Why Can't I have Both?
Integrating Reduced Form and Structural Work

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With wonderful help from Yuan Shi!

Outline

The topics of this talk are not well-defined

- "Reduced-form" means different things to different people.
  - A regression derived from an economic model
  - What happens when you solve a three-stage least squares problem in graduate school (Cowles Foundation)
- "Structural" means different things to different people.
  - A type of model
  - A type of empirical work
- So I am going to need to define terms.

Statistical and Economic Models

- A statistical model describes the relation between two or more random variables:

$$y = x\beta + u$$

  - Reduced form techniques aim for an estimate of β.

- An economic model starts with assumptions about
  - agents' preferences
  - constraints
  - firms' production functions
  - some notion of equilibrium, etc.

- Generates predictions about the relation between observable, often endogenous variables.

Structural Estimation

- Structural estimation ascertains whether optimal decisions implied by a model resemble actual decisions by agents.
- Estimate an economic model's parameters and assess model fit.
- Parameters to estimate often include
  - Preference parameters (e.g., risk aversion coefficient)
  - Technology parameters (e.g. production function's curvature)
  - Other time-invariant institutional features (e.g. agents' bargaining power, financing frictions)

What Kinds of Econometrics for Structural Estimation

- GMM
- MLE
- SMM (SMD)
- SMLE
- Indirect Inference
- All of the two-step methods used by the structural IO folks.

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Reduced form and structural are both **useful** for different purposes

- Reduced form is great for getting answers to causal questions.
  - The bread and butter of program evaluations
  - Only one part of a larger picture of most other fields in finance
  - Only useful for understanding economic mechanisms in the presence of assumptions

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  - Only useful for understanding economic mechanisms in the presence of assumptions
- Structural is useful for questions involving the word "why," but requires a mathematical model.
  - Counterfactual (what-if) questions
  - Impulse responses
  - Economic intuition
- Often a richer answer to a question involves both methods

I am going to illustrate these points with examples

Five "types" of integration

1. The model incorporates reduced-form shocks
2. Part of the model is simplified via a reduced-form regression to reduce complexity
3. The model extends the external validity of the reduced-form result
4. A reduced-form regression serves as a check of external validity
5. Use a model to address regression selection problems

Outline

Type 1: Build the model to incorporate reduced form shocks

- The paper has a clean natural experiment or exogenous shock.
- A model is built to feature this exogenous shock
- Why?
  - quantify unobservable parameters that drive the reduced form exercises
  - observe counterfactuals
  - provide economic intuition by tying the two estimations together

Why not?

- To provide “identification” (Kahn and Whited 2018)
- “Causal” elasticities are often influenced by more than one model parameter.
  - Why we see all of the cross sectional tests that researchers to do uncover “mechanisms.”

Two Examples

- Briggs, Cesarini, Lindqvist, and Östling (2021)
- Ivanov, Pettit, and Whited (2020)

Windfall gains and stock market participation
Briggs et al. (2021)

Three research questions:

- What happens to stock market participation after cash windfalls?
- Why are some households not participating in the stock market?
- What are the costs preventing them from doing so?

What is the reduced form methodology?

- A windfall wealth increase from lottery prizes is an exogenous shock to household wealth.
- Random assignment of lottery prizes payment methods differentiates
  - the one-time stock entry cost from
  - the per-period participation cost

,

What do we learn from the reduced form part?

- A 150K USD windfall from lottery wealth increases the probability of stock ownership in post-lottery years by 4%.
- The effect is concentrated in:
  - previous stock market non-participants
  - lump sum prize payments (instead of monthly installments)
- The last item shows that the one-time entry cost (instead of the per-period participation cost) explains household stock market non-participation.

What is the structural methodology?

- The authors use a life-cycle model with costly stock market participation choice and an unexpected lottery prize windfall.
- Estimation method is Simulated Minimum Distance

What question that can be answered by the structural part?

- How big does the entry cost have to be to explain the data.
- The average entry cost for pre-lottery equity market nonparticipants is over 31K USD, . . .
- But even this cost cannot reconcile the small amount of participation.
- Estimation of models with behavioral biases also does not help.
- Data on survey of beliefs indicates that belief biases (pessimism) are the likely culprit.

What do we learn from a combination of methods that we could not learn otherwise?

- The reduced form setting of random sized lottery prize provides an exogenous shock to household income
  - for identification of the directional effect of wealth on participation.
  - for identification of the **type** stock market participation cost.
- The structural method makes it possible to quantify the size of the cost.
- Eliminate possible explanations for nonparticipation

Taxes Depress Corporate Borrowing: Evidence from Private Firms
Ivanov et al. (2020)

- Research question: How do taxes affect capital structure?
- Reduced-form part uses a staggered difference-in-difference setting to establish
  - Causality
  - Sign and magnitude
- Structural part illustrates
  - Intuition
  - Counterfactual effects on firm value

Newish data on private firms

- Use comprehensive samples of U.S. privately-held firms.
- Staggered diff-in-diff around changes in state corporate income taxes since the late 1980s.
- Distinguish between enactment and effective dates of tax changes.

We obtain directional findings from the reduced form part

- Corporate leverage increases following tax cuts and decreases following tax hikes.
- Firms increase investment following corporate income tax cuts.
- Results are strongest for small, healthy firms but also present in large public firms.

The second part of the paper is structural

- We estimate an equilibrium model of an economy
- Firms are financed by internal profits and external **risky** debt.
- They make debt, hiring, and investment decisions in anticipation of future tax changes.
- Interest expense **is** tax deductible

Where does the reduced-form part fit in?

- One of the "moments" we match is the reduced-form tax elasticity.
- We include it to identify firms perceptions of tax permanence
- Tax changes perceived to last longer have larger effects
- Including the moment also makes the model relevant to this particular experiment

What do we learn from the structural part?

- We get intuition for the reduced-form result:
  - Interest tax shields are just one part of a larger picture that includes the level of default thresholds.
  - The **quantitative** effect of taxes on default thresholds is much larger than the **quantitative** effect on interest tax shields.
- We can look at the effects on firm value:
  - Taxes depress value more than they would in the absence of debt.
  - Loss of interest tax shields.

Outline

Type 2: part of the model is simplified via a reduced-form regression to reduce complexity

- Very useful for highly complex models
- Simplify part of the model whose mechanism is
  - too complicated to add to the current model
  - does not affect the results of other parts of the model
- All of the currently very popular demand estimation methods fit in this category.
- The conditional choice probability methods in Hotz and Miller (1993) and the policy function approach in Bajari, Benkard, and Levin (2007) are two examples.
  - Kang, Lowery, and Wardlaw (2015) use CCP methods
  - Matvos and Seru (2014) use the BBL methods

The costs of closing failed banks: A structural estimation of regulatory incentives

Kang et al. (2015)

- How do regulators choose whether to close a troubled bank?
- Dynamic discrete choice model: close/open
  - an aversion to close banks against
  - higher risk and future deposit-insurance costs from delayed closure
- The difference in the regulator utility from each decision is proportional to the probability of each decision.
- The latter can be estimated via a **logit**.
- With the estimated utility functions, they conduct counterfactuals:
  - Delayed closures are driven by "desire to defer costs, an aversion to closing the largest and smallest troubled banks, and political influence."

Market Power and Monetary Policy Transmission: Evidence from a Structural Estimation

Wang, Whited, Wu, and Xiao (2020)

- To what extent do market power and regulatory frictions affect the pass-through of policy rates to bank lending decisions?
- This is by nature a structural question.
- The model has to be very complicated
  - Equilibrium between borrowers, lenders, and banks
  - Imperfect competition between banks
  - Dynamic optimization decisions by banks

We simplify the problem by using demand estimation

- Estimate loan and deposit elasticities using the methods in Berry, Levinsohn, and Pakes (1995)
- Plug these estimates into the model.
- Markets automatically clear because interest rate choices by banks imply optimal demand from the estimated elasticities.

Several interesting results

- Deposit market power matters a great deal, but so does bank capital regulation
- The bank-capital and deposit market power channels interact to generate a reversal rate.
- Stylized facts support the deposit market power channel and the reversal rate.

Outline

Type 3: the model is used to extend the external validity of the reduced-forms results

- Assessing the general equilibrium consequences of reduced form estimates
  - Lots of examples in urban and environmental economics
- Predicting the effect of non-compliers in a reduced-form regression

Who Creates New Firms when Local Opportunities Arise? Bernstein, Colonnelli, Malacrino, and McQuade (2021)

- Brazilian matched employer-employee data, with rich employee characteristics
- Ask whether changes in *global* commodity prices affect local entrepreneurial activity
- Generate Bartik-style variation in the income of municipalities
- Young potential entrepreneurs respond to these shocks more than older ones
- This strong response is concentrated in municipalities with more developed banking sectors and a skilled population.

The structural part tells us what happens when population composition changes

- This part of the paper extends the results beyond the causal elasticities in the first part.
- Dynamic discrete choice problem between wage employment and entrepreneurship.
- Selection into entrepreneurship depends on the dispersion in a taste parameter that can be disciplined with the data.
- Parameter estimates yield two interesting results.
  - A 10% increase in the fraction of young people increases firm creation by around 2%.
  - If this increase in the young is concentrated in the non-educated, this effect is muted by 30%.

Do the Right Firms Survive Bankruptcy? Antill (2020)

- Are decisions to liquidate efficient, and does inefficient liquidation reduce creditor recovery?
- What is the question that can be answered by the reduced form part?
  - For compliers who are close to the marginal threshold of liquidation versus emerging, ...
  - the average liquidation reduces creditor recovery by 58 cents on the dollar.
- What is the question that can be answered by the structural part?
  - The structural part extends the conclusion to non-compliers and estimates that overall, 60% of liquidations are inefficient.

Do the Right Firms Survive Bankruptcy?
Antill (2020)

- What is the reduced form methodology?
  - Use randomly assigned judge as an exogenous shock to firm liquidation versus reorganization.
  - The result is a local average treatment effect that only applies to compliers.
- What is the structural methodology?
  - A generalized Roy (1951) selection framework: binary choice between liquidation and reorganization.
  - In a way similar to the Heckman model, it allows for a sample-selection correction to extend the results to non-compliers.

Outline

Type 4: Reduced form is used to assess model validity

- Dynamic models provide a plethora of predictions
- Some of these predictions are used to estimate the model
- But others are not and can be compared to actual data predictions
- Formal test of "unused" moment equality in Bazdresch, Kahn, and Whited (2018)
- There are many many many examples

Technological innovation and executive pay inequality

Frydman and Papanikolaou (2018)

- Executive pay and the gap between executive and worker pay have grown in the last 50 years
- Estimate a model of technological innovation to help understand these facts
- The model *also* has predictions about the relations between
  - Executive pay and innovation $(+)$
  - Executive pay and growth opportunities $(+)$
- Both hold up in reduced form regressions

Corporate Money Demand
Gao, Whited, and Zhang (2020)

- Reduced-form regressions of corporate cash on interest rates produce a robust hump shape
- Estimate a model to understand this fact.
- Use mostly mostly means and variances for identification.
- The model can reproduce correlations between output and cash, investment, and debt not targeted in the estimation.

Reputation and investor activism: A structural approach

Johnson and Swem (2021)

- Why do targets settle so frequently with activists who face large costs of proxy fights
- Why do activists initiate so many proxy fights despite the free rider problem?
- Estimate a model of (unobservable) activist reputation by MLE.
- Use the model based reputation measure to predict several outcomes (CARs, 13D filings) in both the model and the data.

Outline

Type 5: the model is used to solve a selection problem in a regression

- A Heckman correction is basically a regression paired up with a probit, ...
- which is itself an outcome of a random utility problem.
  - The agent chooses to stay in the sample if their utility exceeds a threshold
  - This is a very simple structural problem
- But the selection model can be much more elaborate and realistic.

How smart is smart money: A two-sided matching model of venture capital Sorensen (2007)

- Empirical fact: start-up companies funded by more experienced venture capitalists are more likely to go public.
- Why?
  - Direct influence of the VC on the company
  - Sorting of better companies with better VCs
- You cannot answer this question with a regression.

The structural part estimates a two-sided matching model

- Each VC can have more than one match, but each company can have only one VC.
- The equilibrium concept is stability: perturbing the matching outcome would make would make any company's valuation worse.
- Estimate the likelihood of an IPO jointly with the matching model using MCMC.
- The structural part allows for separating the the effects of VC influence versus sorting.

Venture Capital Contracts
Ewens, Gorbenko, and Korteweg (2021)

- How do VC contracts affect startup value?
- How big is the size of the pie? What is the split of the pie between the VC and the startup?
- A naïve regression of startup outcomes on contract features omits endogenous matching of VC and firm quality.
- This selection problem is treated with the estimation of a dynamic search model of VCs and startups

Venture Capital Contracts Model

- VC's offer contracts, and entrepreneurs either accept or continue searching.
- The equilibrium contract is endogenous to the quality of the agents.
  - Sometimes high-quality entrepreneurs match with medium-quality VCs to get a better deal.
- The value of the startup and the split of value between VC and the entrepreneur are modeled in reduced form manner.

Estimation

- Parameters are estimated by GMM.
- The reduced-form parameters describing the effects of contract features on the size and split of the pie are estimated jointly.
- The selection problem is absorbed by the endogenous matching feature of the model.

Venture Capital Contracts

- What do we learn from a combination of methods that we could not learn otherwise?
- The contract terms we observe in reality do not maximize firm value
- The terms give the VC too much pie.
- Startups still benefit from matching with high-quality VCs because they grow the pie.

Outline

Fighting about reduced-form versus structural methods is a waste of time

- Different methods answer different kinds of questions.
- They can be used separately (e.g., Hennessy and Whited 2005; Bennedsen, Nielsen, Pérez-González, and Wolfenzon 2007)
- They can be used together.

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