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

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With wonderful help from Yuan Shi!

Outline

First, some terminology

▶ I am not a big fan of the phrase "structural model."

▶ All economic models are "structural."

▶ Usually when people say "structural model," they really mean "dynamic model."

▶ It makes a lot of sense to talk about "structural" versus "reduced-form" estimation.

Statistical and Economic Models

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

$$y = x\beta + u$$

▶ An economic model starts with assumptions about

  ▶ agents' preferences

  ▶ constraints

  ▶ firms' production functions

  ▶ some notion of equilibrium, etc.

▶ Then it makes predictions about the relation between observable, often endogenous variables.

Structural Estimation

▶ Structural estimation is an attempt to 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 is Structural Estimation?

- ▶ Structural estimation ascertains whether optimal decisions implied by a model resemble actual decisions by agents:

  - ▶ firms

  - ▶ banks

  - ▶ households

  - ▶ venture capitalists

  - ▶ regulatory agencies

What Kinds of Econometrics

▶ GMM

▶ MLE

▶ SMM (SMD)

▶ SMLE

▶ Indirect Inference

▶ All of the two-step methods used by the structural IO folks.

Moments and Likelihoods

▶ The moment estimators ascertain whether model-implied moments in the data resemble real-data moments.

▶ The likelihood estimators use economic models to construct the likelihoods for MLE.

▶ In both cases

▶ The simulation estimators are used with models without closed-form estimating equations.

▶ GMM and MLE are used with models with closed-form estimating equations.

What does "identification" mean in reduced-form work?

▶ In
$$y = x\beta + u,$$
does

  ▶ x affect y

  ▶ y affect x

  ▶ some other variable z affect both y and x?

▶ Exogenous variation is very useful for answering this kind of question.

▶ It allows a **clean, directional** interpretation of an estimated regression coefficient.

▶ It is less useful for understanding the mechanisms that drive causal elasticities.

What does "identification" mean in structural work?

▶ Structural work does not usually identify elasticities.

▶ The goal is to estimate model parameters.

▶ Does the econometric objective have a unique minimum (maximum) at the true parameter vector?

▶ Changes in model parameters predict changes in the data.

    ▶ Unique mapping from parameters to features of the data (e.g. moments or likelihoods).

    ▶ Precisely estimated data features

▶ All parameters can affect all features of the data, but the mapping has to be one-to-one and onto.

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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▶ 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

Why not?

- ▶ To provide "identification" (Kahn and Whited 2018)

- ▶ The reason is related to all of the cross sectional tests that researchers to do uncover "mechanisms."

- ▶ More or less precise stories motivate regressions or sample splits to isolate a specific economic force.

- ▶ These stories are **verbal** models.

- ▶ These stories are analogous to different features of a model.

Two Examples

▶ Briggs, Cesarini, Lindqvist, and Östling (2020)

▶ Ivanov, Pettit, and Whited (2020)

Windfall gains and stock market participation
Briggs et al. (2020)

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 (Borusyak and Jaravel 2017) 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 (2019)

▶ 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

Macroeconomic Implications of Agglomeration
Davis, Fisher, and Whited (2014)

▶ How does urban density affect productivity?

▶ This can be measured with a reduced-regression (Ciccone and Hall 1996).

▶ But what if labor and capital can move between cities?

▶ We estimate a general equilibrium model with a density externality using a Ciccone and Hall (1996) regression as an identifying moment.

▶ Local agglomeration raises per capita consumption by 10%.

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 (2020)

► Why do targets settle so frequently with activists who face large costs of proxy fights

► Why do activists initiate so many 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 (2020)

▶ 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 VC and firm quality.

▶ This selection problem is treated with the estimation of a dynamic search model of VCs and startups

Venture Capital Contracts Methodology

▶ Matched deal value depends on both the qualities of the VC and entrepreneur and the contract terms.

▶ The equilibrium contract is endogenous to the quality of the agents.

▶ The value of the startup and the split of value between VC and the entrepreneur are modeled in reduced form manner.

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.

▶ They can be used together.

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