The book is short, readable and interesting. As with all O.R. the most interesting information would be the extent to which the management based their advertising decisions on the research in the years immediately following the experiments, which took place in the early nineteen-sixties, and whether they still base decisions on this or subsequent work. And whether they feel their decisions are good ones—better than they would have been in the absence of O.R.

ALAN KITCHENER

**Time Series Analysis Forecasting and Control.**

G. E. P. BOX and G. M. JENKINS.

*Holden-Day, San Francisco*, 1970. 537 *pp.* $18.50.

The Box and Jenkins' approach to time series analysis has become well known through a steady stream of articles and research reports issued during the last few years. This work has now been brought together in a book which will rapidly become an indispensable tool for the time series analyst. The book aims to be self-sufficient; it includes numerous appendices on the statistical techniques employed, tables, charts and a collection of actual time series used in the text. This supplementary material will be welcomed by many potential readers even if those with a good statistical background feel that they are paying for much that is already familiar to them.

The starting point of the subject is a univariate discrete time series $z_1, z_2, \ldots, z_t \ldots$. A stochastic model for such a process explains in probabilistic terms how such a series arises. This understanding can then be used to forecast future members of the series. The moving average model assumes that $z_t$ is a finite linear function (filter) of an associated series of identically and independently distributed random variables (noise). The autoregressive model assumes that $z_t$ is distributed with constant variance about a mean value given by a linear combination of previous $z$'s. These two models can be combined and compactly expressed by an elegant use of difference operators.

The foregoing models are developed for use with stationary series. If a series is obviously non-stationary the authors' approach is to carry out successive differencing until the resulting series of differences is stationary. These differences are then modelled by an autoregressive moving average. This is called an autoregressive integrated moving average process (ARIMA, "integrated" because the original series can be recovered by repeated summation).

The ARIMA process is the fundamental model considered in the book. In Part II methods are given for identifying an appropriate class of processes for fitting to data, for estimating its parameters and checking that it provides an adequate fit. Time series with a seasonal component present special problems which are discussed in a separate chapter. Part III deals with models for transfer functions. A transfer function expresses the relationship between the output

from a stochastic system and an input. Thus suppose that it is required to predict or control an output series $\{Y_t\}$ which is expected to depend on an observable input series $\{X_t\}$. Then a transfer function links the $Y$ and the $X$ sequence. In general there will be other inputs affecting the output and these introduce noise into the system which obscures the relationship. The approach requires the postulation of a class of transfer functions, the estimation of their parameters and diagnostic checks on their adequacy. The existence of an observable input sequence opens the prospect of improved forecasting and of control. This last point is taken up in Part IV. If it is possible to manipulate the values of the $X$ sequence then it is possible to influence the values of the $Y$ sequence. The problem of control is to achieve a desired sequence of values for the $Y$'s and the authors show how this may best be done. In essence one adjusts the $X$'s so that the transfer function forecasts the required values for the $Y$'s.

The foregoing outline is too brief to begin to do justice to the comprehensiveness and thoroughness of the treatment. Box and Jenkins have written a handbook in the best sense of the word which provides all that is necessary (except for a computer!) to apply their methods.

The authors' approach to time series analysis obviously owes much to their experience in chemical engineering and related fields. Here there is often a single output in the form of a manufactured chemical and a variety of inputs some of which are controllable by the plant operator. A characteristic of such processes is that they generate, over the course of time, fairly long series. In the book, the same approach is applied to certain economic series such as stock market prices and sales data with apparent success. It is remarked at the beginning of Part IV that the control aspect has obvious applications to the study, among other things, of economics and organizational studies. It is to be hoped that these suggestions will be taken up and explored. Nevertheless, the reviewer has the feeling that success may be less easy to come by in such fields and that sometimes the approach may be the wrong one. An immediate practical difficulty in applying the Box and Jenkins' approach in many fields is that the time series available are too short. This is especially the case with economic series where changes in the method of computing indices often change from time to time. On the other hand, the times series of interest are often multi-dimensional (for example, gross domestic product, unemployment, are just two of a whole set of relevant economic indicators). Though the general approach could no doubt be extended to cover such processes the paucity of data militates against success.

Box and Jenkins treat the system which they are modelling as a black box. Their methods are thus likely to be of greatest use in fields where little is known about how the input and the noise interact to produce the output. In some applications a good deal is known about what goes on inside the black box and where this is so it would be foolish to ignore it. It would be a pity if the