Determinacy without the Taylor Principle

George-Marios Angeletos[1] Chen Lian[2]

[1]MIT and NBER

[2]UC Berkeley and NBER

February 23, 2022

Outline

A Perennial Issue: Indeterminacy in a Monetary Economy

- Core questions of the monetary economics depends on equilibrium selection:
  - What determines the price level?
  - Can monetary policy regulate AD and inflation?
  - Does the ZLB trigger a deflationary spiral?

- Basic problem (back to Sargent & Wallace, 75):
  - **Same path for $R \Rightarrow$ multiple bounded equilibrium paths for π and y**
  - **Different selections $\Rightarrow$ different answers to core monetary questions**

- State of the art: two alternatives
  - **Taylor principle** (TP, raise i more than 1-1 with π)
  - **Fiscal Theory of the Price Level** (FTPL, non-Ricardian fiscal policy)

A New Perspective

- Indeterminacy requires strong **intertemporal coordination ("infinite chain")**
  - Current agents respond to sunspots if future agents respond in a specific way.
  - Future agents respond only if they expect agents further in the future respond; and so on.
- **Small perturbations** in memory/coordination $\Rightarrow$ breaks the chain $\Rightarrow$ **determinacy**
  - Always selects the standard eq. (**MSV**), even with interest rate pegs
- A new perspective on **both** the **Taylor principle** and **FTPL**
  - Recast Taylor principle as stabilization instead eq. selection
  - Reformulate FTPL outside the eq. selection logic

Outline

A Simplified NK Model

1. DIS, with overlapping generations of consumers (who live for 2-periods):

$$c_t = \bar{E}_t\left[\frac{1}{1+\beta}y_t + \frac{\beta}{1+\beta}y_{t+1} - \frac{\beta}{1+\beta}\sigma(i_t - \pi_{t+1} - \rho_t)\right] \tag{DIS}$$

$$y_t = c_t$$

2. Phillips curve:

$$\pi_t = \kappa y_t + \xi_t \tag{PC}$$

3. Taylor rule ($\phi \geq 0$):

$$i_t = z_t + \phi \pi_t \tag{MP}$$

An Equivalent Representation

- Substituting monetary policy and Phillips curve in IS curve $\Rightarrow$

$$c_t = \bar{E}_t\left[(1-\delta_0)\theta_t + \delta_0 c_t + \delta_1 c_{t+1}\right]$$

where $\{\theta_t\}$ is a transformation of $\{\rho_t, \xi_t, z_t\}$ and $\delta_0 \equiv \frac{1-\beta\sigma\phi\kappa}{1+\beta} < 1$ and $\delta_1 \equiv \frac{\beta+\beta\sigma\kappa}{1+\beta} > 0$

- NK economy = a game among consumers
  - δ_0 and δ_1 measure strategic complementarity within and across time
  - summarize all GE feedbacks: income$\leftrightarrow$spending, output$\leftrightarrow$inflation, MP response

Fundamentals, Sunspots, and the Equilibrium Concept

- Fundamentals & sunspots:

$$\theta_t \sim_{\text{i.i.d}} \mathscr{N}(0,1) \quad \text{and} \quad \eta_t \sim_{\text{i.i.d}} \mathscr{N}(0,1)$$

  - In paper: general stochasticity

- State of nature, or (infinite) history, at t:

$$h^t = \{\theta_{t-k}, \eta_{t-k}\}_{k=0}^{\infty}$$

- Equilibrium concept: **REE (based on potentially limited information about h^t)**

$$c_t = \sum_{k=0}^{\infty} a_k \eta_{t-k} + \sum_{k=0}^{\infty} \gamma_k \theta_{t-k}$$

- Focus on bounded eq. (can be justified by escape clauses)

Outline

The Standard Paradigm

- **FIRE/perfect social memory benchmark:**

$$c_t = \theta_t + \delta(\phi)\mathbb{E}_t[c_{t+1}]$$

  - $\mathbb{E}_t[\cdot]$ is rational expectation conditional on entire history h^t

- **The MSV (minimum state variable) solution:**

$$c_t = c_t^F \equiv \theta_t$$

- **Is MSV the only solution?**
  - Standard: depends on the Taylor principle
  - Our perturbation: always

The Standard Paradigm

Proposition 1. Perfect Recall Benchmark

- When $\phi > 1$ (Taylor principle), the MSV equilibrium is the unique eq
- When $\phi < 1$, there exist **a continuum of equilibria**

$$c_t = (1-b)c_t^F + bc_t^B + ac_t^\eta,$$

where $a, b \in \mathbb{R}$ are arbitrary scalars and

$$\underbrace{c_t^\eta \equiv \sum_{k=0}^{\infty} \delta^{-k}\eta_{t-k}}_{\text{sunspot eq.}} \quad \text{and} \quad \underbrace{c_t^B \equiv -\sum_{k=1}^{\infty} \delta^{-k}\theta_{t-k}}_{\text{backward-looking, pseudo-fundamental eq.}}$$

- **Infinite chain**: Current agents respond to payoff-irrelevant histories because they expect future agents to do the same, ad infinitum
- What's Next: **small perturbations breaking the infinite chain**

Outline

The First Perturbation: Fading Social Memory

- At every t, the young consumer learns (θ_t, η_t)
- With prob. λ, she learns nothing more
- With prob. $1-\lambda$, she inherits the info of a random old consumer

Assumption. Fading Social Memory

In every t, information set are given by

$$I_{i,t} = \{(\theta_t, \eta_t), \cdots, (\theta_{t-s}, \eta_{t-s})\},$$

where $s \in \{0, 1, \cdots\}$ is drawn from a geometric distribution with $\lambda \in (0,1)$.

Determinacy without the Taylor Principle

- As $\lambda \to 0$, **almost all agents have *arbitrarily long* memory**
  - nearly perfect informed about $\{\theta_{t-k}, \eta_{t-k}, c_{t-k}, \pi_{t-k}\}$
- But for any $\lambda > 0$, zero mass of agents has *infinite* memory
  - $\lim_{k\to+\infty} \mu_k = 0$ where $\mu_k \equiv$ mass of agents that knows histories of length k or higher

Proposition 2. Determinacy without the Taylor Principle

With fading social memory, the **MSV solution** is the **unique equilibrium**

- **Regardless** of δ, or **equivalently MP** ϕ (e.g., even with pegs).
- No matter how slow the memory decay is (how small $\lambda > 0$ is).

Logic

Key to the proof: anticipation that social memory will fade

$\Longrightarrow$ **perceived complementarity fades with horizon**

$\Longrightarrow$ **determinacy**

Logic:

- I can see the current sunspot very clearly
- It would make sense to react if all future agents will keep responding to it **in perpetuity**
- But I worry that agents **far in the future will fail to do so**
  - either because they will forget it
  - or because they may worry that agents further into the future will forget it
- It therefore makes sense to ignore the sunspot

Outline

Robustness

- Sunspot eq. can be represented in **recursive form** as

$$c_t = \eta_t + \delta^{-1} c_{t-1}.$$

  - supported by $I_{i,t} = \{\eta_t, c_{t-1}\}$
  - c_{t-1} serves as memory/coordination device

Robustness

- Sunspot eq. can be represented in **recursive form** as

$$c_t = \eta_t + \delta^{-1} c_{t-1}.$$

  - supported by $I_{i,t} = \{\eta_t, c_{t-1}\}$
  - c_{t-1} serves as memory/coordination device

Proposition 3

Sunspot eq. **unravel** with tiny idiosyncratic noise in the observation of c_{t-1}

$$I_{i,t} = \{\eta_t, s_{i,t}\}, \qquad \text{with} \qquad s_{i,t} = c_{t-1} + \varepsilon_{i,t}.$$

Robustness

- Sunspot eq. can be represented in **recursive form** as

$$c_t = \eta_t + \delta^{-1} c_{t-1}.$$

  - supported by $I_{i,t} = \{\eta_t, c_{t-1}\}$
  - c_{t-1} serves as memory/coordination device

Proposition 3

Sunspot eq. **unravel** with tiny idiosyncratic noise in the observation of c_{t-1}

$$I_{i,t} = \{\eta_t, s_{i,t}\}, \qquad \text{with} \qquad s_{i,t} = c_{t-1} + \varepsilon_{i,t}.$$

Proposition 4

Even with perfect knowledge of $\{c_{t-k}, \pi_{t-k}\}_{k=0}^{K}$, **uniqueness** provided K is finite and tiny forgetfulness about θ_{t-1}

The Full NK Model: Same Results

- Intertemporal Keynesian cross (proper DIS):

$$c_t = \mathscr{C}\left(\left\{\bar{E}_t[y_{t+k}]\right\}_{k=0}^{\infty}, \left\{\bar{E}_t[i_{t+k} - \pi_{t+k+1}]\right\}_{k=0}^{\infty}\right) + \rho_t$$

- Standard NKPC:

$$\pi_t = \kappa c_t + \beta E_t[\pi_{t+1}] + \xi_t$$

- Monetary policy:

$$i_t = z_t + \phi_c c_t + \phi_\pi \pi_t$$

Proposition 5

With fading social memory ($\lambda > 0$), the equilibrium is **unique** and is given by the **MSV** solution.

A Smooth Taylor Principle

- Our result removes the need for equilibrium selection
  but **leaves ample room for sunspot-like fluctuations** in the form of
  - overreaction to noisy public news (Morris-Shin, 02)
  - shocks to higher-order beliefs (Angeletos-La'O, 13)
  - bounded rationality (Angeletos & Sastry, 21)
- The slope of the Taylor rule admits a new function:
  - **regulates the magnitude of sunspot-like fluctuations** along the unique eq.
  - by regulating the overall complementarity in the economy
- **Recast Taylor principle as stabilization instead eq. selection**

Fiscal Theory of Price Level

Proposition 6.

Assume first-order knowledge of government budget & market clearing + no rational confusion.

Then, gov debt and deficits are **payoff irrelevant** (sunspots)

- Regardless of memory, regardless of monetary/fiscal policy

- **Corollary:** eq. selected by FTPL is not robust to our perturbations
- Fiscal policy ***has* to be Ricardian even when monetary policy is passive**

Standard Result		
	Fiscal Policy is	
	Ricardian	Non-Ricardian
Taylor holds	Determinacy	No equilibrium
does not hold	Multiplicity	Determinacy

With Our Perturbation		
	Fiscal Policy is	
	Ricardian	Non-Ricardian
Taylor holds	Determinacy	No equilibrium
does not hold	Determinacy	No equilibrium

Outline

Take-home Messages

- Warning: as in global games, multiplicity can strike back with enough CK
- Still, our results
  - **illustrate fragility of sunspot/backward looking solutions**
  - **help escape the equilibrium selection conundrum**
- A new perspective on **both** the **Taylor principle** and **FTPL**
  - Recast Taylor principle as stabilization instead eq. selection
  - Reformulate FTPL outside the equilibrium selection logic
    e.g., model MP-FP interaction as a game of between monetary & fiscal authority