Inflation and Fiscal Policy

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University of Oslo and CEPR

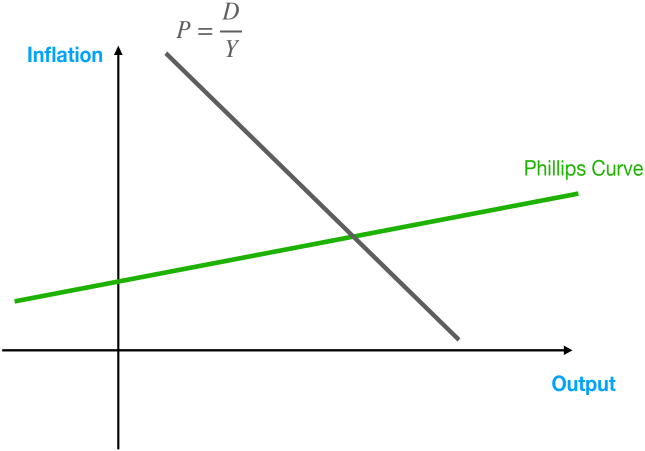
Fiscal Policy Modelling Workshop

Padova, 23 May 2024

Agenda in a (graphical) nutshell
Nominal Demand

Two key elements:

Nominal Demand (D) & Phillips Curve

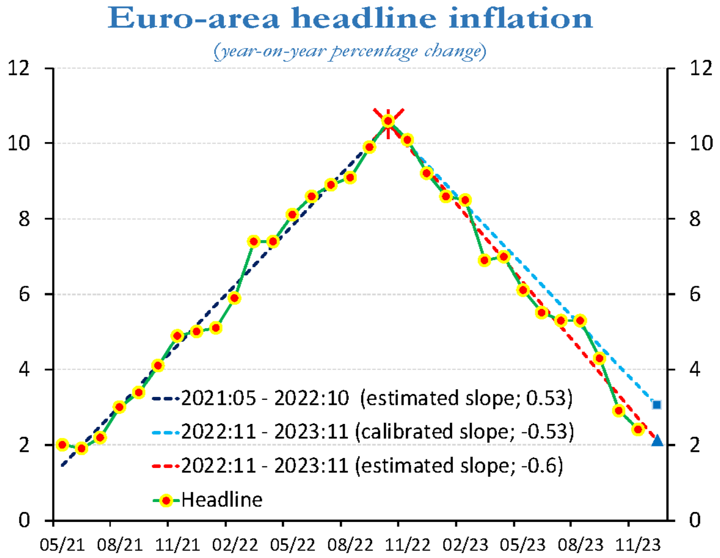


Agenda in a (graphical) nutshell
One Period Version

Local determinacy:

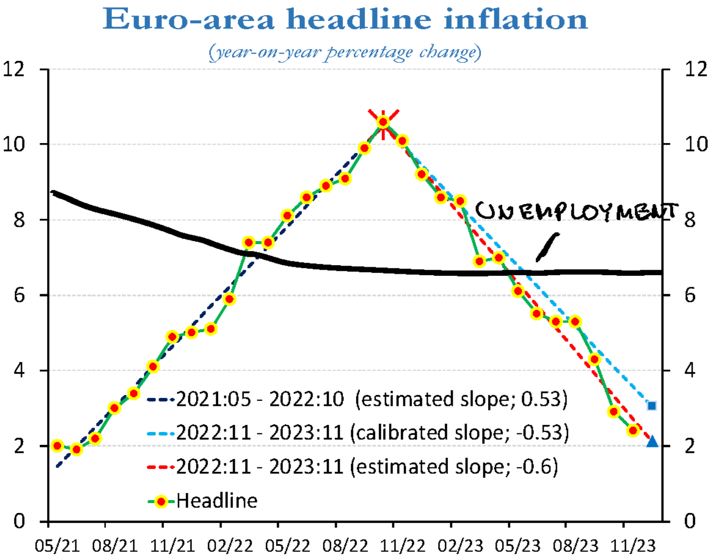
Is the equilibrium locally (around steady state) unique?

Christmas Tree Inflation

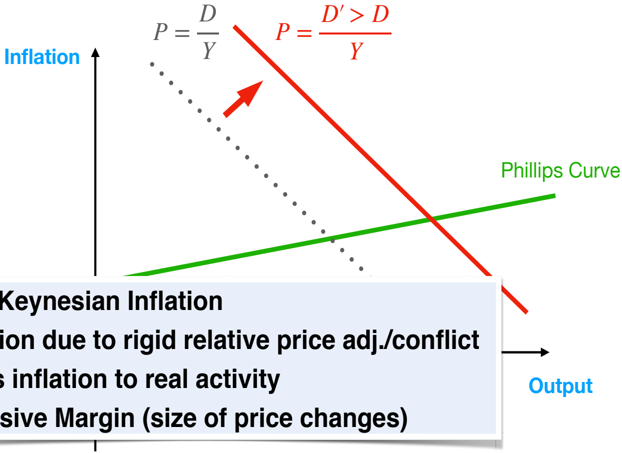


Source: Stefano Neri

Christmas Tree Inflation



Phillips curve shift

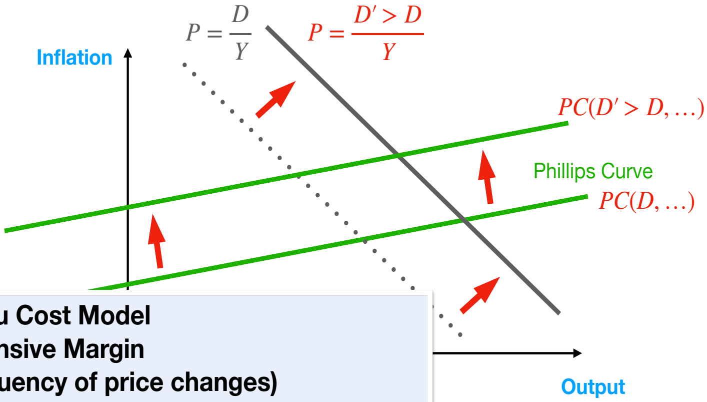


- New Keynesian Inflation
- Inflation due to rigid relative price adj./conflict
- Links inflation to real activity
- Intensive Margin (size of price changes)

Phillips curve shift

Hagedorn (2022):
"A Nominal Demand-Augmented Phillips Curve: Theory and Evidence"

Chek, Hagedorn, Llavador & Mitman (2023):
"Inflation Persistence and a New Phillips Curve"



- Menu Cost Model
- Extensive Margin
  (frequency of price changes)
- Nominal demand
  -> Inflation and real activity decoupled

Determinacy

Asset market clearing condition is key:

$$S_t(r_t, r_{t+1}, \ldots, \tau_t, \tau_{t+1}, \ldots) = \frac{B_{t+1}}{P_t}$$

S_t : Period t asset demand
P_t : Period t price level
r_t : Period t real interest rate
τ_t : Period t tax rate
B_{t+1}: Nominal govt' bonds issued in Period t

Steady-state determinacy:

Is there unique steady-state price level?

$$S_t(r_{ss}, r_{ss}, \ldots, \tau_{ss}, \tau_{ss}, \ldots) = \frac{B_{ss}}{P_{ss}}$$

Local determinacy:

Is the equilibrium locally (around steady state) unique?

Determinacy

Asset market clearing condition is key:

$$S_t(r_t, r_{t+1}, \ldots, \frac{T_t}{P_t}, \frac{T_{t+1}}{P_{t+1}}, \ldots) = 0$$

S_t : Period t asset demand
P_t : Period t price level
r_t : Period t real interest rate
T_t : Nominal Period t taxes
B_{t+1}: Nominal govt' bonds issued in Period t

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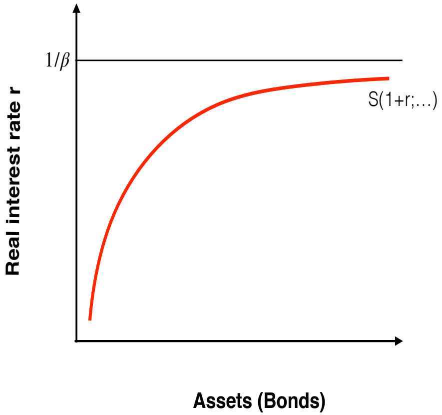
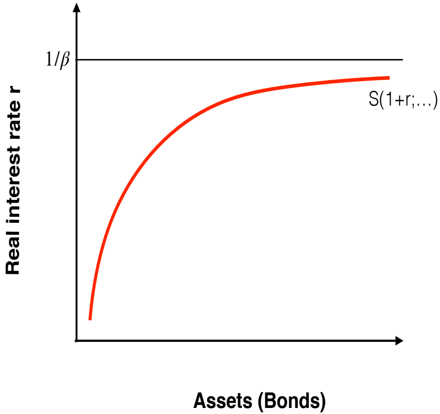
Incomplete Markets



Incomplete Markets



Real Interest Rate:

$(1 + r) = \frac{1+i}{1+\pi}$

Monetary Policy:

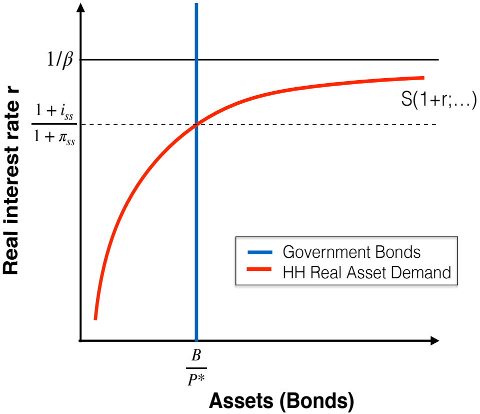
Sets $1 + i$

Fiscal Policy

$\pi = \frac{B' - B}{B}$

i : nominal interest rate B: nominal bonds
r : real interest rate π : inflation rate

Incomplete Markets



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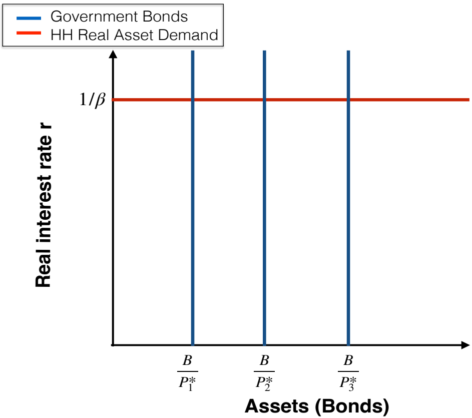
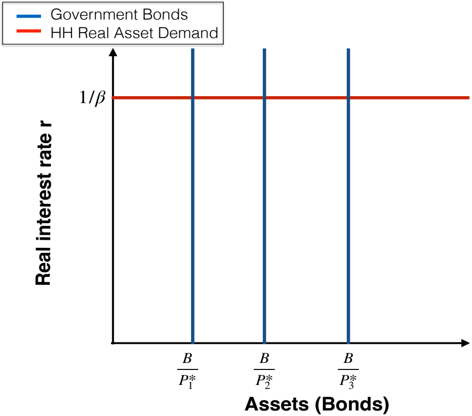


Complete Markets



Complete Markets

$\rightarrow$Ricardian Equivalence

$\rightarrow$ "Bonds have no value"

Incomplete Markets

$\rightarrow$ No Ricardian Equivalence

$\rightarrow$ "Bonds have value"

Steady State Price Level

With endogenous Money M

Steady-state Conditions

$$\frac{B}{P^*} = S\left(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss}\right)$$

$$\frac{M}{P^*} = L\left(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss}\right)$$

$$1+\pi_{ss} = 1+\frac{B'-B}{B} = 1+\frac{M'-M}{M}$$

Central bank provides

$$M = P^* L\left(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss}\right)$$

Steady State Price Level

With endogenous Money M

Steady-state Conditions [Open Market operations]

$$\frac{B - M}{P^*} = S(\frac{1 + i_{ss}}{1 + \pi_{ss}}, 1 + \pi_{ss})$$

$$\frac{M}{P^*} = L(\frac{1 + i_{ss}}{1 + \pi_{ss}}, 1 + \pi_{ss})$$

$$1 + \pi_{ss} = 1 + \frac{B' - B}{B} = 1 + \frac{M' - M}{M}$$

Central bank provides

$$M = P^* L(\frac{1 + i_{ss}}{1 + \pi_{ss}}, 1 + \pi_{ss})$$

Steady State Price Level

With endogenous Money M

Steady-state Conditions [Open Market operations]

$$\frac{B-M}{P^*} = S(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss})$$

$$\frac{M}{P^*} = L(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss})$$

$$\frac{B}{P^*} = S(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss}) + L(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss})$$

$$1+\pi_{ss} = 1 + \frac{B'-B}{B} = 1 + \frac{M'-M}{M}$$

Central bank provides

$$M = P^* L(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss})$$

Steady State Price Level

With endogenous Money M

$$M = P^* L\left(\frac{1+i_{ss}}{1+\pi_{ss}}, 1+\pi_{ss}\right)$$

Key Insight:

- Monetary policy chooses either price or quantity
  - MP sets i_{ss} (as in practice) → M endogenous
  - MP chooses $M \rightarrow i_{ss}$ endogenous
- Demand Theory of the Price Level:
  - Monetary Policy chooses price i_{ss}
  - Fiscal Policy chooses quantity B
  - In DTPL a price and a quantity are chosen!

Other Fiscal Policy Rules

- Simple debt rule

$$\frac{B_{t+1}}{B_t} = const.$$

- Nominal tax rules

$$T_t = \omega_1 i_t B_t + \omega_2 B_t,$$

- Real tax rules (FTPL)

$$s_t = s^* + \gamma(r_t b_t - s^*), \quad \text{s: primary surplus}$$

- $\gamma \in [0, 1)$ (Leeper (91) active pol.)
- $\gamma > 1$ (Leeper (91) passive pol.)

Other Fiscal Policy Rules

- Nominal tax rules

$$T_t = \omega_1 i_t B_t + \omega_2 B_t,$$

yields growth rate of nominal debt:

$$\frac{B_{t+1}}{B_t} = (1 - \omega_1) i_t + (1 - \omega_2),$$

Growth rate of nominal debt is "sufficient statistic":

$$\frac{B_{t+1}}{B_t} \ \rightarrow \ \text{Inflation} \ \ 1 + \pi \ \rightarrow \ \text{Price Level} \ \ P$$

- Real tax rules (FTPL)

Other Fiscal Policy Rules

- Nominal tax rules
- Real tax rules (FTPL)

$$s_t = s^* + \gamma(r_t b_t - s^*),$$

Yields growth rate of debt $\forall\gamma$:

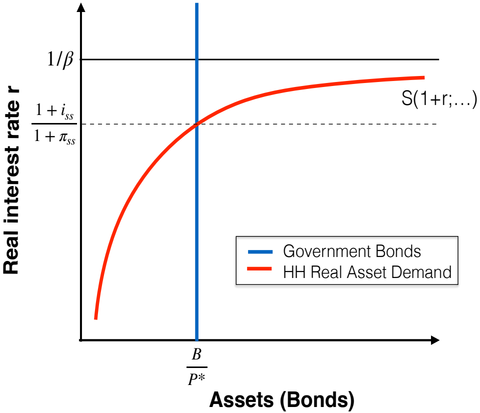
$$\frac{B_{t+1}}{B_t} = (1+i_t)(1-\gamma) + \gamma(1+\pi_t) - \frac{P_t}{B_t}(1-\gamma)s^*$$

$\forall\gamma$: Growth rate of nominal debt is "sufficient statistic":

$$\frac{B_{t+1}}{B_t} \;\rightarrow\; \text{Inflation } \; 1+\pi \;\rightarrow\; \text{Price Level}$$

$\rightarrow$ Determinacy for active and passive fiscal policy:
But only in incomplete markets!

Incomplete Markets
FTPL



Real Interest Rate:

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Monetary Policy:

Sets $1+i$

Fiscal Policy

$$\pi = \frac{B' - B}{B}$$

i : nominal interest rate B: nominal bonds

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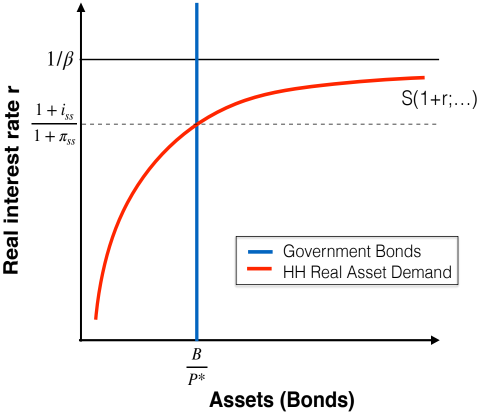
Incomplete Markets
FTPL



Real Interest Rate:

$$(1+r) = \frac{1+i}{1+\pi}$$

Monetary Policy:

Sets $1+i$

Fiscal Policy (FTPL rule)

$$\pi = \frac{B' - B}{B}$$
$$= i - \frac{P}{B}s^*$$

i : nominal interest rate B: nominal bonds
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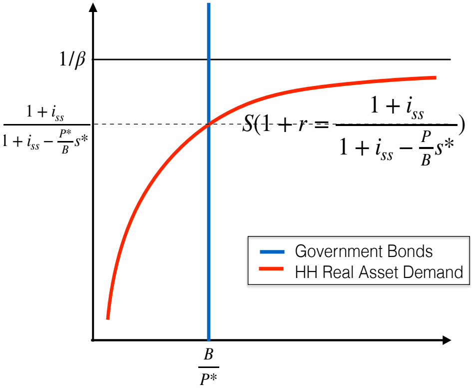
Incomplete Markets
FTPL



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Fiscal Policy

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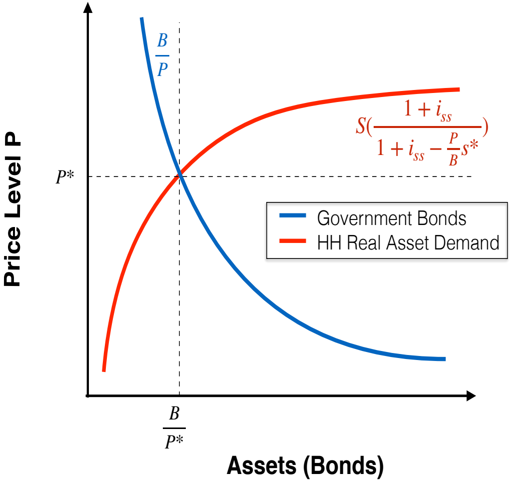
Price Level with FTPL Fiscal Rules

Price - Asset Space

Fiscal rule: $s_t = s^* > 0$

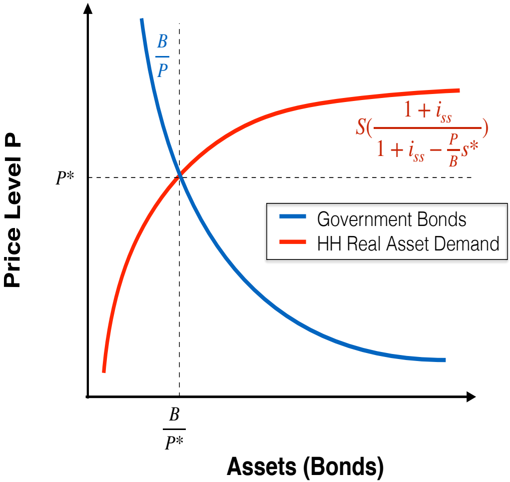


Price Level with FTPL Fiscal Rules

Price - Asset Space

Fiscal rule: $s_t = s^* + \gamma(r_t b_t - s^*)$

Same result for passive/active fiscal rule!

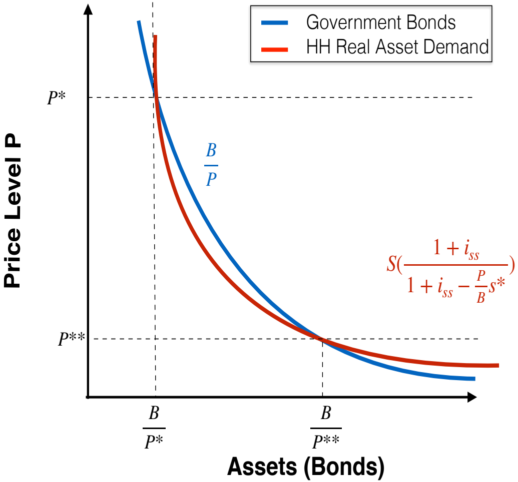


Price Level with FTPL fiscal rules

$s^* < 0$

Same analysis but: S(P) downward sloping

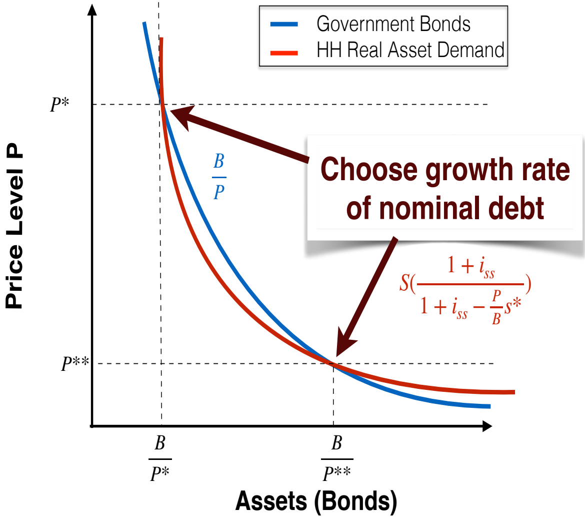
$\Rightarrow$ 2 Steady states



Price Level with FTPL fiscal rules

$s^* < 0$

Solution to overcome multiplicity



Kaplan, Nikolakoudis &Violante (23): HA-FTPL

Use flow (instead of present value) govt budget constraint:

$$b * r = s^*, \quad b\text{: real bonds, } r\text{: real interest rate}$$

That is not the FTPL.

What it means:

- Taxes, spending and new debt are all fixed
- Price level adjust to balance annual budget

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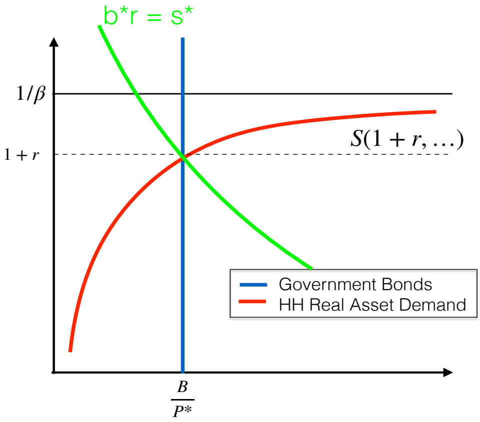

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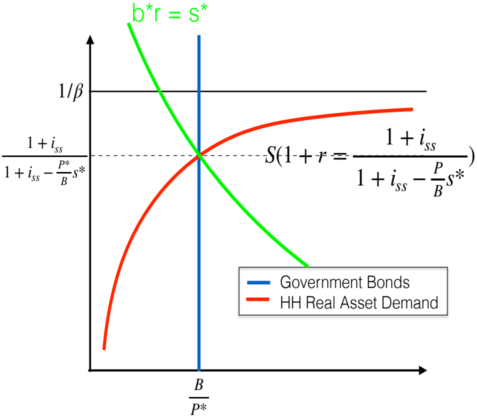

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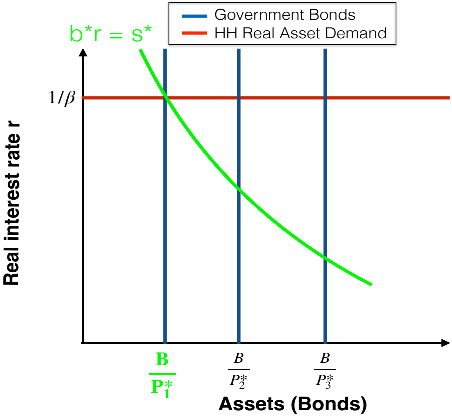

Fiscal Theory of the Price Level

FTPL is a complete markets based theory!

- Complete Markets
  - Ricardian Equivalence holds!
  - But: Active fiscal policy: ~~Ricardian equivalence~~ → "Bonds have value"
  - Why? Violation of TVC:

$$\underbrace{\frac{B_{t+1}-B_t}{B_t}}_{\text{Nom. growth}} = i_{ss} - \frac{P_t}{B_t}s^* \to i_{ss}; \qquad \underbrace{\frac{\frac{B_{t+1}}{P_{t+1}} - \frac{B_t}{P_t}}{\frac{B_t}{P_t}}}_{\text{Real debt growth}} \to r_{ss}$$

  - If not P such that $s^* = \frac{B}{P}(1+r)r$
- Incomplete Markets

Fiscal Theory of the Price Level

- Complete Markets
- Incomplete Markets
  - Market incompleteness: ~~Ricardian equivalence~~ $\rightarrow$ "Bonds have value"
  - No violation of TVC

$$\underbrace{\frac{B_{t+1}-B_t}{B_t}}_{\text{Nom. debt growth}} = i_{ss} - \frac{P_t}{B_t}\tau \rightarrow i_{ss};$$

But:

$$\underbrace{\frac{B_{t+1}/P_{t+1}}{B_t/P_t}}_{\text{Real debt growth}} = \frac{B_{t+1}}{B_t} - (1+\pi) = 0$$

Why?

- Incomplete Markets: $1+\pi = \frac{B_{t+1}}{B_t}$
- Complete Markets: $1+\pi = \beta(1+i_{ss})$

What about FTPL (Equation)

Pick arbitrary initial price level $\hat{P}$. Growth rate of nominal debt:

$$\pi = \frac{B_1 - B_0}{B_0} = i - \frac{\hat{P}}{B_0} s^* = \frac{B_{t+1} - B_t}{B_t} = i - \frac{P_t}{B_t} s^*$$

Satisfies FTPL equation for every $\hat{P}$:

$$\frac{B_0}{\hat{P}}(1+i) = \sum_{j=0}^{\infty} \left(\frac{1+\pi_{ss}}{1+i_{ss}} \right)^j s^*$$

Local Determinacy

Hagedorn (23): "Local Determinacy in Incomplete-Markets Models"

- CM: Blanchard & Kahn (80) eigenvalue counting of:

$$E_t x_{t+1} = A_1 x_t$$

- Linearizing the asset market clearing condition delivers infinite # leads:

$$\sum_{k=-j}^{\infty} A_k E_t x_{t+k} = \Gamma z_t,$$

- Onatski (06) defines complex function

$$\Theta(\lambda) = det \sum_{k=-j}^{\infty} A_k e^{-ik\lambda},$$

- Theoretical results are possible! Numerical evaluation always feasible
- Good news: Toolbox is available!

Local Determinacy

Understanding Onatski

- Winding number: The number of times $\Theta(\lambda)$ rotates around zero counter-clockwise when λ goes from 0 to 2π.
- $$\text{wind}(\Theta(\lambda)) \begin{cases} = 0 & \text{unique solution (determinacy)} \\ < 0 & \text{multiple solution} \\ > 0 & \text{no solution} \end{cases}$$
- Determinacy $\Leftrightarrow$ $\Theta(\lambda)$ does not rotate around $(0,0)$.
- With finite # leads (k: # predetermined, ρ_j eigenvalues)

$$\Theta(\lambda) = e^{-ik\lambda} \prod_{|\rho_j|<1} (e^{-i\lambda} - \rho_j) \prod_{|\rho_j|>1} (e^{-i\lambda} - \rho_j)$$

- The winding number, $wind(\Theta(\lambda))$, equals

$$wind(e^{-ik\lambda}) + \sum_{|\rho_j|<1} wind(e^{-i\lambda} - \rho_j) + \sum_{|\rho_j|>1} wind(e^{-i\lambda} - \rho_j)$$

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$$\underbrace{wind(e^{ik\lambda})} + \sum_{|\rho_j|<1} \underbrace{wind(e^{-i\lambda} - \rho_j)} + \sum_{|\rho_j|>1} \underbrace{wind(e^{-i\lambda} - \rho_j)}$$

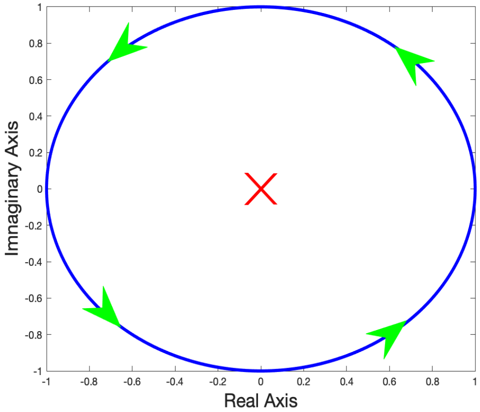
Local Determinacy

Understanding Onatski

$$\underbrace{wind(e^{ik\lambda})}_{=k} + \sum_{|\rho_j|<1} \underbrace{wind(e^{-i\lambda} - \rho_j)} + \sum_{|\rho_j|>1} \underbrace{wind(e^{-i\lambda} - \rho_j)}$$

$$e^{i\lambda} = \cos(\lambda) + i\sin(\lambda)$$

Winding number $= 1$



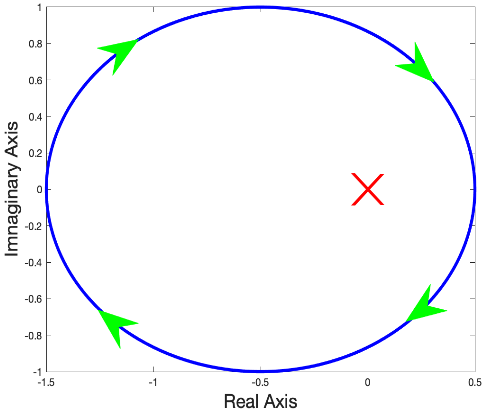
Local Determinacy

Understanding Onatski

$$\underbrace{wind(e^{ik\lambda})}_{=k} + \sum_{|\rho_j|<1} \underbrace{wind(e^{-i\lambda} - \rho_j)}_{=-1} + \sum_{|\rho_j|>1} \underbrace{wind(e^{-i\lambda} - \rho_j)}$$

$$e^{-i\lambda} - 0.5 = \cos(-\lambda) + i\sin(-\lambda) - 0.5$$

Winding number = -1



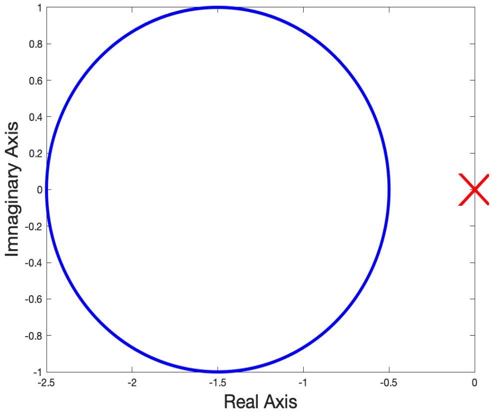
Local Determinacy

Understanding Onatski

$$\underbrace{wind(e^{ik\lambda})}_{=k} + \sum_{|\rho_j|<1} \underbrace{wind(e^{-i\lambda} - \rho_j)}_{=-1} + \sum_{|\rho_j|>1} \underbrace{wind(e^{-i\lambda} - \rho_j)}_{=0}$$

$e^{-i\lambda} - 1.5$

Winding number $= 0$



Local Determinacy

Local Determinacy criteria differ in complete and incomplete markets models

- Redistribution through taxes:
  price/inflation sunspot → taxes → consumption/saving

- Monetary policy redistributes:
  price/inflation sunspot → nom. interest rate → taxes → consumption/saving

- Sticky prices: redistributive effects as in Bilbiie (08)

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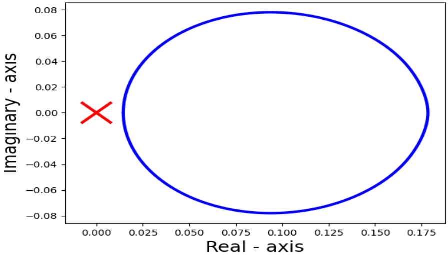

Toolbox

Local Determinacy

Examples

- Complete vs. Incomplete Markets
- Nominal vs. Real Bonds
- Constant Interest rate vs. Inflation Targeting

	Constant Nominal Interest Rate, $i_t = \bar{i}$		Inflation Targeting $i_{t+1} = 1.5\pi_t$
	Nominal Bonds	Real Bonds	Real Bonds
Incomplete Markets	Determinate	Determinate	Indeterminate
Complete Markets	Indeterminate	Indeterminate	Determinate

Local Determinacy
FTPL

Tax rule: $\tau_t = \tau^* + \gamma(r_t b_t - \tau^*)$; **Interest rate rule:** $\hat{i}_{t+1} = \varphi^i \hat{\pi}_t$

		$\varphi^i = 0$ passive monetary	$\varphi^i = 1.1$ active monetary
$\gamma = 1.1$ (passive)	Incomplete Mkt.	Indeterminate	Indeterminate
	Complete Mkt.	Indeterminate	Determinate
$\gamma = 0.9$ (active)	Incomplete Mkt.	Determinate	Determinate
	Complete Mkt.	Determinate	Indeterminate

Local Determinacy
FTPL

Tax rule: $\tau_t = \tau^* + \gamma(r_t b_t - \tau^*)$; **Interest rate rule:** $\hat{i}_{t+1} = \varphi^i \hat{\pi}_t$

		$\varphi^i = 0$ passive monetary	$\varphi^i = 1.1$ active monetary
$\gamma = 1.1$ (passive)	Incomplete Mkt.	Indeterminate	Indeterminate
	Complete Mkt.	Indeterminate	Determinate
$\gamma = 0.9$ (active)	Incomplete Mkt.	Determinate	Determinate
	Complete Mkt.	Determinate	Indeterminate
$\gamma = 0.0$ (active)	Incomplete Mkt.	Determinate	Determinate
	Complete Mkt.	Determinate	Indeterminate

Hagedorn, Manovskii & Mitman (2017): The Fiscal Multiplier:

		$\hat{i}_t = i_{ss}$	$\hat{i}_t = 1.5\pi_t$
Incomplete Markets	Tax Financing	< 1	< 1
	Deficit Financing	$> \mathbf{1}$	< 1
Complete Markets		Indeterminate	< 1

Policy Implications
Various Puzzles

Contractionary TFP shocks expansionary? NO

Forward guidance infinitely powerful? NO

Divergence (of multiplier) at frictionless limit? NO

Conclusion

- A new role for Fiscal Policy in determining inflation
- Role of Incomplete Markets and Nominal Demand
- FTPL in (in)complete markets
- Key idea: Inflation decoupled from real variables

$$D(\text{policy}, \ldots) = PY$$

instead of

$$MV(\text{policy}, \ldots) = PY$$