UNIVERSITY OF COLORADO
BOULDER, COLORADO

Economics 4868:
Optimization and Simulation Modeling in Microeconomics

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Office: Economics Building 216,
Office Hours: T-Th 11:00-12:00 and 14:00-15:00

Course Outline and Reading List

This is a new course not only to CU Economics, and it is something I am crafting from scratch. There is no textbook or other off-the-shelf materials for it (I have taught it once). It should be of interest to students in applied math, computer science and engineering as well as to economics majors. Section size is capped at 30. We take problems from microeconomic theory, public economics, labor, trade, and environmental economics and translate them into numerical, computable models. I am also adding a new part of the that treat some classic problems in "operations research" (such as a network pricing and supply problem) that is very useful when you come to look for jobs.

The good news: there are no exams. Assessment is by problem sets and each student will be in a group project, described below. Last year's course rating was 4.9 and instructor 5.3 (out of 6). Work level was 3.7 out of 5.0. There were no complaints that the course was too difficult or demanding, though there were three who dropped rather late.

The bad news: because there is no textbook and we work through all material in class, attendance at all classes mandatory. Three missed classes results in a full grade point deduction. No kidding. There will be exercises due every second week, and it is mandatory that these all be done and done on time. There will be an exercise due the second week of class, and failing to turn any exercise in on time results in the lost of a quarter grade point.

Intermediate microeconomics, Econ 3070 is necessary (as well as formally required) for the course. The level of math required will NOT be higher than any other 4000 level economics course, nor will the work load. But the nature, requirements, and pacing of the course will be somewhat different. Indeed, there is going to be a lot of "play it by ear" and I am prepared to adapt and improvise when a need or problem becomes clear.

Some of the course is related to what is commonly called "operations research", which is an amalgamation of economics, engineering and applied math. We will of course focus a lot more on the economics parts of operations research, but I'm adding to the latter as just noted.

The idea behind the course is to translate economic ideas and models that are dealt with graphically and algebraically into computable, solvable simulation models. I am hoping that this will prove to be fun as well as really solidifying people's understanding of economics. We will be able to try out ideas and scenarios in order to see the quantitative effects of changes to the economy. These could include taxes and subsidies, environmental externalities, income redistribution policies, international trade restrictions and liberalizations, public goods and so forth. We will learn how to dump simulation output to excel and create graphics.

The course will use a software package called GAMS (general algebraic modeling system), a demo version which is downloadable for free - and large enough for anything we will be doing. It is already installed on all the machines in the Econ building undergraduate computer lab. GAMS is widely used by economists and engineers for optimization problems and for solving systems of equations and inequalities (e.g., GAMS is used by engineers for refinery scheduling programs, by logistics managers for airlines and shipping companies).

Look for the file "Welcome to GAMS" on my personal website for downloading and installing the software. I hope you will find it fairly easily. You can find this at:

http://spot.colorado.edu/~markusen
Then click on "Teaching" on the left menu
Then under "Simulation Modeling in Microeconomics", click on "GAMS Chapter 1 2012 (Jensen)"

Or you can go there directly at:
http://spot.colorado.edu/~markusen/teaching_files/applied_general_equilibrium/GAMS/intro1.pdf

I very much hope that you will do this before the first class.

By the end of the first week, you will also need to start reading
http://spot.colorado.edu/~markusen/teaching_files/applied_general_equilibrium/GAMS/intro2.pdf

I am sorry to say that GAMS doesn't work very well on Apple products, a common problem with many types of scientific computing software. Please see the GAMS website:
www.gams.com
I will also attach a guide for installing GAMS on Apple computers.

Likely method of assessment:

Exercises and problem sets:	40%	these must be done on time
Project:	40%	due at the time of the final exam
Class participation:	20%	ask interesting and challenging questions

The following are a list of topics for the lectures. For the reasons noted above, slides and exercises will be made up as we go along.

1. Installation of gams: GAMSinstallnotes.pdf
   - installing on your laptop, **but please do this ahead of time**
   - installed on machines in the Economics Building computer lab (basement)
   - creating a project file and directory
   - running gams, reading output, debugging

2. Theory light 1: profit maximization for a competitive firm: 4868 notes1.pdf
   - first-order condition, second-order condition, entry condition, complementarity
   - Models: M1-1a, M1-1b

3. Theory light 2: optimization theorems and results: 4868 notes1.pdf
   - Karush-Kuhn-Tucker theorem, Tells us we can convert a non-linear constrained optimization problem into a set of equations and inequalities in matched variables.
   - Value functions, the envelop theorem, Shepard's lemma
   - Lagrangean formulation of the KKT conditions

4. Simple syntax, introduction to the solvers 4868 notes2.pdf
   - NLP (non-linear programming, used in constrained optimization)
   - MCP (mixed complementarity programming - for nxn systems of equations and inequalities in n bounded (e.g., non-negative) unknowns)
   - MPEC (mathematical programming with equilibrium constraints) combines NLP and MCP:
   - Simple profit maximization problem of notes1 explaining complementarity

5. Introduction to complementarity 4868 notes2.pdf
   - example of supply and demand: three types of solutions to two inequalities and unknowns with non-negative price and quantity
   - correspondence between equations and unknowns
   - use and interpretation of marginals (aka slack variables)
   - Models: M2-1a, M2-1b

6. Newton method for solving nxn non-linear problems 4868 notes2.pdf

7. Maximizing utility subject to a budget constraint — 4868 notes2.pdf
   formulated as an nlp
   formulated as an mcp using the KKT (first-order) conditions
   interpreting marginals as shadow values and Lagrangean multipliers
   deriving Marshallian demand functions
   deriving Hicksian demand functions, expenditure functon
   Models: M2-2a, M2-2b

8. Cost, profit and factor-demand functions for competitive firms — 4868 notes2.pdf
   Models: M2-3a, M2-3b

9. General equilibrium as a complementarity problem (MCP) — 4868notes3.pdf
   conditions for equilibrium: zero profits, market clearing, income balance
   micro consistency

10. A basic two-good, two-factor general-equilibrium model — 4868 notes3.pdf
    assessing and interpreting counter-factuals
    add taxes
    Models: M3-1a, M3-1b, M3-1c

11. Variations on the basic model — 4868 notes3.pdf
    slack activities; e.g., solar and wind power unprofitable at market prices
    labor-leisure choice
    two households with different preferences, income distribution
    Models: M3-2, M3-3a, M3-3b, M3-4a, M3-4b

12. Industrial organization, games — 4868 notes4.pdf
    simple monopoly
    oligopoly with free entry and exit
    Cournot and Bertrand duopoly
    Nash equilibria in games with discrete strategies
    Models: M4-1, M4-2, M4-3a, M4-3b, M4-4

13: Classic problems in operations research, finance, econometrics, and information — 4868 notes5.pdf
    operations-research problem: logistics supply network optimization
    finance problem: optimal portfolio decisions
    econometrics problem: constrained non-linear least squares as an NLP
    information and incentives problem: health insurance with adverse selection and moral hazzard
    Models: M5-1a, M5-1b, M5-1c, M5-2, M5-3, M5-4

14. Taxes, distortions, public goods and bads 4868notes6.pdf

benchmarking with taxes
labor supply and distortionary income taxes
equal-yield tax reform
public consumption goods
endogenous, optimal provision of the public good
public infrastructure goods
pollution externality
Models: M6-1, M6-2, M6-3, M6-4a, M6-4b, M6-4c, M6-5, M6-6a, M6-6b, M6-6c

15. Open (trading) economy models: 4868notes8.pdf

small open economy
tariffs versus real trade costs
small open economy with a benchmark tariff
small open economy with a benchmark quota
modeled as an endogenous tax equivalent
modeled as a license: an artificial commodity
Models: M8-1, M8-2, M8-3, M8-4a, M8-4b

Model list:

M1-1a	profit maximization by a competitive firm
M1-1b	profit maximization by a competitive firm - illustrates Lagrangean
M2-1a	supply and demand model illustrating mcp
M2-1b	supply and demand model - add tax
M2-2a	maximizing utility subject to a budget constraint - Marshallian formulation
M2-2b	maximizing utility subject to a budget constraint - Hicksian formulation
M2-3a	maximizing profits by a competitive firm - production function
M2-3b	maximizing profits by a competitive firm - cost function
M3-1a	general equilibrium with two goods, two factors, one consumer - Marshallian
M3-1b	general equilibrium with two goods, two factors, one consumer - Hicksian
M3-1c	general equilibrium with two goods, two factors, one consumer - adds taxes
M3-2	general equilibrium with an initially slack activity
M3-3a	general equilibrium with a labor-leisure choice - Marshallian
M3-3b	general equilibrium with a labor-leisure choice - Hicksian
M3-4a	general equilibrium with two households
M3-4b	general equilibrium with two households - extensions
M3-5	exercise to identify calibration errors
M4-1	partial equilibrium monopoly model
M4-2	oligopoly model with free entry and exit
M4-3a	Cournot competition with continuous strategies
M4-3b	Cournot competition with continuous strategies - extension
M4-4	pure strategy Nash equilibria with discrete strategies

M5-1a	network and logistics optimization
M5-1b	network and logistics optimization - adds demand functions - nlp version
M5-1c	network and logistics optimization - adds demand functions - mcp version
M5-2	finance, optimal portfolio choice
M5-3	non-linear least squares as an NLP
M5-4	health insurance with moral hazzard, adverse selection
M6-1	benchmark taxes, tax reform
M6-2	equal yield tax reform
M6-3	equal yield tax reform extended
M6-4a	public good provision
M6-4b	public good provision - optimal tax via Samuelson rule
M6-4c	public good provision - optimal tax via MPEC
M6-5	public infrastructure good
M6-6a	pollution externality
M6-6b	pollution externality - optimal tax via MPEC
M6-6c	pollution externality - optimal tax via Pigouvian formula
M8-1	small open economy
M8-2	tariffs and trade costs
M8-3	small open economy with a benchmark tariff
M8-4a	small open economy with a benchmark quota - modeled as an endogenous tax rate
M8-4b	small open economy with a benchmark quota - modeled as supply/demand for licenses

Policies, Etiquette

E-mail policy: you may email me with small questions, but I tend not to answer questions that have been answered twice in class. *You are responsible for what is presented in class, including revisions to the syllabus and changes in mid-term dates.* Much of my communication with you will be via class email.

Class attendance policy: Since there is no textbook and we are making things up as we go along, class attendance is **mandatory.**

Athletics, clubs events, religion, weddings, etc. policy: all these things are known well ahead of time. If you have a conflict with an exam, tell me this week or forever hold your peace. I really have to insist that all absences including minor illnesses count as missed classes. That's the nature of this course.

If you qualify for accommodations because of a disability, please submit to me a letter from Disability Services in a timely manner so that your needs be addressed. Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322, and www.Colorado.EDU/disabilityservices Disability Services' letters for students with disabilities indicate legally mandated reasonable accommodations. The syllabus statements and answers to Frequently Asked Questions can be found at www.colorado.edu/disabilityservices

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Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See policies at http://www.colorado.edu/policies/classbehavior.html and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

The University of Colorado at Boulder policy on Discrimination and Harassment, the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships apply to all students, staff and faculty. Any student, staff or faculty member who believes s/he has been the subject of discrimination or harassment based upon race, color, national origin, sex, age, disability, religion, sexual orientation, or veteran status should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Judicial Affairs at 303-492-5550. Information about the ODH, the above referenced policies and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at http://www.colorado.edu/odh

All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic

misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at http://www.colorado.edu/policies/honor.html and at http://www.colorado.edu/academics/honorcode/