Safe Assets and Aggregate Demand

(based on paper “Flight to Safety and New Keynesian Demand Recessions” joint with Ziang Li)

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This Lecture

Questions:

- Modeling questions:
  - How to incorporate New Keynesian (NK) price setting frictions into continuous-time macrofinance models?
  - What are implications of adding them to safe asset framework?
- Broader economic questions (see paper for more details):
  - What are implications of uncertainty shocks for aggregate economic activity?
  - How do these shocks transmit to the real economy?
  - How can (monetary) policy affect this transmission?

Lessons

- Key lessons:
  - demand for outside safe assets ($\approx$ government bonds) is central for fluctuations in aggregate demand
  - portfolio choice (desire to save in safe assets) not intertemporal substitution (desire to save per se) is key for understanding these fluctuations
  - this matters for many NK predictions, including power of interest rate policy
- Some (vague) intuition
  - safe assets play a money-like role ("retrading service flows")
  - ... and they are nominal: their real value is tightly linked to (sticky) nominal goods prices
  - like traditional money demand, safe asset demand creates a nominal anchor that, under sticky prices, drags the real economy with it
  - ... but unlike traditional money, the nominal quantity of safe assets cannot be independently managed but follows largely from government debt accumulation

Key Model Element: Portfolio Choice with Nominal Safe Assets

	conventional NK model	safe asset NK model
aggregate demand	**IS curve**: consumption-saving • forward-looking • relates demand to future $r_t - r_t^*$-gaps	**safe asset demand**: portfolio choice btw. capital (risky) and nominal bonds (safe) • forward-looking **safe asset supply**: debt accumulation equation • backward-looking: gradually adjusts to inflation and interest rates
aggregate supply	**Phillips curve** • forward-looking (or static) • relates inflation to future output gaps	

Outline

Outline

Simplified Money Model from Markus' Talk Yesterday

- Continuous time, infinite horizon, one consumption good
- Continuum of households
  - operate capital subject to idiosyncratic risk, linear production technology
  - can trade capital and government bonds
  - *simplifying assumptions*: no real investment or capital growth; no monetary frictions
- Government
  - taxes capital
  - issues nominal bonds
  - *simplifying assumption*: no government spending
- Financial friction: incomplete markets
  - agents cannot trade idiosyncratic risk
- Aggregate fluctuations: idiosyncratic shock volatility ($\tilde{\sigma}_t$) and productivity (a_t)

Simplified Money Model: Formal Details

- Preferences ($i \in [0,1]$ agent index):

$$\mathbb{E}\left[\int_0^\infty e^{-\rho t} \log c_t^i dt\right]$$

- Each agent manages capital k_t^i
  - output flow: $y_t^i dt = a_t k_t^i dt$
  - capital tax by government: $\tau_t k_t^i dt$
  - capital evolution: $dk_t^i = \underbrace{k_t^i d\Delta_t^{k,i}}_{\text{trading}} + \underbrace{k_t^i \tilde{\sigma}_t d\tilde{Z}_t^i}_{\text{idio. shocks}}$
- Aggregates and market clearing
  - normalize $K_t := \int k_t^i di = 1$
  - goods market clearing $C_t := \int c_t^i di = \int y_t^i di =: Y_t = a_t$
- Government:
  - budget constraint $\overbrace{i_t \mathcal{B}_t}^{\text{interest payments}} = \overbrace{\mathcal{P}_t \tau_t}^{\text{prim. surpluses}} + \overbrace{\mu_t^{\mathcal{B}} \mathcal{B}_t}^{\text{bond issuance}} \Rightarrow i_t = \mu_t^{\mathcal{B}} + \underbrace{\frac{\tau_t}{\mathcal{B}_t / \mathcal{P}_t}}_{=:\check{s}_t}$

Notation: Assets Values

- Assets in positive net supply: capital & bonds
  - capital: aggregate supply $K_t = 1$, value q_t^K
  - bonds: real value of bond stock $q_t^B := \frac{\mathcal{B}_t}{\mathcal{P}_t}$
- Also define total wealth $q_t := q_t^B + q_t^K$
- Share of bond wealth

$$\vartheta_t := \frac{\mathcal{B}_t/\mathcal{P}_t}{q_t^K + \mathcal{B}_t/\mathcal{P}_t} = \frac{q_t^B}{q_t}$$

- In equilibrium:
  - all households choose identical portfolios
  - ϑ_t is also individual portfolio weight in bonds

Model Solution

Recall from previous talk:

- Model solution conditional on ϑ_t and exogenous a_t

$$C_t = \rho q_t \qquad q_t = \frac{a_t}{\rho} \qquad q_t^B = \vartheta_t \frac{a_t}{\rho} \qquad q_t^K = (1 - \vartheta_t) \frac{a_t}{\rho}$$

- Implied price level and inflation dynamics

$$\mathcal{P}_t = \mathcal{B}_t / q_t^B \qquad \Rightarrow \qquad \frac{d\mathcal{P}_t}{\mathcal{P}_t} = (i_t - \check{s}_t)dt + \frac{d(1/q_t^B)}{1/q_t^B}$$

- Endogenous dynamics of ϑ_t: unique solution to *government liabilities valuation equation*

$$\mathbb{E}_t[d\vartheta_t] = (\rho - \check{s}_t - (1 - \vartheta_t)^2 \tilde{\sigma}_t^2)\vartheta_t dt$$

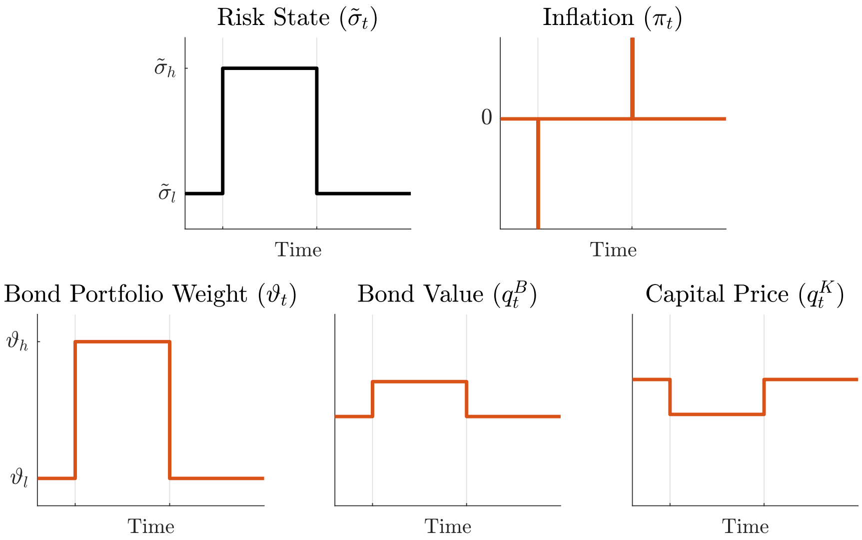
  that satisfies $\liminf_{t\to\infty} \vartheta_t > 0$

  - In steady state (constant $\tilde{\sigma}$, $\check{s}$): $\vartheta = \frac{\tilde{\sigma} - \sqrt{\rho - \check{s}}}{\tilde{\sigma}}$

Outline

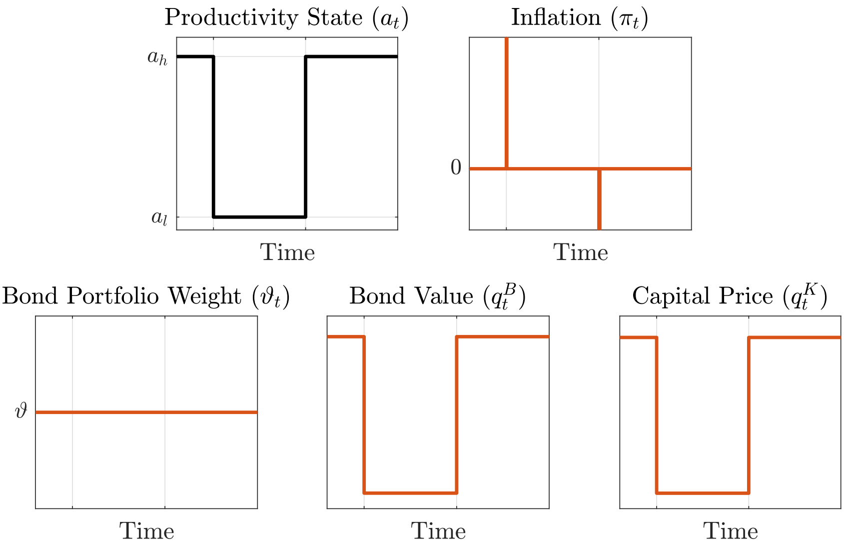
1. Recall: Flexible-Price Money Model with Safe Asset Demand
   - Setup and Solution
   - Effects of Shocks
2. A Sticky Price Model
   - Modified Model Environment
   - Solving the Model
3. Shock Transmission
4. Implications
   - Implications for Interest Rate Policy and Asset Pricing
   - Comparison to Models without Safe Assets

Uncertainty Shock: $\tilde{\sigma} \uparrow$



IRFs are plotted under the assumption that the government does not react (i, $\mu^{\mathcal{B}}$, $\check{s}$ all remain constant).

Negative Aggregate Supply Shock: $a_t \downarrow$



IRFs are plotted under the assumption that the government does not react (i, $\mu^{\mathcal{B}}$, $\check{s}$ all remain constant).

Outline

Accommodating Price Setting Frictions: Variable Capital Utilization

- Goal: add price setting frictions to generate sticky nominal goods price dynamics
- Prerequisite: elastic short-term supply (within dt-period)
  - at "wrong" prices, goods demand may be excessive or insufficient
  - markets can only clear if supply can adjust within the period
- Not the case in our AK-economy
  - ... but can be fixed with variable capital utilization
- Formally, household i can create capital services $\hat{k}^i_t dt = u^i_t k^i_t dt$ by utilizing capital
  - capital services are rented out to firms at unit price p^R_t
  - cost of utilization = disutility (e.g., effort cost)
  - modified household preferences

$$\mathbb{E}\left[\int_0^\infty e^{-\rho t}\left(\log c^i_t - \frac{(u^i_t)^{1+\varphi}}{1+\varphi}\right) dt\right]$$

Extended Model: Final Goods Supply

- The representative firm transforms capital services into final goods
  - production technology:

$$Y_t = a_t \int \hat{k}_t^i di$$

- Behavior under flexible prices:
  - nominal goods price $\mathcal{P}_t$ is free
  - *elastic* demand for capital services at input price $p_t^R = a_t$

- Behavior under sticky prices:
  - nominal goods price $\mathcal{P}_t$ satisfies reduced-form Phillips curve ▸ more microfounded version

$$d\mathcal{P}_t = \pi_t \mathcal{P}_t dt, \qquad \pi_t = \kappa \left(\frac{p_t^R}{a_t} - 1 \right), \qquad \mathcal{P}_0 \text{ given}$$

  - *inelastic* demand for capital services required to serve final goods demand $Y_t = C_t$
  - profits $\omega_t dt := (1 - p_t^R / a_t) Y_t dt$ are distributed to households according to capital shares

Aside: Relationship to Textbook Model with Labor

- Turn off idiosyncratic risk, $\tilde{\sigma}_t = 0$, so that all households are the same
- Can relabel things:
  - utilization $u_t \rightarrow$ labor ℓ_t
  - rental price $p_t^R \rightarrow$ wage w_t
  - make capital non-tradeable
- Then this is the flexible-price version of a textbook NK model (e.g. Gali 2015)
- Why the (unconventional) capital formulation?
  - closer to other models you have seen this weekend
  - with $\tilde{\sigma}_t > 0$: gains from u_t scale with wealth, preserves linear aggregation

Aside II: Relationship to HANK

Outline

Solving the Model: Household Problem

Household problem: choose $\{c_t^i, u_t^i, \theta_t^i\}$ to maximize

$$\mathbb{E}\left[\int_0^\infty e^{-\rho t}\left(\log c_t^i - \frac{(u_t^i)^{1+\varphi}}{1+\varphi}\right) dt\right]$$

subject to

$$dn_t^i = -c_t^i dt + n_t^i\left(\theta_t^i dr_t^B + (1-\theta_t^i) dr_t^{K,i}(u_t^i)\right)$$

- return on capital:

$$dr_t^{K,i}(u_t^i) = \left(\frac{p_t^R u_t^i + \omega_t - \tau_t}{q_t^K} + \mu_t^{q,K}\right) dt + \tilde{\sigma}_t d\tilde{Z}_t^i + \text{aggregate shocks}$$

- optimal choices:

$$c_t^i = \rho n_t^i \qquad \text{(consumption)}$$

$$(u_t^i)^\varphi = \frac{p_t^R k_t^i}{c_t^i} \qquad \text{(utilization effort)}$$

$$\frac{\mathbb{E}_t[dr_t^K]}{dt} - \frac{\mathbb{E}_t[dr_t^B]}{dt} = (1-\theta_t^i)\tilde{\sigma}_t^2 + \text{aggregate risk premium} \qquad \text{(portfolio choice)}$$

Model Solution: Flexible Prices

- Production side:
  - all households choose same $u_t^i \Rightarrow$ aggregate supply is $Y_t = a_t u_t$
  - combine optimal u_t with goods market clearing:

$$u_t^{\varphi} = \frac{p_t^R}{a_t u_t} \Rightarrow u_t = \left(\frac{p_t^R}{a_t}\right)^{\frac{1}{1+\varphi}}$$

  - using $p_t^R = a_t$:

$$\boxed{u_t = u^* := 1}$$

- Asset pricing:
  - in equilibrium: returns on capital and bonds as in baseline model
  - therefore: portfolio choice implies same government liabilities valuation equation as before

$$\boxed{\mathbb{E}_t[d\vartheta_t] = (\rho - \check{s}_t - (1-\vartheta_t)^2 \tilde{\sigma}_t^2)\vartheta_t dt}$$

- Conclusion: identical equilibrium as in baseline model

Conclusion: Flexible Price Equilibrium

Recall equations from baseline model:

- Model solution conditional on ϑ_t and exogenous a_t

$$C_t = \rho q_t \qquad q_t = \frac{a_t}{\rho} \qquad q_t^B = \vartheta_t \frac{a_t}{\rho} \qquad q_t^K = (1-\vartheta_t)\frac{a_t}{\rho}$$

- Implied price level and inflation dynamics

$$\mathcal{P}_t = \mathcal{B}_t / q_t^B \qquad \Rightarrow \qquad \frac{d\mathcal{P}_t}{\mathcal{P}_t} = (i_t - \check{s}_t)dt + \frac{d(1/q_t^B)}{1/q_t^B}$$

- Endogenous dynamics of ϑ_t solve government liabilities valuation equation

$$\mathbb{E}_t[d\vartheta_t] = (\rho - \check{s}_t - (1-\vartheta_t)^2\tilde{\sigma}_t^2)\vartheta_t dt$$

Sticky Price Equilibrium

- Model solution conditional on ϑ_t, u_t, and exogenous a_t

$$C_t = \rho q_t \qquad q_t = \frac{a_t u_t}{\rho} \qquad q_t^B = \vartheta_t \frac{a_t u_t}{\rho} \qquad q_t^K = (1-\vartheta_t)\frac{a_t u_t}{\rho}$$

- Price level and inflation dynamics (from Phillips curve)

$$d\mathcal{P}_t = \pi_t \mathcal{P}_t dt, \qquad \pi_t = \kappa(p_t^R - a_t), \qquad \mathcal{P}_0 \text{ given},$$

where $p_t^R = a_t u_t^{1+\varphi}$ from optimal utilization

- Key change: q_t^B becomes *backward-looking state variable*

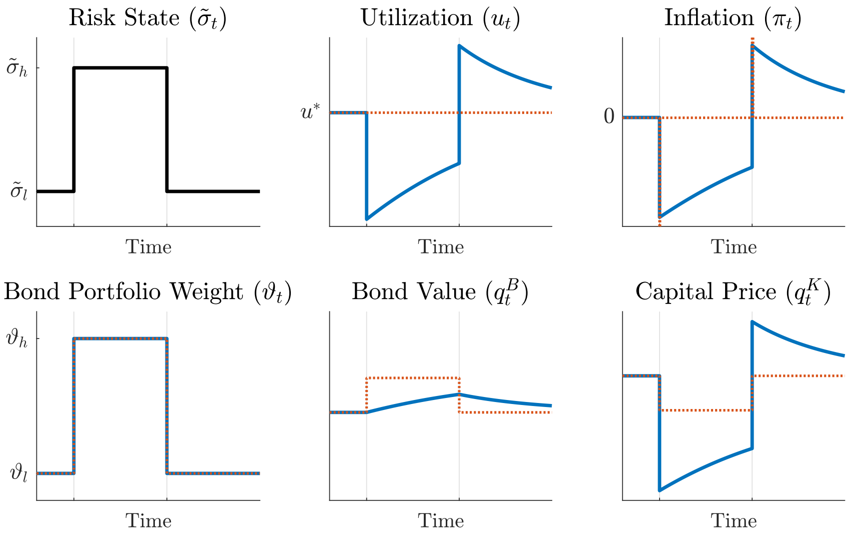
$$dq_t^B = d(\mathcal{B}_t/\mathcal{P}_t) = (\mu_t^{\mathcal{B}} - \pi_t)dt$$

- Endogenous dynamics of ϑ_t solve government liabilities valuation equation

$$\mathbb{E}_t[d\vartheta_t] = (\rho - \check{s}_t - (1-\vartheta_t)^2\tilde{\sigma}_t^2)\vartheta_t dt$$

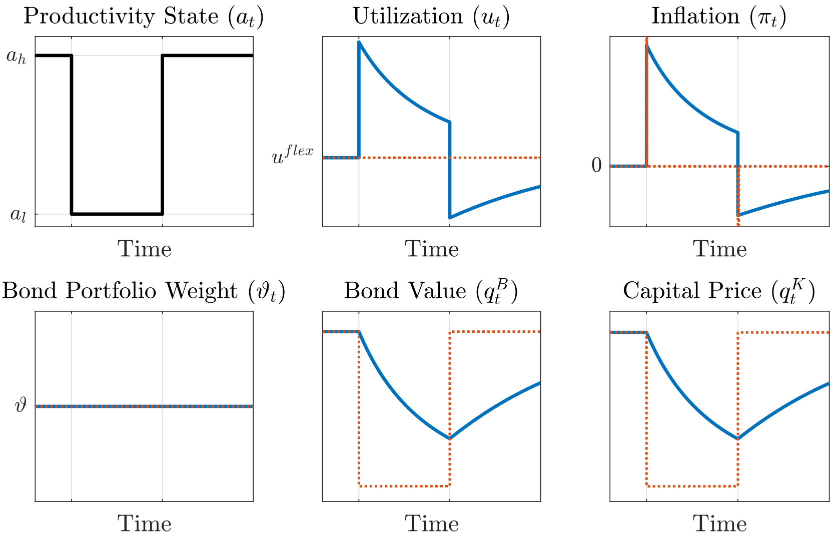
Outline

Uncertainty Shock $\tilde{\sigma} \uparrow$



Blue solid: sticky prices; Red dotted: flexible prices; IRFs are plotted under the assumption that the government does not react (i, $\mu^{\mathcal{B}}$, $\check{s}$ all remain constant).

Negative Supply Shock $a \downarrow$



Blue solid: sticky prices; Red dotted: flexible prices; IRFs are plotted under the assumption that the government does not react (i, $\mu^{\mathcal{B}}$, $\check{s}$ all remain constant).

Transmission Preliminaries I: Separation of Portfolio Choice

- Integrated valuation equation: ϑ_t satisfies in equilibrium

$$\vartheta_t = \mathbb{E}_t \left[\int_t^\infty e^{-\rho(s-t)} \vartheta_s \left(\check{s}_s + (1 - \vartheta_s)^2 \tilde{\sigma}_s^2 \right) ds \right].$$

  - depends only on fiscal instrument $\check{s}_t$ and idiosyncratic risk $\tilde{\sigma}_t$
  - not on aggregate output or price setting frictions

- Separation: if $\check{s}_t$ is function of (X_t, ϑ_t) only, then $\vartheta_t = \vartheta(X_t)$ is determined independently from other endogenous variables (including the bond valuation state q_t^B)
  $\rightarrow$ portfolios adjust "fast" (as under flexible prices)

- *Remark*: separation condition satisfied for conventional linear fiscal reaction rules

$$S_t / Y_t = \alpha + \beta q_t^B / Y_t \qquad \Rightarrow \qquad \check{s}_t = \alpha \frac{\rho}{\vartheta_t} + \beta$$

- Flight to Safety: Unless $\check{s}$-policy leans strongly against it, rise in σ_t leads to increase in ϑ_t

Transmission Preliminaries II: Asset Valuations and Demand

- Goods market clearing relates real activity to *level of asset valuations*

$$a_t u_t = \rho q_t = \rho(q_t^B + q_t^K)$$

- Portfolio choice (ϑ_t) determines *relative asset valuations*

$$q_t = q_t^B + q_t^K = \frac{1}{\vartheta_t} q_t^B$$

- Combining the previous:

$$\boxed{a_t u_t = \rho \frac{q_t^B}{\vartheta_t}}$$

Shock Transmission: Impact Effect

$$\underbrace{a_t u_t}_{\text{supply}} = \underbrace{\rho \frac{q_t^B}{\vartheta_t}}_{\text{demand}}$$

	uncertainty shock $\tilde{\sigma}_t \uparrow$		productivity shock $a_t \downarrow$	
	flexible prices	sticky prices	flexible prices	sticky prices
portfolio choice	$\vartheta_t \uparrow$	$\vartheta_t \uparrow$	$\vartheta_t \rightarrow$	$\vartheta_t \rightarrow$
demand for given q_t^B	$\downarrow$	$\downarrow$	$\rightarrow$	$\rightarrow$
supply for given u_t	$\rightarrow$	$\rightarrow$	$\downarrow$	$\downarrow$
equilibrium adjustment	$u_t \rightarrow$, $q_t^B \uparrow$	$u_t \downarrow$, $q_t^B \rightarrow$	$u_t \rightarrow$, $q_t^B \downarrow$	$u_t \uparrow$, $q_t^B \rightarrow$
required price adjustment	$\mathcal{P}_t \downarrow$	$\mathcal{P}_t \rightarrow$	$\mathcal{P}_t \uparrow$	$\mathcal{P}_t \rightarrow$

Shock Transmission: Adjustment Dynamics under Sticky Prices

- After shock, gradual inflation/deflation slowly adjusts q_t^B towards flexible-price value ("Pigou effect") (Pigou, 1943; Patinkin, 1956)

- Formally,

$$
\begin{aligned}
dq_t^B &= (\overbrace{i_t - \check{s}_t}^{=\mu_t^{\mathcal{B}}} - \pi_t) q_t^B dt && \text{(bond value evolution)} \\
&= \left(i_t - \check{s}_t - \kappa \left(\frac{p_t^R}{a_t} - 1 \right) \right) q_t^B dt && \text{(Phillips curve)} \\
&= \left(i_t - \check{s}_t - \kappa \left(\left(\frac{\rho}{a_t} \frac{q_t^B}{\vartheta_t} \right)^{1+\varphi} - 1 \right) \right) q_t^B dt && \text{(market clearing)}
\end{aligned}
$$

- In particular: Phillips curve slope (κ) affects speed of adjustment but not impact effect

Outline

I. Intertemporal Substitution versus Portfolio Choice

- Standard NK story: intertemporal substitution drives aggregate demand
  - key equation: IS equation (in terms of wealth q_t)

$$\mathbb{E}_t[dq_t] = (i_t - \pi_t - r_t^*)\, q_t dt$$

  - relates *level* of wealth to *level of interest rate*
  - usual interpretation: future q_T fixed (e.g., by "anchored beliefs"), q_0 adjusts
  - if $i_t - \pi_t > r_t^*$ for a while: q_0 falls (demand recession)

- This model: portfolio demand for nominal safe assets drives aggregate demand
  - $q_t = q_t^B / \vartheta_t$ fully determined by ϑ_t and safe asset state q_t^B
  - portf. choice determines *relative* asset values ϑ_t; "level component" is backward-looking q_t^B

Conclusion: Portfolio choice and flight to safety are key for impact (demand) effect of shocks

II. Interest Rate Policy Ineffectiveness

- How does i_t affect aggregate demand?
  1. Portfolio demand for safe assets (ϑ_t) unaffected by i_t
  2. Safe asset value q_t^B is backward-looking state: affected by i_t only gradually over time (via nominal debt growth)

$\Rightarrow$ Impact effect of shock on aggregate demand does not depend on i_t

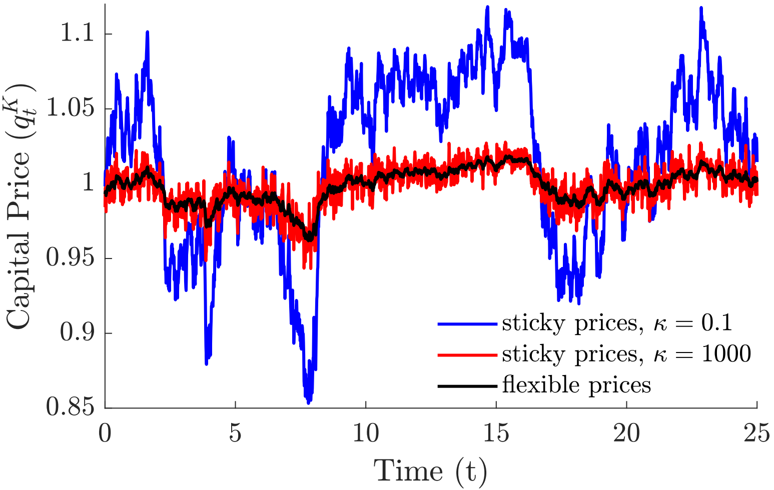
- Conclusion: interest rate policy cannot eliminate aggregate demand recession (in contrast to standard NK models)

- *Remark*: "no impact effect" can be overturned with long-term bonds, broader conclusion is robust

III. Capital Price Overshooting & Flight-to-Safety Volatility

- Portfolio separation: ϑ_t rises as fast as under flexible prices for $\tilde{\sigma}_t$-shock
- Stickiness of bond value: q_t^B unaffected by shock, whereas $q_t^{B,flex} \uparrow$
- Consequence: capital price *overshoots* relative to flexible price response
  - $q_t^K = (1 - \vartheta_t)/\vartheta_t \cdot q_t^B$ falls by more under sticky prices
- Corrects major shortcoming of flexible price model (Brunnermeier, Merkel, Sannikov 2024)
  - in that model: bond market (q^B) more volatile than stock market (q^K)
  - this paper: *any* degree of price stickiness shifts *all* relative volatility into q^K fluctuations
- Reminiscent of Dornbusch's (1976) overshooting model
  - original: sticky domestic price $\rightarrow$ volatile exchange rate
  - here: sticky bond value $\rightarrow$ volatile capital price

Illustration: Overshooting & Flight-to-Safety Volatility



Outline

An Economy without Nominal Bonds

- Consider economy with $\mathcal{B}_t \equiv 0 \Rightarrow \vartheta_t = q_t^B \equiv 0$
- Goods market clearing equation (note $q_t = q_t^K$)

$$u_t = \rho q_t$$

  - pricing wealth $\Leftrightarrow$ pricing capital:

$$\underbrace{\rho + \mathbb{E}_t[dq_t]/(q_t dt)}_{=\mathbb{E}_t[dr_t^K]/dt} = \underbrace{i_t - \pi_t}_{=r_t} \quad + \quad \underbrace{\tilde{\sigma}_t^2}_{=\text{risk premium}}$$

$\rightarrow$ Aggregate demand without bonds is *purely forward-looking* and follows IS equation logic

1. no sticky bond value state ($q_t^B \equiv 0$) & no nominal anchor
2. previous equation

$$\mathbb{E}_t[dq_t]/(q_t dt) = i_t - \pi_t - \overbrace{(\rho - \tilde{\sigma}_t^2)}^{=r_t^*}$$

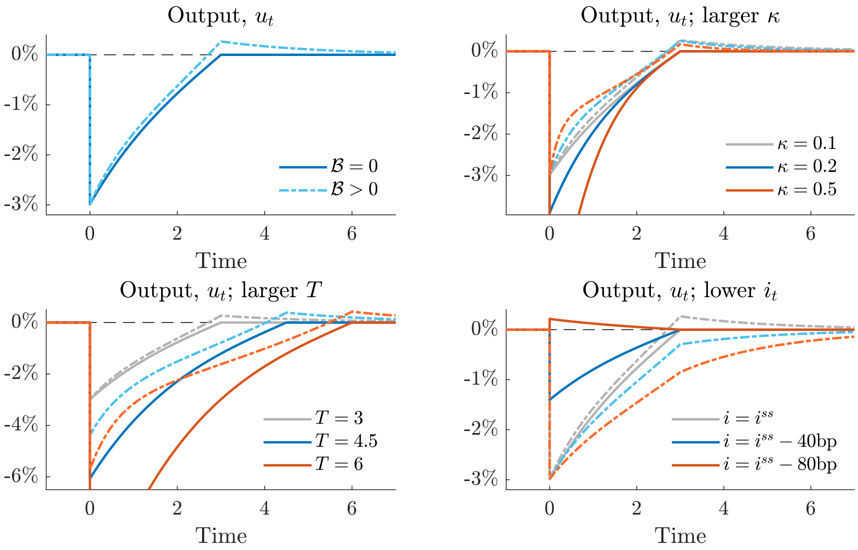
determines *level* of asset values as function of *level* of returns

Demand Recessions & Power of Monetary Policy

Conclusions from such models (e.g. Basu, Bundick 2017; Caballero, Farhi 2018; Caballero, Simsek 2020):

1. if insufficient reduction in $r_t = i_t - \pi_t$, also these models predict shortfall in demand
2. but this is not necessary: sufficient reduction in r_t can prevent demand shortfall
   - e.g. natural rate policy $i_t = r_t^* := \rho - \tilde{\sigma}_t^2$ & appropriate equilibrium selection
   - leads to divine coincidence: $\pi_t = 0$, $u_t = u^*$
   - more generally: only task of policy is *expectations management*
3. corollary: demand recessions are (mostly) a problem at ZLB

Illustration: $\mathcal{B}_t > 0$ versus $\mathcal{B}_t \equiv 0$



A Cleaner Comparison: Two Units of Account

- Issue with previous comparison: $\mathcal{B} = 0$ economy also has no safe assets
- Affects model dynamics even in the absence of price setting frictions
- Cleaner (but artificial!) comparison to highlight what matters: two units of account
  - good prices are quoted in "goods dollars", subject to price setting frictions
  - bonds are quoted in "bond dollars", adjust flexibly
- Also that model behaves close to $\mathcal{B} = 0$ economy
  (exchange rate between two units of accounts does most of the adjustment)

$\Rightarrow$ What really matters: *safe asset is denominated in sticky unit of account*

Conclusion

- Technical aspects of incorporating sticky prices into safe asset framework
  - need elastic short-term supply, e.g., via variable capital utilization
  - sticky prices → safe asset stock becomes a state variable
- Key determinants of aggregate demand
  - forward-looking component: portfolio choice (not intertemporal substitution)
  - backward-looking component: safe asset state
- Some lessons:
  - recession in response to uncertainty shock if (and only if) there is flight to safety
  - asset pricing: capital price overshooting
  - policy implication: interest rate policy cannot fix sticky price distortion (even absent ZLB)
- In paper: optimal policy
  - coordinated monetary-fiscal policy can implement constrained optimal allocation if and only if lump-sum taxes are available
  - without lump-sum taxes: interest rate underreaction on impact and optimal smoothing of demand shortfall

Production Side with Microfounded Phillips Curve

- Two stages of production:
  1. Intermediate goods firms (continuum $j \in [0,1]$):
     - production technology $y_t^j = a_t \hat{k}_t(j)$
     - set nominal output price $\mathcal{P}_t^i$ subject to quadratic adjustment cost $\frac{\psi}{2}(\pi_t^j)^2 Y_t dt$ (rebated to households)
  2. Final goods firms: CES technology

$$Y_t = \left(\int (y_t^j)^{\frac{\epsilon}{\epsilon-1}} dj \right)^{\frac{\epsilon}{\epsilon-1}}$$

- Optimal price setting problem implies a forward-looking Phillips curve

$$\mathbb{E}_t[d\pi_t] = \left(\rho\pi_t - \frac{\epsilon}{\psi}\left(\frac{p_t^R}{a_t} - \frac{\epsilon-1}{\epsilon} \right) \right) dt$$

- How to get the static one?
  - raise discount rate in firm problem (managers have shorter horizons)
  - push it to the limit: infinitesimal horizon of firm managers

return

Remark II: Relationship to HANK Models

1. Technically, ours is a HANK model
   - but we abstract from MPC heterogeneity
     $\rightarrow$ wealth distribution does not matter for aggregates
   - deliberate choice to isolate aggregate effects from safe asset demand
   - HA component merely used to generate safe asset demand
2. HANK papers have many extra (distributional) state variables, often focus on those
   - e.g. Bayer et al. (2019): model with "flight to liquidity" after uncertainty shock
   - but discussion focused on how wealth distribution is affected (and no analytical results)
   - our point: there is something else going on that is not about redistribution

return