INFERENCE IN TIME SERIES*

BY time series is meant data in the form of one or more records of observed magnitudes arranged in order of time. Sometimes we have a continuous record of observations, and at other times the record is a sequence (or sequences) of magnitudes observed at equal intervals of time. These are known respectively as continuous and discrete time series. Geophysical and meteorological time series can be observed over a long period, the annual conditions of weather remaining more or less the same over this long stretch of time. However, time series referring to economic phenomena, are generally short because economic conditions undergo abrupt changes now and then.

The conventional analysis of time series into trend, cyclical part, and the residual, is superficial. Earlier work on time series refers mostly to trend-fitting and periodogram construction. Some tests of significance have already been considered in respect of elimination of trend, significance of harmonic analysis, and autocorrelation. More recently, large sample tests of goodness of fit for auto-regressive and moving average models have also been constructed by a number of workers.

By 1947, time became ripe for the initiation of the classical procedures of statistical inference into time series studies. The work of A. Kolmogoroff (1933) and J. L. Doob (1937) has validated the use of a probability measure in function spaces of time series in a number of cases, if not universally. H. Cramér's spectral representation of stationary processes (1942) and the subsequent work of K. Karhunen (1947) have provided new and powerful tools for the study of time series from the standpoint of stochastic processes.

Frequently, the specification of time series does not go beyond stationarity or the Markoff property. As such, an explicit functional formulation of the likelihood is not possible except in the special cases of processes which are also known to be Gaussian. Thus, maximum likelihood estimation procedure is of limited application in time series studies. The usual criteria of consistency, unbiassedness and minimum variance can, however, be taken over into studies on inference in time series. In 1950, U. Grenander has shown how the concept of the likelihood ratio of Neyman-Pearson theory can be brought over into the study of time series with the help of Radon-Nikodym theorem. He has considered the problem of estimation of the mean value function and of the mean value constant which it takes in the case of stationary processes. In the latter case, the time average of the recorded observations is an unbiassed and asymptotically efficient estimate of the unknown mean value. However, U. Grenander (1950) and K. Nagabhushanam (1952) have shown that it is not necessarily the minimum variance estimate. Optimal estimation is generally found to depend on the solution of an integral equation. K. Nagabhushanam (1951) has obtained an integral equation for optimal prediction of the primary process of a linear relationship which reduces by suitable specialization to Levinson's form of Wiener's integral equation for prediction with filtering.

One of the fascinating fields of study relating to inference in time series is the estimation of the spectrum of a stationary process. The classical periodogram is only an asymptotically unbiassed estimate of the spectral intensity and not a consistent estimate of it. Daniell, U. Grenander, and M. S. Bartlett were led to a consideration of weighted sums of periodogram ordinates for obtaining consistent estimates of the spectral density. The need to enlarge the specification of processes to include the cases of stationary processes whose spectra contain the saltus part also is vital to a spectral study of the problem of search for hidden periodicities. It now appears that this can be done, and we can have a positive line of approach to this classical problem of detection of periodicities in a trend-eliminated stationary time series.

* Abstract of the Presidential Address to the Section of Statistics, by Prof. K. Nagabhushanam, at the 43rd Session of the Indian Science Congress, held at Agra, 1956.

SIR CYRIL HINSHELWOOD

SIR CYRIL HINSHELWOOD, Dr. Lee's Professor of Chemistry in the University of Oxford, has been elected the new President of the Royal Society. Sir Cyril is known internationally both for his researches as a physical chemist, and as Foreign Secretary of the Royal Society since 1950. His researches on complex chemical reactions have thrown new light on fundamental processes in biological systems. He also contributed to the British war-time research programme in chemistry. He has been the recipient of many medals including Davy and Royal Medals.