Princeton Initiative: Macro, Money, and Finance 2024
New Keynesian Macrofinance

(based on paper "Flight-to-Safety in a New Keynesian Model" joint with Ziang Li)

Sebastian Merkel

September 7, 2024

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:
  - What are implications of risk (premium) shocks for aggregate economic activity?
  - How do these shocks transmit to the real economy?
  - How can (monetary) policy affect this transmission?

Will add sticky prices to safe asset framework discussed yesterday and contrast two models:

1. model without safe assets (similar to Caballero, Simsek 2020 (CS) & textbook NK)
2. model with safe assets in positive supply (Li, Merkel 2024)

Preview of Main Takeaways

1. No safe assets
   a. risk shocks may or may not create demand recessions
   b. shock transmission: two equivalent views
      i. intertemporal substitution view (traditional NK intuition)
      ii. portfolio choice view ($\approx$ "risk-centric view" in terminology of CS)
   c. monetary policy can fix recessions $\Rightarrow$ risk shocks only a concern at zero lower bound (ZLB)
2. Safe assets:
   a. risk shocks always create demand recessions
   b. shock transmission: portfolio choice is key, not intertemporal substitution
   c. interest rate policy cannot prevent recession $\Rightarrow$ risk shocks are always a concern

Key reason for difference between 1 and 2: *nominal* safe asset in *positive net supply*

- nominal: value of safe asset tied to sticky unit of account
- positive net supply: valuation affects aggregate demand (wealth effect)

Outline

1. No Safe Assets
   - Setup and Model Solution
   - Fully Rigid Prices
   - Partial Price Flexibility
2. Safe Asset Model
   - Setup
   - Shock Transmission
3. Remark: Long-term Bond Extension and Optimal Interest Rate Policy

Outline

1. No Safe Assets
   - Setup and Model Solution
   - Fully Rigid Prices
   - Partial Price Flexibility
2. Safe Asset Model
   - Setup
   - Shock Transmission
3. Remark: Long-term Bond Extension and Optimal Interest Rate Policy

Model Setup without Safe Assets

- Households ($i \in [0,1]$):
  - preferences: $\mathbb{E}\left[\int_0^\infty e^{-\rho t}\left(\log c_t^i - \frac{(u_t^i)^{1+\varphi}}{1+\varphi}\right) dt\right]$
  - each agent manages capital k_t^i
    - produces capital services $\hat{k}_t^i dt = u_t^i k_t^i dt$, rented out to intermediate goods firms at price p_t^R
    - capital evolution: $dk_t^i = \underbrace{k_t^i d\Delta_t^{k,i}}_{\text{trading}} + \underbrace{k_t^i \tilde{\sigma}_t d\tilde{Z}_t^i}_{\text{idio. shocks}}$
- Intermediate goods firms ($j \in [0,1]$)
  - produce differentiated goods with capital services $y_t^j dt = \hat{k}_t^j dt$, face CES demand
  - set nominal prices $\mathcal{P}_t^j$ subject to quadratic adjustment costs
- Aggregates and market clearing
  - capital market clearing $K := \int k_t^i di$
  - goods market clearing $\int c_t^i di := C_t = Y_t := \left(\int (y_t^j)^{\frac{\epsilon-1}{\epsilon}} dj\right)^{\frac{\epsilon}{\epsilon-1}}$
- Exogenous state $\tilde{\sigma}_t \in \{\tilde{\sigma}_l, \tilde{\sigma}_h\}$ Markov chain (transition rates λ_l, λ_h)

Household Problem and Optimal Choices

The household chooses $\{c_t^i, u_t^i, \theta_t^i\}$ 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

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

(θ_t^i is the portfolio weight in *zero net supply* nominal bonds)

Optimal choices:

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

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

$$\frac{\mathbb{E}_t[dr_t^K]}{dt} = \underbrace{i_t - \pi_t}_{\text{risk-free rate}} + \underbrace{(1-\theta_t^i)\tilde{\sigma}_t^2}_{\text{requ. idio. risk premium}} + \underbrace{\lambda_t \frac{(1-\theta_t^i)\left(q_t^{K+} - q_t^K\right)}{\theta_t^i q_t^K + (1-\theta_t^i)q_t^{K+}} \frac{q_t^{K+} - q_t^K}{q_t^K}}_{\text{requ. aggr. risk premium}} \qquad \text{(portfolio choice)}$$

The Output-Asset Price Relation

- Aggregate supply: $Y_t = u_t K$
  - optimal utilization choice: all households choose same $u_t^i = u_t$
  - will see later: all firms choose same price, $P_t^j = P_t$
- Aggregate demand: $C_t = \rho q_t K$ where $q_t := N_t / K (= q_t^K)$
  - from aggregating optimal consumption choices
- Plug into goods market clearing, cancel K:

$$\boxed{u_t = \rho q_t}$$

- This is the output-asset price relation
  - to understand aggregate demand (and economic activity), we need to determine asset prices

Pricing Aggregate Wealth

1. Portfolio choice view:
   - start from portfolio choice condition, use $\mathbb{E}_t[dr_t^K] = \rho dt + \mathbb{E}_t[dq_t]/q_t$
   - use asset market clearing $\theta_t^i = \theta_t = 0$
2. Intertemporal substitution view:
   - individual consumption Euler equation:

$$\frac{\mathbb{E}_t[d(1/c_t^i)]}{1/c_t^i} = (i_t - \pi_t - \rho)dt$$

   - use $dc_t^i/c_t = dC_t/C_t + \tilde{\sigma}_t d\tilde{Z}_t^i$ and $C_t = \rho q_t K$

In both cases we obtain

$$\boxed{\mathbb{E}_t[dq_t] = \left(i_t - \pi_t - \rho + \tilde{\sigma}_t^2 + \lambda_t \frac{(q_t^+ - q_t)^2}{q_t^+ q_t}\right) q_t dt}$$

Remarks:

i. This is (essentially) the New Keynesian IS equation
ii. Both views are equivalent because capital is only component of net wealth

Optimal Price Setting of Intermediate Goods Firms

- Firm price setting problem with flexible prices
  - constant markup over unit marginal cost

$$\mathcal{P}_t^j / \mathcal{P}_t = \frac{\epsilon}{\epsilon - 1} p_t^R$$

  - in equilibrium $\mathcal{P}_t^j = \mathcal{P}_t$ for all j, so this determines rental price: $p_t^R = \frac{\epsilon - 1}{\epsilon} =: p^{R,flex}$
- Sticky prices (quadratic adj. costs) lead to New Keynesian Phillips curve

$$\frac{\mathbb{E}_t \left[d\pi_t \right]}{dt} = \rho \pi_t - \kappa \left(p_t^R - p^{R,flex} \right) = \rho \pi_t - \kappa \left(u_t^{1+\varphi} - p^{R,flex} \right)$$

- Simpler to analyze, but identical conclusions: static Phillips curve

$$\boxed{\pi_t = \kappa \left(u_t^{1+\varphi} - p^{R,flex} \right)}$$

$\rightarrow$ will work with this version here

Summary: Key Model Equations

$$u_t = \rho q_t$$ output-asset price relation

$$\mathbb{E}_t[dq_t] = \left(i_t - \pi_t - \rho + \tilde{\sigma}_t^2 + \lambda_t \frac{(q_t^+ - q_t)^2}{q_t^+ q_t}\right) q_t dt$$ IS / capital pricing equation

$$\pi_t = \kappa \left(u_t^{1+\varphi} - p^{R,flex}\right)$$ Phillips curve

Summary: Key Model Equations

$$u_t = \rho q_t$$ output-asset price relation

$$\mathbb{E}_t[dq_t] = \left(i_t - \pi_t - \rho + \tilde{\sigma}_t^2 + \lambda_t \frac{(q_t^+ - q_t)^2}{q_t^+ q_t} \right) q_t dt$$ IS / capital pricing equation

$$\pi_t = \kappa \left(u_t^{1+\varphi} - p^{R,flex} \right)$$ Phillips curve

Substituting static equations into dynamic equation yields single equation for u_t:

$$\mathbb{E}_t[du_t] = \left(i_t - \kappa(u_t^{1+\varphi} - p^{R,flex}) - \rho + \tilde{\sigma}_t^2 + \lambda_t \frac{(u_t^+ - u_t)^2}{u_t^+ u_t} \right) u_t dt$$

A Simple Example

Let's make the following assumptions:

- monetary policy implements the flexible price allocation in state $\tilde{\sigma}_l$
  $\Rightarrow \pi_l = 0,\ u_l = u^{flex} := (p^{R,flex})^{1/(1+\varphi)},\ q_l = q^{flex} := u^{flex}/\rho$
- the interest rate is held constant at $i_t = i_h$ in state $\tilde{\sigma}_h$
- look for equilibria that are Markovian in $\tilde{\sigma}_t$
  (minimum state variable selection)

Then key equation in state $\tilde{\sigma}_h$ simplifies to

$$0 = i_h - \kappa\left(u_h^{1+\varphi} - p^{R,flex}\right) - \rho + \tilde{\sigma}_h^2 - \lambda_h\left(1 - \frac{u_h}{u^{flex}}\right)$$

Outline

1. No Safe Assets
   - Setup and Model Solution
   - Fully Rigid Prices
   - Partial Price Flexibility
2. Safe Asset Model
   - Setup
   - Shock Transmission
3. Remark: Long-term Bond Extension and Optimal Interest Rate Policy

Caballero-Simsek Model: Fully Rigid Prices

Let's first consider the case with fully rigid prices, $\kappa = 0$ (Caballero, Simsek 2020)

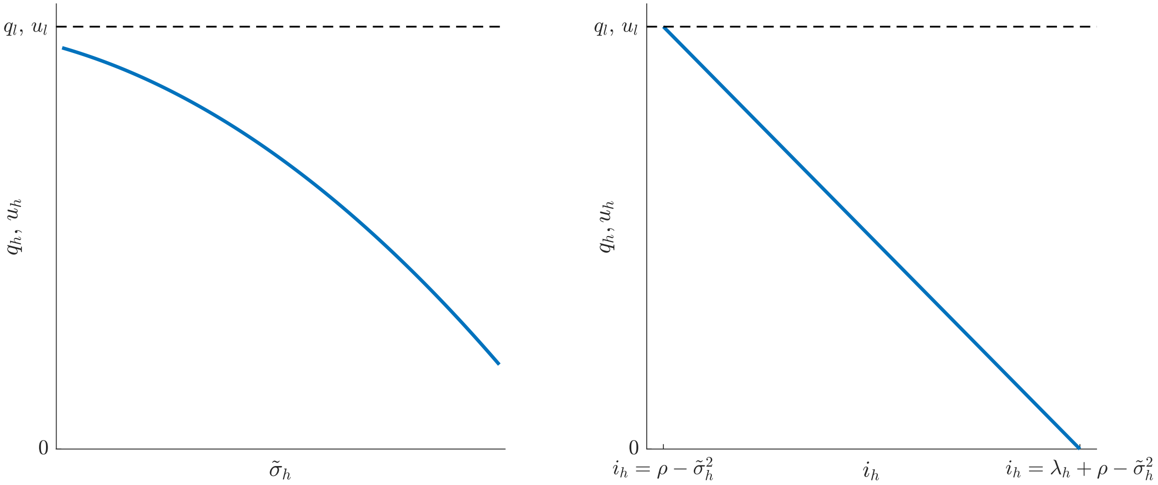
$$0 = i_h - \rho + \tilde{\sigma}_h^2 - \lambda_h \left(1 - \frac{u_h}{u^{flex}}\right)$$

Can solve this in closed form

$$u_h = \frac{\lambda_h + \rho - \tilde{\sigma}_h^2 - i_h}{\lambda^h} u^{flex}$$

Remark: For valid equilibrium, need to assume $\lambda_h + \rho - \tilde{\sigma}_h^2 > i_h$

Comparative Statics with Respect to Risk and Interest Rates



Conclusions

1. Risk shocks (transition to $\tilde{\sigma}_h$) create aggregate demand recessions ($u_h < u^{flex}$) if $i_h > \rho - \tilde{\sigma}_h^2$

2. Two equivalent intuitions:
   - portfolio choice intuition ("risk-centric view"):

     risk premium $\uparrow$ $\rightarrow$ discount rate $i_t + \tilde{\sigma}_t^2$ $\uparrow$ $\rightarrow$ asset price q_t $\downarrow$ $\rightarrow$ aggregate demand $\downarrow$

   - intertemporal substitution intuition (traditional view):

     risk $\uparrow$ $\rightarrow$ precautionary motive $\uparrow$ $\rightarrow$ natural rate $\downarrow$ $\rightarrow$ aggregate demand $\downarrow$

3. Monetary policy can fix demand recessions unless constrained
   - lowering i_h raises asset prices and aggregate demand
   - can restore flex price allocation for $i_h = \rho - \tilde{\sigma}_h^2$
   - with lower bound on interest rates (e.g. ZLB): may not be feasible

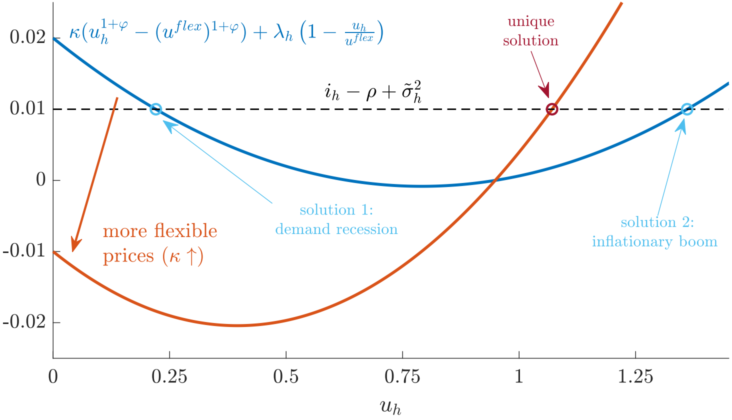
Outline

1. No Safe Assets
   - Setup and Model Solution
   - Fully Rigid Prices
   - Partial Price Flexibility
2. Safe Asset Model
   - Setup
   - Shock Transmission
3. Remark: Long-term Bond Extension and Optimal Interest Rate Policy

What if Prices Are not Fully Rigid?

Assume $\kappa > 0$, rewrite key equilibrium equation:

$$\kappa\left(u_h^{1+\varphi} - (u^{flex})^{1+\varphi}\right) + \lambda_h\left(1 - \frac{u_h}{u^{flex}}\right) = i_h - \rho + \tilde{\sigma}_h^2$$



Structure of Minimum State Variable Equilibria

Proposition

Suppose $i^h \geq \rho - \tilde{\sigma}_h^2$ and $\kappa > 0$. Then there are at most two equilibria:

1. *"Keynesian" equilibrium: an equilibrium that features an aggregate demand recession, $u_h < u^{flex}$, and deflation, $\pi_h < 0$.*
   - *comparative statics: u_h, π_h, and q_h are decreasing in both i_h and $\tilde{\sigma}_h$.*
   - *existence: this equilibrium only exists for sufficient price stickiness, $\kappa < \hat{\kappa} := \frac{\lambda_h + \rho - \tilde{\sigma}_h^2 - i_h}{p^{R,flex}}$*
2. *"Fisherian" equilibrium: an equilibrium that features an aggregate demand boom, $u_h > u^{flex}$, and inflation, $\pi_h > 0$.*
   - *comparative statics: u_h, π_h, and q_h are increasing in both i_h and $\tilde{\sigma}_h$.*
   - *existence: this equilibrium always exists.*

- Previous three conclusions continue to hold for sufficiently sticky prices
  (if we select the Keynesian equilibrium)
- Otherwise, conclusion 1 (demand recession) not implied by the model
  (conclusions 2 & 3 can be suitably adapted, but intuition and ZLB problem change)

Outline

1 No Safe Assets
- Setup and Model Solution
- Fully Rigid Prices
- Partial Price Flexibility

2 Safe Asset Model
- Setup
- Shock Transmission

3 Remark: Long-term Bond Extension and Optimal Interest Rate Policy

Recall: Setup of Previous Model

- Continuum of households
  - manage capital subject to (uninsurable) idiosyncratic shocks
  - decide on capital utilization (utility/effort cost)
- Continuum of intermediate goods firms
  - rent capital from households to produce differentiated goods
  - set nominal prices subject to price adjustment costs
- Final good = CES aggregate of intermediate goods
- Exogenous state: Markov switching in volatility of idiosyncratic shocks ($\tilde{\sigma}_t$)
- *Changes*: add nominal government bonds
  - plays role of safe asset: agents can derive service flow from retrading (as in Markus' lecture yesterday)

Modified Model Setup with Nominal Government Debt

- Government issues nominal bonds
  - nominal face value $\mathcal{B}_t$, evolution $d\mathcal{B}_t = \mu_t^{\mathcal{B}} \mathcal{B}_t dt$
  - pays (floating) interest i_t (in paper: long-term bonds)
  - real value $q_t^B K := \mathcal{B}_t / \mathcal{P}_t$
- Interest paid with new bonds or taxes τ_t on capital

$$i_t \mathcal{B}_t = \mu_t^{\mathcal{B}} \mathcal{B}_t + \mathcal{P}_t \tau_t K_t \qquad \Rightarrow \qquad i_t = \mu_t^{\mathcal{B}} + \frac{\tau_t}{q_t^B} =: \mu_t^{\mathcal{B}} + \check{s}_t$$

- Household net worth evolves according to

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

- Notation: share of bond wealth

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

in equilibrium: $\vartheta_t = \theta_t$ is also individual portfolio weight in bonds

Why Is it Interesting to Add Bonds to this Model?

The bond value q_t^B introduces two important features into the model:

1. Nominal bonds in positive net supply provide a nominal anchor
   - $q_t^B = \mathcal{B}_t/\mathcal{P}_t/K$ depends on price level $\mathcal{P}_t$
   - bonds represent net wealth (Ricardian equivalence fails due to safe asset service flows)
   - hence, nominal prices affect total wealth ($q_t K$) and consumption demand ($\rho q_t K$)
   - this conclusion holds even under flexible prices
2. Under sticky prices: the real quantity of safe assets q_t^B becomes a state variable
   - $\mathcal{B}_t$ is the stock of previously issued bonds $\rightarrow$ natural state variable
   - $\mathcal{P}_t$ follows backward-looking evolution due to price stickiness
   - difference to flexible prices where $\mathcal{P}_t$ and q_t^B are forward-looking "jump variables"
   - q_t^B *is "slow-moving"*: has only drifts, no jumps

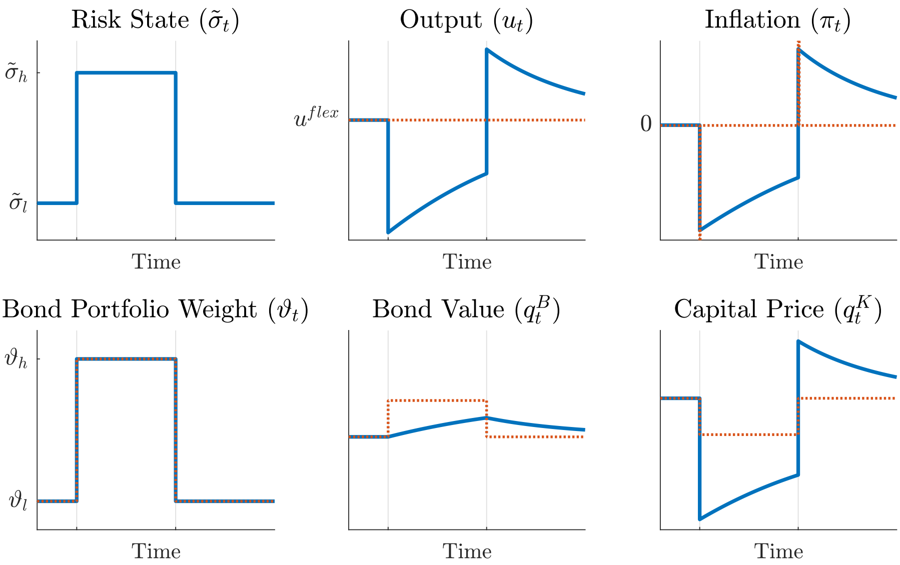
Outline

1 No Safe Assets
- Setup and Model Solution
- Fully Rigid Prices
- Partial Price Flexibility

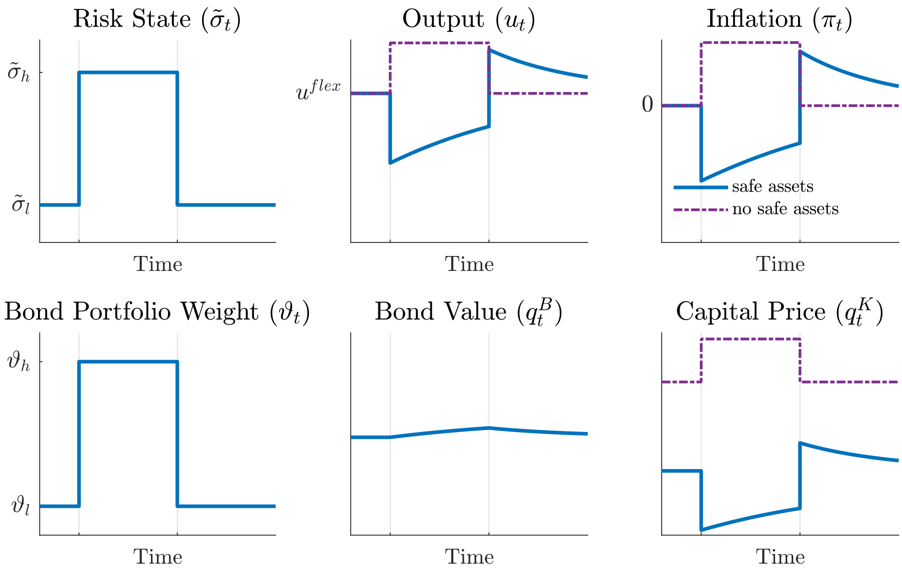
2 Safe Asset Model
- Setup
- Shock Transmission

3 Remark: Long-term Bond Extension and Optimal Interest Rate Policy

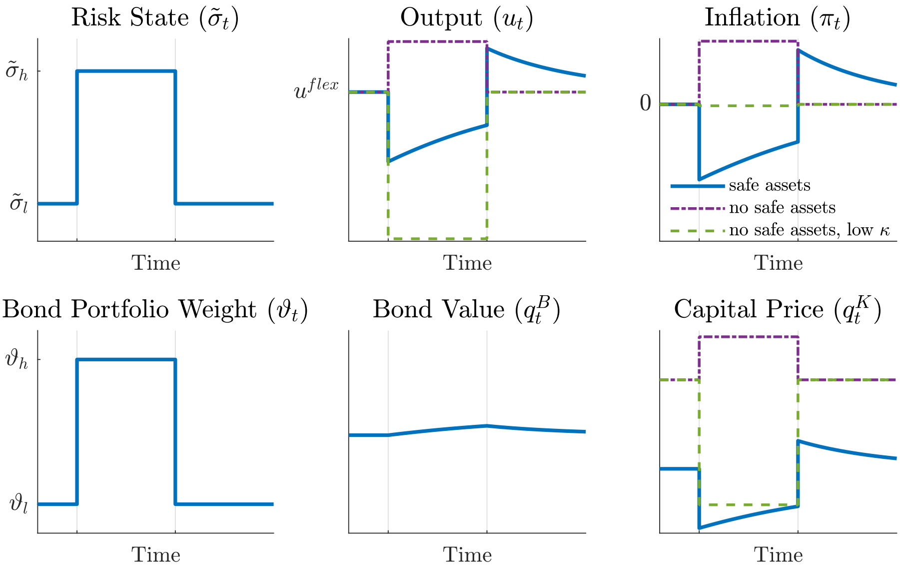
Model Simulation: Flexible and Sticky Prices



Model Simulation: Comparison to Model without Safe Assets



Model Simulation: Comparison to Model without Safe Assets



Transmission Preliminaries I: Separation of Portfolio Choice

- Portfolio choice depends only on the relative return and relative risk of capital and bonds, *not* on aggregate output and price setting frictions

- "Bond Valuation Equation": ϑ_t satisfies in equilibrium

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

- Separation: if $\check{s}_t$ is function of $(\tilde{\sigma}_t, \vartheta_t)$ only, then $\vartheta_t = \vartheta(\tilde{\sigma}_t)$ does not depend on bond valuation state q_t^B

  $\rightarrow$ portfolios adjust "fast" (as under flexible prices)

  (Remark: assumption satisfied, e.g., by linear policy rule that relates surplus-output to debt-output ratio)

- Unless $\check{s}$ leans strongly against it, transition to σ_h leads to increase in ϑ (flight to safety)

Transmission Preliminaries II: Asset Valuations and Demand

- Recall output-asset price relationship (relates real activity to *level of asset valuations*)

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

- 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:

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

Shock Transmission under Flexible Prices – Impact Effect

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

Shock: $\tilde{\sigma}_t \uparrow \quad \rightarrow \quad \vartheta_t \uparrow$

→ For given q_t^B, demand decreases

→ Supply ($u_t = u^{flex}$) is fixed, bond value $q_t^B = \mathcal{B}_t / \mathcal{P}_t / K$ rises to increase demand

⇒ Requires downward adjustment in price level $\mathcal{P}_t$ on impact

Shock Transmission under Sticky Prices – Impact Effect

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

- All terms on right-hand side are already determined
  - ϑ_t by portfolio choice separation (only depends on $\tilde{\sigma}$ and $\check{s}$ paths)
  - q_t^B is a state variable under sticky prices

$\Rightarrow$ Demand is completely rigid on impact, unable to adjust

$\Rightarrow$ Supply (utilization u_t) must clear goods market

Conclusion 1: Uncertainty shocks create demand recessions for any degree of price stickiness
(so long as $\check{s}$-policy does not fully lean against flight to safety)

Shock Transmission under Sticky Prices – Adjustment Dynamics

- After shock, gradual deflation slowly increases q_t^B ("Pigou effect")
- Dynamics guided by two equations
  - Bond value evolution (backward looking):

$$dq_t^B = (\underbrace{i_t - \check{s}_t}_{=\mu_t^{\mathcal{B}}} - \pi_t) q_t^B dt$$

  - Phillips curve:

$$\pi_t = \kappa \left(u_t^{1+\varphi} - p^{R,flex} \right) = \kappa \left(\left(\rho \frac{q_t^B}{\vartheta_t} \right)^{1+\varphi} - p^{R,flex} \right)$$

- Closed-form solution for constant $i_t = i_h$, $\check{s}_t = \check{s}_h$ ($\Rightarrow \mu_t^{\mathcal{B}} = \mu_h^{\mathcal{B}}$ is constant):

$$q_t^B = \left(\frac{\alpha (q_0^B)^{1+\varphi}}{\beta (q_0^B)^{1+\varphi} (1 - e^{-\alpha t}) + \alpha e^{-\alpha t}} \right)^{\frac{1}{1+\varphi}},$$

where $\alpha := (1+\varphi)(\mu_h^{\mathcal{B}} + \kappa p^{R,flex})$, $\quad \beta := (1+\varphi)\kappa \left(\frac{\rho}{\vartheta_h} \right)^{1+\varphi}$

Intertemporal Substitution versus Portfolio Choice

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

$$\mathbb{E}_t[dq_t] = (i_t - \pi_t - \text{“neutral rate”})\, q_t dt$$

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

Intertemporal Substitution versus Portfolio Choice

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

$$\mathbb{E}_t[dq_t] = (i_t - \pi_t - \text{"neutral rate"})\, q_t dt$$

  - relates *level* of wealth to *level of interest rate*
  - usual interpretation: future q_T fixed (e.g., by "anchored beliefs"), q_0 adjusts
  - if $i_t - \pi_t >$ "neutral rate" for a while: q_0 falls (demand recession)
- This model: portfolio demand for nominal safe assets drives aggregate demand
  - recall: $u_t = \rho q_t^B / \vartheta_t$ fully determined by ϑ_t and safe asset state q_t^B
  - Why not equivalent anymore to intertemporal substitution view?
    - portfolio choice determines *relative* asset values ϑ_t from *excess return* & *excess risk* of capital
    - "level component" in $q_t = q_t^B / \vartheta_t$ is backward-looking state variable q_t^B

Conclusion 2: Portfolio choice and flight to safety are key for shock transmission

Interest Rate Policy Ineffectiveness

- How does i_t affect aggregate demand?
  1. Portfolio separation: portfolio demand for safe assets (ϑ_t) unaffected by i_t
  2. Safe asset value q_t^B is slow-moving state: affected by i_t only gradually over time
     - here (due to zero duration): higher $i_t \Rightarrow$ higher $\mu_t^{\mathcal{B}}$
     - in particular: rate hikes are inflationary ("Neo-Fisherian" prediction)

  $\Rightarrow$ Impact effect of shock on aggregate demand unaffected by interest rate policy

- *Conclusion 3*: interest rate policy cannot eliminate aggregate demand recession

Interest Rate Policy Ineffectiveness

- How does i_t affect aggregate demand?
  1. Portfolio separation: portfolio demand for safe assets (ϑ_t) unaffected by i_t
  2. Safe asset value q_t^B is slow-moving state: affected by i_t only gradually over time
     - here (due to zero duration): higher $i_t \Rightarrow$ higher $\mu_t^{\mathcal{B}}$
     - in particular: rate hikes are inflationary ("Neo-Fisherian" prediction)

  $\Rightarrow$ Impact effect of shock on aggregate demand unaffected by interest rate policy

- *Conclusion 3*: interest rate policy cannot eliminate aggregate demand recession

- Difference to model without bonds?
  - *no bonds*: sticky price dynamics essentially stateless
    - q_t, u_t determined by purely forward-looking conditions
    - task of policy: expectations management
  - *with bonds*: aggregate demand depends on (slow-moving) safe asset state
    - new policy consideration: manage dynamics of safe asset supply

Aside: Capital Price Overshooting

- Portfolio separation: ϑ_t rises as fast as under flexible prices
- 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)
  - here: *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

Outline

1. No Safe Assets
   - Setup and Model Solution
   - Fully Rigid Prices
   - Partial Price Flexibility
2. Safe Asset Model
   - Setup
   - Shock Transmission
3. Remark: Long-term Bond Extension and Optimal Interest Rate Policy

How Can Policy Stabilize Aggregate Demand on Impact?

1. Manage *safe asset demand* by distorting portfolio choice
   - use policy instrument $\check{s}_t$ (by adjusting taxes)
   - mitigates flight to safety, but not optimal (in richer model)
     (safe asset services more valuable when $\tilde{\sigma}$ is large, higher ϑ beneficial)

2. Manage *safe asset supply* by introducing safe asset whose value is not (fully) sticky
   a. lump-sum transfers (or taxes, if negative)
      - PV of lump-sum transfers acts as implicit safe asset
      - use dynamic adjustments of transfers to absorb variations in safe asset demand
      - issue: works in theory but difficult in practice
   b. long-term bonds
      - i-policy affects (flexible) nominal bond price through expected future rates
      - *but*: cannot control i_t and q_t^B independently, insufficient to prevent demand recession

      → generates interesting policy problem, details in paper

Conclusion

- New Keynesian model without (nominal) safe assets
  - risk shocks generate demand recessions only for sufficiently sticky prices
  - and interest rate can always prevent recessions if unconstrained
  - so should be worried about these shocks only at the ZLB
- New Keynesian model with safe assets
  - safe asset stock becomes a slow-moving state variable
  - risk shocks lead to flight to safety (portfolio reallocation towards bonds)
  - and this always triggers a demand recession
  - interest rate policy can manage the recovery but not prevent the recession