The I-Theory of Money

Markus Brunnermeier & Yuliy Sannikov

Princeton University

Updates: http://www.princeton.edu/~markus/research/papers/i_theory_slides.pdf

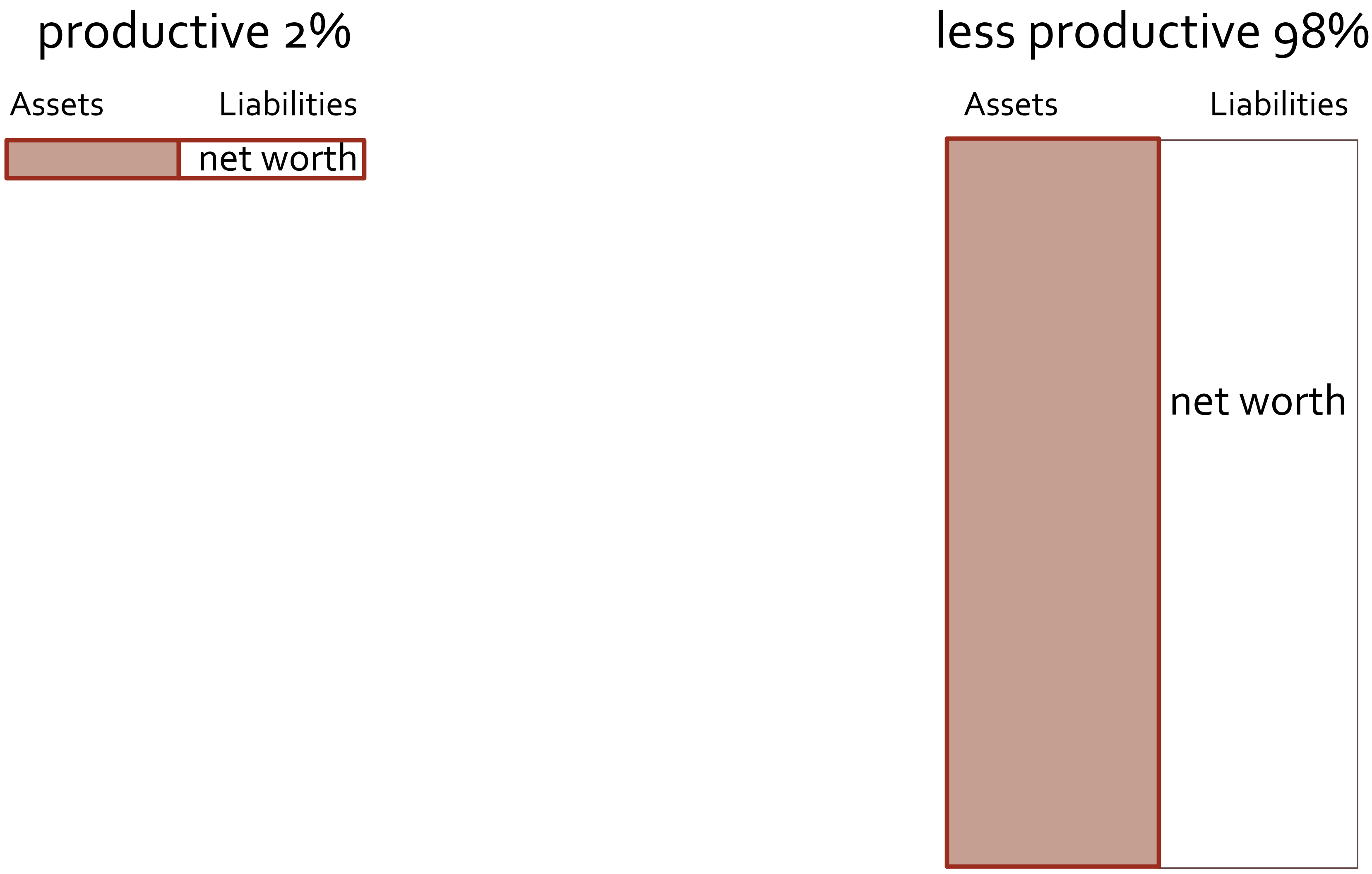
Motivation

- Main features
  - Unified framework to study financial and monetary stability
  - Model that combines money and intermediation – inside money
  - Value of money is endogenously determined – liquidity value
    - (Samuelson, Bewley, KM, …)
  - Fisher (1933) deflationary spiral
    - Negative shock hits assets side of intermediaries' balance sheets and is amplified through leverage and volatility dynamics
    - Decline in inside money, leads to deflationary pressure hits intermediaries' balance sheet on the liability side
  - Inside money and outside money
    "Endogenous" money multiplier = f(health of intermediary sector)
  - Monetary policy
    - Redistribution from/towards intermediary sector
      - Difference to New Keynesian framework
    - "Greenspan put" - time-inconsistency
      - Difference to example in Kydland-Precott

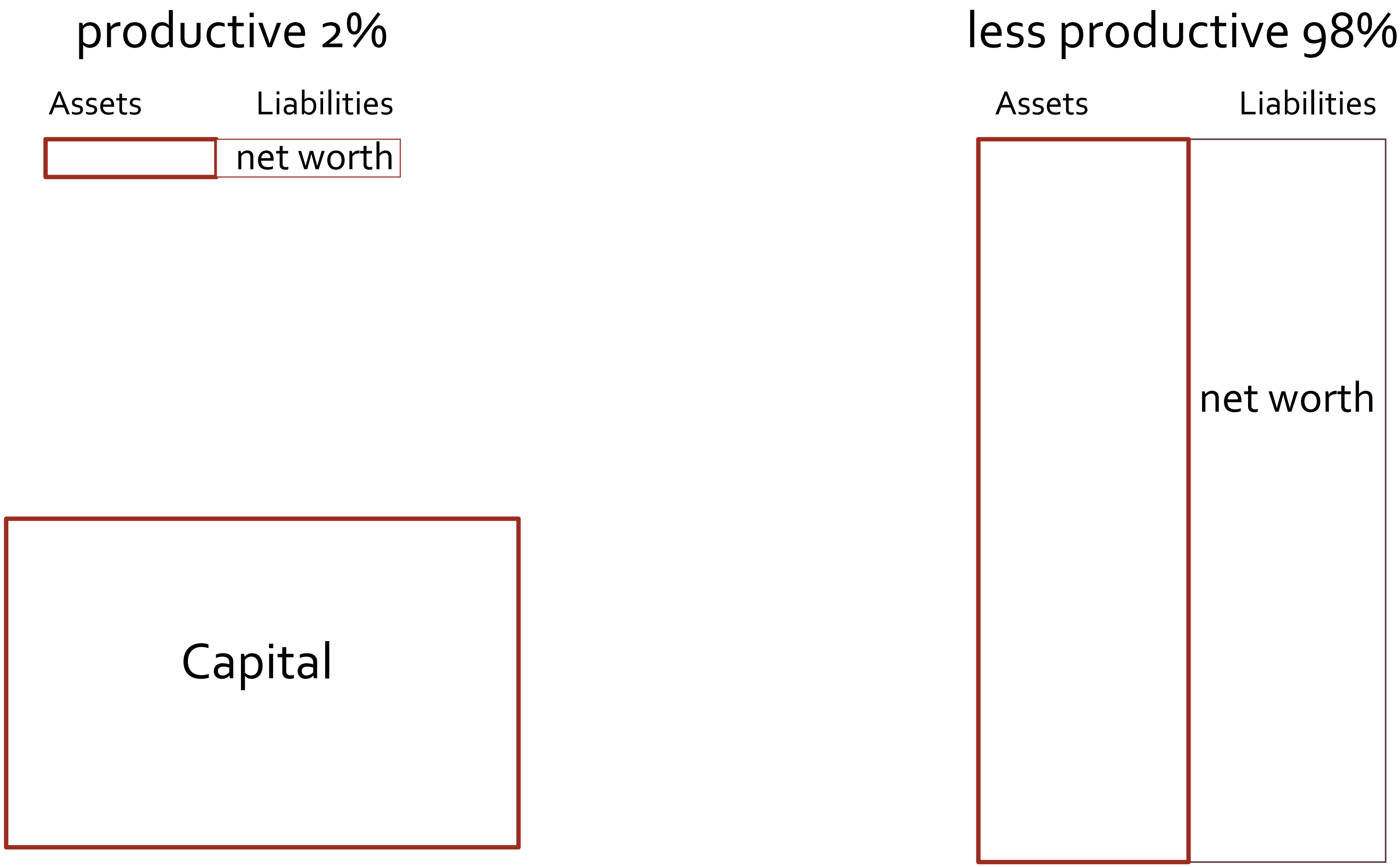
Role of money – some literature

- Medium of exchange → (New) Monetarists
- Store of value & liquidity
  - Samuelson's OLG — Save for future
  - Bewley — Precaution for
    - Scheinkman-Weiss — uninsurable endowment shocks
    - Homstrom-Tirole — to keep project running
    - Kiyotaki-Moore 08 — new investment opportunity + "resell constraint"
- Financial stability + monetary policy
    - Diamond-Rajan (2006)
    - Stein (2010)
    - Curdia-Woodford (2010) → New Keynesian framework
- Macro with financial frictions
    - BGG, KM97, He-Krishnamurthy 2009, BruSan 2010

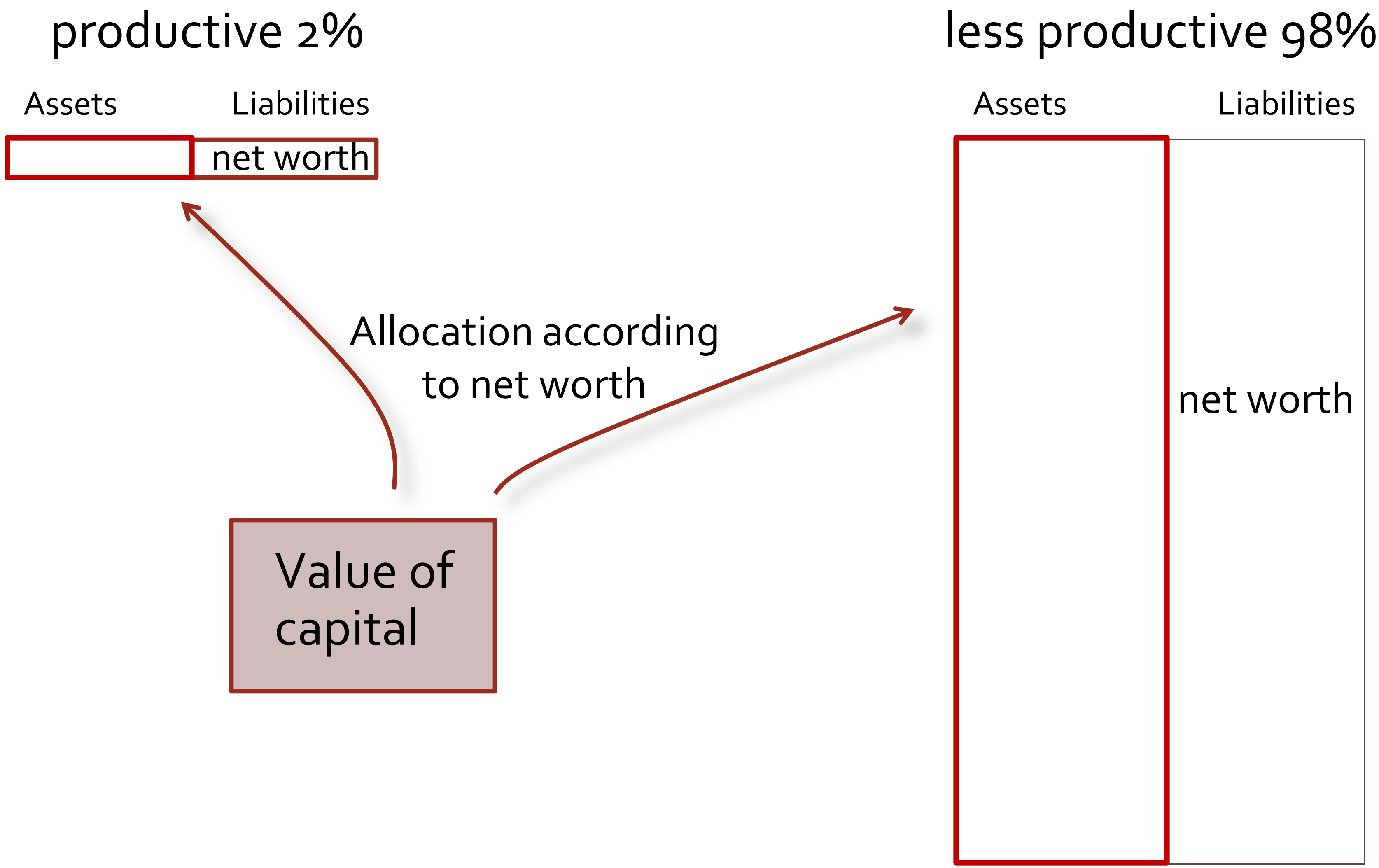
Model outline



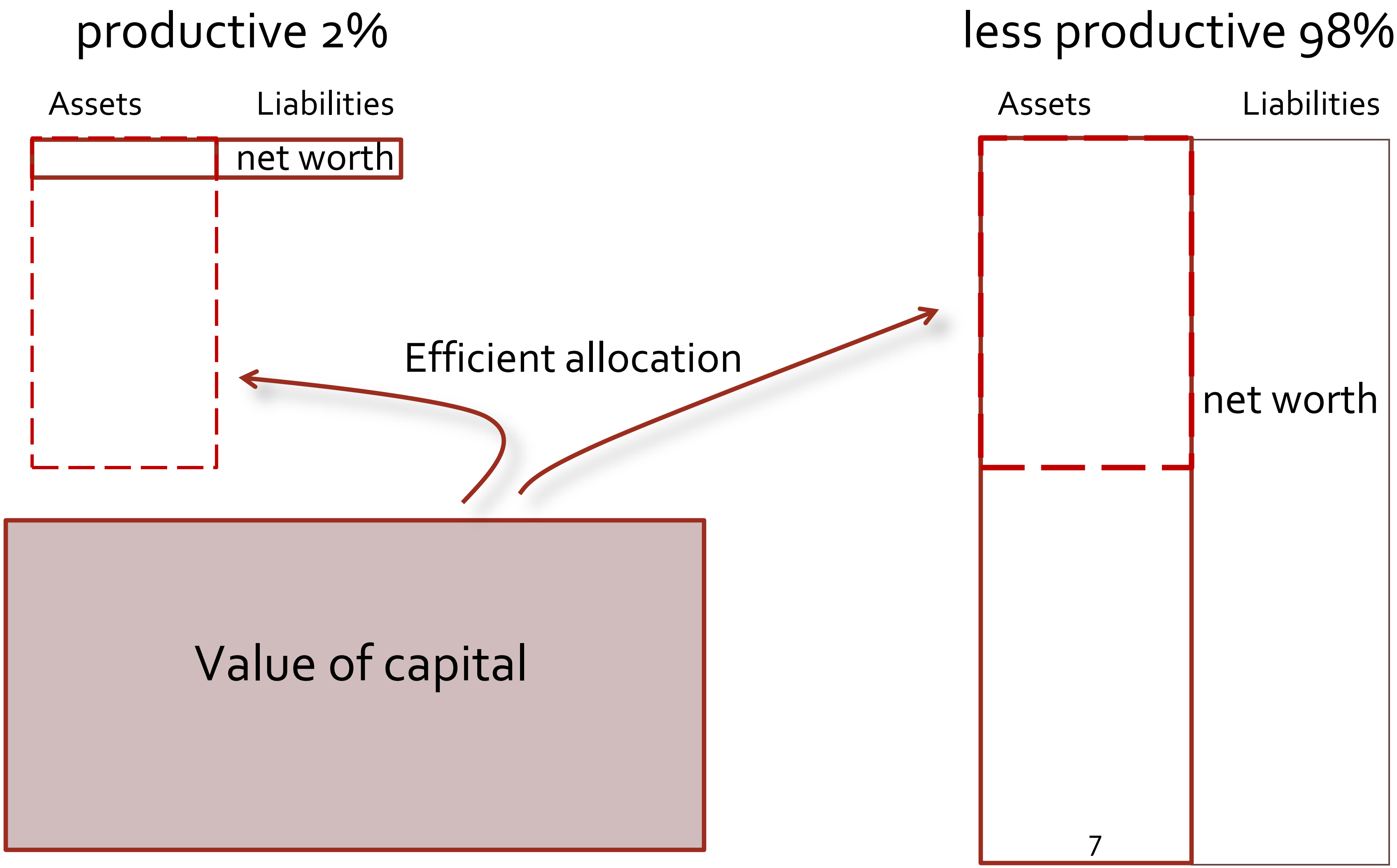
Model outline



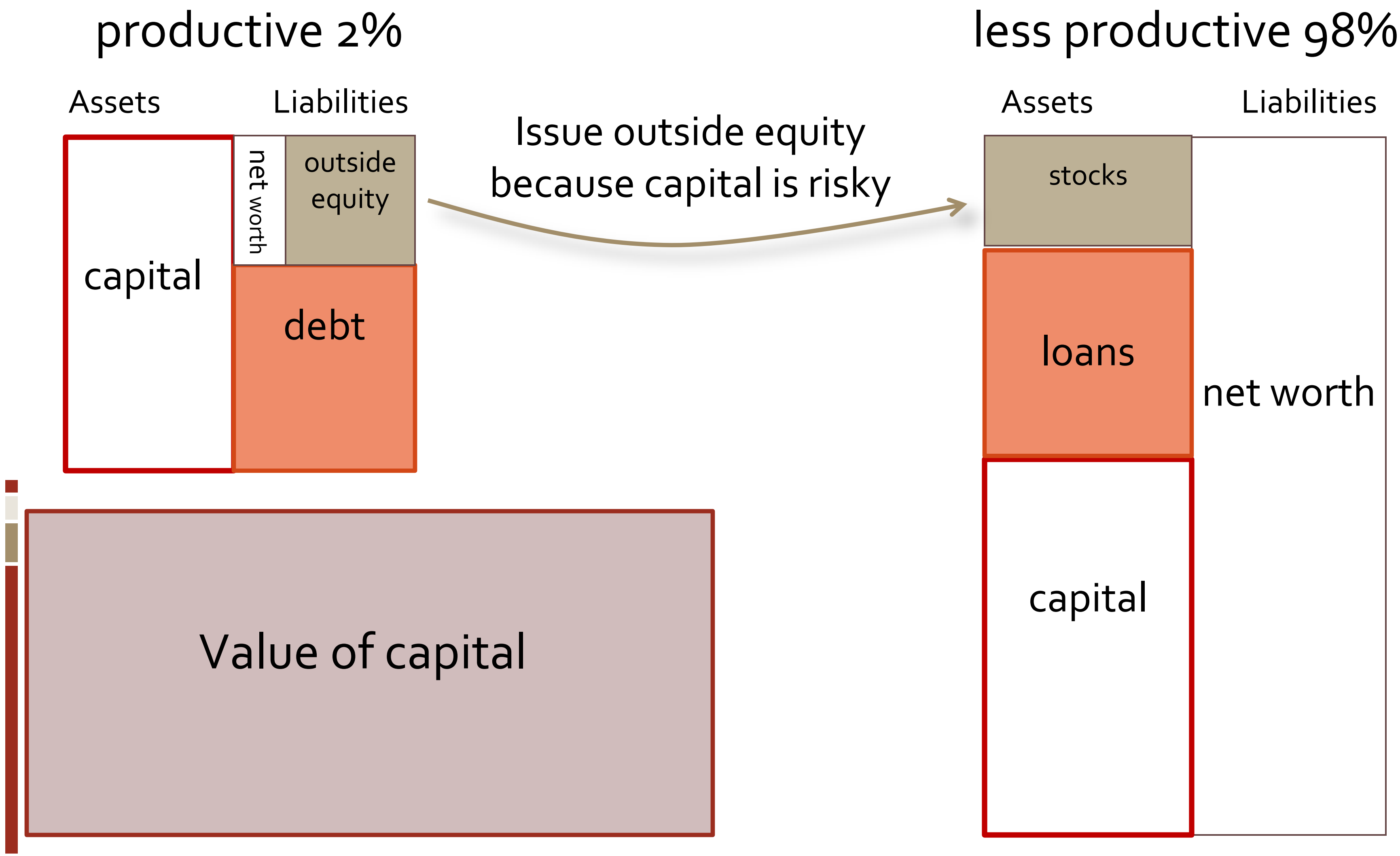
Allocation according to net worth



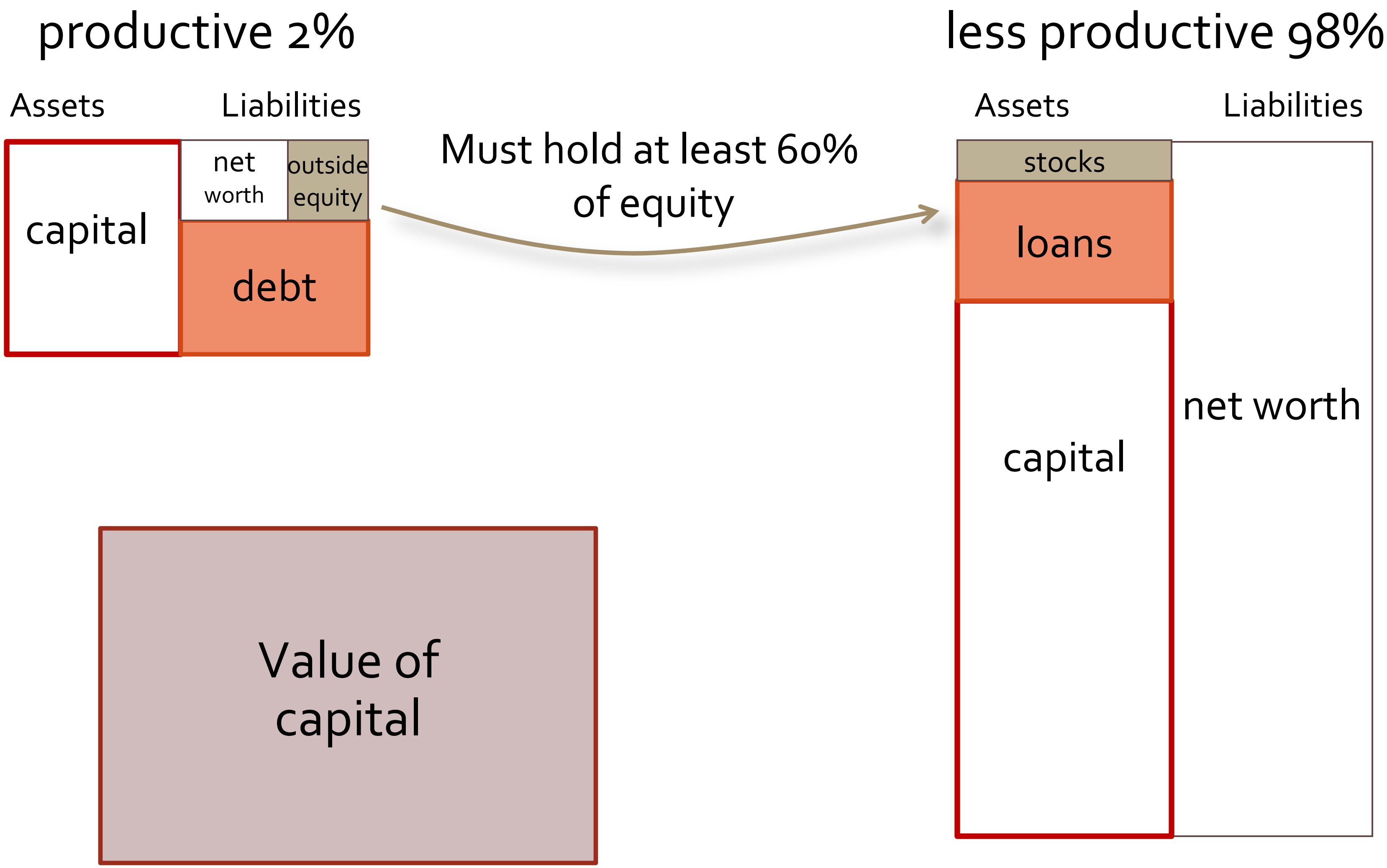
Efficient allocation



Frictionless economy



Allocation with equity constraint



Allocation with equity and debt constraint

productive 2%

Assets | Liabilities

capital | net worth

less productive 98%

Assets | Liabilities

capital | net worth

Value of capital

Monetary economy w/o intermediaries

productive 2%

Assets	Liabilities
capital	net worth

less productive 98%

Assets	Liabilities
capital	net worth
money	

- when agent A becomes unproductive and B becomes productive, A exchanges his capital for B's money (Bewley, Samuelson)
- outcome more efficient than without money (productive hold more than 2% of capital)

Two polar cases

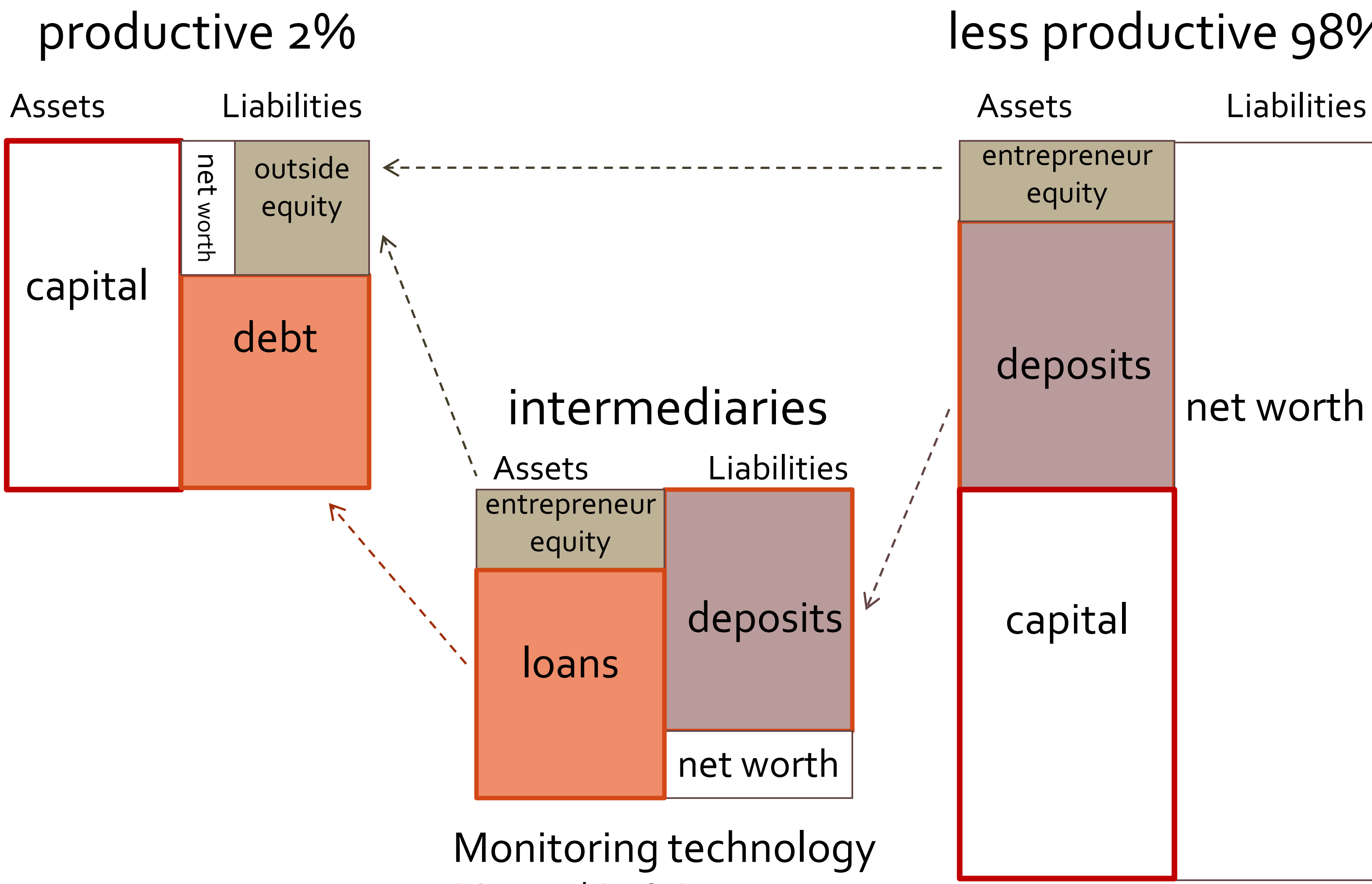
Economy	Assets	Value of fiat money	
Frictionless	Issue claims • Equity • Debt	Low (zero)	
Frictions (severe)	No claims	high	

Two polar cases – introducing intermediaries

Economy	Assets	Value of fiat money		Intermediaries' capitalization
Frictionless	Issue claims • Equity • Debt	Low (zero)		perfect
Frictions (severe)	No claims	high		defunct

- Role of intermediaries
  - Relax financing constraint by monitoring productive agents
  - Have to take on productive agent's equity risk (so that they have incentive to monitor)
  - Intermediation depends on their ability to absorb risk net worth of intermediaries

Allocation with intermediaries



Monitoring technology
Diamond (1984)
Holmström-Tirole (1997)

Monetary economy w/o intermediaries

productive 2%

Assets | Liabilities

net worth

less productive 98%

Assets | Liabilities

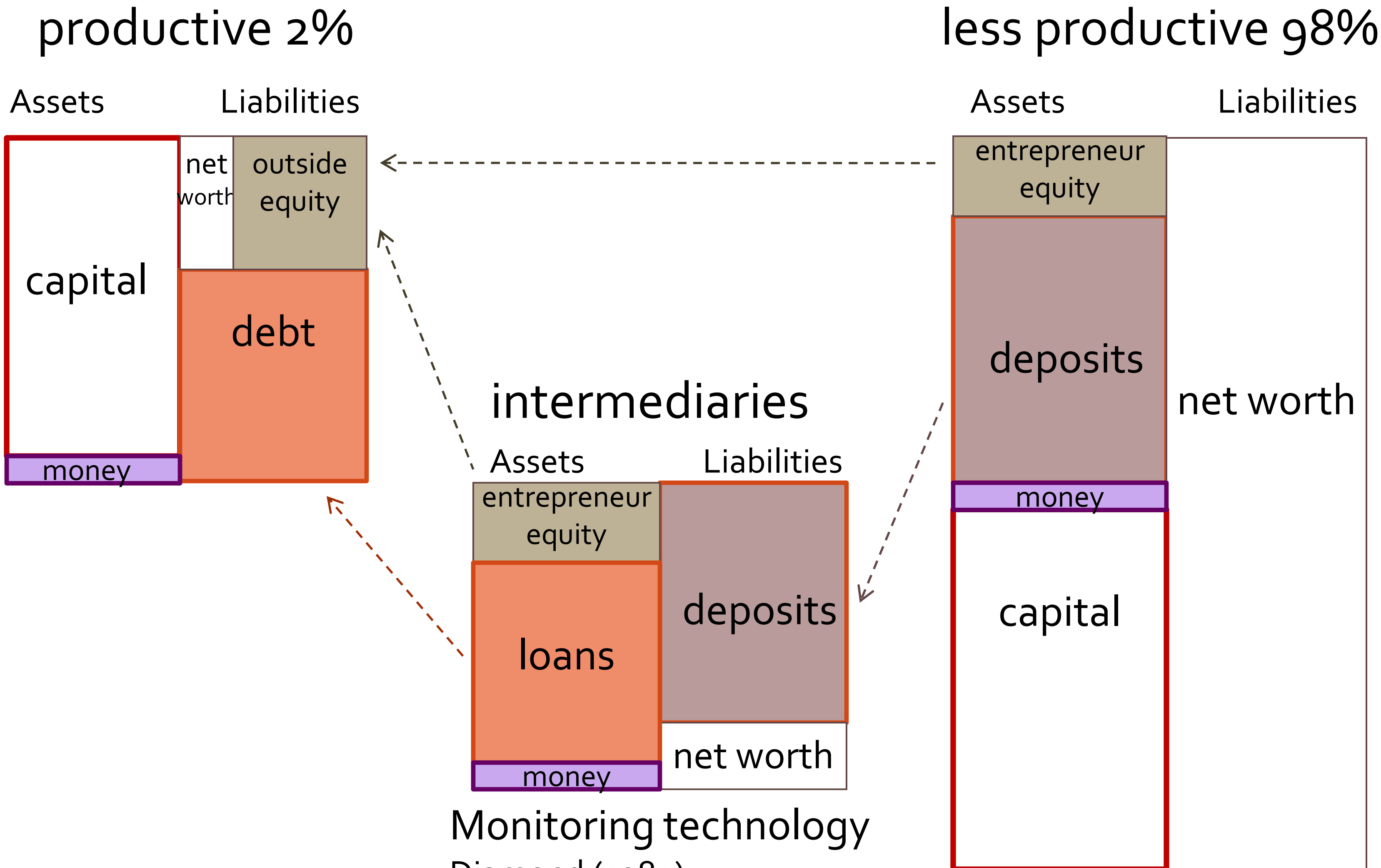
capital

money

net worth

- when agent A becomes unproductive and B becomes productive, A exchanges his capital for B's money (Bewley, Samuelson)
- outcome more efficient than without money (productive hold more than 2% of capital)
- relative to financing through intermediaries, less efficient
  - allocation (productive hold too little capital)
  - valuation (price of capital depressed by limited demand from productive agents, leads to *underinvestment*)

Monetary economy with intermediaries



Monitoring technology

Diamond (1984)

Holmström-Tirole (1997)

The big picture

- Intermediaries net worth
  - Zero: like economy with only outside money (p high)
  - Very large: perfect lending (no frictions) (p low)
  - Intermediate: amplification – (non-linear effects)
    money multiplier changes
    outside money stays constant, inside money fluctuates
- Contracting friction:
  - Intermediaries have to hold α fraction of risk
    (in order to have incentive to monitor)
  - No contracting on productivity switch – relation to Bewley
  - (no distinction between cash flow news, k_t, and SDF news)

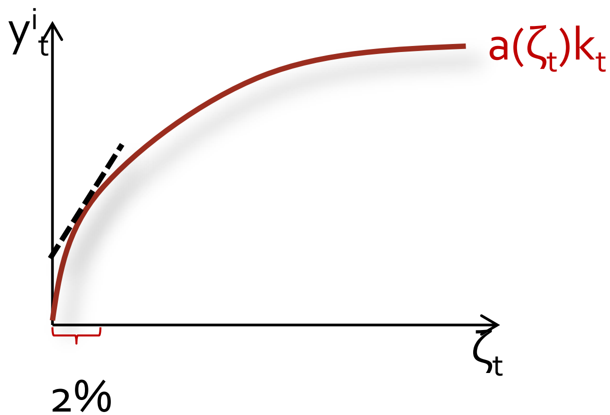
Roadmap

- Big picture overview
  - 2 polar cases
    - Impaired i-sector "lending" via outside money only
    - Perfect i-sector perfect lending
- Passive monetary policy: "Gold standard"
  - Model setup
  - General model (with aggregate risk)
    - Lending and money multiplier depends on net worth of i-sector
    - Deflation spiral
- Active Monetary Policy
  - Introduce long-term bond
    - Short-term interest rate policy
    - Asset purchase and OMO
  - Redistributional effects
  - "Greenspan put" - Time-inconsistency

Model details

(random) switches

- More productive (θ=2%)
  - Fraction of capital
    $\zeta_t = \theta k_t \,/\, [\theta k_t + (1-\theta)\underline{k}_t]$
  - $y_t = a(\zeta_t)\, k_t$, DRS in ζ_t



  - $o_t = (a - i_t)\, k_t$
  - $dk_t = \underbrace{(\phi(i_t) - \delta)}_{g_t}\, k_t\, dt + \sigma\, k_t\, dZ_t$

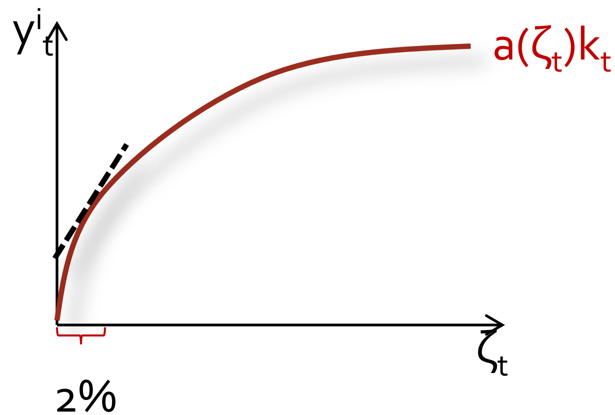
sector shock
(exogenous risk)

- Less productive ($1-\theta$)

Model details

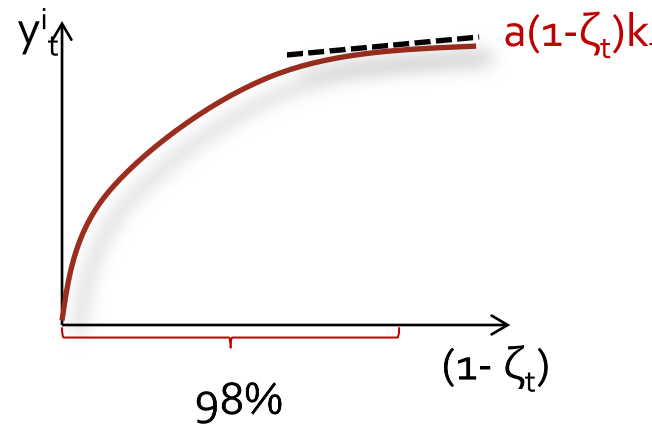
(random) switches

- More productive (θ=2%)
  - Fraction of capital
    $\zeta_t = \theta k_t / [\theta k_t + (1-\theta)\underline{k}_t]$
  - $y_t = a(\zeta_t)\, k_t$, DRS in ζ_t



  - $o_t = (a - i_t)\, k_t$
  - $dk_t = \underbrace{(\phi(i_t) - \delta)}_{g_t}\, k_t\, dt + \sigma\, k_t\, dZ_t$

- Less productive ($1-\theta$)
  - Fraction of capital
    $1-\zeta_t$
  - $\underline{y}_t = \underline{a}(1-\zeta_t)\, k_t$, DRS in $(1-\zeta_t)$



  - $\underline{o}_t = (\underline{a}-\underline{i}_t)\, k_t$
  - $dk_t = (\underline{\phi}(\underline{i}_t) - \underline{\delta})\, k_t\, dt$ $\quad d\underline{Z}_t = 0$

Optimal investment decision: Example

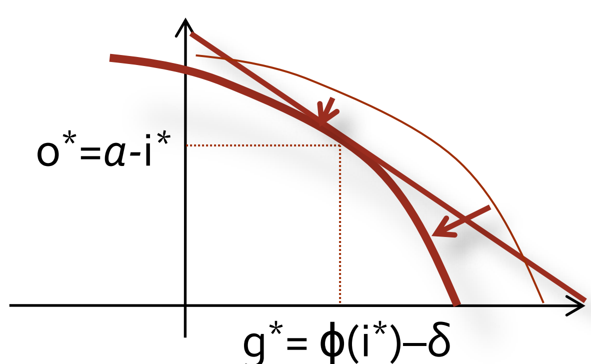
- 2% of agents are productive and 98%, unproductive
- Each group of agents has same decreasing returns to scale production function

$$\left(\frac{a}{\sqrt{\zeta_t}} - i_t\right) k_t dt \qquad dk_t = \left(\sqrt{\frac{2b}{\sqrt{\zeta_t}}}\sqrt{i_t} - \delta\right) k_t$$

where ζ_t is the fraction of capital held by each group

- Optimal investment: $i^* = \frac{1}{\sqrt{\zeta}} b \frac{q^2}{2}$

$$o^*(q,\zeta) = \frac{a}{\sqrt{\zeta}} - i = \frac{1}{\sqrt{\zeta}}\left(a - b\frac{q^2}{2}\right) \leftarrow \text{net output}$$



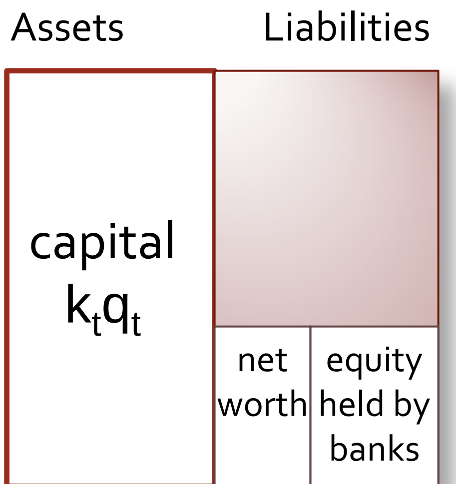
$$g^*(q,\zeta) = \sqrt{\frac{2b}{\sqrt{\zeta}}}\sqrt{i} - \delta = \frac{1}{\sqrt{\zeta}} bq - \delta \leftarrow \text{growth}$$

Production and Pricing

- Assume constant returns to scale at individual level, but decreasing returns to scale at sector level
  - a^* and g^* depend on capital allocation ζ_t to entrepreneur sector
  - interior solution in equilibrium
- Capital held by productive agents
  - $a^*(q_t, \zeta_t)\, k_t\, dt$ $\quad\quad$ $dk_t = g^*(q_t, \zeta_t)\, k_t\, dt + \sigma k_t\, dZ_t$
- Capital held by less productive agents
  - $\underline{a}^*(q_t, 1\text{-}\zeta_t)\, k_t\, dt$ $\quad\quad$ $d\underline{k}_t = g^*(q_t, 1\text{-}\zeta_t)\, \underline{k}_t\, dt$
- Price of capital (in terms of output)
  - $dq = \mu_t^q\, q_t\, dt + \sigma_t^q\, q_t\, dZ_t$

Risks

- Capital risk

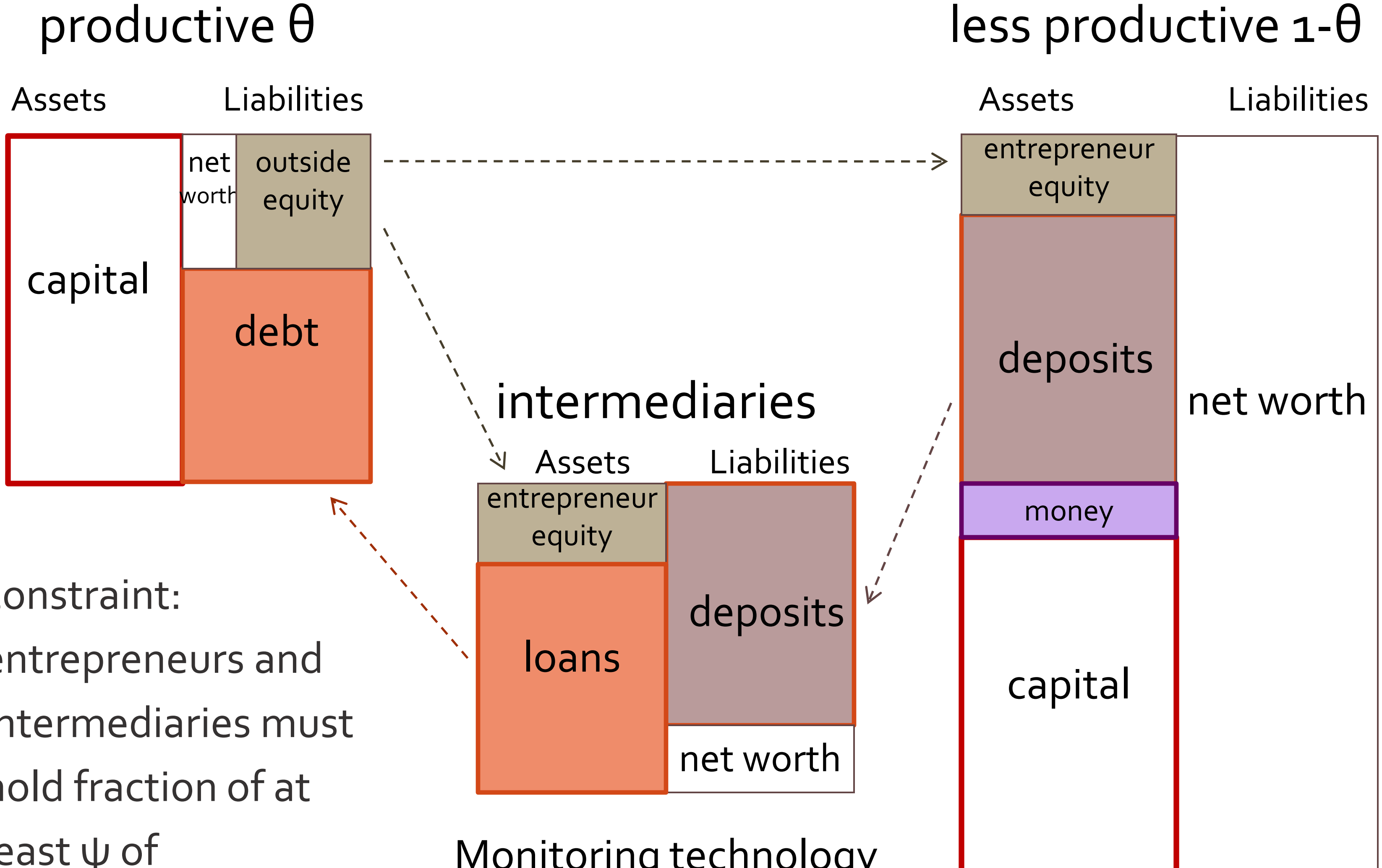


  - $dk_t = g^*(q_t, \zeta_t)\, k_t\, dt + \sigma\, k_t\, dZ_t$ exogenous risk
  - $dq_t = \mu_t^q\, q_t\, dt + \sigma_t^q\, q_t\, dZ_t$ endogenous risk
  - $d(k_t q_t) = (g^*(q_t, \zeta_t) + \mu_t^q + \sigma\sigma_t^q)\,(k_t q_t)\, dt + (\sigma_t^q + \sigma)\,(k_t q_t)\, dZ_t$

Risks

- Capital risk
  - $d(k_t q_t) = (g^*(q_t, \zeta_t) + \mu_t^q + \sigma\sigma_t^q)(k_t q_t)\,dt + (\sigma_t^q + \sigma)(k_t q_t)\,dZ_t$
- Money risk $p_t K_t$
  - $dK_t = (\kappa_t\, g^*(q_t, \zeta_t) + (1-\zeta_t)\, g^*(q_t, 1-\zeta_t) + h)\, K_t\, dt + \zeta_t\, \sigma\, K_t\, dZ_t$
  - $dp_t = \mu_t^p\, p_t\, dt + \sigma_t^p\, p_t\, dZ_t$ endogenous risk exogenous risk
  - $d(p_t K_t) = \quad \ldots \quad (p_t K_t)\,dt + (\sigma_t^p + \zeta_t\,\sigma)(p_t K_t)\,dZ_t$

Balance sheets



constraint:
entrepreneurs and intermediaries must hold fraction of at least ψ of entrepreneur equity

Monitoring technology
Diamond (1984)
Holmström-Tirole (1997)

Equilibrium definition

- An equilibrium consists of functions that for each history of macro shocks $\{Z_s, s \in [0, t]\}$ specify
  - the price of capital q_t, the value of money p_t and fees f_t that insiders (entrepreneurs and banks) charge for managing assets
  - capital holdings ζ_t and $1 - \zeta_t$ and rates of investment of productive and unproductive households
  - Equity holdings of entrepreneurs, ψ_e, banks, ψ_i and households $1-\psi_e - \psi_i$
  - rates of consumption of entrepreneurs, banks and households

  such that
  - given prices and fees all agents choose asset holdings and consumption to maximize utility
  - markets for capital, entrepreneur outside equity and loans/money clear.

Solving for the equilibrium

- Key idea: summarize sector net worths, sector risks, asset allocations, and make sure that asset returns match required risk premia

	Net worth	*Risk*
▫ Banks:	N_t	$(N_t + \theta\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma)$ $+ \psi_t\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)$
▫ Entrepreneurs:	$\theta\,((p_t + q_t)\,K_t - N_t)$	
▫ HH:	$(1-\theta)\,((p_t + q_t)\,K_t - N_t)$	$(1-\theta)\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma)$ $+ (1-\psi_t)\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)$ $(1-\zeta_t)\,K_t\,(\sigma_t^q - \sigma_t^p - \zeta_t\,\sigma)$

- Money has risk $\sigma_t^p + \zeta_t\,\sigma$
- Capital has risk $\sigma_t^q + \sigma$
- Capital – money $\sigma_t^q + \sigma - \sigma_t^p - \zeta_t\,\sigma$

Valuation of Entrepreneur Capital

- *Net worth* / *Risk*
  - Banks: N_t
  - Entrepreneurs: $\theta\,((p_t + q_t)\,K_t - N_t)$
  - HH: $(1\text{-}\theta)\,((p_t + q_t)\,K_t - N_t)$

$(N_t + \theta\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma)$
$+\,\psi_t\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)$

$(1\text{-}\theta)\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma)$
$+\,(1\text{-}\psi_t)\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)$
$(1\text{-}\zeta_t)\,K_t\,(\sigma_t^q - \sigma_t^p - \zeta_t\,\sigma)$

$\hat{a}(q_t,\zeta_t)/q_t + \hat{g}(q_t,\zeta_t) + \mu_t^q + \sigma\sigma_t^q - (\mu_t^K + \mu_t^p + \sigma\sigma_t^p) =$

  - Return on money: $\boxed{(\mu_t^K + \mu_t^p + \sigma\sigma_t^p)}\,dt + (\sigma_t^p + \zeta_t\,\sigma)\,dZ_t$
  - Return on capital: $\boxed{(\hat{a}(q_t,\zeta_t)/q_t + \hat{g}(q_t,\zeta_t) + \mu_t^q + \sigma\sigma_t^q)}\,dt + (\sigma_t^q + \sigma)\,dZ_t$

Valuation of Entrepreneur Capital

-

	Net worth	*Risk*
Banks:	N_t	$(N_t + \theta\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma)$ $+\, \psi_t\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)$
Entrepreneurs:	$\theta\,((p_t + q_t)\,K_t - N_t)$	
HH:	$(1-\theta)\,((p_t + q_t)\,K_t - N_t)$	$(1-\theta)\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma)$ $+\,(1-\psi_t)\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)$ $(1-\zeta_t)\,K_t\,(\sigma_t^q - \sigma_t^p - \zeta_t\,\sigma)$

$$\hat{a}(q_t,\zeta_t)/q_t + \hat{g}(q_t,\zeta_t) + \mu_t^q + \sigma\sigma_t^q - (\mu_t^K + \mu_t^p + \sigma\sigma_t^p) =$$

$$= (\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)\ \times$$

- Return on money: $(\mu_t^K + \mu_t^p + \sigma\sigma_t^p)\,dt + (\sigma_t^p + \zeta_t\,\sigma)\,dZ_t$
- Return on capital: $(\hat{a}(q_t,\zeta_t)/q_t + \hat{g}(q_t,\zeta_t) + \mu_t^q + \sigma\sigma_t^q)\,dt + (\sigma_t^q + \sigma)\,dZ_t$

Valuation of Entrepreneur Capital

- *Net worth* *Risk*
  - Banks: N_t $(N_t + \theta((p_t + q_t)K_t - N_t))(\sigma_t^p + \zeta_t \sigma)$
  - Entrepreneurs: $\theta((p_t + q_t)K_t - N_t)$ $+ \psi_t \zeta_t K_t (\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t \sigma)$
  - HH: $(1\text{-}\theta)((p_t + q_t)K_t - N_t)$ $(1\text{-}\theta)((p_t + q_t)K_t - N_t))(\sigma_t^p + \zeta_t \sigma)$ $+ (1\text{-}\psi_t)\zeta_t K_t (\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t \sigma)$ $(1\text{-}\zeta_t)K_t(\sigma_t^q - \sigma_t^p - \zeta_t \sigma)$

$$\hat{a}(q_t,\zeta_t)/q_t + \hat{g}(q_t,\zeta_t) + \mu_t^q + \sigma\sigma_t^q - (\mu_t^K + \mu_t^p + \sigma\sigma_t^p) =$$

$$= (\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t \sigma) \times \psi_t \frac{(N_t + \theta((p_t + q_t)K_t - N_t))(\sigma_t^p + \zeta_t \sigma) + \psi_t \zeta_t K_t (\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t \sigma)}{N_t + \theta((p_t + q_t)K_t - N_t)}$$

  - Return on money: $(\mu_t^K + \mu_t^p + \sigma\sigma_t^p)\,dt + (\sigma_t^p + \zeta_t \sigma)\,dZ_t$
  - Return on capital: $(\hat{a}(q_t,\zeta_t)/q_t + \hat{g}(q_t,\zeta_t) + \mu_t^q + \sigma\sigma_t^q)\,dt + (\sigma_t^q + \sigma)\,dZ_t$

Valuation of Entrepreneur Capital

	Net worth	*Risk*
Banks:	N_t	$(N_t + \theta\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma) + \psi_t\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)$
Entrepreneurs:	$\theta\,((p_t + q_t)\,K_t - N_t)$	
HH:	$(1-\theta)\,((p_t + q_t)\,K_t - N_t)$	$(1-\theta)\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma) + (1-\psi_t)\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)$ $(1-\zeta_t)\,K_t\,(\sigma_t^q - \sigma_t^p - \zeta_t\,\sigma)$

$$\hat{a}(q_t,\zeta_t)/q_t + \hat{g}(q_t,\zeta_t) + \mu_t^q + \sigma\sigma_t^q - (\mu_t^K + \mu_t^p + \sigma\sigma_t^p) =$$

$$= (\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma) \times$$

$$\psi_t \frac{(N_t + \theta\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma) + \psi_t\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)}{N_t + \theta\,((p_t + q_t)K_t - N_t)} + (1-\psi_t)\frac{(1-\theta)\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma) + (1-\psi_t)\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)\;(1-\zeta_t)\,K_t\,(\sigma_t^q - \sigma_t^p - \zeta_t\,\sigma)}{(1-\theta)\,((p_t + q_t)K_t - N_t)}$$

- Return on money: $(\mu_t^K + \mu_t^p + \sigma\sigma_t^p)\,dt + (\sigma_t^p + \zeta_t\,\sigma)\,dZ_t$
- Return on capital: $(\hat{a}(q_t,\zeta_t)/q_t + \hat{g}(q_t,\zeta_t) + \mu_t^q + \sigma\sigma_t^q)\,dt + (\sigma_t^q + \sigma)\,dZ_t$

Valuation of HH Capital

	Net worth	*Risk*
Banks:	N_t	$(N_t + \theta\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma)$
Entrepreneurs:	$\theta\,((p_t + q_t)\,K_t - N_t)$	$+\,\psi_t\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)$
HH:	$\boxed{(1-\theta)\,((p_t + q_t)\,K_t - N_t)}$	$\boxed{\begin{array}{c}(1-\theta)\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma) \\ +\,(1-\psi_t)\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma) \\ (1-\zeta_t)\,K_t\,(\sigma_t^q - \sigma_t^p - \zeta_t\,\sigma)\end{array}}$

$$\underline{\hat{a}}(q_t,\zeta_t)/q_t + \underline{\hat{g}}(q_t,\zeta_t) + \mu_t^q + \sigma\sigma_t^q - (\mu_t^K + \mu_t^p + \sigma\sigma_t^p) =$$

$$= (\sigma_t^q \cancel{+\,\sigma} - \sigma_t^p - \zeta_t\,\sigma) \times$$

$$\times \frac{\begin{array}{c}(1-\theta)\,((p_t + q_t)K_t - N_t))\,(\sigma_t^p + \zeta_t\,\sigma) \\ +\,(1-\psi_t)\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma) \\ (1-\zeta_t)\,K_t\,(\sigma_t^q - \sigma_t^p - \zeta_t\,\sigma)\end{array}}{(1-\theta)\,((p_t + q_t)K_t - N_t)}$$

- Return on money: $(\mu_t^K + \mu_t^p + \sigma\sigma_t^p)\,dt + (\sigma_t^p + \zeta_t\,\sigma)\,dZ_t$
- Return on capital: $(\hat{a}(q_t,\zeta_t)/q_t + \hat{g}(q_t,\zeta_t) + \mu_t^q + \sigma\sigma_t^q)\,dt + (\sigma_t^q + \sigma)\,dZ_t$

Law of motion of N_t

- So far, asset valuation for given N_t only
-

	Net worth	*Risk*
Banks:	N_t	$\left(N_t + \theta\left((p_t + q_t)K_t - N_t\right)\right)(\sigma_t^p + \zeta_t\,\sigma)$
Entrepreneurs:	$\theta\left((p_t + q_t)K_t - N_t\right)$	$+ \psi_t\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)$
HH:	$(1-\theta)\left((p_t + q_t)K_t - N_t\right)$	$(1-\theta)\left((p_t + q_t)K_t - N_t\right)(\sigma_t^p + \zeta_t\,\sigma)$ $+ (1-\psi_t)\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)$ $(1-\zeta_t)\,K_t\,(\sigma_t^q - \sigma_t^p - \zeta_t\,\sigma)$

$$\sigma_t^N = \frac{\left(N_t + \theta\left((p_t + q_t)K_t - N_t\right)\right)(\sigma_t^p + \zeta_t\,\sigma) + \psi_t\,\zeta_t\,K_t\,(\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t\,\sigma)}{N_t + \theta\left((p_t + q_t)K_t - N_t\right)}$$

= risk premium

earned on incremental risk over

- Return on money: $(\mu_t^K + \mu_t^p + \sigma\sigma_t^p)\,dt + (\sigma_t^p + \zeta_t\,\sigma)\,dZ_t$

Law of motion of N_t

- So far, asset valuation for given N_t only
-

	Net worth	*Risk*
Banks:	N_t	$(N_t + \theta((p_t + q_t)K_t - N_t))(\sigma_t^p + \zeta_t\sigma) + \psi_t \zeta_t K_t (\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t \sigma)$
Entrepreneurs:	$\theta((p_t + q_t) K_t - N_t)$	
HH:	$(1-\theta)((p_t + q_t) K_t - N_t)$	$(1-\theta)((p_t + q_t)K_t - N_t))(\sigma_t^p + \zeta_t\sigma) + (1-\psi_t)\zeta_t K_t (\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t \sigma)$ $(1-\zeta_t) K_t (\sigma_t^q - \sigma_t^p - \zeta_t \sigma)$

$$\sigma_t^N = \frac{(N_t + \theta((p_t + q_t)K_t - N_t))(\sigma_t^p + \zeta_t\sigma) + \psi_t \zeta_t K_t (\sigma_t^q + \boldsymbol{\sigma} - \sigma_t^p - \zeta_t \sigma)}{N_t + \theta((p_t + q_t)K_t - N_t)}$$

= risk premium

earned on incremental risk over

$$dN_t/N_t = (\mu_t^K + \mu_t^p + \sigma\sigma_t^p)\,dt - \rho\,dt + \sigma_t^N(\sigma_t^N - (\sigma_t^p + \zeta_t\sigma))\,dt + \sigma_t^N\,dZ_t$$

- Return on money: $(\mu_t^K + \mu_t^p + \sigma\sigma_t^p)\,dt + (\sigma_t^p + \zeta_t\sigma)\,dZ_t$

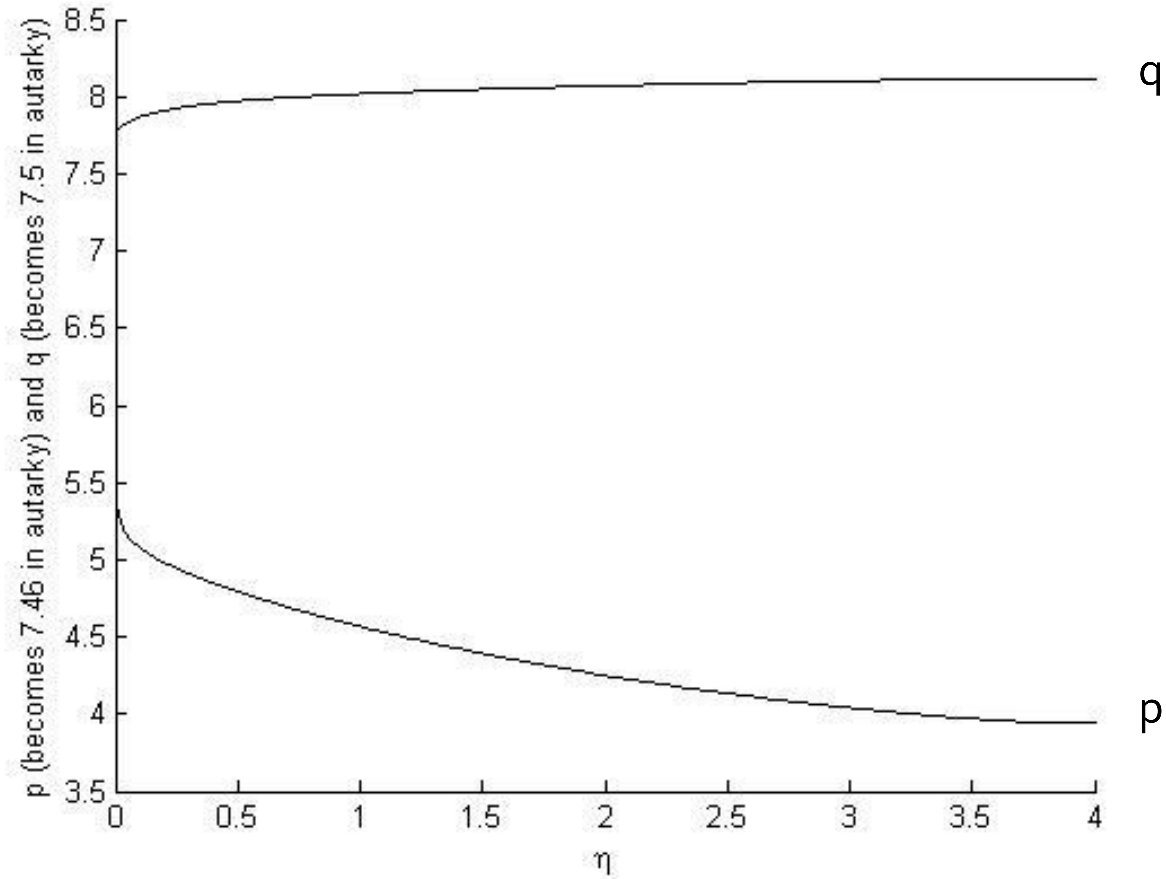
Scale invariance

- Our model is scale invariant in
  - N_t (total intermediary net worth) an
  - K_t (aggregate capital)
- $\boldsymbol{\eta_t = N_t/K_t}$
- Solve for
  - ζ_t = fraction of capital managed by productive HH
  - q_t = price of physical capital
  - p_t = price of money
  - ψ_t = fraction of risk held by entrepreneurs and i-sector
  - f_t = fee for intermediation (spread)

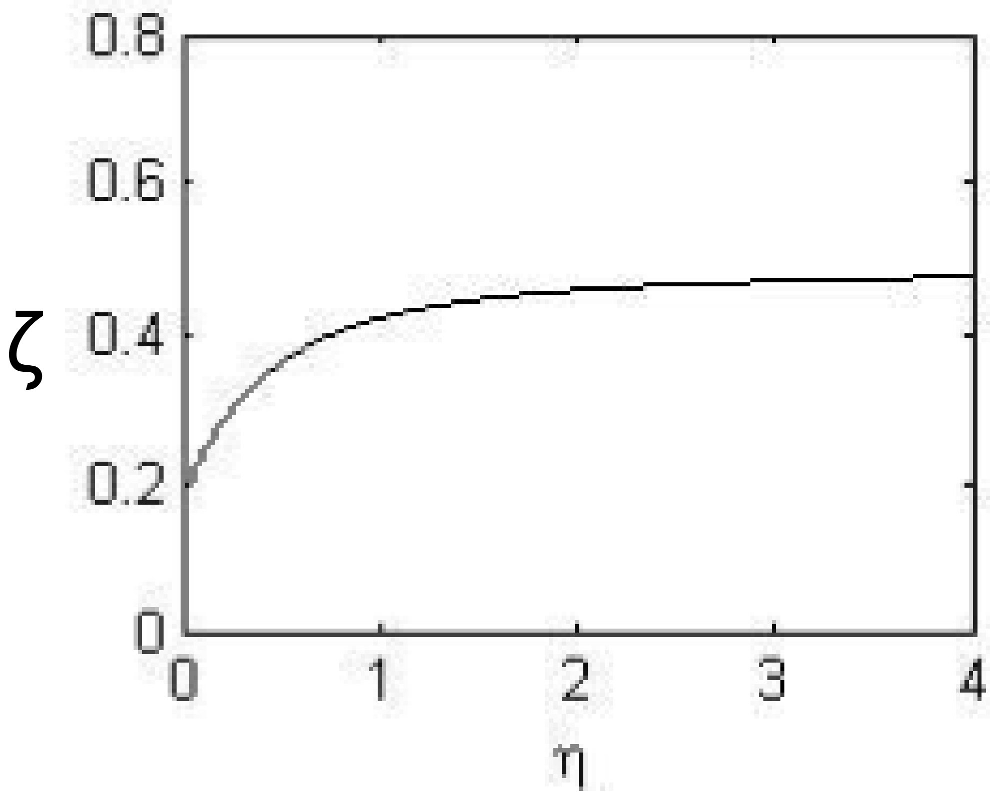
  as a functions of the **state variable $\boldsymbol{\eta_t = N_t/K_t}$**

- Mechanic application of Ito's lemma – equilibrium conditions get transformed into ordinary differential equations for $\zeta(\eta)$, $q(\eta)$, $p(\eta)$ and $\psi(\eta)$

Equilibrium: p and q



Equilibrium - unconstrained



Observations

As η goes up:

- Intermediaries take on more risk, competition increases and fees for intermediation services go down
- Capital is allocated more efficiently, more productively
- The price of capital increases due to higher demand $\Rightarrow$ greater productive efficiency
- Unproductive agents hold more inside money (deposits in financial institutions) and less outside fiat money
- The price of fiat money goes down (so it would go up in the event that η falls, leading to deflation)
- There is an additional source of amplification relative to an economy without money: as η goes down, the value of assets fall, while the value of liabilities increase (due to deflation)

Amplification through "deflation spiral"

- As intermediaries' net worth declines
- Intermediation + *inside money* shrinks
  - Money multiplier collapses
  - Economic activity declines
- Value of *outside money* rises – deflation
  - Externality effect (within i-sector)
- Intermediaries are doubly hit
  - Asset side: asset values decrease
  - Liability side: real debt value increases
- Deflationary spiral

Roadmap

- Big picture overview
- Passive monetary policy: "Gold standard"
  - Model setup
  - General model with aggregate risk
    - Lending and money multiplier depends on net worth of i-sector
    - Deflation spiral
- Active Monetary Policy
  - Introduce long-term bond
    - Short-term interest rate policy
    - Asset purchase and OMO
  - Redistributional effects
  - "Greenspan put" - Time-inconsistency

Motivation – some stylized facts/empirics

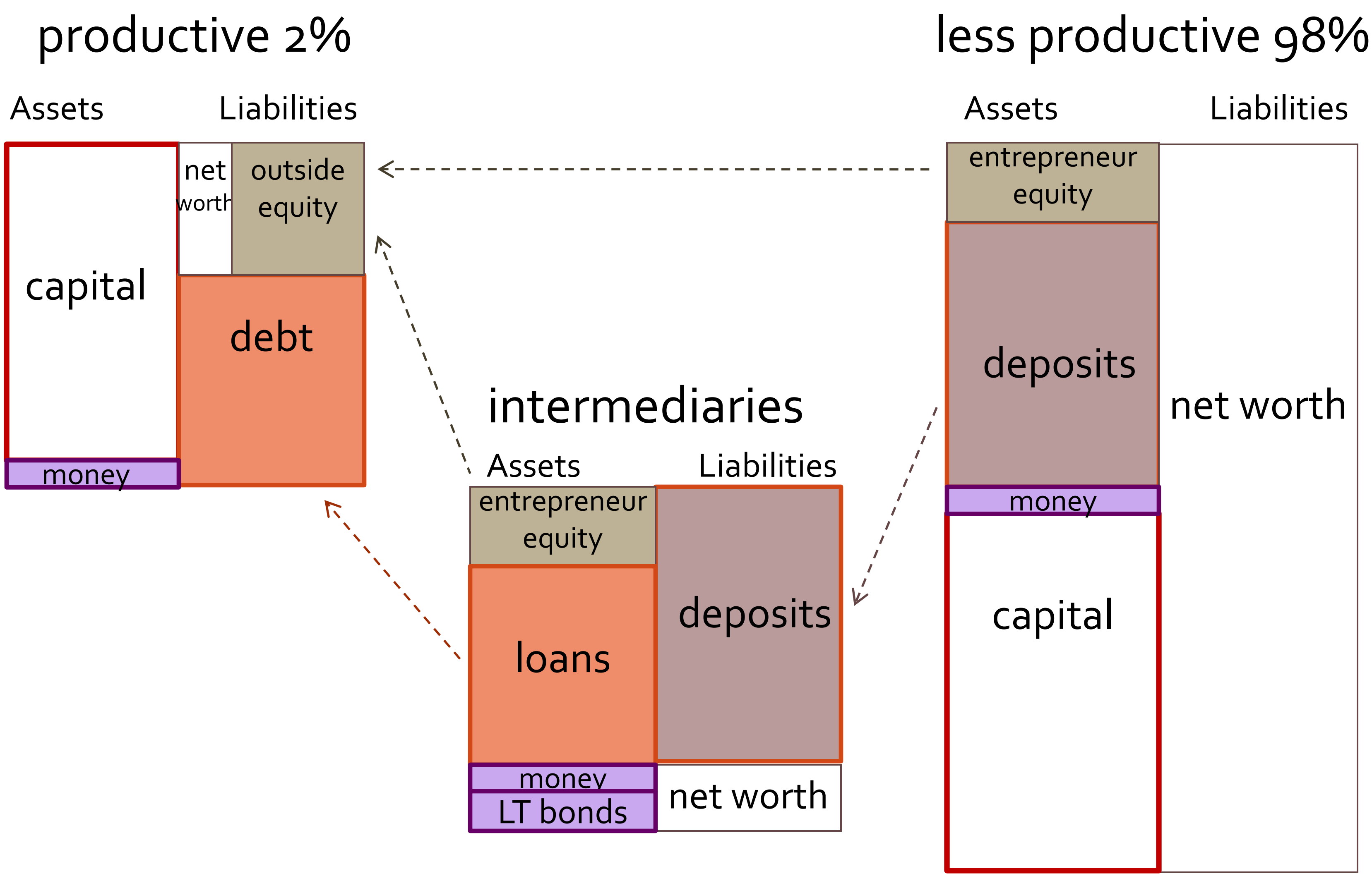
- Stylized facts from current crisis
  - Deflationary pressure
  - Money multiplier collapsed (see e.g. Goodhart 2010)
    - Monetary base increased
    - M3 stayed roughly constant
  - Banking sector profits were helped by monetary policy
  - Aggressive risk-taking before crisis
- Empirical findings
  - Mervin King (1994) more indebted countries suffered sharper downturn in 1990s recession
  - Eisfeld-Rampini (2008) less capital reallocation in downturns
  - King-Ploser (1984) inside money has significantly more power for output than monetary base
  - Friedman (1982) debt/GDP more stable than o-money/GDP suggest money moves endogenously

Monetary policy

So far, outside money fixed, pays no interest ("Gold Standard")
= no central bank

- 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
  - Introduce consul (perpetual) bond
    - pays interest rate in ST (outside) money
  - Budget neutral policies
- Asset purchases
  - Bond – open market operations (OMO)
  - Outside equity
  - Risky capital k_t
- Perfect commitment (Ramsey) vs. imperfect commitment
  - Markovian (in η)

Monetary economy with intermediaries



Instrument 1: short-term interest rate

- Without long maturity assets changes in short-term interest rate has no effect
  - Interest rate change equals instantaneous inflation change
- With long-term bond
  (monetary instruments: fraction χ is cash and $1 - \chi$ are bonds)
- with 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

- Effectiveness of monetary policy depend on maturity structure (duration) of government debt

Moral hazard – "Liquidity bubbles"

- Accommodating Monetary policy rule
  "Greenspan put"
  - Ex-post efficient – recapitalizes intermediary sector
  - Ex-ante inefficient – if excessive
    stimulates risk taking on behalf of intermediaries
    "Liquidity bubble"
- Time consistency problem with
  - Intermediaries/bankers instead of workers/labor unions
- Rationale for banking regulation
  - To reduce probability of low η realizations

Optimality of monetary policy

- Lowers risk on liability side of intermediaries

  $(\sigma_t^q + \sigma - \sigma_t^p - \kappa_t \sigma)$

- Signal = fundamental risk + valuation risk + money risk
  - Signal precision increases
  - Improves "incentives"

Roadmap

- Big picture overview
- Passive monetary policy: “Gold standard”
- Active Monetary Policy
  - Introduce long-term bond
    - Short-term interest rate policy
    - Asset purchase and OMO
  - Redistributional effects
  - “Greenspan put” - Time-inconsistency
- Differences to New Keynesian framework

	New Keynesian	I-Theory
Key friction	Price stickiness	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

	New Keynesian	I-Theory
Risk build-up phase		Endogenous due to accommodating monetary policy
Net worth dynamics	zero profit → no dynamics	dynamic
State variables	Many exogenous shocks Intermediation/friction shock	Endogenous intermediation shock
Monetary policy rule	Taylor rule (is approximately optimal only if difference in u' is well proxied by output gap) • spreads • credit aggregates (?)	Depends on signal quality and timeliness of various observables
Policy instrument	Short-term interest rate + expectations	Short-term interest rate **+ long-term bond** + expectations
Role of money	In utility function (no deflation spiral)	Storage Precautionary savings

Conclusions/further research

- Unified macromodel 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
  - Redistributional feature
  - Time inconsistency problem – "Greenspan put"
- Future research
  - Persistent productivity shocks
  - Maturity mismatch in i-sector
  - Minsky cycles