FORTRAN Programs

The programs included in this distribution primarily allow the implementation and evaluation of the operating characteristics of selection and screening procedures described in Bechhofer, Santner and Goldsman (1995). In addition to these programs there is a variety of commercial and public domain software available to implement various simultaneous confidence methods that are described in the text. Perhaps the most widely available commercial software is that for computing Tukey simultaneous confidence intervals for all pairwise treatment means (Section 4.3) and Dunnett simultaneous confidence intervals for comparing t treatment means with a control mean (Section 5.4). More recently, several packages have added Hsu simultaneous confidence intervals for the difference between each treatment mean and the best of the other treatment means (Section 4.4). Examples of software that calculate Hsu intervals are MINITAB (as a subcommand of "ONEWAY" in Release 8 and higher) and JMP (in the "FIT Y BY X" platform in Version 2 and higher).

We also make special mention of the very useful public domain FORTRAN programs `MVNPRD` and `MVTPRD` in Dunnett (1989) that compute probabilities of rectangular regions for multivariate normal and multivariate t-distributions with product correlation structure, that is, correlations of the form $\lambda_i \times \lambda_j$ for $i \neq j$. These programs can be obtained via ftp from the statlib archive maintained at Carnegie Mellon University at the Internet address lib.stat.cmu.edu (128.2.241.142) or at the address http://lib.stat.cmu.edu/apstat/. The `MVNPRD` [`MVTPRD`] program calculates

$$P\{a_i \leq W_i \leq b_i \ \ (1 \leq i \leq p)\}$$

for given a_i and b_i when $\boldsymbol{W} = (W_1, \ldots, W_p)$ has the multivariate normal distribution [multivariate t-distribution with arbitrary degrees of freedom] with arbitrary mean vector, unit variances and product correlation structure. Dunnett's programs allow any of the endpoints a_i to be $-\infty$ and any of the endpoints b_i to be $+\infty$. (Note that using `MVTPRD` with the internal variable `NDF = 0` invokes `MVNPRD`.)

As an example, consider the calculation of the critical point h required to implement the version of procedure $\mathcal{N}_B$ that selects the s best of t treatments (Section 2.5.1). In terms of the notation of this Appendix, we are required to solve

$$P\{-\infty < W_i \leq h/\sqrt{2} \ \ (1 \leq i \leq t-s); \ 0 < W_i < \infty \ \ (t-s+1 \leq i < t)\} = P^\star/s \quad (0.1)$$

for h, where $(W_1, \ldots, W_{t-1})$ has the multivariate normal distribution with mean vector zero, unit variances and common correlation $1/2$. We take $\lambda_i = 1/\sqrt{2}$ for $1 \leq i < t$, $(a_i, b_i) = (-\infty, h)$ for $1 \leq i \leq t-s$ and $(a_i, b_i) = (0, +\infty)$ for $t-s+1 \leq i < t$ and use `MVNPRD` together with a bisection method or some other zero-finding method to solve (0.1). In particular, the Dunnett programs can be used to determine $Z^{(1-P^\star)}_{p,1/2}$ and $T^{(1-P^\star)}_{p,\nu,1/2}$. However, because $Z^{(1-P^\star)}_{p,1/2}$ is frequently occurring and simple to compute, we include the stand-alone program `USENB` to determine its value.

The main stand-alone programs in this Appendix are described in 1–7, below. Grouped by function, the programs `USENB` and `UNEQNB` evaluate quantities related to the Bechhofer procedure $\mathcal{N}_B$, `NPMC` uses Monte Carlo simulation to study performance characteristics of Paulson's procedure $\mathcal{N}_P$, `RINOTT` calculates constants necessary for procedure $\mathcal{N}_R$, `EVALNG` evaluates performance quantities for the Gupta procedure $\mathcal{N}_G$, `USEGSA` determines constants needed to implement procedure $\mathcal{N}_{GSa}$, and `BPMC` uses Monte Carlo simulation to study performance characteristics of Paulson's procedure $\mathcal{B}_P$. The main program programs are available as executable programs (compiled for use in an MS-DOS window, assuming a pentium class PC and as source code. In addition the main programs, the source code distribution adds the INCLUDE file GLQUAD, and the functions and subroutine given in A–I, below.

Main FORTRAN Programs

1. `USENB`

Description: Calculates $P^\star$, $\delta^\star$ or n so that procedure $\mathcal{N}_B$ from Section 2.2 satisifies the probability requirement (2.1.1) for fixed t and σ.

2. `UNEQNB`

Description: Computes the $P\{\text{CS} \mid \text{LF}\}$ in (2.2.5) for procedure $\mathcal{N}_B$ for fixed t and σ and given $\delta^\star$ and $(n_{(1)}, \ldots, n_{(t)})$.

3. `NPMC`

Description: Uses Monte Carlo simulation to study performance characteristics of Paulson's normal means procedure $\mathcal{N}_P$ from Section 2.3.3.

4. `RINOTT`

Description: Can be used to extend the Rinott tables in Section 2.8.

5. `EVALNG`

Description: Uses Monte Carlo simulation to to study performance characteristics of procedure $\mathcal{N}_G$ from Section 3.2.1.

6. `BOFINGER`

Description: Calculates the critical constant h for the procedure N_{CGHBM} from Section 3.4.1 using the Bofinger-Mengersen critical point.

7. `USEGSA`

Description: Calculates n, h or $\delta^\star$ so that procedure $\mathcal{N}_{GSa}$ from Section 3.4.3 satisfies the probability requirement (3.4.7) for fixed t and σ and given q and $P^\star$.

8. `BPMC`

Description: Uses Monte Carlo simulation to study performance characteristics of Paulson's Bernoulli procedure $\mathcal{B}_P$ from Section 7.4.2

Supporting FORTRAN Common Input File, Functions and Subroutines

A. `GLQUAD`

Description: Input file containing weights and zeroes to compute 64-point Gauss-Laguerre quadrature.

B. `ZCDF`

Description: Function that approximates the $N(0,1)$ c.d.f. using Equation (26.2.17) from Abramowitz and Stegun (1972).

C. `FACTOR`

Description: Function that calculates $n!/x!(n-x)!$ where n, x and $(n-x) \geq 0$.

D. `MULTZ`

Description: Function that calculates $Z_{p,1/2}^{(1-P^{\star})}$.

E. `PCSNB`

Description: Function that evaluates the $P\{\text{CS}\}$ for procedure $\mathcal{N}_B$ at the slippage configuration $\boldsymbol{\mu} = (0,\ldots,0,\delta)$, for fixed t and σ and respective sample sizes $(n(1),\ldots,n(t))$.

F. `PCSNGS`

Description: Function that evaluates the $P\{\text{CS}\}$ for procedure $\mathcal{N}_{GSa}$ at the slippage configuration $\boldsymbol{\mu} = (0,\ldots,0,\delta)$, for fixed t and σ and specified q, n and yardstick h.

G. `UNIF`

Description: Function that generates U(0,1) random numbers using code from Bratley, Fox and Schrage (1987).

H. `RNORML`

Description: Function that generates standard normal random variates using code from Bratley, Fox and Schrage (1987).

I. `STATS`

Description: Subroutine that calculates sample averages and variances.