Motivation

- Framework to study monetary and financial stability
- Interaction between monetary and macroprudential policy
- Connect theory of value and theory of money
- Intermediation (credit)
  - “Excessive” leverage and liquidity mismatch
- Inside money – as store of value
  - In downturns, intermediaries create less inside money
    - Endogenous money multiplier = f(capitalization of critical sector)
  - Demand for money rises with endogenous volatility
  - Value of money goes up – Disinflation spiral a la Fisher (1933)
  - Fire-sales of assets - Liquidity spiral
- Flight to safety
- Time-varying risk premium and endogenous volatility dynamics
Risk, Monetary & Macropru Policy

Risk

- Exogenous risk
  - Sector-specific
  - Idiosyncratic

- Endogenous risk
  - Shifts in wealth share
  - Variation in risk premia

Risk management

- Monetary policy as “risk transfer”
  - Affects (relative) asset prices reduces systemic risk

- Macroprudential policy
  - Affects/limits quantities/risk taking
Some literature

- Baseline model without intermediaries:
  - Money pays no dividend and is a bubble

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- “Money view” (Friedman & Schwartz)
- “Credit view” (Tobin)

BGG, Kiyotaki & More, He & Krishnamurthy, BruSan2014, Drechsler, Savov & Schnabl

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<td>Dynamic inefficiency $r &lt; g$</td>
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# Some literature

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\[ g = \text{capital gains rate on projects} \]

\[ r = \text{risk-free rate in moneyless economy} \]

\[ \text{expected return on projects} \]

\[ \text{income/dividend yield} \]

\[ \text{risk premium} \]
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- “Credit view” (Tobin)
  - Bernanke, Gertler & Gilchrist, Kiyotaki & More, BruSan2014, He & Krishnamurty, Drechsler, Savov & Schnabl

\[
g = \text{capital gains rate on projects} \\
\text{expected return on projects income/dividend yield} \\
\text{risk premium} \\
r = \text{risk-free rate in moneyless economy}
\]
Outline of model

- Technologies $a$
  - Households have to
    - Specialize in one subsector for one period
    - Demand for money
      \[
      \frac{dk_t}{k_t} = \cdots dt + \sigma^a dZ^a_t + \tilde{\sigma} d\tilde{Z}^a_t
      \]

- Technologies $b$
  - Sector specific + idiosyncratic risk
    \[
    \frac{dk_t}{k_t} = \cdots dt + \sigma^b dZ^b_t + \tilde{\sigma} d\tilde{Z}^b_t
    \]
Add outside money

- Technologies $a$
  - Households have to
    - Specialize in one subsector for one period
    - Demand for money
  - Money – store of value
    - Fixed supply, unproductive
    - $g > r$ dynamic inefficiency
    - Bubbles/money increase efficiency

- Technologies $b$

Outside Money

Switch technology
Add outside money

- Technologies $a$

- Households have to
  - Specialize in one subsector for one period
  - Demand for money

- Money – store of value
  - Fixed supply, unproductive
  - $g > r$ dynamic inefficiency
  - Bubbles/money increase efficiency
Add intermediaries

Technologies $a$

- Risk can be partially sold off to intermediaries

Technologies $b$

- Risk is not contractable (Plagued with moral hazard problems)
Add intermediaries

Technologies $\alpha$

- Add intermediaries
  - Net worth

Technologies $\beta$

- Outside Money

Intermediaries
  - Can hold outside equity & diversify within sector $A$
  - Monitoring
Add intermediaries

- Technologies $a$
  - Intermediaries
    - Can hold outside equity & diversify within sector $A$
    - Monitoring
Add intermediaries

- Technologies $\alpha$
  - Inside Money
  - Outside Money
  - Inside equity
  - Risky Claim
  - Risky Claim
  - Risky Claim
  - Net worth
  - Inside Money (deposits)
  - Pass through

- Technologies $\beta$
  - Inside Money
  - Outside Money
  - Inside equity
  - Risky Claim
  - Risky Claim
  - Risky Claim
  - Net worth
  - Inside Money (deposits)
  - Pass through

- Intermediaries
  - Can hold outside equity & diversify within sector $A$
  - Monitoring
  - Create inside money
  - Maturity/liquidity transformation
Shock impairs assets: 1st of 4 steps

- Technologies $a$
  - Money
    - Inside equity
    - Risky Claim
  - Outside Money
    - Risky Claim
    - ... (repeated)
    - Inside Money (deposits)

- Technologies $b$
  - Money
    - Inside equity
    - Risky Claim
  - Outside Money
    - Losses
Shrink balance sheet: 2\textsuperscript{nd} of 4 steps

- Technologies $a$

- Technologies $b$

Switch
Liquidity spiral: asset price drop: 3\textsuperscript{rd} of 4

- Technologies $a$

  Switch

- Technologies $b$

Deleveraging

Outside Money

Inside Money (deposits)

Net worth

Losses

Money

Risky Claim

Inside equity

Risky Claim

Risky Claim

...
Disinflationary spiral: 4\textsuperscript{th} of 4 steps

- Technologies \textit{a}
- Technologies \textit{b}
... after an adverse shock

- Intermediaries are hit and shrink their balance sheets inducing
  - Asset side liquidity spiral financial stability
  - Liability side disinflation spiral price stability

- Response of intermediaries to adverse shock leads to endogenous risk
  - Amplification
  - Persistence

- Other sectors can also be undercapitalized
  - Japan 1980: corporate sector
  - US 2000s: household sector
Policy

- Monetary Policy
  - Introduce long-term bond
  - Central bank’s actions change money supply/transfer risk
    - Interest rate cuts in downturns raise the value of long-term bonds
    - Change relative price between long-term bond and short-term money
    - Risk transfer (ex-post redistribution)

- Macro-prudential policy
  1. Leverage upper bounds
  2. Affect agents portfolio choice directly
### Formal model: capital & output

#### Technologies

**Physical capital** $K_t$
- Capital share

**Output goods**

Aggregate good (CES)
- Consumed or invested
- Numeraire

Price of goods

- Model setup in paper is more general: $Y_t = A(\psi_t)K_t$

<table>
<thead>
<tr>
<th>Technologies</th>
<th>$a$</th>
<th>$b$</th>
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<tr>
<td>Physical capital $K_t$</td>
<td>$\psi$</td>
<td>$1 - \psi$</td>
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<td>Output goods</td>
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### Formulas

- Physical capital $K_t$
  - Capital share

- Output goods
  - Imperfect substitutes
  - CES

- Price of goods
  - Imperfect substitutes

- Comprehensive

\[
Y_t^a = Ak_t^a \quad \text{Imperfect substitutes} \quad Y_t^b = Ak_t^b
\]

\[
Y_t = \left( \frac{1}{2}(Y_t^a)^{(s-1)/s} + \frac{1}{2}(Y_t^b)^{(s-1)/s} \right)^{s/(s-1)}
\]

\[
P_t^a = \frac{1}{2}(Y_t^a)^{1/s} \quad P_t^b = \frac{1}{2}(Y_t^b)^{1/s}
\]
Formal model: risk

- When $k_t$ is employed in sector $a$ by agent $j$

\[ dk_t = (\Phi(i_t) - \delta)k_t \, dt + \sigma^a k_t \, dZ^a_t + \sigma^j k_t \, d\tilde{Z}^a_t \]

- $\Phi(i_t)$ is increasing and concave, e.g. $\log\left(\frac{\kappa i_t + 1}{\kappa}\right)$
- All $dZ$ are independent of each other

- Intermediaries can diversify within sector $A$
  - Face no idiosyncratic risk

- Households cannot become intermediaries or vice versa
## Financing constraints

**Technologies**

<table>
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<th>Equity issuance</th>
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<tr>
<td>- Special case</td>
<td>Inside equity $\chi_t \geq \chi$</td>
<td>Inside equity only</td>
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<td>$\chi = 0%$ (no inside equity)</td>
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**Households’ risk**

- $dZ^a$ & $d\tilde{Z}^a$
  - sector & idiosyncratic

**Intermediaries’ risk**

- $dZ^a$
  - can diversify idiosyncratic risk

- $dZ^b$ & $d\tilde{Z}^b$
  - sector & idiosyncratic
Formal model: preferences

- All agents have logarithmic utility with discount rate $\rho$

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

- Implies
  - Consumption = $\rho$ * net worth
  - Equilibrium Sharpe ratio $\propto$ Covariance with net worth
Asset returns on money

- **Money**: fixed supply in baseline model, total value $p_tK_t$
  - Return = capital gains (no dividend/interest in baseline model)
  - If $dp_t/p_t = \mu_t^p \ dt + \sigma_t^p \ dZ_t,$
  - $dK_t/K_t = (\Phi(\iota_t) - \delta) dt + \psi_t \sigma^a dZ^a_t + (1 - \psi_t) \sigma^b dZ^b_t$

\[
dr_t^M = \left( \Phi(\iota_t) - \delta + \mu_t^p + (\sigma_t^p)^T \sigma_t^K \right) dt + (\sigma_t^p + \sigma_t^K) dZ_t
\]

- $\pi_t = \frac{p_t}{q_t + p_t}$ fraction of wealth in form of money
Equilibrium is a map

Histories of shocks \( \{Z_\tau, 0 \leq \tau \leq t\} \) \( \rightarrow \) prices \( q_t, p_t \), allocation

\[
\begin{align*}
\psi_t, \psi^b_t, \psi^a_t, (\eta^b_t, \eta^a_t), (c_t, c^a_t, c^b_t)
\end{align*}
\]

Wealth distribution

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

A’s and intermediaries’ wealth share

- All agents maximize utility
  - choose portfolio, consumption, technology
- All markets clear \( (\psi_t + \psi^b_t + \psi^a_t = 1, \text{etc.}) \)

At “steady state” \( \eta^* : \mu^\eta_t = 0 \)
Equilibrium conditions of general model

1. Log utility: Consumption = ρ × net worth
   - Clearing of goods market: \( Y_t - \iota_t K_t = \rho (p_t + q_t) K_t \)

2. Log utility: \( E[\text{excess return}] \propto \text{covariance net worth} \)
   - I-net worth: \( dN_t/N_t = x_t dr_t^I + (1 - x_t) dr_t^M - \rho dt \)
     with portfolio share \( x_t = \frac{\psi_t q_t}{\eta_t(p_t + q_t)} \)
   - I-net worth risk:
     \[
     \sigma_t^N = x_t \left( \sigma_t^a 1^a + \sigma_t^q - \sigma_t^p - \sigma_t^K \right) + \sigma_t^K + \sigma_t^p
     \]
     \( \equiv v_t \)
   - Required return:
     \[
     \frac{E[dr_t^a - dr_t^M]}{dt} - \lambda_t = (v_t)^T \sigma_t^N
     \]
Numerical example

\[ \rho = 5\%, a = .5, \sigma^a = \sigma^b = .3, \sigma^j = .9, s = .8, \Phi(t) = \frac{\log[\kappa t + 1]}{\kappa}, \kappa = 2, \chi = 0 \]

Prices

of money and physical capital

\[ \pi = \frac{p}{p+q} \]
Numerical example

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- **Prices**
  - Prices of money and physical capital
  - \( \pi = \frac{p}{p+q} \)

- **Allocation shares**
  - Allocation shares of physical capital across sectors
  - \( 1 - \psi_t, \) households producing good a (inside equity)
  - \( \psi_t(1 - \chi_t), \) intermediaries holding outside equity of households
Numerical example: dynamics of $\eta$

\[
\eta \sigma_t^\eta = \frac{x_t \eta}{1 + \left( \frac{\psi - \eta}{\eta} \right) \frac{\pi'(\eta)}{\pi/\eta}} (\sigma^a 1^a - \sigma^K_t)
\]

- **Steady state drift**
- **volatility**
- **drift**
- **leverage elasticity amplification**
Endogenous risk - amplification

- Let $\pi = \frac{p}{p+q} = \frac{1}{1+q/p}$ “money wealth share”
- Levering up to add capital intermediaries face risk

\[ v_t = \left(1 - \frac{\pi'(\eta)}{\pi(\eta)(1-\pi(\eta))}\right)\left(\sigma^a 1^a - \sigma_K\right) \]
Welfare analysis

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

- No monetary economics
  - Fixed outside money supply
  - Amplification/endogenous risk through
    - Liquidity spiral asset side of intermediaries’ balance sheet
    - Disinflationary spiral liability side

- Monetary policy
  - Wealth shifts by affecting relative price between
    - Long-term bond
    - Short-term money
  - Risk transfers – reduce endogenous aggregate risk

- Macroprudential policy
Money view

- Restore money supply
  - Helicopter drop to savers
Money view

- Restore money supply
  - Helicopter drop to savers

Diagram:
- Government
  - Outside money
  - Reserves

- Banks
  - Reserves
  - Inside money
  - Equity

- Savers
Money view

- Restore money supply
- Switches off Deflationary spiral
  - Intermediaries are better capitalized
  - Slightly more credit but credit is not restored
Credit view

- Restore “healthy” credit
  - Not zombie banks
  - Not vampire banks

- Recapitalization
  - Gift to solvent banks
Credit view

- Restore “healthy” credit
  - Not zombie banks
  - Not vampire banks

- Recapitalization
  - Gift to solvent banks

- Switches off
  - Disinflationary spiral
  - Liquidity spiral
    - Credit is restored, as banks are recapitalized

- Next, realistic monetary policy
Risk transfers through interest rate policy/OMO

- Introduce long-term (perpetual) bond
  - No default ... held by intermediaries in equilibrium
  
  \[ \text{Value } b_t K_t \]

  Perpetual bonds:
  - pay in money (at unit rate)
  - endogenous price \( B_t \) (in money)

  \[ \text{Money} \quad \text{Capital} \]

  \[ \text{Value } p_t K_t \]

  \[ \text{Value } q_t K_t \]

  - Value of long-term bond is endogenous

  \[ dB_t / B_t = \mu_t^B \, dt + \sigma_t^B \, dZ_t \]

- Monetary policy
  
  - Short-term interest rate \( r_t \) & outstanding value \( b_t K_t \)
  - Example:

    \[ \frac{b_t B'(\eta)}{p_t B(\eta)} = \alpha_t \frac{\pi'(\eta)}{\pi(1-\pi)} \]
Monetary policy and endogenous risk

- Intermediaries’ risk (borrow to scale up)

\[
\eta \sigma_t^\eta = \frac{x_t \eta}{1 + \left(\frac{\psi - \eta}{\eta} \frac{\pi'(\eta)}{\pi/\eta} + \frac{\psi - \eta}{\eta} + \frac{\pi}{\eta} (1 - \psi)\right) \frac{b_t B'(\eta)}{p_t B(\eta)/\eta}} (\sigma_A 1^a - \sigma_t^K)
\]

amplification mitigation fundamental risk

- Example:

\[
\frac{b_t B'(\eta)}{p_t B(\eta)} = \alpha_t \frac{\pi'(\eta)}{\pi(1-\pi)}
\]

- Intuition:
  with right monetary policy bond price \( B(\eta) \) rises as \( \eta \) drops “stealth recapitalization”
  - Can reduce liquidity and disinflationary spiral
Numerical example with monetary policy

\[ \rho = 5\%, a = 0.5, \sigma_A = \sigma_B = 0.3, \sigma_i = \sigma_j = 0.9, \epsilon = 0.8, \Phi(\iota) = \frac{\log[\kappa \iota + 1]}{\kappa}, \kappa = 2 \]

- Prices
- Allocation shares
Numerical example with monetary policy

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Recall

\[ \frac{b_t B'(\eta)}{p_t B(\eta)} = \alpha_t \frac{\pi'(\eta)}{\pi(1 - \pi)} \]
Monetary policy ... in the limit

- full risk sharing of all aggregate risk

\[ \eta \sigma_t^\eta = \frac{x_t \eta}{1 + \left(\frac{\psi - \eta}{\eta}\right)\pi'(\eta) - \left(\frac{\psi - \eta}{\eta} + \frac{\pi(1 - \psi)}{\eta}\right)\frac{b_t}{p_t B(\eta)} B'(\eta)} (\sigma_A 1^a - \sigma_t^K) \]

- \(\eta\) is deterministic and converges over time towards 0
Monetary policy .... in the limit

- Welfare is lower, despite aggregate risk sharing

[Graph showing welfare levels with and without policy, illustrating perfect aggregate risk sharing.]
Overview

- **No monetary economics**
  - Fixed outside money supply
  - Amplification/endogenous risk through
    - Liquidity spiral asset side of intermediaries’ balance sheet
    - Disinflationary spiral liability side

- **Monetary policy**
  - Wealth shifts by affecting relative price between
    - Long-term bond
    - Short-term money
  - Risk transfers – reduce endogenous aggregate risk

- **Macroprudential policy**
  - Leverage limit only
  - Directly affect portfolio positions
MacroPru: Leverage bound only

- Intermediaries’ leverage bound
  - Still countercyclical

- Prices $q$ and $p$
  - $p$ is above .5 now
  - Inflation in downturns
    - Stabilizes I’s balance sheet
MacroPru: Leverage bound only + MoPo

- Intermediaries are prevented to lever up
MacroPru policy

- Regulator can control
  - Portfolio choice $\psi$, $x$
  - Investment decision $\nu(q)$
  - Consumption decision $c$

- cannot control

of intermediaries and households
MacroPru policy

- Regulator can control
  - Portfolio choice $\psi s, xs$
- cannot control
  - Investment decision $i(q)$
  - Consumption decision $c$

  of intermediaries and households

- De-facto controls $q$ and $p$ within some range
- De-factor controls wealth share $\eta$
  - Force agents to hold certain assets and generate capital gains

- In sum, regulator maximizes sum of agents value function
  - Choosing $\psi^b, q, \eta$
Numerical example: MacroPru

- Force higher $\psi^b$ production of good $b$
- Force higher value of money $p$ (form of financial repression??) (despite no hedging risk profile)
### Welfare comparison

Remarks:
- Without policy Pareto inefficiency for low $\eta$
- Full aggregate risk sharing → low welfare

- Solid: Value functions
- Dashed: Utility flow
Conclusion

- Unified macro 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

- 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 (due to idiosyncratic risk)

- Macro-prudential policies
  - Leverage constraints + MoPo to achieve superior welfare optimum
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<td>Key friction</td>
<td>Price stickiness &amp; ZLB</td>
</tr>
<tr>
<td>Role of money</td>
<td>Unit of account</td>
</tr>
<tr>
<td>Driver</td>
<td>Demand driven as firms are obliged to meet demand at sticky price</td>
</tr>
<tr>
<td>Monetary policy</td>
<td>Optimal price setting over time</td>
</tr>
<tr>
<td>- implementation</td>
<td>Affect HH’s intertemporal trade-off</td>
</tr>
<tr>
<td>- First order effects</td>
<td>Nominal interest rate impact real interest rate due to price stickiness</td>
</tr>
<tr>
<td>Time consistency</td>
<td>Wage stickiness Price stickiness + monopolistic competition</td>
</tr>
<tr>
<td>Yield curve</td>
<td>Expectation hypothesis only</td>
</tr>
</tbody>
</table>