Lecture 1: Course Overview & Introduction

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MIT

14.461, Fall 2022

Course logistics

- **Instructors**: Jonathan Parker [1st half] & Christian Wolf [2nd half]
  - Lectures: Mon/Wed 10:00-11:30am (Room E52-432)
  - Office hours: by appointment (Room E52-554)
  - E-mail: `ckwolf@mit.edu`
- **TA**: Alex Martin
  - Recitations: Fri 1-2:30pm (Room E51-372)
  - Office hours: Mon 2:30-4:00pm (Room E52-548)
  - E-mail: `alexmr10@mit.edu`
- **Course website**: `https://canvas.mit.edu/courses/15529`

Course overview

1. [Parker] **Macroeconomics of household behavior**
   - PE models of household consumption, saving, and portfolio choices (including borrowing)
2. [Wolf] **Empirical analysis of macroeconomic shocks & their propagation**
   - Time-series & cross-sectional methods to study business-cycle policies & shocks
     Main Q's: What are the origins of business cycles? What are the effects of stabilization policy?
   - Guiding principle: connection between empirical methods & structural GE models
   - To connect with 1.: particular focus on distributional questions/"HANK"-type GE models

Note: will do some structural GE modeling to inform empirical techniques. But much more in 14.462.

Readings

- My half of the class will be largely organized around readings of (recent) papers
  - List of readings is provided on the syllabus
  - Starred (*) papers are required reading before class, rest provides more background. Please read the starred papers critically, thinking about key insights & central assumptions.
- There will be some review of classical time series material. For this I'd recommend consulting a textbook—my favorites include:
  - Brockwell & Davis (theory of covariance-stationary time series, not aimed at economists)
  - Hamilton (classic, slightly dated reference on time series econometrics)
  - Cochrane (well-written introduction to linear time series methods, for economists)
  - Kilian & Lütkepohl (recent book on SVAR methods)

Requirements, grading, and prerequisites

- **Requirements & grading** [remaining 30% from Jonathan's half]
  1. Class participation (10%)
  2. Problem set (10%) [mix of coding & analytical exercises]
  3. Referee report & paper replication (10%)
     - Select two papers cited in Ramey (2016) or Nakamura & Steinsson (2018), but not contained on the syllabus
     - Reference for refereeing best-practice is posted on the course webpage
     - Paper replication: first reproduce main results, then investigate one (minor) extension
  4. Final exam (40%)
     My half: analytical questions, similar in spirit to the problem set.
- **Course prerequisites**: 1st-year PhD course material (macro & econometrics)

A couple of preliminary thoughts

- Only second time teaching this, still **work in progress**. I thus encourage **live feedback**:
  - Are we proceeding too fast/slow?
  - Is there anything you'd like to see more details on?
  - Are some parts particularly boring? ...

  I will do my best to incorporate your comments as we go along

- **Course materials**
  - Lecture notes will be posted before class. They will be organized by topic and not strictly correspond to individual lectures.
  - When applicable I'll also post codes to accompany the slides

Outline

Outline

Course overview: macroeconomic shocks

- **Course objective**: how to use time-series and cross-sectional data to learn about:
  1. The origins of aggregate business-cycle fluctuations [e.g., are TFP shocks really important?]
  2. The effects & optimal design of policy rules [e.g., find the "best" Taylor-type interest rate rule]
  3. Coefficients of structural macroeconomic equations [e.g., the slope of the NKPC]

- **Our approach**: develop empirical methods that allow us to learn about the causal effects of non-policy & policy *shocks*. But why this focus on shocks?
  1. Why shocks as the origins of business cycles? Why e.g. not internal propagation leading to metronomic boom-bust episodes?
  2. What (if anything) do random policy *shocks* teach us about systematic policy *rules*?
  3. Why use shocks to estimate macro equations? Why not estimate them directly?

Outline

1. Macroeconomic Shocks – A Brief History of Thought
    - Business Cycles: Impulse vs. Propagation
    - Other Uses of Shocks
    - Summary: Our Objects of Interest

2. A Bird's-Eye View of the Course

Impulse-propagation framework

- **Objective**: explain properties of macroeconomic aggregates y_t
- Consider writing y_t as [Will later see connection of (1) to Wold decomposition theorem.]

$$y_t = \underbrace{\sum_{\ell=0}^{\infty} \Theta_\ell \varepsilon_{t-\ell}}_{\text{impulse \& propagation}} + \underbrace{\eta_t}_{\text{deterministic cycle}} \tag{1}$$

  where ε_t contains *primitive structural shocks* and η_t is a *deterministic series*

- This suggests **two broad approaches** to generating business cycles:
  1. Fundamental shocks that move the system through the dynamic causal effects Θ
  2. Metronomic view of business cycles: booms deterministically lead to busts
     The pure form of this are deterministic cycles via η_t. But the distinctions are fluid of course: shocks ε_t with very persistent, cyclical effects Θ also have a metronomic flavor.

Modern macro: impulse & propagation

- Modern business-cycle macro largely takes an **impulse-propagation** view: business cycles result from the economy being buffeted by exogenous shocks
  Remember what you saw in Year 1: TFP shocks, mark-up shocks, demand shocks, ...

- A nice summary of the state of the literature is provided in Werning (2016):

  *Early theorizing on business cycles sought to generate **self-sustaining fluctuations**. However, Slutzky (1937) showed the way down a different path with linear systems continuously **buffered by shocks**. Subsequent modeling, the Wold decomposition and its empirical implementations, elevated these ideas to a dominant methodological tradition. Most of the macroeconomic canon today simply assumes business cycles are due to shocks, with stable dynamics otherwise. More generally, the role played by nonlinearities is also secondary.*

Explaining the impulse propagation focus

- So business-cycle macro largely relies on the **impulse-propagation framework** (i.e., relatively persistent shocks + rather weak endogenous propagation). Why?
  - One answer is Occam's razor: you can just do it with shocks, so why not?
  - A bit more deeply: key diagnostic is spectral density $s_y(\omega)$. Loosely speaking, $s_y(\omega)$ gives the importance of cycles with frequency ω. We will discuss this formally in a couple of lectures.
  - Shock propagation vs. metronomic view have distinct implications for $s_y(\omega)$:
    1. Shock propagation: persistent exogenous shocks + weak propagation generally give smoothly declining spectrum. E.g. for a pure AR(1) the spectrum is

$$s_y(\omega) = \frac{1}{2\pi} \frac{\sigma^2}{1 - 2\rho\cos(\omega) + \rho^2}$$

    2. Metronomic cycles with frequency ω would instead imply *peaks* of spectral density at ω

- This suggests a diagnostic: study **spectral densities** of macro time series

Spectral densities: data vs. models

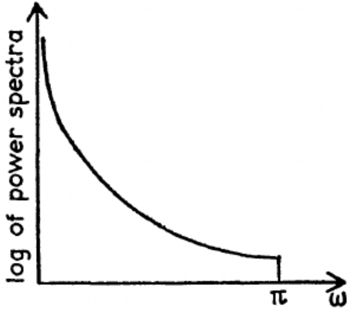
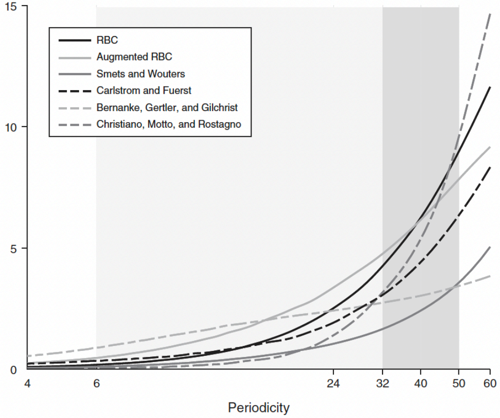


FIGURE 1.—Typical spectral shape.

- Figure shows spectrum of "typical" macro series
  see Granger (1966) for details & figure
  - Construction: remove seasonalities and low-frequency trends
  - Takeaway: no evidence of spectral peaks

Spectral densities: data vs. models



note the axis flip ...

- Figure shows spectrum of "typical" macro series
  see Granger (1966) for details & figure
  - Construction: remove seasonalities and low-frequency trends
  - Takeaway: no evidence of spectral peaks
- Much modern business-cycle analysis builds on this observation: figure from Beaudry et al. (2020)
  - Model cycles as the response to persistent shocks with weak internal propagation
  - Models are evaluated by their ability to match *co-movement* across var's condt'l on shocks

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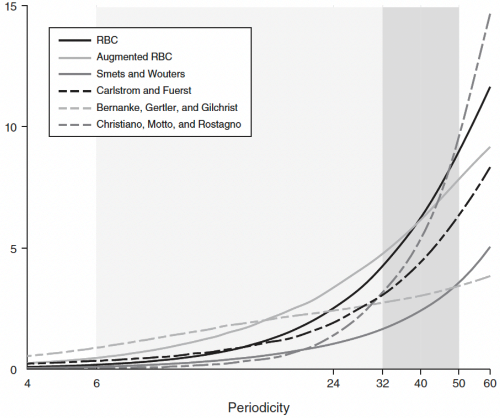

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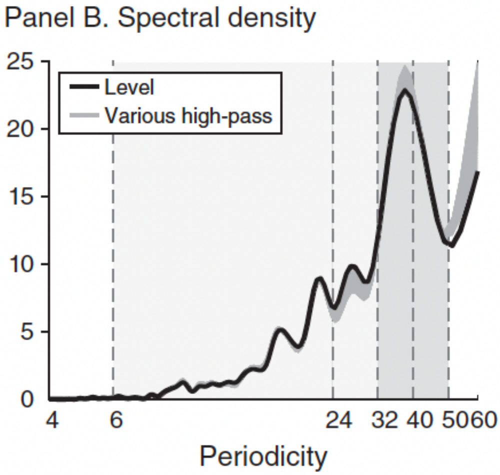
$\Rightarrow$ studying business-cycle origins = **finding shocks**

Spectral densities: a second look



- Note though that this consensus has been challenged in recent work

  figure & discussion in Beaudry et al. (2020)

  - But Werning (2016): hard to *credibly* establish either the presence or absence of limit cycles

- My course will largely take the **classical impulse-propagation** view. But:

  1. You'll learn the spectral analysis needed to assess both approaches
  2. Later with Ricardo you'll see (macro-finance) models with boom-bust dynamics

Outline

Policy shocks

- In our empirical analysis of **macro policy** we will study policy *shocks*
- What are such **policy shocks**?
  - Idealized interpretation: innovation to policy rules $\perp$ to all other structural impulses, e.g.

    $$i_t = f(\Omega_t) + \varepsilon_t^m$$

    where i_t is the policy instrument, Ω_t is the time-t information set, $f(\bullet)$ is the policy *rule* and ε_t^m is the policy shock
  - But central bankers don't flip coins. Alternatively: change in preferences, measurement error in preliminary data, strategic response to private-sector expectations, ...
- Probably not important for business cycles. Also, to inform policy, we care about the effects of **rules**, not **shocks**. So why the focus on shocks?
  - IV intuition: random variation in i_t identifies causal effects of i_t on the economy
  - We will make precise the idea that the dynamic causal effects of *shocks* allow us to predict the effects of changes in *rules* (i.e., go from $f(\bullet)$ to some alternative $g(\bullet)$)

Structural macro equations

- **Conventional macro theory** predicts a couple of key structural relationships. E.g.:

  1. **NKPC**

  $$\pi_t = \kappa y_t + \beta \mathbb{E}_t \pi_{t+1} + \text{supply shocks} \tag{2}$$

  2. **IS curve**

  $$c_t = \mathbb{E}_t c_{t+1} - \frac{1}{\gamma}\left(i_t - \mathbb{E}_t \pi_{t+1}\right) + \text{demand shocks} \tag{3}$$

- Lots of work in the 1980s/1990s on direct estimation of relations like (2) and (3). But that's hard, not least due to the presence of unmeasurable shocks.

- **Identified shocks** may again help. Idea: use them as *instruments*
  - For example: identified demand shocks [like monetary policy shocks] should allow us to estimate an NKPC [= get slope of a supply curve] since uncorrelated with supply shocks
  - Simplest case: if (2) were static ($\beta = 0$) then ratio of π to y responses to monetary policy shocks would identify κ

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Objects of interest

Let ε_t be a vector of shocks, and y_t be a vector of macro var's, and consider the linear model

$$y_t = \sum_{\ell=0}^{\infty} \Theta_\ell \varepsilon_{t-\ell}$$

We want to learn about:

Objects of interest

Let ε_t be a vector of shocks, and y_t be a vector of macro var's, and consider the linear model

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We want to learn about:

1. **Dynamic causal effects**

$$\text{IRF}_{i,j,h} = \Theta_{i,j,h} \equiv \mathbb{E}(y_{i,t+h} \mid \varepsilon_{j,t} = 1) - \mathbb{E}(y_{i,t+h} \mid \varepsilon_{j,t} = 0), \quad h = 0, 1, 2, \ldots$$

- Note: we will largely care only about *relative* dynamic causal effects
  E.g.: how does output respond to a monetary shock that moves the fed funds rate by 100bp.

Objects of interest

Let ε_t be a vector of shocks, and y_t be a vector of macro var's, and consider the linear model

$$y_t = \sum_{\ell=0}^{\infty} \Theta_\ell \varepsilon_{t-\ell}$$

We want to learn about:

2. **Shock importance** for average cyclical fluctuations

$$\text{FVD}_{i,j,h} \equiv 1 - \frac{\text{Var}(y_{i,t+h} \mid \{\varepsilon_{t-\ell}\}_{\ell=0}^{\infty}, \{\varepsilon_{j,t+\ell}\}_{\ell=1}^{h})}{\text{Var}(y_{i,t+h} \mid \{\varepsilon_{t-\ell}\}_{\ell=0}^{\infty})} = \frac{\sum_{m=0}^{h-1} \Theta_{i,j,m}^2}{\sum_{j=1}^{n_\varepsilon} \sum_{m=0}^{h-1} \Theta_{i,j,m}^2}$$

- In words: what share of fluctuations of y_{t+h} comes from shocks $\varepsilon_{j,t}$ (rather than $\varepsilon_{-j,t}$)?
- Will also discuss some other importance concepts.
  E.g.: importance for frequencies rather than forecast dates, change information set from structural shocks $\{\varepsilon_{t-\ell}\}_{\ell=0}^{\infty}$ to macro observables $\{y_{t-\ell}\}_{\ell=0}^{\infty}$, ...

Objects of interest

Let ε_t be a vector of shocks, and y_t be a vector of macro var's, and consider the linear model

$$y_t = \sum_{\ell=0}^{\infty} \Theta_\ell \varepsilon_{t-\ell}$$

We want to learn about:

3. Contribution of shocks to particular **historical episodes**

$$\text{HD}_{i,j,t} = \mathbb{E}\left(y_{i,t} \mid \{\varepsilon_{j,t-\ell}\}_{\ell=0}^{\infty}\right) = \sum_{\ell=0}^{\infty} \Theta_{i,j,\ell} \varepsilon_{j,t-\ell}$$

- The derived path is then compared with the actual realized time path $y_{i,t}$
- In words: did shock $\varepsilon_{j,t}$ contribute meaningfully to a given historical episode?

Outline

Course Outline

0. Background material (lectures 2-3)

   a) Linearized **structural macro models**

      - Will discuss two convenient representations of *linearized* business-cycle models: the state-space representation and the sequence-space representation
      - Key take-away: these are equivalent ways of arriving at a model's structural vector moving average (SVMA) representation: $y_t = \sum_{\ell=0}^{\infty} \Theta_\ell \varepsilon_{t-\ell}$
      - Rest of the course: how to learn about the SVMA coefficients Θ

   b) Linear **time series methods**

      - Review classical topics like lag operators, linear filters, VARMA models, Wold decomposition theorem, spectral analysis
      - Note: we will cover precisely the time series tools needed to discuss ways of going from aggregate time series data to our objects of interest in a), the SVMA coefficients

Course Outline

1. Semi-structural time series identification & estimation of macro shocks (lectures 4-7)

   a) **Identification**

      - The identification challenge: show that, from aggregate time series alone, SVMA models are (severely) under-identified
      - Classes of identifying asn's: invertibility + X, invertibility-robust methods (e.g., macro IVs)
      - Overarching objective: cleanly state *population* identifying assumptions. Move away from language like "VAR identification" (& bring closer to micro/credibility revolution language)

   b) **Estimation**

      - Review standard estimation methods (VARs, LPs) & intermediate shrinkage techniques (e.g., penalized LP), discuss best-practice for empirical analysis
      - Important: this is purely about the statistics of second-moment estimation—completely orthogonal to any economic identifying assumptions

Course Outline

2. Applications: returning to today's big-picture questions (lectures 8-10)

    a) How can we estimate **structural macro equations**?

      - Review classical lagged-instrument single-equation estimation techniques. Compare with identification through structural macro shocks.
      - Application: NKPC estimation

    b) How should we **optimally design** stabilization policy?

      - What can policy "shock" analysis tell us about optimal policy rules?
      - Application: optimal Ramsey policy in HANK-type models

    c) What are the **origins of business cycles**?

      - Are different business-cycle episodes caused by common types of shocks? Or is every recession different? What do our empirical methods suggest?
      - Applications: TFP shocks and investment-specific technology shocks; business-cycle anatomy; business-cycle estimation in HANK-type models

Course Outline

3. Cross-sectional identification & estimation of macro shocks (lectures 11-12)

   a) What does **cross-sectional analysis** actually identify?

      - Key tool: PE-GE decompositions using sequence-space characterization of equilibria

   b) How can we **aggregate** to recover macro shock effects?

      - Discuss two popular approaches to go from micro to macro: macro as explicitly aggregated micro and exploiting shock commonality in GE (notably "demand equivalence")
      - Main application: stimulus check policies