SciencesPo
DEPARTMENT OF ECONOMICS

ScPoEconometrics Advanced

Structural Models

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2024-04-08

Structural Models

Until Now

- Different methods to find causal effects (DiD, Panel, IV)
- Recent applications of these methods to answer relevant (?) questions.

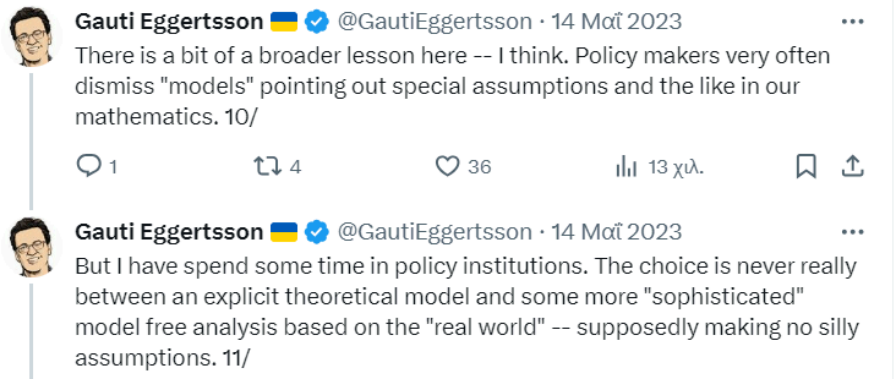
Today

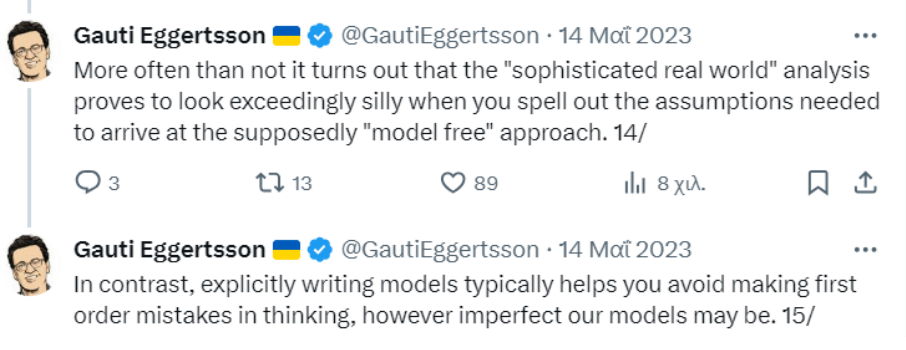
- Different way of finding causal effects + applications

To make this slide deck I have extensively used materials from Attila Gyetvai, Philip Haile and Allan Collard-Wexler

Models are Everywhere

- Arguments about causal effects depend on counterfactuals
- **A model is necessary to define and explore counterfactuals of interest.**
  - Without a model how should I know which are the other factors I have to keep fixed.
- In other disciplines where the construction of "formal" models is not a tradition they have invented new ones: Rubin Causal Model (statistics), DAG (computer science)
- I think Gauti Eggertsson in his tweet explains the need for a model quite nice.





- The model may be simple or complicated, may involve economics or only hypothesized probabilistic relationships **but it is always there!!**

A Simple Labor Supply Model

- **Research Question**: what is the effect of wages w on hours worked h?
- Imagine we observe data (w_i, h_i) for $i \in \{1, \ldots, N\}$ workers.
- What is the simplest model that could explain this behavior?

$$\max_{c,h} u(c,h) = c - \gamma h^{\alpha}$$

$$s.t. \quad c < hw$$

- Taking the first order condition with respect to h and c we get

$$h = (\gamma\alpha)^{\frac{1}{1-\alpha}} w^{\frac{1}{\alpha-1}}$$

- Taking logs we get the **reduced form model**

$$log(h) = \frac{1}{1-\alpha} log(\gamma\alpha) + \underbrace{\frac{1}{\alpha-1}}_{\text{wage elasticity of labor supply}} log(w)$$

- I can't always get the structural parameters from the reduced form model.

Program Evaluation Methods

- The set of methods called Program Evaluation methods (DiD, Randomized IV, RDD) follows the randomized control trial paradigm.
  - Trying to **abstract from a specific economic model** and get **causal effects through exploitation of the statistical properties** of an estimator.
  - No economics in there.

- But **models are always there**

- Since the '10s **The Great Unification**
  - Use rigorously a Program Evaluation method to properly identify and estimate a causal effect and then provide a parsimonious model that can explain the the economics behind the causal effect

Why do Structural (Nevo and Whinston, 2010)?

External Validity

- External validity under the Policy Evaluation methods depends on many prior events where the policy or the change in the economic environment is exogenous (either through RCTs or quasi-random).

- Might not be the case: The change has never occurred before or not under the same conditions.

- Then structural analysis can match observed past behavior to a model and get the underlying parameters
  - Then the model can be used to predict the responses to possibles changes even those that have never happened before assuming that the parameters don't change

Why do Structural (Nevo and Whinston, 2010)?

Welfare

- Even if I could predict the prices for a given policy I can't compare the welfare implications of the proposed policy.
- If we could see previous examples of people or firms choosing between "before" and "after" outcomes for a given policy then estimation of the full model isn't needed.
- Since we want to predict what are the welfare outcomes of a proposed policy we don't have the choices between "before" and "after"
- We can use observed "other" choices to estimate the full model and then use it to predict what are the welfare effects of the proposed policy.

Analysis Based on Structural Model

- We'll see how we build and estimate a structural model and how we can use it to formulate counterfactuals through an example.
- Consider the problem faced by an antitrust authority (DOJ, FTC, EC AD) when there is a suspected cartel in a market.
- The antitrust authority can request detailed data from the suspected firms but still proof of legal violation is not possible. Why?
- A possible increase in prices during the suspected period can be the outcome of the cartel or of a negative cost shock.
    - How do we disentangle the two?
- Today: compare the observed price - cost margins with the ones predicted by a model of competition.
- In general: large literature on cartel detection (much more advanced math/metrics and computational skills needed).

Why we go structural?

- No market is similar to an other.
- Retail gasoline market with luxury bags market?
- The luxury brand market today vs the luxury market 70 years ago?
- There are no good prior events to use as a control group. I need a structural model.

Let's build a simple model of a market.

The Market

- We will concentrate in the market for Over The Counter Painkillers in the US. (Data graciously provided by Allan Collard-Wexler)

- These are real data collected from 73 stores across the US for 48 weeks. We observe prices and sales for the three biggest brands in the US + the private label.

- First we need to think how the firms behave in this market.
  - How do the consumers perceive the products? As complements or substitutes?
  - Are they perfect or imperfect substitutes? Which characteristics would they make them imperfect substitutes?
  - How firms decide their prices? (Cournot vs Bertrand)
- Let's see what we can get from the data

Task 1: Data Exploration (1.5 Minutes)

1. Load the data

```
otc = read_csv(url("https://raw.githubusercontent.com/nikizampetakis/Advanced-Metrics-slides/master/lectures/11-st
```

1. skim the data. How many different `mg` types are there? Is there any other variable known to the consumers that could make them perceive the products as different?

1. Do different firms have different prices when they do not do discounts? for the same product type? between different types?

The OTC painkiller Market in the US

- We see that the firms sell pills with different quantities for the active substance which indicates that consumers value this differentiation.

- Supply of both 50 and 100 mg products by the private label might indicate that consumers have strong preferences over the different sizes.

- We see that **firms have different prices between each other for the same product** and between their own products.
  - This is a key characteristic of a differentiated products **Nash-Bertrand pricing model** (Why?)

- So driven by the data we will make the assumption that the firms follow a Nash-Bertrand model to set their prices.

Nash-Bertrand

- Each firm sells differentiated products and compete on prices.
    - We assume that each product is a different segment in a firm and each segment tries to maximize its own profits.
- Their cost function for a product j is: $C_{jt} = c_{jt}q_{jt}$

*Their profits in a period t, where $\mathbf{p}$ is a vector of all the prices in the market are:

$$\pi_{jt} = (p_{jt} - c_{jt})q_{jt}(\mathbf{p})$$

- The firm tries to find the price that will maximize its profits. Take the FOC.

$$\frac{\partial \pi_{jt}}{\partial p_{jt}} = q_{jt}(\mathbf{p}) + \frac{\partial q_{jt}(\mathbf{p})}{\partial p_{jt}}(p_{jt} - c_{jt}) = 0$$

- Doing the math (on the board) we get that the price-cost margin of the firm is:

$$\frac{p_{jt} - c_{jt}}{p_{jt}} = -\frac{1}{\eta_{jj}}$$

- η_{jj} is the own price elasticity of demand. How can I get the price elasticity?

Demand Model

- I need a demand model to get the price elasticity.

- Berry, Levinshon and Pakes (1995) wrote the workhorse demand model for differentiated products.

- **Key assumption 1**: Each consumer chooses the bundle that maximizes her utility and buy only one product.

Utility Function

- There are J products in the market with $J \in \{0, 1, \ldots, J\}$
  - 0 is the outside good.
- Each consumer i has a utility function of the form:

$$U_{ij} = \delta_j + \epsilon_{ij}$$

- δ_j is the mean utility of product j
- ϵ_{ij} is an idiosyncratic taste for product j.
- **Key assumption 2**: $\epsilon_{ij} \sim Logit(\epsilon)$.

Logit Assumption

- Logit assumption is important because we can write the probability of a consumer to buy product j as:

$$Pr(U_{ij} \geq U_{ik} \; \forall \; k) = \frac{exp(\delta_j)}{\sum_{k=0,1,\ldots,J} exp(\delta_j)}$$

- Since each consumer buys only 1 product this $Prob$ corresponds to product's j **market share** s_j as well.
    - **Important**: If I have a measure of the market size (how many potential consumers are in the market) **I can compute market shares from the data** $\frac{q_j}{M} = s_j$.
- I can compute the share of the outside good s_0 as: $s_0 = 1 - \sum_{j \in \{1 \ldots J\}} s_j$.

Mean Utility

- **Key assumption 3**: δ_j takes the form

$$\sum_l \beta_l x_{lj} - a p_j + \xi_j$$

- x_{lj}: is the characteristic l for product j.
- p_j: is the price of product j.
- ξ_j: is product quality as perceived by consumers unobserved by the econometrician.
- **Key assumption 4**: $\delta_0 = 0$
- Now I have all the components to estimate the parameters of the demand function.

Berry inverssion

- Quick reminder: $e^0 = 1, log(\frac{a}{b}) = log(a) - log(b), log(1) = 0$

Berry used these to rules to simplify the format of the demand function.

$$s_j = \frac{exp(\sum_l \beta_l x_{lj} - ap_j + \xi_j)}{1 + \sum_{k=1,\ldots,J} exp(\sum_l \beta_l x_{lj} - ap_j + \xi_j)}$$

$$s_0 = \frac{1}{1 + \sum_{k=1,\ldots,J} exp(\sum_l \beta_l x_{lj} - ap_j + \xi_j)}$$

Taking logs (on te board) we get:

$$log(sj) - log(s_0) = \sum_l \beta_l x_{lj} - ap_j + \xi_j$$

- I know everything! **I can estimate this with OLS**.

Price endogeneity

- When firms set prices they take into consideration the unobserved quality component ξ_j hence $\mathbb{E}[\xi_j|p_j] \neq 0$.
  - Then a will be a biased estimate.
- I need and instrument to fix that. What can I use as an instrument?
- Something that will shift prices but not how consumers perceive product quality.
- Usual instruments:
  - Variation in cost components (cost shifters)
  - Sums of competitors characteristics - BLP instruments (markup shifters)
  - if we can use market fixed effects then spatially correlated cost shocks - Hausman-Nevo instruments.
- In our case (OTC market) we can use product and market fixed effects. Then our ξ_{jmt} will be $\xi_{jmt} = \xi_j + \xi_m + \Delta\xi_{jmt}$.
  - Then prices in other markets are correlated with the price in market m because cost shocks are the same across space but uncorrelated with $\Delta\xi_{jmt}$ since we have controled for market fixed effects.

Task 2: Demand estimation (2 Minutes)

1. Assuming each store is a different market compute the market shares and the share of the outside good.
    - **Hint**: `count` is number of customers entering a store $\rightarrow$ the market size.
2. compute `delta` as $log(s_j) - log(s_0)$.
3. Run an OLS regression of `delta` on `price_`, `prom_` and `size`. Interpret the coefficients. Is there something peculiar?
4. Create a `market_id` variable where market is defined as a unique store-week combination.
    - **Hint**: use `cur_group_id()` to give a unique identifier to a group .
5. Run the same regression with product (`brand_name`) and market fixed effects.
6. Run a 2sls regression of `delta` on `price_`, `prom_` and `size` using as IV the variable `avoutprice` the average price in the other markets.
7. Run the same 2sls regression with product (`brand_name`) and market fixed effects.
8. compute the own price elasticity for each product using the formula $\hat{a}p_j(1 - s_j)$ using the price coefficient form the last regression.

Task 3: Compare price cost margins (2 Minutes)

1. Compute the price-cost margins `pcm` from the data using the variable `cost_`.

1. Compute the implied price - cost margins `pcm_b` from the Bertrand model we discussed before.
    - **Hint**: the formula is $ \frac{1}{|\eta_{jj}|}$.

1. Compute the average of `pcm` and `pcm_b` over the whole sample and by `brand_name`. What do you see? Can we reach a concmulsion about the competition in the market?

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END

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