NONLINEAR DYNAMICAL PROCESSES , STOCHASTIC PROCESSES, AND TIME SERIES

G31-3105 / 6

1998-1999 ACADEMIC YEAR

COURSE CONCEPT

The idea of this pair of courses is to prepare the student to be able to handle modern concepts in dynamics and time series, both linear and nonlinear. The course will explore new methods of qualitative analysis of dynamical systems, as well as the application of tools emanating from the theory of stochastic processes and of stochastic differential equations. This part of the course builds on the current theory courses, especially those in macro economics. However, it must be emphasized that the theoretical tools developed in this course, especially the Ito calculus are of use in micro economics as well and have their greatest use in finance. Subsequent to the development of the theory, the course will indicate the application of advanced methods in time series, such as spectral techniques and wavelets, that will be useful in implementing the more advanced concepts in economic theory developed in the first part of the course. The emphasis throughout the course is on developing usable skills with understanding and insight into economic processes so that the use of the computer and the analysis of practical applications will be stressed along with the development of the theory.

WHO SHOULD TAKE THE COURSE

The course is recommended to all students who are contemplating their thesis selection, whether in **micro** or **macro** economics, or **finance**, who will utilize concepts in stochastic processes or in dynamics, or who will likely use time series data in their analyses.

The course focuses on helping the student to write research papers so that it provides an excellent vehicle for developing the skills and tools needed to complete the thesis successfully.

OUTLINE OF CONTENT

The first section of the course will introduce difference and differential equations as a precursor to the modern qualitative analysis of nonlinear dynamical systems. The emphasis of this part of the course is on the understanding of the properties of dynamical systems, so that there will be extensive use of the differential / difference equation simulator in Matlab, which will provide deeper insight into the formal equations under analysis. Students will be encouraged to experiment. This section of the course provides a bridge to the second section.

The second section of the course is devoted to the analysis of stochastic processes and of stochastic differential equations, including diffusion and jump processes. With respect to the stochastic processes, most attention will be on Markov processes that prove so useful in the analysis of economic and financial data. The analysis of stochastic differential equations will not be restricted to "Brownian motion." The links between the solutions of stochastic differential equations and time varying transition densities, or time varying transition probabilities, will be developed, as well as to the derivation of time invariant, stationary, equilibrium densities.

The third part of the course begins with a brief review of the time domain analysis of stationary time series models, but viewed as noise driven difference equations. Attention will be paid to Kalman filters. An introduction to the estimation of stochastic differential equations will be provided, as well as the estimation of the transition matrices for analyzing

Markov processes. This discussion is followed by an introduction to the development of modern spectral techniques and their extension to non-stationary processes. The analysis of wavelets will be introduced and practical examples given.

COURSE REQUIREMENTS

The course is two semesters in length, although it is possible for a student to take only one of either semester with benefit. The course is open to students who have completed the mathematical and econometric requirements for the Ph.D. This means that the student who has had at least two courses in statistics beyond the introductory course and is familiar with the analysis of simple linear dynamical processes will have no difficulty in following the material.

Credit for taking each semester's course will be on the basis of either a "take home" examination, or a paper of the student's choosing in consultation with the instructor. Students are strongly encouraged to write a paper in each semester. During the year the various exercises will provide students training in the proper formulation of a manuscript and training in how to set up a research program. The student may choose either option within the first month of the course. The papers may be written jointly with other students, or with the instructor. These papers often form the basis for the student's doctoral thesis and in many cases have been published before the student graduated.

Special Note Regarding Fees:

If you have used up your 72 credits needed for graduation, by special arrangement with the Dean's office you will be able to register without paying any further fees. However, to obtain this benefit you must apply through Professor Nyarko.

If you wish to learn more about this course and what is required, please contact Professor Ramsey of the Dept. of Economics, FAS, office 'phone number 998-8947; email:Ramseyj@Fasecon.Econ.nyu.edu.

COMPUTER FACILITIES PROVIDED.

The computer tools that will be available on the Intel machines on the third floor include, but are not limited to:

Mathematica; Matlab, which contains various specialized modules, such as signal processing, a simulator for solving ordinary differential equations, and so on; Scientific Workplace, which includes Maple V; and S-Plus; a sophisticated statistical package that facilitates the analysis of nonlinear phenomena and the application of modern tools of statistical analysis with emphasis on the graphical presentation of results. In addition there are various graphical packages for exploratory analysis. You will be provided instructions in the use of these packages as needed.

RECOMMENDED TEXTS

Some recommended **references** for the two semesters are:

First Section of Course:

Gabisch,G. and Lorenz,H-W., **Business Cycle Theory**, Springer-Verlag

Gobi, E., Guaranies, L., and Gallate, M., **Nonlinear Dynamics in Economics and Social Sciences**, Springer-Verlag

Carl Chiarella, **The Elements of a Nonlinear Theory of Economic Dynamics**, Springer-Verlag, 1990

Giancarlo Gandolfo, **Economic Dynamics**, Springer-Verlag, 3rd edt., 1996

W. Semmler, **Business Cycles: Theory and Empirical Methods**, Kluwer Academic

Publ. 1994

Masanao Aoki, **New Approaches to Macroeconomic Modeling**, Cambridge Press, 1996

Sargent, Thomas, J., **Macroeconomic Theory**, Academic Press

Second Section of Course:

Arnold,L., **Stochastic Differential Equations**, Wiley

Oksendal, Bernt, **Stochastic Differential Equations,** Springer-Verlag, 1995

Banks, Robert, B., **Growth and Diffusion Phenomena,** Springer-Verlag

Kampen, N. G. van, **Stochastic Processes in Physics and Chemistry**, North-Holland

Gardiner, C. W., **Handbook of Stochastic Methods**, Springer-Verlag

Dixit, Avinash, Pindyck, Robert, S., **Investment Under Uncertainty**,

Devaney, R.L., **An Introduction to Chaotic Dynamical Systems**, Benjamin/Cummings

Berge,P., Pomeau,Y. and Vidal,C., **Order within Chaos**, Wiley

Third Section of Course:

M.A. Priestley, **Spectral Analysis and Time Series**, viols I, II, and III; Academic Press

James D. Hamilton, **Time Series Analysis,** Princeton Univ. Press, 1994

Cox,D.R. and Miller,H.D., **The Theory of Stochastic Processes**, Science

Granger, C.W.J., Terasvirta, T., **Modelling Nonlinear Economic Relationships**, Oxford Univ.

Tong, Howell, **Nonlinear Time Series**, Oxford Science Publs.

Bergstrom, A.R., **Continuous Time Econometric Modelling,** Oxford Univ. Press

The students are encouraged to buy Gilbert Strang, **Introduction to Applied Mathematics**, Wellesley-Cambridge Press; this is an excellent companion volume to anyone doing applied mathematics, it is insightful and very well written. Please note that I have tried to recommend a variety of alternative texts and have tried to pick ones that I feel provide clear expositions with extraordinary insights. You are not expected to read them all, but familiarity with most of them would prepare you very well.

Typed handout notes prepared from my transparencies will be available as I lecture during the year to facilitate student note-taking.