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
  - Model that combines **money and intermediation** – inside money
  - Value of money is endogenously determined
    - (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
  - Unified framework to study financial and monetary stability

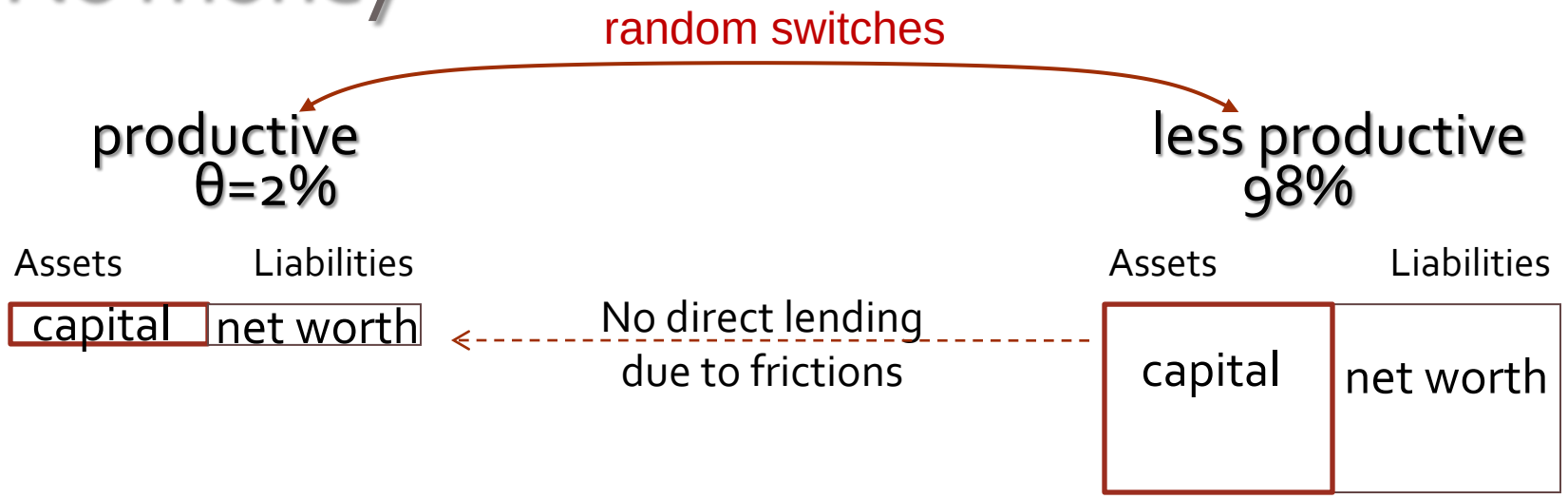
Motivation – some stylized facts/empirics

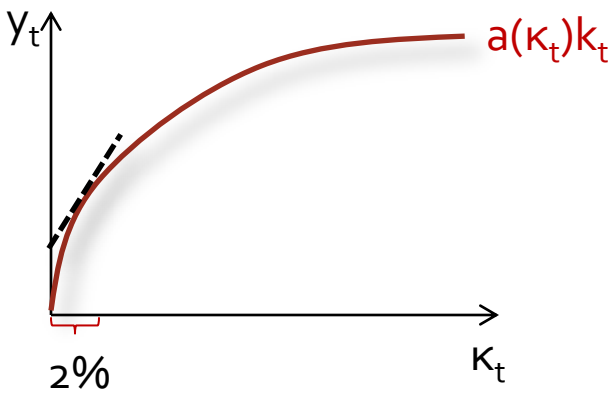
- Stylized facts from current crisis
  - Deflationary pressure
  - Money multiplier collapsed (see e.g. Goodhart 2010)
    - Monetary base increased
    - M3 stayed roughly constant
  - Banking sector profits were helped by monetary economics
  - Aggressive risk-taking before crisis
- Empirical findings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

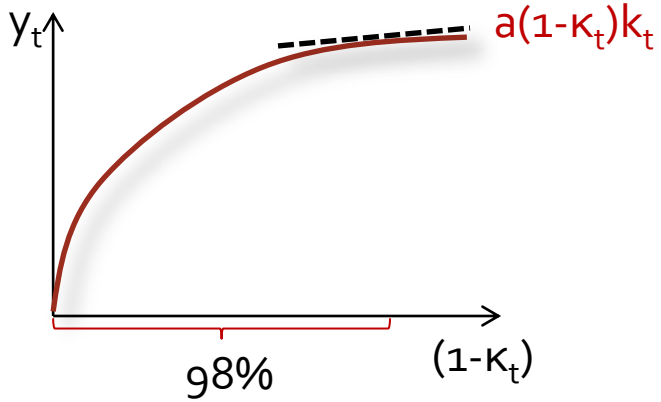
Roadmap

- Passive monetary policy - "Gold standard"
  - No money, no lending
  - Outside money (Polar case 1)
  - Perfect lending (Polar case 2)
  - Lending through intermediated lending (inside money)
    - Lending and money multiplier depends on net worth of i-sector
    - Deflation spiral
- Active Monetary Policy
  - Introduce long-term bond and OMO
  - Redistributional effects
  - "Greenspan put" - Time-inconsistency
- Differences to New Keynesian framework

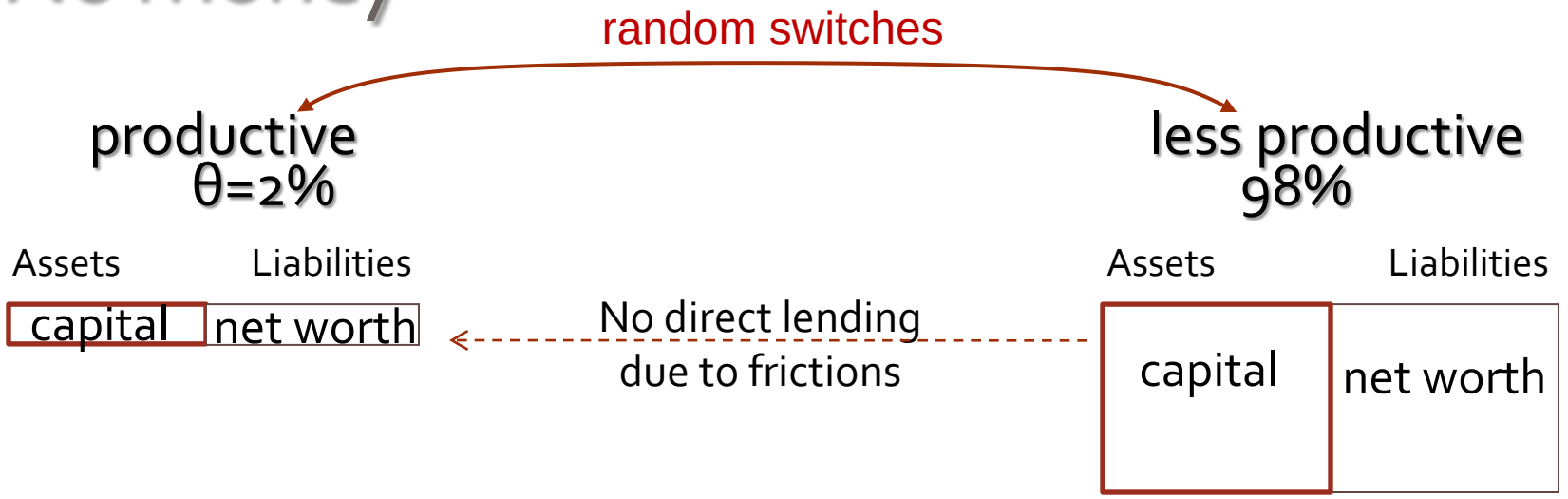
No money

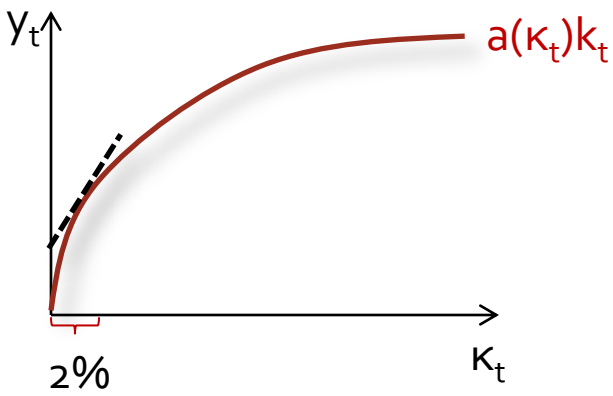

random switches
productive
θ=2%
less productive
98%
Assets
Liabilities
capital
net worth
No direct lending
due to frictions
Assets
Liabilities
capital
net worth

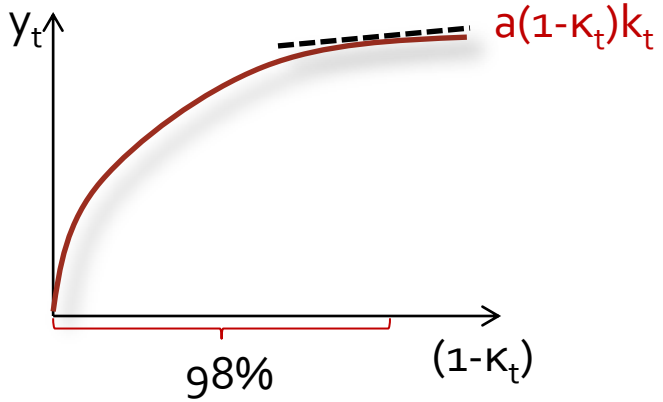

y_t
$a(\kappa_t)k_t$
2%
κ_t


y_t
$a(1-\kappa_t)k_t$
98%
$(1-\kappa_t)$

No money





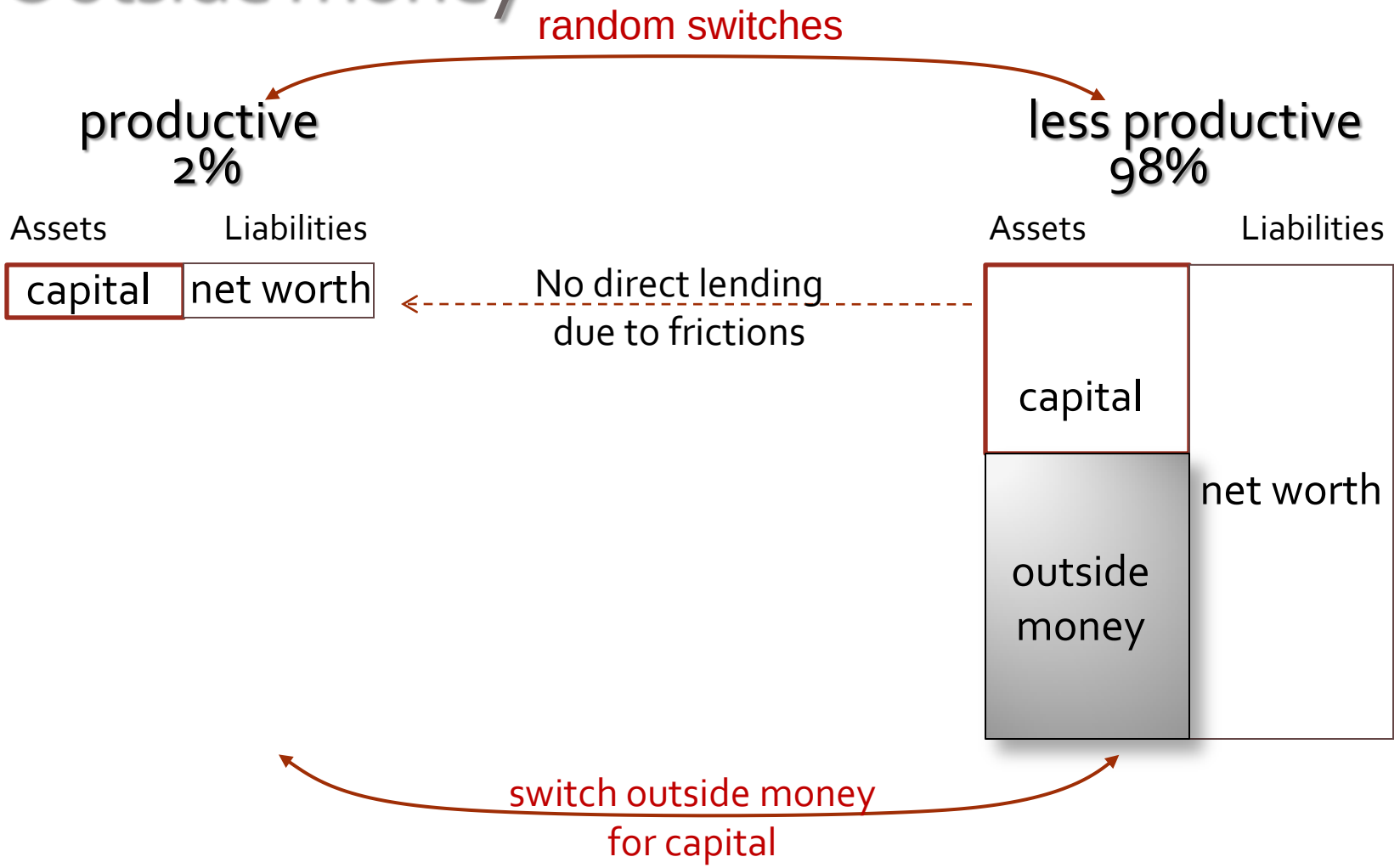


- $dk_t = (\phi(i_t) - \delta)\, k_t\, dt + \sigma\, k_t\, dZ_t$

sector shock (exogenous risk)

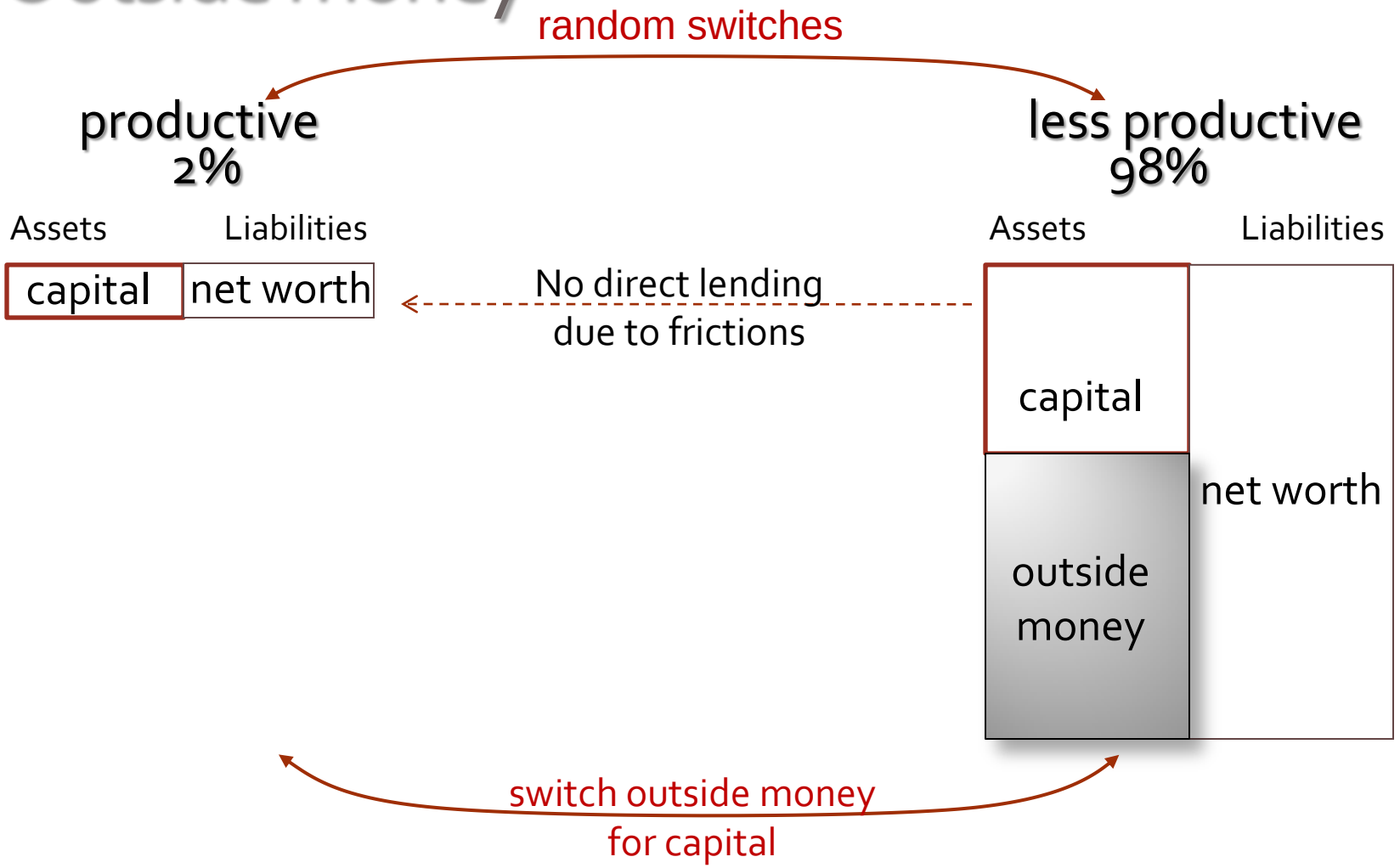
$dZ_t = 0$

Outside money



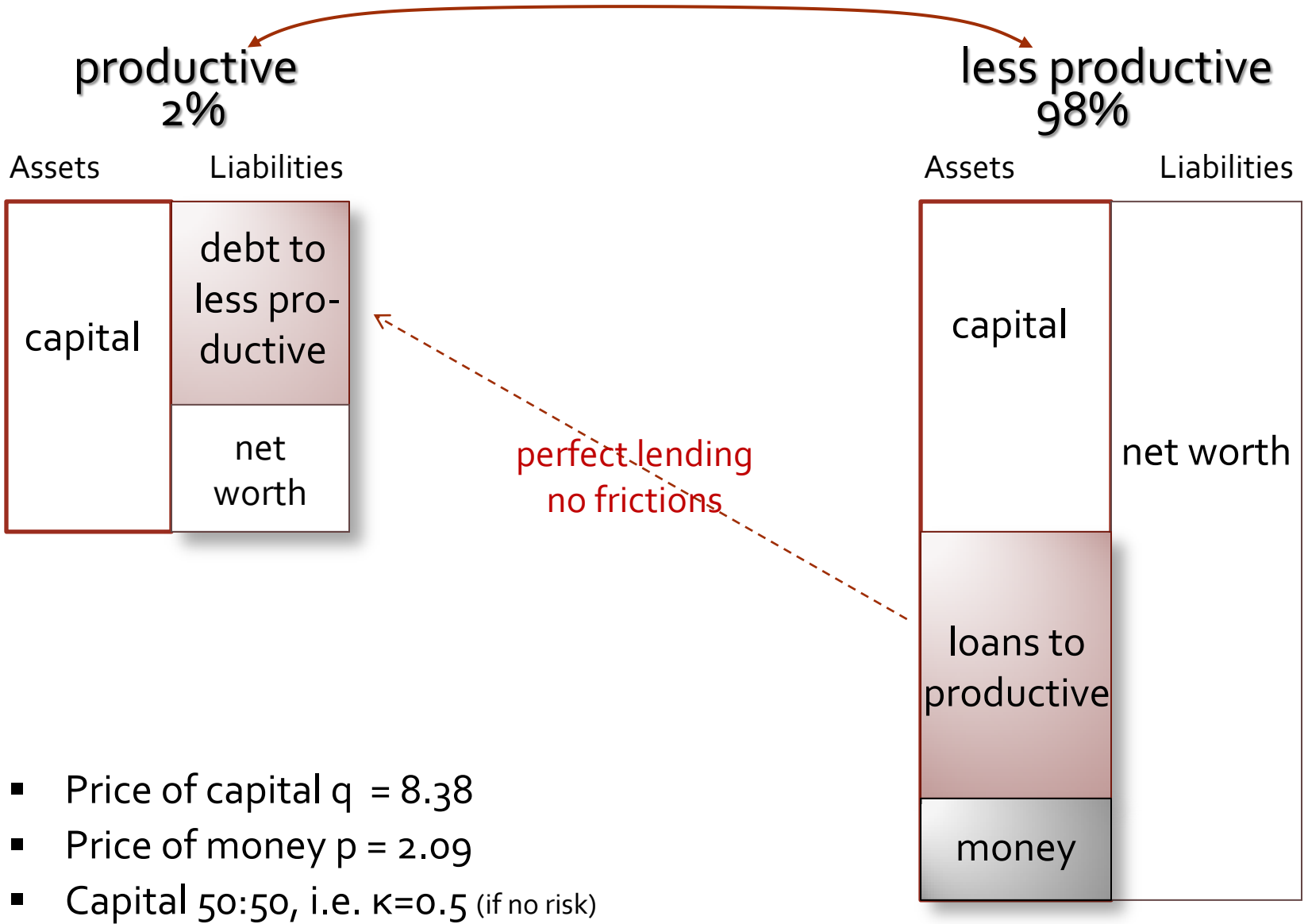
- More capital is in "productive hands"
- Notice difference to Bewley economy
  - Productivity shocks vs. endowment shocks

Outside money



- Price of capital: q = 7.84
- Price of money: p = 7.04
- Fraction of capital held by productive HH: π=4.2 %

Other polar case: Unconstrained borrowing

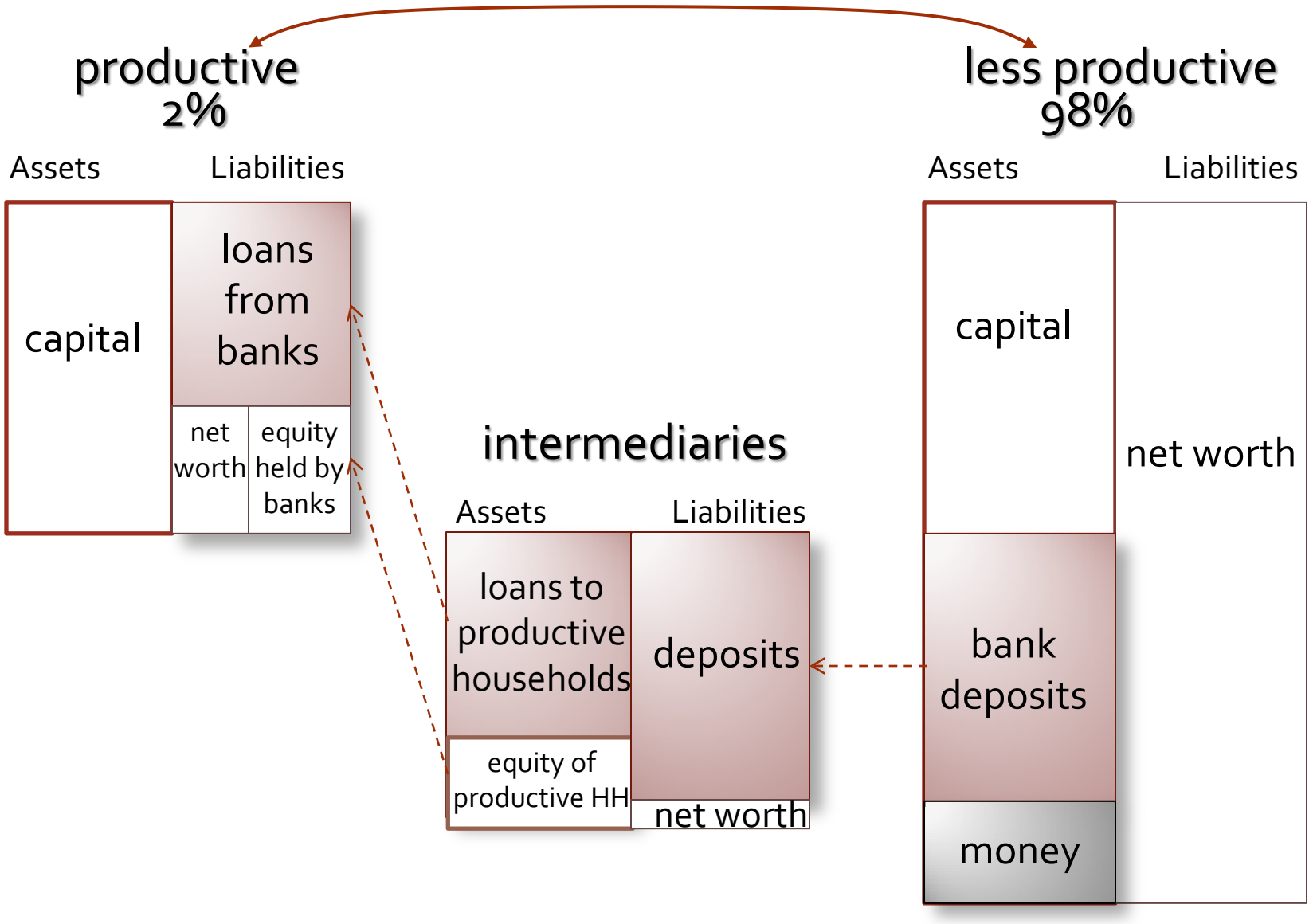


- Price of capital q = 8.38
- Price of money p = 2.09
- Capital 50:50, i.e. κ=0.5 (if no risk)

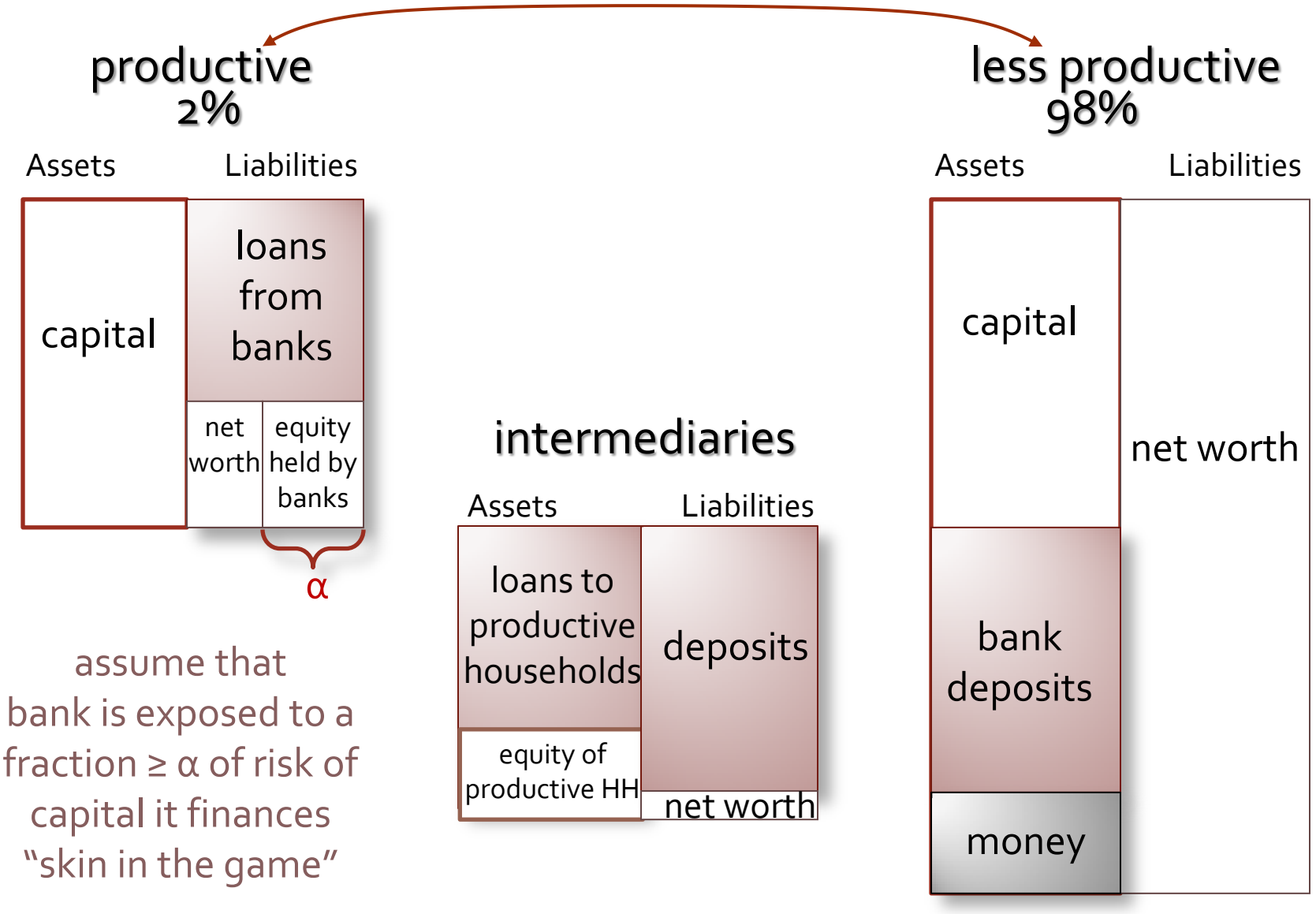
Compare

- With borrowing: $q = 8.38, \quad p = 2.09$
- Without borrowing: $q = 7.84, \quad p = 7.04$
  - capital allocated inefficiently – productive agents hold only 4.2%
  - underinvestment, as the price of capital q is depressed
  - total net worth of living agents (measured in current output) is actually greater, but investments generate lower return

Intermediaries



Intermediaries



assume that bank is exposed to a fraction ≥ α of risk of capital it finances "skin in the game"

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)

Endogenous risk - amplification

- Exogenous risk: cash flow news/shock on k

  $$dk_t = (\phi(i_t) - \delta)\, k_t\, dt + \sigma\, k_t\, dZ_t$$

- Endogenous risk: SDF news
  - Price of capital (in terms of output)

    $$dq_t = \mu_t^q\, q_t\, dt + \sigma_t^q\, q_t\, dZ_t$$

    Endogenous, fluctuating between 7.04 and 8.38, depending on the amount of lending/bank net worth

    - Asset side of HH: $d(k_t q_t) = \ldots + (\sigma_t^q + \sigma)\,(k_t q_t)\, dZ_t$

Endogenous risk - amplification

- Exogenous risk: cash flow news/shock on k

$$dk_t = (\phi(i_t) - \delta)\, k_t\, dt + \sigma\, k_t\, dZ_t$$

- Endogenous risk: SDF news
  - Price of capital (in terms of output)

$$dq_t = \mu_t^q\, q_t\, dt + \sigma_t^q\, q_t\, dZ_t$$

Endogenous, fluctuating between 7.04 and 8.38, depending on the amount of lending/bank net worth

    - Asset side of HH: $d(k_t q_t) = \ldots + (\sigma_t^q + \sigma)\,(k_t q_t)\, dZ_t$
  - Price of money (aggregate value of money is $p_t K_t$)

$$dp_t = \mu_t^p\, p_t\, dt + \sigma_t^p\, p_t\, dZ_t$$

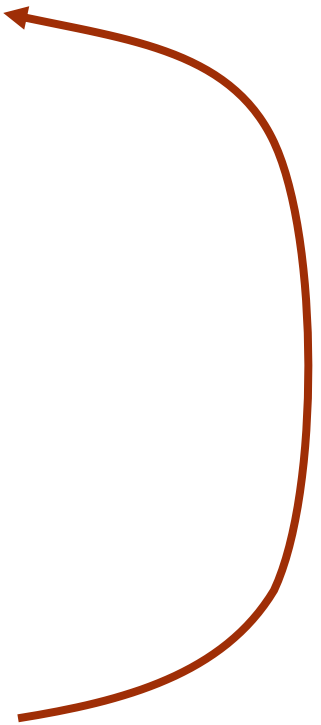
endogenous, fluctuating between 2.09 and 7.84

    - Money risk: $d(p_t K_t) = \ldots (p_t K_t)\, dt + (\sigma_t^p + \pi_t\, \sigma)\,(p_t K_t)\, dZ_t$
    - Bank risk: $n_t\,(\sigma_t^p + \pi_t\, \sigma) + x_t\,(\sigma_t^q + \sigma - \sigma_t^p - \pi_t\, \sigma)$

intermediaries will charge a fee $x_t f_t$ for taking on this risk

Amplification through "deflation spiral"

- 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



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 bank fees f_t
  - capital holdings π_t and $1 - \pi_t$ and rates of investment of productive and unproductive households
  - rates of consumption of productive and unproductive households
  - such that
  - given prices and bank fees, productive households choose asset holdings, consumption and investment to maximize utility
  - given fees, banks lend and consume to maximize utility
  - unproductive households - portfolio of capital and money/deposits
  - markets for capital, output and loans clear

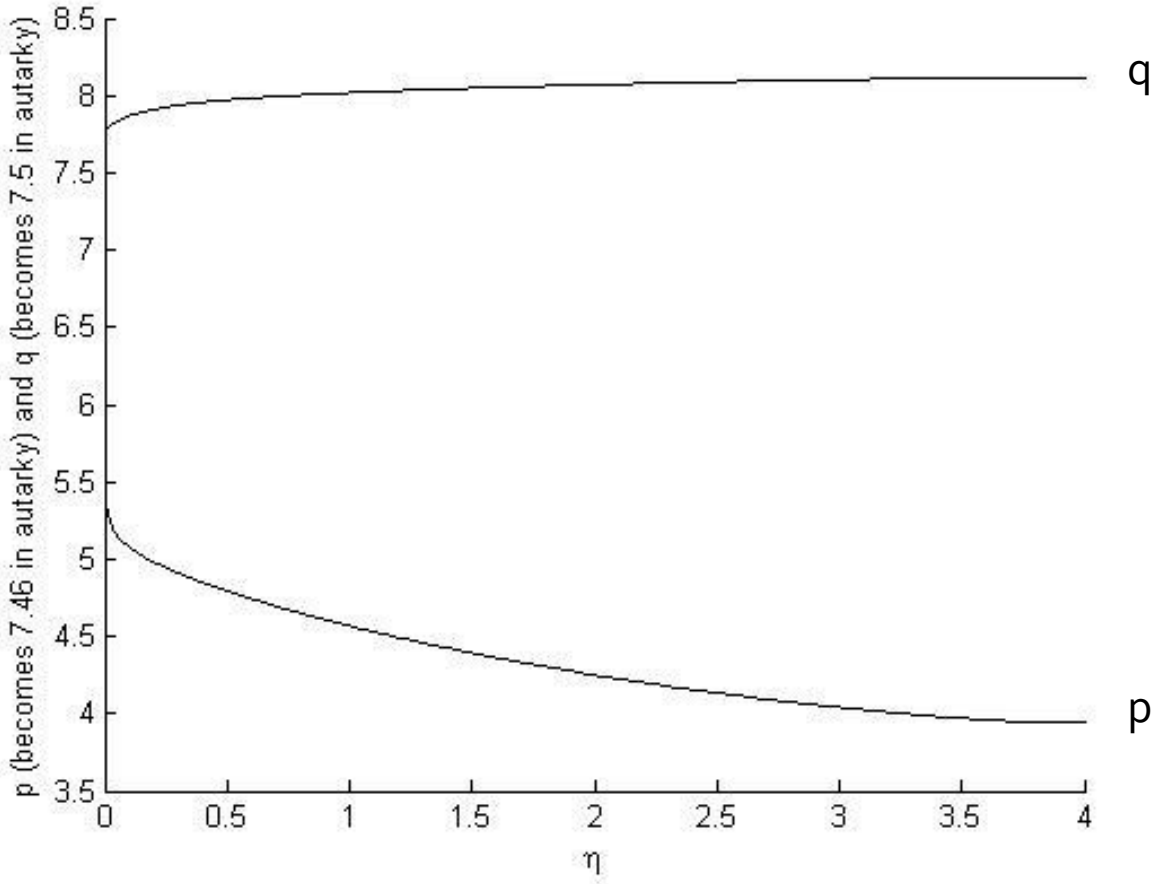
Scale invariance

- Our model is scale invariant in
  - N_t (total intermediary net worth) an
  - K_t (aggregate capital)
- $\eta_t = N_t/K_t$
- Solve for
  - π_t = fraction of capital managed by productive HH
  - q_t = price of physical capital
  - p_t = price of money
  - f_t = fee for intermediation (spread)

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

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

Equilibrium: p and q



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)

Roadmap

- Big picture overview
- Passive monetary policy: "Gold standard"
  - Model setup
  - 2 polar cases
    - Impaired i-sector — "lending" via outside money only
    - Perfect i-sector — perfect lending
  - 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

Monetary policy

So far, outside money fixed, pays no interest ("Gold standard")
+ no central bank

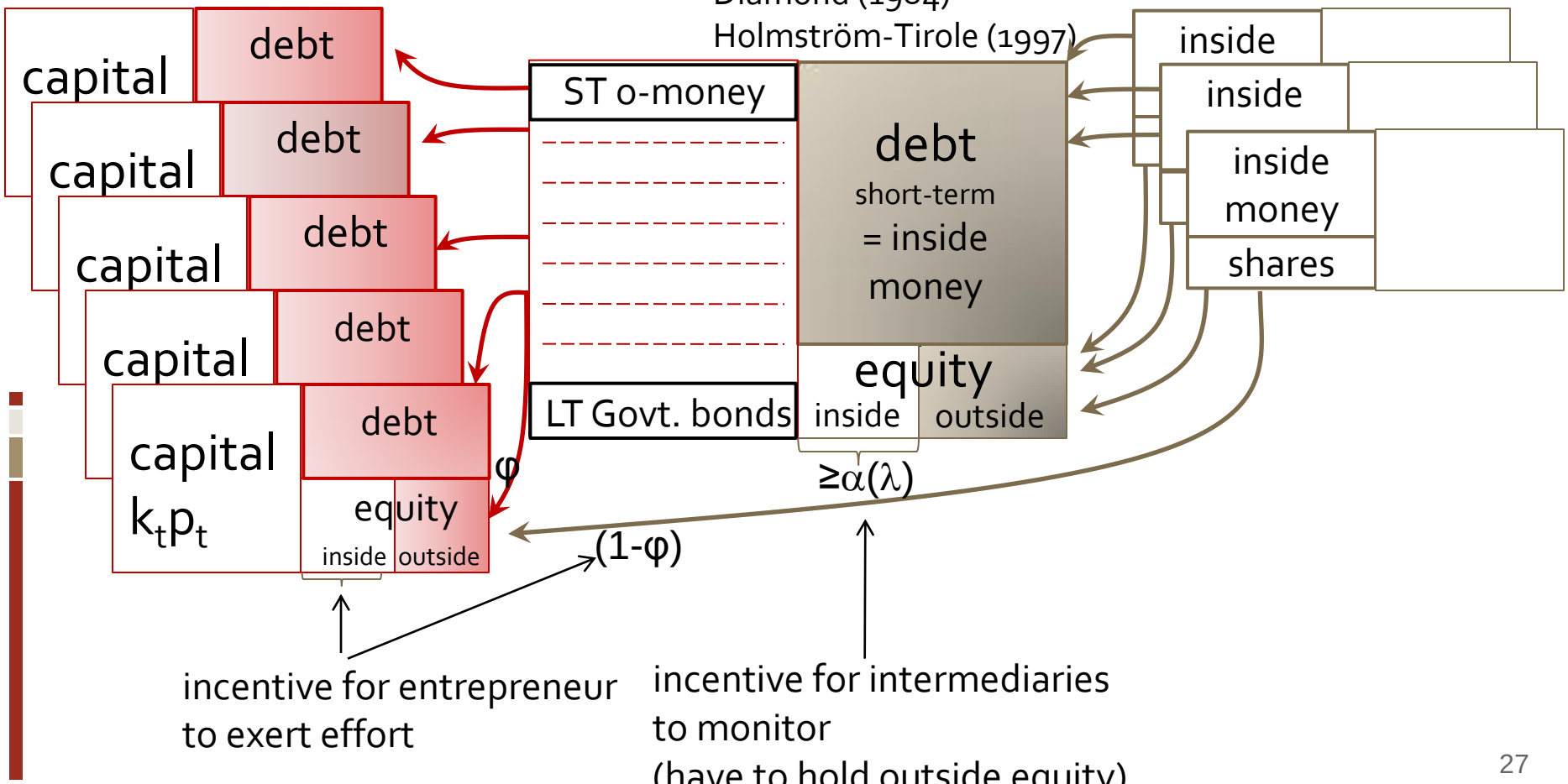
- Short-term interest rate policy
  - Central bank accepts deposits & pays interest (by printing money)
    - E.g. short-term interest rate is lowered when η becomes small
  - Introduce consul (perpetual) bond
    – pays interest rate in ST (outside) money
  - Budget neutral policies
- Asset purchases
  - Bond – open market operations (OMO)
  - Outside equity
  - Risky capital k_t
- Perfect commitment (Ramsey) vs. imperfect commitment
  - Markovian (in η)

Instrument 1: short-term interest rate

- Productive
- Intermediary
  - Monitoring

Diamond (1984)
Holmström-Tirole (1997)

- Less productive



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

Instrument 2: Asset purchase (OMO)

- Open market operation
  - changes "maturity structure of government obligations"
  - Redistributes wealth if monetary policy is accommodative
  - Intuition:
    - As η declines i(η) is lowered. This increases the value of G-bonds which helps to stabilize η.
    - For low η maturity structure of overall o-money rises
    - (Monetary policy should depend on maturity structure of government debt)
- Aside: short-term interest rate changes often also involve very small scale OMO

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"

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

Roadmap

- Big picture overview
- Passive monetary policy: "Gold standard"
  - 2 polar cases
    - Impaired i-sector "lending" via outside money only
    - Perfect i-sector perfect lending
  - General model with aggregate risk
- 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 — 2nd pillar of the ECB
  - Monetary stability — 1st pillar
    - 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 intermediary sector