

# Welcome to ICE10

Sponsored by

University of Chicago  
Argonne National Laboratories

Computation Institute  
Milton Friedman Institute  
Economics Research Center  
Stevanovich Center for Financial Mathematics  
Graduate Program, Chicago Booth School of Business

July 18, 2010

# Why ICE?

- Computational technologies are exploding in their ability to analyze scientific and mathematical problems in every science.
- Economics is different: In the opinion of an applied mathematician, “Economists will soon be so far behind they will not be able to catch up.”
- The computational approach has enormous potential for economic analysis, but very little is being exploited. When told of a possible application of modern methods to an economics problem which I called “low-hanging fruit”, a computer scientist said “That is not low-hanging fruit; that fruit is rotting on the ground.”

# Attitude of Economics Towards Numerical Methods

- “Nothing in numerical analysis would be useful in economics” - statement made in October, 2009, to an audience of applied mathematicians by the chairman of a leading Economics Department.
- “[A new professor] can easily learn about computation after he finishes his thesis and starts his job” - comment on why an offer was made to a job candidate who understood nothing about his computations.
- Very few economics departments offer their students serious training in computational methods.
- A sample of what is taught instead in an actual “course”:
  - Use the simplest possible methods.
  - Use methods that are as transparent as possible (i.e., methods for which the computer code reflects as closely as possible the economic structure of the problem).
  - Watch the computations as they proceed.
  - Use one-dimensional algorithms as much as possible.
  - Avoid black boxes. Understanding how the algorithm works is critical to interpreting the results.

Conventional “Wisdom” versus ICE10

## Optimization Methods

- CW: There have been no advances in optimization algorithms in the past 45 years that would be useful in economics
- ICE10: Todd Munson, author of the best CGE software available (done in his University of Wisconsin Computer Science PhD thesis), and winner of a Presidential Early Career Award for Scientists and Engineers in 2006, will survey the advances going back to Robert Wilson's 1964 Ph. D. thesis and continuing through today.



## Optimization Software

- CW: Stay with simple methods, motivated by economic intuition; stay away from “magical black boxes”
- ICE10: A box ceases to be black when you open your eyes and turn on the lights, which we will help you do in our software tutorial sessions.

## Estimation

- CW: One has to sacrifice statistical efficiency and limit yourself to “computationally light” estimators in order to compute a consistent estimator for “large” problems.
- ICE10: Prof. Che-Lin Su will show you how to use modern optimization methods to compute efficient estimators for both dynamic choice problems and for games.



## Dynamic Programming

- CW: It is difficult to write DP code that is stable, efficient, and accurate, particularly for multidimensional problems.
- ICE10: It is easy to do this for concave problems. One example: solve dynamic portfolio allocation of several assets (stocks, a bond, and options) with proportional transaction costs.

## Models with Heterogeneous Agents

- CW: It is difficult to solve problems with heterogeneous agents without making severe aggregation assumptions.
- ICE10: We will present recent work on methods for solving models with hundreds of types of agents without aggregation.

## Dynamic Games

- CW: Finding feedback equilibria (a.k.a. MPE) is very difficult.
- ICE10: Life is always hard if you use only Gauss-Jacobi and Gauss-Seidel methods. Karl Schmedders will show you how to use complementarity methods to solve dynamic games, even ones where players occasionally hit constraints such as zero output or zero investment.



# Computer Architecture

- CW: It is difficult to use parallel systems.
- ICE10: Greg Thain will demonstrate Condor, a distributed computing system developed at the University of Wisconsin.

## Polynomial Equations

- CW: There are no closed-form solutions for polynomial systems of equations
- ICE10: Karl Schmedders and Felix Kubler will demonstrate tools from algebraic geometry that allow you to solve polynomial systems of equations, and prove theorems about economic models.



## Numerical Integration

- CW: It is not tractable to accurately compute multidimensional integrals. Numerical integration methods are not practical. You must use Monte Carlo.
- CW: Monte Carlo integration is good enough for econometrics
- ICE10: Our answer is *BS!*: Ben Skrainka.



# Auctions

- CW: It is not tractable to solve auctions with heterogeneous bidders.
- ICE10: Harry Paarsch will describe stable and reliable methods to solve auctions.



## Dynamic Supergames

- CW: It is not possible to solve interesting dynamic supergames.
- ICE09: Sevin Yeltekin will demonstrate new algorithms for solving supergames with two and three players, and many states, and use them to find all Nash equilibria of dynamic investment games.



# Why Chicago Economics?

- The Chicago tradition in economics is to do economics, using whatever tools are necessary.
  - If supply and demand curves suffice, then use them.
  - If you need to formulate a problem as a fixed point in  $L_\infty$  then learn the necessary functional analysis - Lucas
  - If you have a problem with censored data, then develop novel econometric methods -Heckman
  - If you can't find cute closed-form solutions to dynamic incentive problems, then compute - Townsend
  - If you want to explore alternatives to full rationality, then study and extend robustness theory - Hansen
- The University of Chicago has made a long-term commitment to give their students the training in computational methods they need in their economic research
- ICE is its way of sharing that expertise with the general economics community.

# Why Chicago?

- The University of Chicago is about doing research.
- The University of Chicago, its partners, and the speakers have provided *all* the funding for ICE workshops.

# Why Argonne National Laboratories?

- Argonne Labs has an excellent center for computational research.
  - Computational mathematicians at Argonne are among the world's leading experts on the kind of computational tools that are most valuable for economists.
  - Scientists at Argonne are interested in working on problems that have economic aspects.
- What is the Computation Institute?
  - The Computation Institute helps stimulate collaboration between scientists at Argonne Labs and faculty and students at the University of Chicago.
  - An excellent example of this is CIM-EARTH, an effort to combine the expertise in economics and computation at Argonne and UC to create the next generation of models for assessing issues related to climate change

# What Are You Going To Do?

- Lectures: Learn basic numerical methods and see them applied to economics problems.
- Software Tutorials: Learn how to use powerful software tools and apply them to economic problems.
- Projects: You will form groups of four or five, formulate an economics problem and solve it using the tools presented here.
- Office hours: Individuals may schedule appointments with the tutorial speakers to discuss their own research.
- Seminar presentations by economists who are using computational tools.

- Have fun
  - Eat and be merry
    - \* Goose Island on Tuesday night, July 20
    - \* Friday night, July 23, dinner at Piccolo Mondo
    - \* A special “Taste of Hyde Park” farewell dinner on Friday, July 30.
  - See Chicago (July 24-25)
    - \* Art Institute
    - \* Architectural Boat Trips
    - \* Top of the Hancock Tower
    - \* See Sue ... at the Field Museum
    - \* See the only U-boat captured in battle
    - \* Many other possibilities