**Control and Cybernetics**

vol. **35** (2006) No. 3

**Book review:**

# ADVANCES IN RANKING AND SELECTION, MULTIPLE COMPARISONS, AND RELIABILITY, Methodology and Applications

by

**N. Balakrishnan, N. Kannan, H. N. Nagaraja, editors**

The volume is dedicated to Professor S. Panchapakesan, who has made an excellent and significant contribution to several different fields of statistics. The book is a collection of twenty papers divided into six parts: *INFERENCE*, *RANKING AND SELECTION*, *MULTIPLE COMPARISONS AND TESTS*, *AGREEMENT ASSESSMENT ANALYSIS*, *RELIABILITY*, *BIOSTATISTICS*. The authors of individual chapters are a representative group of coauthors, friends and professional associates of Professor Panchapakesan. The volume comprises also a concise presentation of Professor's career and accomplishments and the list of publications (articles in Journals/Books, Technical Reports, Book Reviews).

Some of the chapters are devoted to methodological issues (reviews or new results), other ones – to applications (case studies); the areas of applications comprise mainly: industry, technology, biology, and medicine. The results presented are based on main statistical techniques: analytic inference, simulations, bootstrap and graphical analysis. Statistical tables prepared by Authors and an *Index* are also included. The report on the individual chapters presented below is rather concise, because of their considerable number.

The first part (*INFERENCE*) comprises five papers devoted to various aspects of statistical inference. The first of them: *Score Test: Historical Review and Recent Developments* – by C. R. Rao discusses the topics of *Holy Trinity*, i.e. three main approaches to hypothesis testing – Neyman and Pearson Likelihood Ratio, Wald Statistic and Rao's score. It is well-known fact that these approaches are equivalent to the first-order asymptotics, but differ in second order properties. The problems under consideration are: main features of the tests (advantages, anomalies, power comparison) and issues of special importance (e.g. suggestions about a caution in use). The last section of the chapter presents recent developments (especially modifications and refinements) and shows directions of further researches. The chapter is clear, pithy and inspiring; the bibliography comprises significant papers (theory and applications). The review of such kind is not only a synthesis, but also an excellent source of reflexion on hypothesis testing problems.

The paper entitled *EM Algorithm and Optimal Censoring Schemes for Progressively Type-II Censored Bivariate Normal Data*, by N. Balakrishnan and J.-A. Kim, is prepared in a similar way and discusses the topics of optimal censoring schemes. Censored data result from some types of experiments, e.g. clinical trials. Under normality assumption Authors determine the parameters of the probability distribution function for the analyzed type of data (using maximum likelihood approach) and optimal censoring scheme, in terms of minimum trace of variance-covariance matrix. Important features of the paper are: presentation of detailed formulas (and necessary statistical tables), informative example and concise but comprehensive review of the literature.

The next paper, *Inference Guided Data Exploration*, by G. Yothers and A. R. Sampson, considers the problem of comparing two treatments using a test based on full sample and its subsets. The test statistic is assumed in the form of minimal $p$-value from the group of hypothesis tests. A critical value of the test proposed is obtained on the basis of simulations. The approach may be useful in the analysis of experimental data, especially in the case of limited sources for experiments. The approach seems interesting, but its theoretical background is (currently) rather weak; the efficiency – in comparison to other methods – needs further investigations.

The paper *Discriminating Between Normal and Laplace Distribution* – by D. Kundu - is also devoted to a more detailed problem, i.e. discrimination between two probability distributions, playing main role in statistics. The properties of the statistic proposed – ratio of maximized likelihood – are fair: the statistic is independent of unknown parameters and the asymptotic distribution is normal. For small sample size the adequacy of the asymptotic distribution is examined with the use of simulations. The concept proposed is a significant contribution to the problem considered, but it seems necessary to make more extensive comparisons with other tests. Important feature of the approach is the possibility of applying it for other distributions.

The last paper of the first part *A Simple Classification Rule for Directional Data* – by A. SenGupta and S. Roy - proposes a statistic for classification of a new observation into one of two circular populations on the basis of training samples. The exact distribution of the statistic is derived for the case of von Mises populations. The efficiency of the method is compared (numerically) with the Fisher's discrimination rule. The comparison shows that the rule proposed outperforms Fisher's rule, for the criterion expressing the apparent error rate. The approach is illustrated with the use of real-life data. The results presented are consistent with the title – the method proposed is simple, easy for application and also efficient.

The second part of the volume consists of four chapters – more homogenous, than those from the previous part. The first of them *On Some Ranking and Selection Procedures for MANOVA Models with Applications* – by Deng-Yuan Huang and Ren-Fen Lee, proposes a procedure allowing to select the most preferred attributes of products (or services) in the case of existence of attribute

interactions. The approach is based on the appropriate type of the MANOVA model; it is a tool for marketing research, especially useful, when the number of combinations of attribute levels is significant. The parameters of the *MANOVA* model are estimated with the use of the method of moments; estimators are unbiased. The models are formulated for one respondent, but can be extended for more respondents. The predictive ability of the model is evaluated on the basis of well-known tools – Spearman $\rho$ and Kendall $\tau$. The results presented are especially useful for practitioners (and students), because of simplicity and possibility to perform computations with the use of standard statistical software. The main contribution of the paper is ingenious application of the *ANOVA* model. The bibliography comprises only two ,,classical" monographies about multivariate decisions designs of experiments. The last two features mentioned distinguish the paper against the background of the rest of the volume.

The next chapter, *A Restricted Subset Selection Rule for Selecting At Least One of the t Best Normal Populations in Terms of Their Means: Common Known Variance Case* – By Lifang Hsu and S. Panchapakesan, proposes a new procedure (rule) for selecting of a non-empty subset of (at most) $m$ populations from the set of $k$ populations in such a way, that: • at least one of the populations associated with the $t$ largest means ($1 \leqslant m \leqslant k-t$; $1 \leqslant t \leqslant k$-1) is included in the selected subset with a minimum probability $P*$, • the parameters of the selection satisfy some conditions and are specified in advance of the experiment. It is assumed also that populations are normal with unknown means and common known variance. The procedure is an alternative (some generalization) to the earlier rules proposed by other authors (e.g. Santner in 1976). A significant contribution of the paper is derivation (in the analytical way) of important properties of the procedure (especially consistency and strong monotonicity) and comparison with the case of the fixed size $m$. The comparison indicates the advantages of the new rule. The procedure is easy for application, taking into account the complexity of the problem. Some topics are left for further investigations, especially the case, when the variance of the populations is unknown.

The next chapter – *Selecting the Best Population with Two Controls: An Empirical Bayes Approach* – by Wen-Tao Huang and Yao-Tsung Lai, is an extension of the earlier work of Author's, aimed at inference about homogeneity of $k$ populations. More precisely, it concerns selecting a population with the largest mean from the set of $k$ populations ($k \geqslant 2$) with unknown means $\Theta_i$ and variances $\sigma_i^2$, assuming two constraints: the mean is not smaller than $\Theta_0$ and variance is not larger than $\sigma_0^2$. The case is allowed, when constraints lead to an empty set. The selection procedure is based on the Bayes framework; the parameters of the populations (mean and variance) are assumed, as realizations of a random vector. The main result of the paper concerns the case, when some parameters of a priori distributions are estimated. It is proved that estimators applied are consistent and that the Bayes rule proposed is asymptotically optimal, under criterion expressing expected value of the Bayes risk. The theo-

retical results are not illustrated with any example; no suggestion is made about further investigations.

The last chapter of the second part, *Simultaneous Selection of Extreme Populations: Optimal Two-stage Decisions Rules* – by N. Misra and I. D. Dhariyal, presents an optimal two-stage selection procedure obtained under weak assumptions about populations $\Gamma_1$,..., $\Gamma_k$ generating observations. The populations are ordered by the values of unknown parameter $\Theta_i$. The distributions of the populations, characterized by the probability density functions $g(\cdot, \Theta_i)$ ($i$=1, ..., $k$), belong to the exponential family and are unimodal. The optimal decision rules are aimed at selection of extreme populations, i.e. associated with $\Theta_{[1]} = \min\limits_{1 \leqslant i \leqslant k} \{\Theta_i\}$ and $\Theta_{[k]} = \max\limits_{1 \leqslant i \leqslant k} \{\Theta_i\}$ in two stages: screening out of non-extreme populations (the first stage) and selecting extreme populations (the second stage), with the use of additional samples. The procedure is based on sufficient statistics for $\Theta_i$ and some class of loss functions. Apart of optimality it is proved that the class of the procedures under consideration is essentially complete. The results are of excellent significance, but their application is not easy (complex formulas) and no example is discussed.

The third part of the volume comprises three papers. The first of them *Comparing Variances of Several Measurement Methods Using a Randomized Block Design with Repeat Measurements: a Case Study* – by A. C. Tamhane and A. J. Hayter is – in contrast to the previous text – a case study combining graphical and formal methods of data analysis. Authors consider the problem of comparing of variances of several measurement methods/instruments, when repeated measurements are made on a randomly selected sample of subjects/items. Such data are often a result of experiments in some fields of knowledge, especially biology, medicine, psychology, etc. (an empirical problem of insertion gain is analyzed). Typically, the research papers present methodological progress – applications are used mainly as illustrations. Therefore, the example of thorough, careful analysis of empirical data with limited number of observations (often non-homogenous) is of great importance for research workers, practitioners and students. The reader of the text gains an experience without trial-and error method.

The next chapter, *Impact of Missing Data and Imputation Methods on Multiple Test Procedures* – by Alka Indurkhya, discusses the problem of influence of missing data (completely at random and at random) on the Type I familywise error rate of the therapeutic window of a drug, using multiple test procedures. The scope of the chapter is more specialized in comparison to the other ones, but the problem is of great importance in medicine. The inference is based on two methods: bootstrap procedure and (usual) simulations. The paper does not contribute analytical progress, but the simulation methodology and conclusions are important for researchers in the area of medicine.

The last chapter of the third part, *Asymptotic Second-order Efficiency for Two-stage Multiple Comparisons with Components of a Linear Function of*

*Mean Vectors* - by Makoto Aoshima and Takuya Kushida, presents (in contrast to the preceding chapter) significant theoretical results, supported, additionally, by stochastic simulations. It is assumed that components of linear functions are means vectors from $k$ independent $p$-variate ($p \geqslant 2$) normal distributions; the means of the distributions are unknown, covariance matrices are unknown, but spherical, parameters of a linear function are known. The main result of the paper is an analysis of assumptions, which determine the second-order asymptotic efficiency of the examined type of procedure, i.e. when the procedure cannot became efficient and what adjustment is necessary in order to make it efficient. The performance of the procedure proposed (with adjustment of design constant and initial sample size, which provide its asymptotic efficiency) in the case of moderate sample is examined with the use of simulations. Their results validate the application of the procedure in the case of moderate and even small sample size. The paper provides also some practical guidelines concerning the values of the procedure parameters; they are of special importance in the non-easy area.

The next part of the book, *AGREEMENT ASSESSMENT* comprises two papers only. The first of them, *Measuring Agreement in Method Comparison Studies – A Review* – by P. K. Choudhary and H. N. Nagaraya, is a broad review of the literature on the assessment of agreement between two measurement methods and on selection of the best method, when several methods are compared with a reference (assuming random measurements). Such problems appear typically in biology, medicine and other experimental fields of knowledge. The review comprises classical results, recent developments and directions for future investigations. The theoretical considerations are illustrated in a practical example – analysis of disagreement of medical data (two methods of plasma volume measurement). Especially interesting is inference about the nature of differences – from statistical point of view. The paper is an excellent guide of the area – synthetic, concise and deep.

The chapter *Measures of Concordance for Assessing Agreement in Ratings and Rank Order Data*, by M. Raghavachari, proposes a general measure of concordance in the ranking problem, i.e. agreement of rank orders for $n$ items provided by $M$ judges. The measure is the quadratic form including the Pearson's matrix (correlation coefficients of ranks) and the vector expressing deviations of ranks from the group average and overall average. The Author has derived the distribution of the quadratic form under some assumptions about individual rankings (independent of judges, equicorrelated ranks of each judge, normal distribution of ranks of $j$-th judge). The known form of the distribution allows for verifying the hypothesis about concordance of judges (methods of measurements, instruments, etc); such problems appear in biometric or market research. The results presented provide a significant progress in the area and some generalization of earlier findings; they are illustrated with the known data (analyzed earlier by Kendall). However, the distribution of the measure proposed is based on restricted assumptions and their relaxation seems not easy.

The fifth part of the volume, *RELIABILITY*, comprises three papers devoted

mainly to the problem of the optimal order replacement policies and estimation issues in this area. The first paper, *Cost-effective Analysis of Optimal Order-replacement Policies* – by T. Dohi, N. Kaio and S. Osaki, presents a problem of optimization of order-replacement policies for two types of models (one unit systems): order replacement model and order-inspection model. Both models are defined and optimized for continuous and discrete time. The special cases, important for practice, are discussed separately and more extensively; numerical examples are examined, too. The paper is a synthesis of extensive and crucial investigations made by Authors in the area discussed; it comprises also a broad review of the subject literature.

The next chapter, *Estimating Reliabilities Following Purely Sequential Sampling from Exponential Populations* – by N. Mukhopadhyay and G. Cicconetti, examines a problem of sequential point estimation of: • the scale parameter in exponential populations and • difference of means from two independent exponential populations. The properties of twelve estimators for such problems are determined; some of them are derived in the analytic way (especially bias correctness), while the remaining ones – with the use of simulations. Empirical illustrations, i.e.: medical ,,time to relapse" and failures of air conditioning systems are also included. The significant contribution of the paper is advance in some important problems, which seem simple at a first glance, but in fact need a careful analysis.

The last chapter of this part, *Empirical Bayes estimation of Mean Lifetime for an Exponential Distribution: Unequal Sample Sizes Case* – by Tachen Liang, examines the problem of construction of empirical Bayes estimators in an exponential distribution. More precisely, the subject of examination is a sequence of statistical problems with the same generic structure, i.e.: at stage $i$ ($i$=1, ..., ) available the sample is available of a size $m_i$ (unequal), obtained from the exponential distribution with the mean life $\Theta_i$, where $\Theta_i$ is a realization of a positive random variable $\Theta_i$. It is assumed that the mean is included in the interval $[a, b]$ ($0< a < b < \infty$), which may be known or unknown. The paper proposes an empirical Bayes estimator with the use of kernel function and its asymptotic optimal properties are proved – for the known and unknown interval $[a, b]$. For both cases the rate of convergence of the estimator regret to zero is determined; of course, the rate is better for the known interval. The solution of the problem formulated is genuine and efficient, but the analytical side of the considerations is rather complicated.

The last part of the volume, entitled *BIOSTATISTICS*, comprises also three chapters with quite different topics. The first paper, *Bayesian Analysis of Mixtures of Improper Survival Distributions* – by K. Patra, D.K. Dey and S. Ghosh, proposes some mixture models for analysis of survival distributions in the case, when each component of the mixture admits positive probability of cure. The models are extensions of the earlier approach, however they require some additional assumptions. The main contribution of the paper is development of estimation procedure with Bayesian inference. The models are applied to real

data describing the criminal relapse of prisoners. The results obtained seem useful for the researches in the area, but are not compared with earlier models.

The next paper, *Multivariate Survival Analysis with PVF Frailty Models* – by M. Mallick and N. Ravishanker, is devoted to the problem of inference about multivariate lifetime data using conditional proportional hazards model with a power variance frailty (PVF) distribution. Inference is carried out in the Bayesian framework using Markov chain simulation techniques. The approach proposed is applied to analysis of data involving recurrent infections due to insertion of a catheter on dialysis machine. The main contribution of the paper is derivation of the density function of the PVF and the joint posterior distributions of the model parameters (it is a development over the earlier models). The empirical example (first and second occurrence of infection in 38 patients) and some directions of future investigations are included as well.

The last paper, *A Two-stage Design for Choosing Among Experimental Treatments in Clinical Trials* – by L. Rollin and P. Chen, proposes a two-stage selection and testing design for choosing among $k$ ($k \geqslant 2$) experimental treatments, under the condition that the selected treatment is better than a standard one (no population result is admissible too). In fact, the chapter is close to papers from the second part; the results may be applied not only in clinical experiments. The methodology proposed is an extension of earlier results (e.g. Thall, Simon, Ellenberg, Tanya and Dudewicz). The contribution of Authors comprises: general concept, derivation of formulas for parameters of the procedure (size, power, probability of early termination); theoretical background of the procedure is sufficient. The comparison of the efficiency of the procedure with the approach of Tanya and Dudewicz does not indicate that it performs uniformly better – the advantage depends on the values of some parameters. Therefore, the procedure can be regarded as an alternative for known methods.

Let us summarize briefly the main features of the papers from the volume.

• The scope of the volume is quite extensive and varied. Therefore, the volume can be regarded, as a kind of a guidebook in the area considered, especially useful for researchers, practitioners and also students, specializing in these topics.

• The papers are written in a clear and concise manner. Their important features are: significant (often excellent) theoretical and methodological contribution and careful analysis of model adequacy with respect to actual phenomenon. The proposed methods and procedures are efficient (usually optimal in some sense), however sometimes complicated – analytically and computationally. Incorrect use of some statistical tools is also indicated.

• The main results of the papers are derived in analytical way; simulations and bootstrap approach are used for problems not solvable or difficult to solve in another manner. The methods of solution of problems considered are often original and inspirative.

• The case studies are careful and deep – consistent with the features of

empirical data. Some of them can be recommended also for the less advanced readers.

The features of the volume mentioned above make it useful for a wide circle of readers. It is also a basis for reflection on the directions of development of statistics. Thus, the book is an important and unquestionable component of statistical library.

Leszek Klukowski

N. Balakrishnan, N. Kannan, H. N. Nagaraja, eds. *Advances in Ranking and Selection, Multiple Comparisons and Reliability. Methodology and Applications.* Industry and Technology. Birkhäuser Verlag, Basel - Boston - Berlin, XLI+412 pages, 2005. ISBN 0-8176-3232-8. Price (hardcover) CHF 158.00.