Numerical Methods in Economics
MIT Press, 1998

Notes for Chapter 1: Introduction

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The Role of Computation in Economic Analysis

- Traditional roles
  - Empirical analysis
  - Applied general equilibrium
- Nontraditional roles
  - Substitute for theory
  - Complement for theory
- Questions:
  - What can computational methods do?
  - Where does computation fit into economic methodology?

What can we compute now?

- Optimization
  - Dynamic optimization: optimal control, dynamic programming
  - Mechanism design: contracting, optimal taxation, nonlinear pricing
- General equilibrium
  - Arrow-Debreu general equilibrium, complete and incomplete markets
  - Dynamic, perfect foresight models and stochastic recursive models
- Games
  - Finite games- Lemke-Howson, Wilson, McKelvey
  - Correlated equilibria
  - Feedback equilibrium of dynamic games
  - Supergames: APS, supergames with states, reputation models
- Econometrics
  - Structural estimation: maximum likelihood, method of moments
  - Bayesian methods

Progress in Hardware

- Moore's law for semiconductors (Moore gives Moore's law about another 10-15 years)
- Optical computing
- Quantum computing

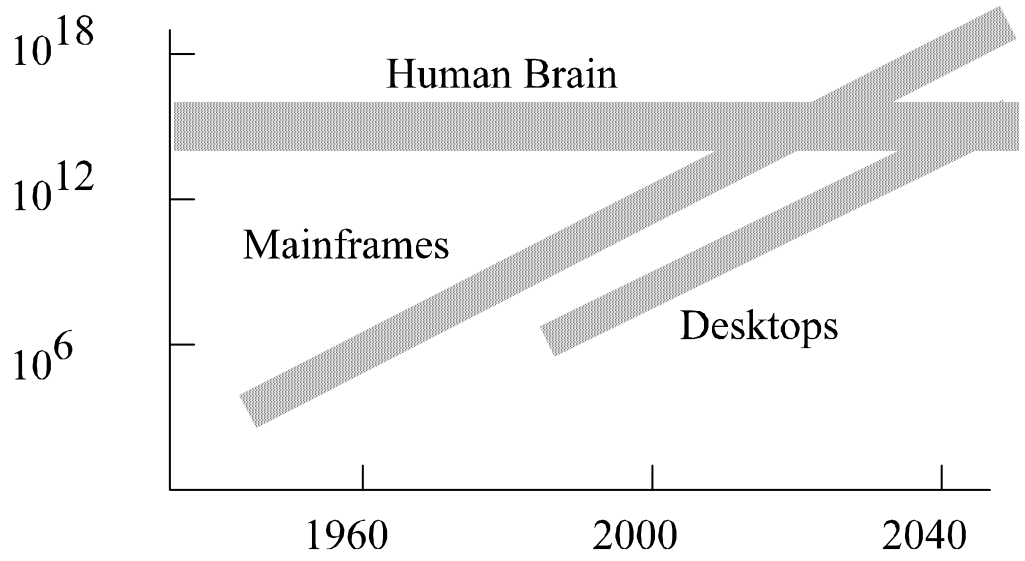

Figure 1: Trends in computation speed: flops vs. year

- Economists usually constrain themselves to using personal computers.

Progress in Numerical Analysis

- Substantial Recent Progress
  - Linear programming - Interior point methods
  - Nonlinear equations, complementarity problems
  - Mathematical Programming - Interior point methods
  - MPEC - Mathematical Programming with Equilibrium Constraints - methods useful for mechanism design problems.
  - Semi-infinite optimization, related to principal-agent problems
  - Systems of polynomial equations: homotopy methods for numerical solutions, Groebner bases for analytic solutions
- Only small (actually, decreasing) amount of numerical analysis is used in economics

Progress in Computer Architecture and Software

- Parallelism: Combine many cheap processors
  - Multicore chips
  - Supercomputers
  - Distributed computing: Condor
  - Grid computing: Globus, BOINC, SETI@home
- Program development tools
- User-friendly interfaces - AMPL, Mathematica, Matlab, etc.
- Economists typically avoid the new computing environments.

The Current State of Computational Economics

- Economists use old methods on weak hardware.
- "Economists will soon be so far behind applied mathematicians that they will have no chance to catch up" - opinion of an applied mathematician who knows economists.
- Few economists get any training in computational methods.
- The leading journals neither have nor want expertise in numerical methods on their editorial boards.
- Published economics papers, even some highly acclaimed ones, contain elementary errors that render the results unreliable.

The Potential Future of Computational Economics

- Technology – Hardware and Software
  - Computing costs continue to decrease
  - New computing environments and technologies can be exploited
  - Economists (hopefully) catch up to hardware, algorithm, and architecture frontiers
  - Numerical analysis develops methods to exploit new technologies
  - Economists develop specific methods (as in CGE, Nash equilibrium)
- An Economic Theory of the Future
  - Inputs: Human time and computers
  - Outputs: Understanding of economic systems
  - Trend: Falling price of computation
  - Prediction: Comparative advantage principles imply
    - Substite computer power for human time in analysis of specific models
    - Humans specialize on formulating concepts and models, and computers decribe the implications