

NAG Library Routine Document

G05PEF

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

G05PEF generates a given number of terms of a type II AGARCH(p, q) process (see Engle and Ng (1993)).

2 Specification

```

SUBROUTINE G05PEF(DIST, NUM, IP, IQ, THETA, GAMMA, DF, HT, ET, FCALL, R,
1                LR, STATE, IFAIL)
    INTEGER          NUM, IP, IQ, DF, LR, STATE(lstate), IFAIL
    double precision THETA(IQ+IP+1), GAMMA, HT(NUM), ET(NUM), R(LR)
    LOGICAL          FCALL
    CHARACTER*1      DIST

```

3 Description

A type II AGARCH(p, q) process can be represented by:

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

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

One of the initialization routines G05KFF (for a repeatable sequence if computed sequentially) or G05KGF (for a non-repeatable sequence) must be called prior to the first call to G05PEF.

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

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

5 Parameters

1: DIST – CHARACTER*1

Input

On entry: the type of distribution to use for ϵ_t .

DIST = 'N'

A Normal distribution is used.

DIST = 'T'

A Student's t -distribution is used.

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

- 2: NUM – INTEGER *Input*
On entry: T , the number of terms in the sequence.
Constraint: NUM ≥ 0 .
- 3: IP – INTEGER *Input*
On entry: the number of coefficients, β_i , for $i = 1, 2, \dots, p$.
Constraint: IP ≥ 0 .
- 4: IQ – INTEGER *Input*
On entry: the number of coefficients, α_i , for $i = 1, 2, \dots, q$.
Constraint: IQ ≥ 1 .
- 5: THETA(IQ + IP + 1) – **double precision** array *Input*
On entry: the first element must contain the coefficient α_o , the next IQ elements must contain the coefficients α_i , for $i = 1, 2, \dots, q$. The remaining IP elements must contain the coefficients β_j , for $j = 1, 2, \dots, p$.
Constraints:

$$\sum_{i=2}^{IQ+IP+1} \text{THETA}(i) < 1.0;$$

$$\text{THETA}(i) \geq 0.0, \text{ for } i = 2, 3, \dots, IP + IQ + 1.$$
- 6: GAMMA – **double precision** *Input*
On entry: the asymmetry parameter γ for the GARCH(p, q) sequence.
- 7: DF – INTEGER *Input*
On entry: the number of degrees of freedom for the Student's t -distribution.
If DIST = 'N', DF is not referenced.
Constraint: if DIST = 'T', DF > 2 .
- 8: HT(NUM) – **double precision** array *Output*
On exit: the conditional variances h_t , for $t = 1, 2, \dots, T$, for the GARCH(p, q) sequence.
- 9: ET(NUM) – **double precision** array *Output*
On exit: the observations ϵ_t , for $t = 1, 2, \dots, T$, 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 R.
- 11: R(LR) – **double precision** 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 G05PEF, with FCALL = .FALSE..

- 12: LR – INTEGER *Input*
On entry: the dimension of the array R as declared in the (sub)program from which G05PEF is called.
Constraint: $LR \geq 2 \times (IP + IQ + 2)$.
- 13: STATE(*lstate*) – INTEGER array *Communication Array*
Note: *lstate* = LSTATE, the dimension of STATE as supplied to the initialization routine G05KFF or G05KGF.
On entry: contains information on the selected base generator and its current state.
On exit: contains updated information on the state of the generator.
- 14: 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.
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, 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.**

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, DIST $\neq$ 'N' or 'T'.

IFAIL = 2

On entry, NUM $\leq$ 0.

IFAIL = 3

On entry, IP $<$ 0.

IFAIL = 4

On entry, IQ $<$ 1.

IFAIL = 7

On entry, DIST = 'T' and DF $\leq$ 2.

IFAIL = 11

The value of IP or IQ is not the same as when R was set up in a previous call.

IFAIL = 12

On entry, $LR < 2 \times (IP + IQ + 2)$.

IFAIL = 13

On entry, STATE vector was not initialized or has been corrupted.

7 Accuracy

Not applicable.

8 Further Comments

None.

9 Example

This example first calls G05KFF to initialize a base generator then calls G05PEF to generate two realizations, each consisting of ten observations, from an asymmetric GARCH(1,1) model.

9.1 Program Text

```
*      G05PEF Example Program Text
*      Mark 22 Release. NAG Copyright 2006.
*      .. Parameters ..
      INTEGER          NOUT
      PARAMETER        (NOUT=6)
      INTEGER          MSTATE, MSEED, NUM, IP, IQ
      PARAMETER        (MSTATE=633,MSEED=1,NUM=10,IP=1,IQ=1)
      INTEGER          LR
      PARAMETER        (LR=2*(IQ+IP+2))
*      .. Local Scalars ..
      DOUBLE PRECISION GAMMA
      INTEGER          DF, GENID, I, IFAIL, LSEED, LSTATE, SUBID
      LOGICAL          FCALL
      CHARACTER        DIST
*      .. Local Arrays ..
      DOUBLE PRECISION ET(NUM), HT(NUM), R(LR), THETA(IP+IQ+1)
      INTEGER          SEED(MSEED), STATE(MSTATE)
*      .. External Subroutines ..
      EXTERNAL          G05KFF, G05PEF
*      .. Executable Statements ..
      WRITE (NOUT,*) 'G05PEF Example Program Results'
      WRITE (NOUT,*)
*      Initialize the seed
      SEED(1) = 1762543
*      GENID and SUBID identify the base generator
      GENID = 1
      SUBID = 1
*      Initialize the generator to a repeatable sequence
      LSTATE = MSTATE
      LSEED = MSEED
      IFAIL = 1
      CALL G05KFF(GENID,SUBID,SEED,LSEED,STATE,LSTATE,IFAIL)
      IF (IFAIL.NE.0) THEN
         WRITE (NOUT,99998) IFAIL
         GO TO 60
      END IF
*      Set up the parameters for the series being generated
      DIST = 'N'
      THETA(1) = 0.08D0
      THETA(2) = 0.2D0
      THETA(3) = 0.7D0
      GAMMA = -0.4D0
      DF = 0
      FCALL = .TRUE.
*      Generate the first realisation
      IFAIL = 1
      CALL G05PEF(DIST,NUM,IP,IQ,THETA,GAMMA,DF,HT,ET,FCALL,R,LR,STATE,
+              IFAIL)
      IF (IFAIL.NE.0) THEN
         WRITE (NOUT,99997) IFAIL
         GO TO 60
      END IF
```

```

*      Display the results
      WRITE (NOUT,*)
      WRITE (NOUT,*) ' Realisation Number 1'
      WRITE (NOUT,*) '      I              HT(I)              ET(I)'
      WRITE (NOUT,*) ' -----'
      DO 20 I = 1, NUM
        WRITE (NOUT,99999) I, HT(I), ET(I)
20 CONTINUE
*      Generate a second realisation
      FCALL = .FALSE.
      IFAIL = 1
      CALL G05PEF(DIST,NUM,IP,IQ,THETA,GAMMA,DF,HT,ET,FCALL,R,LR,STATE,
+              IFAIL)
      IF (IFAIL.NE.0) THEN
        WRITE (NOUT,99997) IFAIL
        GO TO 60
      END IF
*      Display the results
      WRITE (NOUT,*)
      WRITE (NOUT,*) ' Realisation Number 2'
      WRITE (NOUT,*) '      I              HT(I)              ET(I)'
      WRITE (NOUT,*) ' -----'
      DO 40 I = 1, NUM
        WRITE (NOUT,99999) I, HT(I), ET(I)
40 CONTINUE
*
60 CONTINUE
*
99999 FORMAT (1X,I5,2(1X,F16.4))
99998 FORMAT (1X,' ** G05KFF returned with IFAIL = ',I5)
99997 FORMAT (1X,' ** G05PEF returned with IFAIL = ',I5)
      END

```

9.2 Program Data

None.

9.3 Program Results

G05PEF Example Program Results

Realisation Number 1		
I	HT(I)	ET(I)

1	0.6400	0.2790
2	0.5336	-0.9098
3	0.7780	0.5840
4	0.6491	0.6731
5	0.5670	-0.9456
6	0.8275	-0.0172
7	0.6593	-0.2390
8	0.5639	0.5980
9	0.5005	-0.0032
10	0.4303	0.2917

Realisation Number 2		
I	HT(I)	ET(I)

1	0.3874	-1.0205
2	0.7594	-0.5659
3	0.7371	0.2709
4	0.6013	-1.2499
5	1.1133	0.2505

6	0.8638	-0.5457
7	0.8014	-0.6395
8	0.8013	2.2341
9	1.0003	1.2908
10	0.9002	0.0727
