

# NAG Library Routine Document

## G13FHF

**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

G13FHF forecasts the conditional variances,  $h_t, t = T + 1, \dots, T + \xi$  from an exponential GARCH( $p, q$ ) sequence, where  $\xi$  is the forecast horizon and  $T$  is the current time (see Engle and Ng (1993)).

### 2 Specification

```
SUBROUTINE G13FHF (NUM, NT, IP, IQ, THETA, FHT, HT, ET, IFAIL)
INTEGER          NUM, NT, IP, IQ, IFAIL
REAL (KIND=nag_wp) THETA(2*IQ+IP+1), FHT(NT), HT(NUM), ET(NUM)
```

### 3 Description

Assume the GARCH( $p, q$ ) process represented by:

$$\ln(h_t) = \alpha_0 + \sum_{i=1}^q \alpha_i z_{t-i} + \sum_{j=1}^q \phi_j (|z_{t-j}| - E[|z_{t-i}|]) + \sum_{j=1}^p \beta_j \ln(h_{t-j}), \quad t = 1, 2, \dots, T.$$

where  $\epsilon_t | \psi_{t-1} = N(0, h_t)$  or  $\epsilon_t | \psi_{t-1} = S_t(df, h_t)$ , and  $z_t = \frac{\epsilon_t}{\sqrt{h_t}}$ ,  $E[|z_{t-i}|]$  denotes the expected value of  $|z_{t-i}|$ , has been modelled by G13FGF, and the estimated conditional variances and residuals are contained in the arrays HT and ET respectively.

G13FHF will then use the last  $\max(p, q)$  elements of the arrays HT and ET to estimate the conditional variance forecasts,  $h_t | \psi_T$ , where  $t = T + 1, \dots, T + \xi$  and  $\xi$  is the forecast horizon.

### 4 References

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

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

Engle R and Ng V (1993) Measuring and testing the impact of news on volatility *Journal of Finance* **48** 1749–1777

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

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

### 5 Parameters

- 1: NUM – INTEGER *Input*  
*On entry:* the number of terms in the arrays HT and ET from the modelled sequence.  
*Constraint:*  $\max(\text{IP}, \text{IQ}) \leq \text{NUM}$ .

- 2: NT – INTEGER *Input*  
*On entry:*  $\xi$ , the forecast horizon.  
*Constraint:*  $NT > 0$ .
- 3: IP – INTEGER *Input*  
*On entry:* the number of coefficients,  $\beta_i$ , for  $i = 1, 2, \dots, p$ .  
*Constraints:*  
 $\max(IP, IQ) \leq 20$ ;  
 $IP \geq 0$ .
- 4: IQ – INTEGER *Input*  
*On entry:* the number of coefficients,  $\alpha_i$ , for  $i = 1, 2, \dots, q$ .  
*Constraints:*  
 $\max(IP, IQ) \leq 20$ ;  
 $IQ \geq 1$ .
- 5: THETA( $2 \times IQ + IP + 1$ ) – REAL (KIND=nag\_wp) array *Input*  
*On entry:* the initial parameter estimates for the vector  $\theta$ . The first element must contain the coefficient  $\alpha_0$  and the next IQ elements must contain the autoregressive coefficients  $\alpha_i$ , for  $i = 1, 2, \dots, q$ . The next IQ elements must contain the coefficients  $\phi_i$ , for  $i = 1, 2, \dots, q$ . The next IP elements must contain the moving average coefficients  $\beta_j$ , for  $j = 1, 2, \dots, p$ .
- 6: FHT(NT) – REAL (KIND=nag\_wp) array *Output*  
*On exit:* the forecast values of the conditional variance,  $h_t$ , for  $t = T + 1, \dots, T + \xi$ .
- 7: HT(NUM) – REAL (KIND=nag\_wp) array *Input*  
*On entry:* the sequence of past conditional variances for the GARCH( $p, q$ ) process,  $h_t$ , for  $t = 1, 2, \dots, T$ .
- 8: ET(NUM) – REAL (KIND=nag\_wp) array *Input*  
*On entry:* the sequence of past residuals for the GARCH( $p, q$ ) process,  $\epsilon_t$ , for  $t = 1, 2, \dots, T$ .
- 9: IFAIL – INTEGER *Input/Output*  
*On entry:* IFAIL must be set to 0, -1 or 1. If you are unfamiliar with this parameter you should refer to Section 3.3 in the Essential Introduction for details.  
 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, if you are not familiar with this parameter, the recommended value is 0. **When the value -1 or 1 is used it is essential to test the value of IFAIL on exit.**  
*On exit:* IFAIL = 0 unless the routine detects an error or a warning has been flagged (see Section 6).

## 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,  $NUM < \max(IP, IQ)$ ,

or  $IQ < 1$ ,

or  $IP < 0$ ,

or  $\max(IP, IQ) > 20$ ,

or  $NT \leq 0$ .

## 7 Accuracy

Not applicable.

## 8 Further Comments

None.

## 9 Example

See Section 9 in G13FGF.

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