Advanced Applied Econometrics
Static Discrete Choice

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Plan for today

- Structural econometrics
- Examples of a structural model
- Practical session,
- Python and example with Maxi Schaller

What is structural econometrics?

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Structural econometric models...

- "...combine explicit **economic theories with statistical models**" (Reiss and Wolak, 2007)
- "...[infer] underlying parameters that represent **tastes, technology, and other primitives** from observations of individual households and firms..." (Adda and Cooper, 2003)
- ... estimate **features of a data generating process** (i.e., a model) that are (assumed to be) invariant to the policy changes or other counterfactuals of interest (Haile, 2022)

Descriptive vs structural analyses

- Descriptive analysis: establish facts about observable quantities
- RCT
- Policy evaluation
- Economic model

Program Evaluation

Haile (2022):

- Program evaluation (indeed, any type of so-called "causal inference") is always a form of structural estimation. It requires a set of maintained hypotheses about the world (i.e., a model) allowing one to define and identify a counterfactual quantity of interest.
- TT, ATE, LATE, QTE, etc. are all precisely defined only under a well specified model of how the data are being generated. Any suggestion that these objects are **"model free" is nonsense**.
- Causality is always defined by a counterfactual.

Reduced form vs structural

Haile (2022):

- "Reduced form" is sometimes used to mean "equation I won't derive, justify, or take questions on, but which I will nonetheless treat as causal when I talk about conclusions. **This is just bad science.**"

Other views and definitions by Rust (2010), thoughtful (and spiteful) comments on Keane (2013) in Fritjers (2013) vs Rust (2013).

An Introductory Example

How much revenue raised by **introducing income taxes**?

Simple answers?

Effects of tax change I

How much **additional revenue (AR)**

1. AR=new tax rate * wage * number of hours worked
2. AR=new tax rate * wage * **hours worked post tax**

How many hours worked post tax?

Effects of tax change II

How many hours worked post tax?

- estimate **observed corr between wages and hours**
- **interpret as L^S-elasticity**?

Effects of tax change III

using theory... why might **number of hours worked change**?

1. **hours margin**: change in hours for (pre- & post-) workers
2. **participation margin**: change in participation pre vs. post-tax:

Effects of tax change IV

3. **life-cycle** margin:
   changing taxes may influence optimal allocation of work over life
   (eg. if progressivity is increased...)

4. **wage** margin: **equilibrium (gross) wage may change**

Conclude: Predicting reform effect (AR) requires structural model. But: Model choice depends on **margin** and **identification**.

van Soest (1995): Structural Models of Family Labor Supply: A discrete choice approach

Main contributions of paper ?

Main contributions of paper

1. Model labour supply as **discrete choice problem**
2. Taking account of couples' **joint decision problem**
3. Include (more) realistic description of **tax system**
4. Implement **unobservables** into decision problem

Model Structure

Assumptions, Alternatives? Atheoretic answers?

Structure of model

Assumptions, Alternatives? Atheoretic answers?

1. hh **utility max**imization
2. specific structure of preferences
3. **discrete** choice framework
4. **static** model structure
5. labour **supply** focus

What alternatives to (1)?

Structure (1): Household u-max

Alternatives to **household utility maximization**

- **multiple decision-makers**: **collective model** (can be cooperative)
- incorporate **household formation**
- usual caveats re. **utility-max**imizing behaviour

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What assumptions on preferences (2)?

Structure (2): Preferences

Couples' utility depends on income (y) and leisure (l_f, l_m).
How?

Structure (2): Preferences II

Couple utility depends on income (y) and leisure (l_f&l_m).

$$(1) \quad U(v) = v' A\, v + b' v$$

Ensuring global maximum => FOC and SOC on u-function ((3),(4)), e.g.

$$(4) \quad 2\ (\alpha_{11}\ \log y + \alpha_{21}\ \log l_m + \alpha_{31}\ \log l_f) + \beta_1 > 0$$

Alternative preferences ?

Structure of model

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What assumptions on discrete choice (3)?

Structure (3): Discrete choice framework

Couples **max** U **among** $j \in \{1, ..., NH\}$ **alternatives**

$$(5) \quad U_j = U(y_j, lm_j, lf_j) + \varepsilon_j$$

where ε_j is $EV(1)$ (**Logit**) such that

$$(6) \quad Pr[U_j > U_{k \neq j}] = \frac{exp(U(y_j, lm_j, lf_j))}{\sum_{k=1}^{m} exp(U(y_k, lm_k, lf_k))}$$

What are errors ε_j?

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What assumptions on static nature (4)?

Structure (4): Static framework

Only **contemporaneous** variables affect choices - alternatives?

Structure (4): Static framework II

How might **future and past influence labour supply**?

1. Unemployment **insurance payments are not static**
2. The future is **uncertain**

How might these affect choices?

Structure (4): Static framework III

Unemployment insuranace payments are not static

- short spells of unemp attractive for high-earners
- dynamic effect interacts with wage
- can this be addressed by FC of working ?

$$Pr[U(w, l) > U(b + b(t), l)]$$

$$\Leftrightarrow$$

$$Pr[U(w - FC, l) > U(b, l)]$$

Structure (4): Static framework IV

The future is **uncertain**

- **risk averse individuals save** to smooth utility
- **income can be saved, leisure not**

Structure of model

Assumptions, Alternatives? Atheoretic answers?

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What assumptions on labour market (5)?

Structure (5): Labour supply focus

Only labour supply modelled here - alternatives?

Structure (5): Labour supply focus II

Only labour **supply** modelled here - alternatives?

1. **labour demand**

Changes in employment and taxes may change equilibrium wage in imperfect competition.

van Soest ('95): Missing Wages

Wages missing for non-workers: So what?

Missing Wages II

Solutions to unobserved wages

1. **impute wages** based on observables (exploit 1st moment)

$$(10) \quad L = F_{job}(Wbm^e(Z), Wbf^e(Z), X)$$

where $Wbf^e(Z) = exp\left(Z_f'\hat{\pi}_f\right)$... where does $\hat{\pi}$ come from?

2. integrate over wage distribution **(1st & 2nd moments)**
3. proposed practical implementation (relate (10) to (11)).

$$(10) \quad L = \int_0^\infty \int_0^\infty F_{job}(Wbm, Wbf, X)p(Wbm, Wbf)\, dWbm\, dWbf$$

$$(11) \quad L = \frac{1}{R}\sum F_{job}(Wbm_r, Wbf_r, X)$$

Missing Wages III

Integrating over predicted wage distribution:
What problem does it solve, and **what does it not solve**?

van Soest ('95): Why not more part time?

Standard model does not fit data: PT overpredicted

Why?

Hours restrictions

Standard model does not fit data: PT overpredicted

1. **taste for diversity** in utility function (where?)
2. full-time work and/or unemp't more attractive than modelled (**UI neglected**)
3. labour demand **not continuous in hours** - $w = w(h)$ (**"hours restrictions"**)

How include this **labour demand effect**?

Identification of hours restrictions

Add cost-of-PT-parameter (to be estimated), due to

1. **wage discrimination**
2. **search cost**
3. (other) non-monetary cost

Can we discriminate between these?

Hours restrictions

1. Differentiate wage discrimination from search cost: Observe **different wage rates of PT and FT workers**. Let $w = w(h)$.
2. Differentiate search cost from (other) non-monetary cost ? In panel data, **use duration in unemployment** ($\lambda = \lambda(PT)$).

Any concerns about **ad-hoc "cost of PT"-parameter**?

Cost-of-PT

Is new parameter **structural, i.e. policy-invariant**?

Counter example:

- Assume **FC of setting up contract** (specific hours)
- $\Leftrightarrow$ incentive for firms to **design desired contracts**
- search costs **higher for less popular contracts**
- if optimal hours change, **changed incentives for firms to offer contracts**
- cost of PT **parameter changes after tax change**

cf. general critique in Rust (2013)

Hours restrictions: Results

Results $\Rightarrow$ Model with hours restrictions...

1. better **fit of model** - how?
2. **reduces wage-elasticity** of labour supply - how?

Hours restrictions: Results (II)

Lower estimated elasticity with restrictions:

- people reacting less than desired due to restrictions

Heterogeneity

What is heterogeneity & why does it matter ?

Heterogeneity & sampling errors

Is **alternative-specific error** ε_j a sampling error?

- sample is choice (**modelled as** $U_j - U_k$)
- iid $\Rightarrow$ **independence of "irrelevant" alternatives**
- not sampling, rather **appreciation error**

How to include **heterogeneous preferences over choices**?

Preference heterogeneity: observed characteristics

Step 1 - include **interaction with observed chars**

$$(2) \quad \beta_{lf} = \sum_k \beta_{lm\ k} x_k$$

$$\alpha_{lm} = \sum_k \alpha_{lm\ k} x_k$$

- examples of x_k?
- identification?

Preference heterogeneity: unobserved characteristics

Step 2 - include unobserved preference heterogeneity

$$(15) \quad \beta_{lm} = \sum_k \beta_{lm\ k}\ x_k + \eta_{lm}$$

- contrast to ε_j & interactions of β with x_k.
- **additive separable**
- random ($\equiv$ uncorrelated with observables - restriction ?)
- **identification ?**

Preference heterogeneity: unobserved chars II

Relative idiosyncratic preferences of couples for *lm* **and** *lf* unaccounted for by (by construction, orthogonal to) differences in couples' observable characteristics

identification of variance of ζ

- $\Rightarrow$ allow joint errors of partners not to be iid
- Conditional on observables, *how much more similar are* obs from same couple than two other observations?

Unobserved preference heterogeneity: identification

- identification of variance of ζ **purely functional form**

$$
\begin{aligned}
Pr(i,j) &= F_j(Wbm_i, Wbf_i, X_i) \\
&= \frac{exp(v'_{i,j} A\ v_{i,j} + (b+\zeta_i)' v_{i,j})}{\sum_{k \neq j}^{m} exp(v'_{i,k} A\ v_{i,k} + (b+\zeta_i)' v_{i,k})}
\end{aligned}
$$

Estimation of van Soest ('95)

What estimation strategy?

Estimation of van Soest ('95)

First **estimation strategy using ML**

1. Wage & participation estimated jointly.
2. Hours decision using predicted wage from first step

Why not estimate all together?

Presenting results of van Soest ('95)

Where are **estimated labour supply elasticities**?

Presenting results of van Soest ('95)

Wage-**elasticity of labour supply**
Change in hours as result of change in wages.

1. take hh with **median chars**.
2. **vary wage rate** by 1%
3. apply **estimated coefficients**
4. by how many % do predicted hours change?

Standard errors?

Presenting results of van Soest ('95)

Standard errors of elasticities - see table 4 (p.80)

- elasticities: **non-linear function of parameters**
- **draw parameters (β) from asymptotic distrib**
- calculate elasticities for diff draws.

Coding

Principles

1. Use a **script** and **document your code**. Always.
2. There is **always** a solution. Not one.
3. One solution is **fast**,
4. another is **easy to read** & understand,
5. another is **flexible**.
6. You won't find any immediately. No matter. **Try again.**

Simulate to estimate

Good practice: Simulate before estimating. Why?

In practice: Simulation and Estimation

1. Simulate economic behaviour in model with your favourite parameters.
2. Generate simulated data.
3. Save the data. Forget the parameters.
4. Write the likelihood function as a function of data and parameters.
5. Maximize likelihood of observing your simulated data w.r.t. parameters.
6. Rediscover your favourite parameters.