Course Syllabus for Economics 8433:
Computational Economic Equilibrium Analysis

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Overview

The primary goal of this course is to provide graduate students in economics with the mathematical and computer skills required for building and analyzing large scale numerical equilibrium models. The subsidiary goals of the course include:

- Development of a practical working knowledge of the mathematical concepts which underly economic models, including linear algebra and calculus, Karush-Kuhn-Tucker conditions, weak and strong duality for linear programming
- Experience in the formulation of a range of optimization and equilibrium models,
- Acquisition of facility with the GAMS programming language for data management, model formulation and analysis
- Introduction to a range of applications for which economic equilibrium methods have been applied in the study of public finance, international trade and environmental economics.

Prerequisites

This course is open to both MS and PhD students. All students must have completed a graduate course in micro theory. In addition, students are expected to be comfortable with the standard mathematical tools used in economics, specifically calculus, linear algebra and constrained optimization.

Conduct of the Course
Students must attend and participate in classes. Readings must be completed prior to associated lectures. The first half of the term will have a traditional lecture format with periodic reading assignments and problem sets. The second half of the term will involve student presentations of term paper topics and discussions of assigned journal articles. Communication skills, both written and oral, are an important part of how students will be assessed.

**Workload**

Three in-class tests (January 31, February 28, April 10)

One term paper:
- Initial abstract and outline (February 7)
- Revised term paper abstract and outline (March 6)
- Term paper first draft (March 20)
- Term paper final draft (May 1)

Final examination: two hours at time/date scheduled by the university.

**Assessment**

Class participation (10%)
Homework assignments (10%)
First annotated bibliography and outline (5%)
Second annotated bibliography and outline (5%)
First draft (evaluated with an emphasis on form) (15%)
Final draft (evaluated with an emphasis on form) (15%)
Midterm examinations (24%)
Final examination (16%)

**Auditing**

Auditing students are welcome. Graduate students must take the course for credit if they wish to do thesis work using these methods.

**Books and Materials**


Mathematical Economics Kevin Lancaster ($15)

Modeling North American Economic Integration, Kehoe and Kehoe (eds) ($40)

Several journal articles and working papers. A comprehensive reading list will be provided on
the first day of class.

Convenient access to a PC is highly recommended for this class. Minimum hardware requirements are a 386DX-based machine with 4 MB of memory.

Student version of GAMS software are provided without charge to enrolled students.

Students should be well acquainted with a fully-functioned text editor such as Emacs, Epsilon or Brief.

Familiarity with a spreadsheet program (Lotus, Quattro or Excell) and/or a graphics package (gnuplot) is advantageous.

**Topics of Study (more or less one per week)**

1. **Linear Programming**

   Textbook exposition, formulation of some standard linear programming (LP) models, KKT conditions and the linear complementarity problem (LCP), economic interpretation of dual multipliers. Exercises in LP formulation, converting an LP into an MCP, graphical representation.

2. **Linear Programming Theory**

   The dual linear program. Economic interpretation. The weak and strong duality theorems. Problems in linear programming model formulation, converting from primal to dual, interpreting.

3. **Programming with GAMS**


4. **Nonlinear Programming Theory and Applications**


5. **Using Nonlinear Programming for Partial Equilibrium Analysis**

   The spatial equilibrium model. Integrability of demand and supply functions.
Extensions of the competitive model.

6. The Nonlinear Complementarity Problem

This section of the course introduces a comprehensive framework for economic analysis. The introduction focuses on extensions of the spatial equilibrium model to incorporate imperfectly competitive behavior. An exercise will involve the formulation of a market equilibrium model in a NLP format and then converting the model into the nonlinear complementarity format.

7. Other Applications of Complementarity Problems

This course segment will explore a number of applications for complementarity methods, including energy markets (the PIES model), traffic flow modelling, and non-cooperative game theory.

8. Functional Forms in Economics

This segment of the course begins with a review of the basic microeconomic framework for modeling consumer and producer choice. We then introduce the functional forms commonly adopted for applied work based on this theory. The emphasis here is on practical issues: how do we work with different types of functions, what are concise methods for representing these functions in GAMS, how can we compare the performance of different functional forms and how important is the choice of functional form for model results.


This course segment introduces the Arrow-Debreu general equilibrium model using a number of simple examples.

10. General Equilibrium Modeling with MPSGE

This lecture sequence introduces a high-level language for applied general equilibrium analysis. We look at a sequence of increasingly complex models based on ideas from public finance, international trade and environmental economics.

11. General Equilibrium Datasets

We introduce key ideas behind social accounting matrices. Introduce basic GAMS programming for simple data tasks such as aggregation. Exercises will involve working with large-scale datasets and implementing a simple general equilibrium structure.

12. Modeling International Trade Agreements
We will examine regional trading agreements emphasizing the formulation and application of models with imperfect competition and increasing returns to scale.

13. Applications in Environmental Economics

This section emphasizes modeling public goods. Eco-tax reform. Public lands issues, environmental impacts of tourism, modeling congestion externalities.

14. Dynamic Models

15. Global Warming and Integrated Assessment Models