INSTITUTIONAL FINANCE

Lecture 07: Liquidity, Limits to Arbitrage – Margins + Bubbles

DEBRIEFING - MARGINS

$

- No constraints

Initial Margin (50%) Reg. T 50 %

- Can't add to your position;
- Not received a margin call.

Maintenance Margin (35%) NYSE/NASD 25% long
30% short

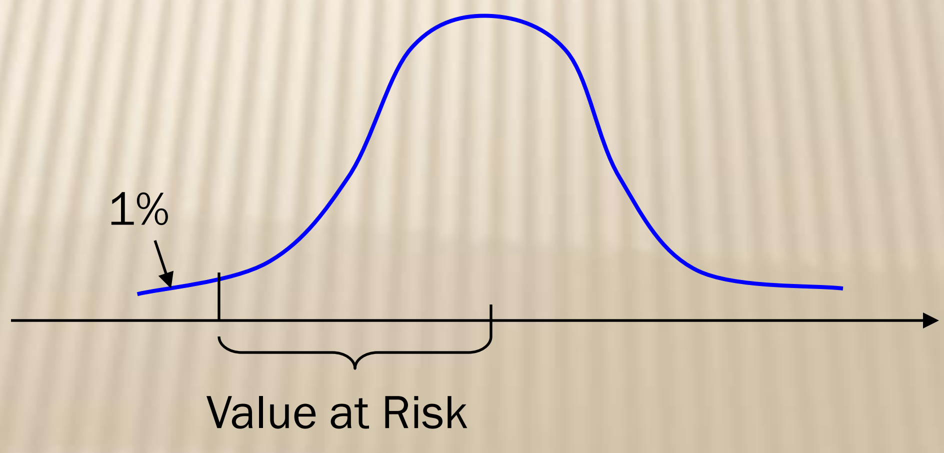
- Fixed amount of time to get to a specified point above the maintenance level before your position is liquidated.
- Failure to return to the initial margin requirements within the specified period of time results in forced liquidation.

Minimum Margin (25%)

- Position is always immediately liquidated

MARGINS – VALUE AT RISK (VAR)

- 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 $x^{j-}_t > 0$ shares:
  - Borrow securities, and lend collateral of 110 dollar per share
  - Short-sell securities at price of 100
  - Margin/haircut: $m^{j-}_t = 110-100 = 10$
  - Capital use: $\$10\ x^{j-}_t$
- 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:

$$\sum_j \left(x^{j+}_t m^{j+}_t + x^{j-}_t m^{j-}_t \right) \leq W_t \text{, where } x^j = x_t^{j+} - x_t^{j-}$$

with perfect cross-margining: $M_t (x_t^1, \ldots, x_t^J) \leq W_t$

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

FUNDING LIQUIDITY FRICTIONS

- 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

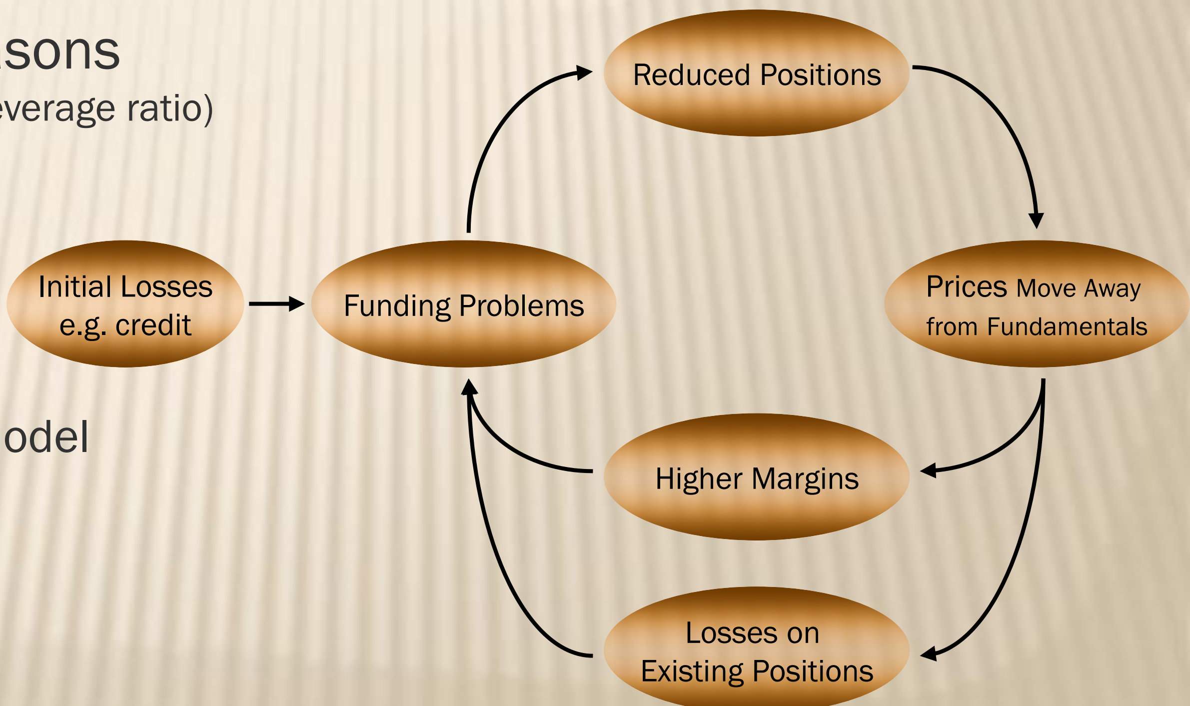
*Maturity structure – **not** capital structure (leverage)!*

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 > α x
      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

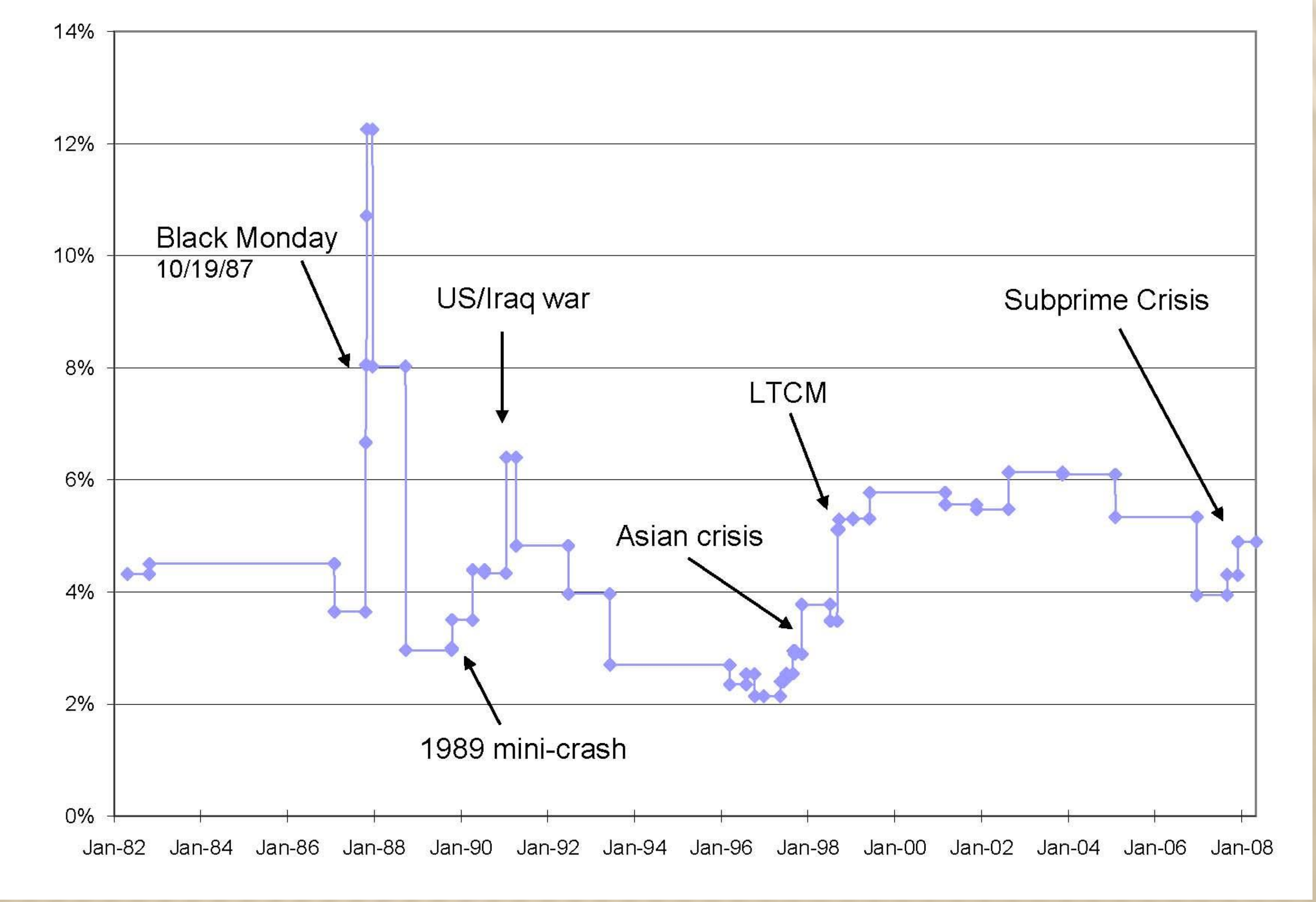
1. BALANCE SHEET CHANNEL

- Liquidity spiral
  - Loss spiral
  - Margin spiral

Margins/Haircuts:

Rating	Jan-May 2007	July-Aug 2007
	Bond	
Investment grade	0-3	3-7
High yield	0-5	10+
	Leveraged Loan	
Senior	10-12	15-20
2^{nd} lien	15-20	20-30
Mezzanine	18-25	30+
	ABS and CDO	
AAA	2-4	8-10
AA	4-7	20
A	8-15	30
BBB	10-20	50
Equity	50	100
Source: Citigroup, IMF Stability report 2007		

1. BALANCE SHEET - MARGIN SPIRAL



1. MARGIN SPIRAL – WHY?

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
  - $x m(\sigma, \Lambda) \leq W(\Lambda) \quad := \quad \max\{0, \underbrace{B}_{\text{cash}} + \underbrace{x_0(E_1[v]-\Lambda)}_{\text{"price" of stock holding}}\}$

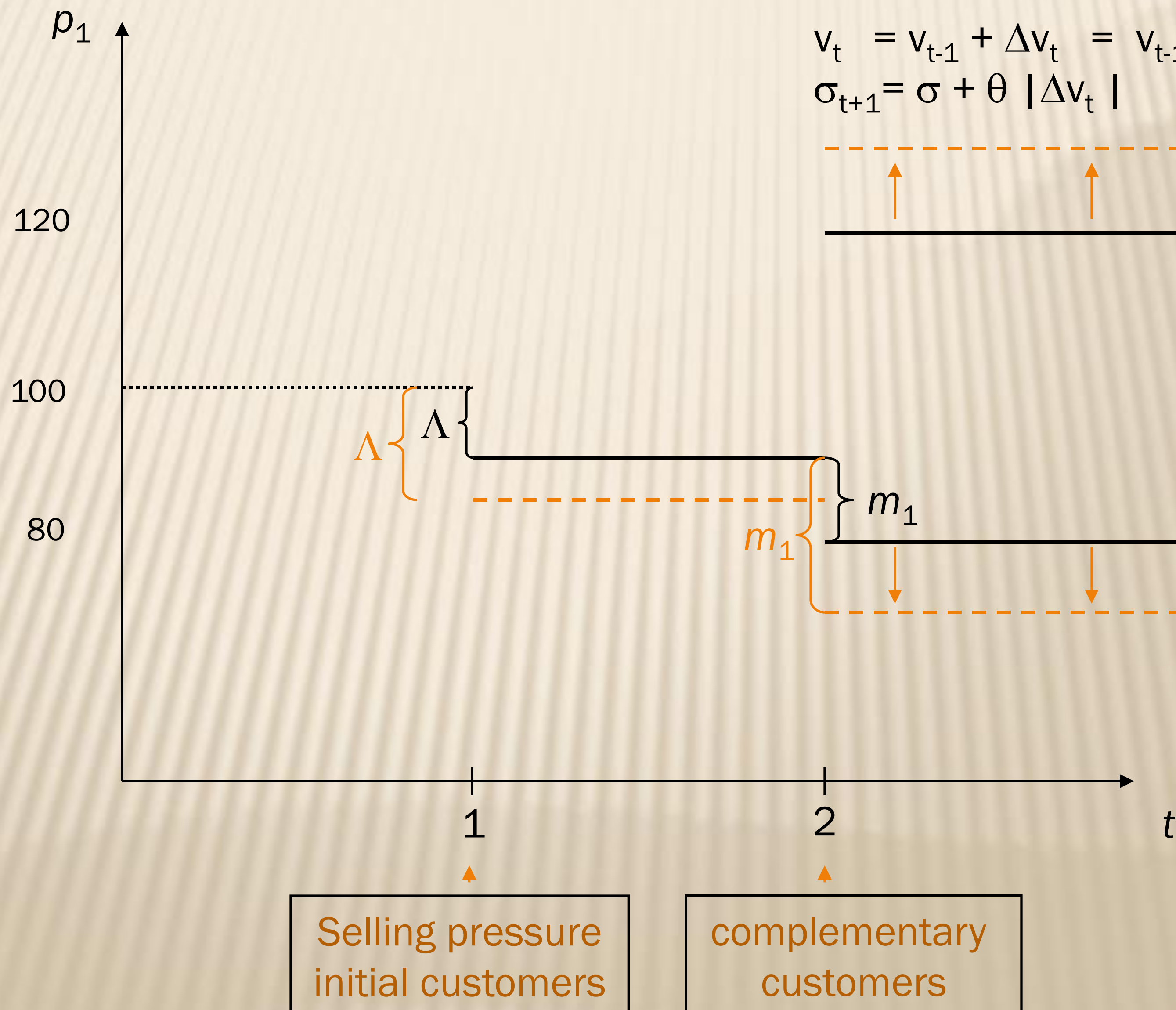
1. FINANCIERS' MARGIN SETTING

- 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.

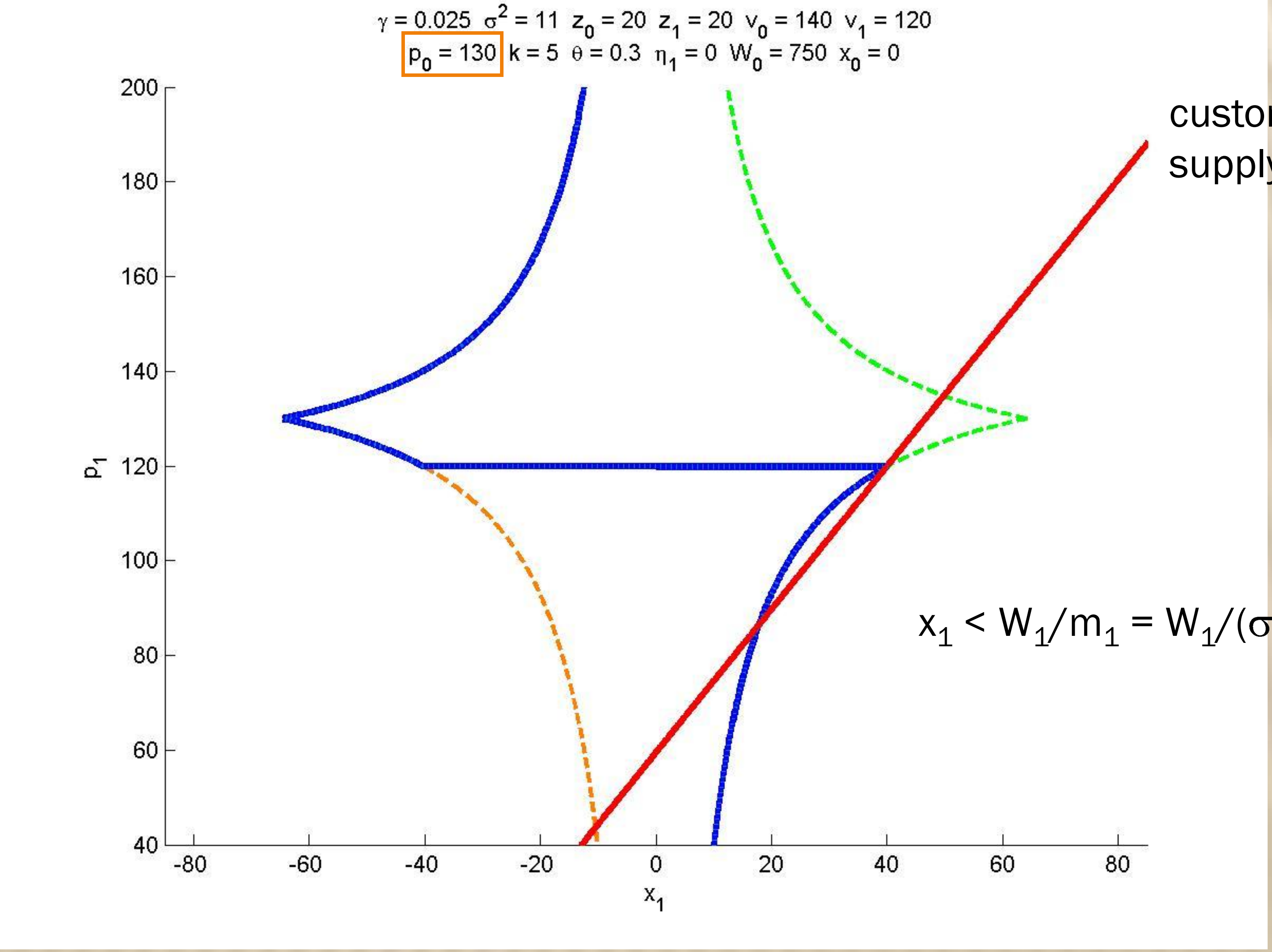
$$m_1^{j+} = \phi^{-1}(1-\pi)\sigma_2 = \bar{\sigma} + \bar{\theta}|\Delta p_1| = m_1^{j-}$$

1. MARGIN SPIRAL – INCREASED VOL.

$$v_t = v_{t-1} + \Delta v_t = v_{t-1} + \sigma_t \varepsilon_t$$
$$\sigma_{t+1} = \sigma + \theta \, |\Delta v_t|$$



1. MARGIN SPIRAL – INCREASED VOL.



customers' supply

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

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 Λ^j/m^j
- Hence, illiquidity/margin ratio Λ^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

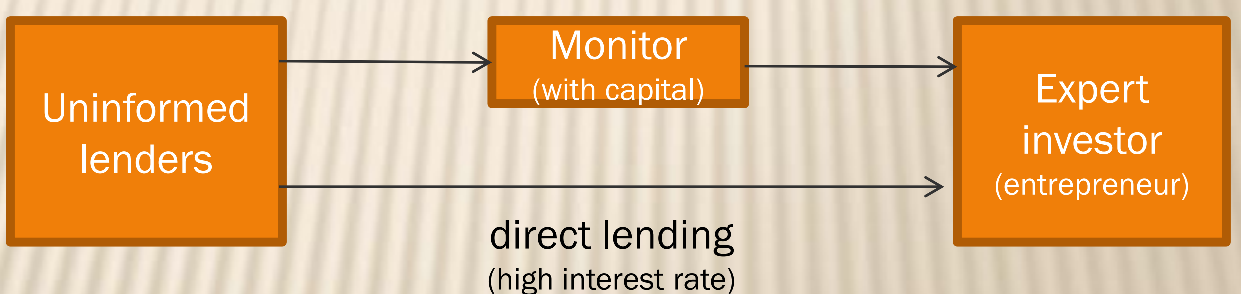
1. SUM UP OF BALANCE SHEET CHANNEL

- 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

No deep pocket

- 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)
     - …

2. LENDING CHANNEL - HOARDING

- Mechanisms (ctd.)
  2. Dynamic: Interim shock ⇒ 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.)

4. NETWORK – CPCR+GRIDLOCK RISK

- Network:
  - Interweaved network of financial obligations
  - Lender and borrower at the same time
- Balance sheet and lending channel simultaneously at work

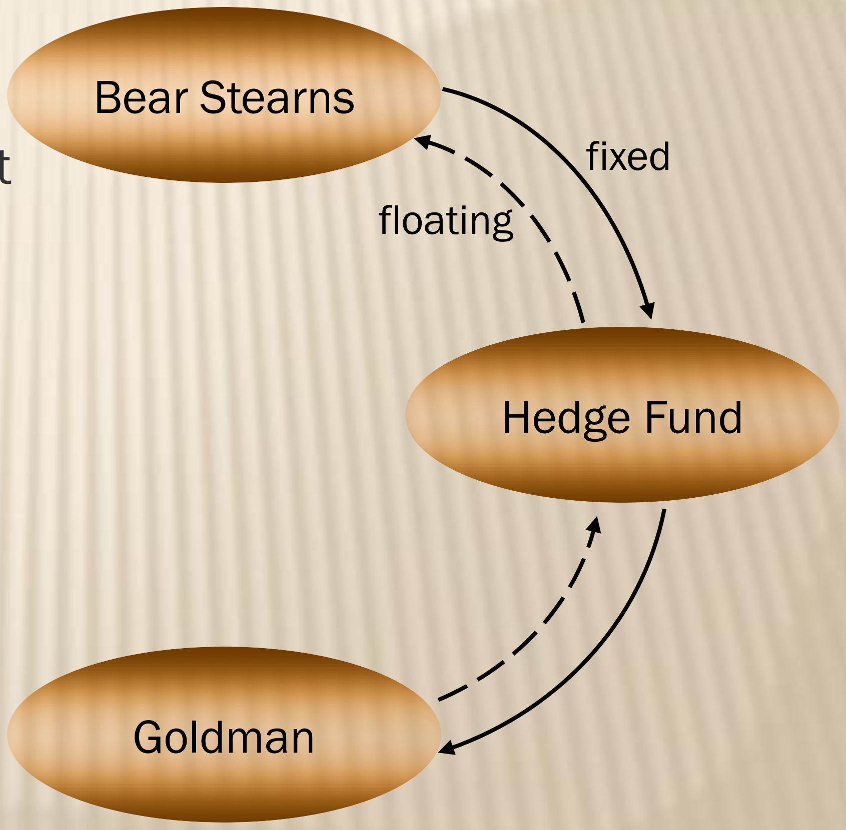
- Investors take on position that might partially cancel each other at some later point
  - Go long a swap with one party and short the swap a week later with some other party – asset need not be totally identical
  - Also explains why CDS US$ ≈45tr while corporate debt ≈US$ 5tr

- Counterparty Credit Risk & Gridlock Risk

4. NETWORK EFFECTS

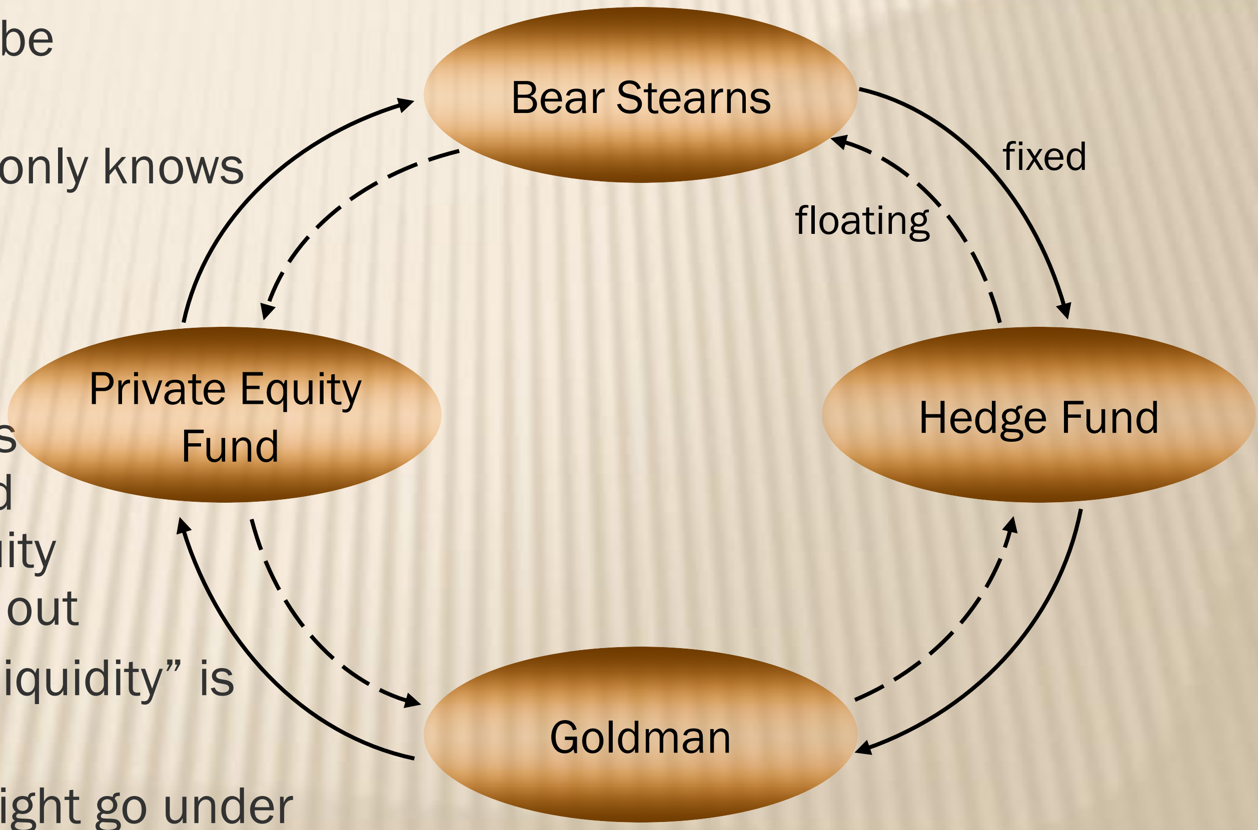
- Example: Interest rate swap
  - Hedge fund can "step out" (by netting/novating)
  - March 11th evening, Goldman sent an e-mail to hedge fund: netting that directly exposes Goldman to Bear Stearns can only approved next morning
  - Question: Did misinterpretation led to hedge fund clients run?

- Let's extend the example



4. NETWORK EFFECTS

- 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.”

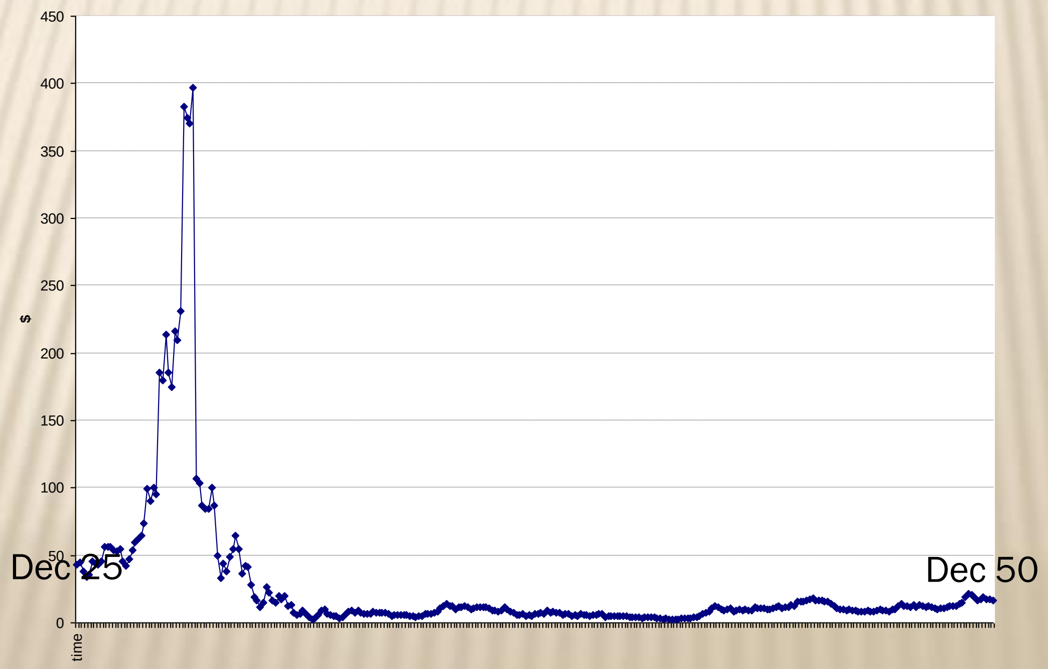
BUBBLES – SPECIAL FORM OF MISPRICING:

STORY OF A TYPICAL TECHNOLOGY STOCK

- 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.

STORY OF RCA - 1920'S

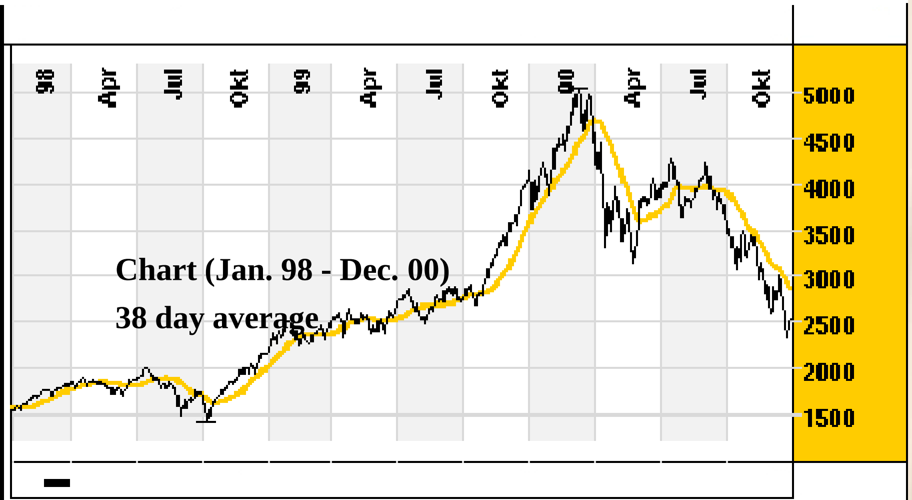
- Company: *Radio Corporation of America (RCA)*
- Technolgoy: *Radio*
- Year: *1920's*



+ It peaked at $ 397 in Feb. 1929, down to $ 2.62 in May 1932,

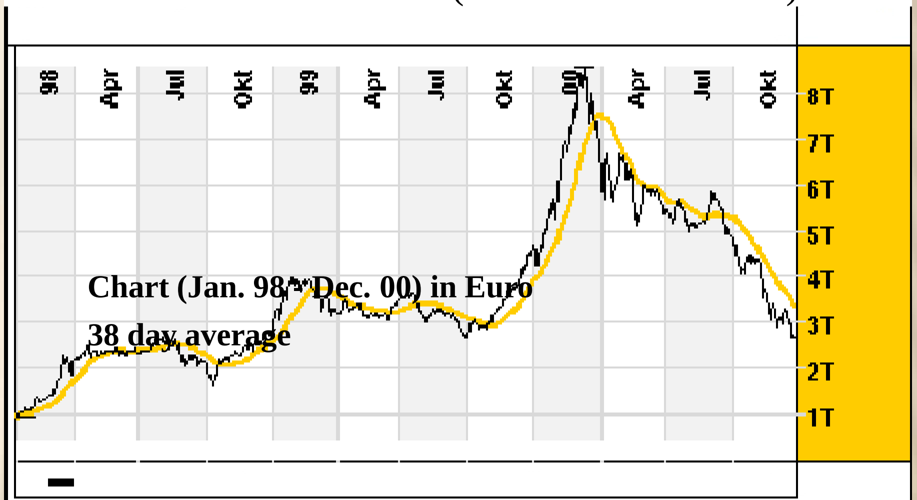
INTERNET BUBBLE? - 1990'S

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

- Why do bubbles persist?
- Do professional traders ride the bubble or attack the bubble (go short)?
- What happened in March 2000?

LIMITS TO ARBITRAGE

- 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)

NOISE TRADER RISK

- *Idea:* Arbitrageurs do not fully correct the mispricing caused by noise traders due
  - 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*

NOISE TRADER RISK – DSSW1990A

- Agents/Traders
  - Mass (1-μ) of rational arbs
  - Mass of μ of noise traders, who misperceive next period's price by $\rho_t \sim N(\rho^*_t, \sigma^2_\rho)$
  - CARA utility function U(W) = -exp{-2γ W} with certainty equivalent E[W] - γ Var[W]
- Individual Demand
  - Arbitrageurs

$$E\left[W\right]-\gamma Var\left[W\right]=c_0+x_t^a\left[r+E_t\left[p_{t+1}\right]-p_t\left(1+r\right)\right]-\gamma\left(x_t^a\right)^2 Var_t\left[p_{t+1}\right]$$

  - Noise traders

$$E\left[W\right]-\gamma Var\left[W\right]=c_0+x_t^n\left[r+E_t\left[p_{t+1}\right]+\rho_t-p_t\left(1+r\right)\right]-\gamma\left(x_t^a\right)^2 Var_t\left[p_{t+1}\right]$$

NOISE TRADER RISK – DSSW1990A

- 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: $(1-\mu)\, x^a_t + \mu\, x^n_t = 1$

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

  - Solve recursively

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

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

  - We will se later that $Var_t[p_{t+\tau}]$ is a constant for all τ

NOISE TRADER RISK – DSSW 1990A

- Solve first order difference equation

$$p_t = 1 + \frac{\mu\left(\rho_t - \rho^*\right)}{1+r} + \frac{\mu\rho^*}{r} - \frac{2\gamma}{r} Var_t\left[p_{t+1}\right]$$

- Note that ρ_t is the only random variable.
  Hence, $Var_t\left[p_{t+1}\right] = Var\left[p_{t+1}\right] = \frac{\mu^2\sigma_\rho^2}{(1+r)^2}$

$$p_t = 1 + \frac{\mu\left(\rho_t - \rho^*\right)}{1+r} + \frac{\mu\rho^*}{r} - \frac{(2\gamma)\,\mu^2\sigma_\rho^2}{r\,(1+r)^2}$$

  + 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)

FUND-OUTFLOW RISK - PERFORMANCE BASED ARBITRAGE

- 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 **bubble**s)
  - 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

PROS' DILEMMA

- "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

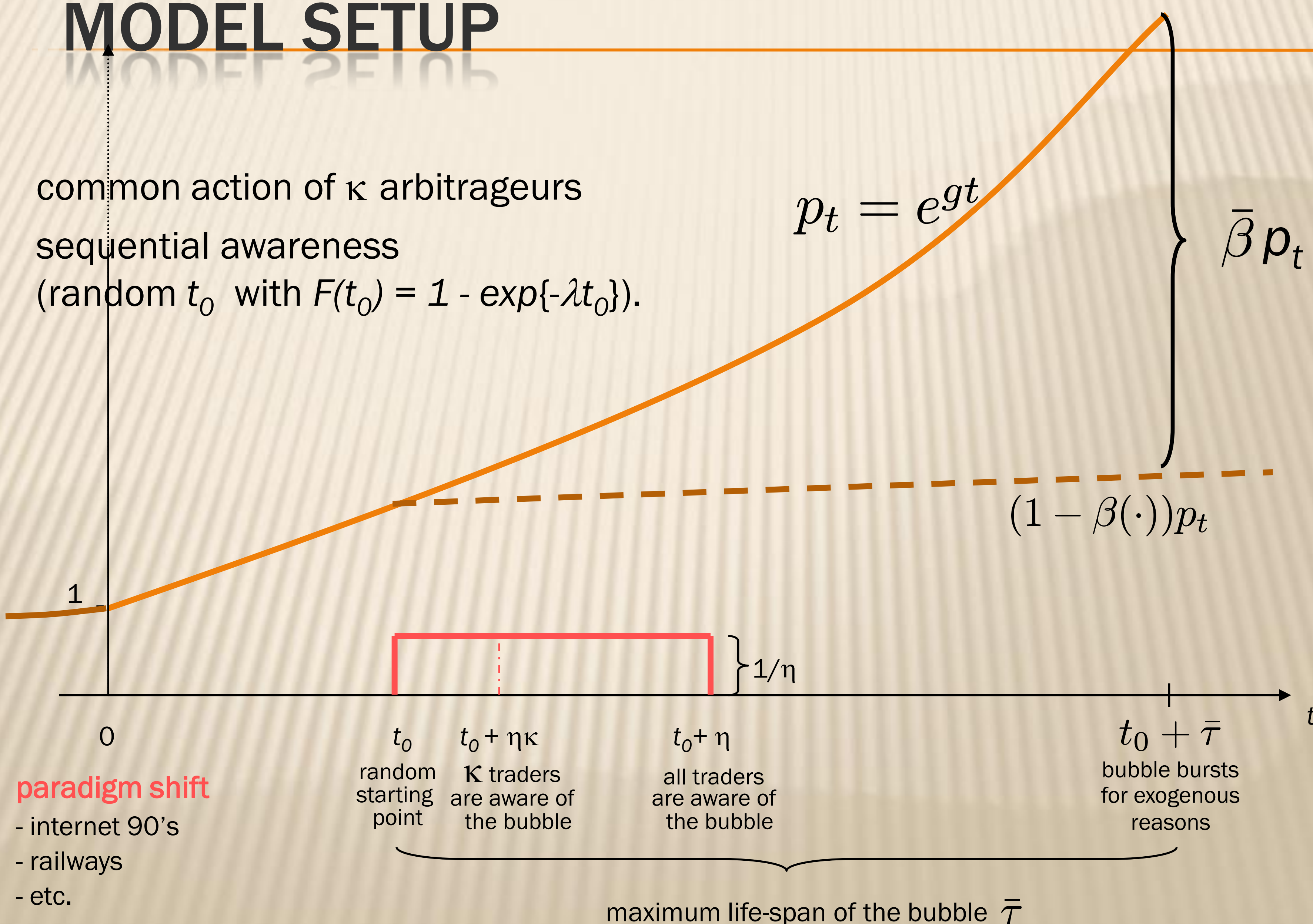
1. *Coordination* at least $\kappa > 0$ arbs have to be 'out of the market'
2. *Competition* only *first* $\kappa < 1$ arbs receive pre-crash price.
3. *Profitable ride* ride bubble (stay in the market) as long as possible.
4. *Sequential Awareness*

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 κ arbitrageurs
- sequential awareness (random t_0 with $F(t_0) = 1 - \exp\{-\lambda t_0\}$).



SELL OUT CONDITION FOR $\Delta \to 0$ PERIODS

- sell out at t if

$$\Delta\, h(t\,|\,t_i) E_t \underbrace{[\text{bubble}\,|\,\bullet]}_{\text{benefit of attacking}} \geq (1-\Delta\, h(t\,|\,t_i)) \underbrace{\overbrace{(g-r)}^{\text{appreciation rate}} p_t\, \Delta}_{\text{cost of attacking}}$$

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

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

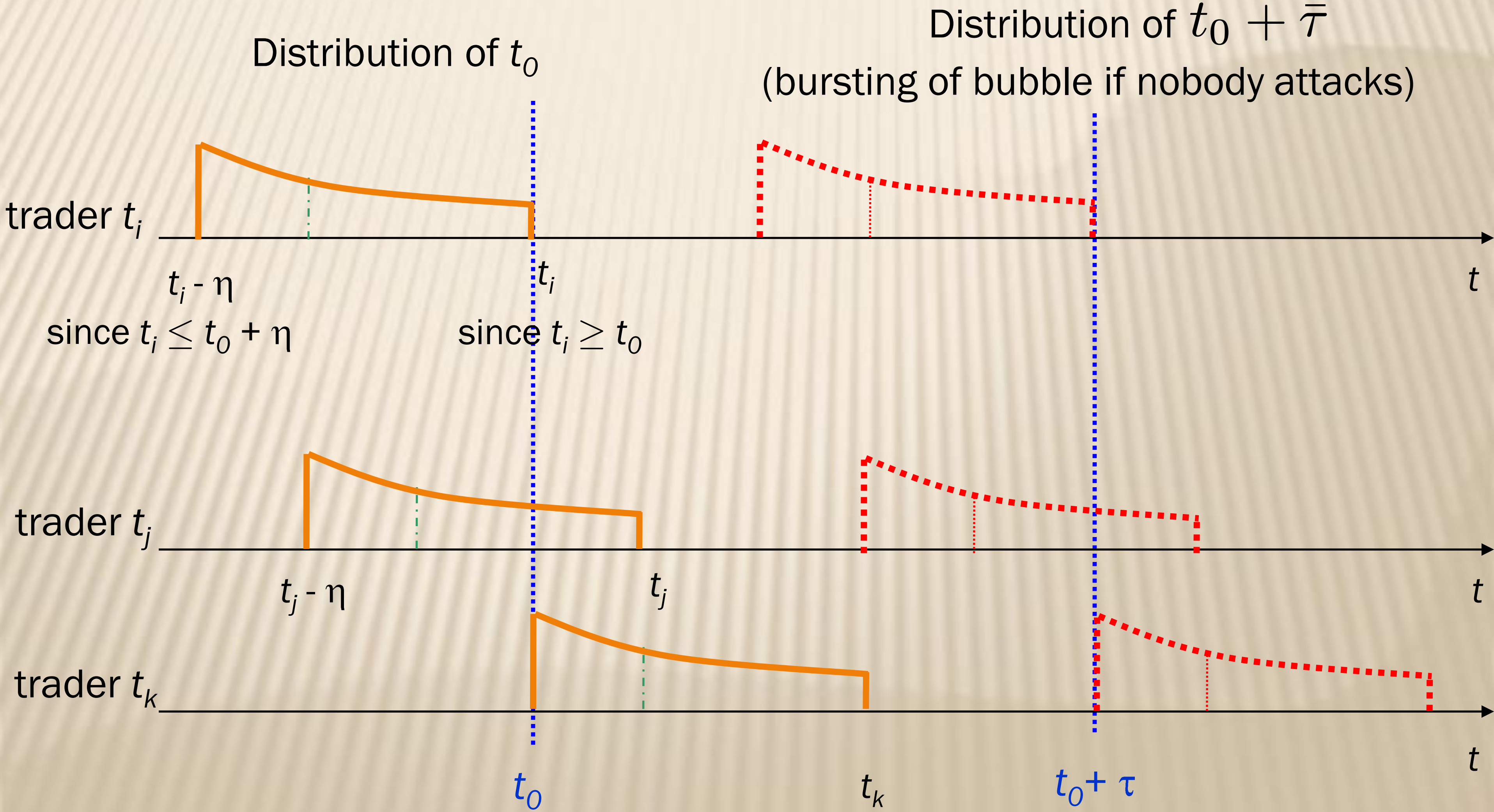
RHS converges to $\to$ $[(g\text{-}r)]$ as $t \to \infty$

INTUITION OF SYNCHRONIZATION RISK

- 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 η).
- 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 trader think the same way.
  $\Rightarrow$ 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 τ periods after receiving his signal.
  $\Rightarrow$ Traders leave the market sequentially

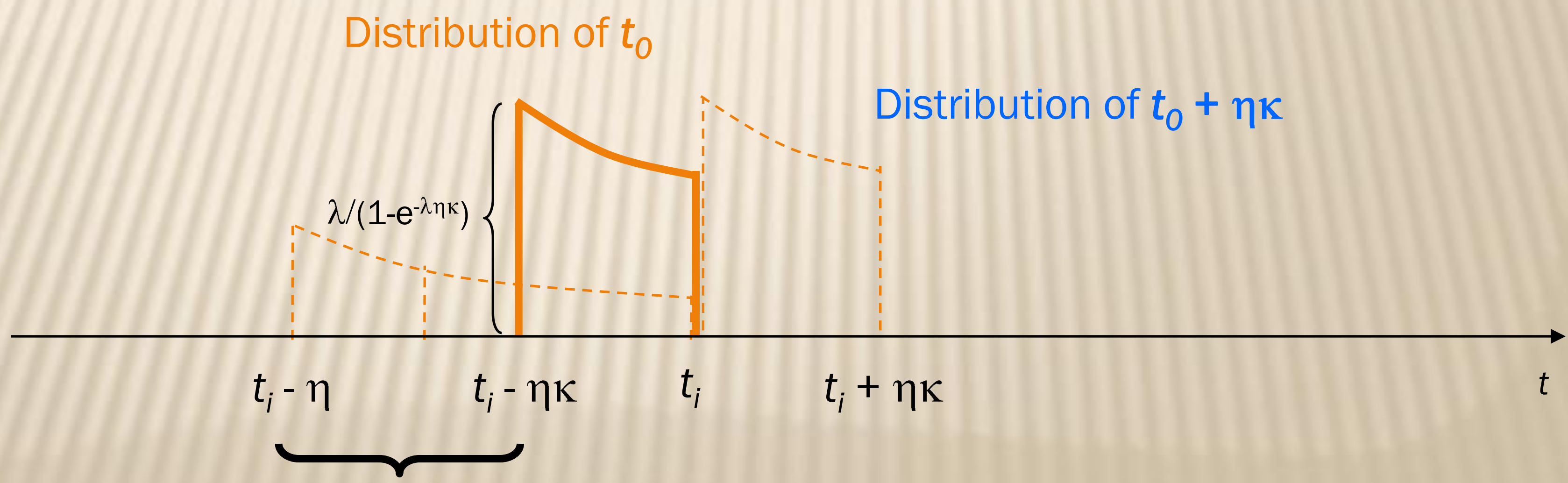
SEQUENTIAL AWARENESS



CONJECTURE 1: IMMEDIATE ATTACK

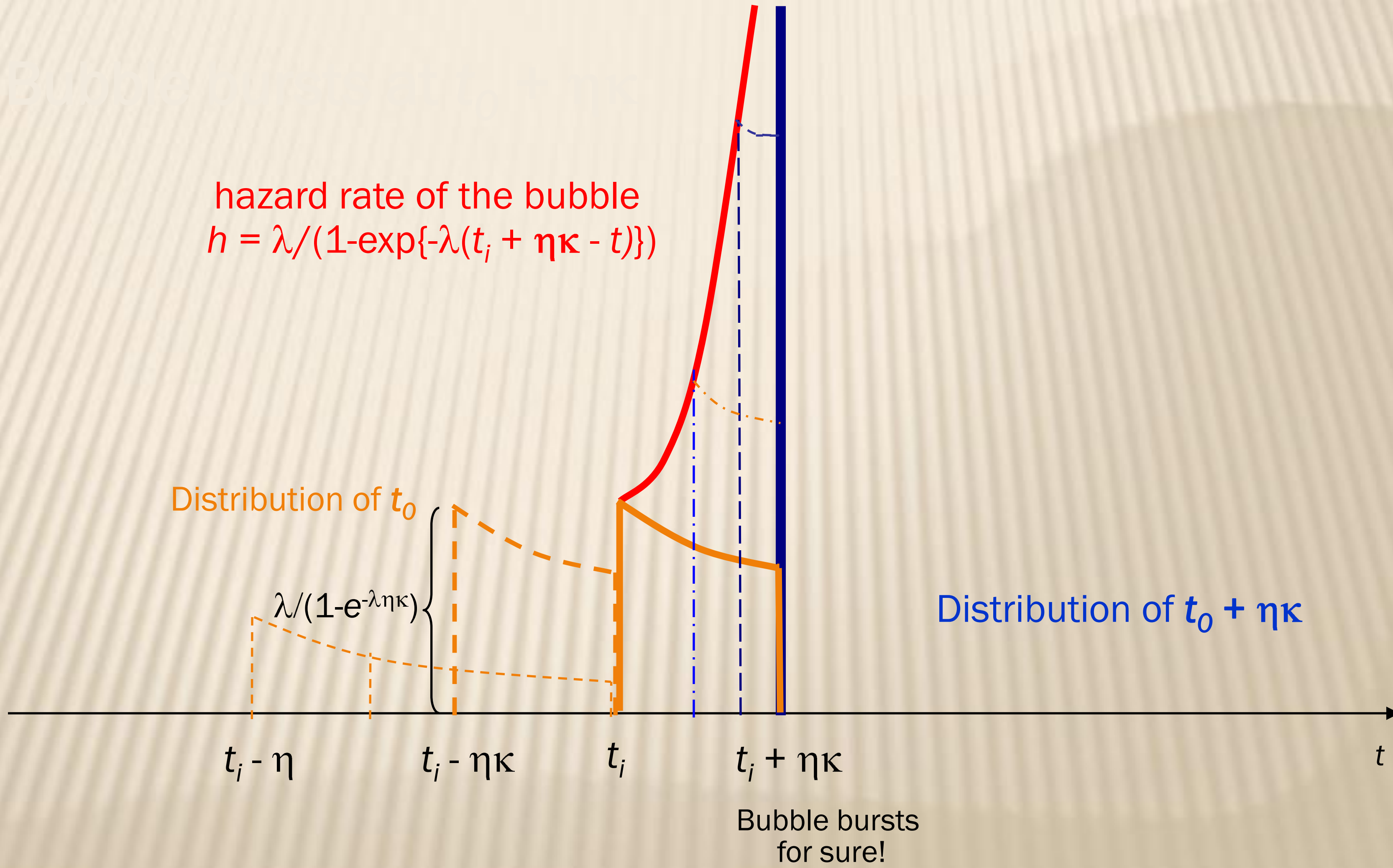
bursts at $t_0 + \eta\kappa$

when κ traders are aware of the bubble



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

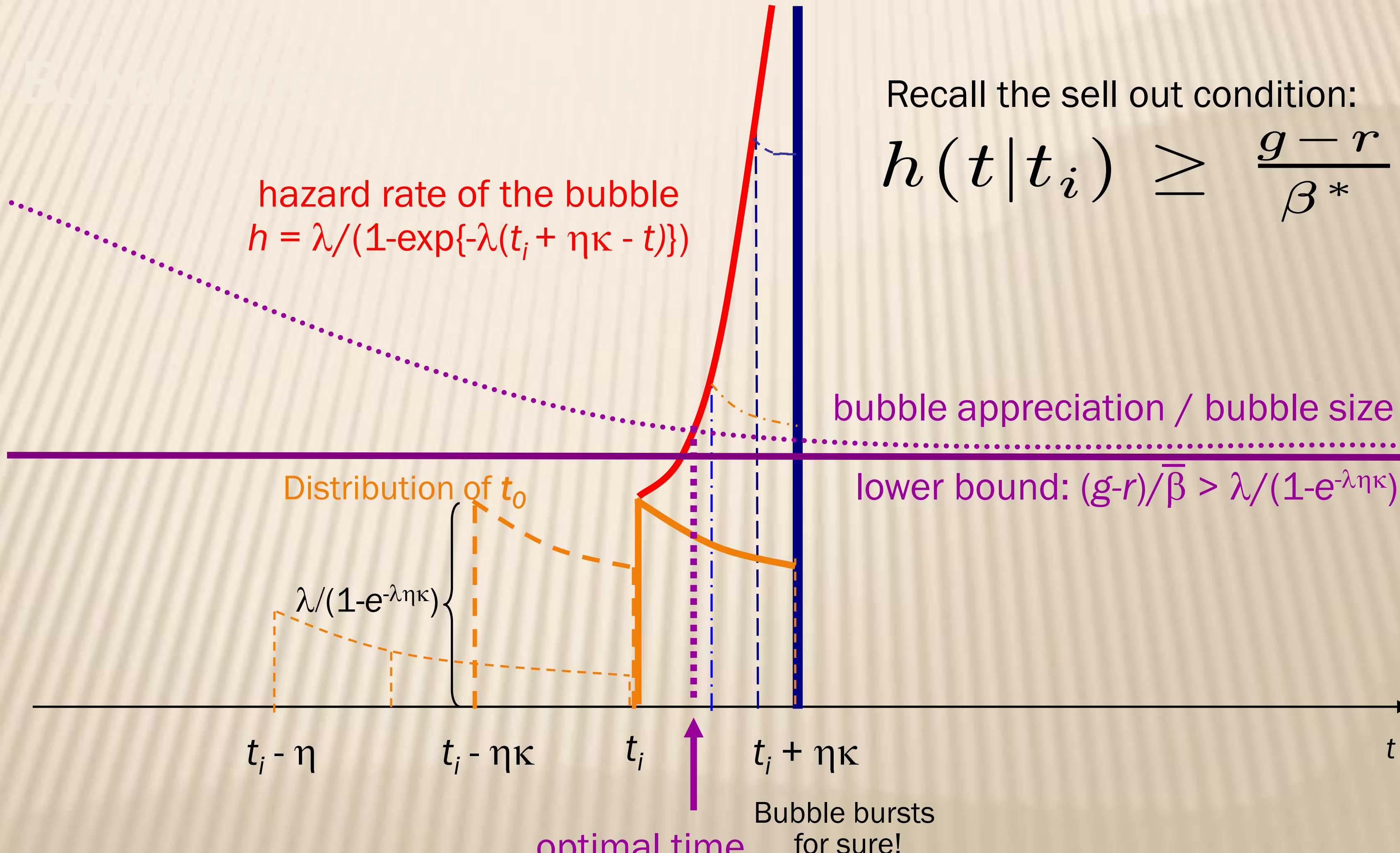
CONJ. 1 (CTD.): IMMEDIATE ATTACK



CONJ. 1 (CTD.): IMMEDIATE ATTACK

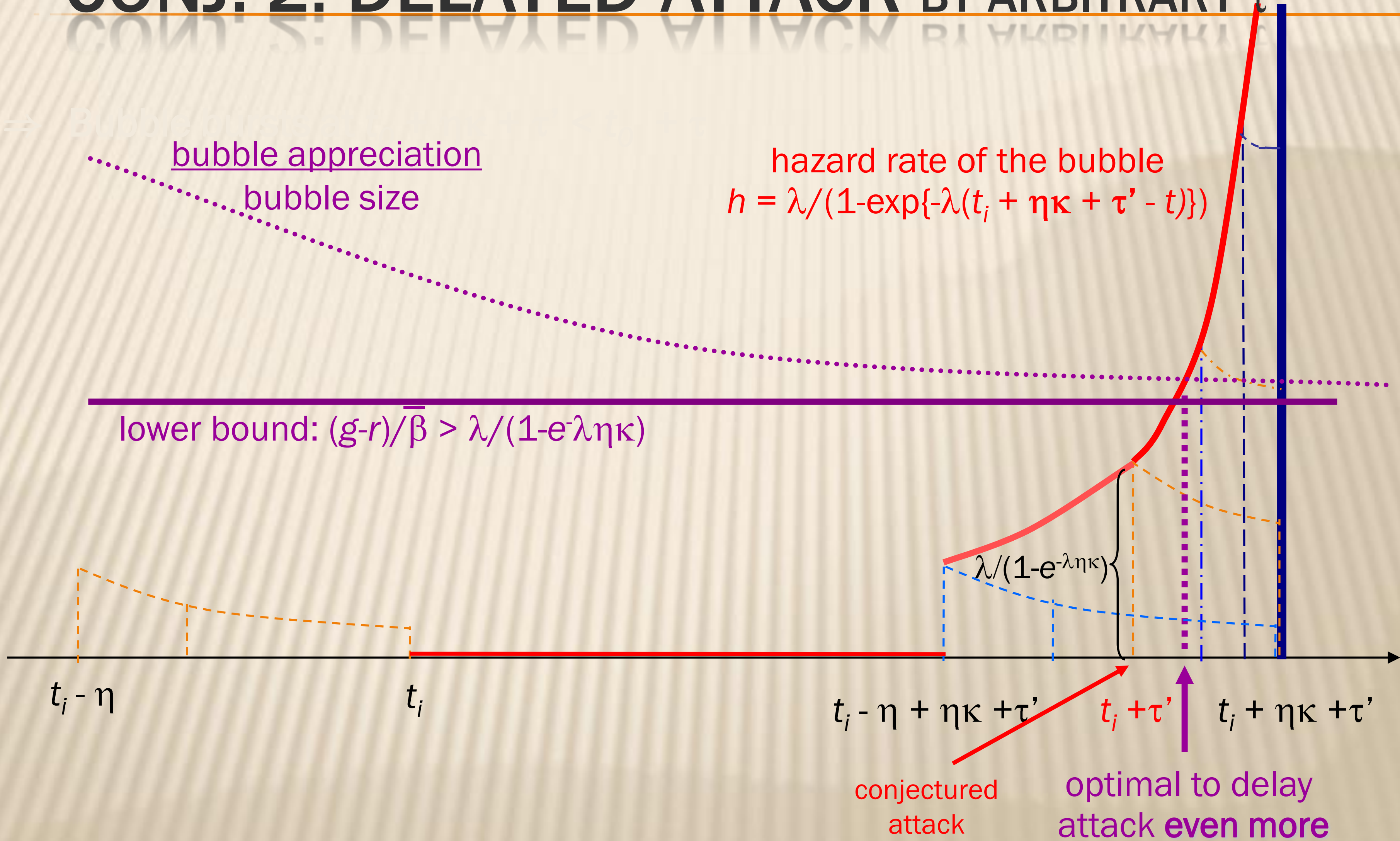
Recall the sell out condition:

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



⇒ "delayed attack is optimal"
no "immediate attack" equilibrium!

Conj. 2: Delayed Attack by arbitrary τ'



⇒ attack is never successful

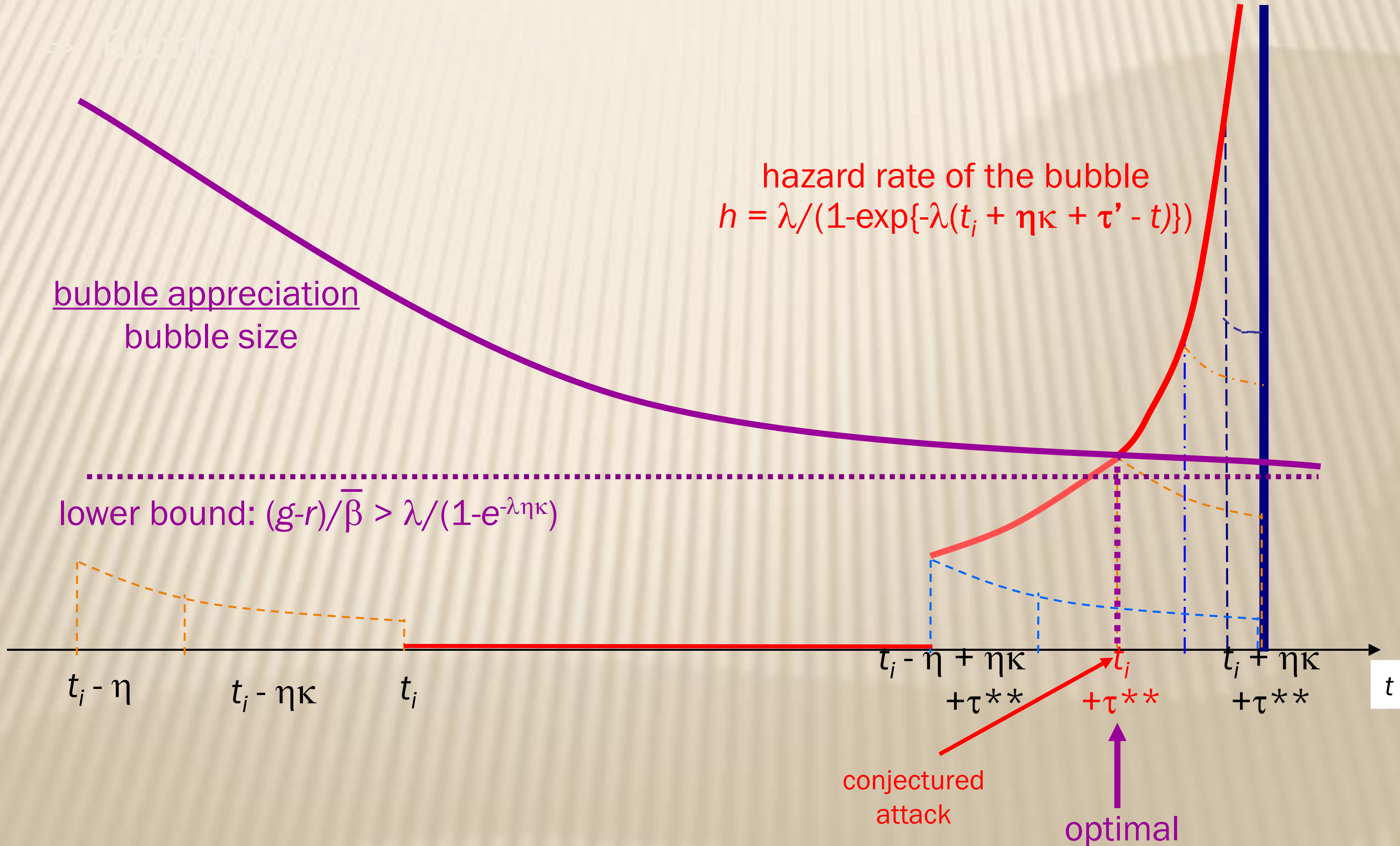
⇒ bubble bursts for exogenous reasons at $t_0 + \tau$

ENDOGENOUS CRASHES

- **Proposition 3:** Suppose $\frac{\lambda}{1-e^{-\lambda\eta\kappa}} > \frac{g-r}{\bar{\beta}}$.
  - **'unique'** trading equilibrium.
  - traders begin attacking after a delay of tau* periods.
  - bubble ***bursts*** due to endogenous selling pressure at a size of p_t times

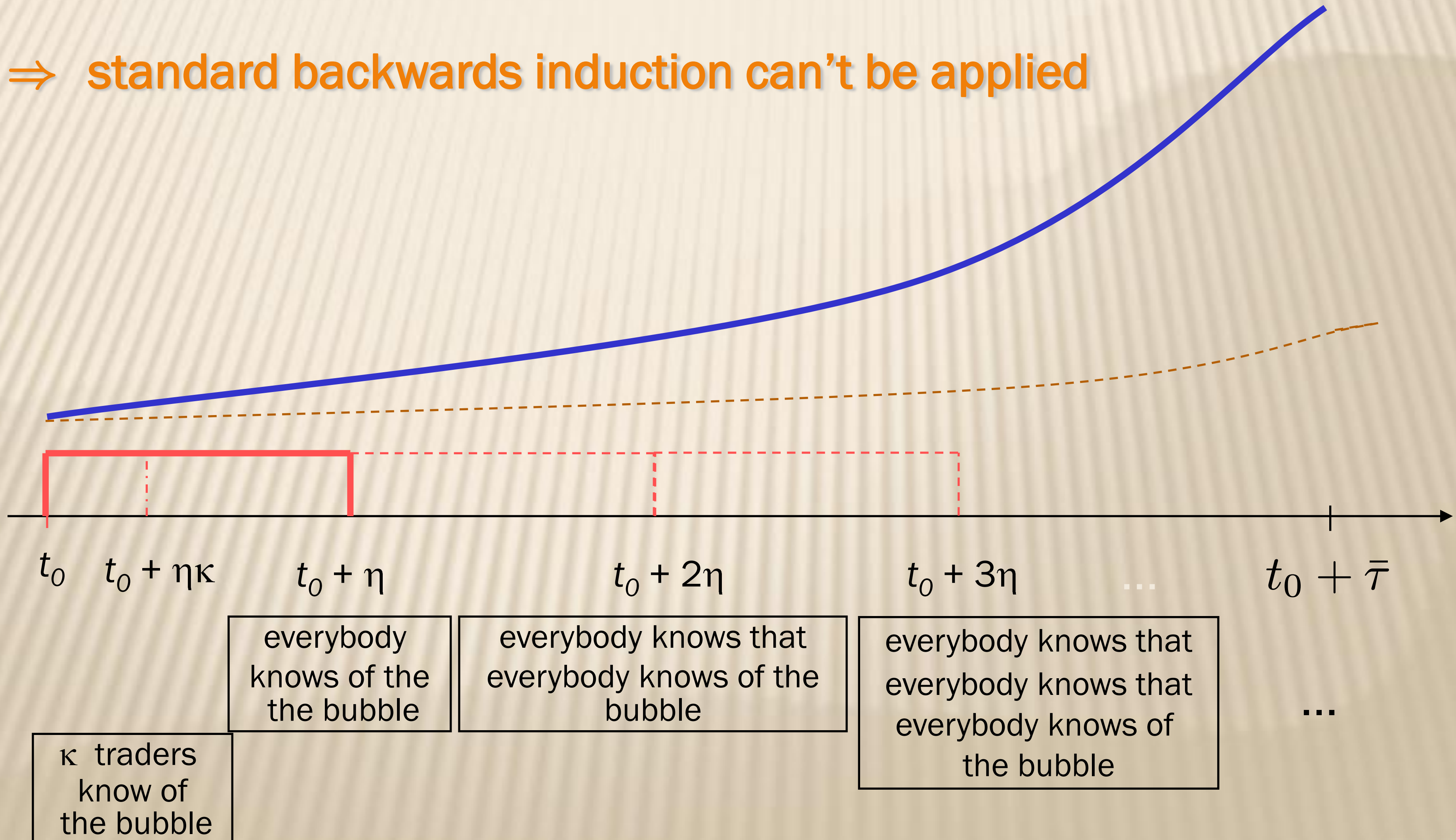
$$\beta^* = \frac{1-e^{-\lambda\eta\kappa}}{\lambda}(g-r)$$

ENDOGENOUS CRASHES



LACK OF COMMON KNOWLEDGE

$\Rightarrow$ standard backwards induction can't be applied



(same reasoning applies for κ traders)

ROLE OF SYNCHRONIZING EVENTS

- 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.

"(UN)IMPORTANT" NEWS IN 03/2000

- *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"
  - Paul Samuelson in *Newsweek* (September 19, 1966): "The Stock Market Has Predicted Nine Out of the Last Five Recessions"

QUOTES

- 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.

WHY DO RATIONALS FAIL TO PREVENT BUBBLES?

1. Unawareness of Bubble

   $\Rightarrow$ 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

   $\Rightarrow$ Rational speculators may be *reluctant to go short* overpriced stocks.

3. Predictable Investor Sentiment
   1. AB (2003), DSSW (JF 1990)

   $\Rightarrow$ 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)

DID HEDGE FUNDS RIDE THE BUBBLE?

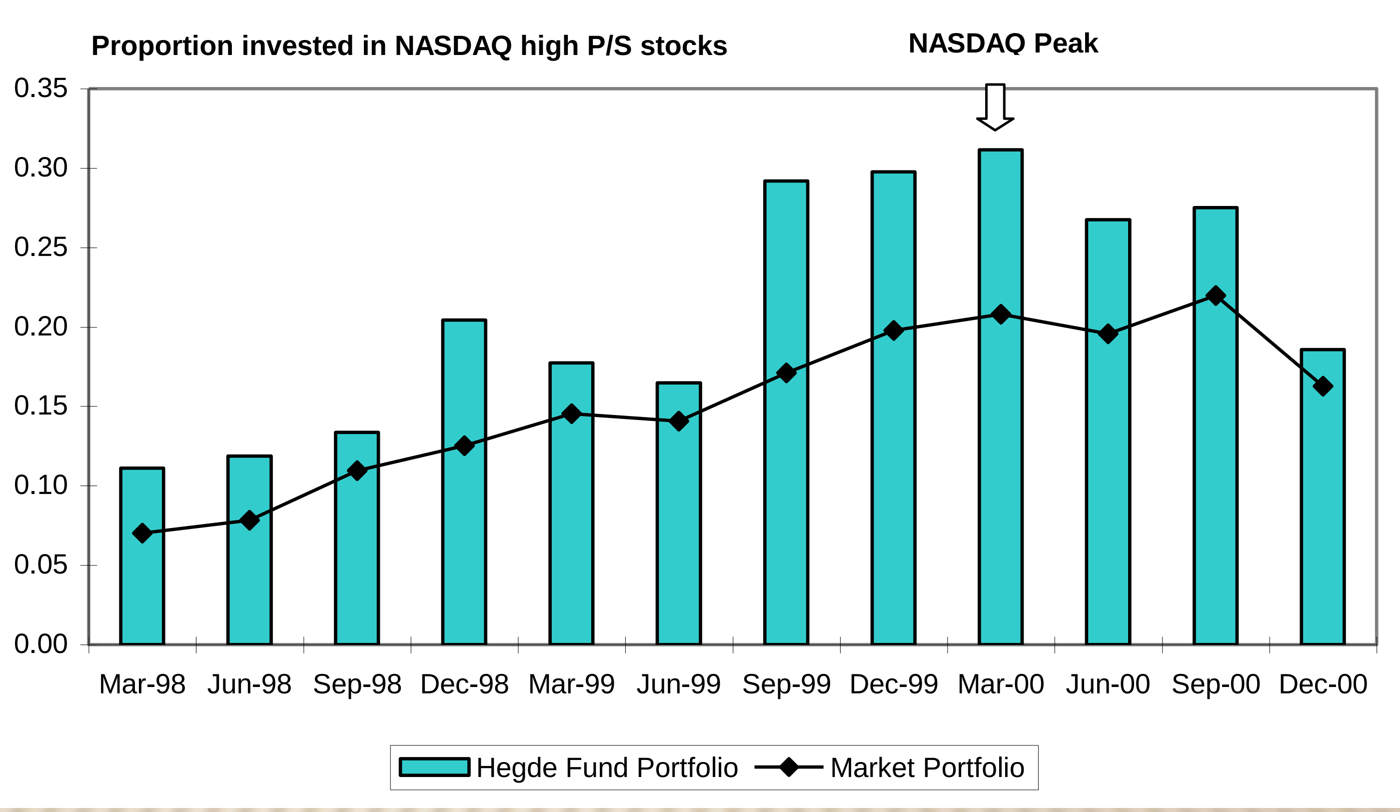


Fig. 2: Weight of NASDAQ technology stocks (high P/S) in aggregate hedge fund portfolio versus weight in market portfolio.

DID SOROS ETC. RIDE THE BUBBLE?

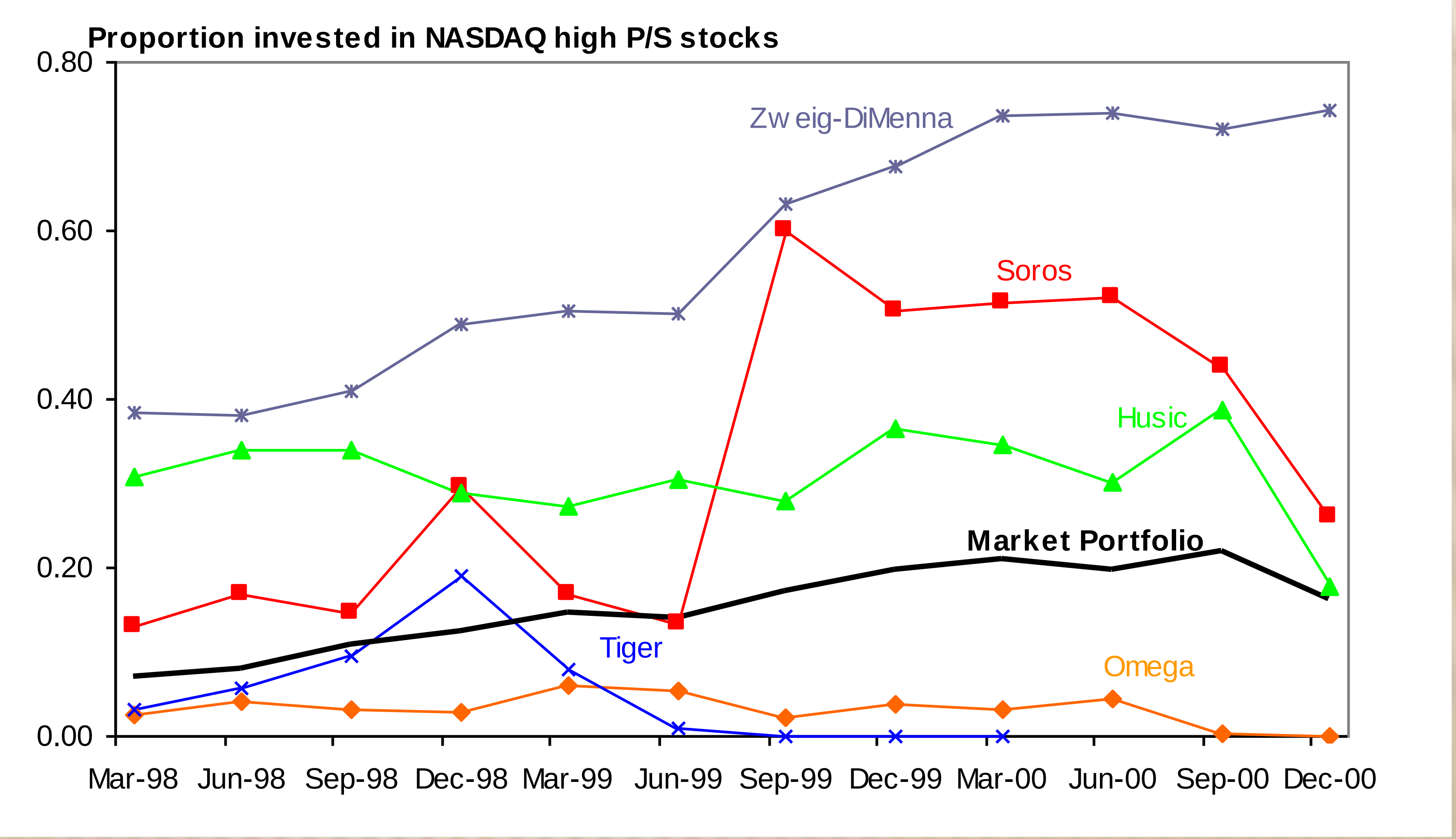
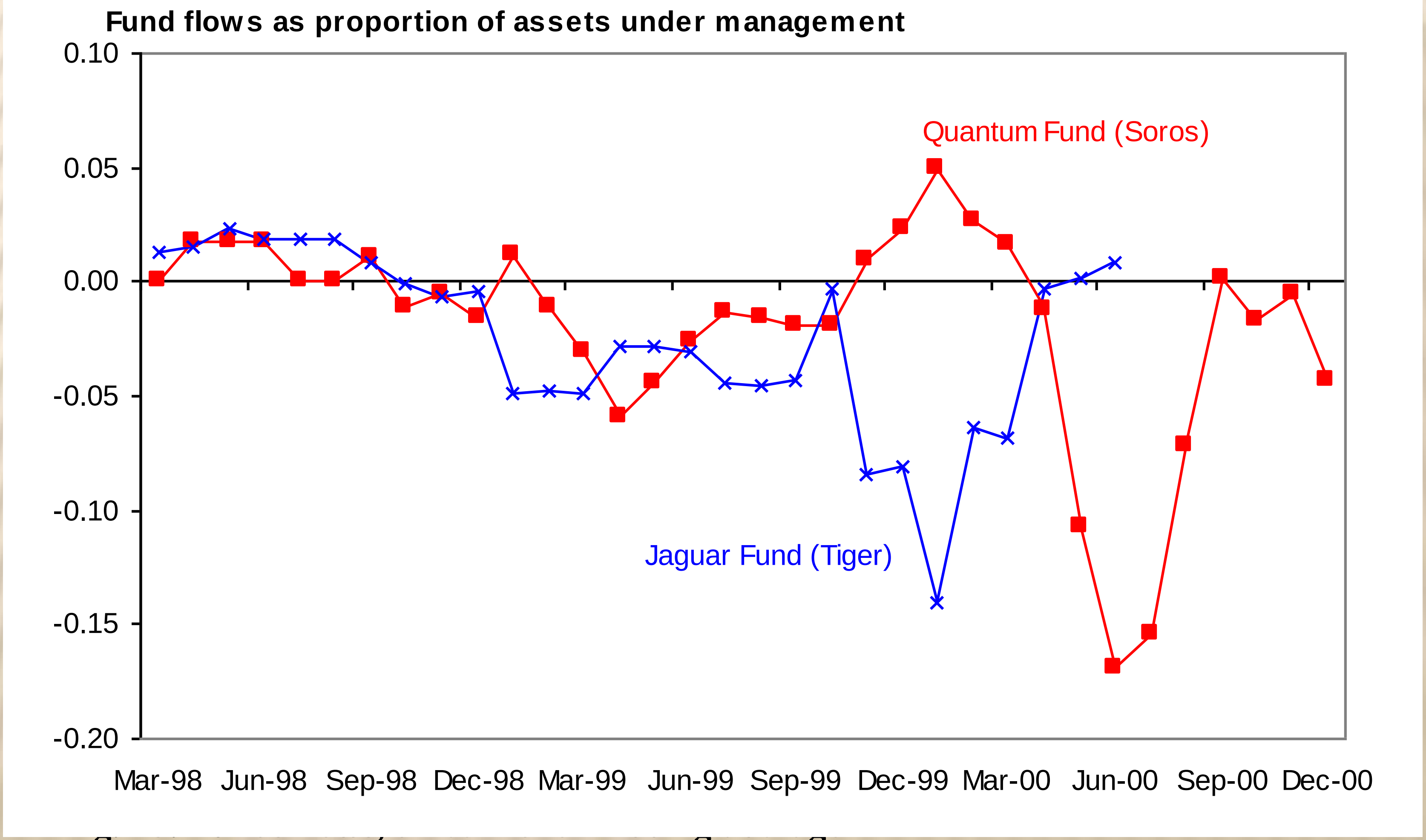


Fig. 4a: Weight of technology stocks in hedge fund portfolios versus weight in market portfolio

FUND IN- AND OUTFLOWS



DID HEDGE FUNDS TIME STOCKS?

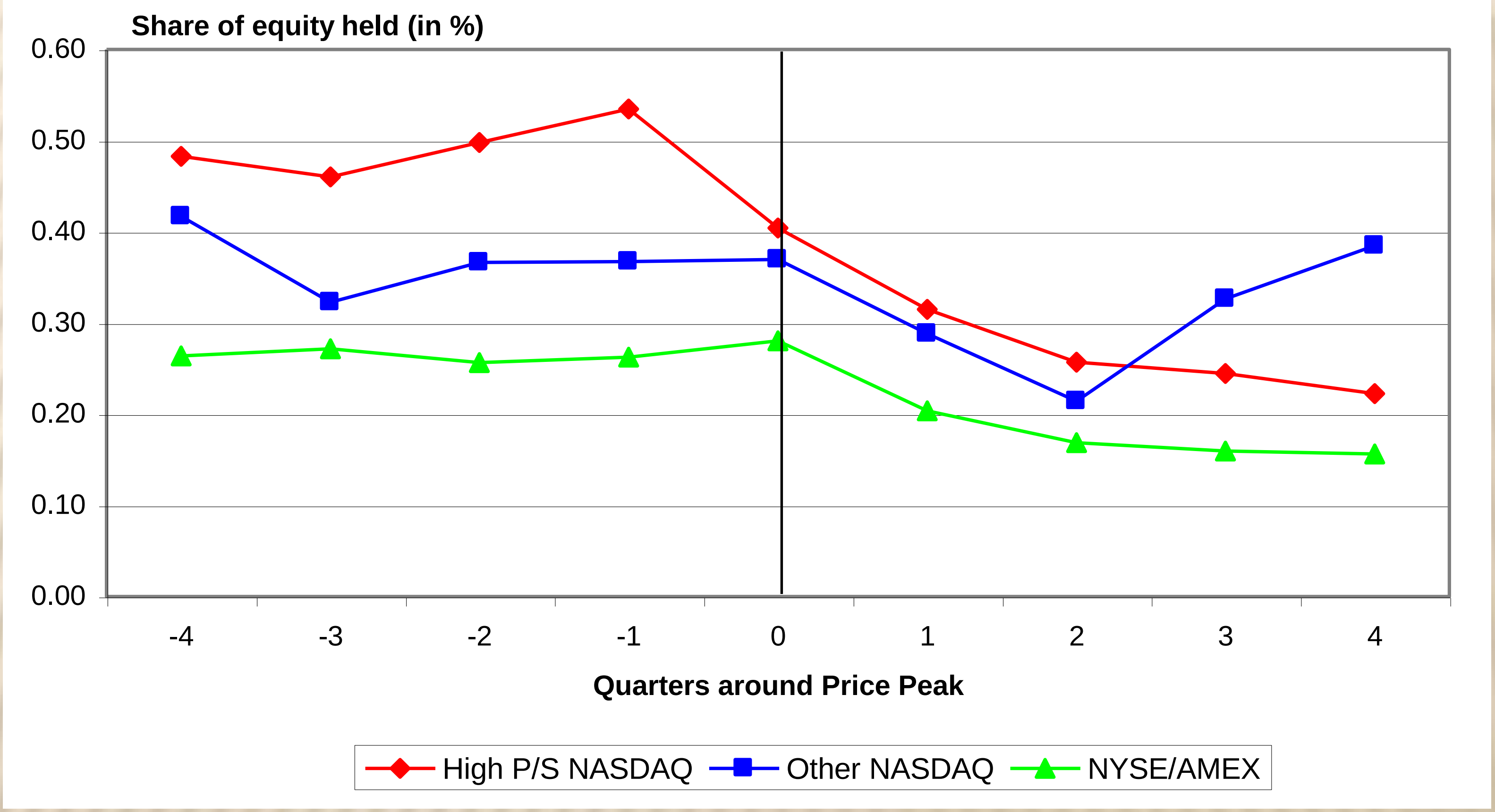


Figure 5. Average share of outstanding equity held by hedge funds around price peaks of individual stocks

DID HEDGE FUNDS' TIMING PAY OFF?

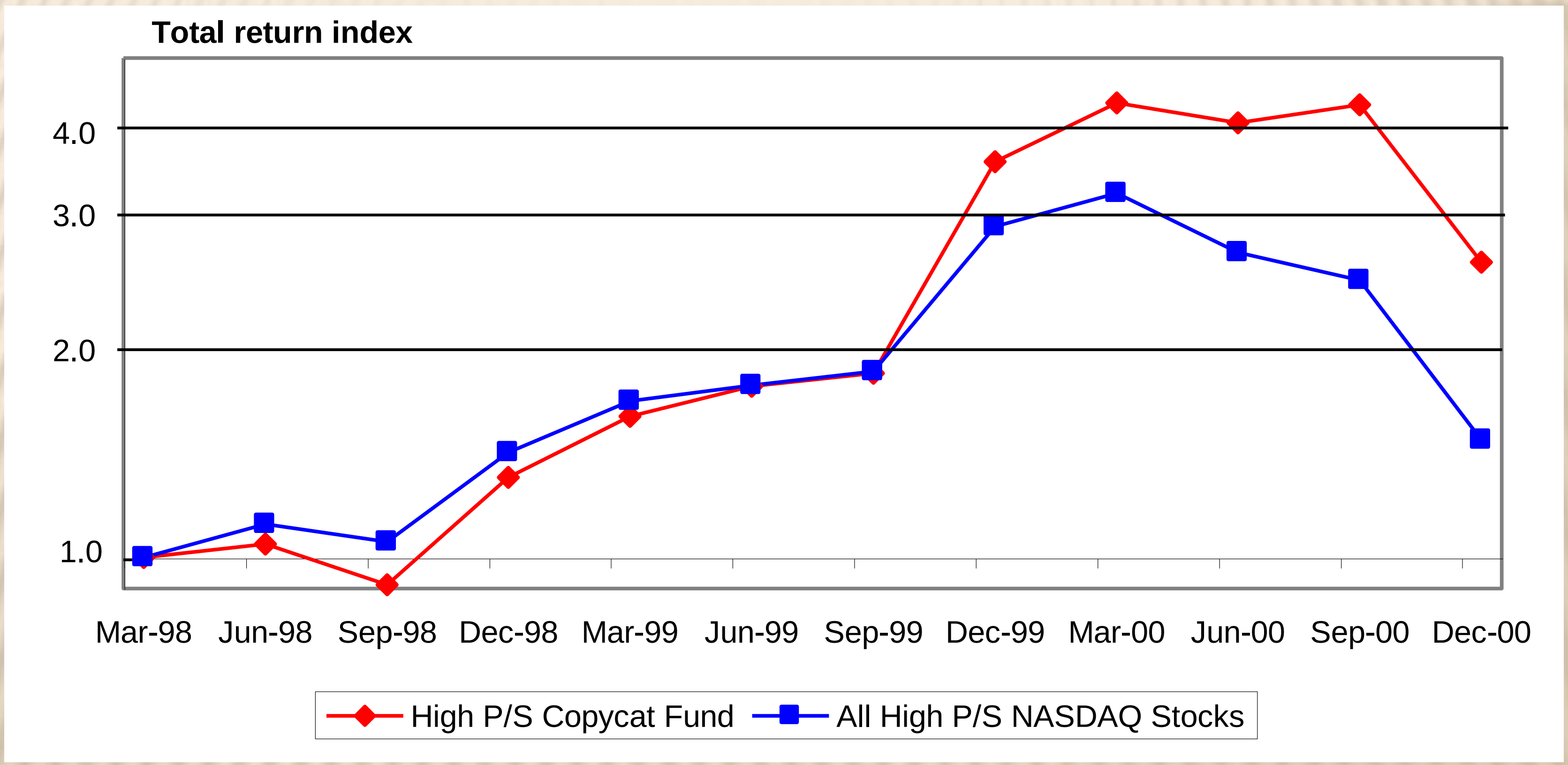


Figure 6: Performance of a copycat fund that replicates hedge fund holdings in the NASDAQ high P/S segment

SUM OF EMPIRICAL ANALYSIS

- 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.

$\Rightarrow$ 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

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

- Securities with
  - finite maturity T, $p_T=0$
  - Infinite maturity $T \rightarrow \infty$, -- many solutions
    first part = v_ t = fundamental – second part assumed

$$\lim_{T\rightarrow\infty} E_t[\frac{1}{(1+r)^T} p_T] = 0$$

RATIONAL BUBBLES (CTD.)

- Many solutions satisfy difference equation

  $$p_t = v_t + b_t$$

  as long as

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

- Blanchard-Watson example: bubble persists each period with probably π and bursts otherwise
  - Bubble has to grow at by a factor $(1+r)/\pi$
- Explosive path necessary!
- Bubbles cannot emerge

HERDING 101

- 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 ½
- 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
  $\alpha, \alpha, \beta, \beta, \beta, \beta, \beta, \beta, \beta, \ldots$
- Rational agents would invest in
  A, A, A, A, A, A, A, A,…
  - First agent follows his signal
  - Second agent infers that first agent got signal α
    - Chooses A if he receives signal α
    - Is indifferent between A and B if he received signal β
      (suppose he follows his own signal β in this case)
  - Third agent infers first agents' signal and thinks that it is more that second agent got α signal
    this dominates his single signal β. 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 $\Rightarrow$ herding
    - Market maker learns at same speed as other informed traders $\Rightarrow$ positive information externality (learn from predecessors' action) is exactly offset by negative payoff externality (price moves against me) $\Rightarrow$ No herding
    - Market maker learns at a slower speed $\Rightarrow$ some herding
      - introduce event uncertainty