CONFIDENCE INTERVAL ESTIMATION FOR THE DIFFERENCE BETWEEN TWO STOCHASTIC PROCESSES USING STANDARDIZED TIME SERIES, Bor-Chung Chen and Robert G. Sargent, Working Paper #84-004, October 1984, Department of Industrial Engineering and Operations Research, Syracuse University, Syracuse, N. Y. 13210.

This paper describes confidence interval estimation for the difference between the means of two independent strictly stationary phi-mixing stochastic processes. This estimation is based on the asymptotic properties of the standardized time series of observations from the two stochastic processes. Interval estimators for the cases of equal sample sizes with unknown variances, unknown common variance, and unequal sample sizes with unknown variances are developed. Two applications of these intervals are validating stationary discrete event simulation models and comparing two alternative policies or system designs via simulation.

AN ILLUSTRATION OF THE SAMPLE SPACE DEFINITION AND VARIANCE REDUCTION, Barry L. Nelson, Department of Industrial and Systems Engineering, The Ohio State University, 1971 Neil Avenue, Colombus, Ohio 43210.

A simulation experiment performed to estimate the expected number of customers served per day in a bank is used to illustrate a new definition of simulation experiments, a new framework for variance reduction, and several variance reduction techniques (VRTs). Particular emphasis is placed on techniques that might be suitable for automated variance reduction procedures.

EDITOR'S CORNER

REGENERATIVE PROCESSES AND THE ϕ-MIXING PROPERTY, by Peter W. Glynn, Department of Industrial Engineering, University of Wisconsin, Madison, Wisconsin 53706.

The development of limit theory for steady-state output analysis algorithms is often simplified by assuming that the output process is either ϕ-mixing or regenerative. The purpose of this note is to show that, contrary to the folklore, stationary positive recurrent regenerative processes are not necessarily ϕ-mixing.

Let $X = \{X_n : n \geq 0\}$ be a Markov chain on state space E = (0, 1, . . .), with transition matrix

$$P_{i,i+1} = p \quad , \quad i \geq 0$$
$$P_{i,i-1} = q \quad , \quad i \geq 1$$
$$P_{0,0} = q$$

where $1 > q = 1-p > 1/2$. If $P\{X_0 = j\} = (1-p/q)^{-1}(p/q)^j$, then X is a stationary Markov chain which is a positive recurrent regenerative sequence with respect to hitting times of state 0 (for instance).

In order that X be ϕ-mixing (see BILLINGSLEY (1968), there must exist constants $\phi(n)$ decreasing to zero such that

$$(1) \quad \sup\{|P(E_2 \mid E_1) - P(E_2)| : E_1 \in \mathcal{F}_0^k, E_2 \in \mathcal{F}_{k+n}^{\infty}, k \geq 0\} \leq \phi(n)$$

where $\mathcal{F}_i^j$ consists of all events generated by $X_i, \ldots, X_j$ $(i \leq j)$. The left-hand side of (1) clearly dominates

$$\sup\{|P\{X_n = 0 \mid X_0 = j\} - P\{X_n = 0\}| : j \geq 0\}$$
$$\geq |P\{X_n = 0 \mid X_0 = n+1\} - P\{X_n = 0\}|$$
$$\geq P\{X_n = 0\} = (1-p/q)^{-1};$$

The second inequality is a consequence of the fact that a birth-death chain cannot move more than n states in n steps. It follows that the left-hand side of (1) does not converge to zero as n tends to infinity. Hence, X is not ϕ-mixing.

Stationary positive recurrent regenerative sequences do satisfy a somewhat weaker mixing hypothesis, namely that of strong mixing:

$$\sup\{|P(E_1 \cap E_2) - P(E_1)P(E_2)| : E_1 \in \mathcal{F}_0^k, E_2 \in \mathcal{F}_{k+n}^{\infty}, k \geq 0\} \leq \alpha(n)$$

where the $\alpha(n)$'s converge to zero (see GLYNN (1982). It turns out that strong mixing is sufficient to prove a large variety of limit theorems that are relevant to simulation; see, for example, HALL and HEYDE (1980).

$$\sup\{P(E_1)\,|P(E_2|E_1) - P(E_2)| : E_1 \in \mathcal{F}_0^k, E_2 \in \mathcal{F}_{k+n}^{\infty}, k \geq 0\} \leq \alpha(n)$$

Acknowledgement: The preparation of this note was supported by the National Science Foundation under Grant No. ECS-8404809.

REFERENCES

[1] BILLINGSLEY, P. (1968). **Convergence of Probability Measures.** John Wiley, New York.

[2] GLYNN, P. (1982). Some new results in regenerative process theory. Technical Report 16, Department of Operations Research, Stanford University, Stanford, CA.

[3] HALL, P. and HEYDE, C. C. (1980). **Martingale Limit Theory and its Applications.** Academic Press, New York.

(Please address comments to the author. Ed.)

SPEAKING FOR TIMS ON PROPER PRACTICE

No individual is empowered to speak for The Institute of Management Sciences in any public sense on what does or does not constitute proper practice of management science, not the members, not the subdivision officers, not the Council members, and not the President.

Nor is any subdivision so empowered.

The Council alone has this power, but in my view, has wisely refrained from exercising it.

TIMS is not an organization whose functions normally include political or other public pronouncements. TIMS is an organization which provides a collection of forums, some completely open, like the submitted-paper mechanism at meetings, and some restricted, like the refereed journals. In these forums, individuals can express their individual opinions on matters relevant to the Management Sciences.

BALLOT FOR COLLEGE AWARD FOR BEST SIMULATION PAPER IN MANAGEMENT SCIENCE

Five papers have been nominated for selection as the best paper on simulation published in the last two volumes (29 and 30) of **Management Science.** (This award covers volume 29 as well as volume 30 since fewer than three nominations were received for last year's award, covering volume 29 alone.) The ballot below contains the authors' names, paper titles, and bibliographic information.

The definition of "best" was intentionally left undefined by the committee that set up the award five years ago, so that each member of the College could use whatever criteria desired.

Each member of the College may cast one vote for one paper. Although not necessary, any comments about your selection are appropriate and appreciated.

NOTE: In order for your ballot to be counted, include your **Newsletter** address label in the envelope with your ballot. This information will be kept confidential and is only to ensure ballot validity.

Mail to: David Kelton
Department of Industrial and Operations Engineering
The University of Michigan
Ann Arbor, Michigan 48109-2117

Ballots must be postmarked by **August 15, 1985.**

1983-1984 "BEST PAPER ON SIMULATION AND GAMING" IN MANAGEMENT SCIENCE

VOTE FOR ONLY ONE

[ ] Roger I. Hall and William B. Menzies, "A Corporate System Model of a Sports Club: Using Simulation as an Aid to Policy Making in a Crisis," **Management Science 29,** No. 1, January 1983, pp. 52-64.

[ ] Nabil R. Adam, "Achieving A Confidence Interval for Parameters Estimated by Simulation," **Management Science 29,** No 7, July 1983, pp. 856-866.

[ ] Carl A. Mauro and Dennis E. Smith, "Factor Screening in Simulation: Evaluation of Two Strategies based on Random Balancing Sampling," **Management Science 30,** No. 2, February 1984, pp. 209-221.

[ ] David Goldsman and Lee Schruben, "Asymptotic Properties of some Confidence Interval Estimators for Simulation Output," **Management Science 30,** No. 10, October 1984, pp. 1217-1225.

[ ] James R. Wilson and A. Alan B. Pritsker, "Experimental Evaluation of Variance Reduction Techniques for Queueing Simulation using Generalized Concomitant Variables," **Management Science 30,** No. 12, December 1984, pp. 1459-1472.