exit(EXIT_SUCCESS);
}
```

8.2. Program Data

None.

8.3. Program Results

```
g05hac Example Program Results

3.4060
1.6952
3.5042
1.1311
0.0640
0.5834
0.5352
-1.7206
-0.4964
1.6448
```