BOOK REVIEWS

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DONALD B. OWEN, *Handbook of Statistical Tables*. Addison-Wesley Publishing Company, Inc., Reading, Massachusetts, 1962. $12.75, £4.14.0. xii + 580 pp.

Review by E. S. PEARSON

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It is exactly 50 years since the publication of Karl Pearson's pioneer *Tables for Statisticians and Biometricians*, and the contrast between the problems faced by a table editor, then and now, is striking. In the early years of the century the difficulty was to find the human labour for hand computing and the funds required to support publication, so that starting in an almost virgin field the preparation of Pearson's volume was spread over some 15 years. In contrast, today's digital computer has made calculation so easy that tables of individual functions are being turned out almost indiscriminately, where and whenever there is free computer time. And so it happens that while in 1914, Pearson could just fill a volume by including all the tables which he and his collaborators had computed up to date, the present day editor of a book of general statistical tables is faced with an embarrassing problem of selection. As a result, his choice will inevitably be to some extent a personal one, depending partly on his own research interests and partly even on the particular rough and ready statistical techniques which he favours.

Dr. Owen's *Handbook* contains 114 tables or charts. While there would be considerable agreement among statisticians on the 20 or 30 most important functions to be tabled, it is clear that there would be far less agreement on the last 50 out of 100! There are a number of tables in this volume which the reviewer cannot imagine wanting to use, and others not included which he would like to use. His reaction, however, is not one of criticism, rather of gratitude because the compiler has brought so much together, sometimes carrying out pioneer computations and always it seems making a critical check on the accuracy of old figures.

The Preface states that the book is intended for three classes of reader: (a) "the student in statistics who needs some readily accessible tables to be used in conjunction with his courses in statistics; (b) the practicing statistician, quality control man, or industrial engineer who wants a set of tables from which he can obtain answers with a minimum of interpolation and other calculations; and (c) the research worker who will find in this collection many functions more extensively tabulated than ever before." The plan has been well fulfilled although it seems likely that the quality control man will need some guidance as to where

to find just what will be useful to him, as the handbook does not illustrate the use of the tables on numerical data.

The research worker also will need a little time to discover among so much just where to locate new results or tabulations more extensive than are available elsewhere. The reviewer must be content to refer to a selected number of items which have struck him in turning over the pages. The figures in parentheses refer to Table numbers.

What may be termed the basic functions of the statistician's "normal theory" have been presented very fully. Thus the normal distribution functions $P(X)$ and $Z(X)$ are given to six decimals and the ratios Q/Z and P/Z to five significant figures (1.1). The critical values of t (2.1) and χ^2 (3.1) are given to four and three decimal places, respectively, with degrees of freedom $f = 1$ (1) 100 (2) 150 (50) 300 (100) 1000. These entries for high values of f are useful for a number of purposes, for instance in providing a check on the accuracy of methods of approximation. On the other hand the number of significance levels provided (upper and lower for χ^2) is perhaps rather on the short side: 25, 10, 5, 2.5, 1.0 and 0.5 percent.

For the F-distribution (4.1) four decimals are tabled with a 50 per cent critical value added to the six levels just mentioned. The degrees of freedom go by units up to $f_1 = 15, f_2 = 30$ and afterwards by the harmonics of 120 with one or two additional values interspersed.

Six pages of tables, following the compact arrangement first suggested by Johnson and Welch, give some basic results for the non-central t-distribution (5.1, 5.2).

These early sections of the volume include some tables and charts, more particularly directed to the category (b) user. They give the operating characteristics of standard tests, the sizes of sample needed to achieve a given chance of discrimination and so on (e.g. 1.5, 1.6, 1.7, 3.2, 3.3, 3.4, 4.2). Into this category falls a nine page table of one-sided tolerance limit factors for a normal distribution (5.3) based on non-central t and Weissberg and Beatty's ten page table (5.4) to be used in making (with confidence coefficient γ) the statement: "at least a proportion P of the normal distribution sampled lies between $\bar{x} \pm ks$."

The section on the range, w, in normal samples includes tables of critical values of w (6.1), of $(\bar{x} - \mu_0)/w$ and $(\bar{x}_1 - \bar{x}_2)/\frac{1}{2}(w_1 + w_2)$, used in analogues of Student's t-test (6.3, 6.4) and of the studentized range w/s (6.5). In the last case, it is not quite clear why in selecting from the more detailed table of Harter, the author has chosen the particular values $f = 1, 3, 5, 10, 15, 20, 60, \infty$ for the degrees of freedom of s. It seems doubtful whether interpolation for intermediate values would be easy; here and elsewhere a guiding statement about interpolation would have been helpful.

A Section (7) containing four tables concerned with normal order statistics is followed by a valuable section of 84 pp. containing 15 tables dealing with different aspects of bivariate and multivariate normal distributions. Here, collected

from various sources are included: a table (i) of offset probabilities for the circular normal distribution (8.2); (ii) of Owen's function $T(h, a)$ for computing bivariate normal probabilities (8.5); (iii) of Steck's function to be used in computing probabilities in the trivariate case (8.9); (iv) of various functions associated with multivariate distributions in cases where the correlations are equal (8.10–8.12); and (v) Heck's 12 charts of some upper percentage points of the distribution of the largest characteristic root of certain matrices commonly met in multivariate analysis (8.14).

Tables of cumulative probabilities of the Poisson, Binomial and Hypergeometric functions (9.3, 9.5, 18.1) do not of course claim to be complete but would give, for example, ample material for illustrative purposes for the student. As an aid to the working statistician we find tables of confidence limits for the Poisson parameter (9.4) and for a proportion (9.6), and a table in a new form for testing significance in a 2×2 table (18.2).

Four tables are allocated to the Wilcoxon-Mann-Whitney two-sample test (11.2–11.5). While the value of this important non-parametric test is unquestionable, it is not clear why it was necessary to give the cumulative distribution and critical values for the statistic in *both* the U (Mann-Whitney) and the T (Wilcoxon) forms. Section 12 deals with sign, runs and quadrant tests (14 tables), Section 13 with rank correlation (2 tables), Sections 15 and 16 with Kolmogorov-Smirnov-Cramér-von Mises statistics (10 tables).

There are tables of useful transformations included in appropriate sections, e.g. of $\phi = 2 \arcsin \sqrt{p}$, $\phi' = 2 \operatorname{arcsinh} \sqrt{x}$ (9.9, 9.10) and $z = \tanh^{-1} r$ (19.2). There is a single-page table of quantities required in orthogonal polynomial fitting (20.1) which would help to illustrate theory in a student course and finally 20 pp. of random numbers (20.2) and the common form of table containing numerical values of special constants (20.3).

A few comments are needed on the arrangement and presentation of the *Handbook*. There is no general Introduction but a description is printed before each table or chart. This defines briefly the function dealt with and gives some indication of its uses and of the method of computation; it also contains numbered references both to other tables and the most relevant literature and often to places where illustrations of the use of techniques requiring the table may be found. Within the limits set, these introductory remarks are on the whole models of conciseness and clarity, but the reader must not expect to find in them illustrative examples and scarcely any comment on methods of interpolation. The tables have been reproduced by a photo-offset process, where possible directly from the output of computers. Such a procedure is sometimes inevitably rather wasteful of space, but there is evidence that careful thought has been given to the arrangement on a page. One only rarely finds the annoying repetition of useless zeros which have tended to appear in a number of recent computer-output reproductions.

From the student's point of view it is a pity that even with this form of table

reproduction the volume has still to be priced at $12.75. In spite of its 580 pp. it is, however, still a "handbook", though only experience can show how far the paper will stand up to constant use.

Today it is sometimes stated that once programmes for standard computations are available, the statistician will have no need of printed tables. It is difficult, however, to believe that the working statistician will ever cease to need a book of collected tables at hand on his desk, and even the writer on theory can gain much by having immediate access to tables expressing his functions in numerical terms. Dr. Owen's book will clearly stand as one of the relatively few published volumes filling this need.