

NAG Library Routine Document

G05PDF

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

G05PDF generates a given number of terms of a type I AGARCH(p, q) process (see Engle and Ng (1993)).

2 Specification

```

SUBROUTINE G05PDF(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 I AGARCH(p, q) process can be represented by:

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

where $\epsilon_t \mid \psi_{t-1} = N(0, h_t)$ or $\epsilon_t \mid \psi_{t-1} = S_t(df, h_t)$. 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 G05PDF.

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 G05PDF, with FCALL = .FALSE..

- 12: LR – INTEGER *Input*
On entry: the dimension of the array R as declared in the (sub)program from which G05PDF 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 ≤ 0 .

IFAIL = 3

On entry, IP < 0 .

IFAIL = 4

On entry, IQ < 1 .

IFAIL = 5

On entry, at least one THETA(*i*) < 0.0 , for $i = 2, \dots, IP + IQ + 1$.

IFAIL = 51

On entry, $\sum_i \text{THETA}(i) \geq 1.0$, for $i = 2, \dots, IP + IQ + 1$.

IFAIL = 7

On entry, DIST = 'T' and DF ≤ 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 G05PDF to generate two realizations, each consisting of ten observations, from a symmetric GARCH(1,1) model.

9.1 Program Text

```
*      G05PGF 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=0, IQ=3)
INTEGER          LR
PARAMETER        (LR=2*(IQ+2*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, G05PDF
*      .. Executable Statements ..
WRITE (NOUT,*) 'G05PDF 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'
GAMMA = -0.4D0
THETA(1) = 0.8D0
THETA(2) = 0.6D0
THETA(3) = 0.2D0
THETA(4) = 0.1D0
```

```

      DF = 0
      FCALL = .TRUE.
*      Generate the first realisation
      IFAIL = 1
      CALL G05PDF(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 G05PDF(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,' ** G05PDF returned with IFAIL = ',I5)
      END

```

9.2 Program Data

None.

9.3 Program Results

G05PDF Example Program Results

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

1	0.9440	0.3389
2	0.8502	-1.1484
3	2.2553	0.9943
4	1.4918	1.0204
5	1.3413	-1.4544
6	2.9757	-0.0326
7	1.6386	-0.3767
8	1.5433	0.9892
9	1.1477	-0.0049
10	1.0281	0.4508

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

1	0.8691	-1.5286

2	3.0485	-1.1339
3	2.9558	0.5424
4	1.6547	-2.0734
5	4.7100	0.5153
6	2.0336	-0.8373
7	2.3331	-1.0912
8	2.4417	3.8999
9	8.7473	3.8171
10	10.4783	0.2480
