

THE ANNALS *of* STATISTICS

AN OFFICIAL JOURNAL OF
THE INSTITUTE OF MATHEMATICAL STATISTICS

	PAGE
Jaroslav Hájek, 1926–1974	VÁCLAV DUPAČ 1031
Articles	
Descriptive statistics for nonparametric models	P. J. BICKEL AND E. L. LEHMANN
I. Introduction	1038
II. Location	1045
The behavior of robust estimators on dependent data	JOSEPH L. GASTWIRTH AND HERMAN RUBIN 1070
Convergence of empirical processes of mixing rv's on [0,1]	C. S. WITHERS 1101
Asymptotically efficient estimators for a constant regression with vector-valued stationary residuals	ROLF K. ADENSTEDT 1109
Asymptotically robust tests in unbalanced variance component models	JAMES N. ARVESEN AND MAXWELL W. J. LAYARD 1122
A method of constrained randomization for $p_1^{n_1} p_2^{n_2} \cdots p_k^{n_k}$ factorials	RICHARD L. SCHWALLER AND KENNETH J. TIAHRT 1135
Resistance of balanced incomplete block designs	BERNARD M. MOST 1149
A simple general approach to inference about the tail of a distribution	BRUCE M. HILL 1163
Short Communications	
A note on substitution in conditional distribution	MICHAEL D. PERLMAN AND MICHAEL J. WICHURA 1175
On a theorem of Morimoto concerning sufficiency for discrete distri- butions	L. BROWN 1180
Estimation of the variance of a branching process	JEAN-PIERRE DION 1183
Note	
Correction to "Upper confidence and fiducial limits to the range of several means"	B. CAUSEY 1188

Vol. 3, No. 5—September 1975

THE INSTITUTE OF MATHEMATICAL STATISTICS

(Organized September 12, 1935)

The purpose of the Institute of Mathematical Statistics is to encourage the development, dissemination, and application of mathematical statistics.

OFFICERS

President:

Donald L. Burkholder, Department of Mathematics, University of Illinois, Urbana, Illinois 61801

President-Elect:

C. Radhakrishna Rao, Indian Statistical Institute, Yojana Bhavan, New Delhi-1, India, 38 44 95.

Past President

Frederick Mosteller, Department of Statistics, Science Center, Room 603, Harvard University, One Oxford Street, Cambridge, Mass. 02138

Executive Secretary:

George J. Resnikoff, Department of Statistics, California State University, 25800 Hillary St., Hayward, California 94542

Treasurer:

Robert M. Elashoff, M.R. IV-Room 111, University of California, San Francisco, California 94143
IMS Business Office, 1367 Laurel Street, San Carlos, California 94070

Program Secretary:

William L. Harkness, Pennsylvania State University, University Park, Pennsylvania 16801

Editor: *Annals of Statistics*

I. Richard Savage, Department of Statistics, P.O. Box 2179, Yale Station, New Haven, Connecticut 06520

Editor: *Annals of Probability*

Ronald Pyke, Department of Mathematics, University of Washington, Seattle, Washington 98195

Managing Editor:

Donald R. Truax, Department of Mathematics, University of Oregon, Eugene, Oregon 97403

Membership. Membership dues including a subscription to one *Annals* and *The Institute of Mathematical Statistics Bulletin* are \$18.00 per year for residents of the United States or Canada and \$12.00 per year for residents of other countries. Special rates of \$9.00 per year are available to students. Rates in each category are one-third higher for members who wish both *Annals* as well as the *Bulletin*. Inquiries regarding membership in the Institute should be sent to the Treasurer of the Institute.

Subscription Rates. Current volumes (six issues per calendar year) of the *Annals of Probability* and the *Annals of Statistics* are each \$25.00. Members of the Institute of Mathematical Statistics pay different rates (see above). Single issues are \$5.00. Back numbers of both *Annals* and the *Annals of Mathematical Statistics* (Volume 1 through 43) may be purchased from the Treasurer.

The Annals of Statistics, Volume 3, Number 5, September 1975. Published bimonthly in January, March, May, July, September, and November by The Institute of Mathematical Statistics, IMS Business Office, 1367 Laurel Street, San Carlos, California 94070.

Mail to the *Annals of Statistics* should be addressed to either the Editor, Managing Editor or the Treasurer as described above. It should *not* be addressed to Waverly Press.

PRINTED AT THE

WAVERLY PRESS, INC., BALTIMORE, MARYLAND 21202 U.S.A.

Second-class postage paid at San Francisco, California and at additional mailing offices

Copyright © 1975 by the Institute of Mathematical Statistics

EDITORIAL STAFF

EDITOR

I. RICHARD SAVAGE

ASSOCIATE EDITORS

ROBERT BERK
DONALD A. BERRY
PETER J. BICKEL
DAVID R. BRILLINGER
L. BROWN
ARTHUR DEMPSTER
J. DURBIN
ROGER H. FARRELL
PETER C. FISHBURN
J. K. GHOSH

DAVID L. HANSON
A. HEDAYAT
AGNES M. HERZBERG
SOREN JOHANSEN
JOSEPH B. KADANE
CHARLES KRAFT
M. R. LEADBETTER
PI-ERH LIN
ALBERT W. MARSHALL
MICHAEL D. PERLMAN

JOHANN PFANZAGL
J. N. K. RAO
J. SETHURAMAN
GALEN R. SHORACK
DAVID O. SIEGMUND
CHARLES STONE
HOWARD TAYLOR
CONSTANCE VAN EEDEN
W. R. VAN ZWET
GRACE WAHBA
ROY E. WELSCH
DONALD YLVISAKER

MANAGING EDITOR

D. R. TRUAX

PAST EDITORS OF THE ANNALS OF MATHEMATICAL STATISTICS

H. C. CARVER, 1930-1938
S. S. WILKS, 1938-1949
T. W. ANDERSON, 1950-1952
E. L. LEHMANN, 1953-1955
T. E. HARRIS, 1955-1958

WILLIAM KRUSKAL, 1958-1961
J. L. HODGES, JR., 1961-1964
D. L. BURKHOLDER, 1964-1967
Z. W. BIRNBAUM, 1967-1970
INGRAM OLKIN, 1970-1972

PAST EDITOR OF THE ANNALS OF STATISTICS

INGRAM OLKIN, 1972-1973

EDITORIAL POLICY

The main aim of the *Annals of Statistics* and the *Annals of Probability* is to publish original contributions related to the theory of statistics and probability. The emphasis is on quality, importance and interest; formal novelty and mathematical correctness alone are not sufficient. Particularly appropriate for the *Annals* are important theoretical papers and applied contributions which either stimulate theoretical interest in important new problems or make substantial progress in existing applied areas. Of special interest are authoritative expository or survey articles, whether on theoretical areas of vigorous recent development, or on specific applications. All papers are refereed.

IMS INSTITUTIONAL MEMBERS

AEROSPACE CORPORATION
El Segundo, California

THE AMERICAN COLLEGE TESTING PROGRAM
Iowa City, Iowa

ARIZONA STATE UNIVERSITY
Tempe, Arizona

ARTHUR D. LITTLE, INC.
Cambridge, Massachusetts

BELL TELEPHONE LABORATORIES, TECHNICAL LIBRARY
Murray Hill, N. J.

BOWLING GREEN STATE UNIVERSITY, DEPT. OF MATHEMATICS
Bowling Green, Ohio

CALIFORNIA STATE UNIVERSITY, FULLERTON, DEPARTMENT OF MATHEMATICS
Fullerton, California

CALIFORNIA STATE UNIVERSITY, HAYWARD, DEPARTMENT OF STATISTICS
Hayward, California

CASE WESTERN RESERVE UNIVERSITY, DEPARTMENT OF MATHEMATICS
Cleveland, Ohio

CORNELL UNIVERSITY, DEPARTMENT OF MATHEMATICS
Ithaca, New York

FLORIDA STATE UNIVERSITY, DEPARTMENT OF STATISTICS
Tallahassee, Florida

FORD MOTOR COMPANY, ENGINEERING AND RESEARCH LIBRARY
Dearborn, Michigan

GENERAL MOTORS CORPORATION, RESEARCH LABORATORIES
Warren, Michigan

GEORGE WASHINGTON UNIVERSITY, DEPARTMENT OF STATISTICS
Washington, D.C.

INDIANA UNIVERSITY, MATHEMATICS DEPT.
Bloomington, Indiana

INSTITUTE FOR DEFENSE ANALYSES
Arlington, Virginia

INTERNATIONAL BUSINESS MACHINES CORPORATION
Armonk, New York

IOWA STATE UNIVERSITY, STATISTICAL LABORATORY
Ames, Iowa

JOHNS HOPKINS UNIVERSITY, DEPARTMENT OF BIostatISTICS, DEPARTMENT OF MATHEMATICAL SCIENCES
Baltimore, Maryland

KANSAS STATE UNIVERSITY, DEPARTMENT OF STATISTICS
Manhattan, Kansas

KNOLLS ATOMIC POWER LABORATORY
Schenectady, New York

MIAMI UNIVERSITY, DEPARTMENT OF MATHEMATICS
Oxford, Ohio

MICHIGAN STATE UNIVERSITY, DEPARTMENT OF STATISTICS AND PROBABILITY
East Lansing, Michigan

NATIONAL SECURITY AGENCY
Fort George G. Meade, Maryland

NEW MEXICO STATE UNIVERSITY, DEPARTMENT OF MATHEMATICAL SCIENCES
Las Cruces, New Mexico

NORTHWESTERN UNIVERSITY, DEPARTMENT OF MATHEMATICS
Evanston, Illinois

OHIO STATE UNIVERSITY, DIVISION OF STATISTICS
Columbus, Ohio

OREGON STATE UNIVERSITY, DEPARTMENT OF STATISTICS
Corvallis, Oregon

PENNSYLVANIA STATE UNIVERSITY, DEPARTMENT OF STATISTICS
University Park, Pennsylvania

PRINCETON UNIVERSITY, DEPARTMENT OF STATISTICS
Princeton, New Jersey

PURDUE UNIVERSITY LIBRARIES
Lafayette, Indiana

RICE UNIVERSITY, DEPARTMENT OF MATHEMATICAL SCIENCES
Houston, Texas

THE ROCKEFELLER UNIVERSITY
New York, New York

SANDIA CORPORATION, SANDIA BASE
Albuquerque, New Mexico

SIMON FRASER UNIVERSITY, DEPARTMENT OF MATHEMATICS
Burnaby, British Columbia, Canada

SOUTHERN ILLINOIS UNIVERSITY, MATHEMATICAL STUDIES
Edwardsville, Illinois

SOUTHERN METHODIST UNIVERSITY, DEPARTMENT OF STATISTICS
Dallas, Texas

STANFORD UNIVERSITY, GIRSHICK MEMORIAL LIBRARY
Stanford, California

STATE UNIVERSITY OF NEW YORK, BUFFALO, DEPARTMENT OF STATISTICS
Amherst, New York

TEMPLE UNIVERSITY, MATHEMATICS DEPARTMENT
Philadelphia, Pennsylvania

TEXAS TECH UNIVERSITY, DEPARTMENT OF MATHEMATICS
Lubbock, Texas 79409

THE TOBACCO INSTITUTE
Washington, D.C.

UNION OIL COMPANY OF CALIFORNIA, UNION
RESEARCH CENTER
Brea, California

UNITED STATES ARMY RESEARCH AND DE-
VELOPMENT CENTER
Aberdeen Proving Ground, Maryland

UNIVERSITY OF ALBERTA, DEPARTMENT OF
MATHEMATICS
Edmonton, Alberta, Canada

UNIVERSITY OF ARIZONA, DEPARTMENT OF
MATHEMATICS
Tucson, Arizona

UNIVERSITY OF BRITISH COLUMBIA, DE-
PARTMENT OF MATHEMATICS
Vancouver, B.C., Canada

UNIVERSITY OF CALGARY, MATHEMATICS
DEPARTMENT
Calgary 44, Alberta, Canada

UNIVERSITY OF CALIFORNIA, BERKELEY,
STATISTICAL LABORATORY
Berkeley, California

UNIVERSITY OF CINCINNATI, DEPARTMENT
OF MATHEMATICAL SCIENCES
Cincinnati, Ohio

UNIVERSITY OF GUELPH, MATHEMATICS AND
STATISTICS DEPARTMENT
Guelph, Ontario, Canada

UNIVERSITY OF ILLINOIS AT CHICAGO
CIRCLE, DEPARTMENT OF MATHEMATICS
Chicago, Illinois

UNIVERSITY OF ILLINOIS, MATHEMATICS
DEPT.
Urbana, Illinois

UNIVERSITY OF IOWA, DIVISION OF MATHE-
MATICAL SCIENCES
Iowa City, Iowa

UNIVERSITY OF MANITOBA, DEPARTMENT
OF STATISTICS
Winnipeg-19, Manitoba, Canada

UNIVERSITY OF MARYLAND, DEPARTMENT
OF MATHEMATICS
College Park, Maryland

UNIVERSITY OF MICHIGAN, DEPARTMENT OF
STATISTICS
Ann Arbor, Michigan

UNIVERSITY OF MINNESOTA, SCHOOL OF
STATISTICS
Minneapolis, Minnesota

UNIVERSITY OF MISSOURI, DEPARTMENT OF
STATISTICS
Columbia, Missouri

UNIVERSITY OF MISSOURI AT ROLLA, DE-
PARTMENT OF MATHEMATICS
Rolla, Missouri

UNIVERSITY OF MONTREAL, DEPARTMENT
OF MATHEMATICS
Montreal, Quebec, Canada

UNIVERSITY OF NEW MEXICO, DEPARTMENT
OF MATHEMATICS AND STATISTICS
Albuquerque, New Mexico

UNIVERSITY OF NORTH CAROLINA, DEPART-
MENT OF STATISTICS
Chapel Hill, North Carolina

UNIVERSITY OF OREGON, MATHEMATICS DE-
PARTMENT
Eugene, Oregon

UNIVERSITY OF OTTAWA, DEPARTMENT OF
MATHEMATICS
Ottawa, Ontario, Canada

UNIVERSITY OF ROCHESTER
Rochester, New York

UNIVERSITY OF SOUTH CAROLINA, DEPART-
MENT OF MATHEMATICS AND COMPUTER
SCIENCE
Columbia, South Carolina

UNIVERSITY OF TEXAS, DEPARTMENT OF
MATHEMATICS
Austin, Texas

UNIVERSITY OF WASHINGTON, DEPARTMENT
OF MATHEMATICS
Seattle, Washington

UNIVERSITY OF WISCONSIN, MADISON, DE-
PARTMENT OF STATISTICS
Madison, Wisconsin

UNIVERSITY OF WISCONSIN, MILWAUKEE,
DEPARTMENT OF MATHEMATICS
Milwaukee, Wisconsin

VIRGINIA COMMONWEALTH UNIVERSITY, DE-
PARTMENT OF MATHEMATICAL SCIENCES
Richmond, Virginia

WAYNE STATE UNIVERSITY, DEPARTMENT
OF MATHEMATICS
Detroit, Michigan

WEST CHESTER STATE COLLEGE
West Chester, Pennsylvania

WESTINGHOUSE ELECTRIC CORPORATION,
RESEARCH LABORATORIES
Pittsburgh, Pennsylvania

YALE UNIVERSITY, STATISTICS DEPART-
MENT
New Haven, Connecticut

THE ANNALS OF STATISTICS

INSTRUCTIONS FOR AUTHORS

Submission of Papers. Papers to be submitted for publication should be sent to the Editor of the *Annals of Statistics*. (For current address, see the latest issue of the *Annals*.) The original (or xerox copy) should be submitted with three additional copies on paper that will take ink corrections. The manuscript will *not* normally be returned to the author; when expressly requested by the author, one copy of the manuscript will be returned.

Preparation of Manuscripts. Manuscripts should be typewritten, entirely double-spaced, including references, with wide margins at sides, top and bottom. Dittoed or mimeographed papers are acceptable only if completely legible; xerox copies are preferable. When technical reports are submitted, all extraneous sheets and covers should be removed.

Submission of Reference Papers. Copies (preferably two) of unpublished or not easily available papers cited in the manuscript should be submitted with the manuscript.

Title and Abbreviated Title. The title should be descriptive and as concise as is feasible, i.e., it should indicate the topic of the paper as clearly as possible, but every word in it should be pertinent. An abbreviated title to be used as a running head is also required, and should be given below the main title. This should normally not exceed 35 characters. For example, a title might be "A Limit Theorem for Conditioned Recurrent Random Walk Attracted to a Stable Law," with the running head "Limit Theorem for Recurrent Random Walk" or possibly "Recurrent Random Walk Attracted to a Stable Law", depending on the emphasis to be conveyed.

Summary. Each manuscript is required to contain a summary, which will be printed immediately after the title, clearly separated from the rest of the paper. Its main purpose is to inform the reader quickly of the nature and results of the paper; it may also be used as an aid in retrieving information. The length of a summary will clearly depend on the length and difficulty of the paper, but in general it should not exceed 150 words. It should be typed on a separate page, under the heading "Summary", followed by the title of the paper. Formulas should be used as sparingly as possible. The summary should not make reference to results or formulas in the body of the paper—it should be self-contained.

Footnotes. Footnotes should be reduced to a minimum and, where possible, should be replaced by remarks in the text or in the references; formulas in footnotes should be avoided. Footnotes in the text should be identified by superscript numbers and typed together, double-spaced, on a separate page.

Key Words. Included as the first footnote on page 1 should be the headings:

American Mathematical Society 1970 subject classifications. Primary—; Secondary—.
Key words and phrases.

The classification numbers representing the primary and secondary subjects of the article may be found with instructions for its use, as an Appendix to *Mathematical Reviews* Index to Volume 39, June 1970. (See, also, *The Notices of the American Mathematical Society*, June 1970, pp. 616–618, for more details.) The key words and phrases should describe the subject matter of the article; generally they should be taken from the body of the paper.

List of Symbols. A completely typewritten list of symbols, identified typographically, not mathematically, should be attached to the manuscript on a separate page. Distinguish between "oh" and "zero"; "ell" and "one"; "kappa" and "kay", etc. Indicate also when special type is required (Greek, German, script, boldface, etc.); other letters will be set in italics.

Figures and Tables. Figures, charts, and diagrams should be prepared in a form suitable for photographic reproduction and should be professionally drawn twice the size they are to be printed. (These need not be submitted until the paper has been accepted for publication.) Tables should be typed on separate pages with accompanying footnotes immediately below the table.

Formulas. Fractions in the text are preferably written with the solidus or negative exponent; thus, $(a + b)/(c + d)$ is preferred to $\frac{a + b}{c + d}$, and $(2\pi)^{-1}$ or $1/(2\pi)$ to $\frac{1}{2\pi}$. Also, $a^{b(c)}$ and $a_{b(c)}$ are preferred to a^{bc} and a_{bc} , respectively. Complicated exponentials should be represented with the symbol exp. A fractional exponent is preferable to a radical sign.

References. References should be typed double-spaced and should follow the style:

[5] Wilks, S. S. (1938). The large-sample distribution of the likelihood ratio for testing composite hypotheses. *Ann. Statist.* 1 60–62.

In textual material, the format "... Wilks (1938) ..." is normally preferred to "... Wilks [5] ...". Multiple references can be distinguished as "... Wilks (1938a) ...". Abbreviations for journals should be taken from *Mathematical Reviews* Index to Volume 40, 1970, pp. 1683–1702.

Proofs. Author will ordinarily receive galley proofs. Corrected galley proofs should be sent to the Managing Editor of the *Annals of Statistics*. (For current address, see the latest issue of the *Annals*.)