SECURITY CLASSIFICATION OF THIS PAGE

(2)

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S): AFOSR-TR-89-1382
6a. NAME OF PERFORMING ORGANIZATION: The Florida State University, Department of Statistics	6b. OFFICE SYMBOL (If applicable)
6c. ADDRESS (City, State, and ZIP Code): Tallahassee, Fl 32306	7a. NAME OF MONITORING ORGANIZATION: AFOSR
	7b. ADDRESS (City, State, and ZIP Code): BLDG 410, BAFB DC 20332-6448
8a. NAME OF FUNDING / SPONSORING ORGANIZATION: AFOSR	8b. OFFICE SYMBOL (If applicable)
	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: AFOSR 78-3678
8c. ADDRESS (City, State, and ZIP Code): BLDG 410, BAFB DC 20332-6448	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO	WORK UNIT ACCESSION NO.
61102F	2304	A5	

11. TITLE (Include Security Classification)
STATISTICAL ASPECTS OF RELIABILITY, MAINTAINABILITY, AND AVAILABILITY

12. PERSONAL AUTHOR(S)
MYLES HOLLANDER AND FRANK PROSCHAN

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM _____ TO _____	29 Sept 1980	10

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

(Continue on reverse if necessary and identify by block number)

AD-A214 631

DTIC
ELECTE
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20. DISTRIBUTION / AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
	767-5025	NM

DD Form 1473, JUN 86 — Previous editions are obsolete. — SECURITY CLASSIFICATION OF THIS PAGE

89 11 27 126

Annual Scientific Report to Air Force Office of Scientific Research.

Grant AFOSR-78-3678
September 30, 1979 - September 29, 1980

Statistical Aspects of Reliability, Maintainability, and Availability

Reliability Center
Department of Statistics
The Florida State University
Tallahassee, Florida 32306

Myles Hollander and Frank Proschan
Co-Principal Investigators

September, 1980

1. List of Publications.

Under Grant AFOSR-78-3678, September 30, 1979 - September 29, 1980, the following publications have been produced:

A. Reports Issued.

Y.Y. Chen, M. Hollander, and N.A. Langberg. Tests for monotone mean residual life using randomly censored data. AFOSR Report No. 78-111. July, 1980.

Y.Y. Chen, M. Hollander, N.A. Langberg. Small sample properties of two survival function estimators based on incomplete data. AFOSR # 78-112. July, 1980.

Y.Y. Chen, M. Hollander, N.A. Langberg. Testing whether new is better than used with randomly censored data. AFOSR Report No. 78-?. August, 1980.

N.A. Langberg and M. Shaked. On the identifiability of multivariate life distribution functions. AFOSR # 114. July 1980.

S. Fahmy, C.A.B. Pereira, and F. Proschan. The influence of the sample on the posterior distribution. AFOSR # 78-107. April 1980.

S. Fahmy and F. Proschan. Bounds on order statistics differences. AFOSR # 78-102. October, 1979.

Y.Y. Chen, M. Hollander, and N. Langberg. Testing whether new is better than used with randomly censored data. AFOSR # 78-12, June 1980.

A-H.N. Ahmed, N.A. Langberg, R.V. León, and F. Proschan. Partial ordering of positive quadrant dependence, with applications. AFOSR # 78-3. March, 1979.

J. Kitchin, N.A. Langberg, and F. Proschan. A new method for estimating life distributions from incomplete data. AFOSR # 78-109. May, 1980.

R.E. Barlow and F. Proschan. Inference for the exponential life distribution. Chapter I of Data Analysis and Inference in Reliability and Biometry. AFOSR # 78-103. January, 1980.

M. Brown and F. Proschan. Imperfect repair. AFOSR # 78-108. April, 1980.

N.A. Langberg, R.V. León, J. Lynch, and F. Proschan. Extreme points of the class of discrete decreasing failure rate average life distributions. AFOSR # 78-106. April, 1980.

E. El-Neweihi, F. Proschan, and J. Sethuraman. A multivariate new better than used class derived from a shock model. AFOSR # 78-105. March, 1980.

E. El-Neweihi and F. Proschan. Unified treatment of some inequalities among ratios of means. AFOSR # 78-101. October, 1979.

B. Papers Published.

M.A. Langberg and F. Proschan. A reliability growth model involving dependent components. Ann. Probability 7 (1979) 1082-1087.

L. Billard, H. Lacayo, and M.A. Langberg. A simple batch epidemic process. Math. Biosciences 48 (1980) 65-70.

L. Peele and G. Kimeldorf. Time series prediction functions based on imprecise observations. Ann. Statist. 7 (1979) 801-811.

M.A. Langberg, R.V. León, J. Lynch, and F. Proschan. Extreme points of the class of discrete decreasing failure rate life distributions. Math. O.R. 5 (1980) 35-42.

E.El-Neweihi and F. Proschan. Multistate reliability models: A survey. Multivariate Analysis V, ed. by P.R. Krishnaiah. (1980) North Holland Pub. Co. 523-541.

N. Langberg. The convergence in distribution of some simple epidemics. Math. Biosciences 50 (1980), 273-284.

L. Billard, H. Lacayo and N. Langberg. The discrete asymptotic behavicur of a simple batch epidemic. J. Appl. Prob. 17 (1980), 25-32.

L. Billard, H. Lacayo and N. Langberg. The symmetric m-dimensional simple epidemic process. J.R.S. Sc. Series B 41 (1979), 196-202.

6. Papers in Press or Accepted for Publication.

N. Langberg, R. León, and F. Proschan. Characterization of partially ordered classes of life distributions. Statistica Neerlandica.

N. Langberg. F. Proschan, and A.J. Quinzi. Estimating dependent life lengths, with applications to the theory of competing risks. Ann. Statist.

A-H.N. Ahmed, R. León, and F. Proschan. Generalized association, with applications in multivariate statistics. Ann. Statist.

F. Proschan. Coherent structure theory: A survey. Encyclopedia of Statistical Sciences, ed. by. N.L. Johnson and S. Kotz. To be published by Wiley.

R.C. Hannum, M. Hollander, and N.A. Langberg. Distributional results for random functionals of a Dirichlet process. Ann. Prob.

M. Hollander, F. Proschan, and J. Sethuraman. Decreasing in transposition property of overlapping sums, and applications. J. Mult. Anal. Applic.

M. Hollander. The "New Better than Used" (NBU) test. Encyclopedia of Statistical Sciences, ed. by N.L. Johnson and S. Kotz. To be published by Wiley.

R. Hannum, M. Hollander and N. Langberg. Distributional results for random functionals of a Dirichlet process. Ann. Prob.

J. Kitchin and F. Proschan. Generalization of Block-Savits convolution result. Ann. Statistics.

M. Hollander. The bivariate symmetry test. Encyclopedia of Statistical Sciences, ed. by N. L. Johnson and S. Kotz. To be published by Wiley.

M. Hollander. Tests for dependence. Encyclopedia of Statistical Sciences, ed. by N. L. Johnson and S. Kotz. To be published by Wiley.

N. Langberg, R. Johnson and R. Bradley. Stochastic results for random location of individuals in a habitat. Stochastic processes and their applications.

L. Billard, H. Lacayo, and N. Langberg. Generalizations of the simple epidemic process. J. Appl. Prob. 17, (1980) (December).

S. Fahmy and F. Proschan. Bounds on order statistics differences. Am. Statistician.

E. El-Neweihi and F. Proschan. Unified treatment of some inequalities among ratios of means. Proc. Am. Math. Soc.

A-H. N. Ahmed N. Langberg, R. León, and F. Proschan. Partial ordering of positive quadrant dependence, with applications. J. Mult. Anal.

A-H. N. Ahmed, N. Langberg, R. León, and F. Proschan. Two concepts of positive dependence, with applications in multivariate analysis. J. Mult. Anal.

D. Reports in Preparation.

C. D' Abadie, R. León, and F. Proschan. Stochastic rearrangement inequalities, with applications in reliability.

E. El-Neweihi, F. Proschan, and J. Sethuraman. Multistate reliability assuming exponential transitions.

J. Kitchin, N. Langberg, and F. Proschan. Weak convergence of a new estimator of reliability when data is incomplete.

P. Lacayo, C. Pereira, F. Proschan, and C. E. Sarndahl. Opimum sample selection.

M. Brown and C. N. Rao. IFRA property of first passage distribution.

H. Joe and F. Proschan. Shock models and wear processes generalized.

M. Hollander and R. C. Hannum. Bayesian nonparametric estimation of a symmetric distribution.

E. Books in Preparation.

R. E. Barlow and F. Proschan. Statistical Theory of Reliability and Life Testing. Holt, Rinehart, and Winston. (1975) To be published in Russian.

R. E. Barlow and F. Proschan. Inference and Data Analysis in Reliability and Biometry.

M. Hollander and F. Proschan. Statistics Explained In Words, Not Symbols.

F. Consultation on Air Force Problems.

The Reliability Center, Department of Statistics, Florida State University, consulted on a problem in sequential sampling for lot acceptance based on attributes. Skipping details, we may state the crux of the problem as follows:

Plan 1. Suppose a single sample plan is being used in which n=6 units are randomly selected from a lot. The lot is accepted if at most 1 failure is observed.

Plan 2. Select a sample of size n=9. Accept the lot if at most 2 failures are observed.

Plan 3. A. Select a sample of size n=6. Accept the lot if at most 1 failure is observed.

B. If 2 failures are observed, select 3 more units. If the additional 3 are each good items, accept the lot.

C. Reject the lot otherwise.

It is clear that under Plan 3, the lot is being given a "second chance". That is, if it fails under Plan 1 because 2 defectives are found among the 6 units randomly selected, the lot is given a second chance to pass since 3 more units are randomly selected under Plan 3. Clearly, the probability of lot acceptance is increased from .11 under Plan 1 when the probability p of an individual unit being defective is .5 to a probability of .14 of lot acceptance under Plan 3.

The acceptance sampling group had not realized that the generous gift of a "second chance" had increased the chance of acceptance of a defective lot by 27% (from .11 to .14)!

The actual analysis contained more general results than those selected

above. Formulas for general p (probability of a defective unit) were included, and a graphical plot of lot acceptance for $0 \leq p \leq 1$ was drawn.

It should be remarked that the fallacy of giving a "second chance" is widely prevalent among quality assurance technicians, especially when pressure exists to accept scarce product.

The analysis was sent to AFOSR in response to a request from them.

G. Research Visitors to Reliability Center.

The Reliability Center benefited from visits of varying length by the following reliability researchers:

1. Richard E. Barlow
2. Nozer D. Singpurwalla
3. Kumar Jogieo
4. Emad El-Neweihi
5. John Conlon.