Liquidity Sentiments

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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 dries 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 **inter-temporal complementarities** emerge
  - If buyers expect a liquid market tomorrow
    - They are less concerned about buying a lemon today
    - 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**
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.
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

- With endogenous asset production (and moderate production costs)
  - Sentiments are a necessary part of any equilibrium
Applications

- Capital reallocation
  - Reallocation is procyclical
  - Productivity dispersion countercyclical

- New investment with financial frictions
  - Higher quantity but lower quality in booms

- Real estate
  - Strong sentiments: high prices, high turnover, low time-to-sale.
  - Weak sentiments: low prices, low turnover, high time-to-sale.
Related literature

  - **Coordination (static)**: Plantin (2009), Malherbe (2014)


Model

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

**Assets:** Unit mass of assets indexed by $i \in [0, 1]$
- Asset $i$ has (fixed) quality $\theta_i \in \{L, H\}$
- Fraction $\pi$ of assets are high quality
Model

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- Fraction \( \pi \) of assets are high quality

**Agents:** Mass \( M \gg 1 \) of agents, indexed by \( j \in [0,M] \)
- Agents are risk-neutral with common discount factor \( \delta \)
- Each agent can hold at most one unit of the asset
- Agent \( j \) at time \( t \) has private value \( \omega_{j,t} \in \{l,h\} \)
- Private value is iid with \( \lambda = P(\omega_{jt} = l) \)
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, $u(H, \omega) > u(L, \omega)$
- Unshocked agents generate higher payoff

\[ v_{\theta} \equiv u(\theta, h) > c_{\theta} \equiv u(\theta, l) \]

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.

- Markets reallocate assets from shocked owners to unshocked buyers.
Information friction

Absent frictions, outcome is efficient.

- Markets reallocate assets from shocked owners to unshocked buyers.

But there is asymmetric information:

- Owner privately observes $(\theta, \omega)$.
- Trading is anonymous
  - History 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 equilibrium is unique. In it,

- All assets are allocated efficiently,
- For all $t$, the price of a type-$\theta$ asset is

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

and total output is

$$Y^{FB} = \int_i v_{\theta_i} di = E\{v_\theta\}$$
Benchmark without information frictions

**Result**

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

- All assets are allocated efficiently,
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and total output is

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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 $(\theta, \omega)$-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:

\[
p^{ET} = V^{ET}(H, l) \quad Y^{ET} = E\{v_\theta\}
\]
Candidate stationary equilibria

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\]

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

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

\[
p^{IT} < V^{IT}(H, l) \quad Y^{IT} = E\{v_\theta\} - \lambda \pi (v_H - c_H)
\]

- **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 \( \pi \in (\underline{\pi}, \bar{\pi}) \).
There exists two thresholds $\underline{\pi} < \bar{\pi}$ such that:

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

- Dynamic considerations are crucial for multiplicity.
Multiplicity and the role of dynamics

![Graph showing the relationship between the proportion of high quality assets and the discount factor.]

- Only Efficient Trade Equilibrium Exists
- Only Inefficient Trade Equilibrium Exists
- Both Equilibria Exist
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:

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

\[
\hat{\pi}v_H + (1 - \hat{\pi})v_L - c_H \geq \delta(1 - \hat{\pi}) E\{V^{ET}(H, \omega) - V^{ET}(L, \omega)\}
\]

\[
\text{today's gain from selling} \quad \text{future loss from selling at low price}
\]

where

\[
\hat{\pi} = \frac{\pi(1 - \lambda)}{\pi(1 - \lambda) + (1 - \pi)} = P\{\theta = H | (\theta, \omega) \neq (H, h)\}
\]
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\(\Delta^{ET}\)

- today's gain from selling
- future loss from selling at low price

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

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

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\hat{\pi} v_H + (1 - \hat{\pi}) v_L - c_H \leq \delta (1 - \hat{\pi}) E\{V^{IT}(H, \omega) - V^{IT}(L, \omega)\}
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\(\Delta^{IT}\)

- today's gain from buying
- future loss from buying at high price
What is the source of multiplicity?

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

(a) Shock frequency ($\lambda$)  
(b) Shock severity ($1 - \chi$)  
(c) Quality differential ($v_H - v_L$)
Are there other equilibria?

In any given period, we say that

- The market is **liquid** if \((H, l)\)-owners trade and **illiquid** otherwise

Result

An equilibrium with deterministic transitions between a liquid market and an illiquid market generically does not exist.

Intuition?

- Suppose market is liquid at \(t + 1\) but illiquid at \(t\) ⇒ \(\Delta t + 1 \leq \kappa\)
- Then future market conditions are weakly better at \(t\) than at \(t + 1\) ⇒ \(\Delta t \leq \Delta t + 1\)
- But the trade must also be efficient at \(t\)
Are there other equilibria?

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  \[\Rightarrow \Delta_t \leq \Delta_{t+1}\]

- But the 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**: market is liquid iff $z_t = G$. 
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  - Candidate equilibrium: market is liquid 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 $\pi \in (\bar{\pi}, \bar{\pi})$ and $\rho \geq \bar{\rho}$, where $\bar{\rho}$ depends on parameters.
A simple class

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- Not anything goes!
  - Sentiments needs to be sufficiently persistent to facilitate 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?

![Graph showing the existence of equilibrium based on sentiment and discount factors]
When do Sentiment equilibria exist?

The diagram illustrates the conditions under which efficient or inefficient trade equilibria exist, depending on the proportion of high quality assets and the discount factor. The shaded area indicates the region where only efficient trade equilibrium exists, while the rest of the graph shows where only inefficient trade equilibrium exists. The lines represent different scenarios, with one showing the proportion of high quality assets and the other showing the discount factor.
When do Sentiment equilibria exist?

![Graph showing the relationship between Sunspot persistence (ρ) and the proportion of high quality assets (π). The shaded area indicates the range where sentiments exist.]
Sentiments can be richer...

Example

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

$$Q = \begin{pmatrix}
\rho & 1 - \rho & 0 & \ldots & 0 \\
\frac{1-\rho}{2} & \rho & \frac{1-\rho}{2} & \ldots & 0 \\
0 & \ddots & \ddots & \ddots & \vdots \\
\vdots & \ddots & \frac{1-\rho}{2} & \rho & \frac{1-\rho}{2} \\
0 & 0 & \ldots & 1 - \rho & \rho
\end{pmatrix}$$

- Candidate Equilibrium: market is liquid iff $z_t \geq n^* \in \{1, N\}$
Sentiments can be richer...

Figure: $N = 40$, $n^* = 20$, $\rho = 0.4$
Sentiments can be richer...

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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 $\omega$ iid and same distribution as agents.
**First Order Condition**

Date-\(t\) producer chooses \(q\) to solve

\[
\max_{q \in [0,1]} \left\{ \delta (q E_t\{V_{t+1}(H,\omega)\} + (1 - q) E_t\{V_{t+1}(L,\omega)\}) - c(q) \right\}
\]
First Order Condition

Date-$t$ producer chooses $q$ to solve

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

The FOC for investment at time $t$ is

$$c'(q_t) = \delta \left( E_t \{ V_{t+1}(H, \omega) - V_{t+1}(L, \omega) \} \right)$$
First Order Condition

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The FOC for investment at time $t$ is

$$c'(q_t) = \delta \left( E_t \{ V_{t+1}(H, \omega) \} - V_{t+1}(L, \omega) \right) \Delta_t$$

And $\Delta_t$ 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.
When asset production is endogenous:

- **Efficient trade is an equilibrium**  \( \iff c'(\pi) \leq c \equiv \Delta_{ET}(\pi) \)
- **Inefficient trade is an equilibrium**  \( \iff c'(\bar{\pi}) \geq \bar{c} \equiv \Delta_{IT}(\bar{\pi}) \)
Sentiments with endogenous production?

Result

When asset production is endogenous:

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

Otherwise, any equilibrium **must involve sentiments** (and a sentiment equilibrium exists).
Illustrating the Result

Only Sentiment Equilibria Exist

Marginal cost of production, $c'(q)$

Level of investment, $q$

$\Delta^{IT}(q)$

$\Delta^{ET}(q)$
What elements of the model are crucial?

1. Informational environment
   - Need asymmetric information about common value component, $\theta$
   - Asymmetric information about $\omega$ not crucial

2. Competition
   - Similar conditions under which sentiments exist with single buyer.

3. Asset quality
   - Need some persistence in quality and some durability.
What elements of the model are crucial?

1. Informational environment
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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.
Application 1: Capital Reallocation

- Agents are **firms**, $\omega_j$ is firm $j$ productivity
- Assets are **capital**, $\theta_i$ is quality of capital unit $i$
- Firm $j$’s output $= u(\theta, \omega_j)$
- Total output $= \int u(\theta_i, \omega_j)\,di$
- Trade corresponds to reallocating capital to more productive firm
Application 1: Capital Reallocation

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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.
Application 2: Real Estate

- Agents are households, $\omega_j$ is private value of ownership
- Assets are houses, $\theta_i$ 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
Application 2: Real Estate

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- Assets are houses, $\theta_i$ is unobservable quality of house $i$
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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.
Application 3: New Investment with Financial Frictions

- Agents are entrepreneurs/managers
- Each agent can manage one project
- New ideas arrive randomly (the idiosyncratic shock)
  - Ideas are identical ex-ante, quality privately realized after investment
  - Agent must sell existing project to invest in a new idea
Application 3: New Investment with Financial Frictions

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  - Ideas are identical ex-ante, quality privately realized after investment
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Predictions

- Both investment and growth depend on sentiments
- Strong sentiments: All new ideas undertaken, high growth
- Weak sentiments: Some new ideas forgone, low growth
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.

- Application to capital reallocation and real estate markets.