Structural Estimation of Games

Intensive course at Aalto University, 2025.

Schedule

- 3 weeks of lectures and tutorials
- Dates: September 1st - 19th
- Monday, Tuesday, Thursday, 9.00 - 12.00
- Where: R001/M140 Majakka in Otakaari 1
- Format: 9 topics with 1-1.5 hours lecture + 1.5-2 hours of practical work

Lecture plan

Each of 9 components is comprised of 3 hours: 1-1.5 hours theory + 1.5-2 hours of implementation

1. Algorithms and complexity

Theory:

- why and how to write programs that work fast
- complexity of algorithms
- examples of good and bad algorithms
- divide and conquer
- recursion

Practice:

- working environment setup: editors, version control
- evaluations of polynomials
- recursion (towers of Hanoi)
- binary search
- bisections
- Newton-Raphson method

2. Static random utility models

Theory:

- Generalized extreme value distribution
- Max stability
- Random utility models with GEV idiosyncratic random terms
- Choice probability (logit, nested logit)
- Logsum functions

Practice:

- Coding up flexible random utility model
- Numerical issues in computing logit probabilities and logsums

- How parameters affect choice probabilities
- Scale parameter
- Understanding identification by *playing with the model*
- Simulations from the model
- Dashboards

3. Dynamic programming

Theory:

- Dynamic discrete choice
- Bellman principle of optimality
- Infinite and finite horizon problems
- Bellman equation
- Solution methods for dynamic programming
- Value function iteration (successive approximations)
- Howard policy iterations
- Newton-Kantorovich iterations
- Convergence rates of different methods

Practice:

- Coding up an inventory problem
- Implementing value function iterations
- Implementing Howard policy iterations
- Implementing Newton-Kantorovich iterations

4. Rust engine replacement model

Theory:

- Rust model in deterministic formulation
- Removing statistical degeneracy by adding EV shocks
- Expressing Bellman equations in expected value form
- Maximum likelihood NFXP method

Practice:

- Coding up Rust model
- Implementing NFXP estimation

References:

- Rust (1987) Zurcher paper

5. CCP based estimation

Theory:

- Inversion theorem
- CCPs and form of utility function

- Finite dependence
- Linear regression in CCP estimation
- Quasi-likelihood estimation
- Swapping NFXP: NPL estimator

Practice:

- Computing CCPs from Rust model
- Estimating Rust model using CCPs
- Linear regression in CCP estimation
- Quasi-likelihood estimation
- Implementation of NPL estimator

References:

- Hotz and Miller (1993) paper
- Arcediacono and Miller (2011) paper

6. Dynamic entry games

Theory:

- Aguirregabiria and Mira entry model setup
- Markov perfect equilibrium
- Existence and uniqueness of MPE
- Estimation through NPL estimator

Practice:

- Implementing the entry model
- NPL estimator for entry model

References:

- Aguirregabiria and Mira (2007) paper

7. Multiplicity of equilibria in static games

Theory:

- Diagnostics for multiple equilibria
- Multiple equilibria in theory and data
- Static entry model setup
- MPEC estimation

Practice:

- Implementing ELS(2015) static model
- Best response functions
- Solving for all equilibria
- Simulating from different equilibria
- Visualizing the likelihood surface

- Implementing MPEC estimator
- Performance of MPEC estimator

References:

- Egesdal, Lai and Su (2015) paper

8. Solving directional dynamic games with multiple equilibria

Theory:

- Directional dynamic games
- Leapfrogging model
- Some algorithms on graphs
- Pakes and McGuire (1994) solution approach
- State recursion algorithm
- Recursive lexicographic search (RLS) algorithm

Practice:

- Implementing the leapfrogging model
- Implementing Pakes and McGuire solution
- Implementing state recursion
- Topological sorting
- Tree traversal
- Coding up RLS algorithm

References:

- Iskhakov, Rust, Schjerning (2018) leapfrogging paper
- Iskhakov, Rust, Schjerning (2016) RLS paper

9. Estimation directional dynamic games with multiple equilibria

Theory:

- Full solution MLE estimator for directional dynamic games
- Brand-and-bound methods
- Tree and bounding function for the directional dynamic games
- NRLS estimator
- Numerical performance of NRLS estimator
- Monte Carlo experiments

Practice:

- Implementing branch-and-bound algorithm
- Implementing NRLS estimator
- Monte Carlo experiments

References:

- Iskhakov, Kristensen, Rust, Schjerning (2018) NRLS paper