### Initial Margin (50%)
- No constraints
- Can’t add to your position;
- Not received a margin call.

### Maintenance Margin (35%)
- Fixed amount of time to get to a specified point above the maintenance level before your position is liquidated.
- Failure to return to the initial margin requirements within the specified period of time results in forced liquidation.

### Minimum Margin (25%)
- Position is always immediately liquidated
Margins give incentive to hold well diversified portfolio

How are margins set by brokers/exchanges?

Value at Risk: \( \Pr (- (p_{t+1} - p_t) \geq m) = 1 \% \)
LEVERAGE AND MARGINS

- Financing a *long position* of $x^j_{t^+} > 0$ shares at price $p^j_{t^+} = 100$:
  + Borrow $90$ dollar per share;
  + Margin/haircut: $m^j_{t^+} = 100 - 90 = 10$
  + Capital use: $10 x^j_{t^+}$

- Financing a *short position* of $x^i_{t^-} > 0$ shares:
  + Borrow securities, and lend collateral of $110$ dollar per share
  + Short-sell securities at price of $100$
  + Margin/haircut: $m^i_{t^-} = 110 - 100 = 10$
  + Capital use: $10 x^i_{t^-}$

- Positions frequently marked to market
  + payment of $x^j_t (p^j_{t^-} - p^j_{t-1})$ plus interest
  + margins potentially adjusted – *more later on this*

- Margins/haircuts must be financed with capital:

$$\sum_j (x^{j+}_{t^+} m^{j+}_{t^+} + x^{j-}_{t^-} m^{j-}_{t^-}) \leq W_t,$$

where $x^j = x^i_{t^-} - x^j_{t^-}$

with perfect cross-margining: $M_t (x^1_{t^-}, \ldots, x^j_{t^-}) \leq W_t$
3. TWO CONCEPTS OF LIQUIDITY

- **Market liquidity**
  - Ease with which one can raise money by **selling** the asset

- **Funding liquidity**
  - Ease with which one can raise money by **borrowing** using the asset as collateral

Each asset has **two** values/prices
1. price
2. collateral value
Illiquidity arises due to frictions which:
- prevent fund flows to investors with expertise
- limits optimal risk sharing

Causes of frictions:
- asymmetric information
  - market breakdowns/credit rationing, market for lemons
- non-verifiable info - incomplete contracts/markets

Speed of arbitrage (dynamic):
- experts only build up capital slowly …
FLAVORS OF FUNDING LIQUIDITY

- **Margin funding risk**  
  Prime broker  
  + Margin has to be covered by HF’s own capital  
  + Margins increase at times of crisis

- **Rollover risk**  
  ABCP  
  + Inability to roll over short-term commercial paper

- **Redemption risk**  
  Depositors, HF-investors  
  + Outflow of funds for HFs and banks

Essentially the same!

**Maturity mismatch:**
Long-term assets (with low market liquidity)
Short-term borrowing

*Maturity structure – not capital structure (leverage)*
3. AMPLIFICATION MECHANISMS

1. Borrowers’ Balance Sheet Effects
   + Loss Spiral
   + Margin Spiral → de-leveraging

2. Lending Channel Effects
   + static
   + dynamic: precautionary hoarding

3. Run on Financial Institutions

4. Network Effects: Gridlock Risk
1. BALANCE SHEET CHANNEL

- Borrowers’ balance sheet
  + Loss spiral
    - Net wealth > \( \alpha \times \) for asym. info reasons
    - (constant or increasing leverage ratio)
    - Bernanke-Gertler, …
  + Margin spiral
    - (forces to delever)

- Mark-to-market vs. mark-to-model
  - worsens loss spiral
  - improves margin spiral

Source: Brunnermeier & Pedersen (2007)

- Both spirals reinforce each other
1. BALANCE SHEET CHANNEL

- Liquidity spiral
  + Loss spiral
  + Margin spiral

Margins/Haircuts:

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>Bond</td>
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<td>10+</td>
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<td>30+</td>
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<td>ABS and CDO</td>
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<td>50</td>
</tr>
<tr>
<td>Equity</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Citigroup, IMF Stability report 2007
1. BALANCE SHEET - MARGIN SPIRAL

- Black Monday 10/19/87
- US/Iraq war
- LTSM
- Asian crisis
- Subprime Crisis
- 1989 mini-crash
1. **Volatility of collateral increases**
   + Permanent price shock is accompanied by higher future volatility (e.g. ARCH)
     × Realization how difficult it is to value structured products
   + Value-at-Risk shoots up
   + Margins/haircuts increase = collateral value declines
   + Funding liquidity dries up
   + Note: all “expert buyers” are hit at the same time, SV 92

2. **Adverse selection of collateral**
   + As margins/ABCP rate increase, selection of collateral worsens
   + SIVs sell-off high quality assets first (empirical evidence)
   + Remaining collateral is of worse quality
1. BRUNNERMEIER-PEDERSEN MODEL

- Time: \( t=0,1,2 \)
- One asset with final asset payoff \( v \) (later: assets \( j=1,\ldots,J \))
- Market illiquidity measure: \( \Lambda_t = |E_t(v) - p_t| \)
  (deviation from “fair value” due to selling/buying pressure)
- Agents
  - Initial customers with supply \( S(z, E_t[v] - p_t) \) at \( t=1,2 \)
  - Complementary customers’ demand \( D(z, E_2[v] - p_2) \) at \( t=2 \)
  - Risk-neutral dealers provide *immediacy* and
    - face capital constraint
  - \( x_m(\sigma, \Lambda) \leq W(\Lambda) := \max\{0, B + x_0(E_1[v] - \Lambda)\} \)
1. FINANCIERS’ MARGIN SETTING

- Margins are set based on Value-at-Risk
- Financiers do not know whether price move is due to
  - Likely, movement in fundamental
  - Rare, Selling/buying pressure by customers who suffered asynchronous endowment shocks.

\[ m_{1}^{j+} = \phi^{-1}(1 - \pi)\sigma_{2} = \bar{\sigma} + \bar{\theta}|\Delta p_{1}| = m_{1}^{j-} \]
1. MARGIN SPIRAL – INCREASED VOL.

\[ v_t = v_{t-1} + \Delta v_t = v_{t-1} + \sigma_t \varepsilon_t \]

\[ \sigma_{t+1} = \sigma + \theta |\Delta v_t| \]

Selling pressure
initial customers

complementary
customers

\( \Lambda \)

\( \Lambda \)

\( m_1 \)
1. MARGIN SPIRAL – INCREASED VOL.

\[
\gamma = 0.025 \quad \sigma^2 = 11 \quad z_0 = 20 \quad z_1 = 20 \quad \nu_0 = 140 \quad \nu_1 = 120 \\
p_0 = 130 \quad k = 5 \quad \theta = 0.3 \quad \eta_1 = 0 \quad W_0 = 750 \quad x_0 = 0
\]

\[
x_1 < W_1/m_1 = W_1/(\sigma + \bar{\theta} |\Delta p_1|)
\]

customers’ supply
1. MULTIPLE ASSETS

- Dealer maximizes expected profit per capital use
  - Expected profit: \( E_1[v^j] - p^j = \Lambda^j \)
  - Capital use: \( m^j \)

- Dealers
  - Invest only in securities with highest ratio \( \Lambda^j/m^j \)

- Hence, illiquidity/margin ratio \( \Lambda^j/m^j \) is constant
1. COMMONALITY & FLIGHT TO QUALITY

- Commonality
  - Since funding liquidity is driving common factor

- Flight to Quality
  - Quality=Liquidity
    Assets with lower fund vol. have better liquidity
  - Flight
    Liquidity differential widens when funding liquidity becomes tight
1. SUM UP OF BALANCE SHEET CHANNEL

- Sudden liquidity “dry-ups” – fragility
  + Fragility
  + Liquidity spirals
  + Due to destabilizing margins
- Commonality of liquidity
  + Funding problems affect many securities
- Correlated with volatility
  + Volatile securities require more capital to finance
- Flight to quality
  + When capital is scarce, traders withdraw from “capital intensive” high-margin securities
- Moves with the market
  + Because funding conditions do
2. LENDING CHANNEL - HOARDING

- Balance sheet of lenders/banks worsens
  - Cut down on lending

- Mechanisms
  1. **Static** - moral hazard in monitoring by lenders
  2. **Dynamic** - precautionary hoarding
     - Afraid of interim shock (state at which refinancing is difficult)
     - ...

No deep pocket
Mechanisms (ctd.)

2. **Dynamic**: Interim shock $\Rightarrow$ larger “funding cushion”
   - SIVs might draw on credit lines
   - Borrowing at interbank lending market might be more difficult/volatile (since other banks might have SIV exposure then)
   - Increased counterparty credit risk

+ Asymmetric information worsens situation
  - Lemon’s problem
    “troubled” banks feel biggest urge to borrow

+ Example: Interbank market (LIBOR-OIS Spread)
3. RUN ON FINANCIAL INSTITUTIONS

- Run before others run – racing b/c it’s better to be among first
  **first mover advantage** - dynamic co-opetition
  + Balance sheet worsens
  + Other lenders face adverse shock

- Financial Institutions
  + On C-Banks: Classic bank-run by demand depositors
  + On I-Banks: “Client run” by margin account holders
    Bear Stearns’ case
  + On HFs: “Margin run” by prime brokers
    Redemption run by investors
  + On SIVs: Rollover stop by money market investors

- Note: “Liquidation policy” of SIVs favors early withdrawals!
- (Aside: Similar problem for mutual due to tax-treatment
  Mutual funds’ NAV should take hidden taxes into account.)
Network:
- Interweaved network of financial obligations
- Lender and borrower at the same time

Balance sheet and lending channel simultaneously at work

Investors take on position that might partially cancel each other at some later point
- Go long a swap with one party and short the swap a week later with some other party – asset need not be totally identical
- Also explains why CDS US$ \( \approx 45 \text{tr} \) while corporate debt \( \approx \text{US$ 5tr} \)

Counterparty Credit Risk & Gridlock Risk
4. NETWORK EFFECTS

- Example: Interest rate swap
  - Hedge fund can “step out” (by netting/novating)
  - March 11th evening, Goldman sent an e-mail to hedge fund: netting that directly exposes Goldman to Bear Stearns can only approved next morning
  - Question: Did misinterpretation led to hedge fund clients run?

- Let’s extend the example
Extended example:
- Everything can be netted out
- But each party only knows his obligations
- After Goldman’s call, hedge fund and private equity fund can’t step out
- More “funding liquidity” is necessary
- Hedge funds might go under as well
STYLIzed FACTS ON MARKET LIQUIDITY

- Sudden liquidity “dry-ups” – fragility
- Commonality of liquidity
  - within asset class (e.g. stocks)
  - across asset classes
- Correlated with volatility
- Flight to quality
- Moves with the market
LIMITS OF ARBITRAGE - ILLIQUIDITY

- Market liquidity provision = (risky arbitrage) trading to exploit temporary mispricing...

- Very similar – just different language

- Why does temporary “mispricing” persist?
  + Illiquidity refers “more” to high frequency mispricing (daily, weekly)
  + Limits to arbitrage literature refers more to long-run mispricings phenomena
EMH AND LIMITS TO ARBITRAGE

- **Keynes (1936)**  
  ![bubble can emerge]  
  “It might have been supposed that *competition between expert professionals*, possessing judgment and knowledge beyond that of the average private investor, would correct the vagaries of the ignorant individual left to himself.”

- **Friedman (1953), Fama (1965)**  
  Efficient Market Hypothesis  ![no bubbles emerge]  
  “If there are many sophisticated traders in the market, they may cause these “bubbles” to burst before they really get under way.”
Company X introduced a revolutionary wireless communication technology. It not only provided support for such a technology but also provided the informational content itself. It’s IPO price was $1.50 per share. Six years later it was traded at $85.50 and in the seventh year it hit $114.00. The P/E ratio got as high as 73. The company never paid dividends.
Company: Radio Corporation of America (RCA)
Technology: Radio
Year: 1920’s

+ It peaked at $ 397 in Feb. 1929, down to $ 2.62 in May 1932,
INTERNET BUBBLE? - 1990’S

Why do bubbles persist?

Do professional traders ride the bubble or attack the bubble (go short)?

What happened in March 2000?

NASDAQ Combined Composite Index

Loss of ca. 60% from high of $5,132

NEMAX All Share Index (German Neuer Markt)

Loss of ca. 85% from high of Euro 8,583
Efficient Market Hypothesis – 3 levels of justification

- All traders are rational, since behavioral will not survive in the long-run
- Behavioral trades cancel each other on average
- Rational arbitrageurs correct all mispricing induced by behavioral traders
LIMITS TO ARBITRAGE

- **Noise Trader Risk**
  - DeLong, Shleifer, Summers and Waldmann (1990 JPE)
  - Myopia due liquidity risk
    - Shleifer and Vishny (1997 JF)

- **Synchronization Risk**
  - Abreu and Brunnermeier (2002 JFE)

- **Fundamental Risk**
  - Campbell and Kyle (1993 REStud)
Idea: Arbitrageurs do not fully correct the mispricing caused by noise traders due to:
- Arbs short horizons (later endogenized)
- Arbs risk aversion (face noise trader risk)

Noise traders survive in the long-run.
NOISE TRADER RISK – DSSW1990A

- OLG model
  - Agents live for 2 periods
  - Make portfolio decision when they are young
- 2 assets
  - Safe asset $s$ pays fixed real dividend $r$
    - perfect elastic supply numeraire, i.e. $p_s = 1$
  - Unsafe asset $u$ pays fixed real dividend $r$
    - no elastic supply $X^{sup} = 1$
    - price at $t$ is $p_t$
  - Fundamental value of $s = $ fundamental value of $u$
Agents/Traders
- Mass $(1-\mu)$ of rational arbs
- Mass of $\mu$ of noise traders, who misperceive next period’s price by $\rho_t \sim \mathcal{N}(\rho_t^*, \sigma^2_{\rho})$
- CARA utility function $U(W) = -\exp\{-2\gamma W\}$ with certainty equivalent $E[W] - \gamma \text{Var}[W]$

Individual Demand
- Arbitrageurs

\[
E[W] - \gamma \text{Var}[W] = c_0 + x_t^a [r + E_t [p_{t+1}] - p_t (1 + r)] - \gamma (x_t^a)^2 \text{Var}_t [p_{t+1}]
\]
- Noise traders

\[
E[W] - \gamma \text{Var}[W] = c_0 + x_t^n [r + E_t [p_{t+1}] + \rho_t - p_t (1 + r)] - \gamma (x_t^n)^2 \text{Var}_t [p_{t+1}]
\]
Individual demand

- arbitrageurs:
  \[ x_t^a = \frac{r + E_t[p_{t+1}] - (1+r)p_t}{2\gamma Var_t[p_{t+1}]} \]

- noise traders:
  \[ x_t^n = \frac{r + E_t[p_{t+1}] - (1+r)p_t}{2\gamma Var_t[p_{t+1}]} + \frac{\rho_t}{2\gamma Var_t[p_{t+1}]} \]

Market Clearing: \((1-\mu)x_t^a + \mu x_t^n = 1\)

\[ p_t = \frac{1}{1+r} \left[ r + E_t[p_{t+1}] - 2\gamma Var_t[p_{t+1}] + \mu \rho_t \right] \]

- Solve recursively

\[ p_{t+1} = \frac{1}{1+r} \left[ r + E_{t+1}[p_{t+2}] - 2\gamma Var_{t+1}[p_{t+2}] + \mu \rho_{t+1} \right] \]

\[ E_t[p_{t+1}] = \frac{1}{1+r} \left[ r + E_t[p_{t+2}] - 2\gamma Var_t[p_{t+2}] + \mu \rho^* \right] \]

- We will see later that \(\text{Var}_t[p_{t+\tau}]\) is a constant for all \(\tau\)
Solve first order difference equation

\[ p_t = 1 + \frac{\mu (\rho_t - \rho^*)}{1 + r} + \frac{\mu \rho^*}{r} - \frac{2\gamma}{r} \text{Var}_t [p_{t+1}] \]

Note that \( \rho_t \) is the only random variable.

Hence,

\[ \text{Var}_t [p_{t+1}] = \text{Var} [p_{t+1}] = \frac{\mu^2 \sigma^2_r}{(1+r)^2} \]

\[ p_t = 1 + \frac{\mu (\rho_t - \rho^*)}{1 + r} + \frac{\mu \rho^*}{r} - \frac{(2\gamma) \mu^2 \sigma^2_r}{r (1 + r)^2} \]

1 = fundamental value
Second-term = deviation due to current misperception
Third-term = average misperception of noise traders
Last-term = arbs’ risk premium
**FUND-OUTFLOW RISK - PERFORMANCE BASED ARBITRAGE**

- Why are professional arbitrageurs’ myopic?
- Modified version of Shleifer & Vishny (1997JF)
  - Two assets
    - Risk-free bond
    - Risky stock with final value $v$
  - Two types of fund managers:
    - Good type knows fundamental value $v$
    - Bad type just gambles with “other people’s money”
  - Two trading rounds $t=1$ and 2 (in $t=3$, $v$ is paid out)
  - Individual investors
    - Entrust their money $F_1$ to a fund manager without knowing the fund managers’ skill level – “separation of brain and money”
    - Can withdraw funds in $t=2$
  - Noise traders submit random demand
FUND-OUTFLOW RISK - PERFORMANCE BASED ARBITRAGE

- Price setting
  - $P_3 = v$
  - $P_2$ is determined by aggregate demand of fund manager and liquidity/noise traders

- Focus on case where
  1. $P_1 < v$ asset is undervalued
  2. $P_2 < P_1$ goes even further down in $t=2$ due to
     - sell order by noise trader
     - sell order by other informed trader

- Performance-based fund flows
  (see Chevalier & Ellison 1997)
Performance-based fund flows

- If price drops, prob. increases that manager is bad
- Clients withdraw their money
- Shleifer-Vishny 1997 assume \[ F_2 = F_1 - aD_1 (1-P_2/P_1) \], where \( D_1 \) is the amount the manager invested in the stock.

“Good” manager’s problem who has invested in risky asset

- Has to liquidate his position at \( P_2 < P_1 \) (exactly when mispricing is largest!)
- Makes losses, even though the asset was initially undervalued.
- Due to this “outflow risk”, a rational fund manager is reluctant to fully exploit arbitrage opportunities
  [Note that fund-outflows exacerbate any risk that margins are binding!]
- Hence, manager focus on short-run price movement
  \( \Rightarrow \) Myopia of professional arbitrageurs (justifies DSSW assumption)
SYNCHRONIZATION RISK

- Noise trader risk
  - Risk that irrational traders drive price even further from fundamentals

- Synchronization risk
  - One trader alone cannot correct the mispricing (can sustain a trade only for a limited time period)
  - Risk that other rational traders do not act against mispricing (in sufficiently close time)
    - Abreu and Brunnermeier (2002, 2003 for bubbles)
  - Relatively unimportant news can serve as synchronization device and trigger a large price correction
DO PROFESSIONAL RIDE THE BUBBLE?

South Sea Bubble (1710 - 1720)

- *Isaac Newton*
  - 04/20/1720 sold shares at £7,000 profiting £3,500
  - re-entered the market later - ended up losing £20,000
  - “I can calculate the motions of the heavenly bodies, but not the madness of people”

Internet Bubble (1992 - 2000)

- *Druckenmiller* of Soros’ Quantum Fund didn’t think that the party would end so quickly.
  - “We thought it was the eighth inning, and it was the ninth.”
- *Julian Robertson* of Tiger Fund refused to invest in internet stocks
“The moral of this story is that irrational market can kill you …
Julian said ‘This is irrational and I won’t play’ and they carried him out feet first.
Druckenmiller said ‘This is irrational and I will play’ and they carried him out feet first.”

Quote of a financial analyst, New York Times
April, 29 2000
ELEMENTS OF THE TIMING GAME

1. **Coordination** at least $\kappa > 0$ arbs have to be ‘out of the market’

2. **Competition** only first $\kappa < 1$ arbs receive pre-crash price.

3. **Profitable ride** ride bubble (stay in the market) as long as possible.

4. **Sequential Awareness**

   A *Synchronization Problem* arises!

   + Absent of sequential awareness competitive element dominates $\Rightarrow$ and bubble burst immediately.
   + With sequential awareness incentive to TIME THE MARKET leads to $\Rightarrow$ “delayed arbitrage” and persistence of bubble.
MODEL SETUP

- common action of $\kappa$ arbitrageurs
- sequential awareness (random $t_0$ with $F(t_0) = 1 - \exp\{-\lambda t_0\}$).

$pt = e^{gt}$

$\beta pt$

$(1 - \beta(\cdot))pt$

- paradigm shift - internet 90’s
- railways
- etc.

$1/\eta$

$t_0$
random starting point

$t_0 + \eta \kappa$
K traders are aware of the bubble

$t_0 + \eta$
all traders are aware of the bubble

$t_0 + \tau$
bubble bursts for exogenous reasons

maximum life-span of the bubble $\bar{\tau}$
SELL OUT CONDITION for $\Delta \to 0$ PERIODS

- sell out at $t$ if

$$\Delta h(t \mid t_i) E_t[\text{bubble} \mid \bullet] \geq (1 - \Delta h(t \mid t_i)) (g - r)p_t \Delta$$

benefit of attacking

appreciation rate

cost of attacking

$$h(t \mid t_i) \geq \frac{g - r}{\beta^*}$$

bursting date $T^*(t_0) = \min\{T(t_0 + \eta \kappa), t_0 + \bar{\tau}\}$

RHS converges to $\to [(g-r)]$ as $t \to \infty$
Hazard rate $h(t | t_i)$ depends on trading behavior of other rational traders.

I received a signal that price is too high at $t_i$, but others might receive this signal much later (for large $\eta$).

Let me ride the bubble (and enjoy growth rate of $g$) as long it is unlikely that enough traders are informed about the overpricing.

All other rational traders think the same way.

⇒ Hence, bubble survives longer.

This allows me to enjoy the ride even longer.

Over time, the size of the bubble grows and eventually it will be so large that I am afraid that it will burst on me.

Everybody sells out $\tau$ periods after receiving his signal.

⇒ Traders leave the market sequentially.
SEQUENTIAL AWARENESS

Distribution of $t_0$

(trusting the trader if nobody attacks)

$t_i - \eta$

since $t_i \leq t_0 + \eta$

$t_i$

since $t_i \geq t_0$

Distribution of $t_0 + \bar{\tau}$

(bursting of bubble if nobody attacks)

$t_0$

$t_k$

$t_0 + \tau$
CONJECTURE 1: IMMEDIATE ATTACK

The bubble bursts at $t_0 + \eta \kappa$

when $\kappa$ traders are aware of the bubble.

If $t_0 < t_i - \eta \kappa$, the bubble would have burst already.

$\lambda/(1 - e^{-\lambda \eta \kappa})$

Distribution of $t_0$

Distribution of $t_0 + \eta \kappa$
hazard rate of the bubble

\[ h = \frac{\lambda}{1 - \exp\{-\lambda(t_i + \eta \kappa - t)\}} \]
CONJ. 1 (CTD.): IMMEDIATE ATTACK

Bubble bursts at $t_0$ for sure!

hazard rate of the bubble

$$h = \lambda/(1 - \exp{-\lambda(t_i + \eta \kappa - t)})$$

Recall the sell out condition:

$$h(t|t_i) \geq \frac{g - r}{\beta^*}$$

Recall the sell out condition:

$$h(t|t_i) \geq \frac{g - r}{\beta^*}$$

no "immediate attack" equilibrium!

Distribution of $t_0$

lower bound: $(g-r)/\bar{\beta} > \lambda/(1-e^{-\lambda \eta \kappa})$

bubble appreciation / bubble size

$t_i - \eta$

$t_i - \eta \kappa$

$t_i$

$t_i + \eta \kappa$

optimal time to attack $t_i + \tau_i$

$\Rightarrow$ "delayed attack is optimal"

Bubble bursts for sure!
CONJ. 2: DELAYED ATTACK by arbitrary $\tau'$

hazard rate of the bubble
$h = \lambda/(1-\exp\{-\lambda(t_i + \eta \kappa + \tau' - t)\})$

bubble appreciation
bubble size

lower bound: $(g-r)/\beta > \lambda/(1-e^{-\lambda \eta \kappa})$

$\Rightarrow$ attack is never successful
$\Rightarrow$ bubble bursts for exogenous reasons at $t_0 + \tau$

$\Rightarrow$ optimal to delay attack even more
Proposition 3: Suppose \( \frac{\lambda}{1-e^{-\lambda \eta \kappa}} > \frac{g-r}{\beta} \).

+ ‘unique’ trading equilibrium.
+ traders begin attacking after a delay of \( \tau^* \) periods.
+ bubble \textbf{bursts} due to endogenous selling pressure at a size of \( p_t \) times

\[
\beta^* = \frac{1-e^{-\lambda \eta \kappa}}{\lambda} (g - r)
\]
ENDOGENOUS CRASHES

hazard rate of the bubble
\[ h = \lambda / (1 - \exp\{-\lambda(t_i + \eta \kappa + \tau' - t)\}) \]

lower bound:
\[ (g - r) / \beta > \lambda / (1 - \exp\{\lambda \eta \kappa\}) \]

bubble appreciation
bubble size

\[ t_i - \eta \]
\[ t_i - \eta \kappa \]
\[ t_i \]
\[ t_i - \eta + \eta \kappa \]
\[ t_i + \eta \kappa + \tau^* \]

conjectured attack

optimal

\[ t_i + \eta \kappa + \tau^{**} \]
LACK OF COMMON KNOWLEDGE

⇒ standard backwards induction can’t be applied

\[ t_0 \quad t_0 + \eta \kappa \quad t_0 + \eta \quad t_0 + 2\eta \quad t_0 + 3\eta \quad \ldots \quad t_0 + \bar{\tau} \]

- everybody knows of the bubble
- everybody knows that everybody knows of the bubble
- everybody knows that everybody knows that everybody knows of the bubble

(\text{same reasoning applies for } \kappa \text{ traders})
News may have an impact disproportionate to any intrinsic informational (fundamental) content.

- News can serve as a synchronization device.

Fads & fashion in information

- Which news should traders coordinate on?

When “synchronized attack” fails, the bubble is temporarily strengthened.
Barron’s article published a week after the peak.

BioTech stock: Clinton and Blair’s announcement to make human clone project publicly available info (Teodoro D. Cocca)

Other articles
- “Mr. Buffet on the Stock Market” in the November 22, 1999 Fortune
- Jeremy Siegel’s in the March 14, 2000 WSJ article “Big Cap Tech Stocks Are a Sucker Bet”
Jeremy Siegel “What Triggered the Tech Wreck?” in the July 2000 *Individual Investor*

“Most of history’s big market moves were not motivated by news, economic or otherwise. ... What, then, causes most price routs? A seemingly innocuous decline turns into a crash when a sufficient number of short-term investors notice that fewer investors than usual are buying at the dips. That lack of buyers stokes fears that an even larger downward price movement will occur. And the declines become self-reinforcing... That’s precisely what happened to tech stocks in March. The Nasdaq became dominated by trend followers and momentum traders who do not care at all about such fundamentals as earnings, revenue, and intrinsic worth.”
IN SUM

- Bubbles
  - Dispersion of opinion among arbitrageurs causes a synchronization problem which makes coordinated price corrections difficult.
  - Arbitrageurs time the market and ride the bubble.
  - $\Rightarrow$ Bubbles persist

- Crashes
  - can be triggered by unanticipated news without any fundamental content, since
  - it might serve as a synchronization device.

- Rebound
  - can occur after a failed attack, which temporarily strengthens the bubble.
1. **Unawareness of Bubble**
   ⇒ Rational speculators perform as badly as others when market collapses.

2. **Limits to Arbitrage**
   1. Fundamental risk
   2. Noise trader risk
   3. Synchronization risk
   4. Short-sale constraint
      ⇒ Rational speculators may be reluctant to go short overpriced stocks.

3. **Predictable Investor Sentiment**
   1. AB (2003), DSSW (JF 1990)
      ⇒ Rational speculators may want to go long overpriced stock and try to go short prior to collapse.
EMPIRICAL STUDY

- Did hedge funds ride or fight the technology bubble?
  + Brunnermeier and Nagel (2004 JF)
Fig. 2: Weight of NASDAQ technology stocks (high P/S) in aggregate hedge fund portfolio versus weight in market portfolio.
Fig. 4a: Weight of technology stocks in hedge fund portfolios versus weight in market portfolio.
FUND IN- AND OUTFLOWS

Fund flows as proportion of assets under management

Quantum Fund (Soros)
Jaguar Fund (Tiger)
DID HEDGE FUNDS TIME STOCKS?

Figure 5. Average share of outstanding equity held by hedge funds around price peaks of individual stocks
**DID HEDGE FUNDS’ TIMING PAY OFF?**

Figure 6: Performance of a copycat fund that replicates hedge fund holdings in the NASDAQ high P/S segment
Hedge funds were riding the bubble

- Short sales constraints and “arbitrage” risk are not sufficient to explain this behavior.

Timing bets of hedge funds were well placed. Outperformance!

- Rules out unawareness of bubble.
- Suggests predictable investor sentiment. Riding the bubble for a while may have been a rational strategy.

⇒ Supports ‘bubble-timing’ models
RATIONAL BUBBLES

- All agents are fully rational
  \[ p_t = \frac{1}{1+r} E_t [p_{t+1} + d_{t+1}] \]

- Solve forward
  \[ p_t = E_t [\sum_{\tau=1}^{T-1} \frac{d_{t+\tau}}{(1+r)^\tau}] + E_t \left[ \frac{1}{(1+r)^T} p_T \right] \]

- Securities with
  + finite maturity \( T \), \( p_T = 0 \)
  + Infinite maturity \( T \to \infty \), -- many solutions
    first part = \( v \) \_ \( t = \) fundamental -- second part assumed

  \[ \lim_{T \to \infty} E_t \left[ \frac{1}{(1+r)^T} p_T \right] = 0 \]
Many solutions satisfy difference equation 
\[ p_t = v_t + b_t \] 
as long as

\[ b_t = E_t \left[ \frac{1}{1+r} b_{t+1} + 1 \right] \]

Blanchard-Watson example: bubble persists each period with probably \( \pi \) and bursts otherwise

- Bubble has to grow at by a factor \( (1+r)/\pi \)

Explosive path necessary!

Bubbles cannot emerge
Two equally likely states: “a” & “b”

Two stocks

- Payoff of stock A: $1 if “a” $0 if “b”
- Payoff of stock B: $1 if “b” $0 if “a”

Price is fixed to $1/2$

Each trader receives a signal $S^i \in \{\alpha, \beta\}$

- $\text{Prob}(\alpha | a) = \text{Prob}(\beta | b) = q > 1/2$

You have $10, which you either invest fully in asset A or in asset B
EXPERIMENT

- (distribute signals to students!) ....
- Consider the following sequence of signals $\alpha, \alpha, \beta, \beta, \beta, \beta, \beta, ...$
- Rational agents would invest in $A, A, A, A, A, A, A, ...$
  - First agent follows his signal
  - Second agent infers that first agent got signal $\alpha$
    - Chooses $A$ if he receives signal $\alpha$
    - Is indifferent between $A$ and $B$ if he received signal $\beta$
      (suppose he follows his own signal $\beta$ in this case)
  - Third agent infers first agents’ signal and thinks that it is more that second agent got $\alpha$ signal
    this dominates his single signal $\beta$. Hence, he chooses $A$ as well.
  - Fourth agent cannot infer anything from third agent. He is in the same shoes as third agent. He herds...
  - ...

...
MARKET MAKER SETS THE PRICE

Setting like in Glosten-Milgrom (See earlier lecture)
Read: Avery-Zemsky (1998 AER) or Brunnermeier (2001 Chapter 5)

Big difference: Price adjusts
+ Speed of price adjustment depends on speed of learning of market maker
  ✗ No learning of market maker, price stays constant ⇒ herding
  ✗ Market maker learns at same speed as other informed traders ⇒ positive information externality (learn from predecessors’ action) is exactly offset by negative payoff externality (price moves against me) ⇒ No herding
  ✗ Market maker learns at a slower speed ⇒ some herding
    ✗ introduce event uncertainty