Computational Learning in Macroeconomics:
Evolving Models and Methods

Paul McNelis

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Outline

Introduction: Some Favorite Quotes

- "All models are wrong but some are useful" – George Box
- "A theory that explains everything explains nothing" – Karl Popper
- "Lets take the *con* out of econometrics" –Ed Leamer
- "Elegance is elimination" – Cristobal Balenciaga
- "Beware of economists bearing free parameters" – Robert E. Lucas, Jr
- "The universe is a joint product of the observer and the observed" – Theilhard de Chardin
- TANSTAAFL: "There ain't no such thing as a free lunch" – Milton Friedman
- "We are all Keynesians now" – Richard Nixon

Meaning of Quotes

- Box: a model has limited goals, it will always be wrong or incomplete in some dimensions
- Popper: we should not try to explain too much
- Leamer: in Macroeconomics we are data challenged, too few observations to test hypotheses
- Balenciaga: elegance or beauty is a goal in itself, small is beautiful
- Lucas: we can be drawn into overfitting data with too many parameters.
- Friedman: we have to take time to study our data and know the context of our research questions
- Nixon: Keynes is alive and well, guiding our policy making in a world of frictions.

Plan

- Model properties: simple, falsifiable, and extensible.
- Computational learning in macro: evolution
- Nonlinearities in empirical macroeconomic estimation.
- Nonlinearities in counterfactual policy simulation.
- We need to know when and how to use, transform, or even discard data
- Bigger data sets are better smaller ones but we need to be careful
- We do not use data from the early 20th century and we need to "de-covid" more recent data.

Motivation I

- Models bridge the world of data and the world of theory
- We all have implicit theoretical priors when we approach data.
- Models force use to make our priors *explicit* when we analyze data.
- Models force us to put our "theoretical cards" on the table.
- Exploring differences among models leads to more open, honest policy debates

Motivation - II

- Models are used for prediction or forecasting as well as classification and compressing data.
- Models are used for understanding and interpreting the past
- Models explain patterns we observe in data
- Models are used for counter-factual policy analysis
- Most importantly, people making decisions about us are using models!
- So understanding the "models" guiding decision makers can only help us anticipate these decisions
- When and how much the interest rate changes is not a trivial piece of information. Just ask any investor in Latin America or Asia.
- Being able to anticipate *when* and by *how much* the interest rate (or tax rate) will change is a clear advantage in financial markets

Types of Models

- Static vs. dynamic, analytical vs. numerical, calibrated vs. estimated, small vs. large, structural vs. non-structural
- Linear vs. nonlinear, forward-looking vs. backward-looking, stochastic vs. deterministic
- The supply-demand curve model is static, analytical, small, deterministic, whose slopes can be calibrated, and it is structural
- But it does not tell us long it takes for prices or quantities to adjust.
- Timing is everything. As Keynes said, rightly or wrongly, "in the long run we are all dead".
- Analytical models which are dynamic are confined to two dimensions. Hard to draw three-dimensional graphs on paper!
- Common method for macro analysis before availability of computation.
- State of the art models: dynamic stochastic non-linear structural forward-looking. More generally, as Sargent notes, a model is a probability distribution over a sequence.

Sargent Definition

- Model as a probability distribution defined over a sequence
- Model assigns probabilities to outcomes based on different states of the world.
- The probabilities are time-varying: we are not only interested in a one period outcome but a dynamic outcome
- Modeling is akin to observing a chess game and trying to infer the rules of chess from the sequential moves of the players

Types of Variables

- We have continuous and categorical
- Observables and non-observable known as *latent variables*
- We have exogenous and endogenous
- We impose laws of motion for latent variables such as risk or human capital.

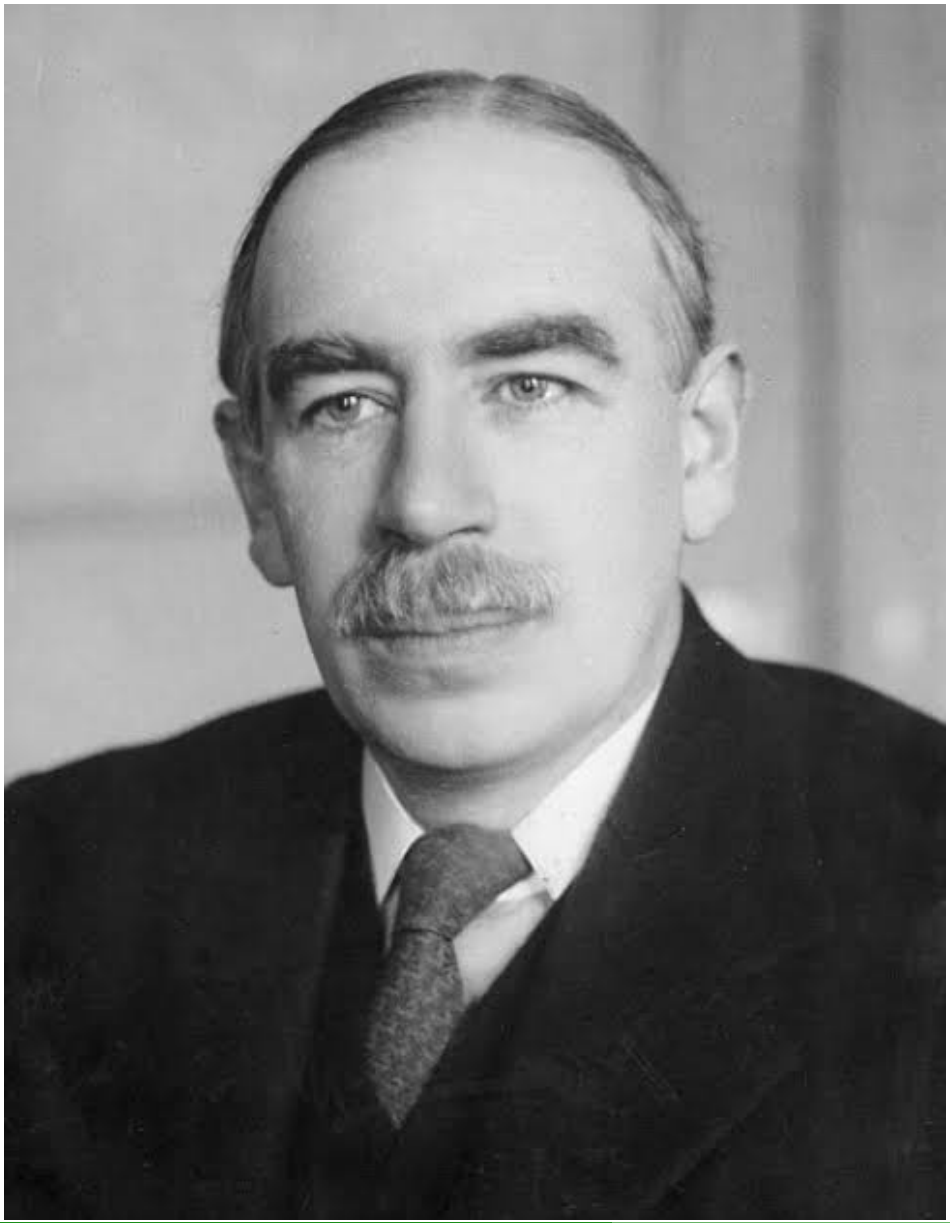
The Age of Big Econometric Models

- Starting in the 60's we saw the use of large-scale (hundreds of equations) models estimated for forecasting and policy analysis.
- They were linear with backward-looking expectations and dynamic
- Brookings, FRB-MIT-Penn, Michigan, Berkeley has a business: businesses paid for monthly forecasts and government agencies pay for counter-factual policy scenario analysis
- Lawrence Klein had Project LINK at Penn, funded by Ford Foundation: grad students send to various countries for a year or two to develop models for each country and then link them together for global forecasting and policy analysis
- These models were decidedly Keynesian: big blowups of the IS-LM curve model. Only exception was the Federal Reserve Bank of St. Louis model, a monetarist model.
- There would be regular forecast comparisons of these model for various sectors as well as comparisons of multipliers for different types of monetary and fiscal policy.

Beginning of the End

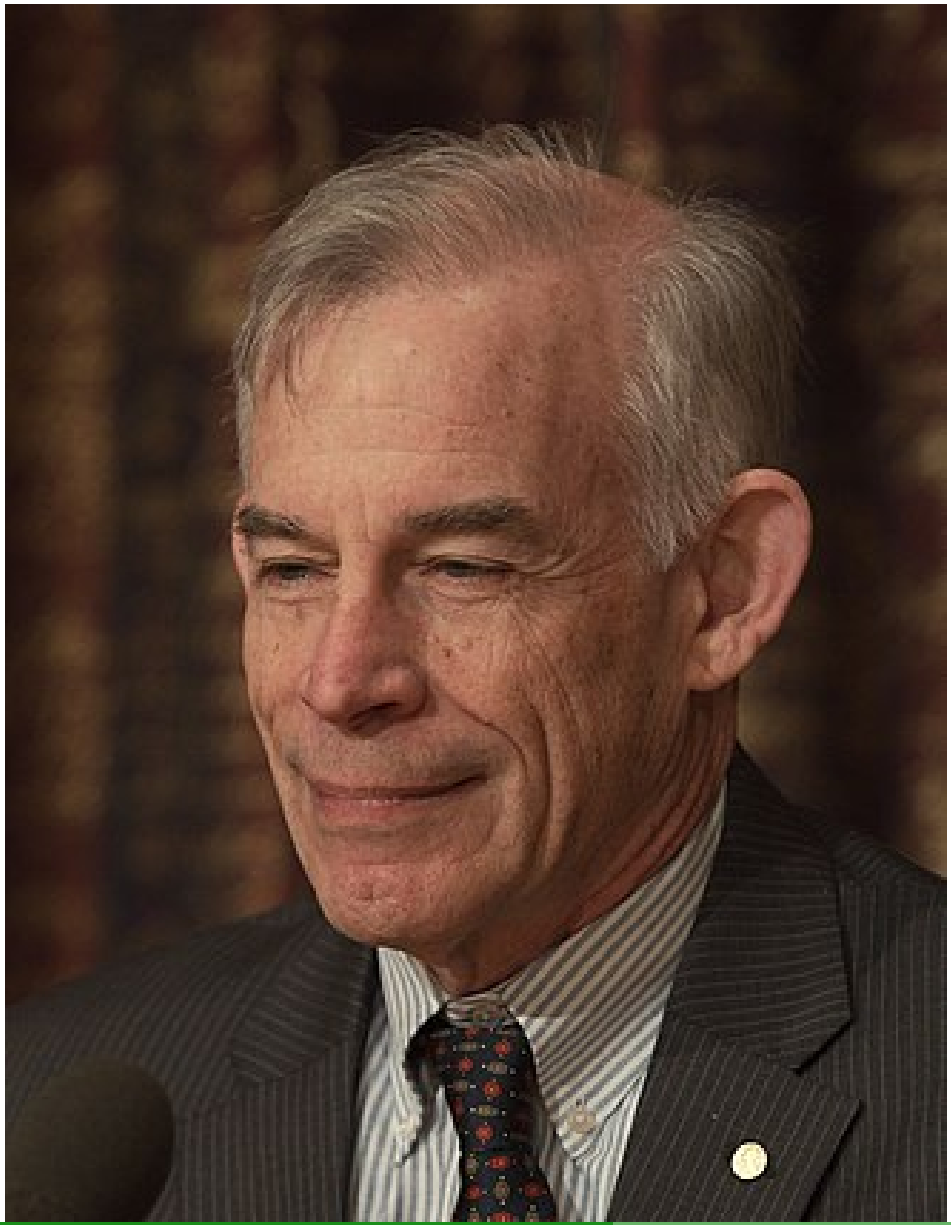
- In 1973 and 1978 we had major shocks to the price of oil around the world.
- In the United States, we had rising inflation and rising unemployment
- This could not happen in the Keynesian "Phillips Curve" world. Rising inflation went with lower unemployment and vice versa.
- However, we know that facts rarely change the viewpoints of people. Facts do not settle argument, only new theoretical insights.

Keynes

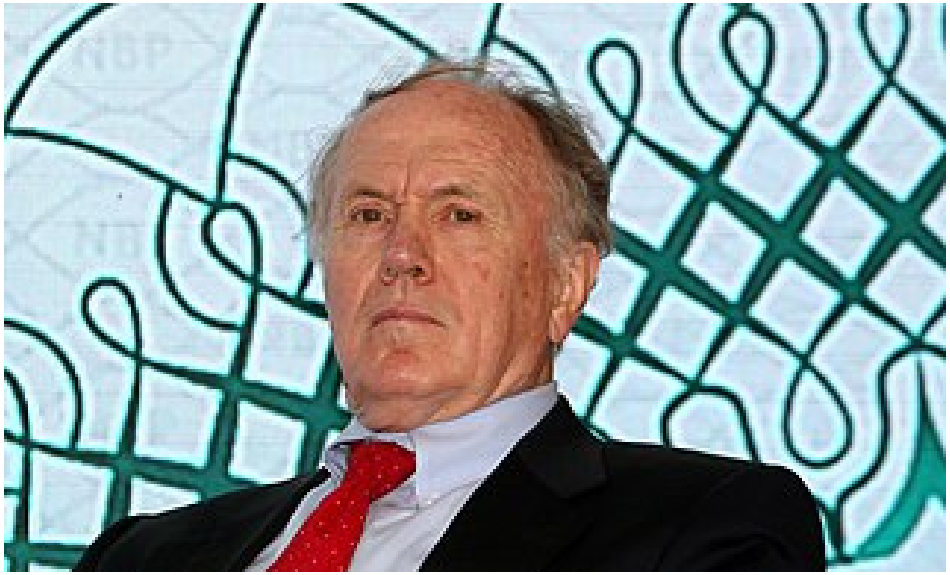


Lucas

Sims



Prescott



Lucas 1976 Critique of Econometric Policy Evaluation

- Lucas argued that the estimated parameters of a model depend on the policy regime in place.
- We are not talking about the behavior of robots: models are about the behavior of people with forward-looking expectations
- So if the government cuts taxes so that I will spend more, but we know that debt will increase, I know that I will have to pay more taxes in the future.
- So before the tax change, I may consume 70 percent of current income, which shows up in the model parameters
- But after the tax change, my marginal propensity to consume will change, to a lower value.
- Agents inside the model know the model itself. The government has a strategy, people have a counter-strategy.
- So we cannot use these models to predict the effects of policy changes, since the underlying parameters will change due to changes in expectations of the agents

Sims 1980 Macroeconomics and Reality

- Sims took on the useful of the large models by advocating the use of small models
- He proposed Vector Autoregressive (VAR) modeling: take a small set of key variables, eg GDP, Money, Interest Rates, and Inflation
- Estimate a model of four equations: each variable depends on its own lags and the lags of the other variables
- Idea is to be non-ideological, neither Keynesian nor monetarist. Let the data show use how these variables interact.
- Startling result: these small models beat for forecasting performance of the large commercial or government funded models

Keynesian Vampire Slayers

- Lucas and Sims were the Keynesian vampire slayers of the 70's and 80'
- The focus of models turned toward "real business cycles", explore the effects of real productivity shocks
- Unemployment was explained by frictions in search and matching models of labor markets.
- Investment lags were explained by adjustment costs and other real frictions
- No need to think about government spending multipliers. Ricardian equivalence is at work.
- Tax policy should be designed for long-run growth, not short term stabilization policy
- We entered into the age of the "Great Moderation".

Return of Keynes

- As we know from movies, vampires always come back
- Keynesian models have made a comeback.
- The Global Financial Crisis of 2008 triggered a prolonged recession.
- There are wage and price rigidities which prevent markets from self-correcting
- Banking shocks are real and more devastating that real-sector productivity and relative price (oil) shocks
- Massive Federal Reserve asset purchases were decidedly Keynesian moves to prevent a new Great Depression.
- Heterogeneous agents, with "rule of thumb" consumers, give more power to fiscal policy.
- So models have become "new Keynesian" with wage-price rigities and inflation-output gap (not unemployment) tradeoffs.

Asking the Question

- We first need to clarify what do we want to do.
- Forecast? One type of model is needed, with more limited scope.
- Explain patterns in recent or past data? More careful formulation of a structural model.
- Do counterfactual policy analysis? Involves formulation of specific policy targets.
- But whatever our goal, we need to look at data, understand our data, filter our data.

Accessing Data, Seeing Patterns

- We can access data from many sources: FRED, Yahoo, and DBnomics
- We can visualize data to frame our questions
- In a Jupyter notebook with Python we focus on several issues

This is the conclusion slide.

Questions

Any questions?

Thank you for your attention!