

**Box G E P & Jenkins G M.** *Time series analysis: forecasting and control.*  
San Francisco, CA: Holden-Day, (1970) 1976. 575 p.  
[University of Wisconsin, Madison, WI and University of Lancaster, England]

Nonstationary models for time series analysis are introduced and methods are discussed for fitting them to data, for forecasting business and economic series, and for applying them to feedback and feedforward control schemes. [The *SCI*® and *SSCI*® indicate that both editions of this book have been cited in over 3,300 publications.]

## An Unexpected Route to Time Series

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It can be interesting to consider by what strange routes real investigations sometimes proceed. What is finally published seldom provides much idea of the rather haphazard and messy route that has been taken. Before I met Gwilym Jenkins, I regarded time series as a very boring subject. I'm sure this was because I had never really used it. In the beginning our discussions weren't about time series at all. They concerned an idea I had had for making an industrial process track a moving optimum. Gwilym agreed that the thing to do was to try to get such an apparatus actually working. After I moved to Wisconsin, the chemical engineers there, especially Olaf Hougen, greeted the project with enthusiasm and an apparatus of this kind was indeed built.

The work that eventually resulted in our book took place roughly between 1960 and 1970. It evolved in this way: Having started off thinking about automatic optimization, we soon realized that we were really involved with a control problem of a very special kind. So we tried to better understand the relation of what we were doing to feedback control. Now, certain problems of feedback control can be thought of in terms of optimal prediction. One can control by acting in such a manner that a predicted discrepancy is cancelled.

So we became interested in prediction theory, which somewhat surprisingly then turned out to have applications in economic and business forecasting.

An important problem was that of characterizing the drifting (nonstationary) disturbance that you needed to control. We knew that a proportional plus integral "controller" had been used more or less empirically in industry for over 100 years. Another somewhat empirical device for forecasting was an exponentially weighted moving average of past data. Now it can be shown that both these devices are optimal if the disturbance to be controlled in the first case, and the series to be forecast in the second, are both members of a class of nonstationary autoregressive-moving average (ARMA) processes whose autoregressive polynomial has one or more zeros on the unit circle. So we studied time series models of this kind.

We came to think (a) of the model building process as the iterative building of a filter that transformed data to white noise that appeared to be independent of any known input; (b) that this could be accomplished by the mind and the computer appropriately combining their talents in an iteration involving *identification, estimation, and diagnostic checking*; (c) that, probably, this was the kind of procedure by which all statistical models ought to be built whether time series or not.

It was about this time that it was first realized that Gwilym was suffering from Hodgkin's disease against which, from then on, he fought a slowly losing battle. In circumstances that would have undermined the courage of a hero, I have seen him continue to work at a pace that many a healthy person would have found impossible, and moreover to somehow still maintain his buoyant optimism and sense of humor. I am happy that he lived long enough to see the success of this book.

Many of the ideas in the book have been further developed by a variety of authors.<sup>1</sup> In particular they have been applied to intervention analysis,<sup>2</sup> seasonal adjustment,<sup>3,4</sup> and to simultaneous analysis of multiple related time series.<sup>5</sup>

1. Newbold P. Some recent developments in time series analysis. *Int. Statist. Rev.* 56:17-29, 1988.
2. Box G E P & Tiao G C. Intervention analysis with applications to economic and environmental problems. *J. Amer. Statist. Assn.* 70:70-9, 1975. (Cited 315 times.)
3. Box G E P, Hillmer S C & Tiao G C. Analysis and modeling of seasonal time series. (Zellner A, ed.) *Seasonal analysis of economic time series*. Washington, DC: US Department of Commerce, Bureau of the Census, 1978. p. 309-34. (Cited 15 times.)
4. Board of Governors of the Federal Reserve System. *Seasonal adjustment of the monetary aggregates: report of the Committee of Experts on Seasonal Adjustment Techniques*. Washington, DC: Board of Governors of the Federal Reserve System, 1981. 55 p.
5. Tiao G C & Box G E P. Modeling multiple time series with applications. *J. Amer. Statist. Assn.* 76:802-16, 1981. (Cited 70 times.)