Princeton Initiative 2014
Macro, Money and Finance

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Macro-literature on Frictions

1. Net worth effects:
   a. Persistence: Carlstrom & Fuerst
   b. Amplification: Bernanke, Gertler & Gilchrist
   c. Instability: Brunnermeier & Sannikov
2. Volatility effects: impact credit quantity constraints
   a. Margin spirals : Brunnermeier & Pederson
   b. Endogenous constraints: Geanakoplos
3. Demand for liquid assets & Bubbles – "self insurance"
   a. OLG, Aiyagari, Bewley, Krusell-Smith, Holmstrom-Tirole,...
4. Financial intermediaries & Theory of Money

DEMAND FOR LIQUID ASSETS, BUBBLES, …

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Demand for Liquid Assets

- So far: Technological and market illiquidity create time *amplification* and *instability*
  - Net worth losses lead depress to price of capital q_t, …
  - Liquidity spirals emerge when price volatility interacts with debt constraints
- Now: Focus on *demand for liquid instruments*
  - No amplification effects:
    perfect techn. liquidity due to reversibility of investment
    - constant price of capital q
    - Borrowing constraint = collateral constraint
  - Steps: Introduce (i) idiosyncratic risk, (ii) aggregate risk,
    (iii) amplification (revisited)

Outline – Demand for Liquid Assets

- Deterministic Fluctuations
  - Overlapping generations
  - Completing markets with liquid asset
- Idiosyncratic Risk
  - Precautionary savings
  - Constrained efficiency
- Aggregate Risk
  - Bounded rationality
- Amplification Revisited

Overlapping Generations

- Samuelson (1958) considers an infinite-horizon economy with two-period lived overlapping agents
  - Population growth rate n
- Preferences given by $u(c_t^t, c_{t+1}^t)$
  - Pareto optimal allocation satisfies $\frac{u_1}{u_2} = 1 + n$
- OLG economies have multiple equilibria that can be Pareto ranked

OLG: Multiple Equilibria

- Assume $u(c_t^t, c_{t+1}^t) = \log c_t^t + \beta \log c_{t+1}^t$
  - Endowment $y_t^t = e, y_{t+1}^t = 1 - e$
- Assume complete markets and interest rate r
- Agent's FOC implies that $\frac{c_{t+1}^t}{\beta c_t^t} = 1 + r$
  - For $r = n$, this corresponds to the *Pareto solution*
  - For $r = \frac{1-e}{\beta e} - 1$, agents will consume their endowment
- Autarky solution is clearly *Pareto inferior*

OLG: Completion with Durable Asset

- Autarky solution is the **unique** equilibrium implemented in a sequential exchange economy
  - Young agents cannot transfer wealth to next period
  - *… related to Chris Sims' lecture*
- A durable asset provides a <u>store of value</u>
  - Effective store of value reflects *market liquidity*
  - Pareto solution can be attained as a competitive equilibrium in which the price level grows at same rate as the population, i.e. $b_{t+1} = (1+n)b_t$
  - Old agents trade durable asset for young agents' consumption goods

OLG: Production

- Diamond (1965) introduces a capital good and production
  - Constant-returns-to-scale production $Y_t = F(K_t, L_t)$
- Optimal level of capital is given by the *golden rule*, i.e. $f'(k^*) = n$
  - Here, lowercase letters signify **per capita** values
- Individual (and firm) optimization implies that
  - $\frac{u_1}{u_2} = 1 + r = 1 + f'(k)$
  - It is possible that $r < n \Rightarrow k > k^* \Rightarrow$ Pareto inefficient

OLG: Production & Efficiency

- Diamond recommends issuing government debt at interest rate r
- Tirole (1985) introduces a rational bubble asset trading at price b_t
  - $b_{t+1} = \frac{1+r_{t+1}}{1+n} b_t$
- Both solutions *crowd out* investment and increase r
  - If baseline economy is inefficient, then an appropriately chosen debt issuance or bubble size can achieve Pareto optimum with $r = n$

OLG: Crowding Out vs. Crowding In

- Depending on the framework, government debt and presence of bubbles can have two opposite effects
  - <u>Crowding out</u> refers to the decreased investment to increase in supply of capital
  - <u>Crowding in</u> refers to increased investment due to improved risk transfer
- Woodford (1990) explores both of these effects

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Precautionary Savings

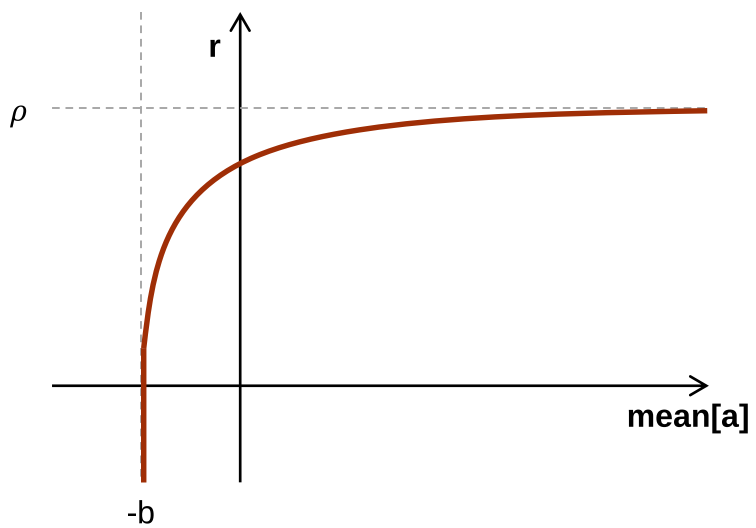
- Consumption smoothing implies that agents will save in high income states and borrow in low income states
  - If markets are incomplete, agents may not be able to efficiently transfer consumption between these outcomes
- Additional precautionary savings motive arises when agents cannot insure against uncertainty
  - Shape of utility function u'''
  - Borrowing constraint $a_t \geq -b$

PCS 1: Prudence

- Utility maximization $E_0[\sum_{t=0}^{\infty} \beta^t u(c_t)]$
  - Budget constraint: $c_t + a_{t+1} = e_t + (1+r)a_t$
  - Standard Euler equation: $u'(c_t) = \beta(1+r)E_t[u'(c_{t+1})]$
- If $u''' > 0$, then Jensen's inequality implies:
  - $\frac{1}{\beta(1+r)} = \frac{E_t[u'(c_{t+1})]}{u'(c_t)} > \frac{u'(E_t[c_{t+1}])}{u'(c_t)}$
  - Marginal value is greater due to uncertainty in c_{t+1}
  - Difference is attributed to *precautionary savings*
- Prudence refers to curvature of u', i.e. $P = -\frac{u'''}{u''}$

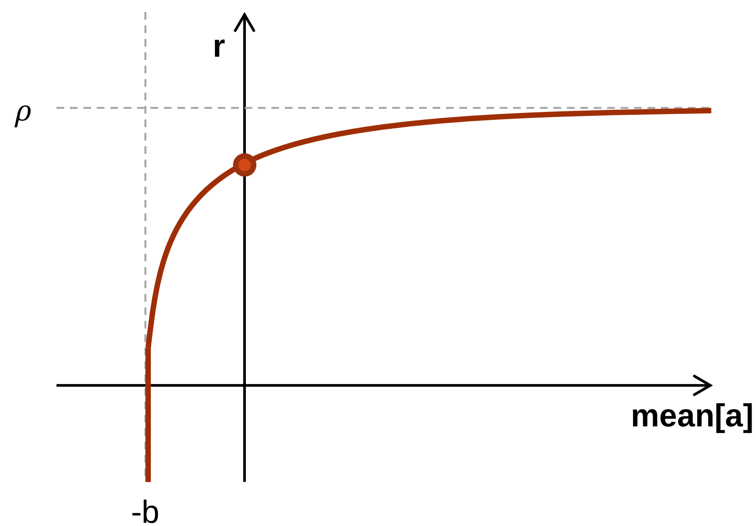
PCS 2: Borrowing constraint + Idiosync. Risk

- With *incomplete markets* and *borrowing constraints*, agents engage in precautionary savings in the presence of <u>idiosyncratic income shocks</u>
- Following Bewley (1977), mean asset holdings $E[a]$ result from individual optimization



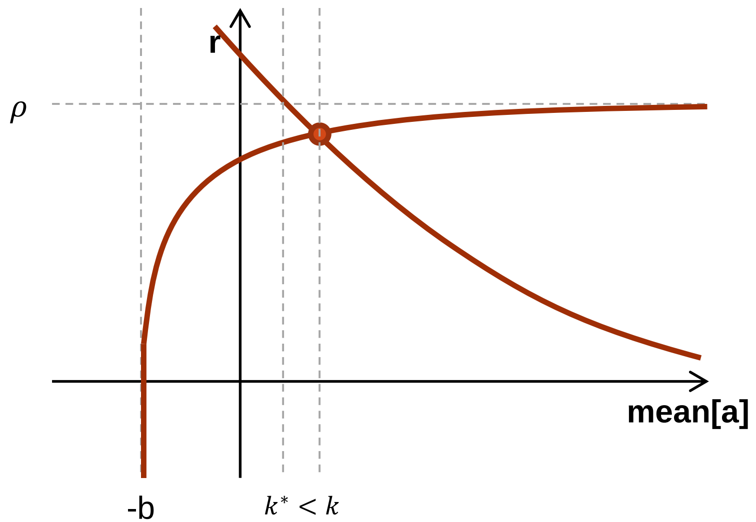
IR: Exchange Economy

- In an exchange economy, aggregate supply of assets must be zero
  - Huggett (1993)
- Equilibrium interest rate always satisfies $r < \rho$



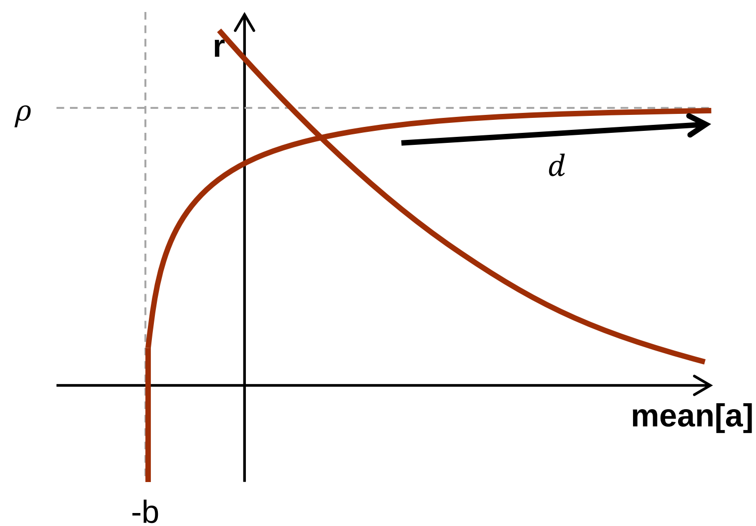
IR: Production Economy

- Aiyagari (1994) combines the previous setup with standard production function $F(K, L)$
  - Constant aggregate labor L
- Demand for capital is given by $f'(k) - \delta = r$
  - Efficient level of capital $f'(k^*) - \delta = \rho \Rightarrow k^* < k$



IR: Production Economy

- Aiyagari (1995) shows that a tax on capital earnings can address this efficiency problem
  - This decreases the net interest rate received by agents
- Government debt does not work "perfectly"
  - No finite amount of government debt will achieve $r = \rho$



Constrained Inefficiency

- Bewley-Aiyagari economies result in competitive allocations that are not only Pareto inefficient, but are also *constrained* Pareto inefficient
  - Social planner can achieve a Pareto superior outcome even facing same market incompleteness
- This result can be attributed to *pecuniary externalities*
  - In competitive equilibrium, agents take prices as given whereas a social planner can induce wealth transfers by affecting relative prices
    - For incomplete markets:
      Stiglitz (1982), Geanakoplos-Polemarcharkis (1986)
    - For borrowing/collateral constraints:
      many papers

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Aggregate Risk

- Krusell, Smith (1998) introduce aggregate risk into the Aiyagari framework
  - Aggregate productivity shock that follows a Markov process z_t and $Y_t = z_t F(K_t, L_t)$
- Aggregate capital stock determines equilibrium prices r_t, w_t
  - However, the evolution of aggregate stock is affected by the **distribution** of wealth since poor agents may have a much higher propensity to save
  - Tracking whole distribution is practically impossible

AR: Bounded Rationality

- Krusell, Smith assume agents are boundedly rational and approximate the distribution of capital by a finite set of moments M
  - Regression R^2 is relatively high even if $\#M = 1$
- This result is strongly dependent on low risk aversion and low persistence of labor shocks
  - Weak precautionary savings motive except for poorest agents
  - Since wealth-weighted averages are relevant, this has a negligible effect on aggregate quantities

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Liquidity Concepts

- Financial instability arises from the fragility of liquidity

A	L

Technological liquidity
▪ Reversibility of investment
Market liquidity
▪ Specificity of capital
Price impact of capital sale
	Funding liquidity
	▪ Maturity structure of debt
	  ▪ Can't roll over short term debt
	▪ Sensitivity of margins
	  ▪ Margin-funding is recalled

Liquidity
~~Maturity~~ mismatch

- *Liquidity mismatch* determines severity of amplification

Brunnermeier, Eisenbach, Sannikov

Amplification Revisited

- Investment possibility shocks
  - Production possibilities: Scheinkman & Weiss (1986)
  - Investment possibilities: Kiyotaki & Moore (2008)
- Interim liquidity shocks
  - Exogenous shock: Holmstrom & Tirole (1998)
  - Endogenous shock: Shleifer & Vishny (1997)
- Preference shocks
  - No aggregate risk: Diamond & Dybvig (1983)
  - Aggregate risk: Allen & Gale (1994)

Holmstrom & Tirole 98

- Three period model with $t \in \{0,1,2\}$
- Entrepreneurs with initial wealth A
  - Investment of I returns RI in $t = 2$ with probability p
  - Interim funding requirement ρI at $t = 1$ with $\rho \sim G$
  - Extreme *technological illiquidity*, as investment is worthless if interim funding is not provided
- Moral hazard problem
  - Efficiency requires $\rho \leq \rho_1 \equiv pR \Rightarrow$ continuation
  - Only $\rho \leq \rho_0 < \rho_1$ of funding can be raised due to manager's private benefit, i.e. principal-agent conflict

Shleifer & Vishny 97

- Fund managers choose how aggressively to exploit an arbitrage opportunity
- Mispricing can widen in interim period
  - Investors question investment and withdraw funds
  - Managers must unwind position when mispricing is largest, i.e. most profitable
  - Low *market liquidity* due to limited knowledge of opportunity
- Fund managers predict this effect, and thus limit arbitrage activity
  - Keep buffer of liquid assets to fund withdrawals

Diamond & Dybvig 83

- Three period model with $t \in \{0,1,2\}$
- Continuum of ex-ante identical agents
  - Endowment of 1 in $t = 0$
  - Idiosyncratic preference shock, i.e. probability λ that agent consumes in $t = 1$ and probability $1 - \lambda$ that agent consumes in $t = 2$
- Preference shock is not observable to outsiders
  - Not insurable, i.e. incomplete markets

DD: Investment

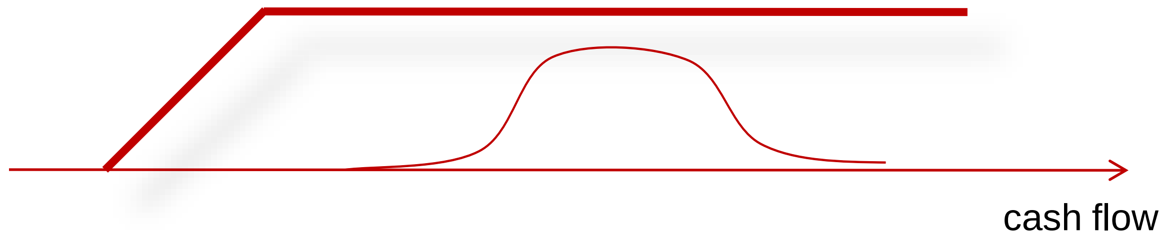
- Good can be stored without cost
  - Payoff of 1 in any period
- Long term investment project
  - Payoff of $R > 1$ in $t = 2$
  - Salvage value of $r \leq 1$ if liquidated early in $t = 1$
  - Market for claims to long-term project at price p
- Trade-off between return and *liquidity*
  - Investment is subject to *technological illiquidity*, i.e. $r \leq 1$
  - Market liquidity is represented by interim price p

Allen & Gale

- AG extend DD framework by adding aggregate risk
  - Here, $\lambda = \lambda_H$ with probability π and $\lambda = \lambda_L < \lambda_H$ with probability $1 - \pi$
- Agents observe realization of aggregate state and idiosyncratic preference shock at $t = 1$
  - After resolution of uncertainty, agents can trade claims to long-term project at $p_s \in \{p_H, p_L\}$
  - Asset's *market liquidity* will vary across states
- For simplicity, assume $r = 0$

Creating Info-Insensitive Securities

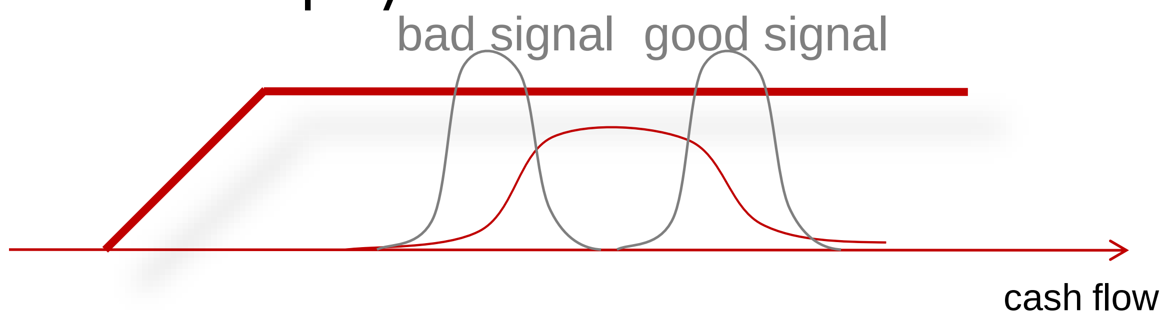
- Debt contract payoff – prior distribution of cash flow



- Asymmetric info (lemons') problem kicks in
  - No more rollover
- Maturity choice:
  - Short-term debt: distribution shrinks (less info-sensitity)

Creating Info-Insensitive Securities

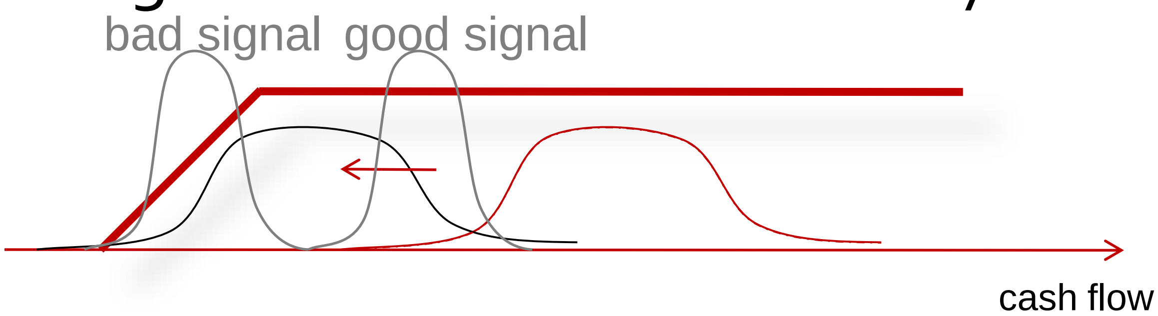
- Debt contract payoff



- Informational value of signal is extremely low (in flat part of contract payoff

Creating Info-Insensitive Securities

- Increasing the information sensitivity of debt



- Now signal is very valuable
- Asymmetric info (lemons') problem kicks in
  - No more rollover
- Maturity choice:
  - Short-term debt: distribution shrinks (less info-sensitity)