Eco529: Lecture 07

The I Theory of Money 6.0

Markus Brunnermeier & Yuliy Sannikov

"Money and Banking" (in macro-finance)

- Money → store of value/safe asset

“Money and Banking” (in macro-finance)

- Money → store of value/safe asset
- Banking → “diversifier”
  holds risky assets, issues inside money

Watch “Money and Banking”
YouTube Video Channel: “markus.economicus”
https://www.youtube.com/channel/UCV8DKoTKvJtuvkI4UsRYIqA/videos?pbjreload=10

Money and Banking, part 3:
Redistributive Monetary...

"Money and Banking" (in macro-finance)

- Money → store of value/safe asset
- Banking → "diversifier"
  holds risky assets, issues inside money
- Amplification/endogenous risk dynamics
  - Value of capital declines due to fire-sales **Liquidity spiral**
    - Flight to safety
  - Value of money rises **Disinflation spiral** a la Fisher
    - Demand for money rises – less idiosyncratic risk is diversified
    - Supply for inside money declines – less creation by intermediaries
      - Endogenous money multiplier = f(capitalization of critical sector)
  - Paradox of Thrift (in risk terms)

"Money and Banking" (in macro-finance)

- Money — store of value/safe asset
- Banking — "diversifier"
  holds risky assets, issues inside money
- Amplification/endogenous risk dynamics
  - Value of capital declines due to fire-sales — **Liquidity spiral**
    - Flight to safety
  - Value of money rises — **Disinflation spiral** a la Fisher
    - Demand for money rises – less idiosyncratic risk is diversified
    - Supply for inside money declines – less creation by intermediaries
      - Endogenous money multiplier = f(capitalization of critical sector)
  - ~~Paradox of Thrift~~ Paradox of Prudence (in risk terms)

"Money and Banking" (in macro-finance)

- Money store of value/safe asset
- Banking "diversifier"
  holds risky assets, issues inside money
- Amplification/endogenous risk dynamics
  - Value of capital declines due to fire-sales **Liquidity spiral**
    - Flight to safety
  - Value of money rises **Disinflation spiral** a la Fisher
    - Demand for money rises – less idiosyncratic risk is diversified
    - Supply for inside money declines – less creation by intermediaries
      - Endogenous money multiplier = f(capitalization of critical sector)
  - ~~Paradox of Thrift~~ Paradox of Prudence (in risk terms)
- Monetary Policy (redistributive)

Some literature

- Roles of money
  - Unit of account
  - Medium of exchange
    (Clower, Lagos & Wright)
  - Store of value
    (Samuelson, Bewley, Aiyagari, Scheinkman & Weiss, Kiyotaki & Moore)
- Models without inside money imply inflation in downturns
  - Less money needed to perform fewer transactions
- "Money view" (Friedman & Schwartz)
  - Downturns → Bank liabilities decrease
- "Credit view"
  - Downturns → equity capital → bank cuts assets/credit
  - BGG, Kiyotaki & Moore, He & Krishnamurthy, BruSan2014,
    Drechsler, Jeanne & Korinek, Savov & Schnabl
- Financial Stability
  - Diamond & Rajan 2010, Curdia & Woodford 2010, Stein 2012

	New Keynesian	I Theory
Key friction	Price stickiness & ZLB	Financial friction
Role of money	Unit of account	Store of value
Driver	Demand driven as firms are obliged to meet demand at sticky price	Misallocation of funds
Monetary policy • implementation	 Optimal price setting over time	 Ex-ante insurance "complete markets"
• First order effects	Affect HH's intertemporal trade-off Nominal interest rate impact real interest rate due to price stickiness	Ex-post: redistributional effects Ex-ante: insurance
Time consistency	Wage stickiness Price stickiness + monopolistic competition	Moral hazard in risk taking (bubbles) - Greenspan put -
Yield curve	Expectation hypothesis only	Term/inflation risk premia

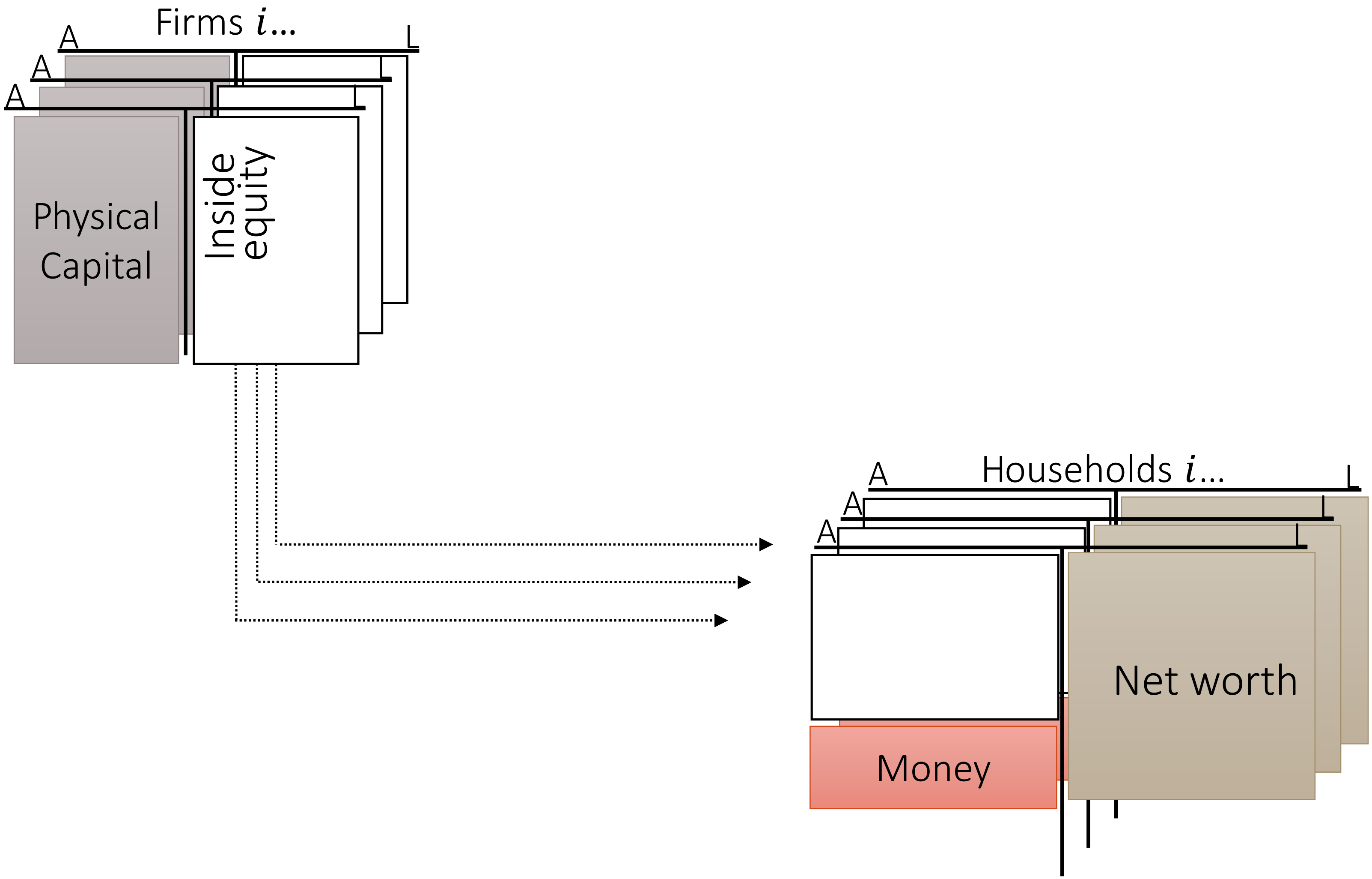
Model

- Agents — Households — Intermediaries
- Preferences $E\left[\int_0^\infty e^{-\rho t}\frac{c_t^{1-\gamma}}{1-\gamma}dt\right]$
- Firm's production technology ak_t
- Capital evolution
  - Reinvestment rate ι_t, $\Phi(\iota_t)=\frac{1}{\kappa}\log(\kappa\iota_t+1)$
  - $\frac{dk_t}{k_t}=(\Phi(\iota_t)-\delta)dt+\sigma dZ_t+\tilde{\sigma}d\tilde{Z}_t^i$
- Outside equity issued by firms
- Money supply $\frac{dM_t}{M_t}=\mu_t^M dt+\sigma_t^M dZ_t$
- Derivatives
- Frictions: Incomplete markets
  - No idiosyncratic risk sharing
  - Limited outside equity issuance (skin in the game constraint)

Portfolio choice

Without "I" Intermediaries

- Recall from earlier lecture



Equilibrium – recall from previous lecture

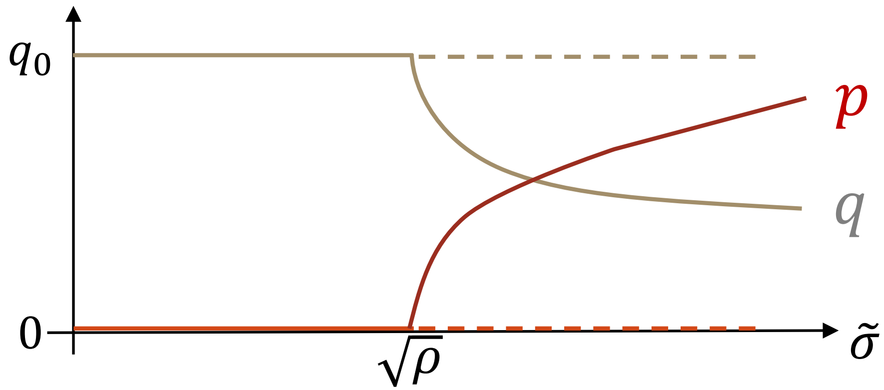
- Collecting the three equations:

$$q = 1 + \kappa\iota$$
$$\rho(p + q) = A - \iota$$
$$\frac{q\tilde{\sigma}^2}{p + q} = \frac{A - \iota}{q}$$

- Equilibrium solved for $\mu^M = 0$

$$p = \frac{\tilde{\sigma} - \sqrt{\rho}}{\sqrt{\rho}} q,$$

$$q = \frac{1 + \kappa A}{\kappa\sqrt{\rho}\tilde{\sigma} + 1}.$$



Flight-to-safety comparative static

Main insights

- Moneyless equilibrium with $p = 0$, shadow r^f very low
- Money is a bubble with $p > 0$ if $\tilde{\sigma} > \sqrt{\rho}$
- Money takes on insurance role
  - r^f is higher compared to moneyless equilibrium
  - Increases households' welfare
- Non-stationary equilibria with exploding hyperinflation

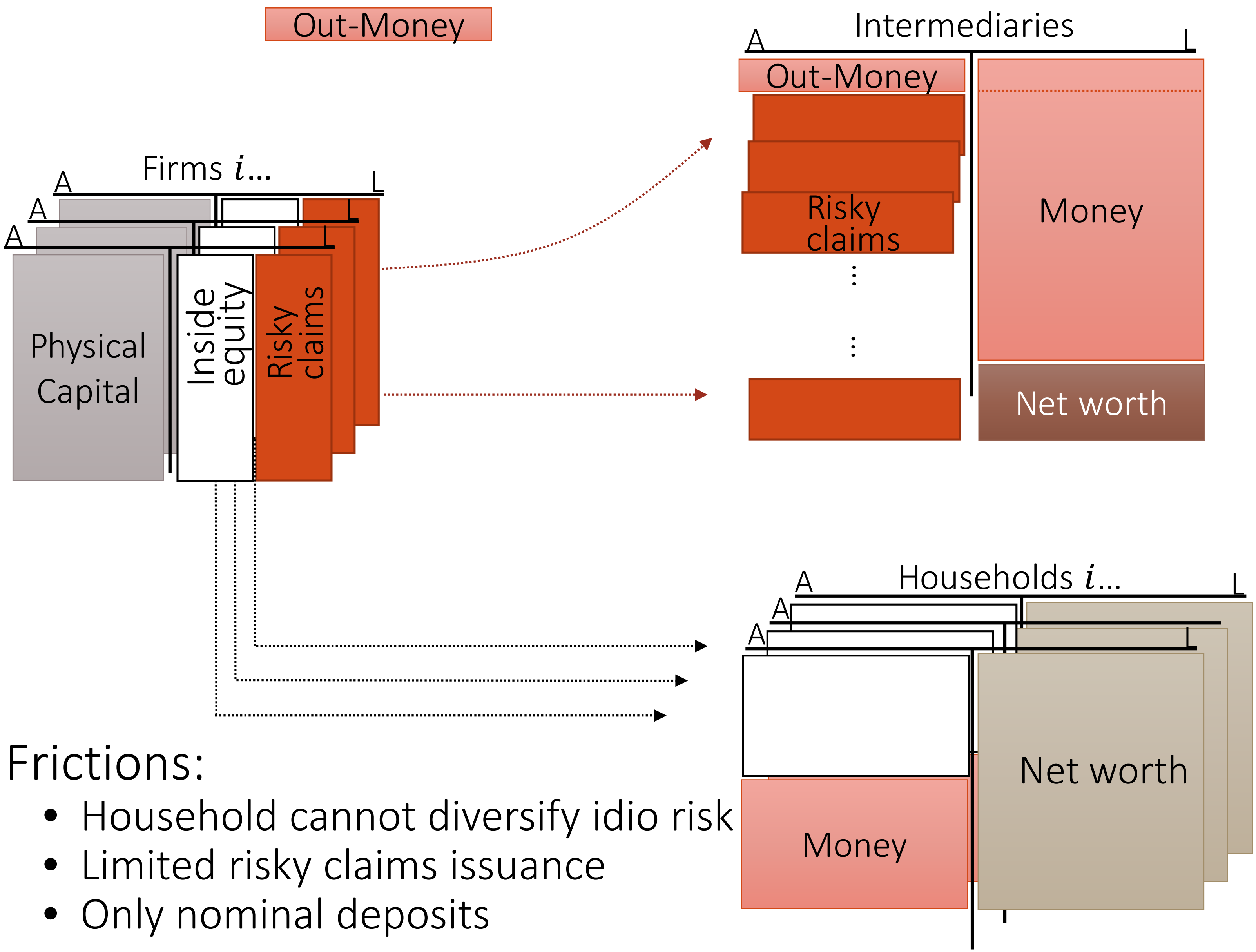
- "Tax backing" (even if only tiny ε)
  - Money is not a bubble ($p =$ discounted value of taxes)
  - Eliminates non-stationary equilibria & moneyless equilibrium
    - Off-equilibrium belief alone are sufficient

With Intermediaries: Overview

- Markets are complete w.r.t. aggregate risk
  - dZ-derivatives can be traded, $\varsigma = \underline{\varsigma}$
  - Incompleteness only w.r.t. idiosyncratic risk
  - Advantages:
    - Clear welfare benchmark
    - Monetary policy does not "complete markets" (no 'chicken model')

- Markets are incomplete w.r.t. aggregate & idio risk
  - dZ-derivatives cannot be traded
  - Advantage:
    - Larger amplification effects
    - Larger pecuniary externalities

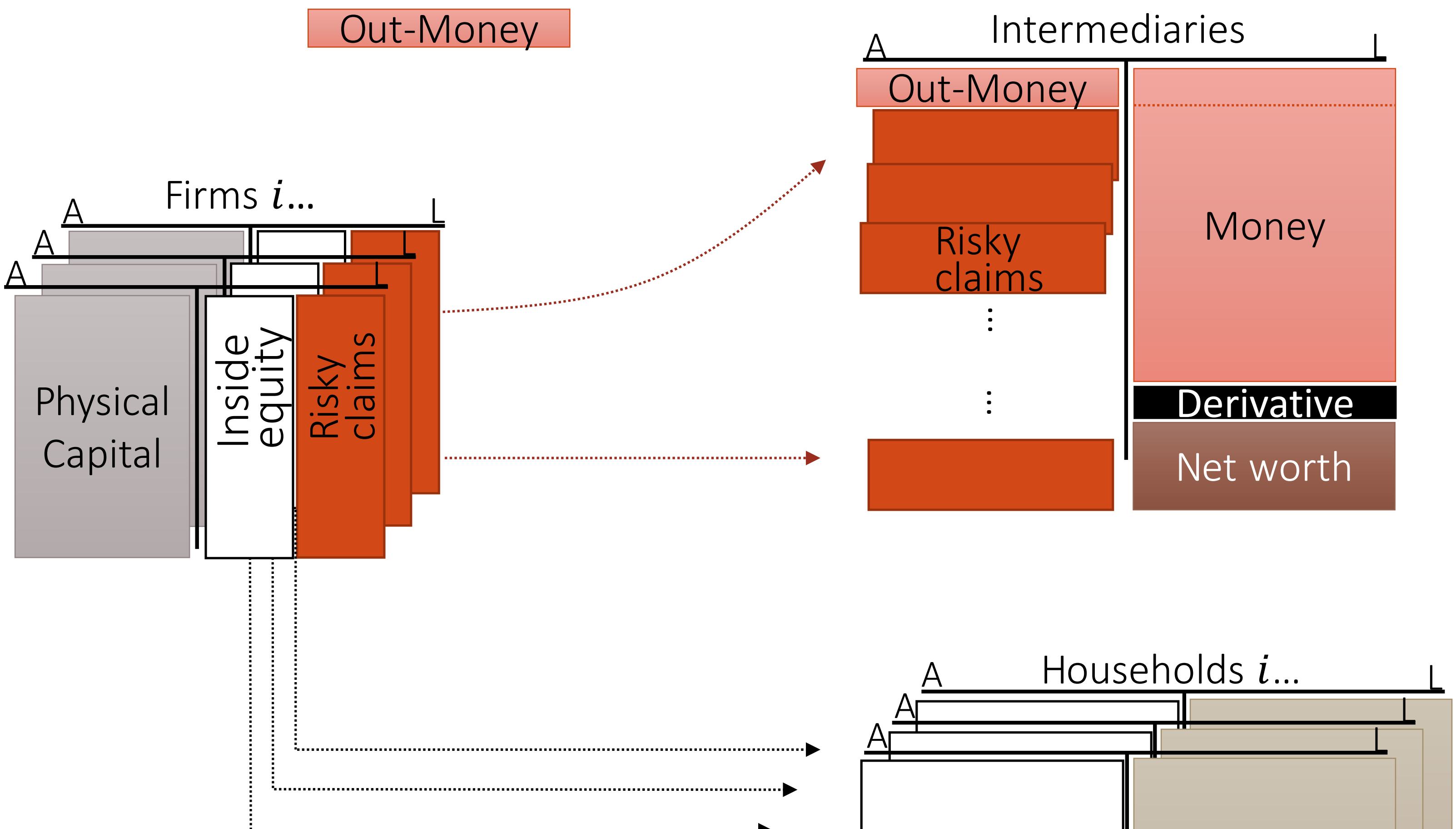
With Intermediaries: Incomplete Markets

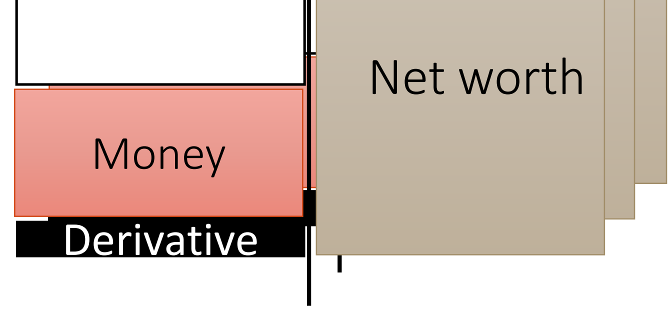


- Frictions:
  - Household cannot diversify idio risk
  - Limited risky claims issuance
  - Only nominal deposits

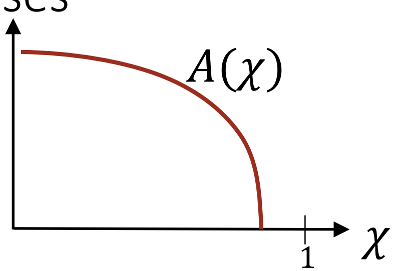
Brunnermeier & Sannikov

With Intermediaries: with η-Derivative





- As I's risk share χ increases $A(\chi)$ declines due to monitoring cost/ moral hazard



Model

- Agents — **Households** | **Intermediaries**
- Preferences
  - Households: $E\left[\int_0^\infty e^{-\rho t}\frac{c_t^{1-\underline{\gamma}}}{1-\underline{\gamma}}dt\right]$
  - Intermediaries: $E\left[\int_0^\infty e^{-\rho t}\frac{c_t^{1-\gamma}}{1-\gamma}dt\right]$
  - $\underline{\gamma} > \gamma$
- Firm's production technology ak_t
- Capital evolution
  - Reinvestment rate ι_t, $\Phi(\iota_t) = \frac{1}{\kappa}\log(\kappa\iota_t + 1)$
  - $\frac{dk_t}{k_t} = (\Phi(\iota_t) - \delta)dt + \sigma dZ_t + \tilde{\sigma} d\tilde{Z}_t^i$
- Outside equity issued by firms
- Money supply $\frac{dM_t}{M_t} = \mu_t^M dt + \sigma_t^M dZ_t$

(Capital evolution, outside equity issued by firms and money supply: Portfolio choice)

- Derivatives
- Frictions: Incomplete markets
  - No idiosyncratic risk sharing
  - Limited outside equity issuance (skin in the game constraint)

Model

- $q_t K_t$ value of physical wealth/capital
- $p_t K_t$ value of nominal wealth/money

- $\vartheta_t = \frac{p_t}{q_t + p_t}$ share of (net) wealth due to (outside) money

- Now amplification will be

$$\sigma_t^\eta \eta_t = \frac{(1-\vartheta)\chi(1-\overline{\chi})}{1-\frac{\chi_t-\eta_t}{\eta_t}\frac{\vartheta'(\eta)}{\vartheta/\eta}}\sigma$$

sum of geometric series

  - Depends on $q(\eta)$ and $p(\eta)$
  - $(1-\bar{\chi})$ is risk of intermediaries' stake relative to economy-wide

Digression: Identical risk aversion $\gamma = \underline{\gamma}$

- Conjecture that q_t, p_t are not affected by σdZ_t aggregate shocks, i.e. $\sigma^q = \sigma^p = 0$
- $q_t K_t$ value of physical capital
  - $dr_t^{K,i} = \frac{A-\iota}{q} dt + \mu_t^q dt + (\Phi(\iota_t) - \delta)\, dt + \sigma dZ_t + \tilde{\sigma} d\tilde{Z}_t^i$
- $p_t K_t$ value of outside money
  - $dr_t^M = \underbrace{(\Phi(\iota) - \delta)}_{g} dt + \mu_t^p dt + \sigma dZ_t$
- Wealth risk exposure to aggregate risk is σdZ_t independent of portfolio choice
- Hence $\sigma^\eta = 0$, which confirms our conjecture.
- Remark:
  - If an aggregate risk asset can be traded, then agents do not want to trade it because $\varsigma = \underline{\varsigma} = \gamma\sigma$ (absent stochastic investment opportunities)

Consequences of a Shock in 4 Steps

1. Shock: destruction of some capital
   - % loss in intermediaries net worth > % loss in assets
   - Leverage shoots up
   - Intermediaries %-loss > Household %-losses, since $\gamma < \underline{\gamma}$
     - η-derivative shifts losses to intermediaries

Consequences of a Shock in 4 Steps

1. Shock: destruction of some capital
   - % loss in intermediaries net worth > % loss in assets
   - Leverage shoots up
   - Intermediaries %-loss > Household %-losses, since $\gamma < \underline{\gamma}$
     - η-derivative shifts losses to intermediaries
2. Response: shrink balance sheet / delever
   - For given prices no impact

Consequences of a Shock in 4 Steps

1. Shock: destruction of some capital
   - % loss in intermediaries net worth > % loss in assets
   - Leverage shoots up
   - Intermediaries %-loss > Household %-losses, since $\gamma < \underline{\gamma}$
     - η-derivative shifts losses to intermediaries
2. Response: shrink balance sheet / delever
   - For given prices no impact
3. Asset side: asset price q shrinks — Liquidity spiral
   - Further losses, leverage↑, further deleveraging

Consequences of a Shock in 4 Steps

1. Shock: destruction of some capital
   - % loss in intermediaries net worth > % loss in assets
   - Leverage shoots up
   - Intermediaries %-loss > Household %-losses, since $\gamma < \underline{\gamma}$
     - η-derivative shifts losses to intermediaries
2. Response: shrink balance sheet / delever
   - For given prices no impact
3. Asset side: asset price q shrinks — Liquidity spiral
   - Further losses, leverage↑, further deleveraging

4a. Liability side: money supply declines
value of money p rises

4b. Households' money demand rises

- HH face more idiosyncratic risk (can't diversify)

(4a–4b: Disinflationary spiral)

Consequences of a Shock in 4 Steps

1. Shock: destruction of some capital
   - % loss in intermediaries net worth > % loss in assets
   - Leverage shoots up
   - Intermediaries %-loss > Household %-losses, since $\gamma < \underline{\gamma}$
     - η-derivative shifts losses to intermediaries
2. Response: shrink balance sheet / delever — PARADOX OF PRUDENCE
   - For given prices no impact
3. Asset side: asset price q shrinks — Liquidity spiral
   - Further losses, leverage↑, further deleveraging

4a. Liability side: money supply declines
value of money p rises

4b. Households' money demand rises
- HH face more idiosyncratic risk (can't diversify)

(4a–4b: Disinflationary spiral)

Brunnermeier & Sannikov

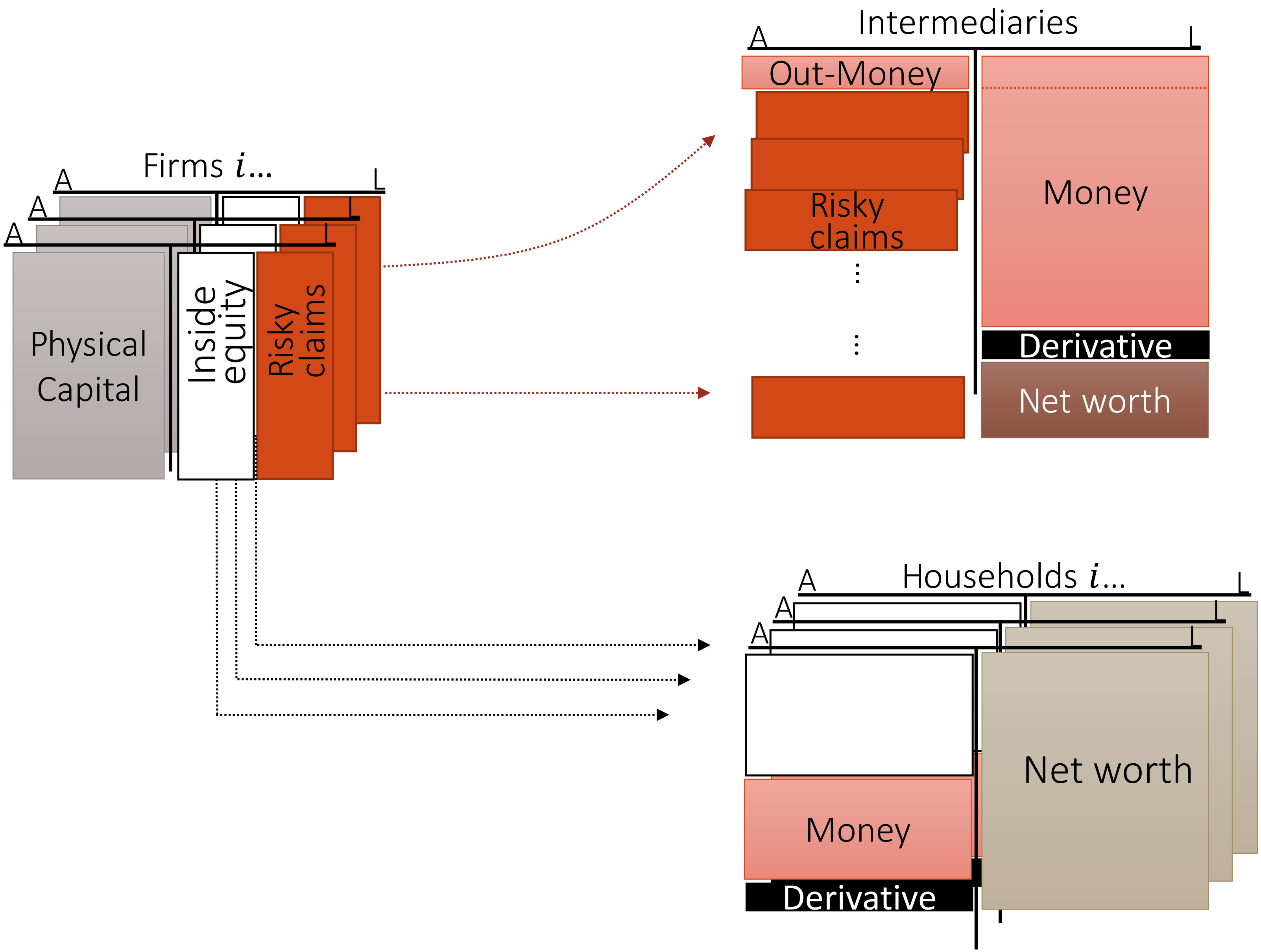
Risk-equivalence & $A(\psi)$-microfoundations

- Risk-equivalent representation
  - Express χ-risk exposure by shifting ψ-capital shares

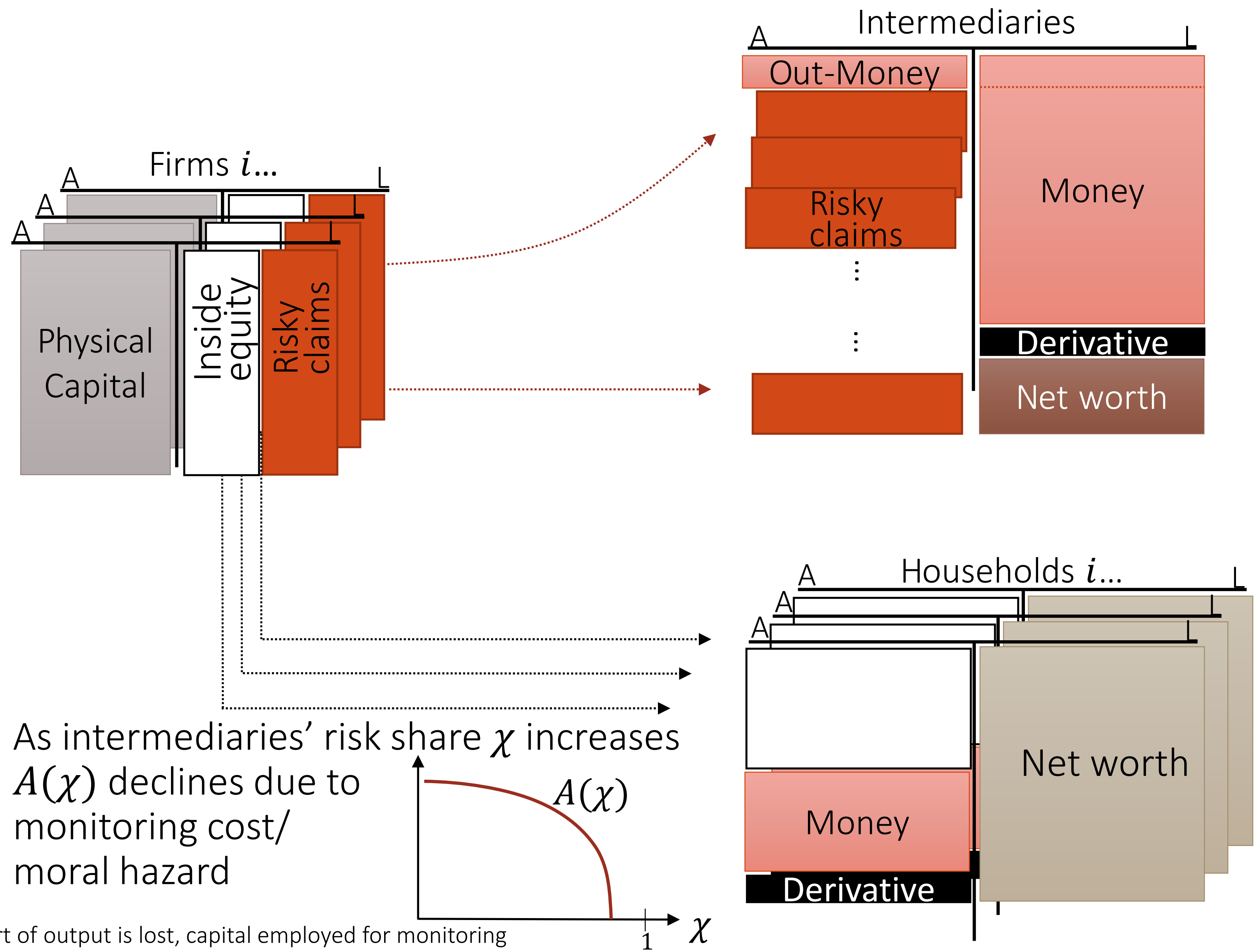
- $A(\psi)$ interpretation
  - As intermediaries capital share increases $A(\psi)$ declines due to monitoring cost

  - Recall in international paper (lecture 04) with 2 goods and CES aggregation
    - Also feasible, but more complicated
    - 2 sectors are needed of which one is bank independent

With Intermediaries: with Z-Derivative



With Intermediaries: with Z-Derivative

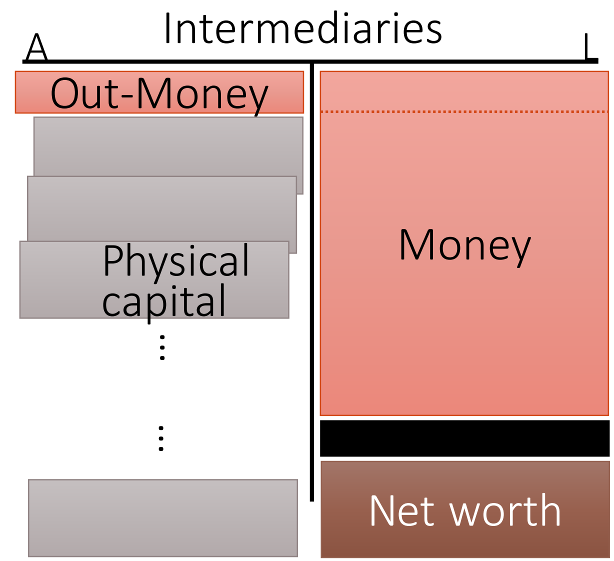


- As intermediaries' risk share χ increases $A(\chi)$ declines due to monitoring cost/ moral hazard

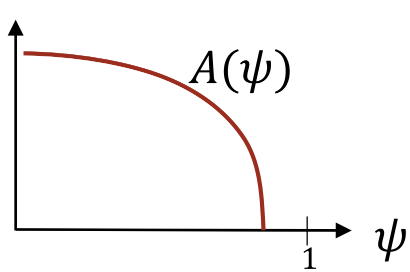
Part of output is lost, capital employed for monitoring

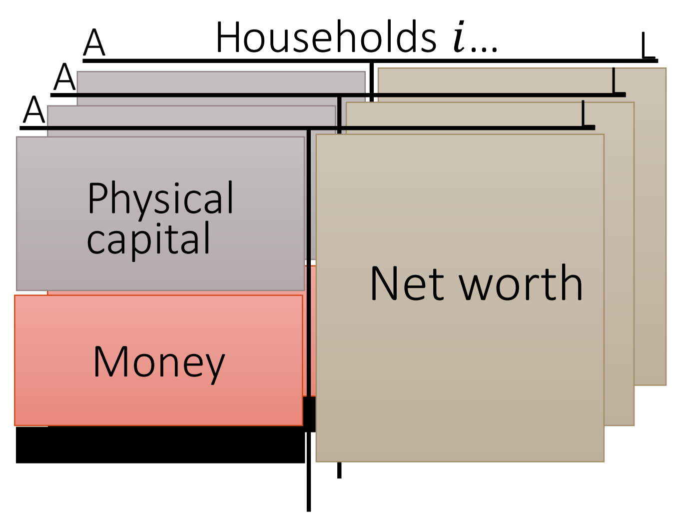
Risk-equivalent Representation

- Intermediaries hold fraction ψ_t of physical capital



- Households hold fraction $1 - \psi_t$ of physical capital





Allocation

- Equilibrium is a map

Histories of shocks ⇢ prices q_t, p_t, ψ_t allocation

$\{\boldsymbol{Z}_\tau, 0 \leq \tau \leq t\}$

wealth distribution

$$\eta_t = \frac{N_t}{(p_t + q_t)K_t} \in (0,1)$$

intermediaries' wealth share

- All agents maximize utility
  - Choose: portfolio, consumption
- All markets clear
  - Consumption, capital, money, (outside equity)

Solving MacroModels Step-by-Step

0. Postulate aggregates, price processes & obtain return processes
1. For given SDF processes *static*
   a. Real investment ι, (portfolio $\boldsymbol{\theta}$, & consumption choice of *each agent*)
      - *Toolbox 1:* Martingale Approach
   b. Asset/Risk Allocation *across types/sectors* & asset market clearing
      - *Toolbox 2:* "price-taking social planner approach" – Fisher separation theorem
2. Value functions *backward equation*
   a. Value fcn. as fcn. of individual investment opportunities ω
      - *Special cases*
   b. De-scaled value fcn. as function of state variables η
      - *Digression:* HJB-approach (instead of martingale approach & envelop condition)
   c. Derive ς-risk premia, C/N-ratio from value fcn. envelop condition
3. Evolution of state variable η *forward equation*
      - *Toolbox 3:* Change in numeraire to total wealth (including SDF)
      - ("Money evaluation equation" μ^{ϑ})
4. Value function iteration & goods market clearing
   a. PDE of de-scaled value fcn.
   b. Value function iteration by solving PDE

Step-by-Step Approach

0. Postulate aggregate, price/return/SDF processes

$$dq_t/q_t = \mu_t^q dt + \sigma_t^q dZ_t,\ dp_t/p_t = ..,\ d\xi_t/\xi_t = ..,\ d\underline{\xi}_t/\underline{\xi}_t =$$

1. For given SDF processes *static*
   a. As before $\kappa\iota_t = q_t - 1$

Recall after using market clearing

$$\iota_t = \frac{(1-\vartheta_t)A(\psi_t)-\bar{\zeta}}{1-\vartheta_t+\kappa\bar{\zeta}},$$

where $\bar{\zeta}$ is the "average" consumption-networth ratio.

This formula is always the same

Step-by-Step Approach

0. Postulate aggregate, price/return/SDF processes

$$dq_t/q_t = \mu_t^q dt + \sigma_t^q dZ_t, dp_t/p_t =.., d\xi_t/\xi_t =.., d\underline{\xi}_t/\underline{\xi}_t =$$

1. For given SDF processes *static*
   a. As before $\kappa\iota_t = q_t - 1$
   b. Asset/Risk allocation via "Price-taking Planner"

$$\max_{\psi_t} A(\psi_t) - \psi_t \tilde{\varsigma}_t \phi \tilde{\sigma} - (1-\psi_t)\tilde{\underline{\varsigma}}_t \tilde{\sigma}$$

FOC: $\frac{A'(\psi_t)}{q} = (\tilde{\varsigma}_t \phi - \tilde{\underline{\varsigma}}_t)\tilde{\sigma}$

Aggregate risk is Independent of ψ_t

2. Value function *backward eqn*

$$\tilde{\varsigma}_t = \gamma \tilde{\sigma}_t^n = \gamma \frac{(1-\vartheta_t)\psi_t}{\eta_t} \phi \tilde{\sigma} \qquad \tilde{\underline{\varsigma}}_t = \underline{\gamma} \frac{(1-\vartheta_t)(1-\psi_t)}{1-\eta_t} \tilde{\sigma}$$

Idio-risk premium on portfolio

$$\gamma(\tilde{\sigma}_t^N)^2 = \frac{\psi_t^2}{\eta_t^2}(1-\vartheta_t)^2 \gamma \phi^2 \tilde{\sigma}^2, \quad \underline{\gamma}\left(\tilde{\underline{\sigma}}_t^N\right)^2 = \frac{(1-\psi_t)^2}{(1-\eta_t)^2}(1-\vartheta_t)^2 \gamma \underline{\tilde{\sigma}}^2$$

$$\varsigma_t = \gamma\sigma_t^c = -\sigma_t^v + \sigma_t^\eta + \sigma_t^q + \sigma_t^p + \gamma\sigma = \underline{\varsigma}_t =$$

$$= \underline{\varsigma}_t = \underline{\gamma}\underline{\sigma}_t^c = -\underline{\sigma}_t^v - \frac{\eta_t \sigma_t^\eta}{1-\eta_t} + \sigma_t^q + \sigma_t^p - \underline{\gamma}\sigma$$

Step-by-Step Approach

2. Value function — *backward eqn*

$$\tilde{\varsigma}_t = \gamma \tilde{\sigma}_t^n = \gamma \frac{(1-\vartheta_t)\psi_t}{\eta_t} \phi \tilde{\sigma} \qquad \underline{\tilde{\varsigma}}_t = \underline{\gamma} \frac{(1-\vartheta_t)(1-\psi_t)}{1-\eta_t} \tilde{\sigma}$$

Idio-risk premium on portfolio

$$\gamma(\tilde{\sigma}_t^N)^2 = \frac{\psi_t^2}{\eta_t^2}(1-\vartheta_t)^2 \gamma \phi^2 \tilde{\sigma}^2, \quad \underline{\gamma}\left(\tilde{\sigma}_t^{\underline{N}}\right)^2 = \frac{(1-\psi_t)^2}{(1-\eta_t)^2}(1-\vartheta_t)^2 \gamma \underline{\tilde{\sigma}}^2$$

$$\varsigma_t = \gamma \sigma_t^c = -\sigma_t^v + \sigma_t^\eta + \sigma_t^q + \sigma_t^p + \gamma\sigma = \underline{\varsigma}_t =$$

$$= \underline{\varsigma}_t = \underline{\gamma} \sigma_t^{\underline{c}} = -\sigma_t^{\underline{v}} - \frac{\eta_t \sigma_t^\eta}{1-\eta_t} + \sigma_t^q + \sigma_t^p - \underline{\gamma}\sigma$$

From Ito's Lemma $\sigma_t^v = \frac{v'}{v}\eta_t \sigma_t^\eta$ and $\sigma_t^{\underline{v}} = \frac{\underline{v}'}{\underline{v}}(1-\eta_t)\frac{\eta_t \sigma_t^\eta}{1-\eta_t}$

$$\frac{C_t}{N_t} = \frac{(\eta_t(q_t + p_t))^{1/\gamma - 1}}{v_t^{1/\gamma}} \qquad \frac{\underline{C}_t}{\underline{N}_t} = \frac{((1-\eta_t)(q_t + p_t))^{1/\gamma - 1}}{\underline{v}_t^{1/\gamma}}$$

3. Evolution of η

η-derivative $\Rightarrow \varsigma_t = \underline{\varsigma}_t, \Rightarrow \sigma_t^\eta = \dfrac{(1-\eta_t)\left(\underline{\gamma} - \gamma\right)\sigma}{(1-\eta_t)\left(\frac{\underline{v}'}{\underline{v}} - \frac{v'}{v}\right) + 1}$

Step-by-Step Approach

2. Value function *backward eqn*

$$\gamma(\tilde{\sigma}_t^N)^2 = \frac{\psi_t^2}{\eta_t^2}(1-\vartheta_t)^2\gamma\phi^2\tilde{\sigma}^2, \quad \underline{\gamma}\left(\tilde{\sigma}_t^{\underline{N}}\right)^2 = \frac{(1-\psi_t)^2}{(1-\eta_t)^2}(1-\vartheta_t)^2\gamma\underline{\tilde{\sigma}}^2$$

$$\frac{C_t}{N_t} = \frac{(\eta_t(q_t+p_t))^{1/\gamma-1}}{v_t^{1/\gamma}} \qquad \frac{\underline{C}_t}{\underline{N}_t} = \frac{((1-\eta_t)(q_t+p_t))^{1/\gamma-1}}{\underline{v}_t^{1/\gamma}}$$

3. Evolution of η *forward eqn*

η-derivative $\Rightarrow \varsigma_t = \underline{\varsigma}_t, \Rightarrow \sigma_t^\eta = \frac{(1-\eta_t)(\underline{\gamma}-\gamma)\sigma}{(1-\eta_t)\left(\frac{\underline{v}'}{\underline{v}}-\frac{v'}{v}\right)+1}$

Recall from earlier lecture (and since $\varsigma_t = \underline{\varsigma}_t$ and $r^F = \underline{r}^F$),

$$\mu_t^\eta = (1-\eta_t)(\varsigma_t - \sigma_t^{\bar{N}})\left(\sigma_t^\eta - \sigma_t^{\underline{\eta}}\right)$$
$$+(1-\eta_t)\tilde{\varsigma}_t\tilde{\sigma}_t^n - (1-\eta_t)\underline{\tilde{\varsigma}}_t\underline{\tilde{\sigma}}_t^n - \left(\frac{C_t}{N_t} - \frac{C_t+\underline{C}_t}{q_t K_t}\right)$$

$\mu_t^\eta =$

$$\sigma_t^\eta(\varsigma_t - \sigma - \sigma_t^q - \sigma_t^p) - (1-\eta_t)\left(\frac{\underline{C}_t}{\underline{N}_t} - \frac{C_t}{N_t} + \gamma(\tilde{\sigma}_t^N)^2 - \underline{\gamma}\left(\tilde{\sigma}_t^{\underline{N}}\right)^2\right.$$

Brunnermeier & Sannikov

Step-by-Step Approach

3. Evolution of η *forward eqn*

$$\sigma_t^\eta = \frac{(1-\eta_t)(\underline{\gamma}-\gamma)}{(1-\eta_t)\left(\frac{\underline{v}'}{\underline{v}}-\frac{v'}{v}\right)+1}\sigma$$

$$\mu_t^\eta = \sigma_t^\eta(\varsigma_t - \sigma - \sigma_t^{q+p}) - (1-\eta_t)\left(\frac{\underline{C}_t}{\underline{N}_t} - \frac{C_t}{N_t} + \gamma(\tilde{\sigma}_t^N)^2 - \underline{\gamma}\left(\tilde{\sigma}_t^{\underline{N}}\right)^2\right)$$

Money evaluation equation

Use same approach as for wealth share μ_t^η for economy wide "money share" ϑ_t

$$\mu_t^\vartheta = +\sigma_t^\vartheta(\varsigma_t - \sigma - \sigma_t^{q+p}) +$$

$$+\underbrace{\frac{C_t + \underline{C}_t}{(q_t + p_t)K_t}}_{=\frac{A(\psi)-\iota_t}{q_t+p_t}} - \mu^M - \eta_t\gamma(\tilde{\sigma}_t^N)^2 - (1-\eta_t)\underline{\gamma}\left(\tilde{\sigma}_t^{\underline{N}}\right)^2$$

4. Value function $v(\eta), \underline{v}(\eta)$ & $\vartheta(\eta)$
   - Solve PDE (growth equation)

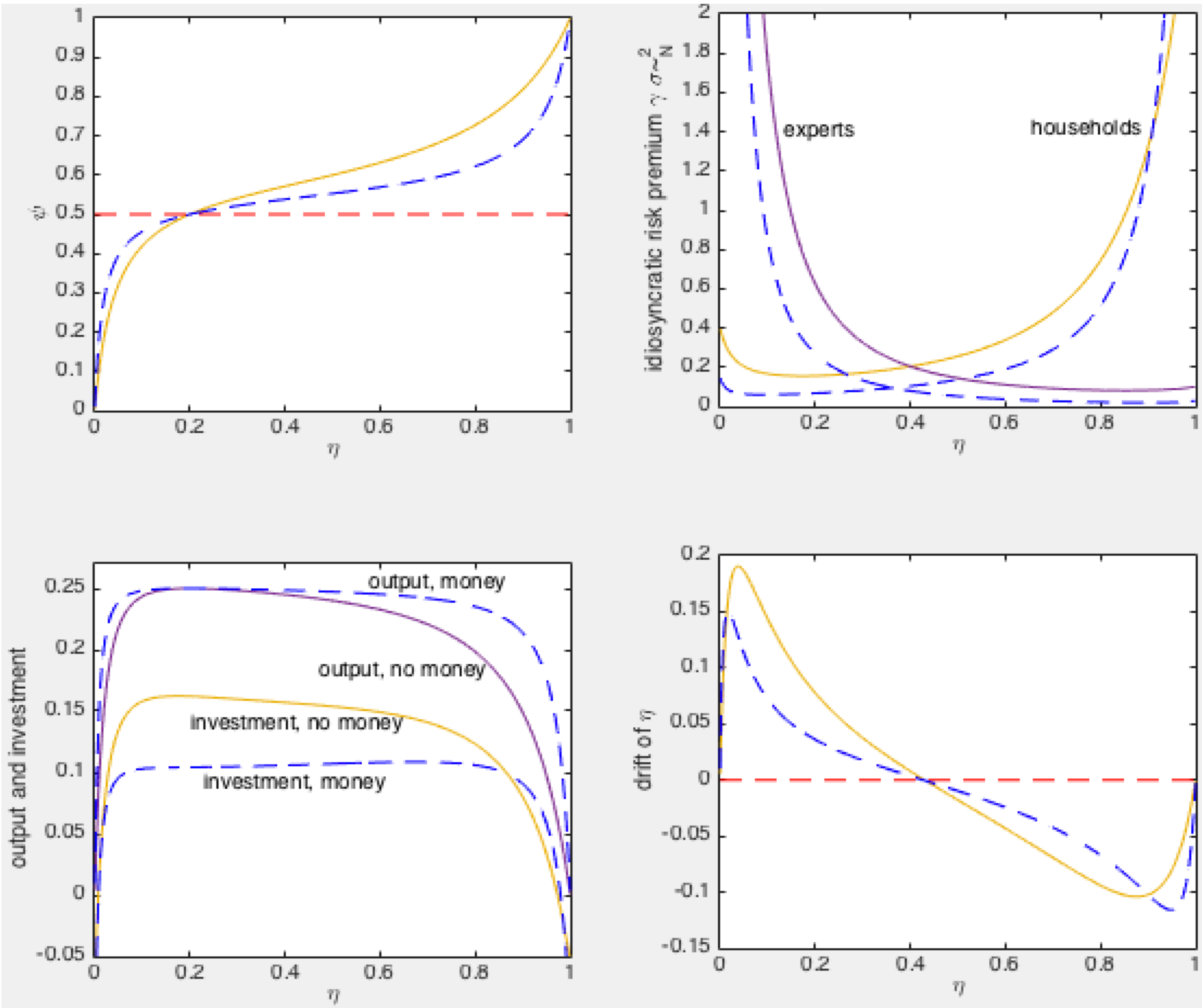
Brunnermeier & Sannikov

Numerical Example

- $\rho = \underline{\rho} = .05, \gamma = 1.5, \underline{\gamma} = 4, \delta = .03, \sigma = 0, \gamma\phi^2\tilde{\sigma}^2 = .1, \underline{\gamma}\tilde{\sigma}^2 = .4,$

$A(\psi) = \psi(1-\psi)$

Assumes more than simply monitoring costs

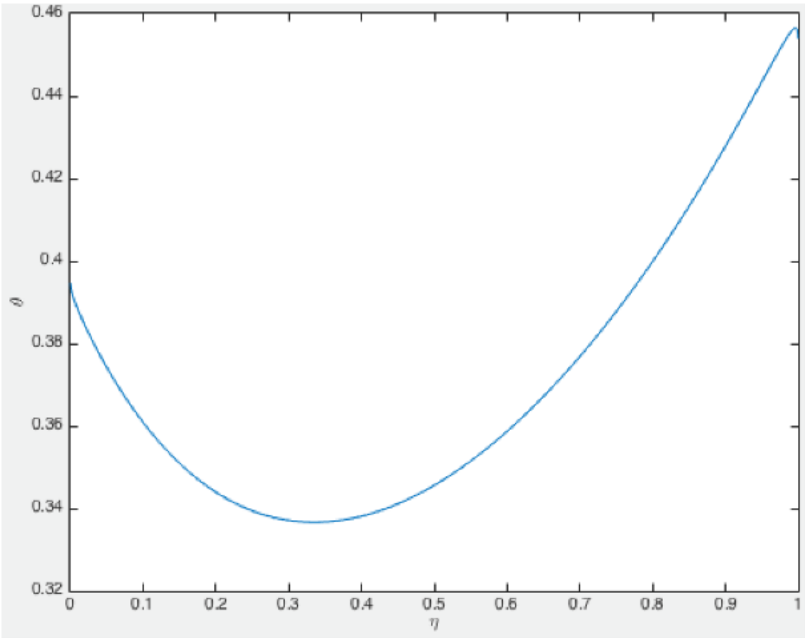


Numerical Example

- $\rho = \underline{\rho} = .05, \gamma = 1.5, \underline{\gamma} = 4, \delta = .03, \sigma = 0, \gamma\phi^2\tilde{\sigma}^2 = .1, \underline{\gamma}\tilde{\sigma}^2 = .4,$

$A(\psi) = \psi(1-\psi)$

- $\vartheta(\eta)$



Poll 40:
Why does the value increase as η *goes it very high?*

Amplification

- What's the right benchmark?
- Assume $\frac{C_t}{N_t}$ and $\frac{\underline{C}_t}{\underline{N}_t}$ were constant
  - Would be the case with Epstein-Zin preferences when $IES = 1$, risk aversion still differ

Take log and derivate w.r.t. η

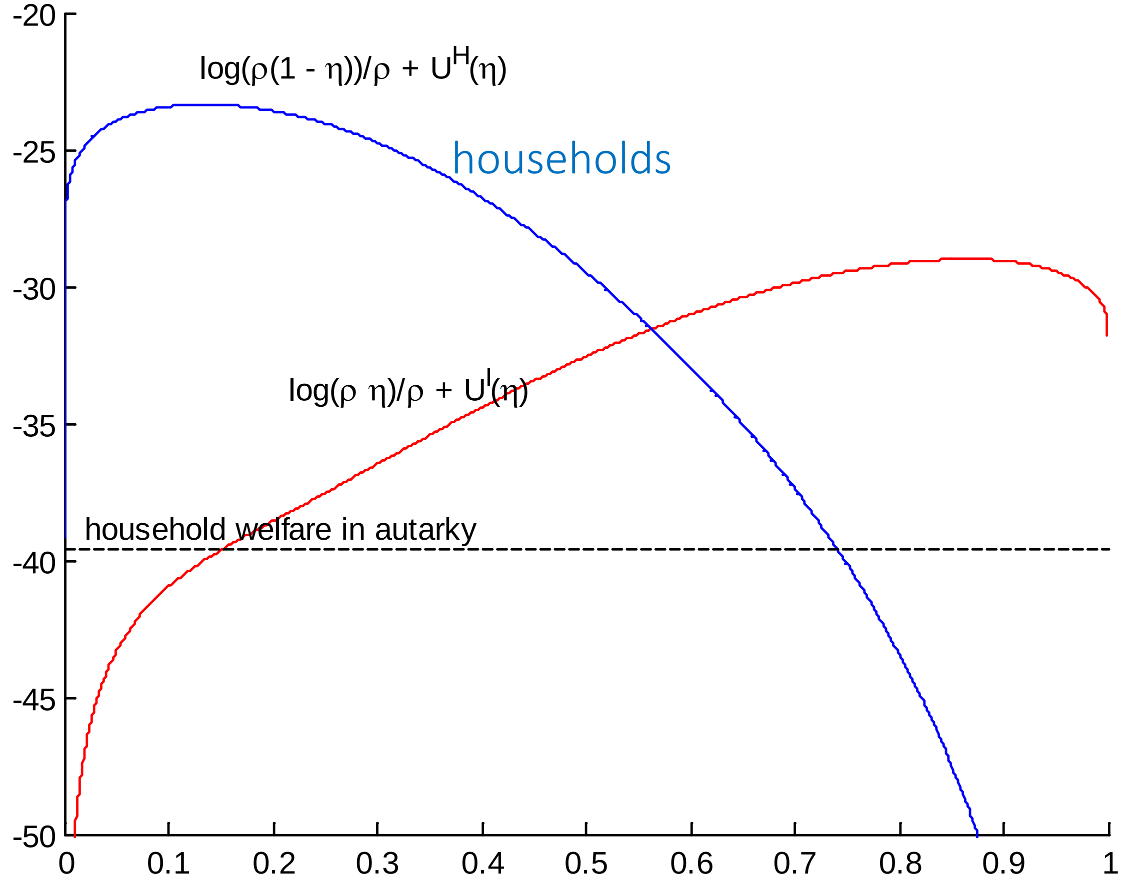
  - Then $\eta^{\gamma-1}(q+p)^{\gamma-1}v = const. \Rightarrow \frac{v'}{v} = (1-\gamma)\left(\frac{1}{\eta} + \frac{q'+p'}{q+p}\right)$
  - Similarly for households $\Rightarrow \frac{\underline{v}'}{\underline{v}} = \left(1-\underline{\gamma}\right)\left(\frac{-1}{1-\eta} + \frac{q'+p'}{q+p}\right)$
- Assume also that $q+p$ were constant, then level of risk without amplification (but risk sharing)

$$\sigma_t^{\eta} = \frac{(1-\eta_t)\left(\underline{\gamma}-\gamma\right)}{\underline{\gamma}\eta_t + \gamma(1-\eta_t)}\sigma$$

With Intermediaries, but no η-Derivative

Welfare analysis – I Theory 5.0

- Challenge: Heterogeneous agents with idiosyncratic risks
- Inefficiencies in
  - Production
  - Investment
  - Risk sharing



Roadmap

- Model without intermediaries
  - Fixed (outside) money supply
  - Optimal money growth rate
    - "On the optimal inflation rate" (inflation target)

- Model with intermediaries
  - Fixed outside money supply - Amplification/endogenous risk
    - Liquidity spiral — asset side of intermediaries' balance sheet
    - Disinflationary spiral — liability side
  - Monetary Policy
  - Macro-prudential policy

- Intermediaries with market power
    - The "Reversal Interest Rate: The Effective Lower Bound"

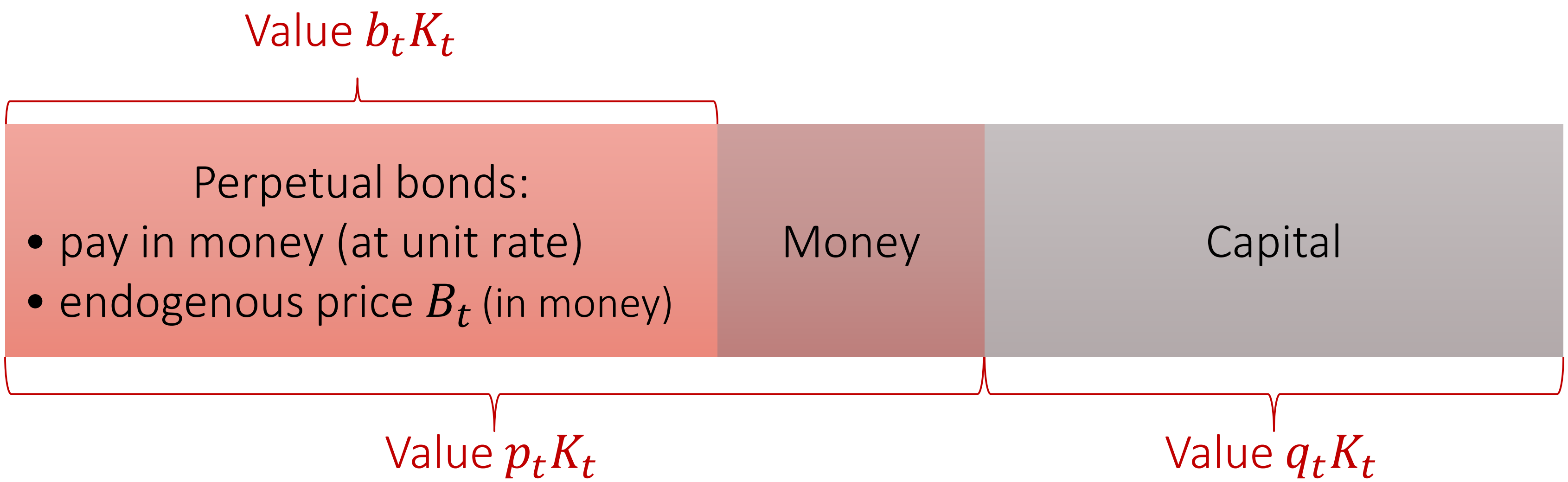
Monetary Policy: Ex-post perspective

- Money view Friedman-Schwartz
  - Restore money supply
    - Replace missing inside money with outside money
  - Aim: Reduce deflationary spiral
    - … but banks extent less credit & diversify less idiosyncratic risk away
    - … as households have to hold more idiosyncratic risk, money demand rises
    - Undershoots inflation target

- Credit view Tobin
  - Restore credit
  - Aim: Switch off deflationary spiral & liquidity spiral

Introducing Long-term Gov. Bond

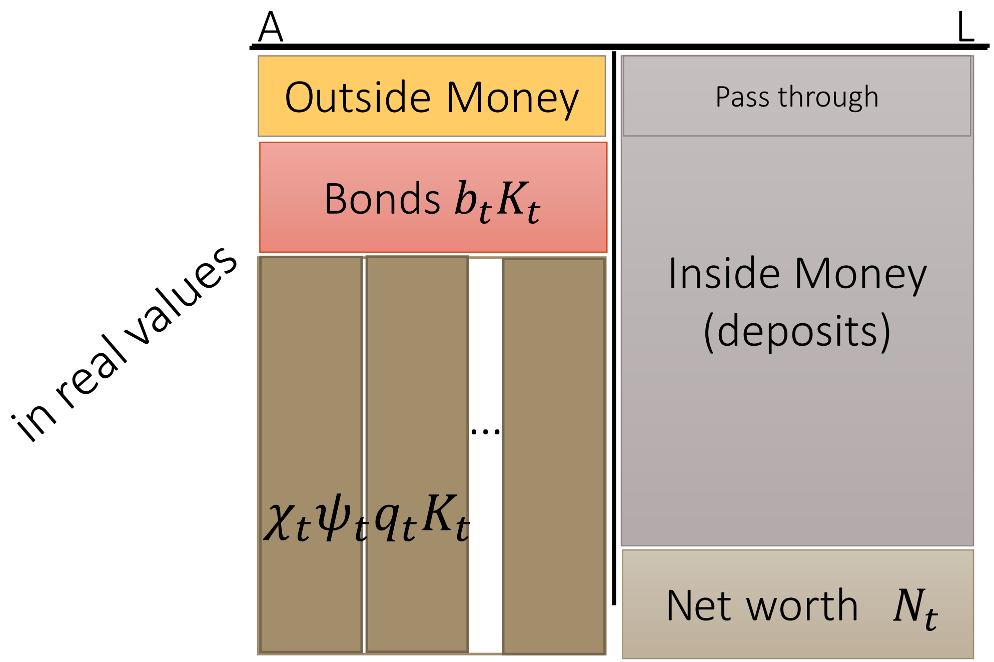
- Introduce long-term (perpetual) bond
  - No default ... held by intermediaries in equilibrium



- Value of long-term bond is endogenous

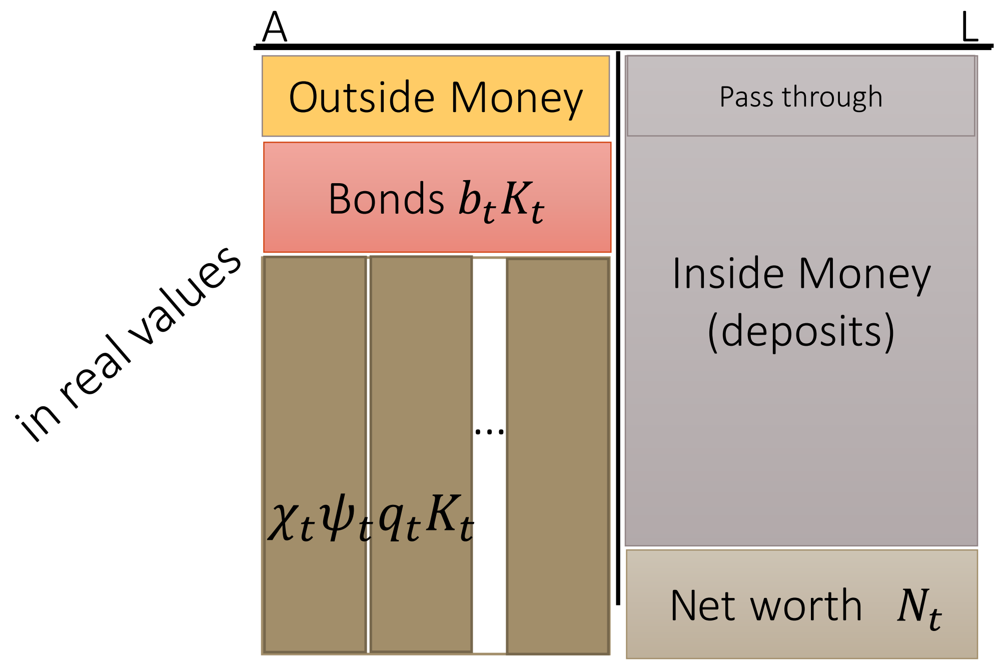
$$dB_t/B_t = \mu_t^B dt + \sigma_t^B dZ_t$$

Redistributive MoPo: Ex-post perspective



- Adverse shock $\rightarrow$ value of risky claims drops
- Monetary policy
  - Interest rate cut ⇒ long-term bond price ↑
  - Asset purchase ⇒ asset price ↑
  - ⇒ "stealth recapitalization" - redistributive
  - ⇒ risk premia ↓
- Liquidity & Deflationary Spirals are mitigated

Redistributive MoPo: Ex-post perspective



- Adverse shock $\rightarrow$ value of risky claims drops
- Monetary policy
  - Interest rate cut $\Rightarrow$ long-term bond price ↑
  - Asset purchase $\Rightarrow$ asset price ↑
  - $\Rightarrow$ "stealth recapitalization" - redistributive
  - $\Rightarrow$ risk premia ↓
- Liquidity & Deflationary Spirals are mitigated

"stealth recapitalization"

LTRO, QE

Monetary policy and endogenous risk

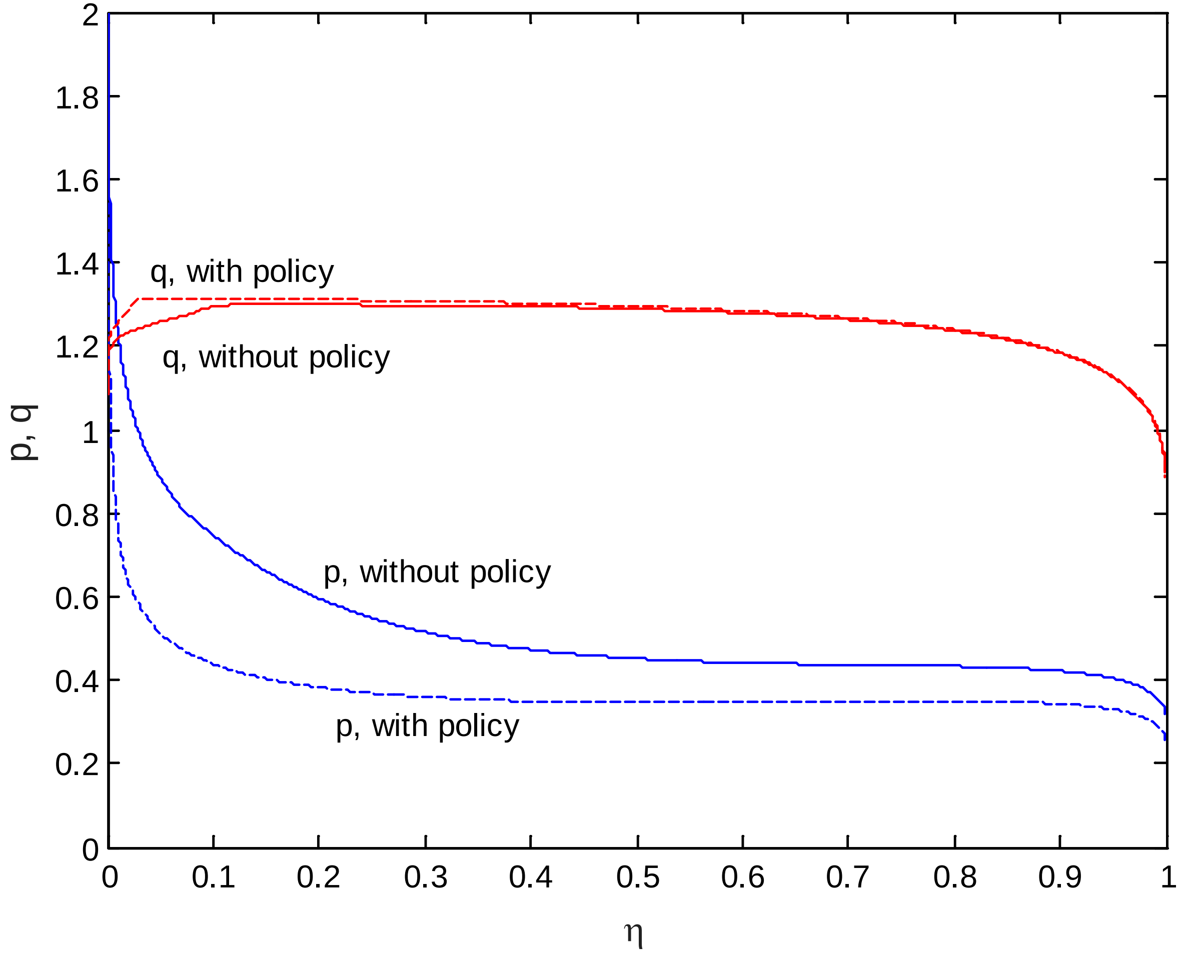
- Intermediaries' risk (borrow to scale up)

$$\sigma_t^\eta = \frac{\overbrace{x_t\,(1^b\sigma^b - \sigma_t^K)}^{\text{fundamental risk}}}{1 + \underbrace{\left(\frac{\chi_t\,\psi_t - \eta}{\eta_t}\right)\frac{\vartheta'(\eta_t)}{\vartheta/\eta_t}}_{\text{amplification}} - \underbrace{\left(x_t + \vartheta_t \frac{1-\eta_t}{\eta_t}\right)\frac{b_t}{p_t}\frac{B'(\eta_t)}{B(\eta_t)/\eta_t}}_{\text{mitigation}}}$$

- MoPo works through $\frac{B'(\eta_t)}{B(\eta_t)/\eta_t}$
  - with right monetary policy bond price $B(\eta)$ rises as η drops "stealth recapitalization"
  - Switch off liquidity and disinflationary spiral
- Example:
  Remove amplification s.t. $\sigma_t^\eta = x_t(1^b\sigma^b - \sigma_t^K)$

Numerical example with monetary policy

- Prices



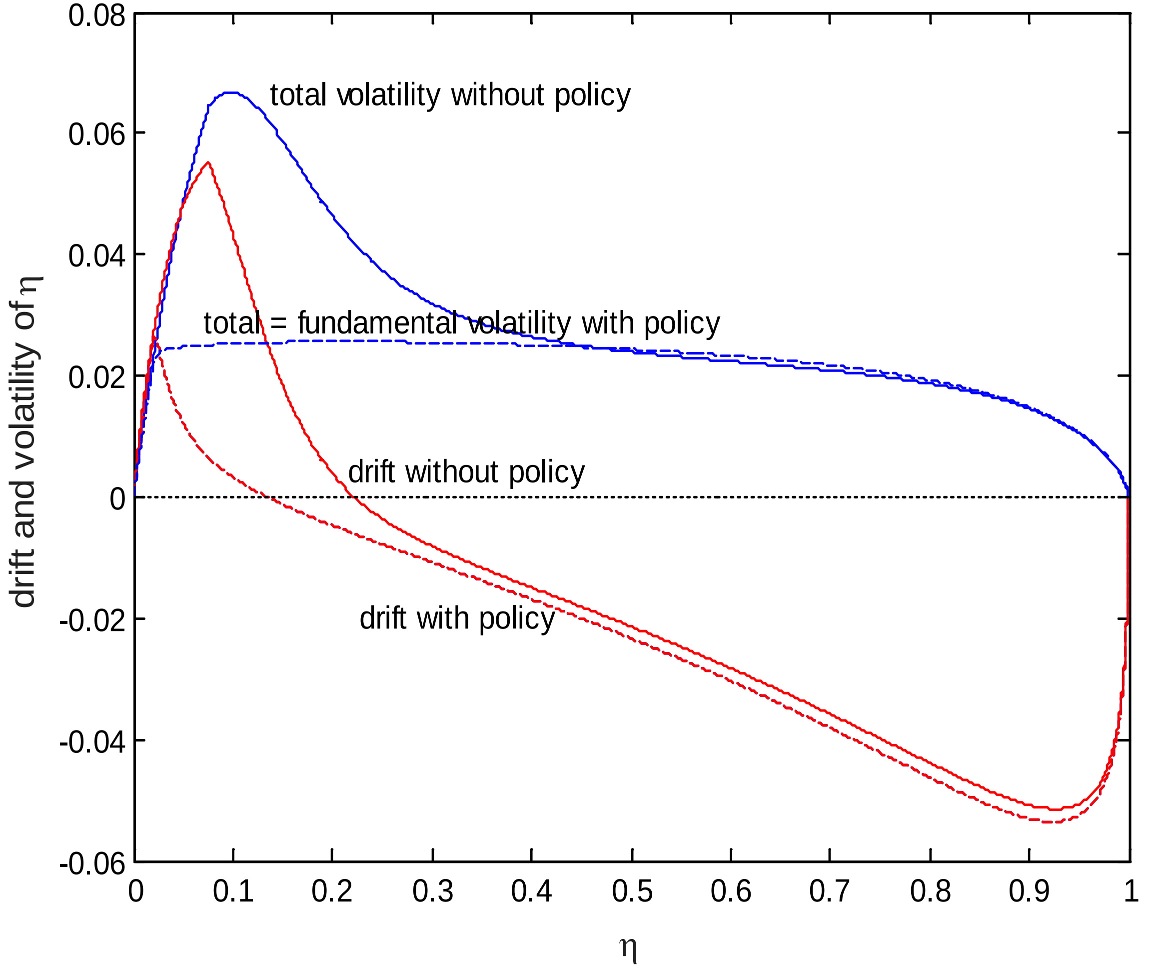
q is more stable

p less disinflation

Brunnermeier & Sannikov

Numerical example with monetary policy

- Drift and volatility of η



Observations

- As interest rate are cut in downturns, bonds held by intermediaries appreciate, this
  - protects intermediaries against shocks
  - increases the supply of asset that can be used as storage (weakens disinflation)

- Ex-post stabilization
  - Liquidity spiral
  - Disinflationary spiral
- Ex-ante
  - Higher leverage
  - (shift in steady state)

Monetary policy … in the limit

- full risk sharing of all aggregate risk

- $$\sigma_t^\eta = \frac{x_t(1^b\sigma^b - \sigma_t^K)}{1 - \left(\frac{\chi\psi-\eta}{\eta}\right)\frac{-\vartheta'(\eta)}{\vartheta/\eta} + \left((1-\vartheta)\frac{\psi\chi-\eta}{\eta} + \vartheta\frac{1-\eta}{\eta}\right)\frac{b_t - B'(\eta)}{p_t B(\eta)/\eta}}$$

  $\longrightarrow -\infty$

- η is deterministic and converges over time towards $\mathbf{0}$

Redistributive Monetary Policy

(New) Keynesian Demand Management		I Theory of Money Risk (Premium) Management
Stimulate aggregate consumption		Alleviate balance sheet constraints
Woodford (2003)	**Tobin (1982)**	**BruSan**
Price stickiness & ZLB Perfect capital markets	Both	Financial frictions Incomplete markets
Representative Agent	Heterogeneous Agents	
Cut i Reduces r due to price stickiness Consumption c rises	Cut i Changes bond prices Redistributes from low MPC to high MPC consumers	Cut i or QE Changes asset prices Ex-post: Redistributes to balance sheet impaired sector
		Ex-ante: insurance -> reduces endogenous risk -> impacts risk premia (Hanson-Stein,…) Moral hazard -> role for MacroPru
Focus on LEVELS		Focus on levels and RISK DYNAMICS

Monetary policy … in the limit

- full risk sharing of all aggregate risk

- Aggregate risk sharing makes q determinisitic
- Like in benchmark toy model
  - Excessive k-investment
  - Too high q
    (pecuniary externality)
    - Lower capital return
- Endogenous risk corrects pecuniary externality

MacroPru

- MacroPru complements MoPo
  - Not substitutes
- Good MacroPru enables more aggressive MoPo
  - More redistribution ex-post
  - More risk-transfers/insurance ex-ante
  - Lower q
    - reduces cost to repurchase capital after shock
    - Lowers importance of idiosyncratic shocks

MacroPru policy

- Regulator can control
  - Portfolio choice ψs, xs

cannot control

- investment decision $\iota(q)$
- consumption decision c

of intermediaries and households

MacroPru policy

- Regulator can control
  - Portfolio choice ψs, xs

  of intermediaries and households

  - De-facto controls q and p within some range — distorts $\iota(q)$
  - De-factor controls wealth share η
    - Force agents to hold certain assets and generate capital gains

- cannot control
  - investment decision $\iota(q)$
  - consumption decision c

- In sum,
  regulator maximizes sum of agents value function
  - Choosing ψ^b, q, η

Recall

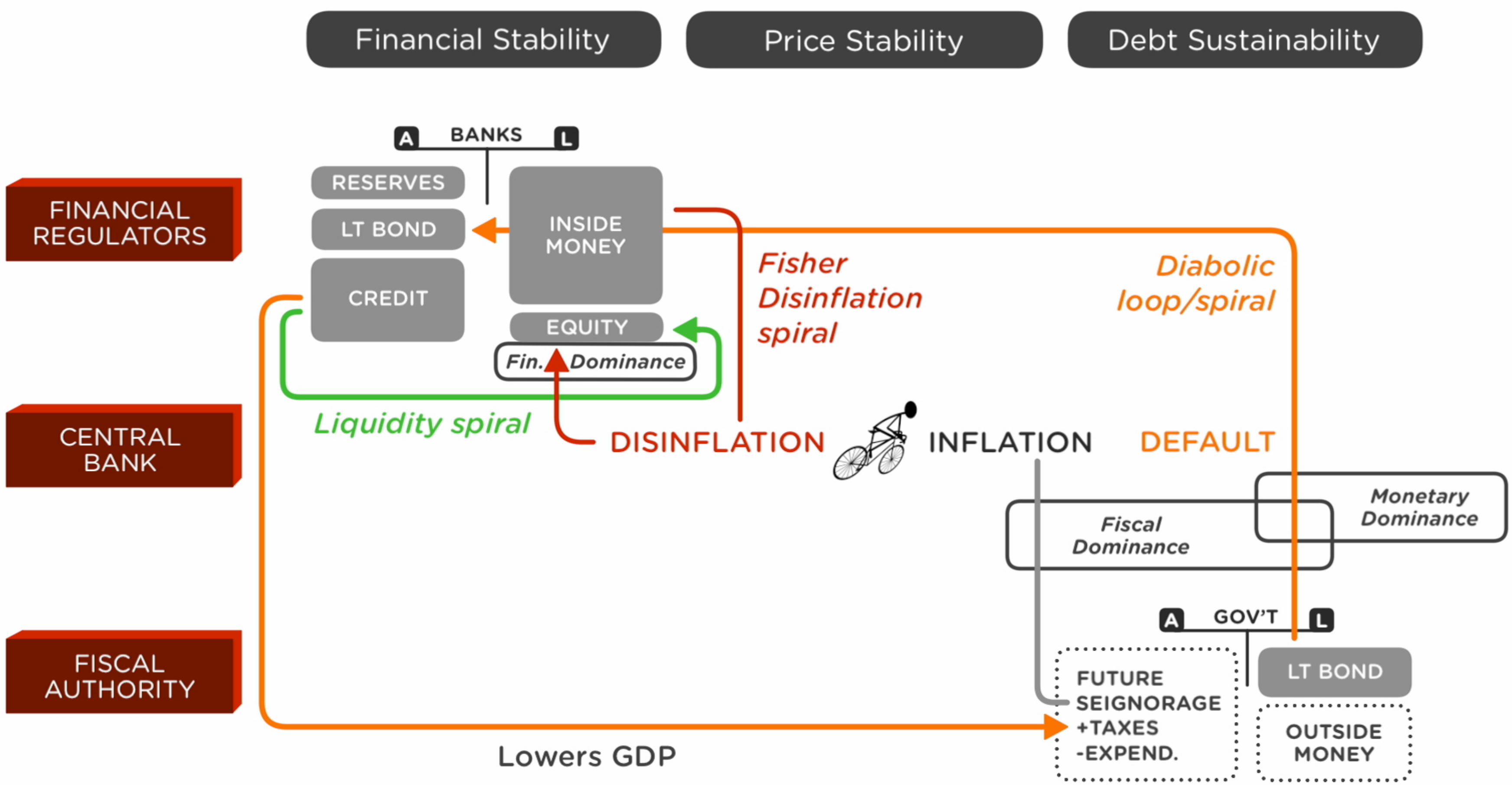
- Unified macro "Money and Banking" model to analyze
  - Financial stability - Liquidity spiral
  - Monetary stability - Fisher disinflation spiral

- Exogenous risk &
  - Sector specific
  - idiosyncratic
- Endogenous risk
  - Time varying risk premia – flight to safety
  - Capitalization of intermediaries is key state variable "Paradox of Prudence"

- Monetary policy rule
  - Risk transfer to undercapitalized critical sectors
  - Income/wealth effects are crucial instead of substitution effect
  - Reduces endogenous risk – better aggregate risk sharing
    - Self-defeating in equilibrium – excessive idiosyncratic risk taking
- Macro-prudential policies
  - MacroPru + MoPo to achieve superior welfare optimum

Flipped Classroom Experience

Series of 4 YouTube videos, each about 10 minutes



Brunnermeier & Sannikov

Redistributive Monetary Policy

(New) Keynesian Demand Management		I Theory of Money Risk (Premium) Management
Stimulate aggregate consumption		Alleviate balance sheet constraints
Woodford (2003)	**Tobin (1982)**	**BruSan**
Price stickiness & ZLB Perfect capital markets	Both	Financial frictions Incomplete markets
Representative Agent	Heterogeneous Agents	
Cut i Reduces r due to price stickiness Consumption c rises	Cut i Changes bond prices Redistributes from low MPC to high MPC consumers	Cut i or QE Changes asset prices Ex-post: Redistributes to balance sheet impaired sector
		Ex-ante: insurance -> reduces endogenous risk -> impacts risk premia (Hanson-Stein,…) Moral hazard -> role for MacroPru
Focus on LEVELS		Focus on levels and RISK DYNAMICS