A Taylor-Russell/Naylor-Shine Utility Calculator

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A program for calculating the Taylor-Russell and Naylor-Shine utility estimates is described. These utility estimates are used for determining the benefit to an organization of certain personnel interventions such as training and selection. Calculation of these estimates involves inversion of the standard normal cumulative distribution function and computation of the standard bivariate normal integral.

Articles about the use of utility theory for determining the value of human resource interventions have proliferated during the last decade. This is because the theory attempts to quantify the practical significance of psychological interventions, even to the extent of specifying their worth in dollars and cents. Three models dominate the field: the Taylor-Russell model (Taylor & Russell, 1939), the Naylor-Shine model (Naylor & Shine, 1965), and the Brogden model (Brogden, 1946, 1949; Cronbach & Gleser, 1957). Although the Brogden model currently holds greatest interest for researchers, the other two models are gaining broader application as knowledge of utility theory increases among practitioners.

The Taylor-Russell and Naylor-Shine models have changed little in recent years because they apply in fairly specific circumstances. For this reason, the present paper focuses on these two models only. The controversy that continues to surround particular uses of the Brogden model (Cascio & Morris, 1990; Cronshaw & Alexander, 1991; Hunter, Schmidt, & Coggin, 1988), does not pertain to the Taylor-Russell and Naylor-Shine models because they do not attempt a mapping onto dollar value. The Taylor-Russell model expresses utility as a conditional probability, which is interpreted as the percent increase in performance due to use of the selection device over the current standard. The Naylor-Shine model expresses utility in terms of an increase in standardized criterion scores. All these methods provide some indication of the usefulness of a selection device; and, although the Brogden model probably provides the most intriguing utility scale, the use of the Taylor-Russell and Naylor-Shine models is more well defined (Cascio, 1987a, 1987b).

Application of computer technology has been slow in coming to the field, and practitioners must still rely on the use of look-up tables and hand calculation. Cascio

(1987b) reproduced the original Taylor-Russell and Naylor-Shine tables in his widely used book on "costing" the human resource function in organizations. To make the Taylor-Russell and Naylor-Shine approaches to utility estimation more accessible, this paper describes a computer program, written in the C programming language, for implementing the models. The program is particularly useful for calculating values that lie outside those included in existing tables, since neither Taylor and Russell (1939) nor Naylor and Shine (1965) presented methods for interpolating between values in their tables.

The Taylor-Russell Model

The model underlying the Taylor-Russell tables is simply the standard bivariate normal distribution. Values presented in the published tables, denoted here as $TR(h, k, r)$, are given by

$$TR(h, k, r) = \frac{\int_h^\infty \int_k^\infty f(x, y, r) dx dy}{\int_h^\infty \int_{-\infty}^\infty f(x, y, r) dx dy}, \quad (1)$$

where

$$f(x, y, r) = \frac{e^{-\left(\frac{x^2 + 2xyr + y^2}{2(1-r^2)}\right)}}{2\pi\sqrt{1-r^2}} \quad (2)$$

is the standard bivariate normal probability density function (pdf), h is the point defining the selection ratio (the proportion of the applicant population lying above the cut score on the predictor); k is the point defining the base rate (the proportion of job incumbents considered successful); and r is the validity coefficient of the selection device. Clearly the criterion and predictor distributions are dichotomized under this model. In some applications, such dichotomization may be undesirable, in which case one of the other models may be used. The program described here outputs values of $TR(h, k, r)$, according to Equation 1. Integration of the standard bivariate normal pdf is all that is required for calculation of the Taylor-Russell results. A closed form does not exist for this integral, however, so it must be evaluated numerically.

The Naylor-Shine Model

The model underlying the Naylor-Shine tables is given by

$$\bar{Z}_c = r \frac{\lambda}{sr}, \quad (3)$$

where $\bar{Z}_c$ is the mean criterion score of the selected group in standard score units, r is the validity coefficient of the selection device, λ is the ordinate of the standard normal distribution at h , and sr is the selection ratio defined by h .

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This model indexes utility as the improvement in the standardized criterion score as a result of selection. It is widely considered to be more generally applicable than the Taylor-Russell model, because it does not assume a dichotomous criterion. Unlike the Taylor-Russell model, which expresses utility as a percentage, the Naylor-Shine model expresses utility according to the criterion scale.

The published Naylor-Shine tables do not contain the value $\bar{Z}_c$ given by Equation 3, since Naylor and Shine compute only λ/sr and require the user to perform the final multiplication by r . The tables also contain two entry points, the selection ratio and the cutoff score on the predictor in standard score units. Since these two values are functions of each other (under the usual assumption of normality) and the selection ratio is more commonly used, the program only requires entry of the selection ratio.

The program does not directly address the following problem: Given a targeted mean criterion score in the selected group, what selection ratio should be used to reach that target? This problem can be solved either by trial and error or by modifying the program. In any case, the evaluation of Equation 3 is the most common application of the model.

Method

The program was written with the Microsoft C Optimizing Compiler (Version 6.0; Microsoft, 1990) for use on IBM-PC-compatible implements two numerical methods: one for inverting the standard cumulative normal distribution function, and the other for integrating the standard bivariate normal pdf. Calculation of the standard normal pdf can be done exactly. Inversion of the standard cumulative normal is performed via the method of algebraic polynomials (Kennedy & Gentle, 1980). Several methods were considered for integration of the bivariate normal; the method finally chosen combined the approaches of Owen (1956) and Gideon and Gurland (1978).

The program prompts for input of the validity coefficient, selection ratio, and base rate and then prints the resulting Taylor-Russell and Naylor-Shine values. For example, three statistics are input: (1) the validity coefficient, 0.5; (2) the selection ratio, 0.5; and (3) the base rate, 0.5. This results in the following output: Taylor-Russell, 0.667; Naylor-Shine, 0.399. In addition, a familiar "Taylor-Russell Table" of values of TR is printed for the input base rate and various values of the selection ratio and validity coefficient.

Summary

A C program has been presented for calculating values from two widely used utility models—the Taylor-Russell

model and the Naylor-Shine model. It is hoped that this will assist researchers and practitioners in the wider application of these models. Although these models do not express utility in dollar value, they do indicate the usefulness of a selection device. The Taylor-Russell model does so in terms of percent improvement in performance of those selected; the Naylor-Shine model does so in terms of average increase in criterion score.

Availability

Copies of the program are available from the author via e-mail at b.hesketh@unsw.edu.au.

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