

THE ANNALS of MATHEMATICAL STATISTICS

FOUNDED AND EDITED BY H. C. CARVER, 1930-1938
EDITED BY S. S. WILKS, 1938-1949

THE OFFICIAL JOURNAL OF THE INSTITUTE
OF MATHEMATICAL STATISTICS

Contents

	PAGE
On the construction of certain transition functions.	CHARLES W. LAMB 439
Weak convergence results for a class of multivariate Markov processes	SIEGFRIED SCHACH 451
Asymptotic behavior of a class of confidence regions based on ranks in regression	HIRA LAL KOUL 466
Markov renewal programming with small interest rates.	ERIC V. DENARDO 477
On non-parametric asymptotically minimax tests.	STURE HOLM 497
On embedding and enumeration of orthogonal Latin squares	A. HEDAYAT AND W. T. FEDERER 509
Some distribution problems in the multivariate complex Gaussian case	K. C. S. PILLAI AND G. M. JOURIS 517
Distribution of the canonical correlations and asymptotic expansions for distributions of certain independence test statistics.	YOONG-SIN LEE 526
Some characteristics of Page's two-sided procedure for detecting a change in a location parameter.	JACK NADLER AND NAOMI B. ROBBINS 538
Equiconvergence of martingales.	EDWARD S. BOYLAN 552
An asymptotic expansion of the non-null distribution of Hotelling's generalized T_0^2 -statistic.	MINORU SIOTANI 560
One-way expected utility with finite consequence spaces.	PETER C. FISHBURN 572
Matchmaking.	MORRIS H. DEGROOT, PAUL I. FEDER AND PREM K. GOEL 578
Marginal homogeneity of multidimensional contingency tables.	S. KULLBACK 594
The law of the iterated logarithm for empirical distributions.	HELEN FINKELSTEIN 607
Projection with the wrong inner product and its application to regression with correlated errors and linear filtering of time series.	WILLIAM S. CLEVELAND 616
Strong laws for ruled sums.	LEONARD E. BAUM, M. KATZ AND H. H. STRATTON 625
A method for the construction of sequential selection procedures.	DAVID G. HOEL 630
Optimal designs with a Tchebycheffian spline regression function.	V. N. MURTY 643
On a class of rank order tests for regression with partially informed stochastic predictors.	MALAY GHOSH AND PRANAB KUMAR SEN 650
Admissibility of the usual confidence sets for a class of bivariate populations	V. M. JOSHI 662
Hyperadmissibility of estimators for finite populations.	V. M. JOSHI 680
Linear spaces and minimum variance unbiased estimation	JUSTUS SEELY AND GEORGE ZYSKIND 691
The distribution of linear combinations of order statistics from the uniform distribution.	HERBERT WEISBERG 704
Quadratic subspaces and completeness.	JUSTUS SEELY 710

Continued on back cover

Vol. 42, No. 2—April 1971

THE ANNALS OF MATHEMATICAL STATISTICS

Subscription Rates. Current issues are \$30 per volume (six issues of one calendar year). Members of the Institute of Mathematical Statistics pay different rates; see inside back cover. Single issues are \$5.75. Back numbers for all issues up to and including 1956 (Volume 27) are \$16.50 per volume, \$4.50 per issue; issues from 1957 through 1964 are \$22.00 per volume, \$5.75 per issue; from 1965 onward, \$33.00 per volume, \$5.75 per issue. Complete sets (Volumes 1 through 27) are \$275.00. If additional volumes are ordered at the same time complete sets are ordered, the price is \$16.50 per volume for Volumes 28 through 35, and \$22.00 per volume for Volumes 36 through 40. Complete sets (Volumes 1 through 40) are \$500.00.

Communications concerning **subscriptions, back numbers, payment of dues, membership, changes of address, etc.**, should be addressed to Professor George J. Resnikoff, Treasurer, Department of Statistics, California State College, Hayward, California 94542.

Papers to be submitted for publication should be sent to the Editor, Ingram Olkin, Department of Statistics, Stanford University, Stanford, California 94305. **Abstracts** and **corrected galley proofs** should be sent to the Managing Editor, K. J. C. Smith, Department of Statistics, University of North Carolina, Chapel Hill, North Carolina 27514.

Instructions for Authors. Each manuscript is required to contain an abstract and to have a title descriptive of its contents.

The abstract 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 an abstract 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 "Abstract" followed by the title of the paper. Formulas should be used as sparingly as possible. The abstract should not refer to the theorems or formulas in the body of the paper—it ought to be intelligible by itself. Occasionally the abstract will make an introduction unnecessary but more often an introductory section in the paper will still be needed.

The title should be descriptive but concise, i.e. it should indicate the topic of the paper as clearly as possible but every word in it ought to be pertinent.

In the near future the *Annals* will introduce a requirement for authors to list key words and phrases and classifying numbers, as now used in publications of the American Mathematical Society. Authors may want to anticipate this requirement by including such data now.

Manuscripts should be typewritten, entirely double-spaced including references, with wide margins at sides, top and bottom. The original should be submitted with two additional copies on paper that will take corrections. Dittoed or mimeographed papers are acceptable only if completely legible. 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. References should follow the style: [5] Wilks, S. S. (1963). Multivariate statistical outliers. *Sankhyā Ser. A* 25 407–426.

Figures, charts, and diagrams should be professionally drawn on plain white paper or tracing cloth in black India ink, twice the size they are to be printed.

(Continued on inside back cover)

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

COMPOSED AND PRINTED AT THE
WAVERLY PRESS, INC., BALTIMORE, MARYLAND 21202 U.S.A.
Second-class postage paid at Baltimore, Maryland 21202 and at additional mailing offices.
Copyright © 1971 by the Institute of Mathematical Statistics

EDITORIAL STAFF

EDITOR

INGRAM OLKIN

ASSOCIATE EDITORS

R. L. ANDERSON

R. R. BAHADUR

PETER J. BICKEL

DAVID R. BRILLINGER

L. BROWN

H. D. BRUNK

THOMAS S. FERGUSON

RONALD K. GETOOR

S. S. GHURYE

JAROSLAV HÁJEK

W. J. HALL

JAMES F. HANNAN

DAVID L. HANSON

DONALD L. IGLEHART

J. H. B. KEMPERMAN

J. F. C. KINGMAN

JOHN W. LAMPERTI

ALBERT W. MARSHALL

JEROME SACKS

I. R. SAVAGE

FRANK L. SPITZER

HENRY TEICHER

MANAGING EDITOR

K. J. C. SMITH

PAST EDITORS OF THE ANNALS

H. C. CARVER, 1930-1938

T. E. HARRIS, 1955-1958

S. S. WILKS, 1938-1949

WILLIAM KRUSKAL, 1958-1961

T. W. ANDERSON, 1950-1952

J. L. HODGES JR., 1961-1964

E. L. LEHMANN, 1953-1955

D. L. BURKHOLDER, 1964-1967

Z. W. BIRNBAUM, 1967-1970

Published bimonthly by the Institute of Mathematical Statistics in February,
April, June, August, October and December.

EDITORIAL POLICY

The main aim of the *Annals of Mathematical Statistics* is to publish original contributions to theoretical statistics and to probability theory. The emphasis is on quality, not just on formal novelty and correctness of the contents of a paper. Expository papers are also welcome, especially if they provide authoritative surveys of areas that have been in vigorous development.

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
New York, New York
- BOEING SCIENTIFIC RESEARCH LABORATORIES
Seattle, Washington
- CASE WESTERN RESERVE UNIVERSITY, DEPARTMENT OF MATHEMATICS
Cleveland, Ohio
- CATHOLIC UNIVERSITY OF AMERICA, STATISTICAL LABORATORY
Washington, D.C.
- CHEVRON RESEARCH COMPANY
Richmond, California
- CIBA PHARMACEUTICAL COMPANY
Summit, New Jersey
- COLORADO STATE UNIVERSITY, STATISTICAL LABORATORY
Fort Collins, Colorado
- CORNELL UNIVERSITY, DEPARTMENT OF MATHEMATICS
Ithaca, New York
- FLORIDA STATE UNIVERSITY, DEPARTMENT OF STATISTICS
Tallahassee, Florida
- FORD MOTOR COMPANY, SCIENTIFIC LABORATORIES
Dearborn, Michigan
- GENERAL MOTORS CORPORATION, RESEARCH LABORATORIES
Warren, Michigan
- GEORGE WASHINGTON UNIVERSITY, DEPARTMENT OF STATISTICS
Washington, D.C.
- INDIANA UNIVERSITY, THE LIBRARY
Bloomington, Indiana
- INTERNATIONAL BUSINESS MACHINES CORPORATION
Armonk, New York
- IOWA STATE UNIVERSITY, STATISTICAL LABORATORY
Ames, Iowa
- JOHNS HOPKINS UNIVERSITY, DEPARTMENT OF BIostatistics, DEPARTMENT OF STATISTICS
Baltimore, Maryland
- KANSAS STATE UNIVERSITY, DEPARTMENT OF STATISTICS
Manhattan, Kansas
- KENT STATE UNIVERSITY, DEPARTMENT OF MATHEMATICS
Kent, Ohio
- KNOLLS ATOMIC POWER LABORATORY
Schenectady, New York
- MIAMI UNIVERSITY, DEPARTMENT OF MATHEMATICS
Oxford, Ohio 45056
- MICHIGAN STATE UNIVERSITY, DEPARTMENT OF STATISTICS
East Lansing, Michigan
- MINNESOTA MINING AND MANUFACTURING COMPANY, APPLIED MATHEMATICS AND STATISTICS
Saint Paul, Minnesota
- 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, DEPARTMENT OF MATHEMATICS, STATISTICAL LABORATORY
Columbus, Ohio
- OKLAHOMA STATE UNIVERSITY, DEPARTMENT OF MATHEMATICS AND STATISTICS
Stillwater, Oklahoma
- OREGON STATE UNIVERSITY, DEPARTMENT OF STATISTICS
Corvallis, Oregon
- PENNSYLVANIA STATE UNIVERSITY, DEPARTMENT OF MATHEMATICS LIBRARY
University Park, Pennsylvania
- PRINCETON UNIVERSITY, DEPARTMENT OF STATISTICS
Princeton, New Jersey
- PURDUE UNIVERSITY LIBRARIES
Lafayette, Indiana
- THE RAND CORPORATION
Santa Monica, California
- THE ROCKEFELLER UNIVERSITY
New York, New York
- ROCKLAND STATE HOSPITAL, RESEARCH CENTER
Orangeburg, New York
- SANDIA CORPORATION, SANDIA BASE
Albuquerque, New Mexico
- SIMON FRASER UNIVERSITY, DEPARTMENT OF MATHEMATICS
Burnaby, British Columbia, Canada
- SOUTHERN METHODIST UNIVERSITY, DEPARTMENT OF STATISTICS
Dallas, Texas
- STANFORD UNIVERSITY, GIRSCHICK MEMORIAL LIBRARY
Stanford, California
- STATE UNIVERSITY OF NEW YORK, BUFFALO, DEPARTMENT OF STATISTICS
Amherst, New York
- SYSTEM DEVELOPMENT CORPORATION
Santa Monica, California
- TEXAS A & M UNIVERSITY, INSTITUTE OF STATISTICS
College Station, Texas

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
 UNITED STATES STEEL CORPORATION, AP-
 PPLIED RESEARCH LABORATORY
 Monroeville, Pennsylvania
 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 CALIFORNIA, BERKELEY
 STATISTICAL LABORATORY
 Berkeley, California
 UNIVERSITY OF CALIFORNIA, DEPARTMENT
 OF MATHEMATICS
 Davis, California
 UNIVERSITY OF CALIFORNIA, DEPARTMENT
 OF MATHEMATICS
 Irvine, California
 UNIVERSITY OF CALIFORNIA, SCHOOL OF
 PUBLIC HEALTH
 Los Angeles, California
 UNIVERSITY OF CALIFORNIA, DEPARTMENT
 OF MATHEMATICS
 Riverside, California
 UNIVERSITY OF CALIFORNIA, DEPARTMENT
 OF MATHEMATICS
 Santa Barbara, California
 UNIVERSITY OF GUELPH, LIBRARY, SERIALS
 DEPARTMENT
 Guelph, Ontario, Canada
 UNIVERSITY OF ILLINOIS AT CHICAGO
 CIRCLE, DEPARTMENT OF MATHEMATICS
 Chicago, Illinois
 UNIVERSITY OF ILLINOIS, LIBRARY, SERIALS
 DEPARTMENT
 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 MASSACHUSETTS, DEPART-
 MENT OF MATHEMATICS & STATISTICS
 Amherst, Massachusetts
 UNIVERSITY OF MICHIGAN, DEPARTMENT OF
 MATHEMATICS
 Ann Arbor, Michigan
 UNIVERSITY OF MINNESOTA, DEPARTMENT
 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 & STATISTICS
 Albuquerque, New Mexico
 UNIVERSITY OF NORTH CAROLINA, DEPART-
 MENT OF STATISTICS
 Chapel Hill, North Carolina
 UNIVERSITY OF PENNSYLVANIA, THE
 LIBRARY
 Philadelphia, Pennsylvania
 UNIVERSITY OF PUERTO RICO, DEPART-
 MENT OF MATHEMATICS
 Mayaguez, Puerto Rico
 UNIVERSITY OF ROCHESTER
 Rochester, New York
 UNIVERSITY OF WASHINGTON, LABORATORY
 OF STATISTICAL RESEARCH
 Seattle, Washington
 UNIVERSITY OF WISCONSIN, MADISON, DE-
 PARTMENT OF STATISTICS
 Madison, Wisconsin
 UNIVERSITY OF WISCONSIN, MILWAUKEE,
 DEPARTMENT OF MATHEMATICS
 Milwaukee, Wisconsin
 WAYNE STATE UNIVERSITY, DEPARTMENT
 OF MATHEMATICS
 Detroit, Michigan
 WEST CHESTER STATE COLLEGE
 West Chester, Pennsylvania
 WESTAT RESEARCH, INC.
 Bethesda, Maryland
 WESTINGHOUSE ELECTRIC CORPORATION,
 RESEARCH LABORATORIES
 Pittsburgh, Pennsylvania

MEETINGS OF THE INSTITUTE

NOTE: This calendar lists all of the meetings which have been approved by the IMS Council to date. Meeting dates which fall rather far in the future are subject to change.

Meet- ing No.	Place	Date	Abstract Deadline*	Joint With
131	Fort Collins, Colorado (Annual)	August 23-26, 1971	June 24, 1971	ASA
	Blacksburg, Virginia (Eastern Regional)	Spring 1972		ASA
	Ames, Iowa (Central Regional)	Spring 1972		ASA, ENAR
	Seattle, Washington (Western Regional)	Spring 1972		
	Ithaca, New York (Eastern Regional)	Spring 1973		ASA, ENAR
	Albuquerque, New Mexico (Western Regional)	Spring 1973		

* Abstracts should be submitted in duplicate to the Managing Editor, K. J. C. Smith, Department of Statistics, University of North Carolina, Chapel Hill, North Carolina 27514, on abstract blanks which may be obtained from him. Abstracts of papers to be presented *in person* at the meetings must be received on or before the corresponding deadline. Only one contributed paper may be given in person at any one meeting. Abstracts contributed by title may be submitted at any time and will be printed in the next issue to go to press. Abstracts should not exceed 200 words and should avoid displayed expressions and complicated formulae. They can be accepted from non-members of the IMS only if introduced by members. Abstracts must follow the stylistic requests on the abstract blank or they may be returned.