What have we Learned from Structural Models?
Learning From Data in Economics

Richard Blundell (*UCL and IFS*)

Draft paper and full set of references on AEA website
(also my webpage http://www.ucl.ac.uk/ uctp39a/)

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Learning from Data and Structural Models

Focus on structural (micro)econometric models for policy analysis.

Broad definition: A structural economic model is one where the *structure* of *decision making* is (fully) incorporated in the specification of the model.

Aim to identify:

1. structural 'deep' parameters: e.g. Frisch vs Marshallian elasticities.
2. underlying mechanisms: e.g. partial vs self-insurance.
3. policy counterfactuals: e.g. ex-ante tax policy evaluation.

The ability to provide counterfactual policy simulations set structural models apart from 'reduced-form'/treatment effect approaches.

- But require the detailed specification of the decision-making problem.
- Typically placing tougher (explicit) conditions on measurement and relying, in part, on stronger identifying assumptions.

Distinguish identification of **full-structural** from **quasi-structural** models.

Draw on three related areas in empirical micro/econometrics:

1. Revealed preference and unobserved heterogeneity.
2. Discrete choice and welfare reform.
3. Dynamic structural models with human capital investments.

These areas have extensive policy applications:

- where *structural functions* and *policy counterfactuals* are well defined.
- that ask well-formulated questions e.g. from the ex-post impact of taxes, prices & wages, to ex-ante predictions and optimal design;
- analyse static choice *and* dynamic choice;
- use new data, new methods and new computational developments.

I emphasize:

a. Models that minimize assumptions on the *structural function* and on *unobserved heterogeneity*.

b. Approaches that *align structural and 'reduced form'* moments/ *treatment effects*.

Mainly single agent models: do not focus here on equilibrium concepts, incompleteness and coherency: IO, networks, ...

1. Revealed Preference with Heterogeneity

Consider a simple structural demand function of interest:

$$y = g(p, I, z, u)$$

which describes demand for good(s) 'y' by consumer (z, u) facing (p, I).

RP inequalities summarise structural information:

• Use RP to bound (set identify) *individual demand counterfactuals*,

- if reject, analyse *taste change* /derive inequalities for *alternative theories*.

∗ additive u is implausible - with nonseparable u & monotonicity, *conditional nonparametric quantiles* identify individual demands.

∗ relax conditional independence ass. on u to allow endogeneity of prices p.

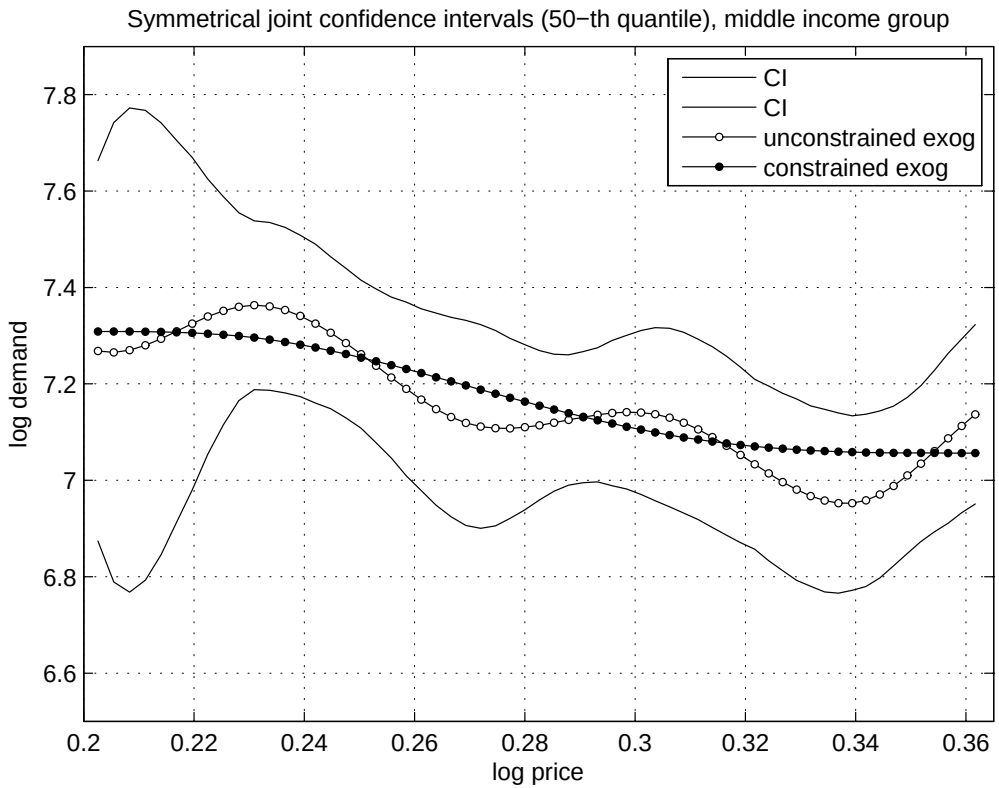
∗ with multivariate heterogeneity only identify average structural welfare.

∗ with multiple demands invertibility in u is not sufficient for identification.

New methods address multiple demands and multiple heterogeneity using proxies/'excluded covariates' with 'large' data to identify counterfactuals.

=> *New insights on consumer preferences* - e.g. gasoline demand...

Gasoline example: quantile demands under RP inequalities:



Source: Blundell, Horowtiz and Parey (2015)

* price/tax responses are non-monotonic across the income distribution,

* calculate distribution of individual welfare costs of gasoline tax.

2. Structural discrete choice models for policy analysis

Use labor supply and welfare-benefit reform to highlight **'five key steps'** involved in *learning from data in empirical policy design*, (Mirrlees Review)

1. Key margins of adjustment
2. Measurement of effective incentives
3. The importance of information and complexity
4. Evidence on the size of responses and on causality
5. Implications for policy design

-> Step 4: quasi-experimental approaches can provide robust measures of ex-post policy impacts but are necessarily local and limited in scope.

-> Structural models uncover mechanisms and provide counterfactual policy simulations which feed into a policy (re-)design in step 5.

Key elements of a structural labor supply model for welfare reform:

1. precise definition of budget constraint - tax and benefit interactions.
2. specification of preferences for discrete hours & benefit combinations.
3. essential heterogeneity in 'tastes' for work, stigma and fixed costs.
4. identification using variation in welfare/tax rules by time and location.

Findings:

* Ex-ante counterfactuals match post-reform behavior, (see references)
* Extensive responses larger for low educated mothers with young children.
* Derive optimal structure for tax-credit design -> UK policy impact.

Can we use stochastic nonparametric RP?

* Adapt RP inequalities to discrete outcomes and nonlinear budget sets:
* Conditions on heterogeneity for partial identification of counterfactuals,
* Recent applications identify quasi-structural contrasts - taxable income functions and derivatives (taxable income elasticities).

3. Structural Dynamic Models

Life-cycle labor supply *and* human capital investment in tax policy/design.

* Identification of structural dynamic models requires strong assumptions
-> on subjective discount rates and distribution of beliefs.
=> quasi-structural models are more valuable.

* Identify key life-cycle counterfactuals and mechanisms
-> e.g. 'insurance value' of redistributive policies - essential for tax design.

* Human capital investment breaks intertemporal separability
-> e.g. wage depends on experience capital in learning-by-doing model.
=>quasi-structural models and quasi-experimental contrasts more difficult.

• Draw on a specific application: structural model of education choices, human capital and labor supply in the UK: use *linked* admin/panel data and the time series of local tax, tax-credit, welfare, and tuition reforms to identify parameters, conditioning on *early life-history* variables.

For example, at the heart is a dynamic structural wage function estimated jointly with education and life-cycle labor supply decisions =>

Dynamic structural wage function (women):

$$\ln w_{sit} = \ln W_{sit} + \gamma_{si} \ln (e_{sit} + 1) + v_{sit} + \xi_{sit}$$

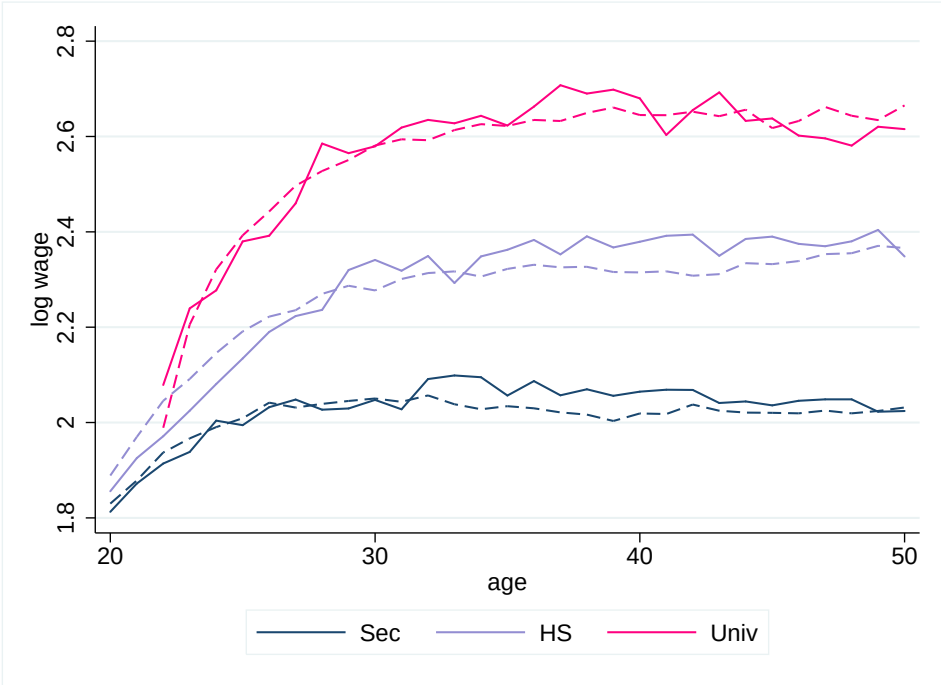


Figure: Implied **female** wage profiles from structural model and the data (by education).
Source: Blundell, Dias, Meghir and Shaw (2016)

* Structural model fit is good (also for labor supply and education choices)
-> only achieved by allowing the experience returns to differ by education,
-> conditioning on extensive background factors,
-> and including a part-time work penalty in experience capital.

(Some) lessons learned

∗ Structural parameters:

- Experience effects display **strong dynamic complementarity,** with lower experience effects for low educated and those in part-time work.

∗ Mechanisms:

- The **insurance value of tax-credits is substantial** part of welfare gain.

∗ Counterfactuals and policy design:

- Lower education women with young kids have **larger supply** responses $=>$ tax credits are an optimal design (but little earnings progression).

- Significant, but small, effect of **tax credits on education choice**, $=>$ attenuating some of the employment gains.

• Reconciliation of past results:

- Can **explain past (static) structural and quasi-experimental results** - human capital depreciation and part-time work imply negligible experience capital wage dynamics/non-separability for low educated women.

Quasi-Structural Models

Identify a subset of structural parameters and/or mechanisms rather than full counterfactuals. Can also be used to test/assess the full model spec.

Three examples from dynamic structural models (references in paper):

1. under intertemporal separability, 'life-cycle' consistent within period preferences are identified by conditioning on consumption (net saving) which represents a *sufficient static* for future expectations and discount rates, and robust to liquidity constraints
2. partial insurance, in which structural 'insurance' parameters are identified without parametric specification of expectations. Can also test for *advanced information*.
3. estimation of an Euler equation, which identifies 'Frisch' elasticities under weaker conditions on information and expectations

- Do not identify full life-cycle counterfactuals.
- Note recent RCTs designed to identify subsets of structural parameters.

Summary: Structural econometric models can deliver new insights

(i) the recovery of structural 'deep' parameters: e.g. the size of extensive and intensive elasticities in a dynamic model with experience capital.

(ii) the identification of underlying mechanisms: e.g. the separation of incentive effects from insurance effects in tax policy reform.

(iii) counterfactuals and policy design: e.g. the ex-ante simulation of a reform to the tax-credit and welfare system.

But full counterfactuals require careful modelling of preferences, constraints, non-separabilities and heterogeneity.
Quasi-structural approaches can relax some of these modeling assumptions and quasi-experimental approaches can deliver robust moments to match.

The last words to Ragnar Frisch..... "No amount of statistical information, however complete and exact, can by itself explain economic phenomena. If we are not to get lost in the overwhelming, bewildering mass of statistical data, we need the guidance of a powerful theoretical framework. Without this no significant interpretation of our observations will be possible."