Liquidity Sentiments

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March 2019

Motivation

Asset markets exhibit time variation in “liquidity”

- E.g., real estate, MBS, repo, merger waves, “physical” capital
- Liquidity is procyclical, positively correlated with prices
  - e.g., liquidity drys up in bad times
- The volatility in liquidity and prices often appears unrelated to new information or shocks to fundamentals
  - Usually interpreted as a ‘behavioral’ phenomenon: irrational exuberance, animal spirits, overconfidence, sentiments...

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Questions: Is there a fundamental link between prices and liquidity within a rational framework? Is there a role for "sentiments"?

Our (hopefully) non-controversial starting point

- The efficient owner of an asset may vary over time
  - Capital should be reallocated to the most productive firms
  - Real estate transacts due to life cycle, labor market shocks, etc.
- Trade is the consequence of the emergence of gains from trade
- Liquidity – ease with which these gains are realized – is therefore an intrinsic determinant of “fundamental” value
- Without frictions, all gains are realized immediately.
  - Assets always held by those who value them the most.

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- Information frictions can hinder liquidity.

What we do

Analyze a model with asymmetric information and resale considerations

- Buyers worry about:
  1. Quality of assets for which they compete, and
  2. Liquidity they will face when trying to resell in the future.
- We show that **intertemporal complementarities** emerge
  - If buyers expect a liquid market tomorrow
    - They are willing to bid more aggressively for the assets today
    - Quality of assets that sellers willing to trade improves
    - Which leads to high liquidity and high prices today

Main Results

- The intertemporal coordination problem generates multiple self-fulfilling equilibria
- Sentiments: defined as expectations about future market conditions, generate endogenous volatility
  - The model disciplines set of equilibrium sentiment dynamics
  - Sentiments must be stochastic and sufficiently persistent

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- Sentiments: defined as expectations about future market conditions, generate endogenous volatility
    - The model disciplines set of equilibrium sentiment dynamics
    - Sentiments must be stochastic and sufficiently persistent
- With endogenous asset production (and moderate production costs)
    - Sentiments are a necessary part of any equilibrium
    - Quality produced is higher in “bad” times

Applications

- Capital reallocation among firms
  - Reallocation is procyclical
  - Productivity dispersion can go either way
  - Aggregate productivity depends on sentiments
- Real estate boom/bust cycles
  - Strong sentiments: high prices, high turnover, low time-to-sale.
  - Weak sentiments: low prices, low turnover, high time-to-sale.

Related literature

- Adverse selection: Akerlof (1970), Wilson (1980)
  - Dynamic: Eisfeldt (2004), Martin (2005), Kurlat (2013), Chari et al. (2014), Guerrieri and Shimer (2014), Bigio (2015), Gorton and Ordonez (2014), Fuchs et al. (2016), Daley and Green (2016), Chiu and Koeppl (2016), Maurin (2016), Makinen and Palazzo (2017)
  - Coordination (static): Plantin (2009), Malherbe (2014)
- Money and rational bubbles: Samuelson (1958), Tirole (1985), Weil (1987), Santos and Woodford (1997), Martin and Ventura (2012)
- Sentiments/sunspots: Benhabib and Farmer (1998), Lorenzoni (2009), Angeletos and La'O (2013), Hassan and Mertens (2011), Benhabib et al. (2015)

Model

Discrete time, infinite horizon, $t = 0, 1, 2, ...$

Assets: Unit mass of assets indexed by $i \in [0, 1]$

- Asset i has (fixed) quality $\theta_i \in \{L, H\}$
- Fraction π of assets are high quality

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Agents: Mass $M \gg 1$ of agents, indexed by $j \in [0, M]$

- Agents are risk-neutral with common discount factor δ
- Each agent can hold at most one unit of the asset
- Agent j at time t has private value or productivity $\omega_{j,t} \in \{l, h\}$
- Productivity is iid with $\lambda = P(\omega_{jt} = l)$

Flow Payoffs

If agent j owns asset i at date t:

- She receives a flow payoff $x_{ijt} = u(\theta_i, \omega_{jt})$
- High quality assets deliver higher payoff, $u(H, \omega) > u(L, \omega)$
- More productive agents generate higher payoff

$$\underbrace{v_\theta \equiv u(\theta, h) > c_\theta \equiv u(\theta, l)}_{\text{Gains from trade exist}}$$

Markets

Asset markets are competitive and decentralized. In each period:

- Multiple productive buyers bid for each asset à la Bertrand.
- Seller can accept an offer or reject and wait until the next period.
  - Buyer whose offer is accepted becomes asset owner
  - Owner who sells an asset becomes a buyer next period

Information friction

Absent frictions, outcome is efficient.

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But there is asymmetric information:

- Owner privately observes asset quality and productivity, (θ, ω).
- Trading is anonymous
  - History of asset or owner transactions is not observable
  - Rules out signaling through delay

Equilibrium concept

We look for Stationary Rational Expectations Equilibria. This has three main requirements:

- Owner optimality. Each owner makes her selling decisions optimally, taking as given the strategies of all other agents.
- Buyer optimality. Each buyer makes her bidding decision optimally, given her beliefs and the strategies of other buyers.
- Belief consistency. Buyer's beliefs about future play and who trades today are consistent with the equilibrium strategies.

Benchmark without information frictions

Result

If asset qualities are observable, then the equilibirum is unique. In it,

- *All assets are allocated efficiently,*
- *For all t, the price of a type-θ asset is*

$$p_\theta = \frac{v_\theta}{1-\delta}$$

and total output is

$$Y^{FB} = \int_i v_{\theta_i} di = E\{v_\theta\}$$

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- How do information frictions change this picture?

Stationary equilibrium

First characterize stationary equilibria in which the price is constant, p^*.

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1. Owner optimality.
   - A (θ, ω)-owner's value function satisfies:

$$V^*(\theta, \omega) = \max\{p^*, u(\theta, \omega) + \delta E\{V^*(\theta, \omega')\}\}$$

   - The set of owner types who optimally accept a (maximal) offer p is:

$$\Gamma(p) = \{(\theta, \omega) : u(\theta, \omega) + \delta V^*(\theta, \omega') \leq p\}$$

Stationary equilibrium

2. Buyer Optimality
   - Bertrand competition among buyers $\implies$ zero profit

$$p^* = E\{v_\theta + \delta V^*(\theta, \omega')|(\theta, \omega) \in \Gamma(p^*)\}.$$

   - No profitable deviation for buyers $\iff$ for all $p \geq p^*$

$$p \geq E\{v_\theta + \delta V^*(\theta, \omega')|(\theta, \omega) \in \Gamma(p)\}.$$

Characterization of Stationary Equilibria

Result

In any stationary equilibrium,

$$V^*(L,l) = V^*(L,h) = p^* \leq V^*(H,l) < V^*(H,h).$$

Thus, (L,l)-owners always trade, whereas (H,h)-owners never do.

- Two candidate stationary equilibria, depending on whether (H,l)-owner trades.

Candidate stationary equilibria

Efficient trade equilibrium: (H, l)-owner trades

- All gains from trade are realized, prices and total output are:

$$p^{ET} = V^{ET}(H, l) \qquad Y^{ET} = E\{v_\theta\}$$

Candidate stationary equilibria

Efficient trade equilibrium: (H, l)-owner trades

- All gains from trade are realized, prices and total output are:

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Inefficient trade equilibrium: (H, l)-owner does not trade

- Some gains from trade are unrealized, prices and toal output are:

$$p^{IT} < V^{IT}(H, l) \qquad Y^{IT} = E\{v_\theta\} - \underbrace{\lambda\pi(v_H - c_H)}_{\text{loss from misallocation}}$$

Multiplicity

Theorem

There exists two thresholds $\underline{\pi} < \bar{\pi}$ such that:

1. *Efficient trade is an equilibrium iff $\pi \geq \underline{\pi}$,*
2. *Inefficient trade is an equilibrium iff $\pi \leq \bar{\pi}$.*

Notably, both equilibria exist for $\pi \in (\underline{\pi}, \bar{\pi})$.

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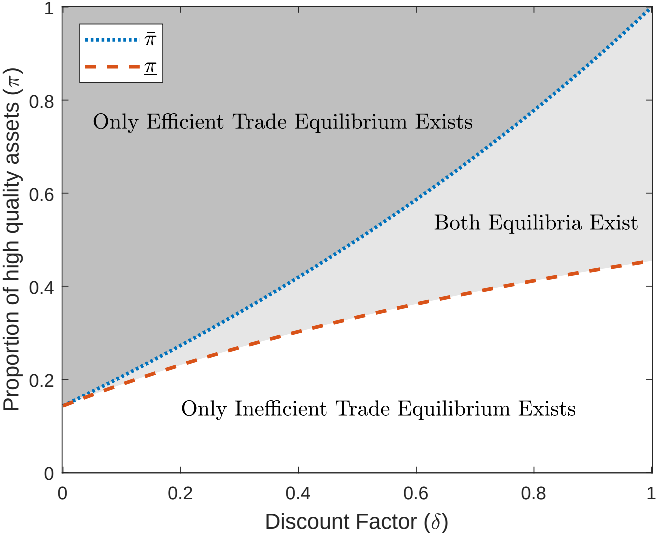
- Dynamic considerations are crucial for multiplicity.

Multiplicity and the role of dynamics



What is the source of multiplicity?

An intertemporal coordination problem:

- If buyers today expect future markets to be illiquid.
  - Their unconditional value today for an asset is low.
  - Hence the highest (pooling) price they are willing to offer is low.
  - At this low offer, the (H, l)-owners prefer to hold.
- Conversely, if buyers today expect future markets to be liquid.
  - Their unconditional value today for an asset is high.
  - Hence they are willing offer a high (pooling) price.
  - At this high price, the (H, l)-owners are willing to sell.

What is the source of multiplicity?

Efficient trade. Must be that (H, l)-owner does not want to reject:

$$V^{ET}(H, l) = p^{ET} \geq c_H + \delta E\{V^{ET}(H, \omega')\}$$

$$\underbrace{\hat{\pi} v_H + (1 - \hat{\pi}) v_L - c_H}_{\text{today's gain from selling}} \geq \underbrace{\delta (1 - \hat{\pi}) \overbrace{E\{V^{ET}(H, \omega) - V^{ET}(L, \omega)\}}^{\Delta^{ET}}}_{\text{future loss from selling at low price}}$$

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Inefficient trade. Sufficient to check that buyers do not want to deviate:

$$V^{IT}(H,l) \geq \hat{\pi} V^{IT}(H,h) + (1-\hat{\pi})\left(v_L + \delta E\{V^{IT}(L,\omega')\}\right)$$

$$\underbrace{\hat{\pi} v_H + (1-\hat{\pi}) v_L - c_H}_{\text{today's gain from buying}} \leq \underbrace{\delta(1-\hat{\pi}) \overbrace{E\{V^{IT}(H,\omega) - V^{IT}(L,\omega)\}}^{\Delta^{IT}}}_{\text{future loss from buying at high price}}$$

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You might have noticed that it is actually the same condition, with the inequality reversed

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You might have noticed that it is actually the same condition, with the inequality reversed...but

$$\Delta^{IT} > \Delta^{ET}$$

- High quality assets are relatively more valuable when assets are harder to trade.

Are there other equilibria?

Result

An equilibrium with deterministic transitions between efficient trade and inefficient trade generically does not exist.

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Intuition?

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Result

An equilibrium with deterministic transitions between efficient trade and inefficient trade generically does not exist.

Intuition?

- Suppose trade efficient at $t+1$ but inefficient at t
- Then future market conditions are weakly better at t than at $t+1$
- Hence trade must also be efficient at t

Sentiment equilibrium

- Let z_t denote a publicly observable stochastic process.
- An equilibrium is said to be a **sentiment equilibrium** with sunspot z_t if prices and allocations depend on its realization.

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- An equilibrium is said to be a **sentiment equilibrium** with sunspot z_t if prices and allocations depend on its realization.
- Let's begin with a simple Markov family
  - Binary: $z_t \in \{B, G\}$.
  - Symmetric: $\rho = \mathbb{P}(z_{t+1} = B | z_t = B) = \mathbb{P}(z_{t+1} = G | z_t = G)$.
  - Candidate Equilibrium: play efficient trade iff $z_t = G$.

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  - Candidate Equilibrium: play efficient trade iff $z_t = G$.
- When does such a sentiment equilibrium exist and what are its properties?

A simple class

Result

A sentiment equilibrium with a binary-symmetric first-order Markov sentiment process z_t exists if and only if $\pi \in (\underline{\pi}, \bar{\pi})$ and $\rho \geq \bar{\rho}$, where $\bar{\rho}$ depends on parameters.

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Result

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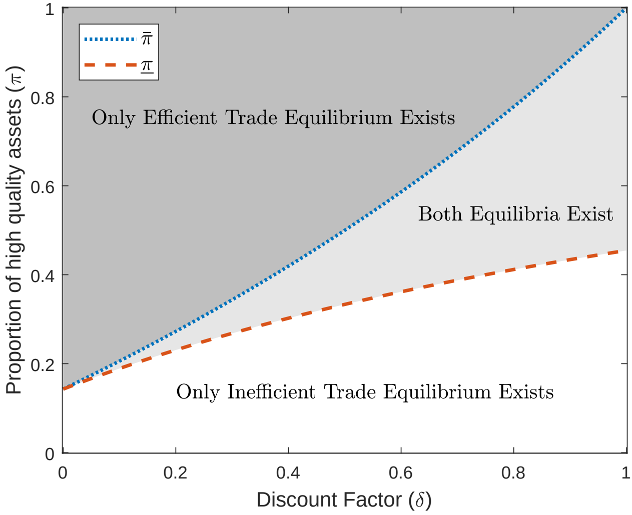
- Not anything goes!
  - Sentiments needs to be sufficiently persistent to faciliate intertemporal coordination.
- It needs to signal to agents:
  - How to behave today
  - That liquidity is likely to be similar in the future
- Otherwise, profitable deviations exist!

When do Sentiment equilibria exist?



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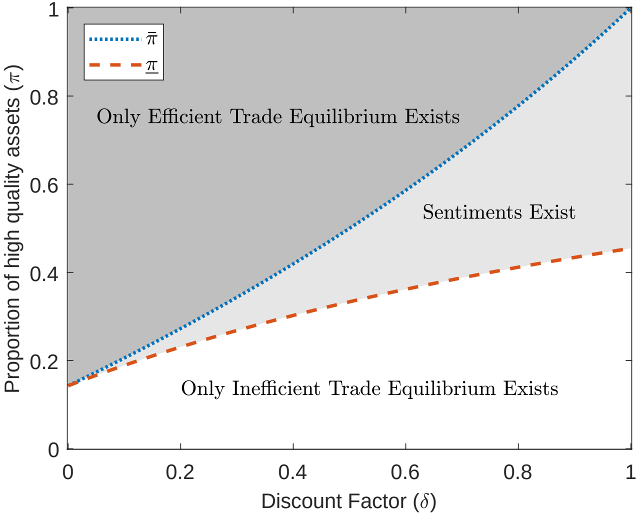

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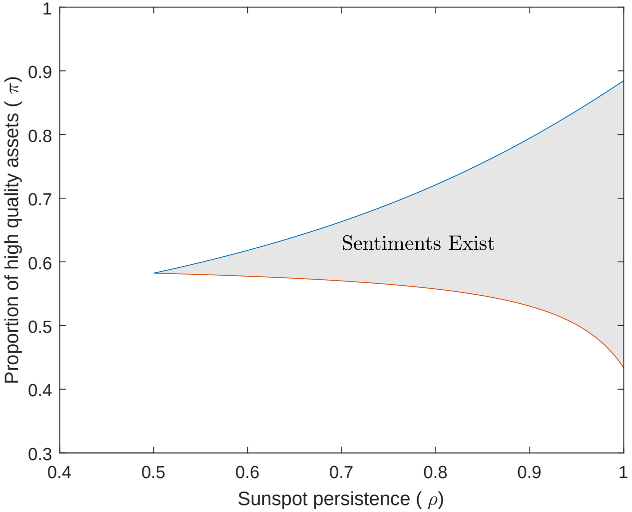

Sentiments can be richer...

Example

- Sunspot process: Markov chain $z_t \in \{1, ..., N\}$
- Transition matrix: Q

$$Q = \left\{ \begin{array}{ccccc} \rho & 1-\rho & 0 & \ldots & 0 \\ \frac{1-\rho}{2} & \rho & \frac{1-\rho}{2} & \ldots & 0 \\ 0 & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ldots & \frac{1-\rho}{2} & \rho & \frac{1-\rho}{2} \\ 0 & 0 & \ldots & 1-\rho & \rho \end{array} \right\}$$

- Candidate Equilibrium: play efficient trade iff $z_t \geq n^* \in \{1, N\}$

Sentiments can be richer...

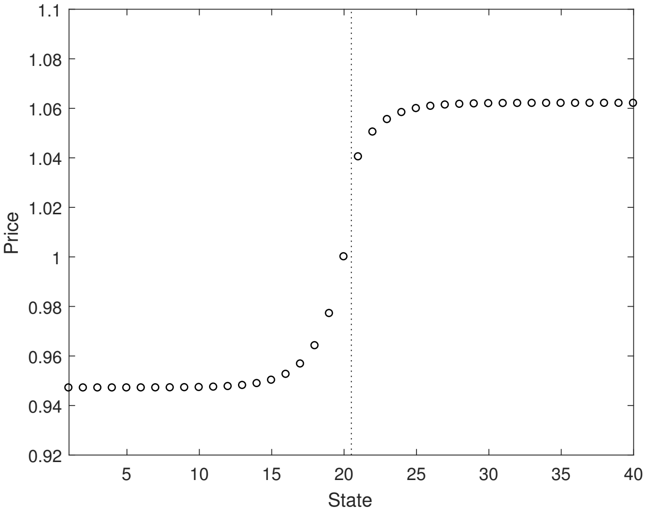

Figure: $N = 40,\ n^* = 20,\ \rho = 0.4$

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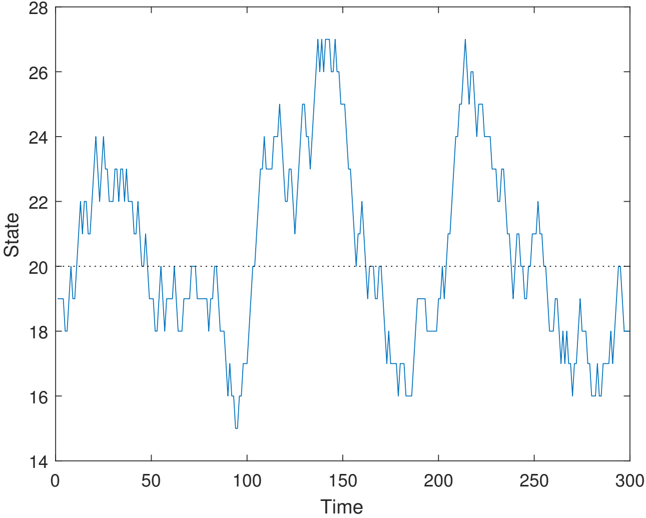

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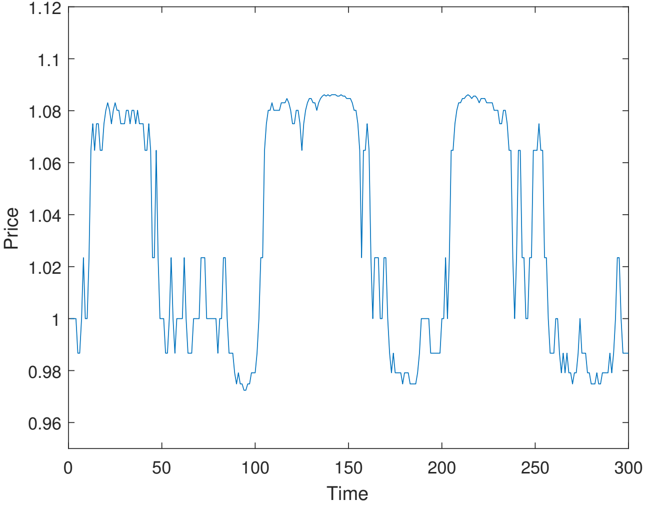

Figure: $N = 40$, $n^* = 20$, $\rho = 0.4$

Going beyond the simple family

Theorem (Sentiments)

A sentiment equilibrium with a Markov sunspot z_t exists if and only if $\pi \in (\underline{\pi}, \bar{\pi})$ and the equilibrium play it supports is sufficiently "persistent"

- Formal notion of sufficiently persistent provided in the paper
- Intuition is similar to before: to induce liquidity today, must be sufficiently likely that market will remain liquid tomorrow.

Production

Thus far, distribution of asset quality was exogenous.

- Suppose that each period, a mass of producers can create an asset.
- In period t, each producer chooses how much to invest.
  - Choose investment level q at cost $c(q)$, with $c' > 0$, $c'' \geq 0$
  - Produces H quality asset w.p. q (and L quality otherwise)
- In period $t+1$, the producer becomes the owner of the asset.

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- In period $t+1$, the producer becomes the owner of the asset.

For simplicity, we will assume that:

- Asset vintage is observable.
  - Avoids constructing equilibria with time-varying distribution of assets.
- Producer ω iid and same distribution as agents.

First Order Condition

Date-t producer chooses q to solve

$$\max_{q\in[0,1]} \left\{\delta\left(qE_t\{V^*_{t+1}(H,\omega)\} + (1-q)E_t\{V^*_{t+1}(L,\omega)\}\right) - c(q)\right\}$$

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The FOC for investment at time t is

$$c'(q_t) = \delta \underbrace{\left(E_t\{V^*_{t+1}(H,\omega) - V^*_{t+1}(L,\omega)\}\right)}_{\Delta^*_{t+1}}$$

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And Δ^* is lower when liquidity sentiments are higher (e.g., $z_t = G$)

- Implication: If a sentiment equilibrium exists, then lower quality assets will be produced in "good" times.

Sentiments with endogenous production?

Result

When asset production is endogenous:

- *Efficient trade is an equilibrium* $\iff c'(\underline{\pi}) \leq \underline{c} \equiv \Delta_{ET}(\underline{\pi})$
- *Inefficient trade is an equilibrium* $\iff c'(\bar{\pi}) \geq \bar{c} \equiv \Delta_{IT}(\bar{\pi})$

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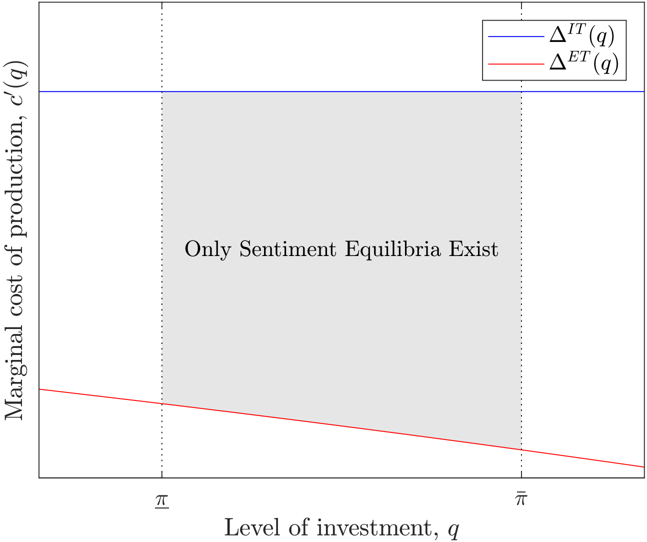
Otherwise, any equilibrium must involve sentiments (and a sentiment equilibrium exists).

Illustrating the Result



What elements of the model are crucial?

1. Informational environment
   - Need asymmetric information about common value component, θ
   - Asymmetric information about ω not crucial
2. Competition
   - Similar conditions under which sentiments exist with single buyer.
3. Asset quality
   - Need some persistence in quality and some durability.

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2. Competition
   - Similar conditions under which sentiments exist with single buyer.
3. Asset quality
   - Need some persistence in quality and some durability.
4. Non iid productivity shocks $\implies$ market history matters
   - Deterministic liquidity cycles can exist (Chiu and Koeppel 2016)
   - Positive autocorrelation: higher liquidity in the past implies lower liquidity today.

Applications of Sentiments: Capital Reallocation

- Agents are firms, ω_j is firm j productivity
- Assets are capital, θ_i is quality of capital unit i
- Firm j's output and productivity $= u(\theta, \omega_j)$
- Total output and productivity $= \int u(\theta_i, \omega_j) di$
- Trade corresponds to reallocating capital to more productive firm

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Predictions

- Good times ($z_t = G$): higher output and productivity, only efficient firms operate capital, higher rates of capital reallocation.
- Bad times ($z_t = B$): lower output and productivity, some inefficient firms operate, lower rate of capital reallocation.

Applications of Sentiments: Real Estate

- Agents are households, ω_j is private value of ownership
- Assets are houses, θ_i is unobservable quality of house i
- Flow payoff to household j from ownership $= u(\theta, \omega_j)$
- Trade corresponds to selling house to higher private value HH

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Predictions

- Boom ($z_t = G$): high prices and volume, low time on the market.
- Bust ($z_t = B$): low prices and volume, high time on the market.

Conclusions

- Adverse selection + resale considerations leads to an inter-temporal coordination problem:
  - Multiple self-fulfilling equilibria exist.
- Sentiments: expectations about future market conditions, generate endogenous volatility in prices, liquidity, output, etc.
  - The model disciplines set of possible sentiment dynamics.
  - Must be stochastic and sufficiently persistent.
- With endogenous asset production:
  - Sentiments are necessary for intermediate production costs.
  - Quality of assets produced is better in "bad" times.
- Applications to capital reallocation and real estate markets.