The I Theory of Money

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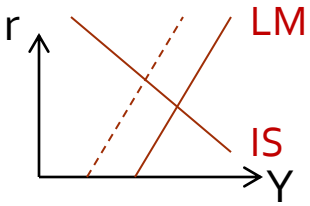
Updates: http://scholar.princeton.edu/markus/files/i_theory_slides.pdf

Motivation

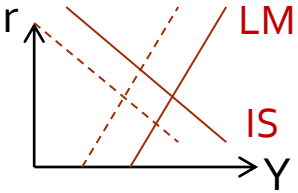
- Unified framework to study financial and monetary stability
- **I**: **I**ntermediation (credit) - **I**nside money
- Value of money endogenous - store of value, liquidity
- In downturns, intermediaries create less inside money
  - Value of **outside** (base) money goes up
  - Fisher (1933) **disinflationary spiral** hits borrowers on liability side
  - **Endogenous** money multiplier = f(health of intermediary sector)
- Monetary policy (interest rates, open market operations)
  - Fills in demand for money when money multiplier contracts
  - "Stealth redistribution" from/towards intermediary sector

Some Literature

- Role of money
  - Unit of account — affects price setting if prices are sticky
  - Medium of exchange — cash in advance constraint, money in utility function
  - Store of value — Samuelson, Bewley, Scheinkman-Weiss, Kiyotaki-Moore
- Without intermediaries
  - Inflation in downturns: less money needed since fewer transactions



- With intermediaries – have special role
  - Money view: (Friedman & Schwartz 1963)
    - "Moneyness" of bank liabilities decrease in downturns of intermediation
  - Credit view (demand/supply): (Tobin 1969)
    - BGG, KM, He & Krishnamurthy, BruSan10, Goodfriend 05, Curdia & Woodford 10, …



- Financial stability + monetary policy
  - Diamond & Rajan (2006), Stein (2012)

Main results

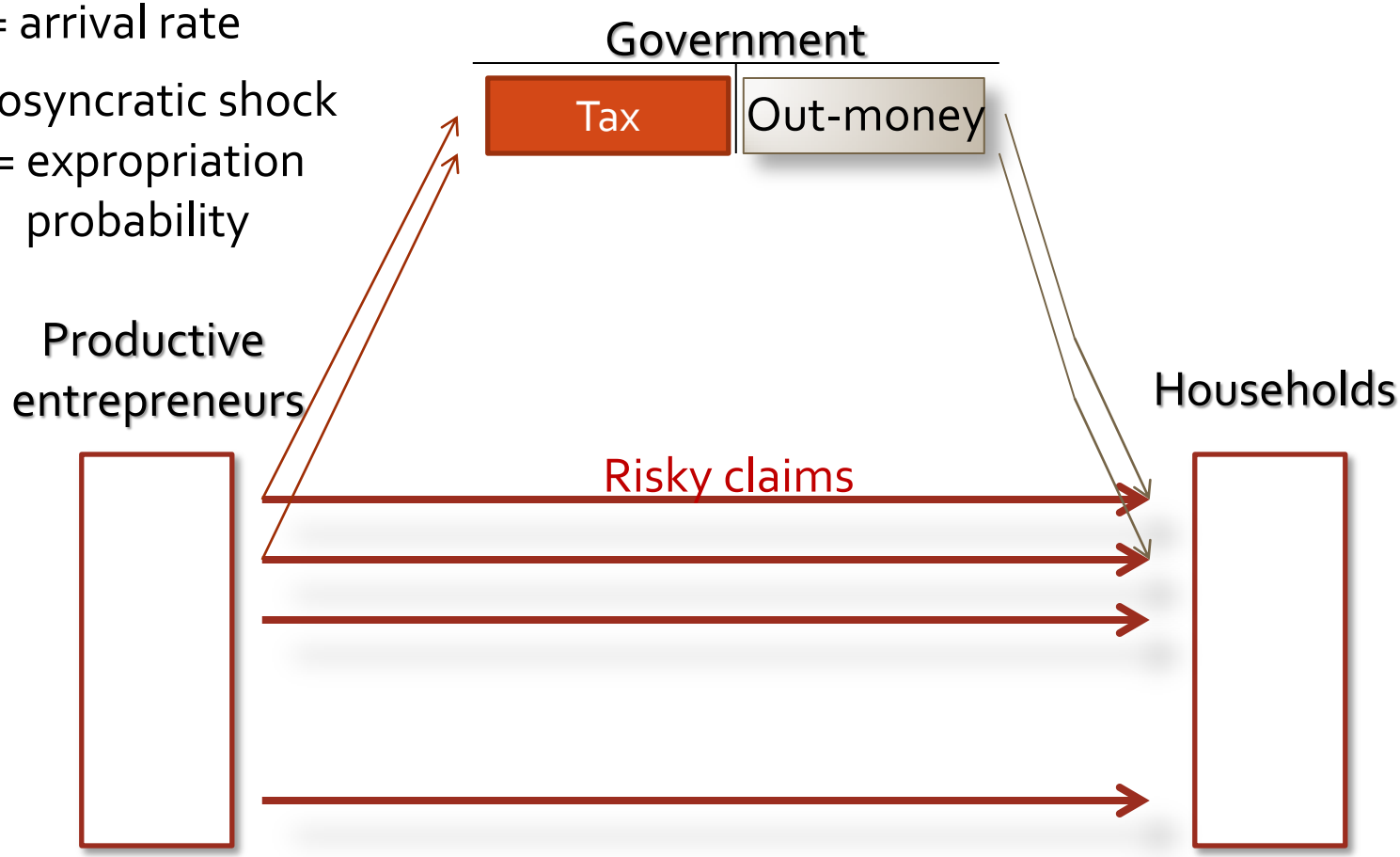
- Passive monetary policy

A	L
Liquidity Spirals	Disinflationary spiral

  - Endogenous risk
  - Redistributional effects
- Active monetary policy
  - Interest rate
    - Current rate
    - Forward guidance
  - Asset purchase programs – open market operation
  - "Stealth" recapitalization

Baseline model without intermediaries

- Macro shock
  λ = arrival rate
- Idiosyncratic shock
  $\underline{\phi}$ = expropriation probability



Baseline model without intermediaries

- Output: $y_t = (a - \iota)k_t$
- Capital: $dk_t = (\Phi(\iota_t) - \delta)k_t dt$, $\Phi(0) = 0, \Phi' > 0, \Phi'' < 0$
- Shocks
  - λ arrival rate of macro shock
  - $\underline{\phi}$ probability of expropriation
- Productive entrepreneurs
  - No net worth – no risk bearing capacity
- Households $E\left[\int_0^\infty e^{-rt} \log c_t \, dt\right]$
  - Risky claims towards **one** entrepreneurs
    - Cannot diversify across entrepreneurs
  - Outside money

Baseline model without intermediaries

- Wealth in the economy: $q_t K_t + p_t K_t$
- Assume degenarate $\underline{\Phi}(i)$ & denote $g \equiv \underline{\Phi}(0) - \delta$
-

Return	Absent shock	shock
On capital r_t^K	$\frac{(1-\tau)a}{\underline{q}} + g$	Loss with prob $\lambda\phi$
On money r_t^M	$\frac{\tau a}{\underline{p}} + g$	

- Optimal portfolio choice for households
  - …

Brunnermeier & Sannikov 2012

Baseline model without intermediaries

- Optimal portfolio choice for HH

$$\max_{\underline{x}} \underline{x} r_t^K + (1-\underline{x}) r_t^M + \lambda \underline{\phi} \ln(1-\underline{x})$$

- FOC: $\left(\frac{(1-\tau)a}{\underline{q}} + g\right) - \left(\frac{\tau a}{\underline{p}} + g\right) - \lambda \underline{\phi} \frac{1}{1-\underline{x}} = 0$
- Market clearing:
  - Capital market: $\underline{x} = \underline{q}/(\underline{q} + \underline{p})$
  - Goods market: $r\left(\underline{q} + \underline{p}\right) K = aK$
- Hence, $\underline{q} = \frac{(1-\tau)a}{r+\lambda\underline{\phi}}$ and $\underline{p} = \frac{a}{r} \frac{\tau r + \lambda \underline{\phi}}{r + \lambda \underline{\phi}}$
- Value of money even if $\tau = 0$ (tax can be even slightly negative)

Frictionless model with $\lambda = 0$

- No risk, hence $r^M = r^K$

- $\underline{q} = \frac{(1-\tau)a}{r}$ and $\underline{p} = \frac{a\tau}{r}$

- Value of capital is higher
- Value of money is lower
  - Tax backing essential

Two Polar Regimes

Regime	Frictions	Value of fiat money	Price of capital
“Money”	severe	high	low
“Bliss”	small	low	high

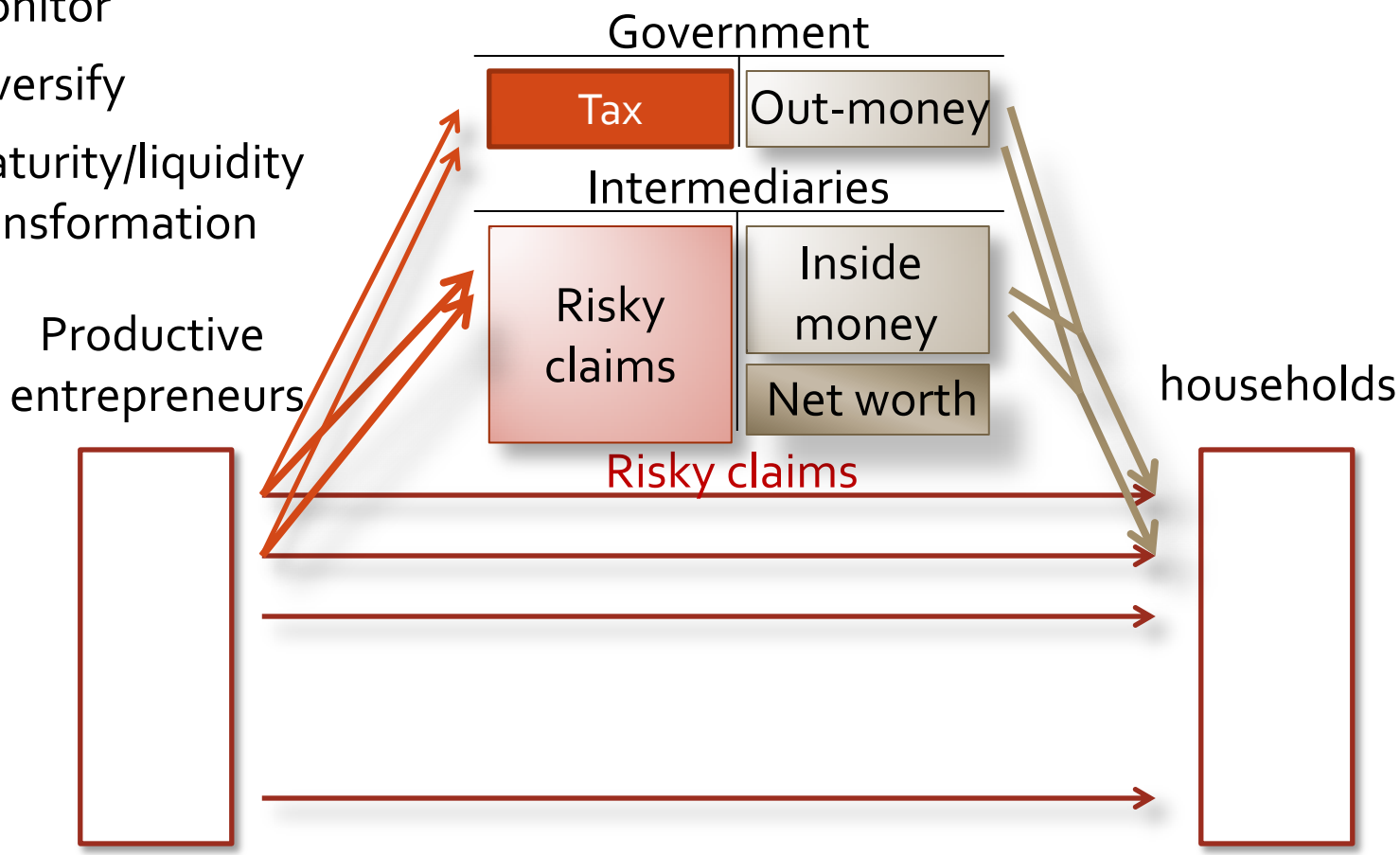
Two Polar Regimes with Intermediaries

Regime	Frictions	Value of fiat money	Price of capital		Intermediaries' capitalization
"Money"	severe	high	low		poor
"Bliss"	small	low	high		well

- Role of intermediaries
  - Monitoring and thereby reduce friction from $\underline{\phi}$ to ϕ
    - Have to take on productive agent's equity risk to have incentive to monitor
    - Depends on their ability to absorb risk
  - Diversify
  - Maturity/liquidity transformation

Introducing intermediaries

- Monitor
- Diversify
- Maturity/liquidity transformation



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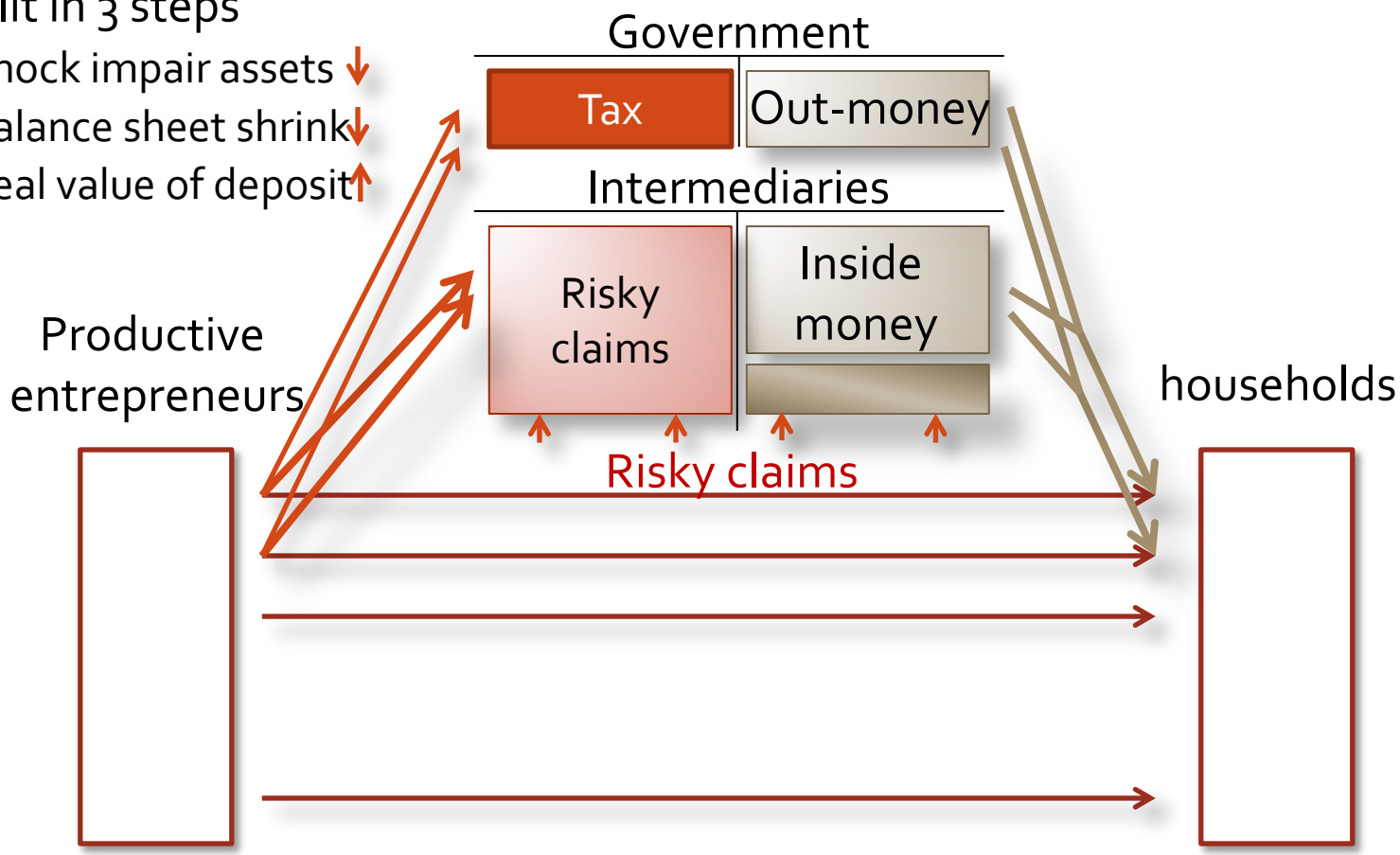
Adverse shock

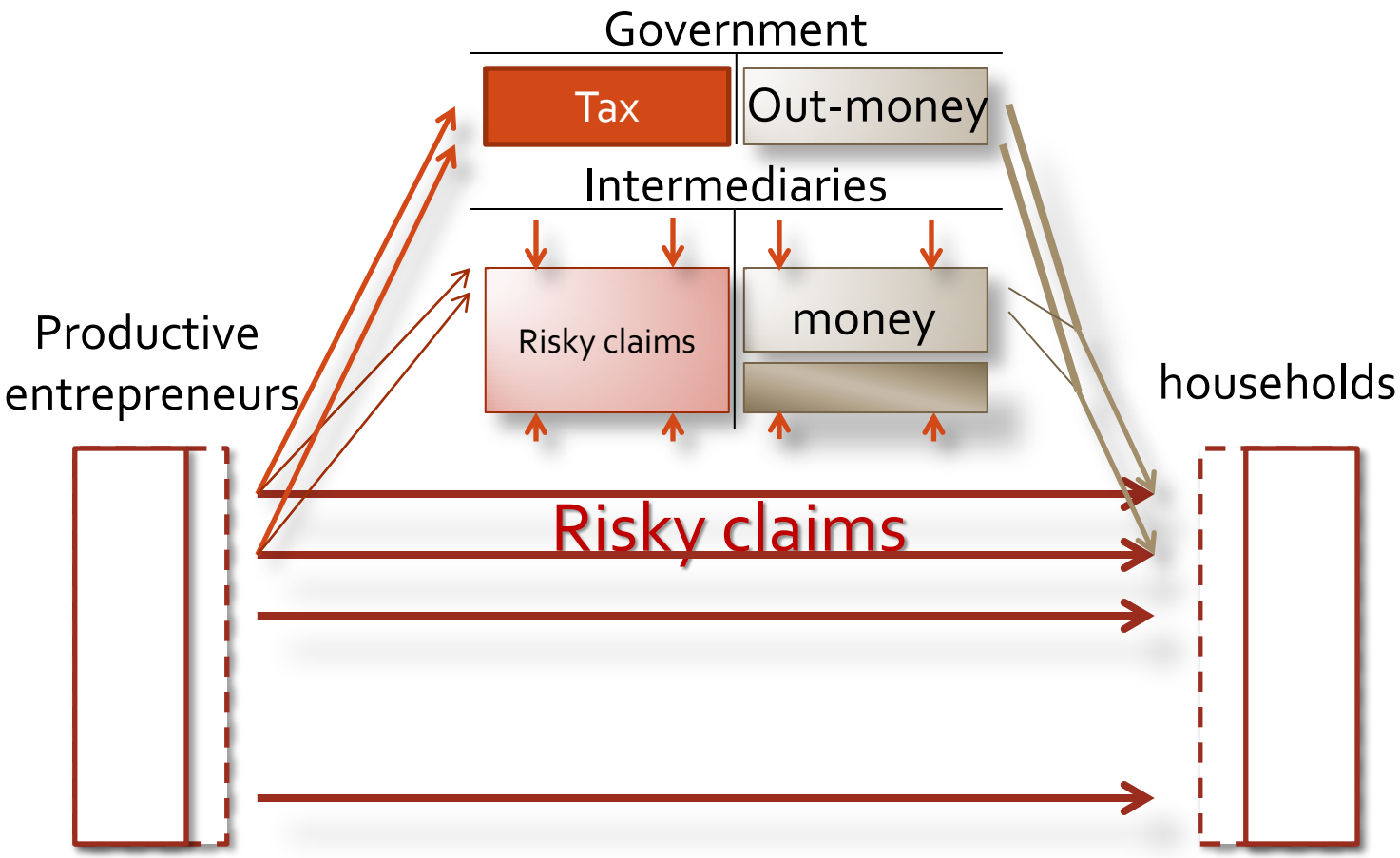
- Split in 3 steps

1. Shock impair assets ↓
2. Balance sheet shrink ↓
3. Real value of deposit ↑

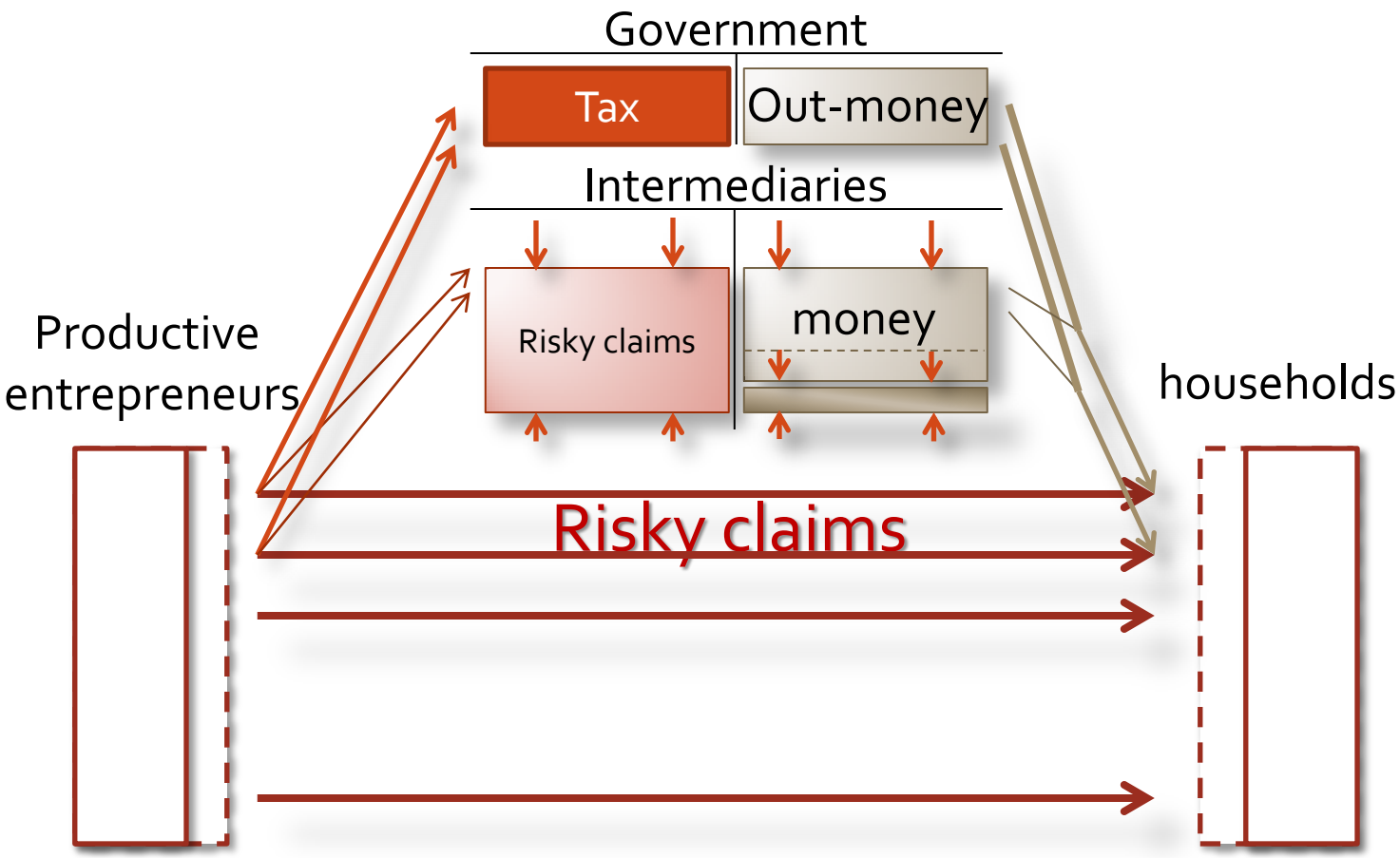


Brunnermeier & Sannikov 2012

Shrink balance sheet – sell off of assets



Disinflation effect – value of liabilities expand



Model with intermediation

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Return	Absent shock	Shock	
		intermediaries	household
On capital r_t^K	$\frac{(1-\tau)(a-\iota_t)}{q_t} + \mu_t^q + \Phi(\iota_t) - \delta$	$(1-\phi)\frac{q_t'}{q_t}$	Loss with prob. $\underline{\phi}$ $\frac{q_t'}{q_t}$ with prob. $(1-\underline{\phi})$
On money r_t^M	$\frac{\tau(a-\iota_t)}{\underline{p}} + \mu_t^p + \Phi(\iota_t) - \delta$	$\frac{p_t{}'}{p_t}$	$\frac{p_t{}'}{p_t}$

- Optimal investment

$$\max_i \Phi(i) - \frac{(1-\tau)i}{q_t} \quad \Rightarrow \quad \Phi'(i_t) = (1-\tau)/q_t$$

- Optimal portfolio choice

Model with intermediation

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Return	Absent shock	shock	
		intermediaries	household
On capital r_t^K	$\frac{(1-\tau)(a-\iota_t)}{q_t} + \mu_t^q + \Phi(\iota_t) - \delta$	$(1-\phi)\frac{q_t'}{q_t}$	Loss with prob. $\underline{\phi}$ $\frac{q_t'}{q_t}$ with prob. $(1-\underline{\phi})$
On money r_t^M	$\frac{\tau(a-\iota_t)}{\underline{p}} + \mu_t^p + \Phi(\iota_t) - \delta$	$\frac{p_t{}'}{p_t}$	$\frac{p_t{}'}{p_t}$

- Optimal investment

$$\max_i \Phi(i) - \frac{i}{q_t} \qquad \Rightarrow \qquad \Phi'(i_t) = 1/q_t$$

- Optimal portfolio choice

Model with intermediation

- Portfolio choice of … similar to before
  - Households
  - Intermediaries discount rate of $\rho > r$
- Law of motion of net worth
- State variable

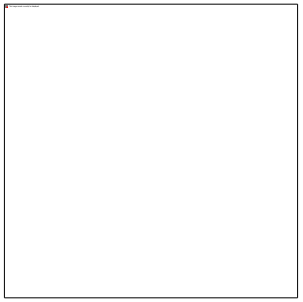
$$\eta_t = \frac{N_t}{(q_t + p_t)K_t}$$

  - Law of motion (Ito's lemma)

- Let's denote $\theta_t \equiv \frac{q_t}{q_t + p_t}$ (fraction of "physical wealth")

Numerical Simulation

- Yuliy can you email me the simulation?



After adverse shock

- Intermediary net worth ↓

- **Capital:**
  - fire sales, price q ↓
  - Allocation efficiency ↓

- **Money:**
  - Lending + deposits ↓
  - value of money p ↑
  - Multiplier ↓

- **Banking**
  - Hit on both sides of balance sheet
  - Externality among banks
  - Competition ↓

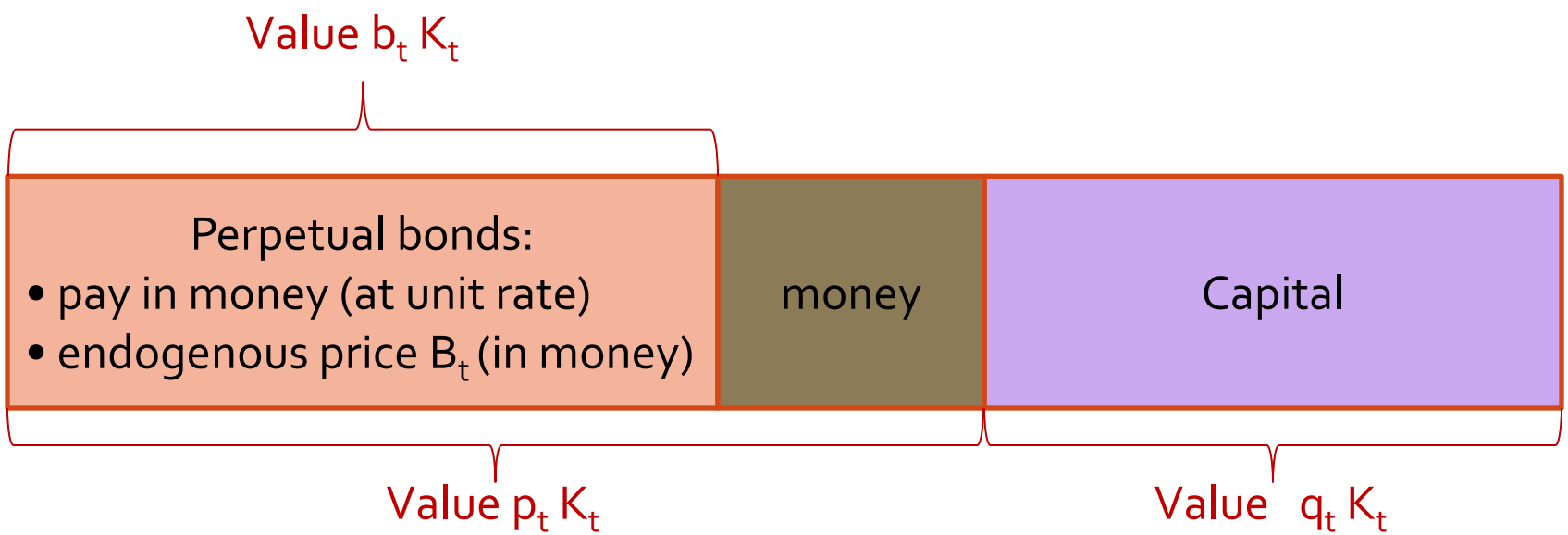
Monetary Policy

- So far, "Gold Standard"
  - outside money supply is fixed
  - pays no interest
  - no central bank

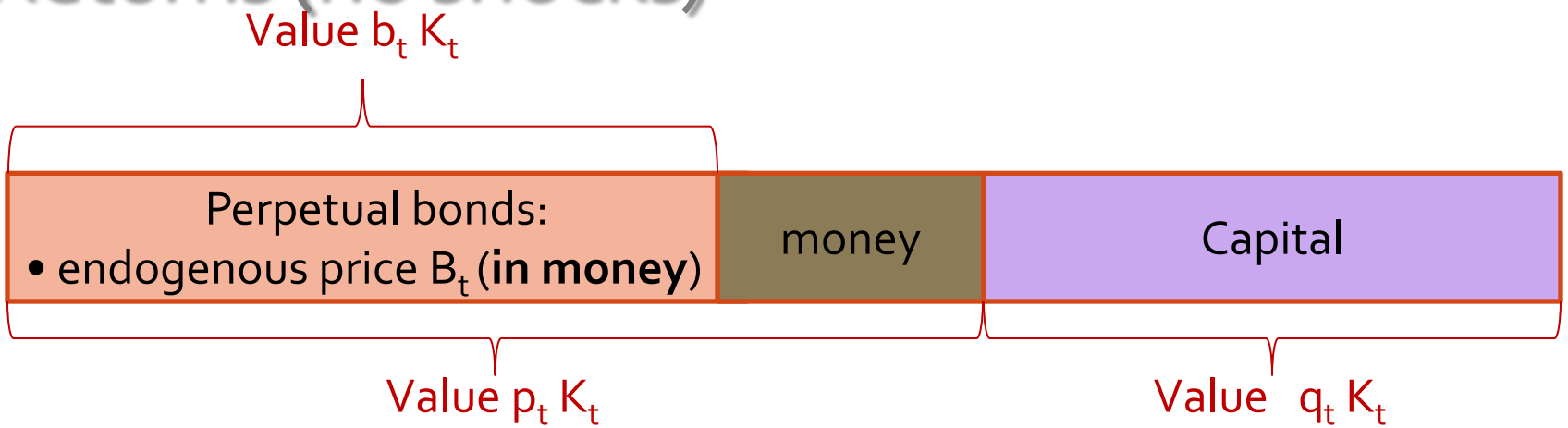
- Introduce consul (perpetual) bond
  - pays interest rate in short-term (outside) money
- Monetary Policies
  - Short-term interest rate policy
    - Central bank accepts deposits & pays interest rate (by printing money)
      - E.g. short-term interest rate is lowered when η becomes small
    - Budget neutral policies (at any point in time)
  - Asset purchase program
    - Bond – open market operations (OMO/QE)

Monetary policy

- Government issues long-term (perpetual) bonds
- Controls short-term interest rate ρ_t, value $b_t K_t$ of bonds outstanding (through open-market operations)
- Now there are three assets in the economy



Returns (no shocks)



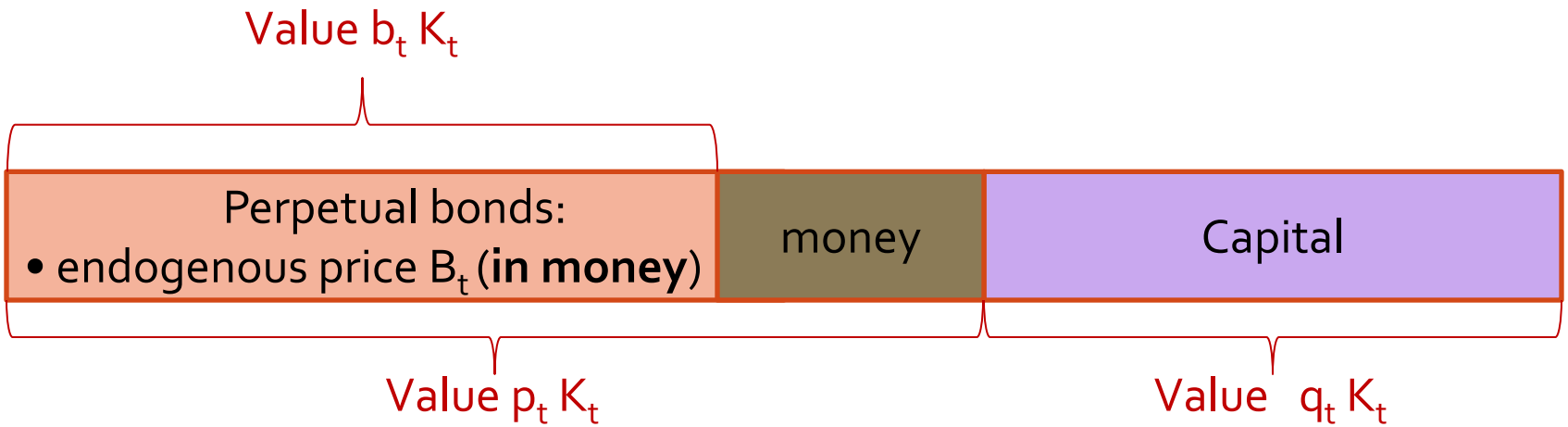
- Buy bond, short money:
  - get current yield $1/B_t$
  - get appreciation in the price of the bond μ_t^B (relative to money)
  - pay short-term interest ρ_t
  - but perfectly hedged to fluctuations in money value (as B_t is price in money)
- Thus, $dr_t^B - dr_t^M = 1/B_t + \mu_t^B - \rho_t$ (in the absence of shocks)
- A world portfolio of money and bonds earns return

$$(1 - b_t/p_t)\, dr_t^M + b_t/p_t\, dr_t^B = \underbrace{\tau\,(a - \iota)/p_t}_{\text{dividend yield}} + \underbrace{\mu_t^p + \Phi(\iota_t) - \delta}_{\text{capital gains of } p_t K_t}$$

- Combining these two equations,

we can derive dr_t^M and dr_t^B separately…

Returns (shock)



- Bond (relative to money) rises in value by B_t'/B_t
- If money rises in value by X, then a world portfolio of money & bonds rises by

$$X\,(1 - b_t/p_t + b_t/p_t\, B_t'/B_t) = p_t'/p_t$$

- Thus, we can get $X = \ldots$

Equilibrium conditions

- Intermediary portfolio choice (with bonds)

$$\max_{x,y}\ x\, dr_t^K + y\, dr_t^B + (1 - x - y) dr_t^M + \lambda \log(x\,(1-\phi) q_t'/q_t + y\, B_t'/B_t X + (1 - x - y)\, X)$$

- Market clearing: same as before, except to clear bonds

$b_t/(p_t + q_t) = y\, \eta_t$ (assuming only intermediaries hold bonds)

Intermediary aggregate net worth evolves as

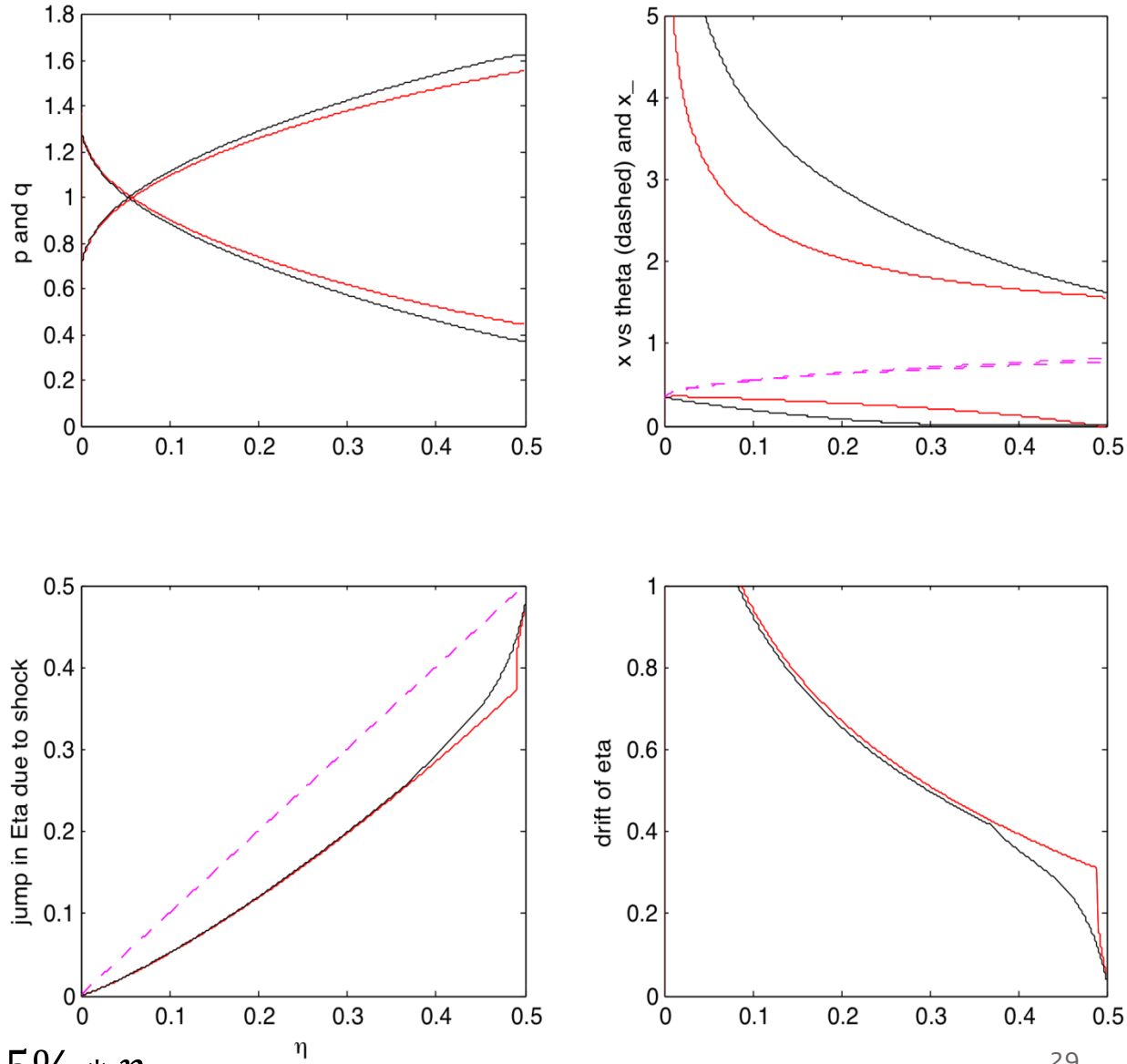
$dN_t/dt = N_t\,(x\, dr_t^K + y\, dr_t^B + (1 - x - y) dr_t^M - r)$ (if no shocks)

$N_t' = N_t\,(x\,(1-\phi) q_t'/q_t + y\, B_t'/B_t X + (1 - x - y)\, X)$ (if shock)

… a bit more algebra to solve, but logic the same as before

Example

- Parameters
  - $r = 5\%$
  - $a = 10\%$
  - $\delta = 4\%$
  - $\phi = 1\%$
  - $\underline{\phi} = 20\%$
  - $\iota = 0$ (degenerate)
  - No policy (red)
  - Policy (black)
    - $\rho(\eta) = .25\% + 5\% * \eta$



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 deflation)
- Because downturns are softened, for all η
  - drop in η conditional on a shock $\downarrow$
  - price of capital $\uparrow$
  - money multiplier $\uparrow$
  - price of money $\downarrow$
  - intermediary allocation to capital $\uparrow$
  - household allocation to capital $\downarrow$
  - risk premia (and thus the rate of recovery, conditional on no shocks) $\downarrow$

Short-term interest rate policy

- Without long-maturity assets changes in short-term interest rate have no effect
  - Interest rate change equals instantaneous inflation change
- With bonds: of all monetary instruments, fraction $p_t/(p_t+b_t)$ is cash and $b_t/(p_t+b_t)$ are bonds
  - deflationary spiral is less pronounced because as η goes down, growing demand for money is absorbed by increase in value of long-term bonds
  - also, intermediaries hedge risks better by holding long-term bonds
  - however, intermediaries also have greater incentives to increase leverage/risk-taking ex-ante
- Effectiveness of monetary policy depend on maturity structure (duration) of government debt

	New Keynesian	I-Theory
Key friction	Price stickiness & ZLB	Financial friction
Driver	Demand driven as firms are obliged to meet demand at sticky price	Misallocation of funds increases incentive problems and restrains firms/banks from exploiting their potential
Monetary policy • First order effects	Affect HH's intertemporal trade-off Nominal interest rate impact real interest rate due to price stickiness	Ex-post: redistributional effects between financial and non-financial sector Ex-ante: insurance effect leading to moral hazard in risk taking (bubbles) - Greenspan put -
• Second order effects	Redistributional between firms which could (not) adjust price	
Time consistency	Wage stickiness Price stickiness + monopolistic competition	Moral hazard

Conclusion

- Unified macro model to analyze both
  - Financial stability
  - Monetary stability
    - Liquidity spirals
    - Fisher deflation spiral

- Capitalization of banking sector is key state variable
  - Price stickiness plays no role (unlike in New Keynesian models)

- Monetary policy rule
  - Affects money supply
  - Redistributional monetary transmission channel
    - "stealth recapitalization"
  - Time inconsistency problem
    - "Greenspan put"

After a negative shock

- Intermediary net worth ↓
- **Capital:**
  - fire sales, price q ↓
  - Allocation efficiency ↓
- **Money:**
  - Lending + deposits ↓
  - value of money p ↑
  - Multiplier ↓
- Banking
  - Hit on both sides of balance sheet
  - Externality among banks
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