T. W. SCHULTZ LECTURE

Markus Brunnermeier

based on

A Macro-Model with a Financial Sector + …

with Yuliy Sannikov

Chicago, June 3rd, 2010
Motivation

- Financial crises occur periodically, Kindleberger (1993)
  - Spirals and adverse feedback loops
  - Spillovers
    - Across financial institutions
    - To real economy
  - Deflationary pressure, Fisher (1933)

- Current macro approach
  - Many DSGE models use representative agents, ignore financing frictions and spillover effects
  - Models with a financial sector (e.g. Bernanke-Gertler-Gilchrist) log-linearize near steady state, miss instability below steady state (due to non-linear dynamics)
  - Monetary effects are often due to price stickiness
  - Price stability vs. financial stability analyzed in different frameworks
Main messages

- Macro-framework with financial sector at the center
- Paper today:
  - Non-linear amplification effects due to volatility dynamics and precautionary motive
  - Asset price correlation in times of crisis
  - Spillover effects
- Money paper:
  - Endogenous role of money
  - Interaction between outside money and inside money
  - Deflationary spirals during financial crisis
Heterogeneous agents + some literature

- Productive
  - BGG
  - Kiyotaki-Moore
  - He-Krishnamurthy
  - Moll
- Less patient
- Less risk averse
  - Garleanu-Pedersen
- More optimistic
  - Geanakoplos

Limited direct lending due to frictions

- Less productive
- More patient
- More risk averse
- More pessimistic
MDG Model outline

- Productive
  - Intermediary
    - Monitoring
      - Diamond (1984)
      - Holmström-Tirole (1997)
  - Less productive
Model outline

- Productive
- Intermediary
  - Monitoring
    - Diamond (1984)
    - Holmström-Tirole (1997)
- Less productive

Why short-term debt?
- Less info-sensitive
- Maturity rat race

Brunnermeier-Oehmke
Some Literature … on amplification

- **Bernanke-Gertler (1989)**
  - Overlapping generations model, but with **persistence**
  - Bad shocks erode net worth of young entrepreneurs, who cut back on investments, leading to low productivity and low net worth of entrepreneurs in the next period

  - Infinitely-lived agents
  - KM: Leverage bounded by margins-KM; BGG: bankruptcy costs
  - Stronger **amplification** effects through **prices** (low net worth reduces leveraged institutions’ demand for assets, lowering prices and further depressing net worth)

- **Brunnermeier-Pedersen (2009)**
  - Volatility effect due to higher margins/haircuts
Some Literature ... on amplification

- Bernanke-Gertler (1989)
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- Brunnermeier-Pedersen (2009)
  - Volatility effect due to higher margins/haircuts
1. **Unstable dynamics** away from steady state due to (nonlinear) liquidity spirals

   - **Shock to capital**
   - **Loss of net worth**
   - **Precaution + tighter margins**
   - **Fire sales**
   - **Volatility price**

2. **Welfare: externalities**
   - **within financial sector:** When leveraging up, institutions ignore that their fire-sales depress prices for others — inefficient pecuniary externality to real economy

3. **Asset prices become more correlated in crisis**

4. **Securitization** can lead to excessive leverage
As intermediaries’ net worth declines
- Intermediation + *inside money* shrinks
  - Economic activity declines
- Value of *outside money* rises - deflation
- Intermediaries are doubly hit
  - Asset side: asset values decrease
  - Liability side: real debt value increases
- Deflationary spiral
Roadmap

- Motivation and Preview
- Non-linear amplification
  - volatility dynamics + precautionary hoarding
- Money effect: deflationary spiral
- Externalities
  - Competitive = social planners’ solution in baseline model
  - Within financial sector (Mod. 1: speculative HH)
  - Towards real economy (Mod. 2: labor sector)
- Asset pricing implication (Mod. 3: idio-shocks)
- Defaultable debt and securitization (Mod. 4: idio-jumps)
Model details

- **Preferences**
  - Risk neutral but consumption $\geq 0$ for all agents
  - Discount rate: $r$ for households, $\rho \geq r$ for experts

- **Output**
  - $y_t = a k_t$ (easily manipulated)

- **Capital**
  - $dk_t = (\Phi(i_t/k_t) - \delta) k_t dt + \sigma k_t dZ_t$

- **Investment**
  - Internal: $i_t$ positive or negative (partial reversibility = technological liquidity)
  - External: purchase or sell capital $k_t$ at price $p_t$

- **Endogenous price process for capital**
  \[
  \frac{dp_t}{p_t} = \mu_t^p \ dt + \sigma_t^p \ dZ_t
  \]
Less productive households
- face depreciation of $\delta > \delta$ and
- cannot speculate (added later)

liquidation value:
- $p_t \geq p$

$$p = \max_i \frac{a - i^*}{r - (\phi(i^*) - \delta)}$$

$:= q(p)$
Capital structures

- Productive
- Intermediary
  - Monitoring
    - Diamond (1984)
    - Holmström-Tirole (1997)
- Less productive

\[
\begin{align*}
\frac{\alpha^E}{\alpha^I} & \quad \text{incentive for entrepreneur to exert effort} \\
\frac{\alpha^I}{\text{of total risk}} & \quad \text{incentive for intermediaries to monitor} \quad \text{(have to hold outside equity)}
\end{align*}
\]
Microfoundation of capital structures

- **Assumption**: value of assets $p_t k_t^i$ is contractable, $k_t^i$ not
- **Agency problem of entrepreneur**
  - Can take projects w/ NPV < 0, private benefit $b(m) < 1$ per $1$ destroyed
  - $m$ is amount of monitoring by intermediary
  - Incentive constraint: $\alpha^E \geq b(m)$, binds in equ. $\Rightarrow \alpha^E (m)$
- **Agency problem of intermediary**
  - Save monitoring cost $c(m)$ per $1$ if shirking
  - Incentive constraint: $\alpha^I \geq c(m)$
- **Solvency constraint**: $n_t \geq 0$ (implied by IC constraints)

Assume $c(m) + b(m)$ is a constant for all $m$
- entrepreneurs’ & intermediaries’ net worth are substitutes
- Special case: if entrepreneurs’ net worth = 0, then $m$ s.t. $b(m) = 0$
Merging productive HH & Intermediaries

- **Productive**
  - Capital
  - Debt
  - Equity
  - $k_t p_t$

- **Intermediary**
  - Monitoring
    - Diamond (1984)
    - Holmström-Tirole (1997)
  - Debt (short-term)
  - Equity (inside, outside)
  - $\alpha^I$ of total risk

- **Less productive**

\[ \alpha := \alpha^E + \alpha^I \geq b(m) + c(m) \]

“merged experts”
Merging productive HH & Intermediaries

- **Productive**
  - Capital
  - Financing
  - \( \alpha^E = 0 \)
  - Productive entrepreneurs have no capital, \( \alpha^E = 0 \)
  - Perfect monitoring required, \( b(m) = 0 \)

- **Intermediary**
  - Debt: short-term
  - Equity: inside
  - \( \alpha^I = 1 \)
  - Intermediary can’t issue outside equity, \( \alpha^I = 1 \) (appropriate choice of \( b(m), c(m) \))

- **Less productive**
Balance sheet dynamics

- Productive
- Intermediary
- Less productive

\[ \frac{dk_t}{k_t} = (\Phi(i_t/k_t) - \delta) dt + \sigma dZ_t \]
\[ \frac{dp_t}{p_t} = \mu_p dt + \sigma_p dZ_t \]
Balance sheet dynamics

- Productive
- Intermediary
- Less productive

\[
dk_t/k_t = (\Phi(i_t/k_t) - \delta)dt + \sigma dZ_t
\]
\[
dp_t/p_t = \mu_t^p dt + \sigma_t^p dZ_t
\]

Product rule of Ito’s Lemma:
\[
d(X_t Y_t) = dX_t Y_t + X_t dY_t + \sigma_X \sigma_Y dt
\]
**Balance sheet dynamics**

- **Productive**
  
  
- **Intermediary**
  
- **Less productive**

\[
\begin{align*}
\frac{dk_t}{k_t} &= \left(\Phi \left(\frac{i_t}{k_t}\right) - \delta\right) dt + \sigma dZ_t \\
\frac{dp_t}{p_t} &= \mu^p_t dt + \sigma^p_t dZ_t \\
\frac{dk_t}{kp_t} &= \left(\Phi \left(\frac{i_t}{k_t}\right) - \delta + \mu^t_p + \sigma^t_p\right) (k_t p_t) dt + \left(\sigma + \sigma^t_p\right) (k_t p_t) dZ_t \\
dd_t &= (r d_t - a k_t + i_t) dt + dc_t \\
qn_t &= d(k_t p_t) - dd_t \\
qn_t &= r n_t dt + a k_t dt - i_t dt - k_t p_t \left[\left(\Phi \left(\frac{i_t}{k_t}\right) - \delta + \mu^t_p + \sigma^t_p\right) dt + \left(\sigma + \sigma^t_p\right) dZ_t\right] - dc_t
\end{align*}
\]
Equilibrium

- Aggregate variables \( N_t, K_t \)
- State variable \( \eta_t = N_t/K_t \)

1. Internal investment
   - Entrepreneur takes price \( p_t \) as given
     \[
     \max_{i_t} p_t k_t \left( \Phi\left(\frac{i_t}{k_t}\right) - \delta\right) - i_t
     \]
   - FOC: \( p_t \Phi'(i_t/k_t) - 1 = 0 \) (Tobin’s q)
     \[
     \Rightarrow \lambda(p_t) = \frac{i_t}{k_t}, \text{ rate of investment per unit of capital}
     \]
   - \( g(p_t) := \Phi\left(\frac{i_t}{k_t}\right) - \delta = \text{(optimized) growth rate of capital} \)
   - Note: \( g(p_t) = -\infty \) for \( p_t < (a - i^*)/(r - g) \): capital is sold to unproductive HH

2. External investment
   - Given price process
     \[
     \frac{d\sigma_t^p}{p_t} = \mu_t^p \, dt + \sigma_t^p \, dZ_t
     \]
   - Solvency constraint \( n_t \geq 0 \)

3. When to consume?

4. Market clearing:
   - Total demand = \( K_t \)
Intuition – main forces at work

- **Investment:**
  - *Scale up*
    - Scalable profitable investment opportunity
  - *Higher leverage (borrow at r)*
  - *Scale back*
    - **Precaution:** - don’t exploit full (GE) debt capacity – “dry powder”
      - Ultimately, stay away from fire-sales at $p_t$
      - Debt can’t be rolled over if $d > k_t p_t$ (note, price is depressed)
  - **Ways to scale back:**
    - Internal disinvestment, limited by $\Phi(.)$
    - External disinvestment, sale of assets (price impact $f(\text{others’ leverage})$)

- **Consumption**
  - Consume *early* and borrow $r < \rho$
  - Consume *late* to overcome investment frictions
**External investment & consumption**

- **Price**
- **Intermediary’s value function**

\[ p(\eta_t) \]

\[ f(\eta_t)n_t \]

- solve for equilibrium \( p(\eta_t) \) and \( f(\eta_t) \)

- **Bellman equation**

\[ \rho f(\eta_t)n_t = \max_k E[dc + d(f(\eta_t)n_t)] = \ldots \]

- Optimal “external investment/trading strategy” \( k_t \) (as a function of \( \eta_t \) and \( n_t \))
Solving...

- **Bellman equation:**
  \[
  \rho f(\eta_t)n_t \, dt = \max_k E[d(f(\eta_t)n_t)] \quad \text{(when } f(\eta) > 1)\
  E[d(f(\eta_t)n_t)] = \mu_t^f n_t \, dt + f'(\eta_t) \sigma_t^\eta k_t p_t (\sigma + \sigma_t^p) \, dt + f(\eta_t) (r n_t + (a - \iota(p_t)) k_t + k_t p_t (g(p_t) - r + \mu_t^p + \sigma \sigma_t^p))
  \]

- **FOC:**
  \[
  \frac{(a - \iota(p_t))}{p_t} + g + \mu_t^p + \sigma \sigma_t^p - r = -\frac{f'(\eta_t)}{f(\eta_t)} \sigma_t^\eta (\sigma + \sigma_t^p)
  \]
  - expected excess return on capital
  - risk premium from precautionary motive

- Using FOC, Bellman equation simplifies to
  \[
  (\rho - r) f(\eta_t) = \mu_t^f
  \]

- Derive \( \mu_t^p, \mu_t^f, \sigma_t^\eta, \sigma_t^p \) in terms of \( p', p'', f', f'' \) to obtain ODE for \( p(\eta) \) and \( f(\eta) \)
Solving …

1. \[
\frac{a - \iota(p_t)}{p_t} + g(p_t) + \mu_t + \sigma^p_t - r = -\frac{f'(\eta_t)}{f(\eta_t)} \sigma^\eta_t (\sigma + \sigma^p_t)
\]
where
\[
\mu^p_t = \frac{p'(\eta_t)[(r - g(p_t) + \sigma^2)(\eta_t - p_t) + a - \iota(p_t)] + \frac{1}{2} (\sigma^\eta_t)^2 p''(\eta_t)}{p_t (1 - p'(\eta_t))}
\]
\[
\sigma^p_t = \frac{p'(\eta_t)\sigma(p_t - \eta_t)}{p_t (1 - p'(\eta_t))}
\]
\[
\sigma^\eta_t = \frac{\sigma(p_t - \eta_t)}{1 - p'(\eta_t)}
\]

2. \[
(r - r) f(\eta) = f'(\eta)((r - g(p_t) + \sigma^2)(\eta - p_t) + a - \iota(p_t) + p_t \mu^p_t) + \frac{1}{2} (\sigma^\eta_t)^2 f'''(\eta_t)
\]
from \((\rho-r) f(\eta) = \mu^f_t\)

- 4 boundary conditions: \(p(0) = p, \ p'(\eta^*) = 0, \ f(\eta^*) = 1, \ f'(\eta^*) = 0\)
- Solve for \(p(\eta), \ p'(\eta), \ p''(\eta), \ f(\eta), \ f'(\eta), \ f''(\eta)\)
**Equilibrium**

- Boundary conditions: \( p(0) = p, ~ p'(\eta^*) = 0, ~ f(\eta^*) = 1, ~ f'(\eta^*) = 0 \)

- Bonuses paid out

- Steady state
Equilibrium

steady state
Dynamics near and away from steady-state

- **Steady state:** experts unconstrained
  - Bad shock leads to lower payout rather than lower capital demand
  - \( p'(\eta^*) = 0, \sigma_t^p (\eta^*) = 0 \)

- **Below steady state:** experts constrained
  - Negative shock leads to lower demand
  - \( p'(\eta^*) \) is high, strong amplification, \( \sigma_t^p (\eta^*) \) is high
  - ... but when \( \eta \) is close to 0, \( p \approx p (\eta_t) \), \( p'(\eta) \) and \( \sigma_t^p (\eta^*) \) is low

\[
\sigma_t^p = \frac{p'(\eta_t)\sigma(p_t - \eta_t)}{1 - p'(\eta_t)}.
\]
Roadmap

- Motivation
- Non-linear amplification
  - volatility dynamics + precautionary hoarding
- Money effect: deflationary spiral
- Externalities
  - Competitive = social planners’ solution in baseline model
  - Within financial sector (Mod. 1: speculative HH)
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Money

- More productive
- Less productive

capital

Limited direct lending due to frictions

capital

random switches
More productive

Money

- More productive
- Less productive

More capital is in “productive hands”

Notice difference to Bewley economy
- Productivity shocks vs. endowment shocks
- Capital is not dominating money
Intermediation + inside money

- Productive
- Intermediary
  - Monitoring
    - Diamond (1984)
    - Holmström-Tirole (1997)
- Less productive

- 
  - Intermediation + inside money
  - Money
  - Shares
  - Intermediary
  - Monitoring
  - Diamond (1984)
  - Holmström-Tirole (1997)

- Less productive

- Incentive for intermediary to monitor (have to hold outside equity)
- Incentive for entrepreneur to exert effort

- Debt
- Equity
- Capital
- $k_t p_t$

- Short-term debt = inside money

- $\alpha^I$

- $\alpha^E$

- $i$-money
- $o$-money
- Shares
Extra: Money model (with two types)
Roadmap

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... so far there are no externalities

**Proposition.** The competitive equilibrium in this economy is equivalent to the optimal policy by a monopolist expert.

**Sketch of proof.** (1) Write Bellman equation for monopolist. (2) Define price $p_t = 1/ \Phi'(i_t/k_t)$. (3) Show that prices etc. are as in competitive eq.

Intuition: In competitive equilibrium experts do affect prices by their choices (payout and investment), but they are isolated from prices because they don’t trade given equilibrium prices.
Modification 1: speculative households

- So far fixed liquidation value at \( p = a/(r + g) \)... now households can sell back to experts
  - Break even for HH
  - Depreciation rate is \( \delta > \delta \)
  - \( p_t \geq p(\eta) \)

- In equilibrium households pick up assets when financial sector suffers losses, i.e. \( \eta_t \) becomes small
- Introduce: “Some” households with limited capital, s.t. \( f > 1 \)
- Fire sale externalities (within financial sector) – when leveraging up, experts hurt prices that other experts can sell to households in the event of a crisis
Speculative vs. non-spec households

\[ a - \text{i} = 1, \rho = .06, r = .05, \]
\[ g = .04, \delta = .05, \sigma = .1 \]

\[ \eta^* = 42.6 \text{ vs. } 46.8 \]
\[ p(\eta^*) = 55.7 \text{ vs. } 53.2 \]
Comparative Static on $\sigma (0.025, 0.05, 0.1)$
Modification 2: add labor sector

- Fixed labor supply $L$
- Production Function: $\left(a' K_t^\gamma \right) k_t^{1-\gamma} l_t^\gamma$
- Intermediary $i$'s payoff: $\left(1 - \gamma \right) a' L^\gamma k_t$
- Workers' wage $w_t$: $\gamma a' K_t L^{\gamma-1}$
- Intermediaries' choice of leverage determines $K_t$
  - Investment decisions
  - (Bonus) payout policy
- Workers' welfare (value function) depends on $K_t$
Externalities with workers
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Stochastic Discount Factor

- Capital goods market
  - Intermediaries’ SDF: \( m_{o,t} = e^{-\rho t} \frac{f(\eta_t)}{f(\eta_0)} \)
    - time preference an agency constraint

- Outside equity market
  - Households’ SDF: \( m_{o,t}^{HH} = e^{-rt} \)
    - Note that \( m_{o,t} \neq m_{o,t}^{HH} \), since \( \delta > \delta \)

- Derivatives market
  - Volatility smirk of options
  - Index options vs. stock options
Modification 3: asset pricing (cross section)

- Correlation increases with $\sigma^p$
  - Extend model to many types $j$ of capital

\[
\frac{dk_t^j}{k_t^j} = (\Phi(\frac{i_t^j}{k_t^j})-\delta)dt + \sigma^{}dZ_t + \sigma' dz^j
\]

- Experts hold diversified portfolios
  - Equilibrium looks as before, but
  - Volatility of $p_t^j k_t^j$ is $\sigma + \sigma^p + \sigma'$
  - For uncorrelated $z^j$ and $z^l$
    - correlation ($p_t^j k_t^j$, $p_t^l k_t^l$) is $(\sigma + \sigma^p)/(\sigma + \sigma^p + \sigma')$
    - which is increasing in $\sigma^p$
Roadmap

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**Modification 4: Idiosyncratic losses**

\[
\text{dk}_t^i = g \ k_t^i \ dt + \sigma \ k_t^i \ dZ_t + k_t^i \ dJ_t^i
\]

\( J_t^i \) is an idiosyncratic compensated Poisson loss process, recovery distribution \( F \) and intensity \( \lambda(\sigma_t^p) \)

\( v_t = k_t p_t \) drops below \( d_t \), costly state verification by debt
Developed by Townsend (1979), used in Diamond (1984), Bernanke-Gertler-Gilchrist (1999)

- Time 0: principal provides funding I to agent
- Time 1: agent’s profit $y \sim F[0, y^*]$ is his private information but principal can verify $y$ at cost
- Optimal contract (with deterministic verification) is debt with face value $d$: agent reports $y$ truthfully and pays $d$ if $y \geq d$, triggers default and pays $y$ if $y < d$
- In our context: intermediary can cause losses (reduce $v_t$ for private benefit); debtholders verify if $v_t$ falls below $d_t$
Modification 4: Idiosyncratic losses

\[ dk_t^i = g k_t^i dt + \sigma k_t^i dZ_t + k_t^i dJ_t^i \]

\( J_t^i \) is an idiosyncratic compensated Poisson loss process, recovery distribution \( F \) and intensity \( \lambda(\sigma_t^p) \)

\( v_t = k_t p_t \) drops below \( d_t \), costly state verification by debt

- Debtholders’ loss rate
  \[ \lambda(\sigma^p) v \int_0^d \left( \frac{d}{v} - x \right) dF(x) \]

- Verification cost rate
  \[ \lambda(\sigma^p) v \int_0^d cxdF(x) \]

- Leverage bounded not only by precautionary motive, but also by the cost of borrowing

\[
\begin{align*}
\text{Asset} & \\
& v_t = k_t p_t \\
\text{Liabilities} & \\
& d_t = k_t p_t - n_t \\
& n_t
\end{align*}
\]
Equilibrium

- Experts borrow at rate larger than \( r \)
- Rate depends on leverage, price volatility
- \( d\eta_t = \text{diffusion process (without jumps) because losses cancel out in aggregate} \)
Securitization

- Experts can contract on shocks $Z_t$ and $J_t^i$ directly among each other, contracting costs are zero
- In principle, good thing (avoid verification costs)
- Equilibrium
  - experts fully hedge idiosyncratic risks
  - experts hold their share (do not hedge) aggregate risk $Z$, market price of risk depends on $\sigma_t^f (\sigma + \sigma_t^p)$
  - with securitization, experts lever up more (as a function of $\eta_t$) and pay themselves sooner
  - financial system becomes less stable
Conclusion

- Incorporate financial sector in macromodel
  - Higher growth
  - Exhibits instability
    - similar to existing models (BGG, KM) around steady state
    - non-linear liquidity spirals (away from steady state)

- Inside money - intermediaries are hit on both side of balance sheet: Deflation spiral

- Externalities when leverage/payouts are chosen
  - Within financial sector:
    - possible fire sales compromise others’ balance sheets
  - Towards real economy (workers)

- Securitization helps share idiosyncratic risk, but amplifies systemic risk
Thank you!
Differences to Bernanke-Gertler-Gilchrist

BGG

1. “small” aggregate shocks, log-linearization around steady state
2. Price dynamics driven by idiosyncratic shocks and default risk
   □ Higher state verification costs when expert capital goes down
3. Expert incentives to keep “dry powder” (liquidity/precautionary) are negligible
   Leverage is limited by increase in interest rate spread reflecting expected verification costs
4. Payout/consumption policy is exogenous
5. Countercyclical leverage
   □ Experts take on same position after drop in net worth
   □ Leverage increases after drop in net-worth

Brunnermeier-Sannikov

1. Focus on (large) aggregate shocks (idiosyncratic shocks not essential), explore nonlinearities using Bellman equation
2. Asset price drops also due to fire sales
3. Expert’s rent depends on state $\eta_t$
   Incentive to keep “dry powder” (liquidity)
4. Payout/consumption endogenous (unconstraint at this point)
5. Procyclical leverage: Experts reduce position after drop in net worth
   □ Liquidity spirals
6. Securitization (debt, inside + outside equity)
7. Fire-sale externality
Differences to Kiyotaki-Moore

**KM – (Kiyotaki version)**

1. Zero-prob. temporary shock
   - Persistent (**dynamic** loss spiral)
   - Amplified through collateral value
2. Always at the constraint
3. Exogenous payout policy at death
4. Non- vs. productive (leveraged) sector
5. Dual role of durable asset
   1. Production
   2. Collateral
6. Exogenous contract
   - One period contract
   - Debt is limited by collateral value
7. Durable asset doesn’t depreciates, capital fully

**BruSan**

1. Permanent shocks
   - Volatility effects through precautionary motive
   - Loss spiral (level effect)
2. Precautionary cushion away from constraint – size varies
3. Endogenous payout/consumption
4. Investment through leveraged financial sector
5. Dual role of durable asset
   1. Production
   2. Securitization
6. (Partially) optimal contract
   - Dynamic contract
   - Debt is limited due idiosyncratic risk and costly state verification
7. $\delta$-depreciation rate
Differences to He-Krishnamurthy

He-Krishnamurthy

1. Endowment economy
   - GDP growth is exogenously fixed
   - No physical investment
2. No direct investment in risky asset by households
   - Limited participation model
3. Contracting
   - Only short-run relationship \((t \text{ to } t+dt)\)
   - Fraction of return, fee
   - Asset composition (risky vs. risk-free) is not contractable
   - Non-effort lowers return by \(x dt\), \(x\) is exogenous, not linked to fundamental
   - Private benefit from shirking
   - No benchmarking
4. Pricing Implications
   - When experts wealth declines, their market power increases, and so does their fee
   - Price impact depends on assumption that household have larger discount rate than experts
5. Procyclical Leverage
6. In H-K calibration paper
   1. No fee, households are rationed in their investment
   2. As expert wealth approaches 0, interest rate can go to \(-\infty\)
   3. Heterogeneous labor income for newborns of \(lD_t\)
   4. Non-log utility function

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1. Production economy
   - GDP growth depends on net-wealth
   - Physical investment
2. Direct investments by all households
3. Contracting
   - (Potential) long-run relationship
   - Fraction of return, fee, size of asset pool
   - Effort increases fundamental growth to \(gd_t\)
   - Monetary benefit from shirking
   - No benchmarking
4. Pricing Implication
   - Price drop with state variable
5. Countercyclical Leverage
   - Entrepreneur take on same position after drop in networth
   - Leverage increases after drop in net-worth