

G13DLF – NAG Fortran Library Routine Document

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

G13DLF differences and/or transforms a multivariate time series. It is intended to be used prior to G13DCF to fit a vector autoregressive moving average (VARMA) model to the differenced/transformed series.

2 Specification

```
SUBROUTINE G13DLF(K, N, Z, IK, TR, ID, DELTA, W, ND, WORK, IFAIL)
INTEGER          K, N, IK, ID(K), ND, IFAIL
real           Z(IK,N), DELTA(IK,*), W(IK,*), WORK(K*N)
CHARACTER*1     TR(K)
```

3 Description

For certain time series it may first be necessary to difference the original data to obtain a stationary series before fitting a VARMA model. This routine also allows the user to apply either a square root or a log transformation to the original time series to stabilize the variance if required.

If the order of differencing required for the i th series is d_i , then the differencing operator is defined by $\delta_i(B) = 1 - \delta_{i1}B - \delta_{i2}B^2 - \dots - \delta_{id_i}B^{d_i}$ where B is the backward shift operator, that is $BZ_t = Z_{t-1}$. Let d denote the maximum of the orders of differencing, d_i , over the k series. The routine computes values of the differenced/transformed series $W_t = (w_{1t}, w_{2t}, \dots, w_{kt})^T$ for $t = d + 1, d + 2, \dots, n$ as follows;

$$w_{it} = \delta_i(B)z_{it}^*, \quad \text{for } i = 1, 2, \dots, k$$

where z_{it}^* are the transformed values of the original k -dimensional time series $Z_t = (z_{1t}, z_{2t}, \dots, z_{kt})^T$.

The differencing parameters δ_{ij} , for $i = 1, 2, \dots, k$; $j = 1, 2, \dots, d_i$ must be supplied by the user. If the i th series does not require differencing, then $d_i = 0$.

4 References

- [1] Box G E P and Jenkins G M (1976) *Time Series Analysis: Forecasting and Control* Holden–Day (Revised Edition)
- [2] Wei W W S (1990) *Time Series Analysis: Univariate and Multivariate Methods* Addison–Wesley

5 Parameters

- 1: K — INTEGER *Input*
On entry: the dimension, k , of the multivariate time series.
Constraint: $K \geq 1$.
- 2: N — INTEGER *Input*
On entry: the number, n , of observations in the series, prior to differencing.
Constraint: $N \geq 1$.

- 3:** Z(IK,N) — *real* array Input
On entry: Z(*i*, *t*) must contain, z_{it} , the *i*th component of Z_t , for $i = 1, 2, \dots, k$; $t = 1, 2, \dots, n$.
Constraints:
 if TR(*i*) = 'L', then $Z(i, t) > 0.0$ and
 if TR(*i*) = 'S', then $Z(i, t) \geq 0.0$, for $i = 1, 2, \dots, k$; $t = 1, 2, \dots, n$.
- 4:** IK — INTEGER Input
On entry: the first dimension of the arrays Z, DELTA and W as declared in the (sub)program from which G13DLF is called.
Constraint: $IK \geq K$.
- 5:** TR(K) — CHARACTER*1 array Input
On entry: TR(*i*) indicates whether the *i*th time series is to be transformed, for $i = 1, 2, \dots, k$.
 If TR(*i*) = 'N', then no transformation is used;
 If TR(*i*) = 'L', then a log transformation is used;
 If TR(*i*) = 'S', then a square root transformation is used.
Constraint: TR(*i*) must equal either 'N', 'L' or 'S', for $i = 1, 2, \dots, k$.
- 6:** ID(K) — INTEGER array Input
On entry: the order of differencing for each series, d_1, d_2, \dots, d_k .
Constraint: $0 \leq ID(i) < N$, for $i = 1, 2, \dots, k$.
- 7:** DELTA(IK,*) — *real* array Input
Note: the second dimension of the array DELTA must be at least $\max(1, d)$ where $d = \max(ID(i))$.
On entry: if $ID(i) > 0$, then DELTA(*i*, *j*) must be set equal to δ_{ij} , for $j = 1, 2, \dots, d_i$; $i = 1, 2, \dots, k$.
 If $d = 0$, then DELTA is not referenced.
- 8:** W(IK,*) — *real* array Output
Note: the second dimension of the array W must be at least Nd .
On exit: W(*i*, *t*) contains the value of $w_{i,t+d}$, for $i = 1, 2, \dots, k$; $t = 1, 2, \dots, n - d$.
- 9:** ND — INTEGER Output
On exit: the number of differenced values, $n - d$, in the series.
- 10:** WORK(K*N) — *real* array Workspace
- 11:** IFAIL — INTEGER Input/Output
On entry: IFAIL must be set to 0, -1 or 1. For users not familiar with this parameter (described in Chapter P01) the recommended value is 0.
On exit: IFAIL = 0 unless the routine detects an error (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 detected by the routine:

IFAIL = 1

On entry, K < 1,
or N < 1,
or IK < K.

IFAIL = 2

On entry, ID(*i*) < 0, for some *i* = 1, 2, ..., *k*,
or ID(*i*) ≥ N, for some *i* = 1, 2, ..., *k*.

IFAIL = 3

On entry, at least one of the first *k* elements of TR is not equal to 'N', 'L' or 'S'.

IFAIL = 4

On entry, one or more of the elements of Z is invalid, for the transformation requested; that is, the user may be trying to log or square root a series, some of whose values are negative.

7 Accuracy

The computations are believed to be stable.

8 Further Comments

The same differencing operator does not have to be applied to all the series. For example, suppose we have *k* = 2, and wish to apply the second order differencing operator ∇^2 to the first series and the first order differencing operator ∇ to the second series:

$$w_{1t} = \nabla^2 z_{1t} = (1 - B)^2 z_{1t} = (1 - 2B + B^2) z_{1t}, \text{ and}$$

$$w_{2t} = \nabla z_{2t} = (1 - B) z_{2t}.$$

Then $d_1 = 2, d_2 = 1, d = \max(d_1, d_2) = 2$, and

$$\text{DELTA} = \begin{bmatrix} \delta_{11} & \delta_{12} \\ \delta_{21} & \delta_{22} \end{bmatrix} = \begin{bmatrix} 2 & -1 \\ 1 & 1 \end{bmatrix}.$$

9 Example

A program to difference (nonseasonally) each of two time series of length 48. No transformation is to be applied to either of the series.

9.1 Program Text

Note. The listing of the example program presented below uses bold italicised terms to denote precision-dependent details. Please read the Users' Note for your implementation to check the interpretation of these terms. As explained in the Essential Introduction to this manual, the results produced may not be identical for all implementations.

```
*      G13DLF Example Program Text
*      Mark 15 Release. NAG Copyright 1991.
*      .. Parameters ..
      INTEGER          NIN, NOUT
      PARAMETER       (NIN=5, NOUT=6)
```

```

INTEGER          KMAX, NMAX, IK, IDMAX
PARAMETER        (KMAX=3,NMAX=100,IK=KMAX,IDMAX=2)
*
.. Local Scalars ..
INTEGER          I, IFAIL, J, K, MAXD, MIND, N, ND
*
.. Local Arrays ..
  real           DELTA(IK,IDMAX), W(IK,NMAX), WORK(KMAX*NMAX),
+               Z(IK,NMAX)
INTEGER          ID(KMAX)
CHARACTER        TR(KMAX)
*
.. External Subroutines ..
EXTERNAL         G13DLF
*
.. Intrinsic Functions ..
INTRINSIC        MAX, MIN
*
.. Executable Statements ..
WRITE (NOUT,*) 'G13DLF Example Program Results'
*
Skip heading in data file
READ (NIN,*)
READ (NIN,*) K, N
IF (K.GT.0 .AND. K.LE.KMAX .AND. N.GT.0 .AND. N.LE.NMAX) THEN
  READ (NIN,*) (ID(I),I=1,K)
  MIND = 0
  MAXD = 0
  DO 20 I = 1, K
    MIND = MIN(MIND,ID(I))
    MAXD = MAX(MAXD,ID(I))
20  CONTINUE
  IF (MIND.GE.0 .AND. MAXD.LE.IDMAX) THEN
    DO 40 I = 1, K
      READ (NIN,*) (Z(I,J),J=1,N)
40  CONTINUE
    READ (NIN,*) (TR(I),I=1,K)
    IF (MAXD.GT.0) THEN
      DO 60 I = 1, K
        READ (NIN,*) (DELTA(I,J),J=1,ID(I))
60  CONTINUE
    END IF
    IFAIL = 0
*
    CALL G13DLF(K,N,Z,IK,TR,ID,DELTA,W,ND,WORK,IFAIL)
*
    WRITE (NOUT,*)
    WRITE (NOUT,*) ' Transformed/Differenced series'
    WRITE (NOUT,*) ' -----'
    DO 80 I = 1, K
      WRITE (NOUT,*)
      WRITE (NOUT,99999) ' Series ', I
      WRITE (NOUT,*) ' -----'
      WRITE (NOUT,*)
      WRITE (NOUT,99998) ' Number of differenced values = ', ND
      WRITE (NOUT,*)
      WRITE (NOUT,99997) (W(I,J),J=1,ND)
80  CONTINUE
*
    END IF
  END IF
  STOP
*
99999 FORMAT (1X,A,I2)

```

```

99998 FORMAT (1X,A,I6)
99997 FORMAT (1X,8F9.3)
      END

```

9.2 Program Data

```

G13DLF Example Program Data
2 48 1 : K, N
1 1 : ID(1), ID(2)
-1.490 -1.620 5.200 6.230 6.210 5.860 4.090 3.180
2.620 1.490 1.170 0.850 -0.350 0.240 2.440 2.580
2.040 0.400 2.260 3.340 5.090 5.000 4.780 4.110
3.450 1.650 1.290 4.090 6.320 7.500 3.890 1.580
5.210 5.250 4.930 7.380 5.870 5.810 9.680 9.070
7.290 7.840 7.550 7.320 7.970 7.760 7.000 8.350
7.340 6.350 6.960 8.540 6.620 4.970 4.550 4.810
4.750 4.760 10.880 10.010 11.620 10.360 6.400 6.240
7.930 4.040 3.730 5.600 5.350 6.810 8.270 7.680
6.650 6.080 10.250 9.140 17.750 13.300 9.630 6.800
4.080 5.060 4.940 6.650 7.940 10.760 11.890 5.850
9.010 7.500 10.020 10.380 8.150 8.370 10.730 12.140 : End of time series
'N' 'N' : TR(1), TR(2)
1.0 : delta(1,1)
1.0 : delta(2,1)

```

9.3 Program Results

G13DLF Example Program Results

Transformed/Differenced series

Series 1

Number of differenced values = 47

```

-0.130 6.820 1.030 -0.020 -0.350 -1.770 -0.910 -0.560
-1.130 -0.320 -0.320 -1.200 0.590 2.200 0.140 -0.540
-1.640 1.860 1.080 1.750 -0.090 -0.220 -0.670 -0.660
-1.800 -0.360 2.800 2.230 1.180 -3.610 -2.310 3.630
0.040 -0.320 2.450 -1.510 -0.060 3.870 -0.610 -1.780
0.550 -0.290 -0.230 0.650 -0.210 -0.760 1.350

```

Series 2

Number of differenced values = 47

```

-0.990 0.610 1.580 -1.920 -1.650 -0.420 0.260 -0.060
0.010 6.120 -0.870 1.610 -1.260 -3.960 -0.160 1.690
-3.890 -0.310 1.870 -0.250 1.460 1.460 -0.590 -1.030
-0.570 4.170 -1.110 8.610 -4.450 -3.670 -2.830 -2.720
0.980 -0.120 1.710 1.290 2.820 1.130 -6.040 3.160
-1.510 2.520 0.360 -2.230 0.220 2.360 1.410

```