Computational Methods in Macroeconomics

Introduction: Evolving Models and Methods

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What We'll Explore Today

1. Why Models Matter
2. Wisdom from the Masters
3. The Model-Building Toolkit
4. The Evolution of Macroeconomic Modeling
5. Building Your Own Models
6. Course Roadmap

The Big Question: Why Study Macroeconomic Models?

People making decisions about your future are using models.

- Central banks deciding interest rates
- Governments setting fiscal policy
- Financial institutions pricing assets
- International organizations advising countries

Key Insight

Understanding these models helps you anticipate decisions that affect your financial future, career opportunities, and economic environment.

What Models Actually Do For Us

1. **Bridge Theory and Reality**
   - We all have intuitions about how the economy works
   - Models force us to make these intuitions explicit and testable
2. **Predict and Forecast**
   - When will interest rates change? By how much?
   - What happens if taxes increase?
3. **Understand the Past**
   - Why did the 2008 crisis happen?
   - What caused the 1970s stagflation?
4. **Test Policy Alternatives**
   - What if we had raised rates earlier?
   - How would a different tax structure affect growth?

Wisdom from Giants

On Models and Truth

"All models are wrong but some are useful" – George Box

"A theory that explains everything explains nothing" – Karl Popper

On Simplicity and Elegance

"Elegance is elimination" – Cristobal Balenciaga

"A simple and beautiful theory that agrees well with observation is often closer to the truth than a complicated ugly theory that agrees better with observation" – Copernicus

On Honesty in Economics

"Let's take the con out of econometrics" – Ed Leamer

"Beware of economists bearing free parameters" – Robert E. Lucas, Jr

What These Quotes Mean for You

Box A model has limited goals. It will always be incomplete in some way. That's okay – embrace it!

Popper Don't try to explain everything. Good models focus on specific questions.

Leamer In macro, we're data-challenged. We have too few observations to test hypotheses with confidence.

Lucas Too many adjustable parameters let you fit any data, but explain nothing.

Friedman (TANSTAAFL) There's no free lunch. Rigorous analysis takes time and effort.

Nixon "We are all Keynesians now" – even policy makers who resist admit markets have frictions.

The Anatomy of Economic Models

Key Dimensions

Models vary along multiple dimensions, and each choice matters:

Time Structure

- Static vs. Dynamic
- Forward vs. Backward looking

Uncertainty

- Deterministic vs. Stochastic

Mathematical Form

- Linear vs. Nonlinear
- Analytical vs. Numerical

Scale

- Small (3-5 equations)
- Large (100+ equations)

Foundation

- Structural (theory-based)
- Non-structural (data-driven)

Parameters

- Calibrated (assigned)
- Estimated (from data)

Example: Supply and Demand

The classic supply-demand model is:

- Static – no time dimension
- Analytical – we can draw it on paper
- Small – just 2 equations
- Structural – based on optimization theory
- Deterministic – no randomness

The Problem

It doesn't tell us **how long** adjustment takes or **when** equilibrium is reached.

Timing is everything. As Keynes said: "In the long run we are all dead."

Types of Variables in Models

By Nature

- **Continuous** (GDP, inflation, interest rates)
- **Categorical** (recession yes/no, credit rating)

By Observability

- **Observable** (prices, output, employment)
- **Latent** (risk aversion, human capital, productivity)

By Causality

- **Exogenous** (determined outside the model)
- **Endogenous** (determined by the model)

Note: Latent variables often have "laws of motion" imposed on them to track their evolution.

Act I: The Age of Big Models (1960s-1970s)

The Golden Age of Keynesian Macro

- Large-scale models with **hundreds of equations**
- Linear, backward-looking, dynamic systems
- Famous examples: Brookings, FRB-MIT-Penn, Michigan
- Lawrence Klein's Project LINK at Penn

The Philosophy

These were big expansions of the IS-LM framework. The idea: model every sector in detail, use it for policy guidance.
Exception: Federal Reserve Bank of St. Louis – the lone monetarist model

The Crisis That Changed Everything

The 1970s: When Models Met Reality

The Shocks

- 1973: Oil price shock
- 1978: Second oil shock

The Outcome

- Rising inflation
- Rising unemployment
- Simultaneously!

The Problem

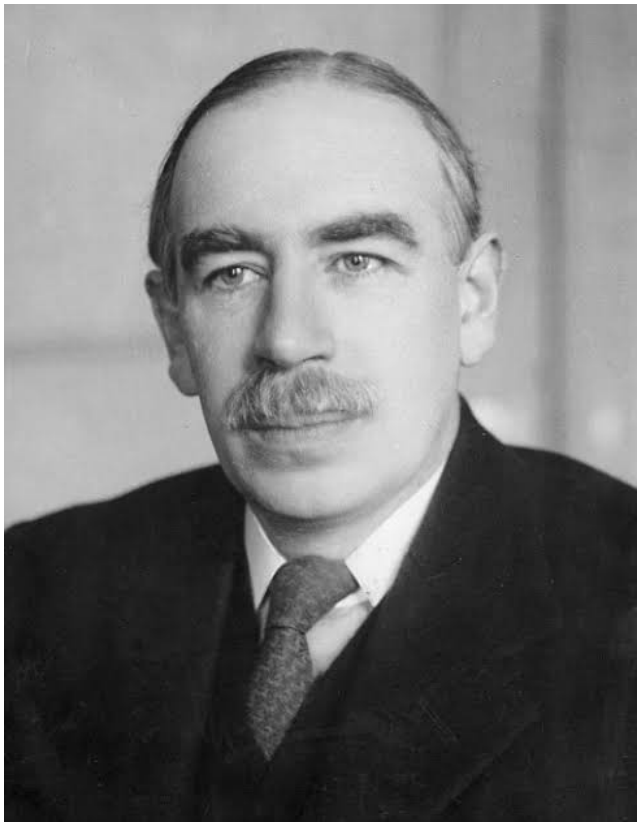
The Phillips Curve said this was impossible!

- High inflation $\rightarrow$ Low unemployment
- Low inflation $\rightarrow$ High unemployment

Facts rarely change viewpoints. Only new theoretical insights settle arguments.

Meet the Revolution Makers

John Maynard Keynes



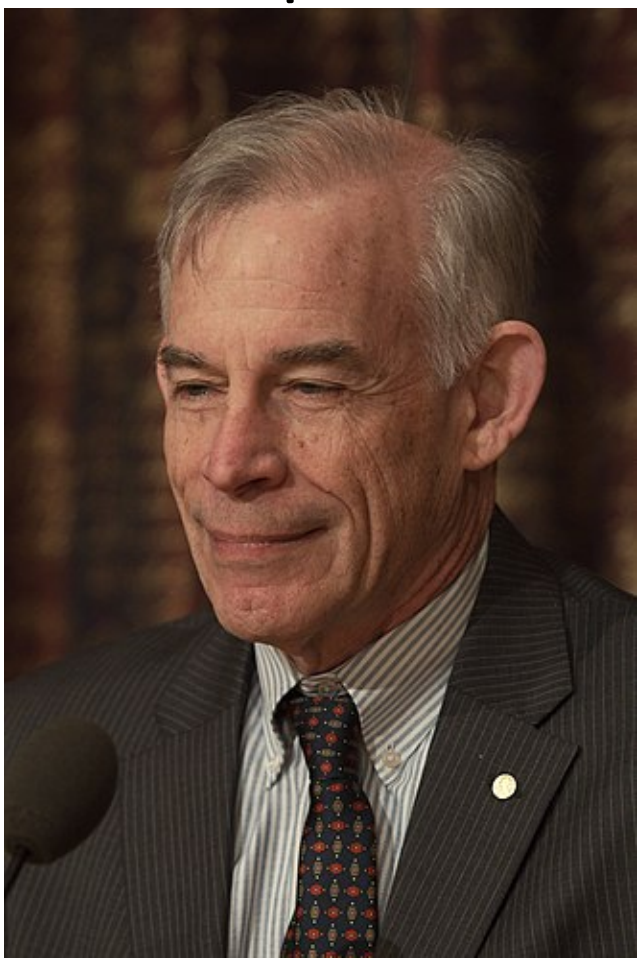
The Original Giant
Markets need help; policy matters

Robert E. Lucas, Jr.

The Revolutionary
Expectations change everything

Meet the Revolution Makers (cont.)

Christopher Sims



The Pragmatist

Edward Prescott

The Real Business Cycler
Technology shocks drive cycles

Act II: Lucas's Devastating Critique (1976)

The Lucas Critique

The problem: Estimated parameters depend on the policy regime.
Why? People have forward-looking expectations!

Tax Cut Example:

1. Government cuts taxes today
2. Old model: "People spend more!"
3. Lucas: "Wait... people think ahead"
   - Lower taxes today $\rightarrow$ Higher debt $\rightarrow$ Higher taxes tomorrow
   - So people save the tax cut!
4. Model's parameters shift; predictions fail

The Lesson

You can't use these models for policy evaluation because behavior changes when policy changes!

Act III: Sims's Alternative (1980)

Sims: "Let's try something different"

Vector Autoregression (VAR)

- Pick a small set of key variables (GDP, Money, Interest Rates, Inflation)
- Each variable depends on its own past *and* the past of other variables
- Four variables $\rightarrow$ four equations
- Let the data tell us how variables interact

The Philosophy: Be non-ideological. Neither Keynesian nor Monetarist.

The Shock

These small models **beat** the large commercial models at forecasting!

The Anti-Keynesian Era (1980s-1990s)

Lucas and Sims: The Keynesian Vampire Slayers

The New Paradigm:

- Focus on **Real Business Cycles** – technology shocks, not demand
- Unemployment? Explained by search and matching frictions
- Investment lags? Adjustment costs and real frictions
- Government spending multipliers? Forget them – Ricardian Equivalence
- Tax policy? For long-run growth, not short-run stabilization

The Message

Markets work. Frictions are real, not monetary. Policy should focus on removing distortions, not managing demand.

Act IV: The Return of Keynes (2008-Present)

Vampires Always Come Back

The Global Financial Crisis Changed Everything:

- Banking shocks more devastating than productivity shocks
- Wage and price rigidities prevented self-correction
- Massive Fed asset purchases (QE) – decidedly Keynesian!

New Keynesian Consensus

Modern models now include:

- Wage and price rigidities
- Heterogeneous agents (not just representative consumers)
- "Rule of thumb" consumers
- Financial frictions and banking sectors
- Inflation-output gap tradeoffs

Where We Are Now: The Synthesis

Today's State-of-the-Art Models:

- Dynamic
- Stochastic
- Nonlinear
- Structural
- Forward-looking
- With frictions (both real and nominal)

The Modern Consensus

Markets are powerful but imperfect. Both monetary and fiscal policy can matter. The question is *when* and *how much*, not *if*.

Step 1: Ask the Right Question

Clarity of Purpose is Everything

Forecasting? You need predictive models with limited scope

- Focus on patterns and regularities
- Less concerned with causal mechanisms

Explaining Patterns? You need structural models

- Based on economic theory
- Parameters have clear interpretations

Policy Analysis? You need models with explicit policy targets

- Must satisfy Lucas Critique
- Forward-looking expectations
- Clearly specified policy rules

Step 2: Get to Know Your Data

Data Sources:

- FRED (Federal Reserve Economic Data)
- Yahoo Finance and Stooq (https://stooq.com)
- DBnomics
- WRDS (Wharton Research Data Services)

Tools for Visualization and Analysis:

- Excel (with FRED add-in)
- Python (Jupyter notebooks)
- Julia, MATLAB, Stata, R

Don't Fear Coding!

ChatGPT, Claude.ai, and other AI assistants are there to help you write code, debug, and learn as you go.

Step 3: Choose Your Model Type

Simple Dynamic Models

No micro foundations, but useful for specific questions

- Example: Dornbusch Overshooting Model
- Example: New Keynesian Phillips Curve
- Good for understanding specific mechanisms

Dynamic Stochastic General Equilibrium (DSGE)

Larger, multidimensional, computationally intensive

- Built from micro foundations (optimization)
- Multiple sectors and agents
- Best for counterfactual policy analysis
- Example: See AMRO website for sample models

What We'll Learn This Semester

1. **Model Properties**
   - How to make models simple, falsifiable, and extensible
2. **Computational Methods**
   - Evolution of computational learning in macro
   - Modern solution techniques
3. **Nonlinearities**
   - In empirical estimation
   - In counterfactual policy simulation
4. **Pattern Recognition**
   - How to identify patterns in data
   - Which patterns matter most

Key Takeaways

1. **Models are tools**, not truth. Use them wisely.
2. **Everyone uses models** – some are just more explicit about it.
3. **History matters**. Understanding past debates helps you navigate current ones.
4. **Good models** balance simplicity with realism.
5. **The question shapes the model**, not the other way around.
6. **Timing is everything**. Static models miss what matters most.

Welcome to Computational Macroeconomics!