# Big Data, Small Models

Alp Simsek (Yale SOM)

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# How to integrate micro-evidence into macro models?

Question: "Can micro data be used to identify behavioral elasticities and build models of individual behavior that can be usefully aggregated into macro models?"

- I took as: How to integrate micro evidence into macro modeling?
- Timely: Age of Big Data and methods for identification/prediction!
- Conceptually important to move the literature forward:
  - High-quality micro-data evidence is often informative about PE
  - But important macro-policy questions often depend on GE

My position: (Proper) small models, (properly) disciplined by data

- "More data" is better. "More/bigger model" is not always better....

# Mis(adventures) of big/ambitious macro models

- Old Keynesian macro-econometric models (pre Lucas-critique)
- First generation(s) DSGE models (before the Great Recession)
- Computable general equilibrium models in international trade
  - Tim Kehoe: "Ex-post evaluations of the performance of applied GE models are essential if policy makers are to have confidence in the results produced by this sort of model."
- Covid-macro models with a quantitative focus
  - Robust lessons are qualitative. Did we need the big models?

# Lessons from (mis)adventures of big macro models

Narrow lesson: Add more ingredients (RE, financial frictions, HANK...)

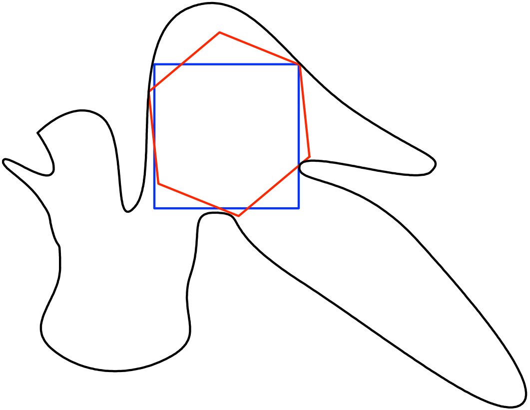
Broader lesson: Macro phenomena are enormously complicated

- **"Model of everything"** is tempting but **can be misguiding**
- **Different questions/mechanisms require different models**

- Appropriate small models can also capture **quantitative** GE forces

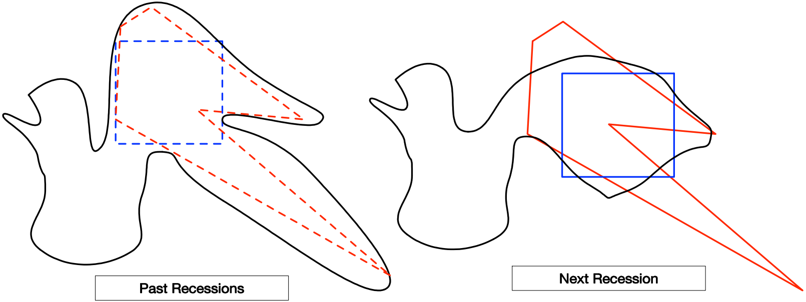
**Suppose we have quantitative ambitions (bring in micro evidence): Is a 17-equation GE model necessarily better than 4-equation?**

# Why small? Reality is messier than what we know to model



- Rich heterogeneity/interactions, dynamics, informational/behavioral frictions (rational expectations shortcut is useful but...)
- For a similar fit, might as well opt for simplicity/transparency

# Why small? Less overfitting, more robust out of sample




Recent recessions/crises seem like Tolstoy's unhappy families:

- **Small, less ambitious** models designed for **specific mechanisms**

# Insights from statistical learning: Model selection

- Statistical learning has a similar problem: Bias-variance trade-off
- Complex models tend to have smaller bias but more sampling variance
- Key idea: **Penalize complexity** to reduce variance (regularization)
- Key idea: **Model-selection techniques** (cross-validation)

We need: **Principles of model-building** that **penalizes complexity**

# Model building: General principles

- Start with a **mechanism/question** (do NOT start with a framework)
- Start with a **small model** and add ingredients (NOT the opposite)
- Add **central ingredients** that matter for mechanism **qualitatively**
  - Measure these ingredients & estimate related elasticities carefully
- For more **tangential ingredients**, need to use judgement:
  - **Noise:** Is there strong micro evidence for the ingredient?
  - **Relevance:** How much does it matter **for the mechanism?**
  - **Shortcuts:** Can I capture essence with simpler ingredient (**as-if**)?

# Example: Macro effects of stock market wealth effect

Chodorow-Reich, Nenov, Simsek (AER, 2021): Regional variation to identify **local GE effects of stock wealth**. Purpose of model:

- Roughly quantify the **aggregate GE effects**
- Roughly quantify the **implied household-level MPCs**

**Central ingredients:**

- Regions with heterogeneous stock wealth (try to measure well)
- Nontradables and tradables (qualitatively different response)
- Nominal rigidity
- Monetary policy at the aggregate level (affects the macro response)
- A Keynesian multiplier (with bounding argument, aggregate $>$ local)

**Result:** Aggregate response (w/ passive policy) $>$ Local **NT** response

# Judgement call ingredients are open to debate

Endogenous stock prices, but with no aggregate risk (**as-if**)

- Shouldn't we explain the Equity Premium Puzzle? No

Minimal household-heterogeneity, mostly to hit multiplier (**as-if**)

- Didn't we learn from GFC that MPC-heterogeneity is important?
- Doesn't it matter for the mechanism: Stocks are held by the wealthy?
- Upon closer look, this heterogeneity isn't central in our context:
    - Most wealth inequality is **within-counties** rather than **across**
    - Simulations: County weighted-average MPC $\simeq$ Aggregate MPC

Infinite horizons, though effectively two horizons (**tractability**)

- Don't we need dynamics? Perhaps, but costly and not our focus

- Shouldn't we add: Financial frictions, housing sector, fiscal policy, luxury goods, geographic spillovers...? Not necessarily

# Example: Permanent income inequality and savings

Straub (2019):

- Consumption elasticity to **permanent income** is 0.7 (textbook =1).
- Model with **non-homothetic** preferences. $\uparrow$ Income inequality $\Longrightarrow \uparrow$ Aggregate wealth (&inequality), $\downarrow$ Equilibrium interest rate
- Quantitative model to assess the magnitudes of macro effects

**Central ingredients:**

- Income elasticity that rises with age (the novel non-homotheticity)
- Bequests (a known, competing source of non-homotheticity)
- Heterogeneous skill distribution, and inheritance of parental skill
- Sensible aggregate wealth dynamics (absent non-homotheticity)
- Asset supply and its interest-elasticity (to gauge $\Delta r$)

**Judgement-call ingredients:** Build on "canonical" life-cycle model

- **Big package** with idiosyncratic/persistent shocks, taxes/transfers...
- Pro: Can tap into existing knowledge. Con: Not strictly necessary

# A bigger model, but carefully measured small/central core

**Table 4:** Calibrated parameters of the baseline non-homothetic life cycle model.

| Parameter | Description | Value | Origin | |
|---|---|---|---|---|
| *Birth, death, skills* | | | | |
| $S$ | Number of permanent types | 3 | see text | |
| $\{\mu_s\}$ | Population shares by type | $\{0.9, 0.09, 0.01\}$ | see text | |
| $\{\delta_k\}$ | Mortality rates by age | | CDC, 2011 | |
| *Production* | | | | |
| $\alpha$ | Capital share | 0.37 | NIPA, 2014 | |
| $\{\gamma_s\}$ | Labor income shares | $\{0.65, 0.24, 0.11\}$ | Piketty and Saez (2003), updated to 2014 | Micro evidence |
| $\delta$ | Depreciation | 0.055 | match $K/Y = 3.05$ (NIPA, 2014) | |
| $A$ | Total factor productivity | 0.63 | normalize $Y = 1$ | |
| *Government* | | | | |
| $B/Y$ | Federal debt held by the public / GDP | 0.73 | NIPA, 2014 | |
| $\tau^b$ | Bequest tax | 0.10 | see text | |
| $\underline{y}$ | Income floor | 0.30W | literature | |
| $\lambda$ | Income tax progressivity | 0.18 | PSID, 2013 | |
| $\tau^{inctax}$ | Average income tax | 0.30 | NIPA, see text | |
| $\tau^{cap}$ | Capital tax | 0.40 | NIPA, see text | |
| $G/Y$ | Government spending / GDP | 0.13 | gov. budget constraint | |
| *Productivities* | | | | |
| $\rho$ | Income shock persistence | 0.90 | PSID | |
| $\sigma_\eta^2$ | Var. of innovations to persistent shock | 0.028 | PSID | |
| $\sigma_\psi^2$ | Var. of transitory income shocks | 0.055 | PSID | |
| $\sigma_\nu^2$ | Var. of measurement error in incomes | 0.02 | literature, see text | |
| $p_{inherit}$ | Prob. of intergen. skill transmission | 0.35 | Chetty et al (2014) | Micro evidence |
| *Preferences* | | | | |
| $\beta$ | Discount factor | 0.89 | match interest rate $r = 0.03$ | |
| $\overline{\sigma}$ | Elast. of intertemp. substitution, median age | 2.5 | literature | |
| $z$ | Scale term in utility function | 0.30 | 30% of average income | |
| $\sigma^{slope}$ | Ratio of elasticities $\sigma_{k+1}/\sigma_k$ | 0.94 | match $\phi = 0.699$ | Elasticity from empirical section |
| $\kappa$ | Weight on bequest motive | 15.84 | match bequests / GDP = 0.05 | |
| $\underline{a}$ | Intercept in bequest utility | 1.72 | 30% share with beq. $\leq$ 6.25% avg. income | |

# A bigger model, but with a thoughtful discussion

**Justify the complexity:**

- "Why do I allow for both sources of non-homothetic consumption-savings behavior, and not merely focus on non-homotheticity in bequests?...because bequest flows are typically...around 5% of GDP, limiting their quantitative role."

**Beware of hidden central ingredients:**

- $F$ is Cobb-Douglas. Matters for asset supply elasticity and $\Delta r$
- Justified on tradition, not micro data. Hard to estimate.
- Ludwig's solution:
  - Show also PE response for given $\Delta r$
  - Analyze also alternative setup with inelastic assets/Lucas tree

# Conclusion: Macro needs big data but small models

Solow (JEP, 2008): "My general preference is for **small, transparent, tailored models**, often partial equilibrium, **usually aimed at understanding some little piece of the (macro-)economic mechanism**. I would also be for **broadening the kinds of data that are eligible for use in estimation and testing.** One of the advantages of this alternative style of research is that it should be easier to accommodate relevant empirical regularities derived from behavioral economics as they become established."