NAG Library Function Document

nag_prob_chi_sq_vector (g01scc)

1 Purpose

nag_prob_chi_sq_vector (g01scc) returns a number of lower or upper tail probabilities for the
$\chi^2$-distribution with real degrees of freedom.

2 Specification

```c
#include <nag.h>
#include <nagg01.h>

void nag_prob_chi_sq_vector (Integer ltail,
             const Nag_TailProbability tail[],
             Integer lx, const double x[],
             Integer ldf, const double df[],
             double p[], Integer ivalid[],
             NagError *fail)
```

3 Description

The lower tail probability for the $\chi^2$-distribution with $\nu_i$ degrees of freedom, $P = (X_i \leq x_i : \nu_i)$ is
defined by:

$$P = (X_i \leq x_i : \nu_i) = \frac{1}{2^{\nu_i/2} \Gamma(\nu_i/2)} \int_0^{x_i} X_i^{\nu_i/2-1} e^{-X_i/2} \, dX_i, \quad x_i \geq 0, \nu_i > 0.$$  

To calculate $P = (X_i \leq x_i : \nu_i)$ a transformation of a gamma distribution is employed, i.e., a
$\chi^2$-distribution with $\nu_i$ degrees of freedom is equal to a gamma distribution with scale parameter 2 and
shape parameter $\nu_i/2$.

The input arrays to this function are designed to allow maximum flexibility in the supply of vector
arguments by re-using elements of any arrays that are shorter than the total number of evaluations
required. See Section 2.6 in the g01 Chapter Introduction for further information.

4 References

Publications


5 Arguments

1:  ltail – Integer  
    
    **Input**

    *On entry:* the length of the array *tail*.

    *Constraint:* *ltail* > 0.

2:  tail[ltail] – const Nag_TailProbability  
    
    **Input**

    *On entry:* indicates whether the lower or upper tail probabilities are required. For
    $j = (i - 1) \mod \text{ltail}$, for $i = 1, 2, \ldots, \max(\text{ltail}, \text{lx}, \text{ldf})$:
    
    *tail*[j] = Nag_LowerTail
    
    The lower tail probability is returned, i.e., $p_i = P(X_i \leq x_i : \nu_i)$.  

Mark 25

G01SCC
The upper tail probability is returned, i.e., \( p_i = P(X_i \geq x_i : \nu_i) \).

**Constraint:** \( \text{tail}[j - 1] = \text{Nag}\_\text{LowerTail} \text{ or } \text{Nag}\_\text{UpperTail}, \text{ for } j = 1, 2, \ldots, \text{ltail}. \)

3: \( \mathbf{l}\mathbf{x} \) - Integer  
*Input*

*On entry:* the length of the array \( \mathbf{x} \).

*Constraint:* \( \mathbf{l}\mathbf{x} > 0 \).

4: \( \mathbf{x}[\mathbf{l}\mathbf{x}] \) - const double  
*Input*

*On entry:* \( x_i \), the values of the \( \chi^2 \) variates with \( \nu_i \) degrees of freedom with \( x_i = \mathbf{x}[j] \), \( j = (i - 1) \mod \mathbf{l}\mathbf{x} \).

*Constraint:* \( \mathbf{x}[j - 1] \geq 0.0 \), for \( j = 1, 2, \ldots, \mathbf{l}\mathbf{x} \).

5: \( \mathbf{l}\mathbf{df} \) - Integer  
*Input*

*On entry:* the length of the array \( \mathbf{df} \).

*Constraint:* \( \mathbf{l}\mathbf{df} > 0 \).

6: \( \mathbf{df}[\mathbf{l}\mathbf{df}] \) - const double  
*Input*

*On entry:* \( \nu_i \), the degrees of freedom of the \( \chi^2 \)-distribution with \( \nu_i = \mathbf{df}[j] \), \( j = (i - 1) \mod \mathbf{l}\mathbf{df} \).

*Constraint:* \( \mathbf{df}[j - 1] > 0.0 \), for \( j = 1, 2, \ldots, \mathbf{l}\mathbf{df} \).

7: \( \mathbf{p}[\text{dim}] \) - double  
*Output*

*Note:* the dimension, \( \text{dim} \), of the array \( \mathbf{p} \) must be at least \( \max(\text{ltail}, \mathbf{l}\mathbf{df}, \mathbf{l}\mathbf{x}) \).

*On exit:* \( p_i \), the probabilities for the \( \chi^2 \) distribution.

8: \( \text{iinvalid}[\text{dim}] \) - Integer  
*Output*

*Note:* the dimension, \( \text{dim} \), of the array \( \text{iinvalid} \) must be at least \( \max(\text{ltail}, \mathbf{l}\mathbf{df}, \mathbf{l}\mathbf{x}) \).

*On exit:* \( \text{iinvalid}[i - 1] \) indicates any errors with the input arguments, with

\[
\begin{align*}
\text{iinvalid}[i - 1] &= 0 \\
& \text{No error.}
\end{align*}
\]

\[
\begin{align*}
\text{iinvalid}[i - 1] &= 1 \\
& \text{On entry, invalid value supplied in } \text{tail} \text{ when calculating } p_i.
\end{align*}
\]

\[
\begin{align*}
\text{iinvalid}[i - 1] &= 2 \\
& \text{On entry, } x_i < 0.0.
\end{align*}
\]

\[
\begin{align*}
\text{iinvalid}[i - 1] &= 3 \\
& \text{On entry, } \nu_i \leq 0.0.
\end{align*}
\]

\[
\begin{align*}
\text{iinvalid}[i - 1] &= 4 \\
& \text{The solution has failed to converge while calculating the gamma variate. The result returned should represent an approximation to the solution.}
\end{align*}
\]

9: \( \text{fail} \) - NagError *  
*Input/Output*

The NAG error argument (see Section 3.6 in the Essential Introduction).
6 Error Indicators and Warnings

NE_ALLOC_FAIL
Dynamic memory allocation failed.
See Section 3.2.1.2 in the Essential Introduction for further information.

NE_ARRAY_SIZE
On entry, array size $= \langle\text{value}\rangle$.
Constraint: $\text{ldf} > 0$.

On entry, array size $= \langle\text{value}\rangle$.
Constraint: $\text{ltail} > 0$.

On entry, array size $= \langle\text{value}\rangle$.
Constraint: $\text{lx} > 0$.

NE_BAD_PARAM
On entry, argument $\langle\text{value}\rangle$ had an illegal value.

NE_INTERNAL_ERROR
An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please contact NAG for assistance.

An unexpected error has been triggered by this function. Please contact NAG.
See Section 3.6.6 in the Essential Introduction for further information.

NE_NO_LICENCE
Your licence key may have expired or may not have been installed correctly.
See Section 3.6.5 in the Essential Introduction for further information.

NW_IVALID
On entry, at least one value of $x$, $\text{df}$ or $\text{tail}$ was invalid, or the solution failed to converge.
Check $\text{ivalid}$ for more information.

7 Accuracy
A relative accuracy of five significant figures is obtained in most cases.

8 Parallelism and Performance
Not applicable.

9 Further Comments
For higher accuracy the transformation described in Section 3 may be used with a direct call to nag_incomplete_gamma (s14bac).

10 Example
Values from various $\chi^2$-distributions are read, the lower tail probabilities calculated, and all these values printed out.
10.1 Program Text

/* nag_prob_chi_sq_vector (g01scc) Example Program.*/
/* Copyright 2014 Numerical Algorithms Group.*/
/* Mark 23, 2011.*/
#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagg01.h>

int main(void)
{
    /* Integer scalar and array declarations */
    Integer ltail, lx, ldf, i, lout;
    Integer *ivalid = 0;
    Integer exit_status = 0;
    /* NAG structures */
    NagError fail;
    Nag_TailProbability *tail = 0;
    /* Double scalar and array declarations */
    double *x = 0, *df = 0, *p = 0;
    /* Character scalar and array declarations */
    char ctail[40];
    /* Initialise the error structure to print out any error messages */
    INIT_FAIL(fail);
    printf("nag_prob_chi_sq_vector (g01scc) Example Program Results\n\n");
    /* Skip heading in data file*/
    #ifdef _WIN32
        scanf_s("%*[`\n ");
    #else
        scanf("%*[`\n ");
    #endif
    /* Read in the input vectors */
    #ifdef _WIN32
        scanf_s("%"NAG_IFMT"%*[`\n ", &ltail);
    #else
        scanf("%"NAG_IFMT"%*[`\n ", &ltail);
    #endif
    if (! (tail = NAG_ALLOC(ltail, Nag_TailProbability))) {
        printf("Allocation failure\n");
        exit_status = -1;
        goto END;
    }
    for (i = 0; i < ltail; i++) {
        #ifdef _WIN32
            scanf_s("%39s", ctail, _countof(ctail));
        #else
            scanf("%39s", ctail);
        #endif
        tail[i] = (Nag_TailProbability) nag_enum_name_to_value(ctail);
    }
    #ifdef _WIN32
        scanf_s("%"NAG_IFMT"%*[`\n ", &lx);
    #else
        scanf("%"NAG_IFMT"%*[`\n ", &lx);
    #endif
END:
        return exit_status;
    }
}
if (!(x = NAG_ALLOC(lx, double))) {
    printf("Allocation failure\n");
    exit_status = -1;
    goto END;
}
for (i = 0; i < lx; i++)
    #ifdef _WIN32
        scanf_s("%lf", &x[i]);
    #else
        scanf("%lf", &x[i]);
    #endif
    #ifdef _WIN32
        scanf_s("%*[\n ] ");
    #else
        scanf("%*[\n ] ");
    #endif
    #ifdef _WIN32
        scanf_s("%"NAG_IFMT"%*[\n ] ", &ldf);
    #else
        scanf("%"NAG_IFMT"%*[\n ] ", &ldf);
    #endif
    if (!(df = NAG_ALLOC(ldf, double))) {
        printf("Allocation failure\n");
        exit_status = -1;
        goto END;
    }
for (i = 0; i < ldf; i++)
    #ifdef _WIN32
        scanf_s("%lf", &df[i]);
    #else
        scanf("%lf", &df[i]);
    #endif
    #ifdef _WIN32
        scanf_s("%*[\n ] ");
    #else
        scanf("%*[\n ] ");
    #endif
	/* Allocate memory for output */
lout = MAX(ltail,MAX(lx,ldf));
if (!(p = NAG_ALLOC(lout, double)) ||
    !(ivalid = NAG_ALLOC(lout, Integer))) {
    printf("Allocation failure\n");
    exit_status = -1;
    goto END;
}
	/* Calculate probability */
nag_prob_chi_sq_vector(ltail, tail, lx, x, ldf, df, p, ivalid, &fail);
if (fail.code != NE_NOERROR) {
    printf("Error from nag_prob_chi_sq_vector (g01scc).\n%sn", fail.message);
    exit_status = 1;
    if (fail.code != NW_IVALID) goto END;
}
	/* Display title */
printf(" tail x df p ivalid\n");
printf(" --------------------------------------------------------\n");
	/* Display results */
for (i = 0; i < lout; i++)
    printf(" %15s %6.3f %6.1f %6.4f %3"NAG_IFMT"\n",
        nag_enum_value_to_name(tail[i%ltail]), x[i%lx], df[i%ldf],
        p[i], ivalid[i]);
END:
NAG_FREE(tail);
10.2 Program Data

nag_prob_chi_sq_vector (g01scc) Example Program Data

1 :: ltail
Nag_LowerTail :: tail
3 :: lx
8.26 6.2 55.76 :: x
3 :: ldf
20.0 7.5 45.0 :: df

10.3 Program Results

nag_prob_chi_sq_vector (g01scc) Example Program Results

<table>
<thead>
<tr>
<th>tail</th>
<th>x</th>
<th>df</th>
<th>p</th>
<th>invalid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nag_LowerTail</td>
<td>8.260</td>
<td>20.0</td>
<td>0.0100</td>
<td>0</td>
</tr>
<tr>
<td>Nag_LowerTail</td>
<td>6.200</td>
<td>7.5</td>
<td>0.4279</td>
<td>0</td>
</tr>
<tr>
<td>Nag_LowerTail</td>
<td>55.760</td>
<td>45.0</td>
<td>0.8694</td>
<td>0</td>
</tr>
</tbody>
</table>