Inefficient Investment Waves

Zhiguo He
University of Chicago

Péter Kondor
Central European University

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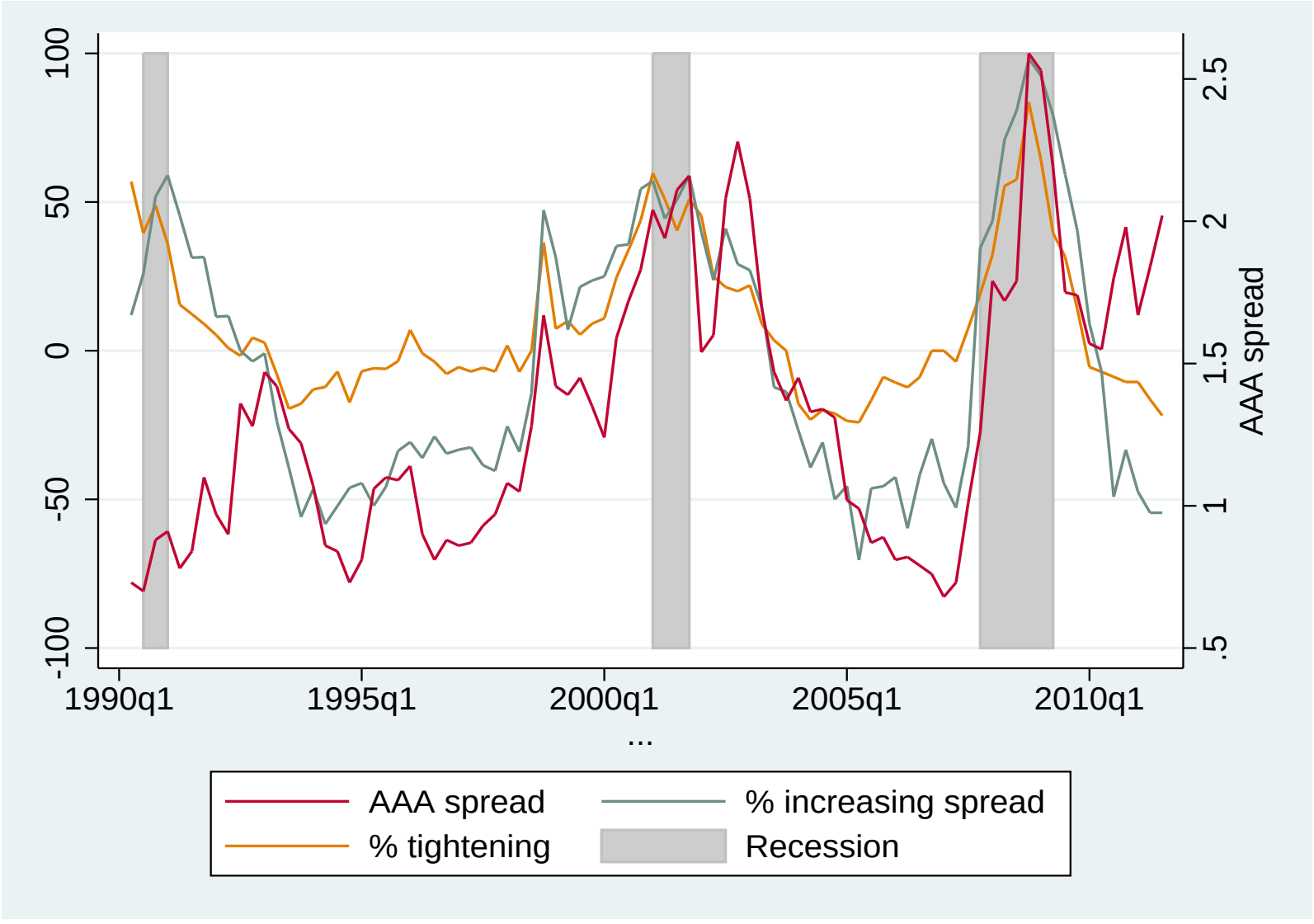
Investment Waves

- supply of financing is procyclical
  - in booms: more projects are financed $\Rightarrow$ high investment, low returns
  - in recessions: less projects are financed $\Rightarrow$ low investment, high returns
- two possible contexts: aggregate cycles/ industry cycles

Aggregate Investment Waves: Corporate loans/bonds



Inefficient Investment Waves

- Do investment waves arise by simple financing frictions (without persistent shocks in technology)?
- Are these investment waves (constrained) inefficient?
- If yes, too much investment in booms, too little investment in recessions or both?
- Should the government intervene in booms/recessions or both?

- In this paper, analytically tractable dynamic stochastic model of trade and investment to show:
  - Aggregate constraint on available capital $\Rightarrow$ (constrained) efficient investment waves

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    - in booms: too much investment in productive technology, too little cash holding
    - in recessions: too little investment, too much liquidity hoarding

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  - Aggregate constraint on available capital $\Rightarrow$ (constrained) efficient investment waves
  - Unverifiable idiosyncratic investment-opportunities $\Rightarrow$ (often) two-sided inefficiency
    - in booms: too much investment in productive technology, too little cash holding
    - in recessions: too little investment, too much liquidity hoarding
  - Were government intervene only in the recession
    - makes over investment in booms worse
    - even if effective, might make everyone worse off
  - Applications: (1) housing cycle, (2) industry cycles, (3) financial development and growth volatililty

A Simplified 2-Period Example: Setting

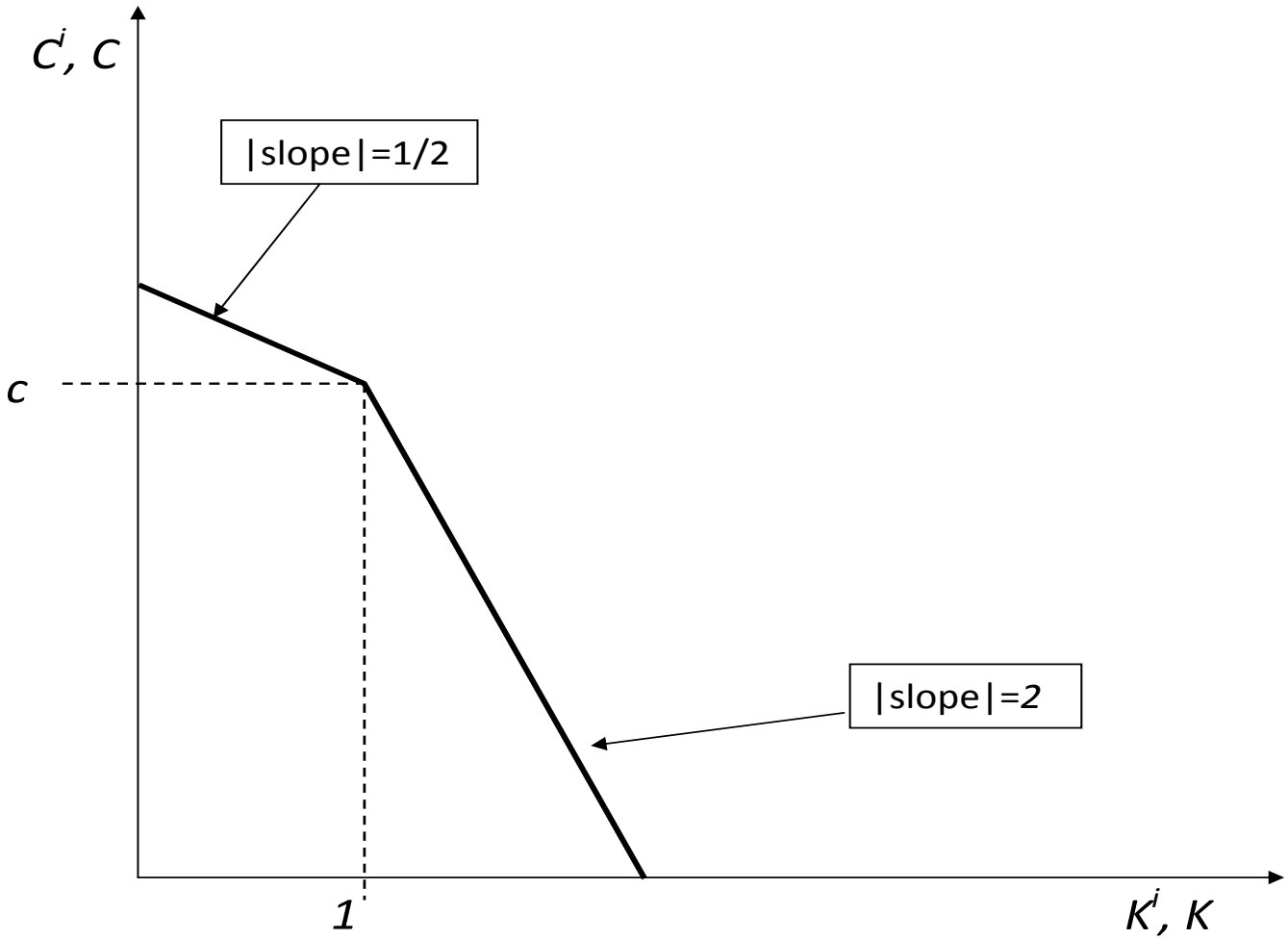
- ex ante identical agents with 1 **capital** (K), c **cash** (C)
- period 0, investment: agent i can convert 2 units of cash to a unit of capital or 2 units of capital to a unit of cash
- period 1: shocks and trade
  - half agents can produce 3 units of consumption from each unit of capital,
  - other half can turn each unit of cash to 3 units of consumption (through a new investment opportunity)
  - agents trade capital at price p, and then consume

- individual's problem

$$\max_{K^i, C^i} \frac{1}{2}\left(K^i + \frac{C^i}{p}\right)3 + \frac{1}{2}\left(K^i p + C^i\right)3$$

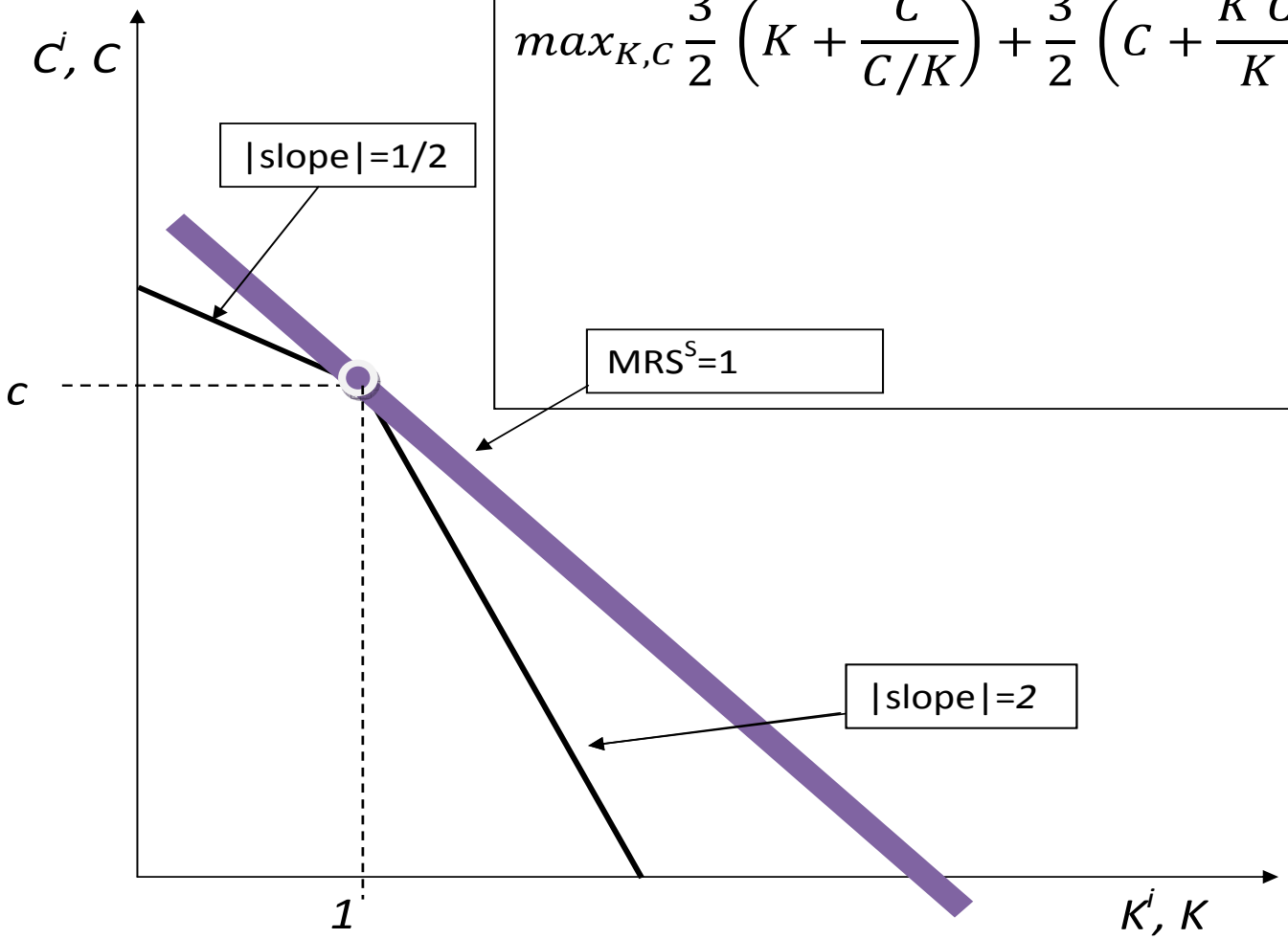
  subject to investment technology
- equilibrium period 1 price $p = \frac{C}{K}$. Ex post efficient allocation

A Simplified 2-Period Example: Technology



A Simplified 2-Period Example: Social Optimum

$$max_{K,C}\ \frac{3}{2}\left(K+\frac{C}{C/K}\right)+\frac{3}{2}\left(C+\frac{K\,C}{K}\right)=3(K+C)$$

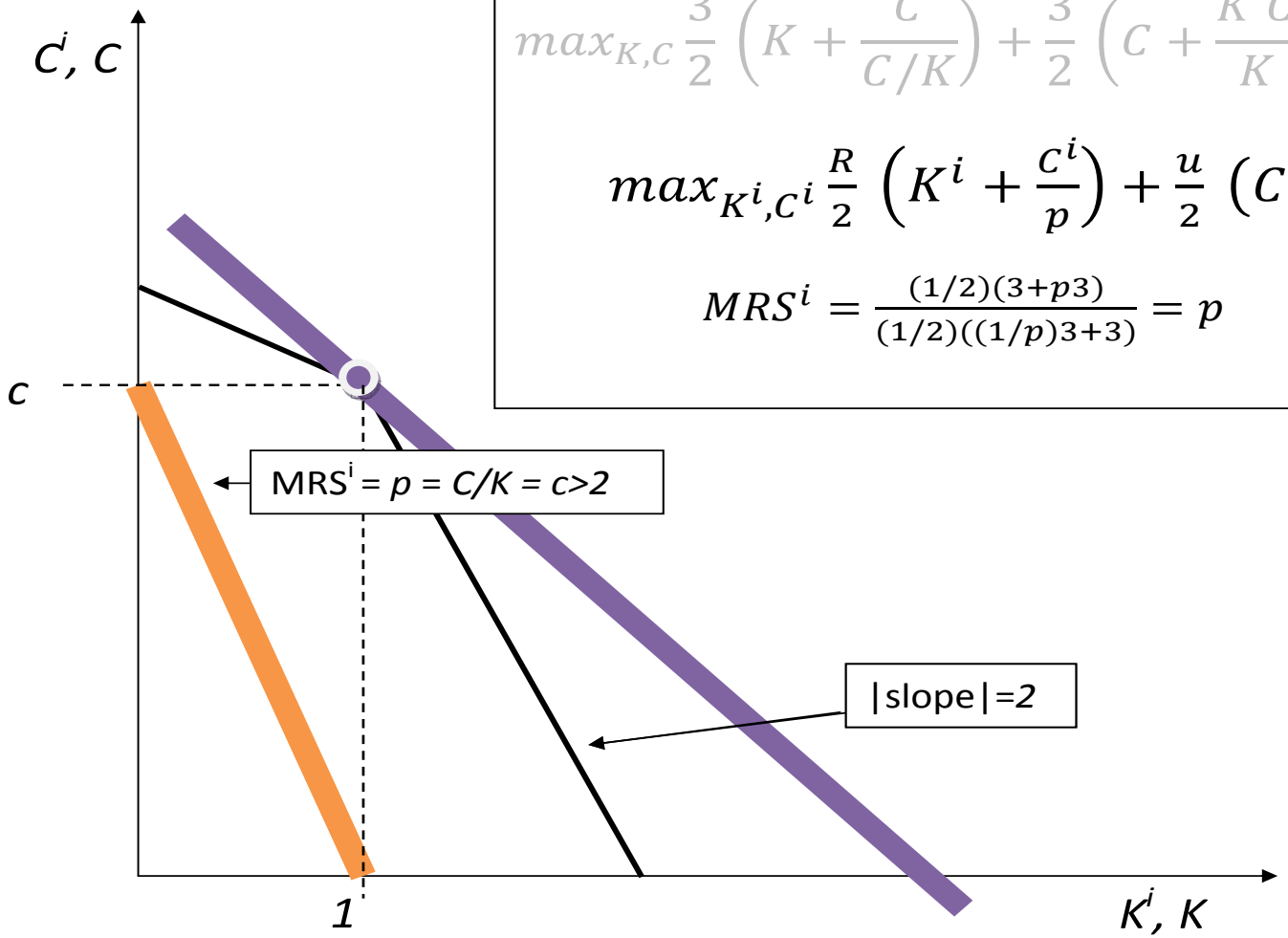


A Simplified 2-Period Example: Market Solution I.

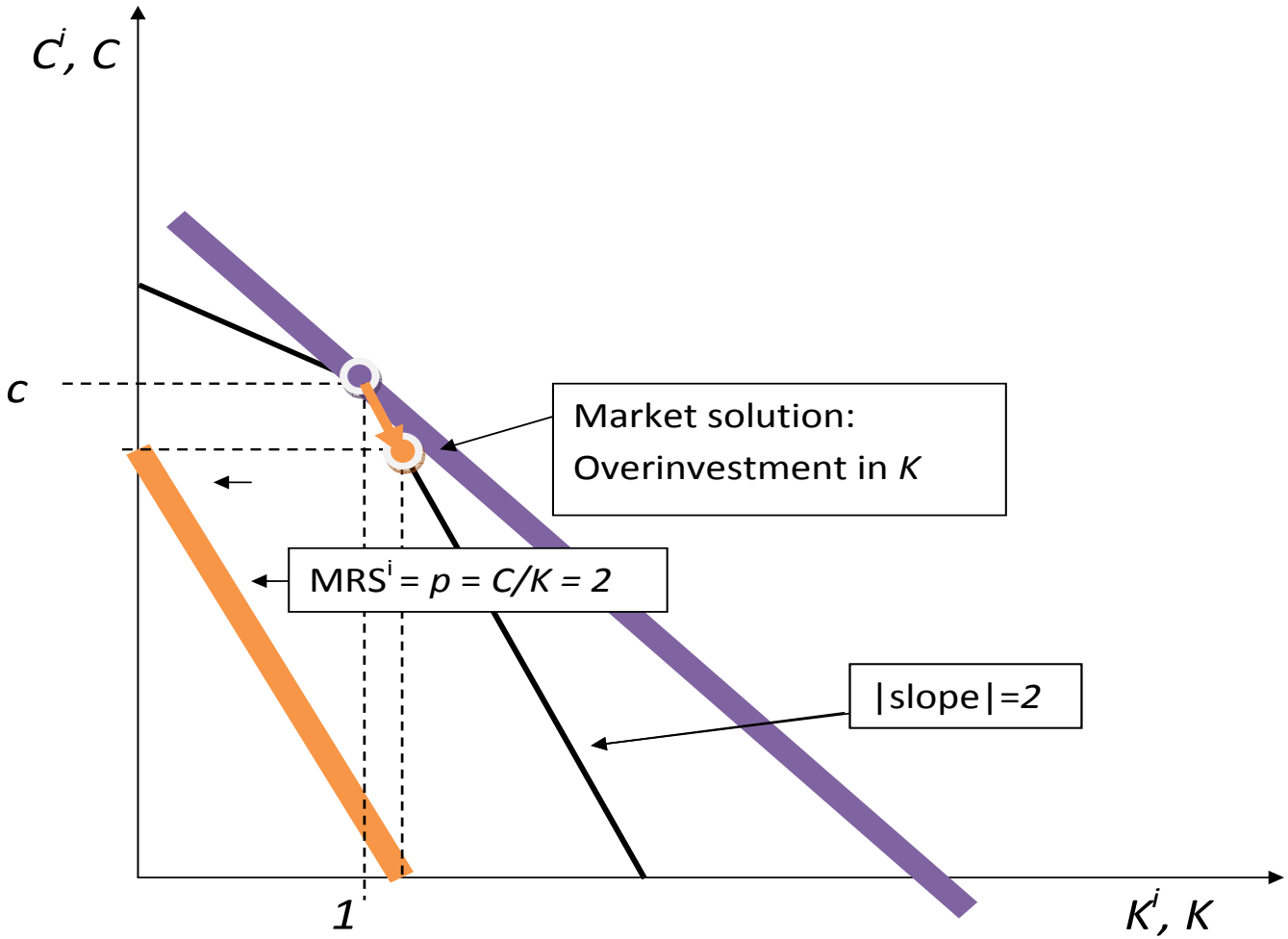
$$max_{K,C} \frac{3}{2}\left(K + \frac{C}{C/K}\right) + \frac{3}{2}\left(C + \frac{K\,C}{K}\right) = 3(K + C)$$

$$max_{K^i,C^i} \frac{R}{2}\left(K^i + \frac{C^i}{p}\right) + \frac{u}{2}\left(C^i + K^i p\right)$$

$$MRS^i = \frac{(1/2)(3+p3)}{(1/2)((1/p)3+3)} = p$$



A Simplified 2-Period Example: Market Solution II.



- two frictions in background:
  1. in period 1 output not fully pledgeable (e.g. stealing)
     - implies $p = C/K$ instead $p = 1$
     - otherwise C-person could hire K-person to harvest capital
  2. no contract on skill (e.g. misreporting)

- ex post cash-in-the-market price ensures efficient allocation, but distorts ex ante incentives
- a form of pecuniary externality
- the sign of distortion depends on relative supply
- symmetry: the relative supply matters, overinvest in scarce one
- the formal dynamic model: capital produces cash, solve for interim prices and investment, generalize the two-sided inefficiencies

Model

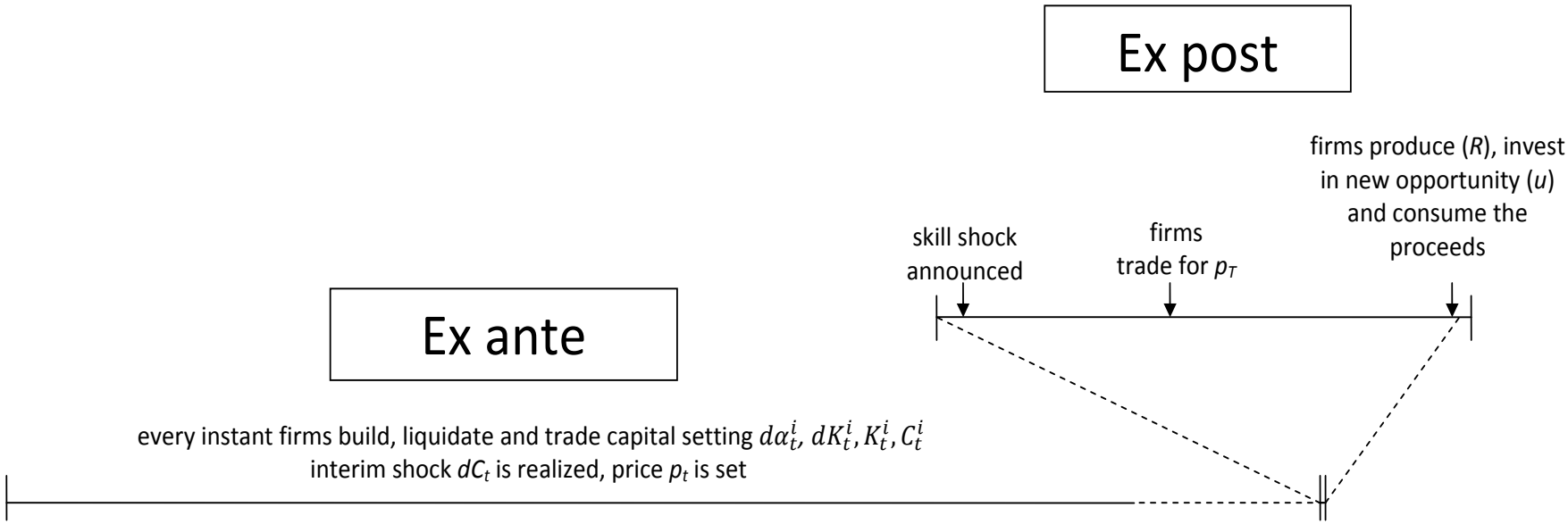
- consumption good and capital good: cash C_t and capital K_t
  - final date with Poison intensity ξ: capital produces R or 0
  - before it arrives, generate positive or negative cash (non-persistent AK technology)

$$dC_t = K_t \sigma dZ_t$$

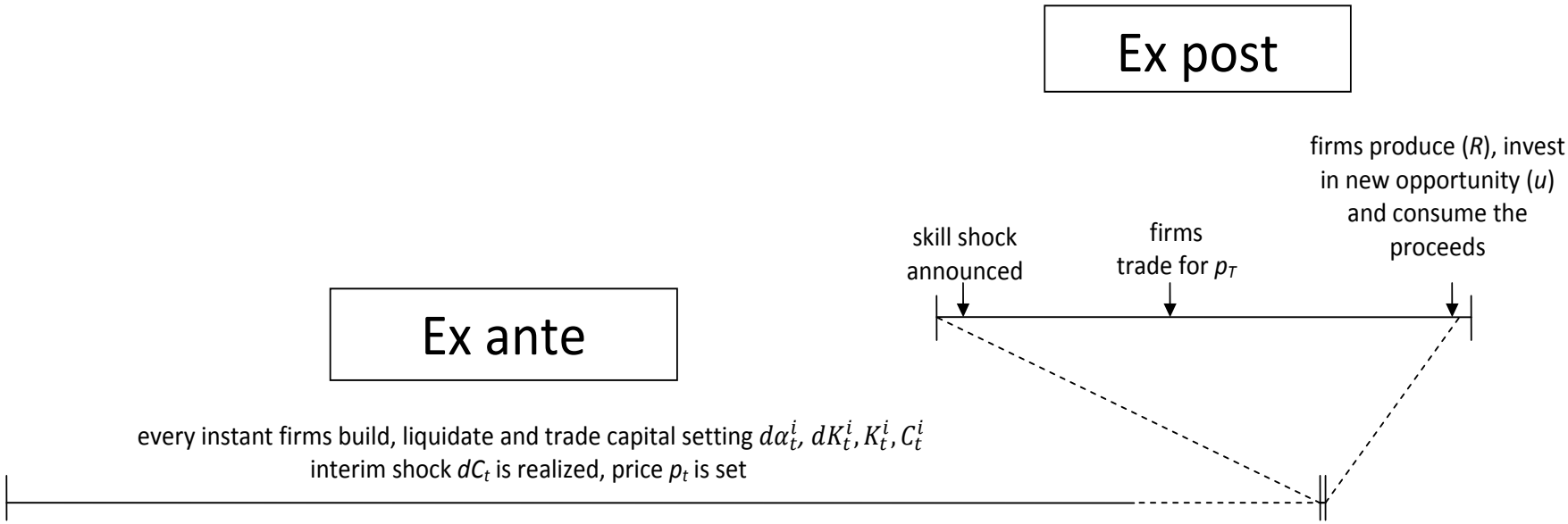
  - if negative, capital needs maintenance
- market populated by long-lived risk neutral firms who can:
  - invest: build new capital for h
  - disinvest: dismantle capital for l ($< h$)
  - trade capital for market price (in terms of cash) p_t
- zero discount rate, storage technology available

- No outside cash
- Unverifiable idiosyncratic shock: in final date firms learn that they differ in their skills
  - half ”hit by skill-shock” : can invest in a new technology $u > 1$, but cannot use capital (produce 0)
  - half ”are not hit”: cannot invest in new technology, bu experience poductivity hike on capital (produce R per unit)
  - a last round of trade before production or investment into new technology
- $\frac{R}{h} > u$, building capital socially optimal

Timeline


Ex post
firms produce (R), invest in new opportunity (u) and consume the proceeds
skill shock announced
firms trade for p_T
Ex ante
every instant firms build, liquidate and trade capital setting $d\alpha_t^i$, dK_t^i, K_t^i, C_t^i
interim shock dC_t is realized, price p_t is set

Timeline



- ex-post agents with skill-shock sell, others buy:

$$\frac{1}{2}C = \frac{1}{2}Kp_T \quad \Rightarrow \quad p_T = c$$

- (as long as $c < R$ which we make sure)
- Note that trade guarantees ex post allocation efficiency

- firms i maximizes

$$\max_{d\alpha_t^i \geq 0, K_t^i, C_t^i, dK_t^i} E_t\left[\int_0^\infty d\alpha_t^i\right] =$$

$$= \max_{d\alpha_t^i, K_t^i, C_t^i, dK_t^i} E_t\left\{\int_0^\infty \xi e^{-\xi t}\left[\int_0^t d\alpha_s + \left[\frac{1}{2}\left(K_t^i + \frac{C_t^i}{p_T}\right)R + \frac{1}{2}\left(K_t^i p_T + C_t^i\right)u\right]\right]\right.$$

- subject to $w_t^i \equiv p_t K_t^i + C_t^i \geq 0$ and

$$dw_t^i = -d\alpha_t^i - (1_{dK_t^i > 0} h + 1_{dK_t^i < 0} l) dK_t^i + K_t^i (dp_t + \sigma dZ_t)$$

Solving for the Equilibrium

- Looking for standard Walrasian equilibrium
- In general only aggregate quantities determined: we can pick the symmetric one
- Value function is separable!

$$J\left(C, K, K_t^i, C_t^i\right) = K_t^i v(c) + C_t^i q(c).$$

- state variable: cash to asset ratio, $c_t \equiv \frac{C_t}{K_t}$

- pricing by indifference:

$$p = p(c) \equiv \frac{v(c)}{q(c)}$$

- build capital when $p = h$, liquidate capital when $p = l$
  - keeps c between reflective barriers c_h^*, c_l^*
- value of cash, q always larger than 1, consume only at maturity

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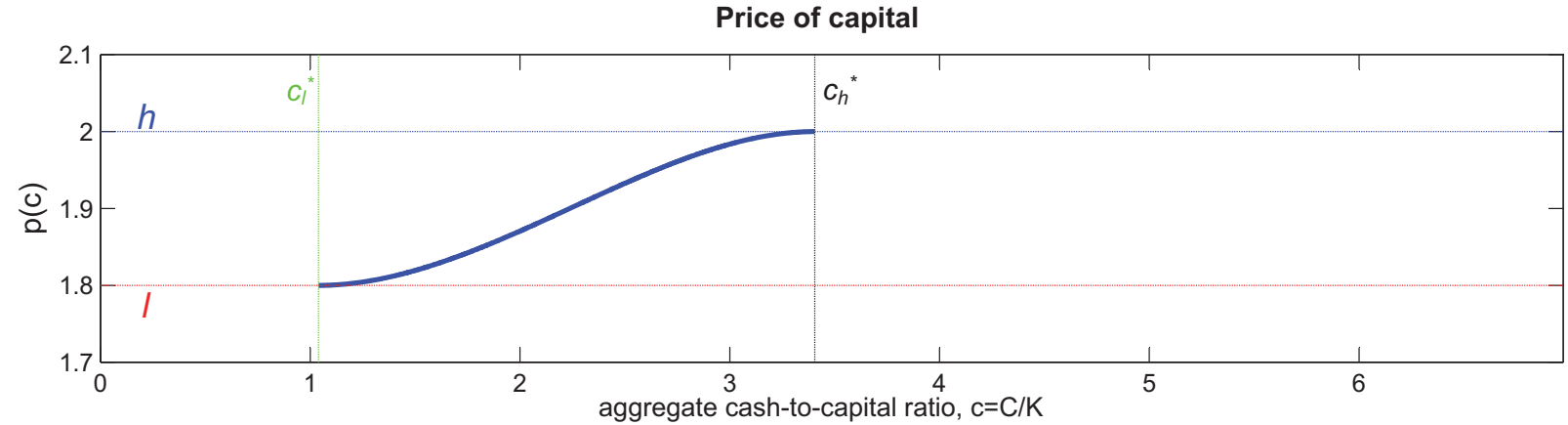
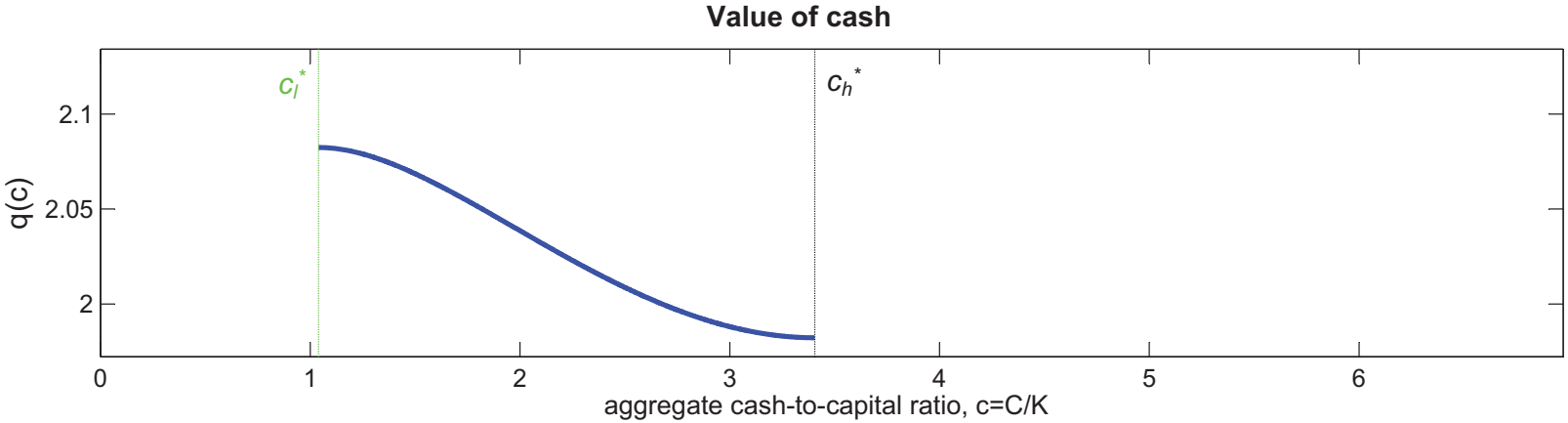
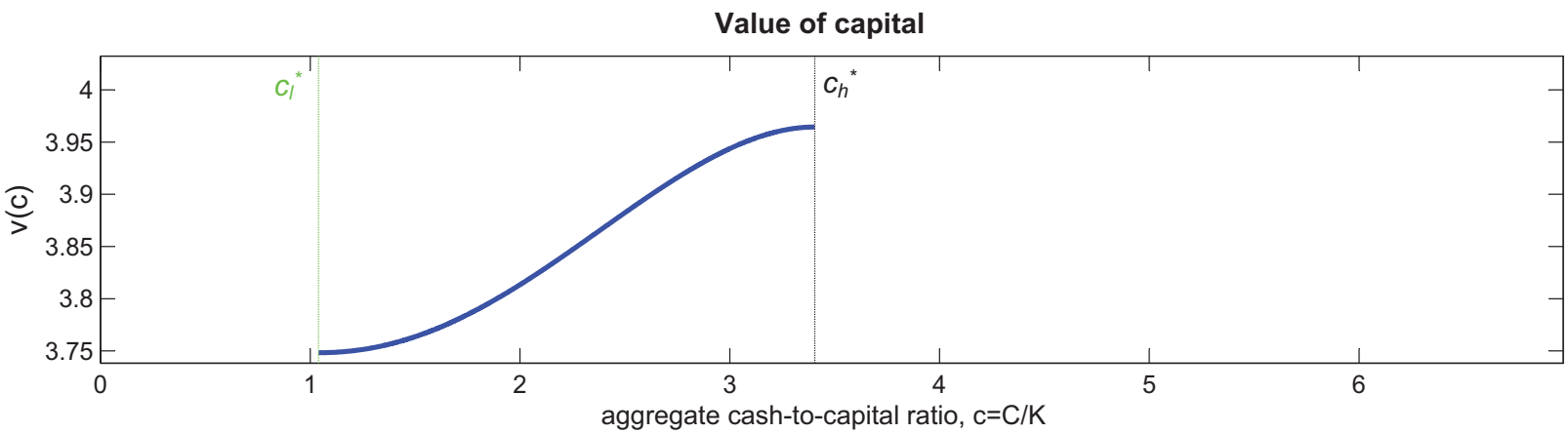
- HJB gives separate ODEs for v and q: have closed form general solutions

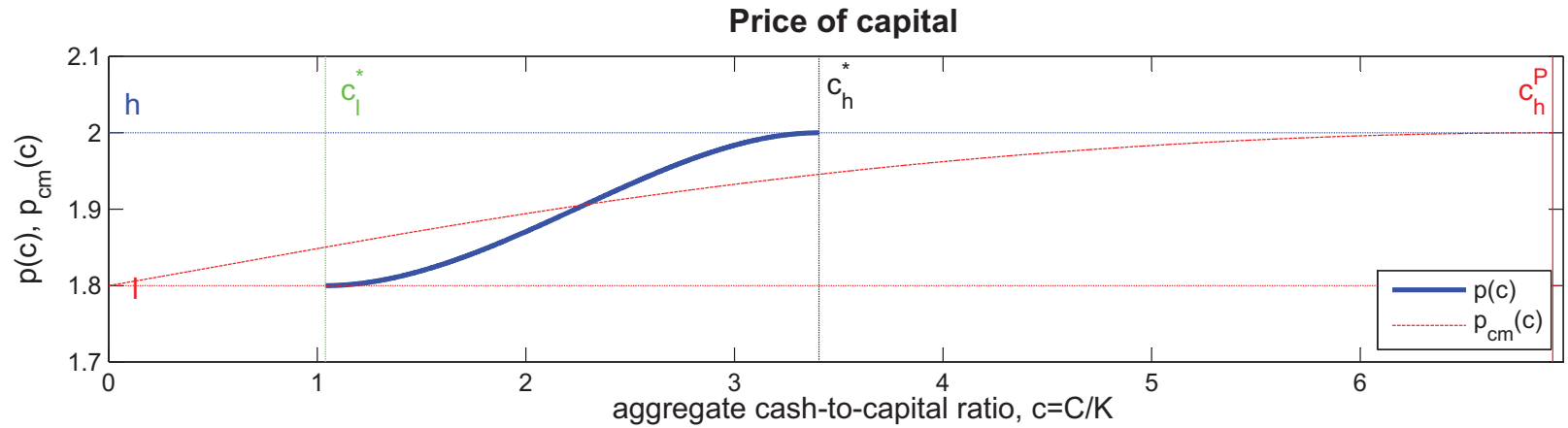

Price of capital
p(c)
h
l
c_l^*
c_h^*
2.1
2
1.9
1.8
1.7
0
1
2
3
4
5
6
aggregate cash-to-capital ratio, c=C/K

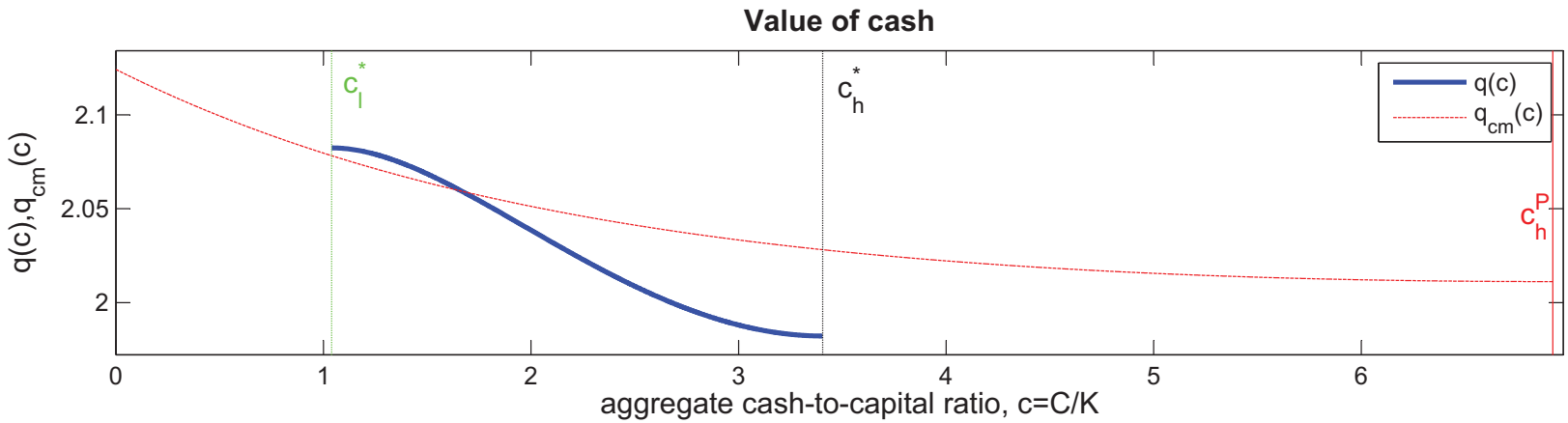

Value of cash
q(c)
c_l^*
c_h^*
2.1
2.05
2
0
1
2
3
4
5
6
aggregate cash-to-capital ratio, c=C/K

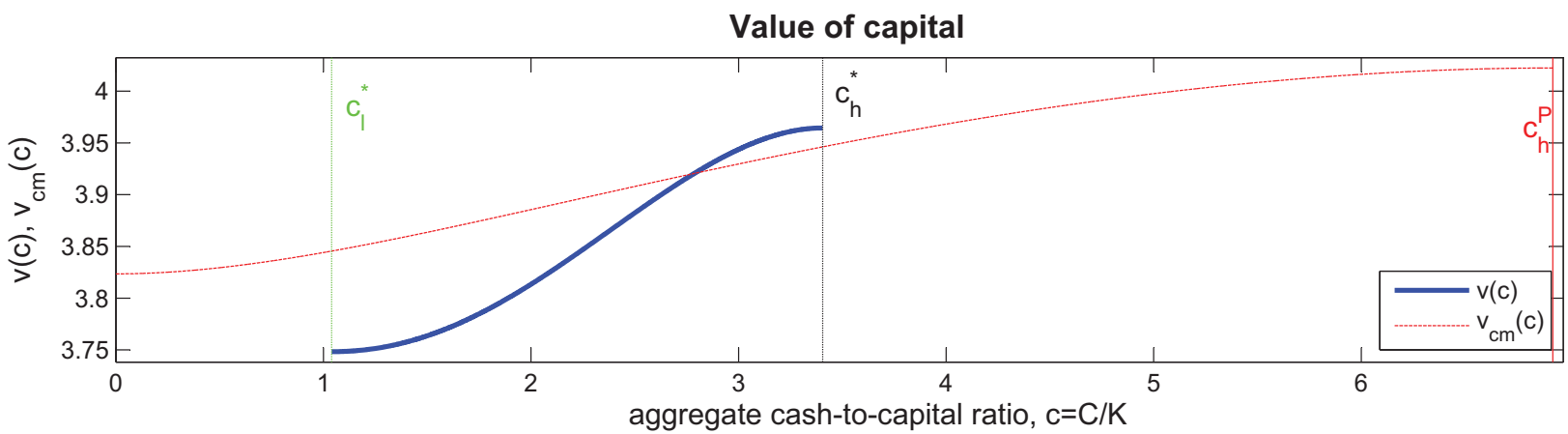

Value of capital
v(c)
c_l^*
c_h^*
4
3.95
3.9
3.85
3.8
3.75
0
1
2
3
4
5
6
aggregate cash-to-capital ratio, c=C/K

Constrained Efficient Benchmarks

- Second Best benchmarks:
  1. Social Planner can pick investment/disinvestment, but cannot influence ex-post allocation
  2. either idiosyncratic shocks are verifiable or R, u are pledgeable
- recall: ex post distribution is efficient, inefficiency is driven by ex ante investment decision
- both benchmarks lead to same ex-ante value and same thresholds: c_l^P, c_h^P


Price of capital
p(c), p_cm(c)
aggregate cash-to-capital ratio, c=C/K
h
l
c*_l
c*_h
c^P_h
p(c)
p_cm(c)


Value of cash
q(c),q_cm(c)
aggregate cash-to-capital ratio, c=C/K
c*_l
c*_h
c^P_h
q(c)
q_cm(c)


Value of capital
v(c), v_cm(c)
aggregate cash-to-capital ratio, c=C/K
c*_l
c*_h
c^P_h
v(c)
v_cm(c)

- distorted incentives in market solution
  - social planner:
    - cares only about the trade-off: capital is productive $\frac{R}{h} > u$
    - but risky: if aggregate cash is low, might be liquidated inefficiently
    - values cash as a buffer against inefficient liquidation
    - but does not care about p_T!
  - individual agents:
    - care also about inefficient liquidation
    - but also care about available rent through last minute trading (p_T)
    - e.g. C_t very low (high), price of capital expected to be very low (high), they overinvest in cash (capital).

- missing market to trade the state of skill-shock $\Rightarrow$ distorted ex-post price $\Rightarrow$ changed incentives to hold cash/capital $\Rightarrow$ distorted ex-ante price $\Rightarrow$ distorted investment thresholds
- Critical element: price distortion changes sign with business cycle!

- as $p_T = c$ and fluctuates in $[c_l^*, c_h^*]$ for two-sided inefficiency we need (app.):

$$min(p_T) = c_l^* < \frac{R}{u} < c_h^* = max(p_T)$$

- first inequality always holds, second one depends
- vaguely:
  - when capital are very productive, large $R/h - u$: underinvestment in booms as well
  - when capital are not that productive, over investment in booms
- we have propositions that formally show the existence of two-sided inefficiency

Application I: Inefficient Construction Waves

- consider a real-estate developer who faces different investment opportunities each time (i.e., Donald Trump)
- has to decide how to store his capital he might want to invest at a future opportunity
- our model: relative liquidity of capital and consumption good varies over the cycle
- bad times: real estate can be sold only with a discount, not a good store of value, developer prefers to hoard cash, push price even further, disinvestment
- good times: real estate can be sold for high price, liquid store of value, push price higher, developer builds more.

- ”Reverse fire-sale” pattern in Japan:

> *It took most Japanese banks years to whittle down the tens of billions of dollars in unrecoverable loans left on their books after the collapse of a real estate bubble[...]. But analysts criticize most banks for* **failing to find new, more profitable – and less risky – ways of doing business. Instead, analysts say many have gone back to lending heavily to real estate development companies and investment funds, as the rebounding economy has touched off a construction boom in Tokyo.** *”If the economy stalled, Japanese banks would have a bad loan problem all over again,” said Naoko Nemoto, an analyst for Standard & Poor’s in Tokyo. (The New York Times, January 17, 2006)*

Application II: Real and Financial Industry Booms and Busts

- Hoberg-Phillips (JF, 2010)
- high valuation, investment, financing predicts low profitability
- Not necessarily along famous stories:
  - 1970s: Motion Picture Theaters, Wholesale Apparel
  - 1980s: Electrical Work, Paper Products
  - 1990s: Fabricated Rubber Goods, Semi-Conductors + Elect. Comp
  - 2000s: Coal Mining, Management and Consulting Services

- only in competitive industries
  - their story: signal extraction problem from return shocks
  - our story: no contracts on future investment opportunities $\Rightarrow$ pecuniary externality
    - would not occur in a non-competitive setting where agents take into account their price effect
    - (we show this formally for the two-period version)

Application III: Financial Development and Volatility

- (financially) less developed countries experience less growth and more volatile growth
- consistent if we measure
  - growth by expected final production (or consumption) compared to current size of economy:

$$\frac{E(K_t R_t + C_t u)}{K_0}$$

  - volatility of growth by expected total adjustment of capital:

$$E\left[\int \frac{|dK_t|}{K_t}\right]$$

  - compare incomplete market setting (less developed) with complete market setting (more developed)
- new element: excess volatility partly comes from too much investment in productive assets in booms

One-sided interventions

- Suppose government realizes only the inefficiency in recessions
- when p gets close to I intervene:
  - One-sided intervention: tax cash, subsidize capital, keep a balanced budget, stop it when the price is sufficiently high again
  - If two-sided inefficiency: one-sided intervention makes over investment in booms worse
  - Ex-ante value takes full distribution into account! it is a conditional expectation given the current state
  - Adverse effect in booms can be so bad that ex-ante welfare goes down everywhere
  - Even if intervention effective in recession, everyone is worse off even in the recession

- But: If underinvestment in booms as well, one-sided intervention makes sense!
- depends on relative size of $R/h - u$ and $\gamma \equiv \frac{\sqrt{2\xi}}{\sigma}$,, vaguely:
  - when capital are very productive, large $R/h - u$: underinvestment in booms as well
  - when capital are not that productive, over investment in booms

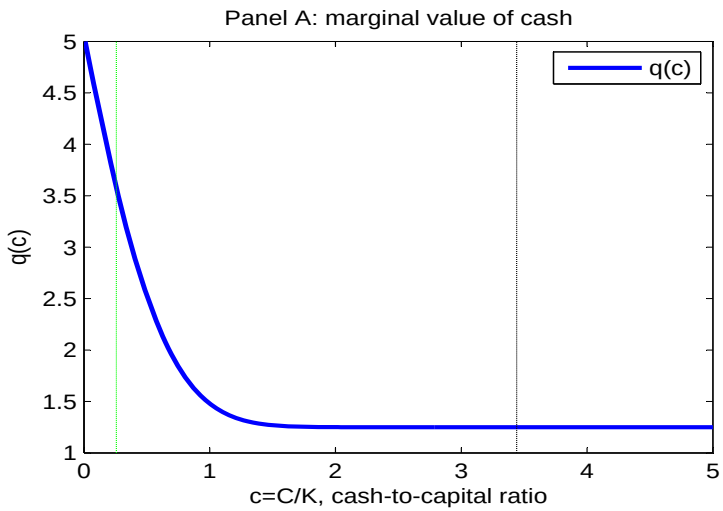
Alternative specification

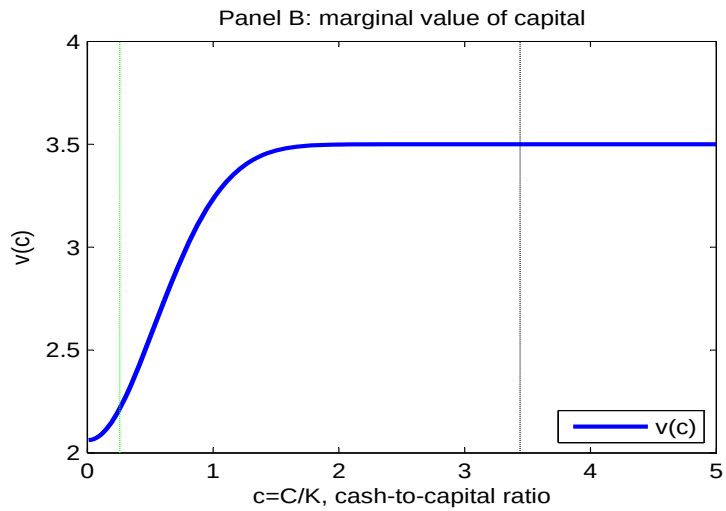
- For general mechanism three main ingredients:
  1. Two assets of which relative supply is affected by a stochastic process.
  2. A group of agents who can transform each asset to the other one by a linear technology, but with some loss in the process.
  3. An idiosyncratic shock which changes some agents' relative valuation of the assets compared to other agents.
- essentially symmetric structure
- timing is not important

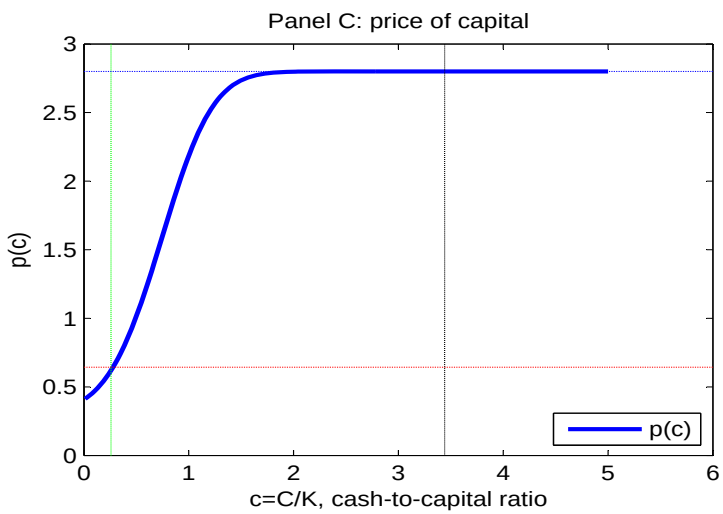
- We can get rid of two-stage dynamic structure : results remain the same, more natural, less tractable, less transparent
- in each instant:
  - ϕ fraction of capital mature, agent who holds the capital eats the resulting cash
  - ξ friction realizes that cannot harvest, but learns about opportunity, sells assets and invest outside for u

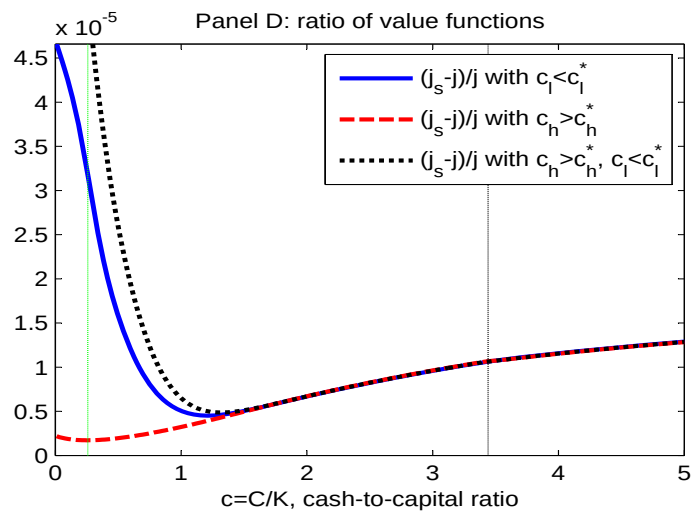
- can invest and disinvest only occasionally: when another aggregate Poisson-event hits, they can do to the extent they want: still thresholds
  - if event hits AND $c < c_l^*$: disinvest till c jumps to c_l^* and price jumps to l
  - if event hits AND $c > c_h^*$: invest till c drops to c_h^* and price drops to h
- how would social value change, if the planner changes the thresholds a bit?

Alternative specification









- instead of ex-ante price and ex-post price, just price
- serves both (conflicting) roles
  1. determines terms of transfer for exit (if new investment opportunity)
  2. drives investment decision
- just as ex-post price before, first function changes incentives how to store wealth
  - increases price in booms, decreases price in recessions
  - distorts second function

Literature

- welfare and pecuniary externalities: Geanakoplos and Polemarchakis (1986), Davila (2011)
  - fire-sale feed-back loop induced, typically, by a collateral constraint (e.g. Kiyotaki and Moore (1997), Gromb and Vayanos (2002), Krishnamurthy (2003), Stein (2011), Jeanne and Korinek (2011), Bianchi and Mendoza (2010), Bianchi (2010), Lorenzoni (2008), Hart and Zingales (2011))
  - ex ante identical agents: Shleifer and Vishny (1992), Gale and Yorulmazer (2011), Caballero and Krishnamurthy (2001, 2003), Holmstrom and Tirole (2008)
  - Investment with inaction region: Abel and Eberly (1994)
- Banks' moral hazard in macro-context: Fahri and Tirole (2011), Diamond and Rajan (2011), Gersbach and Rochet (2011)

Conclusion

- Constraint on aggregate capital: investment waves, can be constrained efficient
- unverifiable idiosyncratic shock for relative value of productive assets and cash: inefficiency
  - ex post cash-in-the-market price ensures efficient allocation, but distorts ex ante incentives
  - a form of pecuniary externality
  - the sign of distortion depends on relative supply
- dynamic model:
  - relative supply is given by the state of the cycle
  - policy experiments with agents appreciating the eternal fluctuation
- cool framework: fully dynamic model with analytical tractability, we will use it for other cool stuff