ECONOMICS 606
NEW TRENDS IN ECONOMIC THEORY
W.A. BROCK, SPRING, 2006

Since I did not teach 606 last year and since the research frontier has changed, this year's 606 will try to get you up to date on major new research trends in economics. Besides trying to identify "cutting edge" research topics in economics and trying to identify good PhD thesis topics, I try to use 606 to teach basic tools that are hard to get elsewhere. Hence, if you have had 606 before, and you would like to take this course for credit, even though you may have "taken it before," I will sign the necessary paperwork to do this for you.

On the first day of class I will sketch different potential areas of teaching concentration listed in the syllabus below and hand out 3x5 cards where each student is asked to identify areas of interest that they would like me to teach. I will also ask students to tell me what courses they have taken on these cards. I will then try to design the course to optimize a combination reflected by the preferences and backgrounds revealed on these cards. I will also try to link the teaching to research projects of faculty here.

I will list some recent and current UW PhD students who have gotten PhD theses (or are currently working on PhD theses) out of the areas to be taught below. You will want to talk to the ones who are currently here.

The topics below seem unrelated. I shall show how a few analytical principles organize the lot. There will be some similarity between the material of previous 606 courses but 606 Spring, 2006 will contain much more work on "new" decision theory including different criteria for "optimization" when underlying structure is partially known. This area is sometimes called "Decision making under ambiguity." This area includes the following items and ideas: Bayesian model averaging, maximin decision making, minimax regret decision making, design limits, etc. Writers in the area include Larry Epstein, Charles Manski, Lars Hansen, Thomas Sargent, Itzhak Gilboa, David Schmeidler, and some faculty here. Key references to work outside UW are located on the websites of Lars Hansen, Thomas Sargent, Larry Epstein, and Charles Manski.

We shall also discuss recent econometric approaches to the analysis of time series data and of panel data in an attempt to separate "spurious" "spatial" and temporal dependencies from "true" dependencies that have some notion of "multiplier." Documentation of existence of "multipliers" is important for policy analysis because multipliers are associated with externalities which policy may be able to correct.

There will also be more attention paid to the relationship between dynamical systems phenomena such as bifurcations and jumps caused by presence of "multipliers" to assist identification of such "endogenous interactions" than recent work on identification of self selection effects and treatment effects which was treated in years before. This will be a blending of stochastic dynamical systems approaches with the review article,
"Interactions-Based Models," for the HANDBOOK OF ECONOMETRICS by Brock and Durlauf.

We will spend some time on very recent work in econometrics on "early warning signals" of an impending bifurcation in settings where the time scales can be separated. Rigorous treatment of the notion of "separation of time scales" will be developed in the course.

Researchers such as N. Bockstael of University of Maryland and E. Irwin of Ohio State (see the dramatic maps generated by simulated urban/suburban interacting systems models compared with actual patterns on E. Irwin's website at Ohio State) have recently taken interactive systems models towards exciting empirical applications. We shall cover some of this new work.

The topics below have become very popular, not only because of their intrinsic interest, but also because of the recent entry of "establishment" figures. The popularity is projected to increase even more due to recent empirical applications to issues of high political salience such as the control of urban sprawl. At the risk of repeating, the purpose of this course is to bring our students to the research frontier as well as to inform our students of recent empirical applications as well as to suggest open research problems.

GRADING
This course is designed to help students locate and identify potential thesis topics as well as to teach basic analytical tools. I believe that students learn analytical tools and techniques much faster when applications that lead to potential thesis topics are used as the main pedagogical vehicles. Hence, I will base grades on a take home test and problem sets. Students will be given a week to do the take home test. The problems on the test and homeworks will be "toy" research problems that apply ideas taught in the course. The take home test will be designed so that those students who faithfully do their homework problem sets will almost surely do well on the take home test. The key idea here is to help students adjust from the usual type of course environment to the research environment.

OVERVIEW AND MORE DETAILS
Since much of the material that I have taught before in this course is available elsewhere (Examples: Dynamic Programming is taught in first year macroeconomics, Stochastic Calculus and Stochastic Optimal Control Theory is taught in the Business School and the Math Department, Game Theory is taught by other courses here) I keep revamping this course to teach material that is not so easily available elsewhere on campus. I will teach newer methods that have become popular in recent years. I list these methods and topics below.

The emphasis in teaching the methods will be to isolate potential PhD thesis topics. More will be said about this below.

Some major writers and/or sources are included in parentheses beneath each topic. However, these will be very incomplete because, during the course, I shall make up lists of current papers and their website locations in order to build the good research habit of drawing up a list of high priority websites and the habit of continuously monitoring these in order to keep up in
today's fast moving research environment.

LEVEL AND OVERVIEW OF DESIGN OF THIS COURSE
This course will be accessible to students with preparation at the level of "mature" first year graduate students in economics and business. Hence, I am choosing a mathematical level to widen the accessibility of the course compared to the past. I will also attempt to make the course accessible (and relevant by using applications in the following areas if students in those areas enroll in the course) to students in other disciplines such as statistics, physics, biology, ecology, limnology, etc.

Since much of the material for the course consists of current working papers as well as many published papers, I will make much use of websites and other internet resources. I shall teach my own favorite internet search methods for framing a research topic and projecting potential value-added of the proposed topic before investing time on it. While this might seem banal, it is surprising how many people fail to do this and end up re-inventing the wheel. Students here have too many time commitments to have their research time wasted on projects that have already been done by someone else.

This course will represent a good hunting ground for potential thesis topics because the new methods can be applied to many different areas of economics, finance, and other areas including ecology. I shall try to outline potential thesis topics during the lectures. For other students, the course will give a tour of some interesting scenery on the research frontier of economics and related areas such as ecology. The course is also designed to be useful to advanced undergraduate students that are contemplating academic research careers.

The unifying concepts and tools of the course will be: (i) stochastic dynamical systems theory, (ii) decision theory in settings of partially known or partially identified structures. Emphasis will be placed on data-disciplined approaches. (iii) theories of self-organization, agent-based modelling, scaling laws, evolutionary dynamics with many agent types, including theories of the Santa Fe Institute variety, and some of the tools being used by papers posted on websites that can be found by googling on "CeNDEF" (Center for Nonlinear Dynamics, University of Amsterdam), "econophysics," "the New England Complex Systems Institute," and the like. (iv) econometric methods that stress heterogeneity and detection of regime changes, e.g. bifurcations, caused by slow moving underlying variables.

I will also teach recent econometric and statistical methods of dealing with separation of time scales, construction of early warning indicators of impending bifurcations. Interesting material may be found by simply doing a google search on the words "econophysics," "complex systems," "genetic algorithms," "bifurcations", and other jargon words from "complexity theory."

The Santa Fe Institute website and CeNDEF website http://www.santafe.edu http://www.fee.uva.nl/cendef/ are good places to start looking at complex systems materials. We will use a lot of materials on the CeNDEF website above.
I use applications heavily in my teaching of analytical tools and techniques. For UW applications of complex adaptive systems ideas and related ideas to ecological economics, see the following SSRI working papers:


SSRI Working Papers are available on the Sixth Floor in the SSRI Office. They are also available at the SSRI website where you can download them.

AN OVERVIEW OF POTENTIAL TOPICS
We will cover topics below in order of I, II, ... Hence we may run out of time before we cover all the topics listed here. But I will try to give you at least a taste of all of them.

I. Bayesian Model Averaging, Robust Control, Design Limits in control theory, Decision Making Under Ambiguity, and other methods of appraising and dealing with decision making in contexts of partially identified structures. Several UW students have gotten thesis topics out of this area, but I believe the frontier is still wide open.

The articles on robust control and the book, ROBUST CONTROL AND MODEL UNCERTAINTY IN MACROECONOMICS by Lars Peter Hansen and Thomas Sargent and their coworkers (available on Sargent's website at NYU) has stimulated a lot of recent interest. Get to Sargent's website at NYU by googling on "Thomas J. Sargent." We shall cover the highlights of this work as well as related work being done here.

Recent UW work in the area is in SSRI working papers by Brock and Durlauf, Brock, Durlauf, and West. Some very recent UW theses in this area include Oya Ardic (now at University of the Bosphorus), Chi Ming Tan (now at Tufts), Andros Kourtellos (now at University of Cyprus), Sibel Sirakaya (now at University of Washington, Seattle). Mehmet Eris, Giacomo Rondina, and Ethan Cohen-Cole, are some current UW PhD students working in this area.

For example the papers, "Policy Evaluation in Uncertain Economic Environments, by Brock, Durlauf, and West (SSRI 2003-15), as well as "Growth Economics and Reality" by Brock and Durlauf (available at the SSRI office and website) review this area and applies it to growth econometrics and monetary economics. The SSRI working paper, 2004-21, by Brock, "Profiling problems under partially identified structures" discusses decision making under minimax regret, maximin decision making and adaptive learning under these two criteria. This paper can serve as an introduction to some economic applications of general decision making and adaptive learning under ambiguity where the ambiguity (i.e. the level of partial
identification) is disciplined by data. Key references are papers by Charles Manski which are located on Charles Manski's website.

We will discuss some of these methods and potential applications for them in the course.

II. Recent econometric and theoretical modelling of increasing returns, threshold effects, interaction effects, and theories of endogenous emergence of spatial patterns.

We will teach some of the latest work of this genre. Some illustrative references are given below.


Main sources of recent work that was stimulated by the economics program at the Santa Fe Institute are the second and third SFI Volumes: Arthur, Durlauf, and Lane, eds., (1997), [Blume and Durlauf (2005)] THE ECONOMY AS AN EVOLVING COMPLEX SYSTEM II, [III] Addison Wesley: Redwood City, CA. [Oxford University Press]. The review by Brock and Durlauf "Interactions-Based Models," SSRI W.P. 9910 contains much material on econometrics of social interactions.)

III. Neural Nets, Connectionist Networks, Bootstrapping, Surrogate Data and their relationship to other received methods in econometrics such as nonlinear least squares.

Some relevant references are below.


This year's 606 will also discuss the problem of controlling for data-snooping in econometric methodology in general as well as in the application of bootstrap-based specification tests (cf. Sullivan, Timmerman, and White). See also the discussion below on how this material will be taught and used this year.

IV. Self Organized Criticality Models

Some references are listed below.
Bak, P., Chen, K., Scheinkman, J., Woodford, M., (1993), RICHERCHE ECONOMICHE. Krugman, P., (1995), THE SELF ORGANIZING ECONOMY. Purpose: Attempt to explain the evidence for long dependence in economic and financial data stressed by Mandelbrot and others. Recent articles on Self Organized Criticality (SOC) that are mentioned in Per Bak's book, HOW NATURE WORKS, Springer 1996 will also be covered. See also the ECONOPHYSICS website for much material on SOC applied to economics. See especially the joint work of Martin Shubik of Yale Economics with Per Bak of Physics.)

I will review some high points of this type of work posted on ECONOPHYSICS websites as well as other related websites such as the Santa Fe Institute. We will discuss how we might use this kind of material to advance the frontiers of econometrics and theory in economics.

V. Econometric and Theoretical issues raised by the possible presence of chaos and other forms of deep nonlinearity in economic and financial data.

The Problem of Detecting "Spurious" Nonlinearity in Data.

Some references are listed below.

(NONLINEAR DYNAMICS AND ECONOMETRICS SPECIAL ISSUE: JOURNAL OF APPLIED ECONOMETRICS, December, 1992. Barnett, W., Gallant, A., Hinich, M., Jungeilges, J., Kaplan, D., Jensen, M., "A Single-Blind Controlled Competition between Tests for Nonlinearity and Chaos," Washington University, St. Louis working paper. See William Barnett's website at the University of Kansas, Lawrence, Kansas, for many interesting papers and as useful links. Some interesting books are Benhabib J., ed., (1992), CYCLES AND CHAOS IN ECONOMIC EQUILIBRIUM, Princeton University Press: Princeton, NJ. Brock, W., Hsieh, D., LeBaron, B., (1991), NONLINEAR DYNAMICS, CHAOS, AND INSTABILITY: STATISTICAL THEORY AND ECONOMIC EVIDENCE, MIT Press: Cambridge, MA. Granger, C., Terasvirta, T., (1993), MODELLING NONLINEAR ECONOMIC RELATIONSHIPS, Oxford University Press: Oxford. De Graauwe, P., Dewachter, H., Embrechts, M., (1993), EXCHANGE RATE THEORY: CHAOTIC MODELS OF FOREIGN EXCHANGE RATES, Basil Blackwell: Oxford. A challenge to this literature is posed by Bickel and Buhlmann, (1996) "What is a Linear Process?" PROC. NAT. ACAD. SCI. USA, Vol. 93, pp. 12128-12131, December. BB argue that the closure of the set of ARMA processes "under a suitable metric" is "unexpectedly large" (Caution: This is NOT the Wold representation). Further work on this problem should be at Peter Bickel (Berkeley Statistics) and Peter Buhlmann's websites. The CeNDEF website has lots of material on this topic. We will relate this type of work to work by UW's Bruce Hansen on econometrics of nonlinear models, UW's Dennis Kristensen on econometrics of diffusion processes, and other work at the UW.)

This area has grown rapidly. I shall pick highlights, teach the basics, and show what still needs to be done. New work that has become available recently will be covered. The emphasis will be to inform students on what research problems are still open in this area and how it relates to the recent surge of interest in modelling "bounded rationality" and "process approaches" to economics rather than "equilibrium" approaches.
VI. Complex Systems Modelling and Scaling "Laws"
Some references are listed below.


Browse the ECONOPHYSICS website (see especially the links to "minority games.")

Here are examples of Scaling "Laws" in economics and finance: (i) Gibrat's Law of firm size distribution, (ii) logistic "laws" of growth and diffusion, (iii) Pareto's Law of income distribution, (iv) Mandelbrot's "self similar" stochastic processes and "1/f" scaling in economics and finance, (v) the stylized facts of finance such as autocorrelation structure of returns, volatility measures, and volume measures across individual stocks and indices, (vi) the stylized autocorrelation and cross correlation structure of aggregative and less aggregated macroeconomic time series. See Brock, W., and LeBaron, B., "A dynamic structural model for stock return volatility and trading volume," REVIEW OF ECONOMICS AND STATISTICS, 78(1), February, 1996, 94-110 for a list of these stylized facts in finance and a discussion of theories to explain them.

An attempt will be made to show what useful insights can be learned from locating scaling laws and how to correct for improper treatment of heterogeneity. In particular we will stress how "spurious" "unconditional" scaling "laws" can easily be produced from a system of individual stochastic processes relaxing to different stochastic steady states (even though the relaxation rate is the same for each process). This exercise will stress the importance of correctly controlling for heterogeneity, i.e. correctly controlling for mixing observations from different distributions. Scaling laws appear also in ecology and we will teach some of this material and draw lessons from it for econometric practice.

VII. Adaptive Learning, Partially Identified Structures, Evolutionary Learning
There has been much recent interest in econometrics in settings where point identification is replaced by partial identification. See Charles Manski's website at Northwestern for key articles and books on this topic as well as a good entry point into this topic. Standard decision theory is being modified to deal with decision making under data disciplined but partially identified structures. This movement creates an interesting interaction between econometrics and decision theory. It creates new opportunities to evaluate decision making criteria on the basis of how fast decision makers learn partially identified features of structures. A good place to start reading this literature is Charles Manski's website at Northwestern and Larry Epstein's website at Rochester.

More references are listed below.

Fudenberg/Levine's book, THE THEORY OF LEARNING IN GAMES (1998), Larry Samuelson's book on evolutionary games, Peyton Young's book on evolution of conventions in games, ECONOPHYSICS website (see especially the links to "minority games"), R. Selten's lab on strategy experiments in oligopoly theory, CeNDEF work on strategy experiments in other types of games.)

The basic first year courses say little about dynamics and adaptive learning towards a notion of "equilibrium." For example, Selten's lab at Bonn has recently shown that optimization appears to play no role at all in repeated oligopoly games (i.e. finite horizon supergames) with small numbers of players. Rather something somewhat like Axelrod's TIT-FOR-TAT strategy emerges as players evolve "ideal points" and induce play towards them by "measure for measure".

First year courses say even less about any kind of socially interactive learning on any kind of network or Selten-like behavior of players trying to "train" each other towards a more cooperative outcome. Since much of economics is based on equilibrium concepts which impose restrictions on data which can be tested and since introduction of "disequilibrium" concepts such as adaptive learning introduces extra "free parameters," this imposes an even higher priority to discipline theorizing by data than usual.

Researchers here, at the Santa Fe Institute, and other research centers are trying to carry out this kind of research program consistent with observed "scaling laws" and observed estimated conditional distributions in economics and finance. We shall cover the basic methods and highlights of this new literature. We shall also review experimental results. For example CeNDEF has been using strategy experiments (originating from Selten's work) to produce a set of stylized regularities about the expectations formation process which is separated from other aspects of the game (such as strategy involved via sharing a market as in oligopoly games) via a special design of the experiment to "control-out" all other aspects of the game except for the expectation formation process itself.

Research on the "El Farol" problem (called the "minority game" by physicists) has documented a "phase transition" and a "scaling law" (cf. work on the ECONOPHYSICS website by Robert Savit of the University of Michigan and many others). The parameters are "s" the "size of brain" of each player (measured by the size of the strategy set available to each player), the "size of the universal brain" (measured by the size of the universal set Omega(m) of potential strategies that could be played) and memory "m" (measured by the number of lagged observations allowed to be in each prediction function which describes each forecasting strategy). The focus of the CeNDEF group is on the dynamic evolution of adaptive forecasting systems whereas the focus of Savit et al. is on uncovering "scaling" relationships and evidence of "phase transitions" via computational experiments. There is also analytical work
reported on the ECONOPHYSICS website.

We shall spend some time comparing and contrasting these different approaches to the modelling of adaptive learning as well as learning what we can from results reported from laboratory experiments around the world. The emphasis of this part of the course will be to develop model systems that replicate experimental results, but at the same time develop analytical methods for general use in this area.

Development of methods from natural science in searching for useful "order parameters" to uncover "phase transitions" and "scaling laws" and relating these to "scaling laws" from sampling theory in statistics (such as central limit theorems, Edgeworth expansions, large deviations "scaling" relations, breakdowns of central limit theorems due to series of cross correlations diverging) will be stressed.

We will stress the incentive differences inherent in "small numbers" adaptive (or other) "learning" situations of repeated play in contrast to "large numbers" situations of repeated play. Selten's lab stressed the inherent incentives of repeated "small numbers" play to "train" each other to reach a cooperative outcome. Such incentives will get smaller as the number of players increases because each player will be increasingly unable to capture the benefits of her own "training efforts" onto the other players. This relates to work on "evolution of norms and conventions" in Peyton Young's book.

As one varies the number of players, the memory allowed in their strategies, the size of their individual strategy sets and the size of all potential strategies of fixed memory as well as other quantifiable aspects of the game the "order parameter" approach suggests looking for key "order parameters" such that when an order parameter increases, the system goes through an abrupt change in dynamical behavior (a "phase transition" and/or a "bifurcation"). Analysis of continuous state space dynamical systems of increasing size creates a demand for analytic results on eigenvalues of dynamical systems of increasing size. Alan Edelman's website at MIT Math contains very nice papers on this problem (e.g. "circular laws") which we shall discuss.

Since we will be on new ground here, this should be an exciting part of the course.

VIII. Cellular Automata, Ising Models, Spin Glass Models

Some references to this area are listed below.

This material will give math modules from which we can build models of adaptive interaction and parse out the components due to socially interactive learning from "plain vanilla" adaptive expectations formation and other kinds of "individualistic" adaptation. However, our posture will be somewhat different than the large recent theory literature on networks and games. It will be guided by a desire to formulate useful econometric frameworks where tools like the Efficient Method of Moments (cf. George Tauchen's website at Duke) and Computational Bayes (cf. John Geweke's website at Iowa, and his paper, "Computational Experiments and Reality" available at his website at University of Iowa, Iowa City, along with software available there) can be used to measure the "statistical significance" of the "extra free parameters" brought by adaptive learning theory. Emphasis will also be placed upon econometrically separating interactive effects from empirically similar looking effects due to correlated unobservables and other phenomena.


Some references are listed below.


This material relates naturally to the above discussions in the sense that it lays out a variety of channels through which interaction may operate in a dynamically evolving social system as an economy. Emphasis will be placed on econometric identification of the different "observable empirical signatures" produced by each of these very different mechanisms of interaction that may look the same to an econometric exercise if it is not carefully formulated. Formulation of econometric exercises to differentiate different channels of interaction including "social learning," "informational cascades," "positional reward structures" (e.g. "tournament" payoff structures), and other related channels of possible interaction will take a very high priority in this year's 606.

X. "Process vs. Equilibrium"

A common theme throughout the above materials is moving thinking about the economy away from "equilibrium" (even that of the stochastic process Real Business Cycle type modelling) towards a view more like Artificial Life and John Holland's Complex Adaptive Systems (cf. Leigh Tesfatsion's website, Tom Ray's TIERRA, The Santa Fe Artificial Stock Market, "Sugarscape," and other Artificial Life frameworks) where the system never settles down. This kind of approach to economics can be viewed as a modern form of Austrianism. We shall try to develop some analytics (rather like large system limits over a hierarchy of "spatial" and temporal scales) to complement the exciting computational work in this area.