

This Week's Citation Classic™

Granger C W J & Hatanaka M. *Spectral analysis of economic time series.*
Princeton, NJ: Princeton University Press, 1964. 299 p.
[Department of Economics, University of Nottingham, England]

Spectral analysis essentially decomposes a stationary series into a number of uncorrelated components, each associated with a different frequency. The relevant importance of each component can be measured by variance, and these variances plotted against frequency give the spectrum. A number of economic hypotheses can be tested by looking at the shape of this curve. The approach can be extended to bivariate situations and multivariate and nonstationary series. The book concludes with two substantial applications, including an analysis of leading indicators. [The *Science Citation Index*® (SCI®) and the *Social Sciences Citation Index*® (SSCI®) indicate that this book has been cited in over 330 publications since 1964.]

C.W.J. Granger
Department of Economics
University of California
La Jolla, CA 92093

August 3, 1984

"In 1959, while at the University of Nottingham, I won a Harkness Fellowship to study at an American university of my choice. I wrote to several and had a reply from Oskar Morgenstern at Princeton University inviting me to join a new time series project he was just starting. On arrival at Princeton, I found that the project was essentially just Michio Hatanaka and me, although some others soon joined us. Apparently Morgenstern's coauthor of the *Theory of Games and Economic Behavior*,¹ the eminent mathematician John Von Neumann, had insisted that economists should be using Fourier techniques when analyzing their data. It was immediately clear that he had Fourier transform ideas in mind, that is, the use of frequency decompositions, which gives rise to spectral techniques.

"The mathematics underlying single series was quite well known by 1960, but we were

extremely fortunate that the very well-known Princeton statistician, John Tukey, had recently extended the ideas to pairs of series, which gave potentially more interesting interpretations.² He taught us in an unconventional manner. We started with some data, of exchange rates, and were told to perform a certain calculation. Once this was completed, he told us how to interpret the results. It was left up to us to work out the underlying mathematics.

"The sum of the calculations, interpretations, and mathematics became the book. A mathematical chapter was followed by one concentrating on interpretation using as little mathematics as possible. The book finished with two application chapters prepared by Hatanaka. Throughout, we tried to discuss the weaknesses of the techniques as well as their strengths. The one difficult concept that had to be developed was a usable definition of causality, so that the phase diagram in the cross-spectrum could be interpreted.

"The actual book was written on the top floor of a building at Princeton facing Nassau Hall, which housed Morgenstern's Econometrics Research Program, and which was without air conditioning, during three summers. I am unclear if the lack of comfort had any effect on the style used in the book.

"I believe that the book was a success, and thus widely cited, because there was a growing dissatisfaction with classical econometric approaches, which largely ignored the time series aspect of economic data. Spectral methods were viewed as a promising new viewpoint and were widely used until the time domain modeling methods of Box and Jenkins appeared in 1970.³

"The book is still in print, sells about 100 copies a year, and has total sales of over 5,000, which is remarkable for such a narrow, technical topic.

"See reference 4 for a recent publication in this field."

1. Von Neumann J & Morgenstern O. *Theory of games and economic behavior.* New York: Wiley, 1967. 641 p.
2. Tukey J W. *Exploratory data analysis.* Reading, MA: Addison-Wesley, 1977. 688 p.
3. Box G E P & Jenkins G M. *Time series analysis: forecasting and control.* San Francisco, CA: Holden-Day, 1970. 553 p.
4. Granger C W J & Newbold P. *Forecasting economic time series.* New York: Academic Press, 1977. 333 p.