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FINAL TECHNICAL REPORT

on

OFFICE OF NAVAL RESEARCH
CONTRACT N00014-82-K-0207
Project NR 042-479

9 May 1986

Department of Statistics
Southern Methodist University
Dallas, Texas 75275

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PREFACE

This document constitutes the Final Technical Report in accordance with the contract terms. The funding covered a three-year period. The majority of the research effort was made during the summer of 1982, 1983 and 1984. An extension of the period through 31 August 1985 was granted without any additional allotment of funds.



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William R. Schucany

Randall L. Eubank

I. INTRODUCTION

✓ A summary of research accomplishments sponsored by this Office of Naval Research Contract during the period from 1 February 1982 to 31 August 1985. The technical objectives of this project involved i) further extensions and applications of the jackknife, ii) minimum distance estimation, iii) optimal and robust designs for a broad class of regression and time series problems and iv) splines. A total of 16 articles were published in refereed journals. A brief description of the results are given in Section II. The complete citations of the papers are given in Section III. Other professional activities of the two investigators, William R. Schucany and Randall L. Eubank, are listed in Section IV and the two respective Curriculum Vitae are attached as an Appendix.

II. SUMMARY OF RESEARCH ACCOMPLISHMENTS

A. JACKKNIFE

The continuing development of the jackknife is making this tool a widely used practical technique for estimating standard errors. In paper [1] the behavior of linear combinations of order statistics (L-statistics) under jackknifing is examined. Some asymptotic properties are examined and the usual pseudo-value based variance estimator is shown to be consistent under moderate smoothness and a trimming condition on the weight function.

The application of the jackknife in a rank correlation setting is treated in both [9] and [10]. The context of both articles is that of U -statistics of degree 2 for concordance of rankings. The studentized statistics are asymptotically distribution free. However, in these two articles it is established that for small and moderate sample sizes the Student- t approximations are improved by estimating the degrees of freedom. A related study [8] that did not involve the jackknife directly, examined the current most satisfactory distribution-free approaches to comparing related correlation coefficients.

B. Minimum Distance

The decomposition of goodness-of-fit statistics into components sheds some light upon the robustness of minimum distance (MD) estimators. M -estimation can be viewed as a special case. In [2] both the efficiency and the robustness are shown to relate to Fourier approximations. The efficient score function and the discrepancy measure have expansions that must correlate well for near full efficiency. The trade off for robustness is that high fidelity duplication of high frequency components may not yield robust estimators.

In a more specialized direct application of minimum distance in [11] the estimation of mixing proportions in the mixture model is investigated. Some practical issues of implementing the techniques are discussed. Simulations demonstrate small sample superiority of MLE if the assumption of two normal components is correct. However, for symmetric departures from normality MD is better than ML. Strong consistency and asymptotic normality is established for MDE in the multi-parameter case under conditions that encompass the mixture-of-normals model.

A related project on goodness-of-fit was also underway during this period. A full revision of a chapter was completed for a forthcoming book, edited by D'Agostino and Stephens. The book entitled Goodness of Fit Techniques will not appear until after the end of the contract period. The chapter covers a broad variety of methods for situations in which one has censored sample information.

Paper [15] derives a general type of minimum distance estimator for estimation of parameters with randomly censored data. The asymptotic distribution theory and robustness properties of the estimator are investigated. An optimal weight function is derived for estimation in the case of one unknown parameter. When the parameter of interest is either a location or scale parameter the resulting estimator is closely related to the estimator proposed in paper [6] for this case. The difference is that in [6] estimators are also developed which are simultaneously optimal for both estimation of the location and scale parameters, rather than just each parameter separately.

Article [16] explores an area of overlap between the optimal design problems discussed in Section II.C and the minimum distance estimation problems. A family of robust, minimum quantile domain estimators are studied for estimation in the three-parameter Weibull distribution. The estimators are based on a subset of the sample order statistics which can be optimally selected using regression design techniques for time series. The asymptotic distribution theory of the proposed estimators is also developed.

C. Design

The four articles [3], [4], [5] and [13] represent some of the progress that was made during the support period on several of the design problems proposed under this contract. Paper [3] provides an extension of previous design work by Eubank, Smith and Smith to a more general class of processes than had been studied previously. Paper [4] develops the computational side of the results in [3] and provides an algorithm for the explicit computation of optimal designs. Article [13] characterizes the relationship between certain types of regression problems which have the same optimal designs.

Paper [5] establishes that the design results in [3], [4], and [13] have a wide range of application to many other statistical problems. Included are problems in sampling, estimation from grouped data, construction of optimal groupings for goodness-of-fit tests and multivariate distributions as well as many others. SMU Technical Report #164 (1982) entitled, "Optimal grouping, spacing, stratification and piecewise constant approximation" by R. L. Eubank also covers some of these problems areas.

Article [7] develops the details behind the robust design selection procedure that was proposed for investigation. The resulting algorithm is utilized to solve a related problem of robust order statistic selection for the asymptotically best linear unbiased estimators of location and scale parameters based on a subset of the sample quantiles. This result is a robust approach to data compression. It is reported in "Robust ABLUE's for location and scale parameter estimation," SMU Tech. Report No. 175 (1983), by R. L. Eubank and H. J. Lindsey.

D. Splines

The regression design work discussed in Section II.C is related in a fundamental way to problems in numerical analysis and approximation theory which concern splines. Another area of statistics where results concerning splines are useful is in nonparametric regression and data smoothing. Papers [12] and [14] represent a natural branching out of the interest of their author in splines to other statistical problems.

III. PUBLISHED PAPERS AND TECHNICAL REPORTS

A. Papers Published

- [1] "Jackknifing L-Statistics with Smooth Weight Functions," William R. Schucany with William Parr, J. Amer. Statist. Assoc., 77, (1982), 629-638.
- [2] "Minimum Distance Estimation and Components of Goodness-of-fit Statistics," William R. Schucany with William Parr, J. Roy. Statist. Soc., Ser. B, 44 (1982), 178-189.
- [3] "A Note on Optimal and Asymptotically Optimal Designs for Certain Time Series Models," R. L. Eubank with P. L. and P. W. Smith, Ann. Statist. 10, (1982), 1295-1301.
- [4] "On the Computation of Optimal Designs for Certain Time Series Models with Applications to Optimal Quantile Selection for Location and Scale Parameter Estimation," R. L. Eubank with P. L. and P. W. Smith, SIAM J. Sci. Statist. Comput. 3, (1982), 238-249.
- [5] "A Quantile Domain Perspective on the Relationship Between Optimal Grouping, Spacing and Stratification Problems," R. L. Eubank, Statistics & Probability Letters 1, (1982), 69-73.
- [6] "Location and Scale Parameter Estimation from Randomly Censored Data," R. L. Eubank with LaRiccia, Commun. Statist.-Theor. Meth. A11(25), (1982) 2869-2888.
- [7] "A Note on Optimal and Robust Spacing Selection," R. L. Eubank, Commun. Statist.-Theor. Meth. A12(21), (1983), 2483-2492.

- [8] "An Empirical Study of Related Correlation Coefficients," William R. Schucany with Boyer and Palachek, J. Edu. Statist., 8 (1983), 75-86.
- [9] "On the Correlation of a Group of Rankings with an External Ordering Relative to the Internal Concordance," William R. Schucany with Palachek, Letters Prob. Statist., 1 (1983), 259-263.
- [10] "On Approximate Confidence Intervals for Measures of Concordance," William R. Schucany with Palachek, Psychometrika, 49 (1984), 133-141.
- [11] "A Comparison of Minimum Distance and Maximum Likelihood Estimation of a Mixture Proportion," William R. Schucany with Woodward, Parr and Lindsey, J. Amer. Statist. Assoc., 79 (1984), 590-598.
- [12] "The Hat Matrix for Smoothing Splines," R. L. Eubank, Statistics & Probability Letters 2, (1984), 9-14.
- [13] "On the Relationship Between Functions with the Same Knots in Spline and Piecewise Polynomial Approximation," R. L. Eubank, J. Approx. Theory 40, (1984), 327-332.
- [14] "Approximate Regression Models and Splines," R. L. Eubank, Commun. Statist.-Theor. Meth., A13(4), (1984), 433-484.
- [15] "Weighted L^2 Quantile Distance Estimators for Randomly Censored Data," R. L. Eubank with V. N. LaRiccia, J. Multivariate Anal. 14, (1984), 348-359.
- [16] "A Family of Minimum Quantile Distance Estimators for the Three-Parameter Weibull Distribution," R. L. Eubank with Carmody and LaRiccia, Statistiche Hefte 25, (1984), 69-82.

B. Papers Presented

- [1] "U-Statistics for Evaluating Two-Group Concordance", W. R. Schucany with Palachek, Proceedings of the Social Statistics Section, ASA National Meeting, Cincinnati, August 1982.
- [2] "Regression Design for Time Series and Quantile Selection," R. L. Eubank, Invited paper. Central Regional Meeting of IMS, San Antonio, Texas, March 1982.
- [3] "Piecewise Constant Approximation in Statistics," R. L. Eubank, Invited paper, Department of Mathematical Sciences Statistical Colloquium, Old Dominion University, Norfolk, Virginia, June 1982.
- [4] "Some Piecewise Constant Approximation Problems in Statistics," R. L. Eubank, Invited paper, Department of Mathematical Sciences Colloquium, Rice University, Houston, Texas, October 1982.

- [5] "The Relationship Between Certain Optimal Grouping, Spacing and Stratification Problems," Invited paper, 1983 Conference for Texas Statisticians, Waco, Texas, April 1983.
- [6] "Comparison of Approximate Confidence Interval Procedures for Multihit Quantal Response Models", William R. Schucany with Dorsett, Joint Statistical Meetings, Toronto, August 1983.
- [7] "Splines in regression," R. L. Eubank, Invited paper, 1983 SREB Summer Research Conference, Gatlinburg, TN, June 1983.
- [8] "Diagnostics and Inference for Smoothing Splines," R. L. Eubank, Invited paper, University of Texas at Dallas Mathematical Sciences Department Distinguished Lecture Series, October 1983.
- [9] "Optimal Grouping, Spacing, Stratification and Piecewise Constant Approximation," R. L. Eubank, Contributed paper, Joint Statistical Meetings, Cincinnati, Ohio, August 1982.
- [10] "The Hat Matrix for Smoothing Splines," R. L. Eubank, Contributed paper, Joint Statistical Meetings, Toronto, Ontario, August 1983.
- [11] "Diagnostics for Smoothing Splines," R. L. Eubank, Contributed paper, Annual Meeting of the Institute of Mathematical Statistics, Lake Tahoe, CA, August 1984.
- [12] "Using the Jackknife and Bootstrap Cautiously," William R. Schucany, Invited paper, Cincinnati Chapter of ASA Conference on Statistics, October 1984.

C. Reports Submitted

- [1] "Optimal grouping, spacing, stratification and piecewise constant approximation," R. L. Eubank, SMU Tech. Rpt. No. 164 (1982).
- [2] "Robust ABLUE's for location and scale parameter estimation," R. L. Eubank, SMU Tech. Rpt. No. SMU-DS-TR-183 (1984).
- [3] "Sample Re-Use", W. R. Schucany, SMU Tech. Rpt. No. SMU-DS-TR-186 (1984).
- [4] "An optimality property of smoothing splines," R. L. Eubank, SMU Tech. Rpt. No. SMU-DS-TR-188 (1984).

IV. OTHER ACTIVITIES

Several professional activities of the investigators deserve mention. Two Ph.D. dissertations were supervised by W. R. Schucany; "Minimum Distance Estimation of a Truncation Parameter" was completed by N. J. Bosmia in August, 1982 and "An Improvement of the Bootstrap Methodology" by Y. H. lee in August, 1983. Schucany served as Associate Editor for JASA (1983 through 1985), J. Edu. Statist. (1981 through 1983) and Commun. Statist. (1972 to the present). Eubank refereed submissions for 9 different journals and evaluated proposals for NSF and ARO.

APPENDIX

MEMBERSHIP IN PROFESSIONAL SOCIETIES:

American Statistical Association, Institute of Mathematical Statistics, Sigma Xi, Society for Industrial and Applied Mathematics.

AWARDS: 1978 W.S. Connor Award, Institute of Statistics, Texas A & M University.

PUBLICATIONS

a) Papers published or accepted:

Assessing rural community viability. Western J. of Agricultural Econ., 1 (1976). With G. Carruthers, K. Renner and N. S. Urquhart.

A goodness of fit test for a proposed null function. J. Indian Statist. Assoc. 17, 109-123 (1979). With A.M. Kshirsagar.

A density-quantile function approach to optimal spacing selection. Ann. Statist. 9, 494-500 (1981).

Estimation of the parameters and quantiles of the logistic distribution by linear functions of sample quantiles. Scandinavian Actuarial J., 229-236 (1981).

Uniqueness and eventual uniqueness of optimal designs in some time series models. Ann. Statist. 9, 486-493 (1981). With P. L. and P. W. Smith.

A note on optimal and asymptotically optimal designs for certain time series models. Ann. Statist. 10, 1295-1301 (1982). With P. L. and P. W. Smith.

On the computation of optimal designs for certain time series models with applications to optimal quantile selection for location and scale parameter estimation. SIAM J. Sci. Statist. Comput. 3, 238-249 (1982). With P.L. and P.W. Smith.

Location and scale parameter estimation from randomly censored data. Commun. Statist.-Theor. Meth. A11(25), 2869-2888 (1982). With V. N. LaRiccia.

A quantile domain perspective on the relationships between optimal grouping, spacing and stratification problems. Statistics & Probability Letters 1, 69-73 (1982).

A note on optimal and robust spacing selection. Commun. Statist.-Theor. Meth. A12(21), 2483-2492 (1983).

The hat matrix for smoothing splines. Statistics & Probability Letters 2, 9-14 (1984).

On the relationship between functions with the same knots in spline and piecewise polynomial approximation. J. Approx. Theory 40, 327-332 (1984).

Approximate regression models and splines. Commun. Statist.- Theor. Meth., A13(4), 433-484 (1984).

Weighted L^2 quantile distance estimators for randomly censored data. J. Multivariate Anal. 14, 348-359 (1984). With V. N. LaRiccia.

A family of minimum quantile distance estimators for the three-parameter Weibull distribution. Statistiche Hefte 25, 69-82 (1984). With T. J. Carmody and V. N. LaRiccia.

The singular-value decomposition as a tool for solving estimability problems. Amer. Statist. 39, 64-66 (1985). With J. T. Webster.

Diagnostics for smoothing splines. J. Roy. Statist. Soc. B, to appear (1985).

Optimal spacing problems. The Encyclopedia of Statistical Sciences, (N. Johnson and S. Kotz, eds.) 6, 452-458.

b) Other writings:

A regression design approach to optimal and robust spacing selection. SMU Tech. Rep. No. 144 (1981).

A density-quantile function approach to adaptive location or scale parameter estimation. SMU Tech. Rep. No. 155 (1981).

Uniqueness and eventual uniqueness of optimal designs for some time series models, II. SMU Tech. Rep. No. 150 (1981). With P. L. and P. W. Smith.

Asymptotically optimal designs for some time series models. SMU Tech. Rep. No. 151 (1981). With P. L. and P. W. Smith.

A bibliography for the ABLUE. SMU Tech. Rep. No. 162. (1982).

Optimal grouping, spacing, stratification and piecewise constant approximation. SMU Tech. Rep. No. 164 (1982).

Robust ABLUE's for location and scale parameter estimation. SMU Tech. Rep. No. 175. (1983). With H. J. Lindsey.

Deleting an observation from a linear regression. SMU Tech. Rep. No. SMU-DS-TR-183 (1984).

An optimality property of smoothing splines. SMU Tech. Rep. No. SMU-DS-TR-183 (1984).

INVITED ADDRESSES:

- Some useful inefficient statistics. 50 minute talk. Department of Mathematical Sciences Statistics Colloquium, Old Dominion University, Norfolk, Virginia. March 1980.
- Adaptive data summary construction. 50 minute talk. Guest speaker at the meeting of the North Texas Section of the American Statistical Association, Dallas, Texas. November 1980.
- Variable knot and smoothing spline problems in statistics. Two 50 minute talks. Department of Mathematics. Visiting Speaker Program, University of Nebraska-Lincoln. May 1981.
- Regression design for time series and quantile selection. 35 minute talk. Central regional meeting of IMS, San Antonio, Texas. March 1982.
- Piecewise constant approximation in statistics. 50 minute talk. Department of Mathematical Sciences Statistics Colloquium, Old Dominion University, Norfolk, Virginia. June 1982.
- Some piecewise constant approximation problems in statistics. 50 minute talk. Department of Mathematical Sciences Colloquium, Rice University, Houston, Texas. October 1982.
- The relationship between certain optimal grouping, spacing and stratification problems. 30 minute talk. 1983 Conference for Texas Statisticians, Waco, Texas. April, 1983.
- Splines in regression. 90 minute talk. 1983 SREB Summer Research Conference, Gatlinburg, Tennessee. June, 1983.
- Diagnostics and inference for smoothing splines. 50 minute talk. University of Texas at Dallas Mathematical Sciences Department Distinguished Lecture Series. October, 1983.
- Diagnostics and inference for smoothing splines. 50 minute talk. Department of Statistics, Texas A & M University. October, 1984.
- Parameter estimation from randomly censored data. 35 minute talk. IMS regional meeting, Austin, Texas. March, 1985.
- Components of $\hat{\mu}$. 50 minute talk. Department of Statistics, Texas A & M University. October, 1985.

OTHER ADDRESSES:

Designs for regressions with certain correlated normal errors.
American Statistical Association Meeting, Houston,
Texas. August 1980. Contributed talk.

Regression designs for the quantile process. NSF Regional
Conference on Quantile Processes. Texas A & M University,
July 1981. Outside funding was provided. Contributed talk.

Asymptotic and uniqueness properties of regression designs for certain
time series models. Institute of Mathematical Statistics
Meeting, Vail, Colorado. August 1981. Contributed talk.

Optimal grouping, spacing, stratification and piecewise constant
approximation. Joint statistical meetings, Cincinnati, Ohio.
August 1982. Contributed talk.

The hat matrix for smoothing splines. Joint Statistical Meetings,
Toronto, Ontario. August 1983. Contributed talk.

Diagnostics for smoothing splines. Annual meeting of the Institute of
Mathematical Statistics, Lake Tahoe, California. August 1984.
Contributed talk.

OTHER PROFESSIONAL ACTIVITIES:

Refereed papers for Journal of the American Statistical Association
American Statistician
Annals of Statistics
Communications in Statistics
Journal of Approximation Theory
Journal of Business and Economics Statistics
Journal of Statistical Planning and Inference
Sankhya
Statistics & Probability Letters

TEACHING EXPERIENCE AND ACTIVITIES:

a) Courses taught:

<u>Title</u>	<u>Text Author(s)</u>	<u>Description</u>
Applied Multivariate Analysis (SMU)	Johnson and Wichern	Graduate multivariate methods
Elements of Statistics (ASU)	Johnson	Undergraduate methods for social sciences
Introductory Applied Statistics (ASU)	Ott	Graduate methods for non-majors
Introduction to Statistics (SMU)	Freedman, Pisani & Purves	Freshmen level "statistical appreciation" course
Introduction to Statistical Inference (SMU)	Koopmans	Undergraduate methods course for psychologists
Mathematical Theory of Sampling	Cochran	Graduate theory of sampling
Nonparametric Statistics (ASU)	Hollander & Wolfe	Graduate nonparametric methods
Statistics for Modern Business Decisions	Daniel for business	Undergraduate methods majors
Statistics for Social Science (SMU)	Ott, Mendenhall & Larson	Undergraduate methods course for social sciences
Spline Approximation in Statistics (SMU)	---	Study of spline and least squares approximation oriented toward statistics
Stochastic Processes (SMU)	Parzen	Graduate level introduction to stochastic processes and time series
Survey of Nonparametric Statistics (SMU)	Randles and Wolfe	Graduate nonparametric theory

b) Other Activities:

Director of Undergraduate Studies

From 1980-1985: Chaired 4 Master's Committees
Member of 11 Ph.D. Committees

CURRICULUM VITAE

SCHUCANY, WILLIAM R.

PII Redacted

Education:

1963 B.A. with Honors, The University of Texas (Mathematics)

1965 M.A., The University of Texas (Mathematics)

Thesis: "Orthogonal Polynomials and the Holmgren-Riesz Transform"

1970 Ph.D., Southern Methodist University (Statistics)

Dissertation: "The Reduction of Bias in Parametric Estimation".

Honors:

Phi Beta Kappa

Research Award, SMU Chapter, Sigma Xi (1979)

Fellow of the American Statistical Association (1981)

Don Owen Award given by San Antonio Chapter of ASA (1984)

Offices:

Communications in Statistics, Associate Editor (1972-Present)

J. Amer. Statist. Assoc., Associate Editor (1983-1985)

J. Educational Statistics, Associate Editor (1981-1983)

North Texas Chapter of the American Statistical Association
Vice President (1970-71); President (1971-72), Secretary
(1972-73)

ASA, Section on Statistical Education, Nominations Committee
(1977), Chair-elect (1985), Chair (1986)

Sigma Xi, SMU Chapter, Treasurer (1976-77), Vice President
(1982-83), President (1983-84)

Phi Beta Kappa, SMU Chapter, Audit Committee Chairman (1982)

Organizer and Program Chairman, Texas Conference of Statisticians
(1981 and 1982)

Professional Affiliations:

American Statistical Association
Institute of Mathematical Statistics
Sigma Xi

Experience:

June 1963-May 1966; Tracor, Inc., Austin, Texas, Engineer/Scientist.
Primary responsibility was in scientific computation.

June 1966-August 1968; LTV Electrosystems, Inc., Greenville, Texas.
Senior Systems Engineer. Provided mathematical and statistical
support to various research and development programs.

September 1968-July 1970; Southern Methodist University, Dallas,
Texas, Instructor of Statistics and Manager of Statistical
Laboratory. Served as consultant to the scientific community in
the areas of statistical design and analysis of experiments,
mathematical models, interpretation and computer processing of
data. Instructed graduate students in use of the computer as a
tool in statistics.

July 1970-September 1971; Southern Methodist University, Dallas,
Texas, Assistant Professor and Manager of the Statistical
Research Laboratory. Taught graduate level introductory
mathematical statistics courses (for studio class and closed
circuit TV). Served on thesis and dissertation committees.
Consultation as before.

September 1971-September 1974; Southern Methodist University, Dallas,
Texas, Assistant Professor of Statistics. Taught Mathematical
Statistics. Directed thesis and dissertation research.

September 1974-1979; Associate Professor of Statistics. SMU.
Teaching and Research. Organized and sustained weekly
departmental graduate student, faculty and visiting speaker
program.

September 1979-Present; Professor of Statistics. SMU

September 1980-81; Director of the Division of Mathematical Sciences
and Professor of Statistics. SMU.

May 1984-Present; Chairman, Department of Statistics. SMU.

Refereeing:TechnometricsJ. American Statist. Assn.The American StatisticianNaval Research Logistics QuarterlyIEEE, Trans. on Systems, Man and CyberneticsJ. Operations Research SocietyJ. of Assoc. Comp. Mach.PsychometrikaBiometrikaAnnals of StatisticsCommun. Statist.

Textbook for Addison-Wesley Publishers

Textbook for Marcel Dekker, Inc., Publisher

National Science Foundation (Mathematical Statistics Division)

Research Council Canada (Natural Sciences and Engineering)

Principal Investigator:

ONR Research Contract , "Bias Reduction"

N00014-72-A-0296, \$ 76,000 (January 1972-February 1975)

N00014-75-C-0439, \$288,000 (March 1975-January 1982)

N00014-82-K-0207, \$145,000 (February 1982-February 1985).

ONR Research Contract, "Sample Reuse in Statistical Modeling"

N00014-85-K-0340, \$195,684 (June 1985 - May 1988)

Sandia National Laboratories, "Simulation Methodology on
MELCOR Program", \$9,931 (Sept 1984 - March 1985).Book and ChaptersThe Generalized Jackknife Statistic, H. L. Gray and W. R.
Schucany, Marcel Dekker, Inc., New York (1972)."Analysis of data from censored samples," with Michael, Chapter
Goodness-of-Fit Techniques, ed., by R. D'Agostino and M. Stephens,
Marcel Dekker, Inc., New York (1986).Publications in Refereed Journals:

1. "The Gegenbauer Function", Annali della Scuola Normale Superiore di Pisa, 21 (1967), 349-351.
2. "A New Approximation Related to the Error Function," with Gray, Mathematics of Computation, 22 (1968), 201-202.
3. "On the Evaluation of Distribution Functions," with Gray, J. Amer. Statist. Assoc., 63 (1968), 715-720.
4. "Lower Confidence Limits for Availability Assuming Lognormally Distributed Repair Times," with Gray, IEEE Transactions on Reliability, R-18 (1969), 157-162.

5. "Some Limiting Cases of the G-Transformation," with Gray, Mathematics of Computation, 23 (1969), 849-860.
6. "Bayesian Prediction and Population Size Assumptions," with Bratcher and Hunt, Technometrics, 13 (1971), 678-681.
7. "On Bias Reduction in Estimation," with Gray and Owen, J. of the Amer. Statist. Assoc., 66 (1971), 524-533.
8. "A Survey of Statistical Packages," with Shannon and Minton, Computing Surveys 4 (1972), 65-79.
9. "Order Statistics in Simulation," J. Statist. Compt. Simul., 1 (1972), 281-286.
10. "A Rank Test for Two Group Concordance," with Frawley, Psychometrika, 38 (1973), 249-258.
11. "On the Jackknife Statistic and its Relation to UMVU Estimators in the Normal Case," with Gray and Watkins, Commun. in Statist., 2 (1973), 285-320.
12. "Some Properties of a Test for Concordance of Two Groups of Rankings," with Li, Biometrika, 62 (1975), 417-423.
13. "On the Generalized Jackknife and its Relation to Statistical Differentials," with Gray and Watkins, Biometrika, 62 (1975), 637-642.
14. "Generating Random Variates Using Transformations with Multiple Roots," with Michael and Haas, The American Statistician, 30 (1976), 88-90.
15. "Best Estimates of Functions of Parameters in the Gamma and Gaussian Distributions," with Gray and Woodward, IEEE Trans. on Reliability, R-25 (1976), 95-99.
16. "Efficient Estimation of $P(Y < X)$ in the Exponential Case," with Kelley and Kelley, Technometrics, 18 (1976), 359-360.
17. "Analysis of Multiple Sets of Incomplete Rankings," with Beckett, Commun. Statist., 5 (1976), 1327-1334.
18. "Improvement of Kernel Type Density Estimators," with Sommers, J. Amer. Statist. Assoc., 72 (1977), 420-423.
19. "Combination of a Preference Pattern with the Triangle Taste Test," with Woodward, Biometrics, 33 (1977), 31-39.
20. "Adjusting the Degrees of Freedom for the Jackknife," with Woodward, Commun. Statist., 6 (1977), 439-442.
21. "Bibliography for Statistical Consulting," with Woodward, Biometrics, 33 (1977), 564-565.

22. "Correlation Structure in Farlie-Gumbel-Morgenstern Distributions," with Parr and Boyer, Biometrika, 65 (1978), 650-653.
23. "A New Approach to Testing Goodness of Fit for Censored Samples," with Michael, Technometrics, 21 (1979), 435-441.
24. "Analysis of the Reliability of a New Scale for Housing Quality," with Mansfield, Woodward and Hess, J. Statist. Planning and Inference, 3 (1979), 305-313.
25. "Concordance among Categorized groups of Judges," with Beckett, J. of Edu. Statist., 4 (1979), 125-137.
26. "Robustness of Minimum Distance Estimation," with Parr, J. Amer. Statist. Assoc., 75 (1980), 616-624.
27. "A Special Distribution Result for Bilinear Forms," with Beckett and Broffitt, J. Amer. Statist. Assoc., 75 (1980), 466-468.
28. "The Jackknife: A Bibliography" with Parr, Int. Statist. Rev., 48 (1980), 73-78.
29. "Jackknifing L-Statistics with Smooth Weight Functions," with Parr, J. Amer. Statist. Assoc., 77, (1982), 629-638.
31. "Minimum Distance Estimation and Components of Goodness-of-fit Statistics," with Parr, J. Roy. Statist. Soc., Ser. B, 44 (1982), 178-189.
32. "An Empirical Study of Related Correlation Coefficients", with Boyer and Palachek, J. Edu. Statist., 8 (1983), 75-86.
33. "On the Correlation of a Group of Rankings with an External Ordering Relative to the Internal Concordance", with Palachek, Letters Prob. Statist., 1 (1983), 259-263.
34. "On Approximate Confidence Intervals for Measures of Concordance," with Palachek, Psychometrika, 49 (1984), 133-141.
35. "A Comparison of Minimum Distance and Maximum Likelihood Estimation of a Mixture Proportion," with Woodward, Parr & Lindsey, J. Amer. Statist. Assoc., 79 (1984), 590-598.
36. "Testing the Correlation Coefficient with Incomplete Observations", with Beckett and Bosmia, submitted to Amer. Statistician.
37. "The Influence Curve and Goodness of Fit" with Michael, J. Amer. Statist. Assoc., 80 (1985), 678-682.

Invited Commentaries, Book Reviews and Other Contributions:

1. "Comment on 'A Review of the Manuals for BMDP and SPSS'", J. Amer. Statist. Assoc., 72 (1978), 92-93.
2. "Comment on 'Testing for agreement between two groups of judges', by Hollander and Sethuraman," Biometrika, 65 (1978), 410-411.
3. "Review of 'Introduction to the Theory of Nonparametric Statistics' by Randles and Wolfe" Interfaces, 15 (1985), 115-117.
4. "Sample Re-use" entry in Encyclopedia of Statistical Sciences (1985), Wiley.

Technical Reports:

1. "Analysis of Bearing Errors in Direction Finding Systems," LTV Report No. 3001.00109, (1967).
2. "Have Dagger Feasibility Study" (U) with M. A. Bondy, et al., Technical Report F33657-68-C-0103, February 1968.
3. "A Technique for the Approximation of Functions," LTV Report No. G-3681.21.016, May 1968.
4. "Dallas Community Crossroads Study," with S. C. Reagan, et al., SMU Institute of Urban Studies, February 1970.
5. "Table of the Concordance Statistic," with W. H. Frawley, SMU Statistics Department, Technical Report No. 116 (1972).
6. "On Wolfe's test for related correlation coefficients," with J. E. Boyer, Jr., SMU Statistics Department, Technical Report No. 127 (1978).

Presented Papers:

1. "Another Approach to Nonlinear Least Squares Regression," with J. W. Drane, presented at the 7th Annual Symposium on Biomathematics and Computer Science in the Life Sciences, March, 1969, Houston, Texas.
2. "Some Limiting Forms of the G-Transformation and Their Application to the Calculation of Tail Probabilities," Proceedings of the Symposium on Empirical Bayes Estimation and Computing in Statistics, Texas Tech University, August 1969, Mathematical Series No. 6, pp. 218-36.
3. "Bias Reduction in Estimation," presented to the Joint Meeting of the Washington Chapters of the Association of Computing Machinery and the Washington Statistical Society, February 26, 1971.

4. "A Rank Test for Two Group Concordance," contributed paper to the Western Regional Meeting of the Institute of Mathematical Statistics, March 22-24, 1971, Las Vegas, Nevada, Ann. Math. Statist. (Abstract) 42, 1146.
5. "Bias Reduction with Generalized Jackknives," presented at A Day of Jackknifery, Department of Statistics, Princeton University, June 25, 1971, Princeton, New Jersey.
6. "Properties and Examples of the Generalized Jackknife," invited paper before the Joint Statistical Meetings of ASA, Biometric Society (ENAR and WNAR) and IMS, 131st Annual Meeting, August 23-26, 1971, Fort Collins, Colorado.
7. "Order Statistics in Simulation," invited paper before the North Texas Chapter of the American Statistical Association, September 23, 1971, Dallas, Texas.
8. "Availability ratio with Lognormal repairs and Fixed time tests - A possible jackknife application," presented to the Applied Mathematics group at Naval Torpedo Station, June 22, 1972, Keyport, Washington.
9. "Some remarks on educating problem solvers," Proceedings of the Computer Science and Statistics Sixth Annual Symposium on the Interface, October 16-17, 1972, Berkeley, California, ed. by M. E. Tarter.
10. "Monte Carlo methods for serial reliability estimation," presented to the Applied Mathematics group at Naval Torpedo Station, August 1, 1973.
11. Moderator of "Open Discussion on Statistical Consulting Centers," National Meeting of ASA and Biometrics Society, New York City, December 1973.
12. "An efficient statistic for determining the diameter of thin sectioned uniform spheres from measurements of biological samples," 32nd annual meeting of the Electron Microscopy Society of America, August 13-15, 1974, St. Louis, Mo.
13. "Some properties of a test for concordance," 134th annual meeting of American Statistical Association, August 26-29, 1974, St. Louis, Mo.
14. "Preliminary report of a survey of statistical consulting centers," (and chairman of session on Consulting Centers) at 134th annual meeting of the American Statistical Association, August 26-29, 1974, St. Louis, Mo.
15. "Solution of statistical Distribution Problems by Monte Carlo," Chairman of round table panel at American Mathematical Heritage Symposium on the History of Statistics and Probability, May 27-29, 1974.

16. "Probability and Statistics at the High School Level," invited talk to Math. Teachers Club, Highland Park and McCullum Middle School, April 3, 1974.
17. "Combination of a Preference Test with the Triangle Taste Test," with W. A. Woodward, Joint Statistical Meetings, Atlanta, Ga., August 25-28, 1975.
18. "ANACONDA: Analysis of Concordance of g Groups of Judges," with J. Beckett, Joint Statistical Meetings, Atlanta, Ga., August 25-28, 1975.
19. "Preference Testing in the Food Industry," Moderator of a panel discussion for No. Texas Chapter of ASA, November 19, 1975.
20. "The Jackknife, Statistical Differentials, Numerical Methods, and Sample Reuse--a Unifying Theory," with H. L. Gray. Invited paper Joint Spring Regional Meetings, College Station, Texas, March 8-10, 1976.
21. "Goodness of fit in the censored sample case," with J. R. Michael, IMS Western Regional Meeting, Stanford, California, June 1977.
22. "Major Ideas of Elementary Statistics." Invited address to the San Antonio Meeting of the National Council of Teachers of Mathematics, February 1978.
23. "Related Correlation Coefficients." Invited presentation to the Quality Theory Research Seminar, Bell Labs, West Long Branch, New Jersey, July 1978.
24. "A New Approach to Testing Goodness of Fit for Censored Samples," with Michael. Invited as the Technometrics paper at the 1979 Fall Technical Conference, Minneapolis, Minn., November 1979.
25. "Internal and External Rank Correlation." Invited presentation to Kansas-Missouri Chapter of ASA, Manhattan, KS., 1979.
26. "Minimizing goodness-of-fit measures." Invited presentation E. I. Dupont, Wilmington, Delaware, April 27, 1980.
27. "Page's L without random rankings." Invited presentation at IMS Regional Meeting, Iowa City, Iowa, April 30, 1980.
28. "L-Statistics with smooth weight functions jackknife well," with Parr, IMS Regional Meeting, Iowa City, Iowa, April 29, 1980.
29. "Inter-group concordance as a U-statistic." Invited presentation, ASA National Meeting, Houston, Texas, August 31, 1980.
30. "Useful Nonparametric Techniques." Invited presentation AIDS National Meeting, Las Vegas, November 1980.
31. "Ordered alternatives in the Two-way Layout" with Palachek, ASA National Meeting, Detroit, August 1981.

32. " On approximate confidence intervals for measures of concordance," with Palachek, Joint Regional Meetings of Biometrics Society, ASA and IMS, San Antonio, March 1982.
33. "Students as consumers: Predicting satisfaction", with Barry and Gilly, An Assessment of Marketing Thought and Practice, 1982 Educators Conference Proceedings, pp. 109-112.
34. "U-Statistics for evaluating two-group concordance", with Palachek Proceedings of the Social Statistics Section, ASA National Meeting, Cincinnati, August 1982.
35. "Comparison of approximate confidence interval procedures for multihit quantal response models", with Dorsett, Joint Statistical Meetings, Toronto, August 1983.
36. "Using the Jackknife and Bootstrap Cautiously" Invited presentation to Cincinnati Chapter of ASA daylong Conference on Statistics, October 5, 1984.
37. "Statistical Issues in Employment Discrimination Litigation", Invited presentation to Florida Chapter ASA Annual meeting, Orlando, Fla., March 1-2, 1985.

Invited Departmental Seminars:

Stanford University, January 1971
Bishop College, March 1974
Stephen F. Austin, March 1978, March 1985
Kansas State University, Nov. 1979
Texas A & M University, Nov. 1979
Florida University, January 1980, February 1985
Clemson University, January 1980
Rice University, March 1981
University of Texas, April 1981
Ohio State University, May 1981
University of Florida, February 1985

Service to the University Community:

Computer Usage Committee (1971-1974)
Undergraduate Interdisciplinary Majors Committee (1973-1976)
Computer Policy Committee (1973-1976)
Director of Statistical Research Laboratory (1971-1980)
H & S Committee for University College Course Development
(Summer 1975)
Dean's Advisory Committee for Tenure and Promotion, Div. II
(Fall 1975-Spring 1978)
Commission on the Status of Women at SMU (Spring 1977-Fall 1978)
Advisory Board to the Vice President for Student Affairs
(1977-1978)
Committee on Economic Status of Faculty (Faculty Senate)
(Spring 1978-Fall 1979)
Tenure Review Committee for the Provost (Spring 1978)
Faculty Steering Committee for Accreditation Self Study
(Summer 1978-1981)
Search Committee for Department Chairperson for Computer Science
and Engineering (1978-1979)
Dean's Advisory Committee for Tenure and Promotion, H&S Div.
III (Fall 1978-Fall 1979)
Working Group on Curriculum (1978-79)
Advisory Selection Committee for Administration of The College
(Executive Subcommittee: Fall 1979)
Advisory Committee to Chairman of Mathematical Sciences Division
(1979-80)
Presidential Advisory Selection Committee (Vice Chairman) (Summer
1980-Fall 1980)
Council on Graduate Education (1980-81)
Search Committee for the Dean of Cox School of Business
(Spring 1981-Spring 1982)
Dean's ad hoc Advisory Committee on Tenure, Dedman, Div. III
(1981-1982))
Dean's Advisory Committee on Tenure, Dedman Div. II (Spring 1981)
Dean's Advisory Committee on Foreign Language Requirement
(Spring 1983)
Advisory Search Committee for Albritton Chair in Geosciences
(1983-1984)
Computer Literacy Committee (1983-84)
Search Committee for Simmons Chair in Marketing (1985-86)

Ph.D. Dissertations Supervised:

1. Sommers, John P. On the Improvement of Kernel Type Density Estimators (June 1972).
2. Frawley, William H. Improved Approximate Confidence Levels. (December 1972).
3. Li, Lai-Hung Loretta. A Rank Test Sensitive to Common Concordance in Two Groups (August 1973).
4. Minor, James Marshall Improved Estimation of $f'(y)/f(y)$ (August 1973).
5. Beckett, James III. Some Properties and Applications of a Statistic for Analyzing Concordance of Rankings of Groups of Judges (June 1975).
6. Michael, John R. Goodness-of-Fit: Type II Censoring and Influence Functions (August 1977).
7. Parr, William C. Minimum Distance and Robust Estimation (August 1978).
8. Ulrich, Gary Bilinear Rank Statistics (December 1980).
9. Palachek, Albert D. Applications of U-Statistics to Testing and Estimation of Concordance (August 1981).
10. Bosmia, Natwarlal J., Minimum Distance Estimation of a Truncation Parameter (August 1982).
11. Lee, Young-Ha, An Improvement of the Bootstrap Methodology (August 1983).
12. Thombs, Lori A., Bootstrap Prediction Intervals for Autoregressive Processes (August 1985)

Consulting:

In official capacity as Manager of the Statistical Laboratory or independently has served as a consultant to:

City of Dallas, Community Renewal Program
Children's Medical Center
Southwest Airmotive Corp.
Otis Engineering Corp.
Information Technology Associates
Louis, Bowles and Grove
Mechanics Research, Inc.
Alcon Laboratories
Southland Corporation
E-Systems, Inc.
Medicus Corporation
Industrial Aids International
Sun Oil Company
Compucon
Vought Corporation
Mobil Oil Corp.
Texas Society of CPA
Office of Civil Rights
Energy Filing Corporation
The Horchow Corporation
The Humana Corporation
Texas Society of Anesthesiologists
Baskin-Robbins

Various law firms involved in employment discrimination
litigation