

# NAG Fortran Library Routine Document

## G05HMF

**Note:** before using this routine, please read the Users' Note for your implementation to check the interpretation of **bold italicised** terms and other implementation-dependent details.

### 1 Purpose

G05HMF generates a given number of terms of a GJR GARCH( $p, q$ ) process (see Glosten *et al.* (1993)).

### 2 Specification

```

SUBROUTINE G05HMF(DIST, NUM, IP, IQ, THETA, GAMMA, DF, HT, ET, FCALL,
1          RVEC, IGEN, ISEED, RWSAV, IFAIL)
INTEGER    NUM, IP, IQ, IGEN, ISEED(4), IFAIL
real     THETA(IQ+IP+1), GAMMA, DF, HT(NUM), ET(NUM), RVEC(40),
1          RWSAV(9)
LOGICAL    FCALL
CHARACTER*1 DIST

```

### 3 Description

A GJR GARCH( $p, q$ ) process is represented by:

$$h_t = \alpha_0 + \sum_{i=1}^q (\alpha_i + \gamma S_{t-i}) \epsilon_{t-i}^2 + \sum_{i=1}^p \beta_i h_{t-i}, \quad t = 1, \dots, T.$$

where  $S_t = 1$ , if  $\epsilon_t < 0$ ,  $S_t = 0$ , if  $\epsilon_t \geq 0$ , and  $\epsilon_t | \psi_{t-1} = N(0, h_t)$  or  $\epsilon_t | \psi_{t-1} = S_t(df, h_t)$ . Here  $S_t$  is a standardised Student's  $t$ -distribution with  $df$  degrees of freedom and variance  $h_t$ ,  $T$  is the number of observations in the sequence,  $\epsilon_t$  is the *observed* value of the GARCH( $p, q$ ) process at time  $t$ ,  $h_t$  is the conditional variance at time  $t$ , and  $\psi_t$  the set of all information up to time  $t$ . Symmetric GARCH sequences are generated when  $\gamma$  is zero, otherwise asymmetric GARCH sequences are generated with  $\gamma$  specifying the amount by which negative shocks are to be enhanced.

One of the initialisation routines G05KBF (for a repeatable sequence if computed sequentially) or G05KCF (for a non-repeatable sequence) must be called prior to the first call to G05HMF.

### 4 References

Engle R (1982) Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflation *Econometrica* **50** 987–1008

Bollerslev T (1986) Generalised autoregressive conditional heteroskedasticity *Journal of Econometrics* **31** 307–327

Engle R and Ng V (1993) Measuring and Testing the Impact of News on Volatility *Journal of Finance* **48** 1749–1777

Hamilton J (1994) *Time Series Analysis* Princeton University Press

Glosten L, Jagannathan R and Runkle D (1993) Relationship between the expected value and the volatility of nominal excess return on stocks *Journal of Finance* **48** 1779–1801

### 5 Parameters

1: DIST – CHARACTER\*1

*Input*

*On entry:* the type of distribution to use for  $\epsilon_t$ .

DIST = 'N'

Then a Normal distribution is used.

DIST = 'T'

Then a Student's  $t$ -distribution is used.

*Constraint:* DIST = 'N' or 'T'.

- 2: NUM – INTEGER *Input*  
*On entry:* the number of terms in the sequence,  $T$ .  
*Constraint:* NUM > 0.
- 3: IP – INTEGER *Input*  
*On entry:* the number of coefficients,  $\beta_i$ , for  $i = 1, \dots, p$ .  
*Constraints:*  

$$\begin{aligned} IQ + IP + 1 &\leq 20, \\ IP &\geq 0. \end{aligned}$$
- 4: IQ – INTEGER *Input*  
*On entry:* the number of coefficients,  $\alpha_i$ , for  $i = 1, \dots, q$ .  
*Constraints:*  

$$\begin{aligned} IQ + IP + 1 &\leq 20, \\ IQ &\geq 1. \end{aligned}$$
- 5: THETA(IQ+IP+1) – *real* array *Input*  
*On entry:* the first element contains the coefficient  $\alpha_0$ , the next IQ elements contain the coefficients  $\alpha_i$ , for  $i = 1, \dots, q$ . The remaining IP elements are the coefficients  $\beta_j$ , for  $j = 1, \dots, p$ .
- 6: GAMMA – *real* *Input*  
*On entry:* the asymmetry parameter  $\gamma$  for the GARCH( $p, q$ ) sequence.
- 7: DF – *real* *Input*  
*On entry:* the number of degrees of freedom for the Student's  $t$ -distribution. It is not referenced if DIST = 'N'.  
*Constraint:* DF > 2.
- 8: HT(NUM) – *real* array *Output*  
*On exit:* the conditional variances  $h_t$ , for  $t = 1, \dots, T$  for the GARCH( $p, q$ ) sequence.
- 9: ET(NUM) – *real* array *Output*  
*On exit:* the observations  $\epsilon_t$ , for  $t = 1, \dots, T$  for the GARCH( $p, q$ ) sequence.
- 10: FCALL – LOGICAL *Input*  
*On entry:* if FCALL = .TRUE., a new sequence is to be generated, otherwise a given sequence is to be continued using the information in RVEC.
- 11: RVEC(40) – *real* array *Input/Output*  
*On entry:* the array contains information required to continue a sequence if FCALL = .FALSE..  
*On exit:* contains information that can be used in a subsequent call of G05HMF, with FCALL = .FALSE..

- 12: IGEN – INTEGER *Input*  
*On entry:* must contain the identification number for the generator to be used to return a pseudo-random number and should remain unchanged following initialisation by a prior call to one of the routines G05KBF or G05KCF.
- 13: ISEED(4) – INTEGER array *Input/Output*  
*On entry:* contains values which define the current state of the selected generator.  
*On exit:* contains updated values defining the new state of the selected generator.
- 14: RWSAV(9) – *real* array *Workspace*
- 15: IFAIL – INTEGER *Input/Output*  
*On entry:* IFAIL must be set to 0, –1 or 1. Users who are unfamiliar with this parameter should refer to Chapter P01 for details.  
*On exit:* IFAIL = 0 unless the routine detects an error (see Section 6).  
 For environments where it might be inappropriate to halt program execution when an error is detected, the value –1 or 1 is recommended. If the output of error messages is undesirable, then the value 1 is recommended. Otherwise, because for this routine the values of the output parameters may be useful even if IFAIL  $\neq$  0 on exit, the recommended value is –1. **When the value –1 or 1 is used it is essential to test the value of IFAIL on exit.**

## 6 Error Indicators and Warnings

If on entry IFAIL = 0 or –1, explanatory error messages are output on the current error message unit (as defined by X04AAF).

Errors or warnings detected by the routine:

IFAIL = 1

On entry, IP < 0,  
 or IQ < 1,  
 or DF  $\leq$  2,  
 or NUM  $\leq$  0,  
 or DIST  $\neq$  'N' and DIST  $\neq$  'T',  
 or IQ + IP + 1 > 20.

IFAIL = 2

On entry,  $\alpha_i + \gamma < 0$  for some  $\alpha_i$

## 7 Accuracy

Not applicable.

## 8 Further Comments

None.

## 9 Example

See Section 9 of the document for G13FEF.