Princeton Initiative: Bubbles

Markus Brunnermeier

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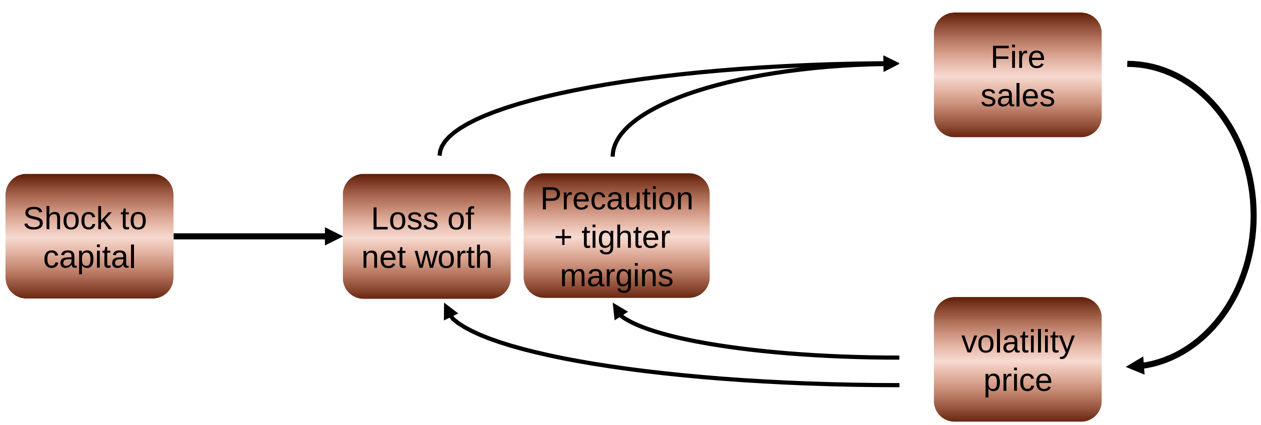
Systemic risk – a broad definition

- Systemic risk build-up during (credit) bubble
  ... and materializes in a crisis
  - "Volatility Paradox" → contemp. measures inappropriate
- Spillovers/contagion – externalities
  - Direct contractual: domino effect (interconnectedness)
  - Indirect: price effect (fire-sale externalities)
    credit crunch, liquidity spirals



  - *Adverse GE response* ➡ amplification, persistence

preventive

crisis management

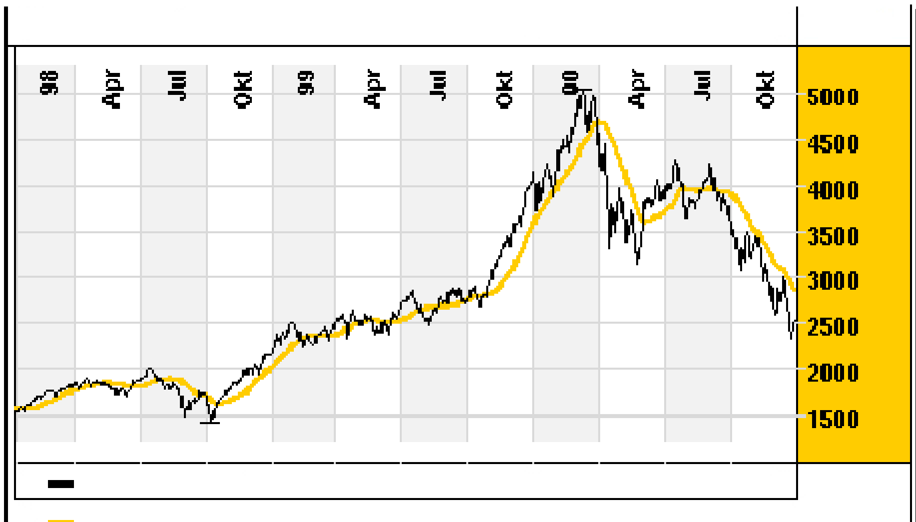
Brunnermeier

Bubbles and Crashes

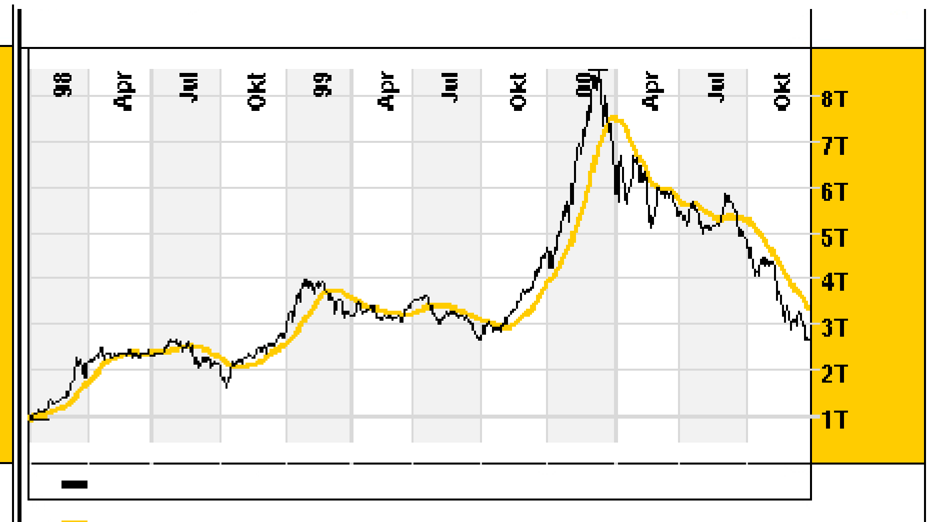
Dilip Abreu and Markus Brunnermeier

Princeton University

Internet bubble - 1990's



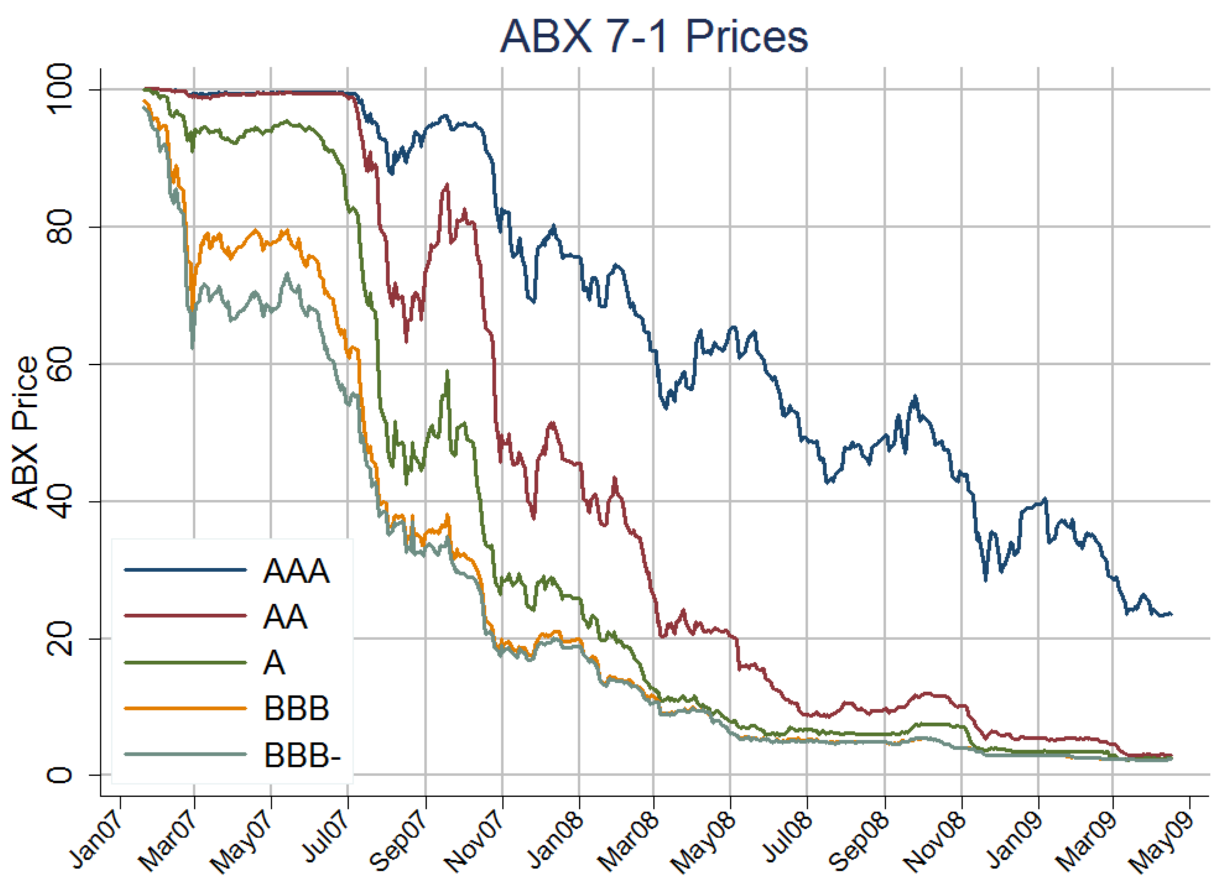
Loss of ca. **60 %**
from high of $ 5,132



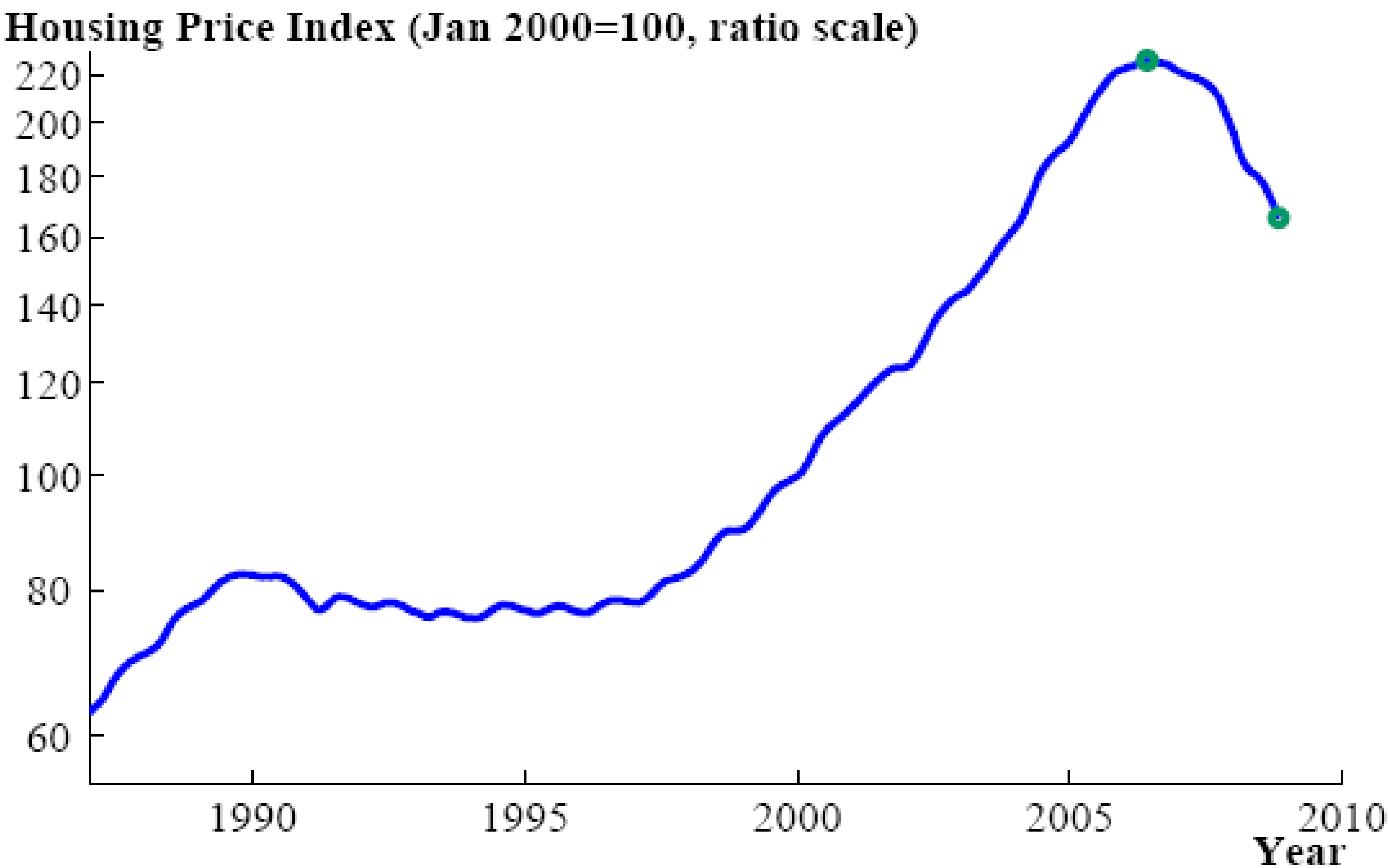
Loss of ca. **85 %**
from high of Euro 8,583

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

Credit bubble 2004-2006



US House price index – Case-Shiller



Do (rational) professionals ride the bubble?

- South Sea Bubble (1710-1720)
  - Issac Newton
    - 04/20/1720 sold shares at £ 7,000 profiting £3,500
    - Re-entered the market later – ending 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 he party would end so quickly.
    - "We thought it was the eighth inning, and it was the ninth."
  - Julian Robertson of Tiger Fund refused internet stocks.
- Housing bubble (2007)
  - Chuck Prince "Dance as long as the music is playing"

Stylized facts

- Initial innovation justifies some price increase
- Momentum leads to price overshooting
  - Extrapolative expectations
- Many market participants seem to be aware that the "price is too high" but keep on holding the asset
  - "Play as long as the music is playing"
- Resell-option is crucial for speculative bubbles
- Minksy moment – triggered by "trivial news"
- Credit bubbles lead to extra amplification effects in downturn (since they can impair financial sector)
  - subprime borrowing was only 4% of US mortgage market

Minsky moment – Wile E. Coyote Effect

Overview of Bubble Literature

- Rational bubbles
  - Difference equation $b_t = E_t^Q[\frac{1}{1+r} b_{t+1}]$
  - No zero-sum argument
- OLG and incompleteness frictions (morning lecture)
  - Samuelson, Triole,… Bewley, …Noise trader risk (DSSW)
- Informational frictions
  - Synchronization Risk (Abreu & Brunnermeier 2003)
- Delegated investment friction
  - Allen & Gorton 1993, Allen & Gale 2000, Shleifer & Vishny 1997
- Heterogeneous beliefs bubbles
  - Harrison & Kreps 1978, Scheinkman & Xiong, Hong & Stein

On Market Efficiency

- Keynes (1936) $\Rightarrow$ 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 $\Rightarrow$ no bubble emerges
  - "If there are many sophisticated traders in the market, they may cause these "bubbles" to burst before they really get under way."

Limits to Arbitrage

- Fundamental risk (Campell & Kyle 1993)
  - Risk that fundamental overturns mispricing
- Noise trader risk (DSSW)
  - Risk that irrational traders drive price even further from fundamentals
- Synchronization risk
  - One trader alone cannot correct mispricing (can sustain a trade only for a limited time)
  - Risk that other rational traders do not act against mispricing (in sufficiently close time)
  - Relatively unimportant news can serve as synchronization device and trigger a large price correction

Timing Game - Synchronization

- (When) will behavioral traders be overwhelmed by rational arbitrageurs?
- *Collective* selling pressure of arbitrageurs *more than suffices* to burst the bubble.
- Rational arbitrageurs understand that an *eventual* collapse is inevitable.
  But when?
- Delicate, difficult, dangerous *TIMING GAME !*

Elements of the Timing Game

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

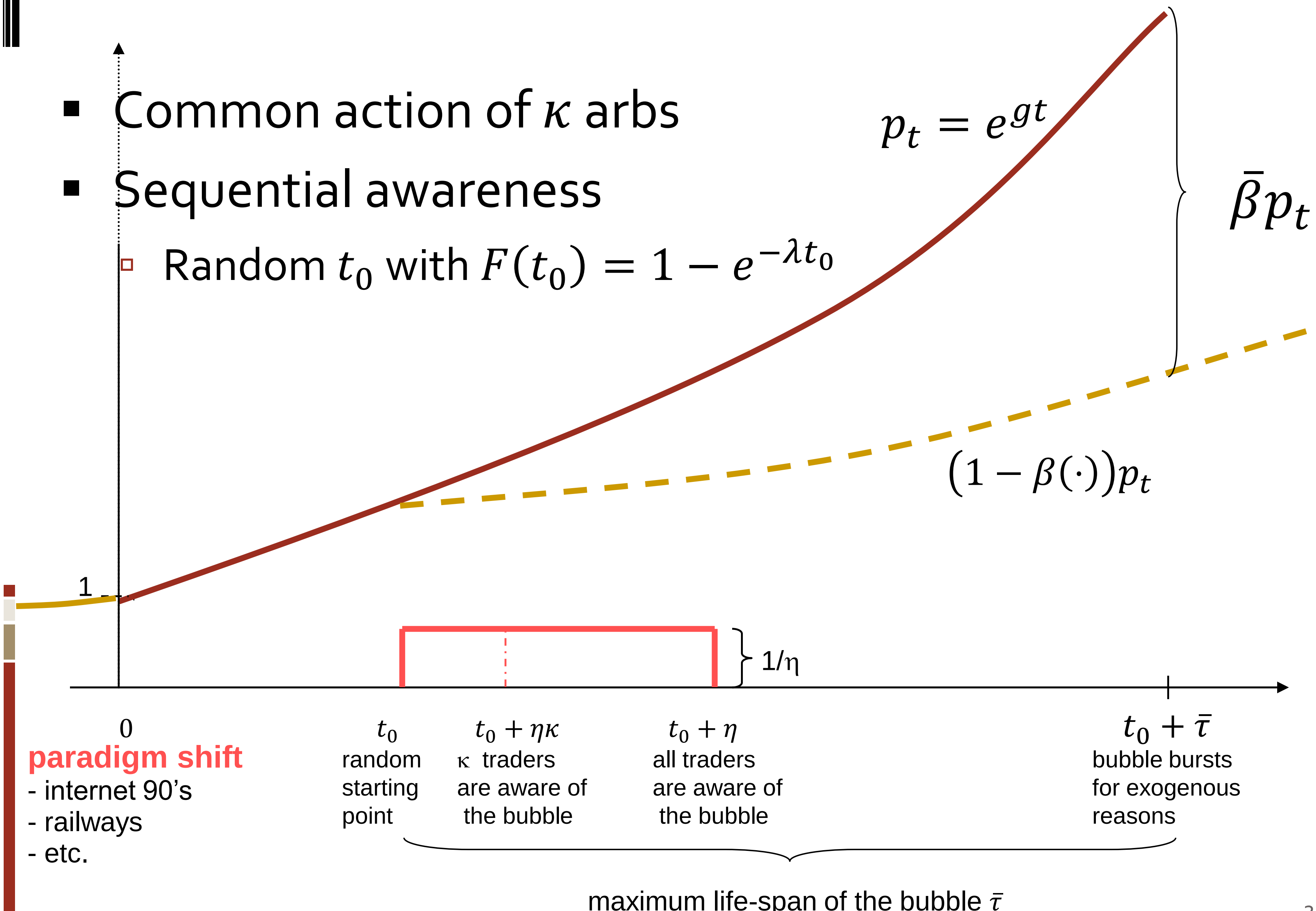
A *Synchronization Problem* arises!

- Absent of sequential awareness
  competitive element dominates $\Rightarrow$ and bubble burst immediately.
- With sequential awareness
  incentive to TIME THE MARKET $\Rightarrow$ "delayed arbitrage"
  $\Rightarrow$ persistence of bubble

Overview

- Introduction
- Model setup
- Preliminary analysis
- Persistence of bubbles
- Public events
- Price cascades and rebounds
- Empirical evidence & Hedge funds
  - Brunnermeier & Nagel (2004)

- Common action of κ arbs
- Sequential awareness
  - Random t_0 with $F(t_0) = 1 - e^{-\lambda t_0}$



Payoff structure

- Focus: “when does bubble burst”
- t_0 is only random variables, all other variables are CK
- Cash payoff (difference)
  - Sell one share at $t-\Delta$ instead of at t

$$p_{t-\Delta}e^{r\Delta}-p_t$$

where $p_t = \begin{cases} e^{gt} & \text{prior to crash} \\ \big(1-\beta(t-t_0)\big)e^{gt} & \text{after the crash} \end{cases}$

  - Price at the time of bursting (tie breaking rule)
    - Pre crash price for first random orders up to κ

Payoff structure, Trading

- Small transaction costs ce^{rt}
- Risk-neutrality but max/min stock position
  - Max long position
  - Max short position
  - Due to capital constraints, margin requirements etc.
- Definition 1: trading equilibrium
  - Perfect Bayesian Nash Equilibrium
  - Belief restriction: trader who attacks at time t believes that all traders who became aware of the bubble prior to her also attack at t.

Sell out condition for $\Delta \to 0$ periods

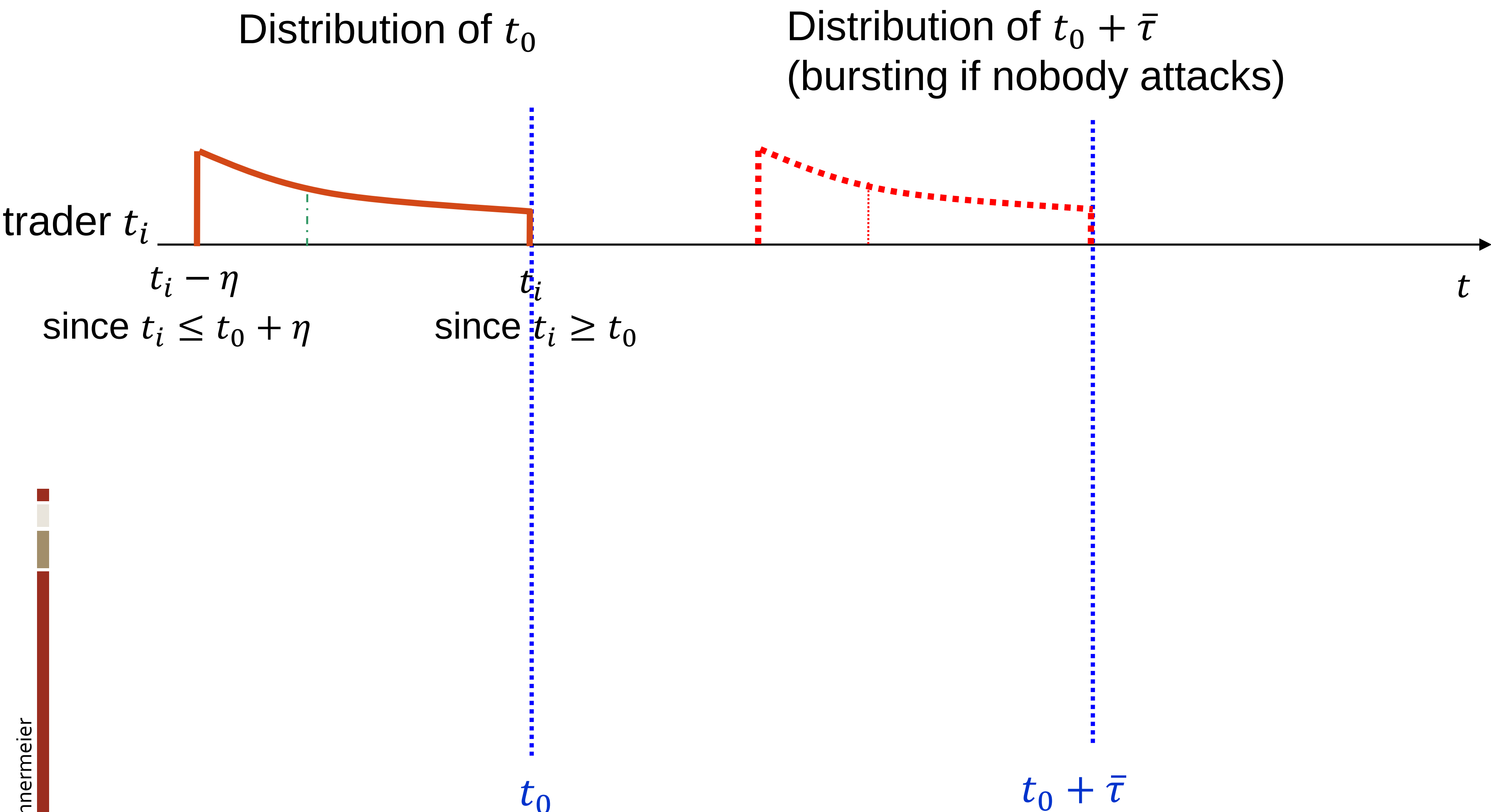
- Sell out at t
  if

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

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

- RHS $\to (g-r)$ as $t \to \infty$
  - Bursting date: $T^*(t_0) = \min\{T(t_0+\eta\kappa), t_0+\bar{\tau}\}$

Sequential awareness



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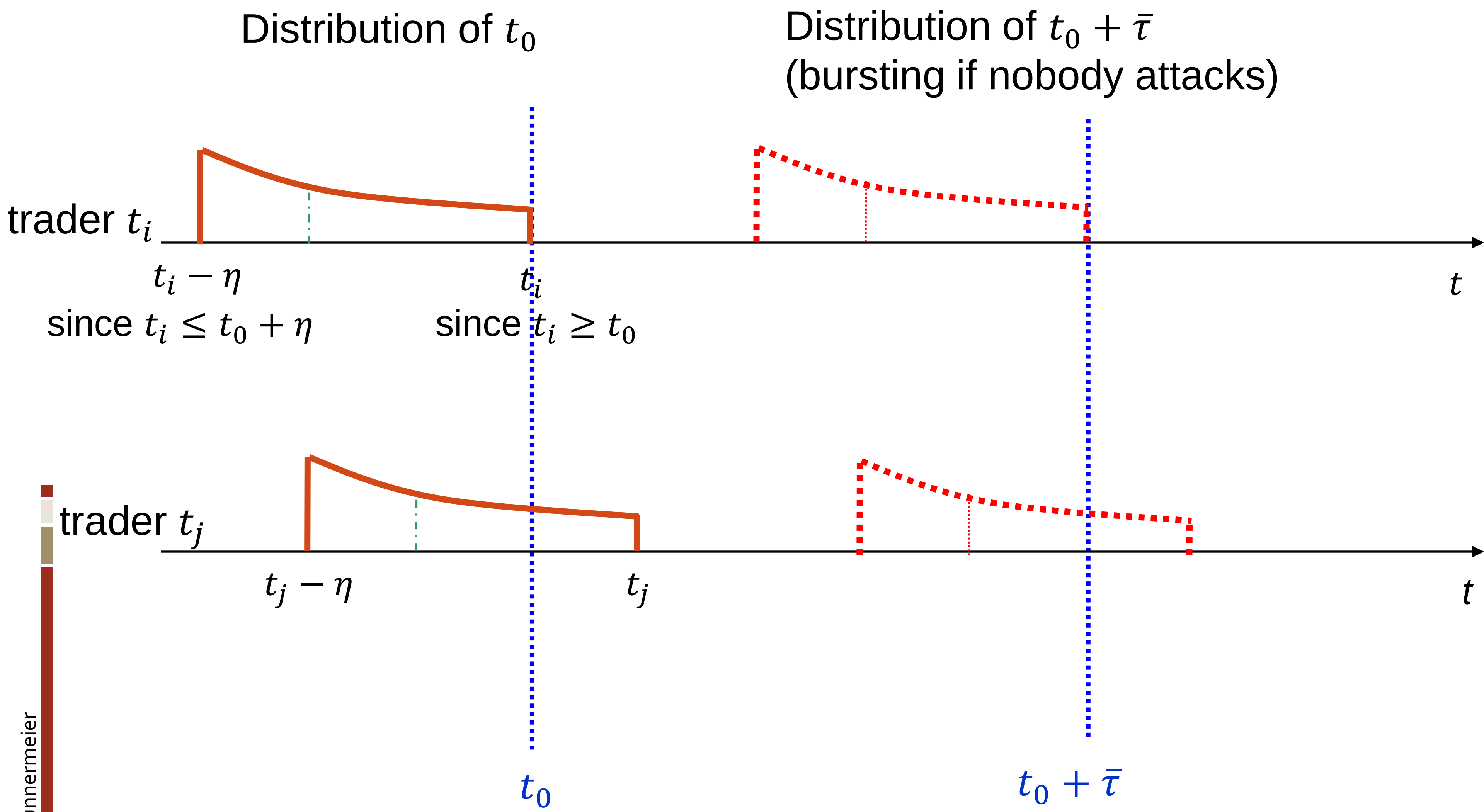

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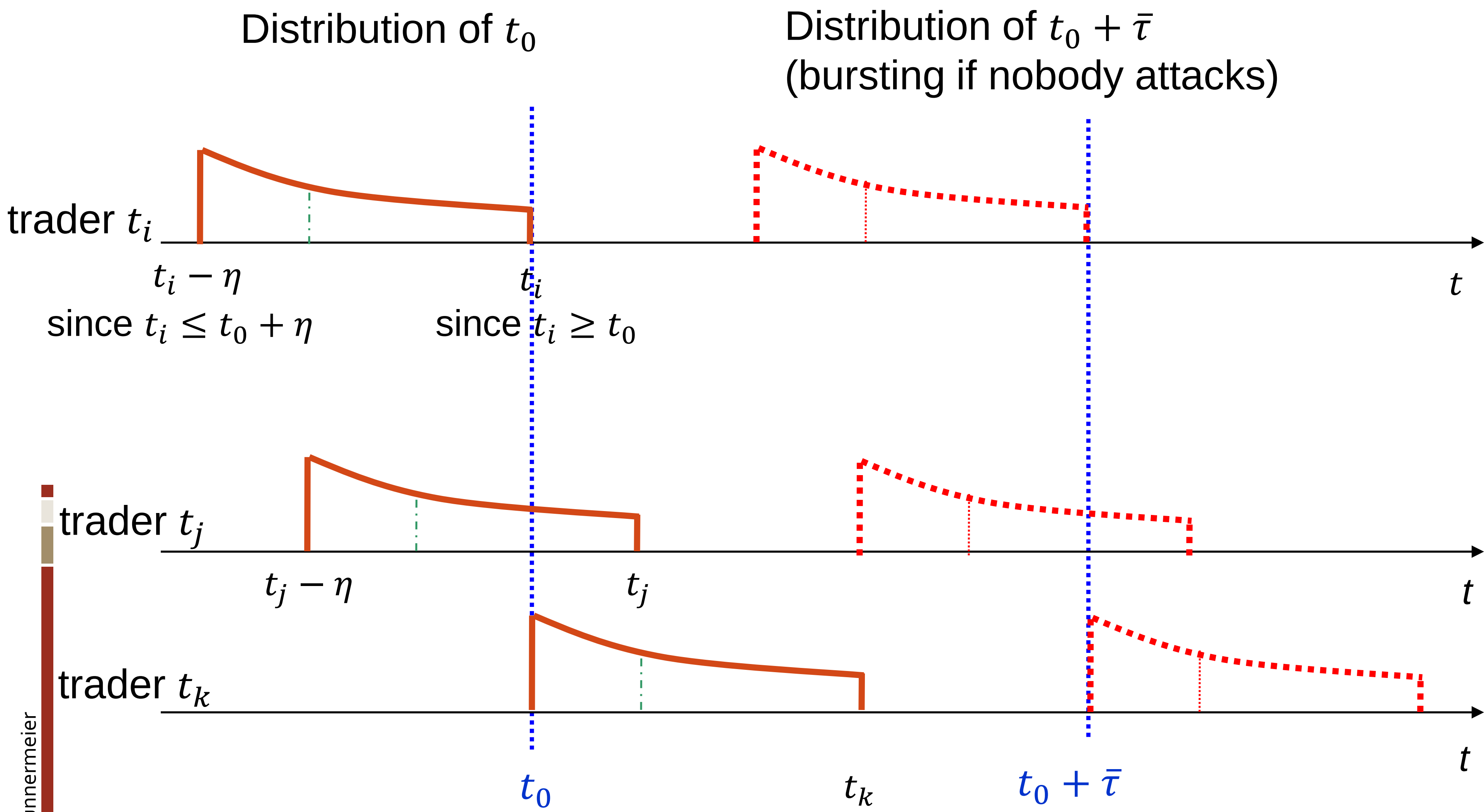
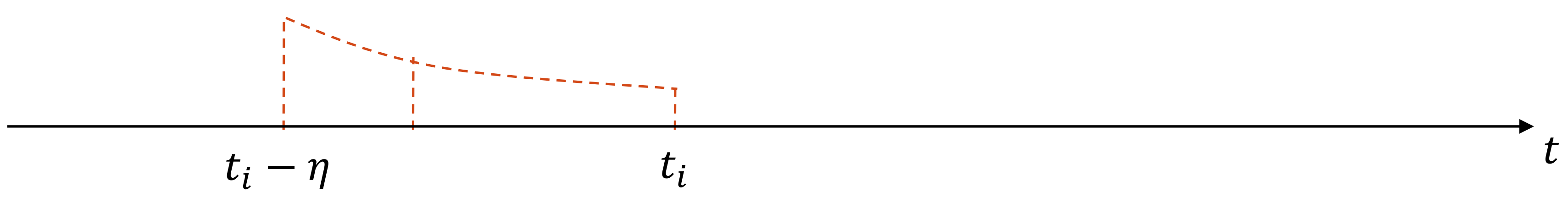


Conjecture 1: Immediate attack

⇒ Bubble bursts at $t_0 + \eta\kappa$

when κ traders are aware of the bubble



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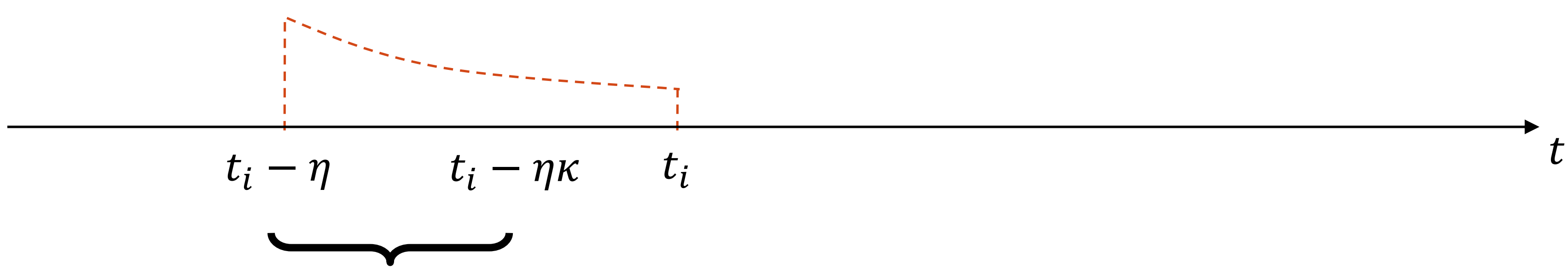

If $t_0 < t_i - \eta\kappa$, the bubble would have burst already.

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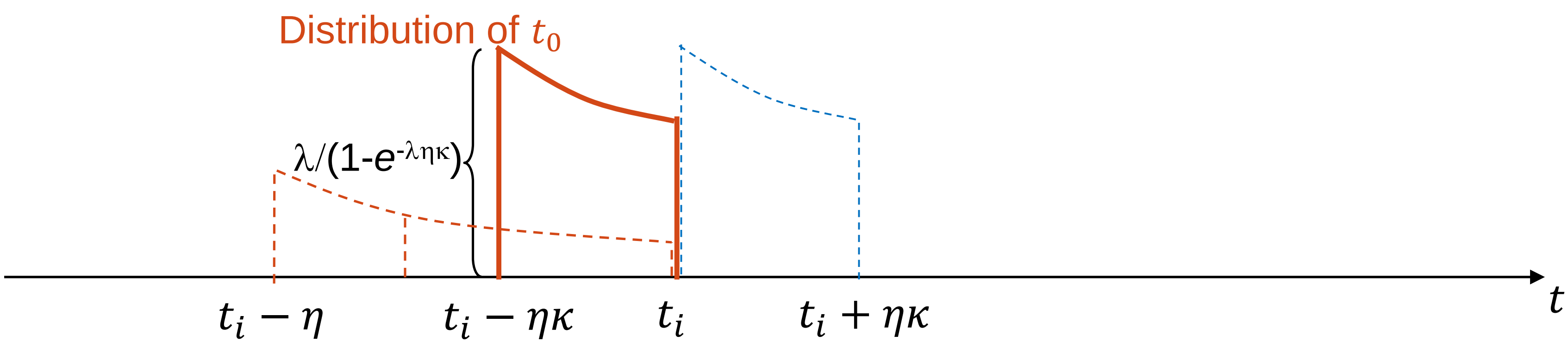

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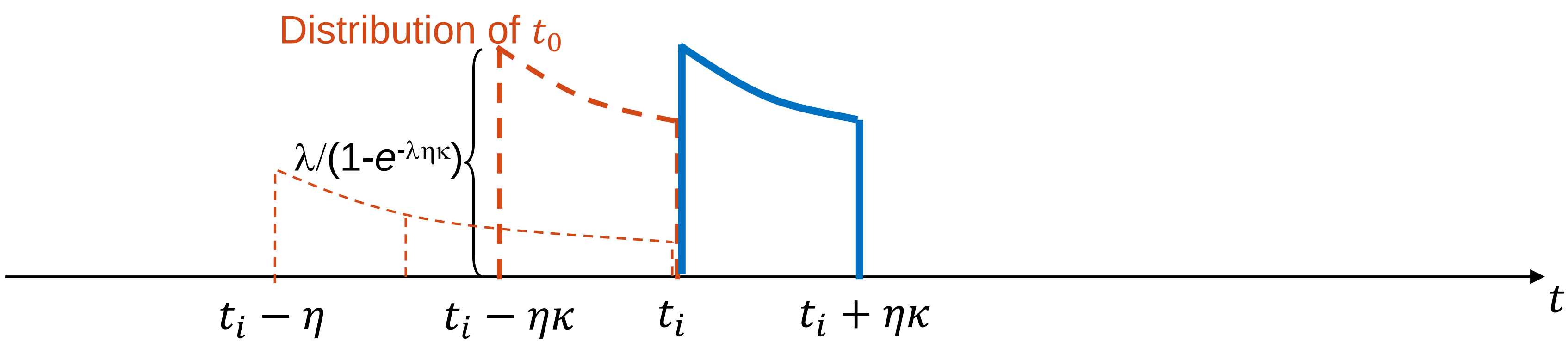

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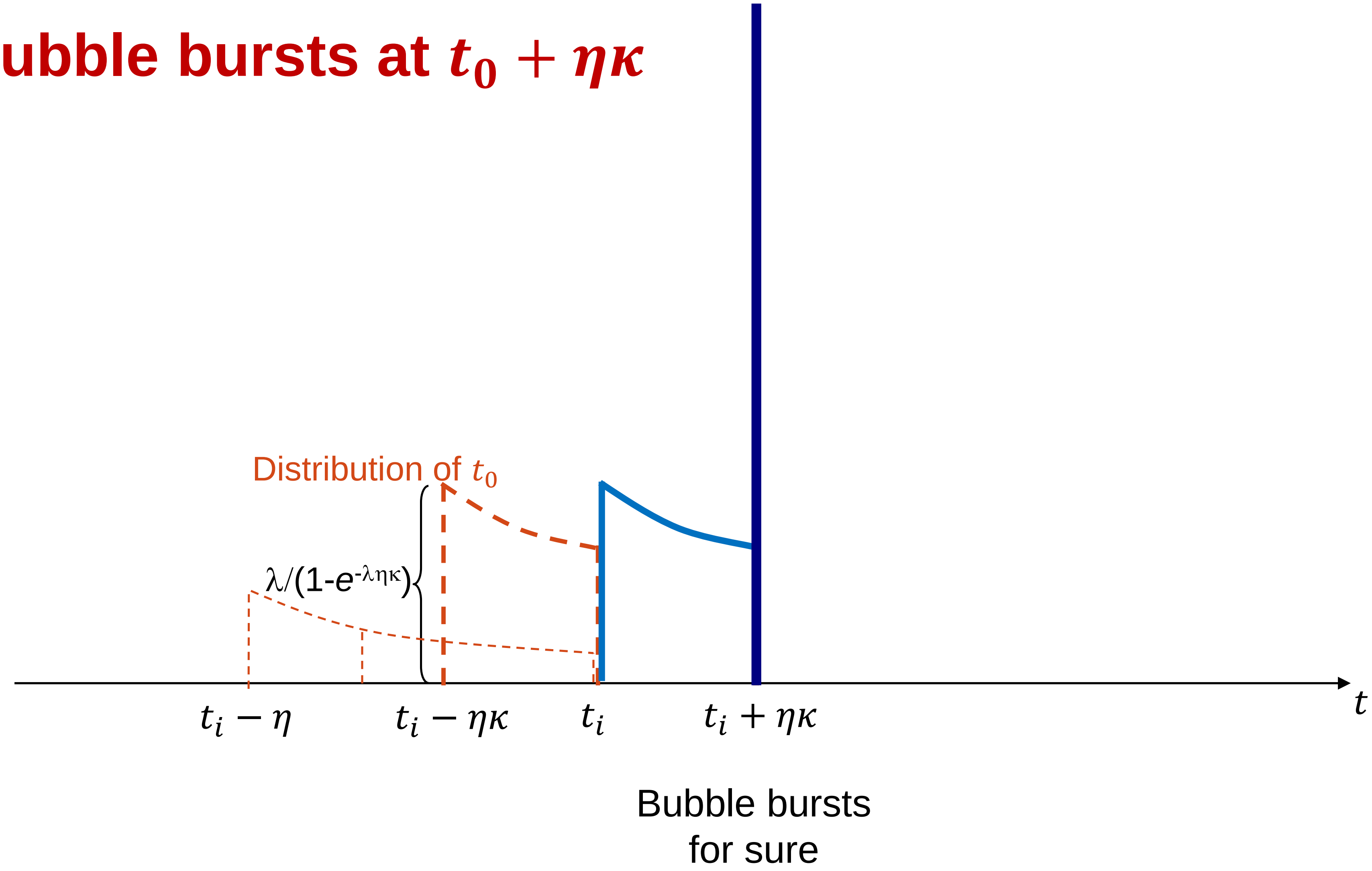

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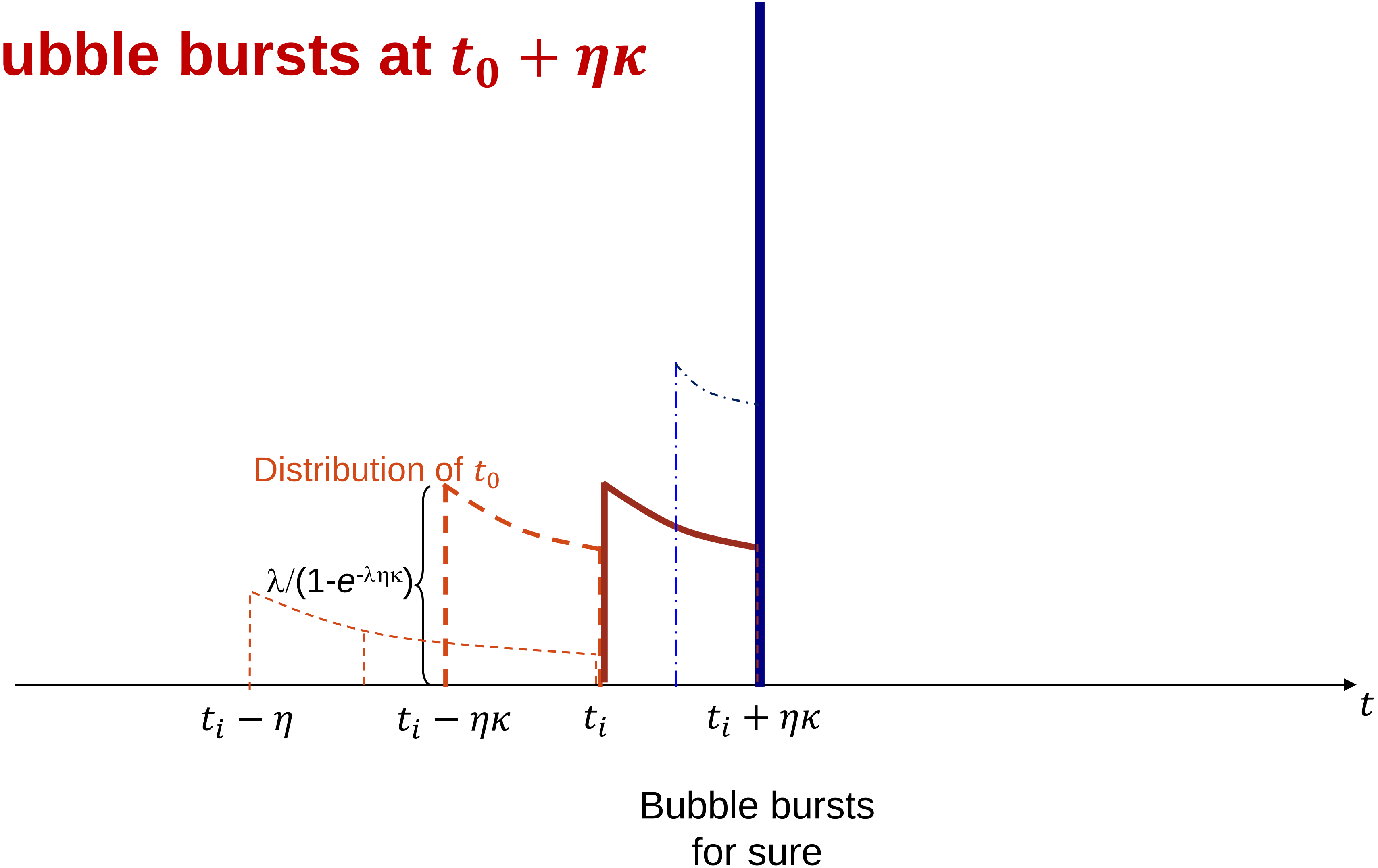

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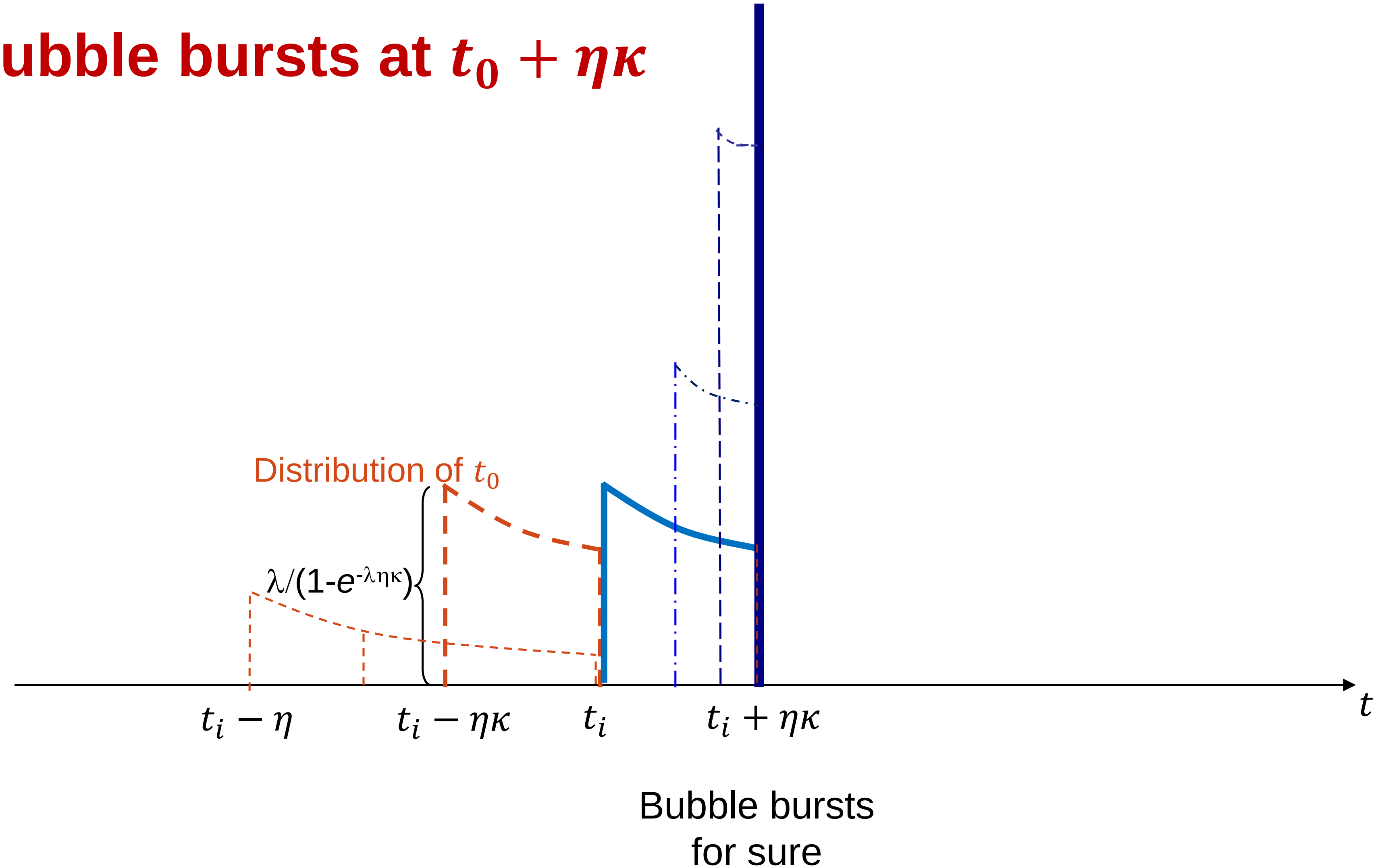

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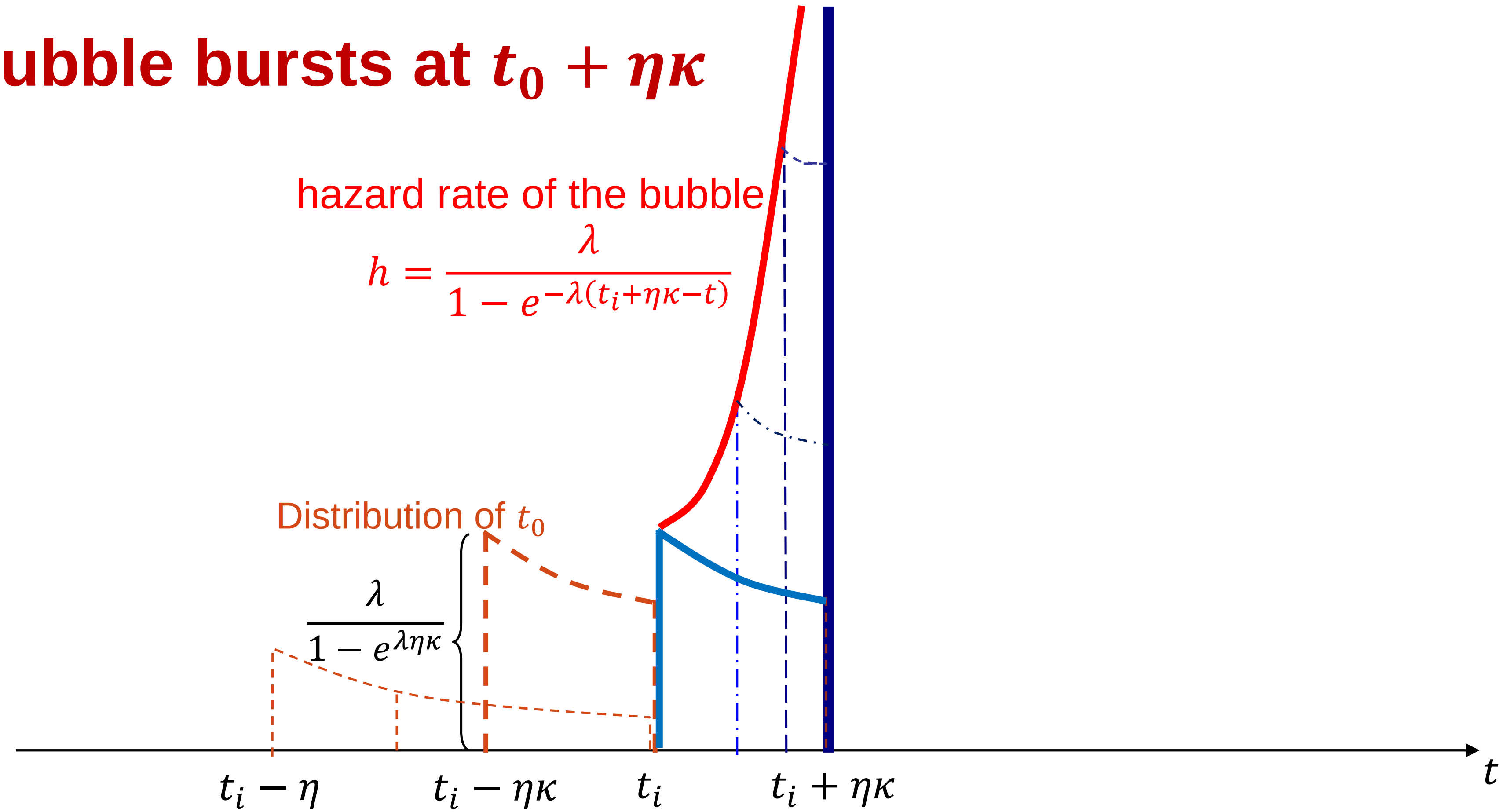
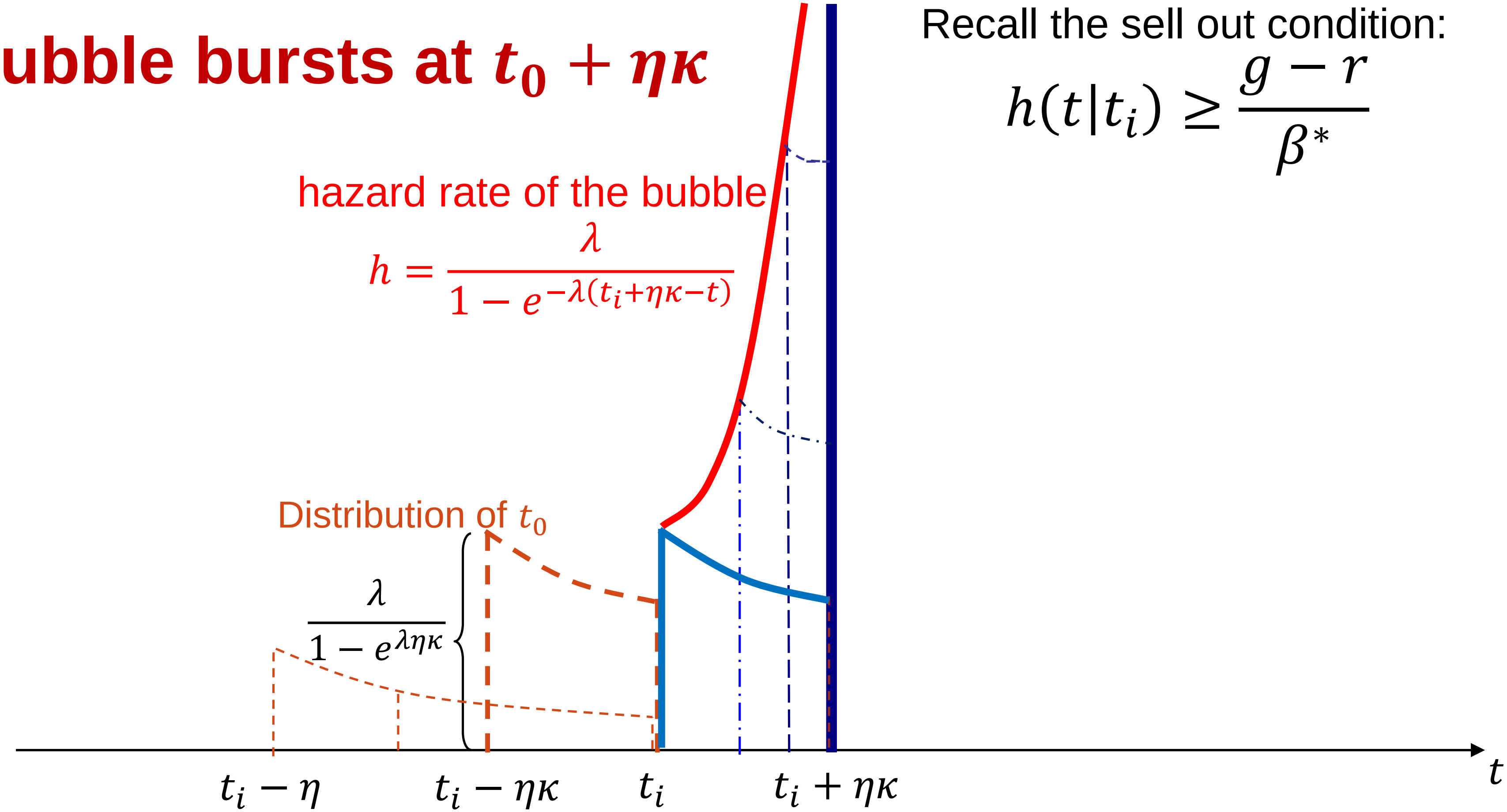


Conjecture 1: Immediate attack

⇒ Bubble bursts at $t_0 + \eta\kappa$

Recall the sell out condition:

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



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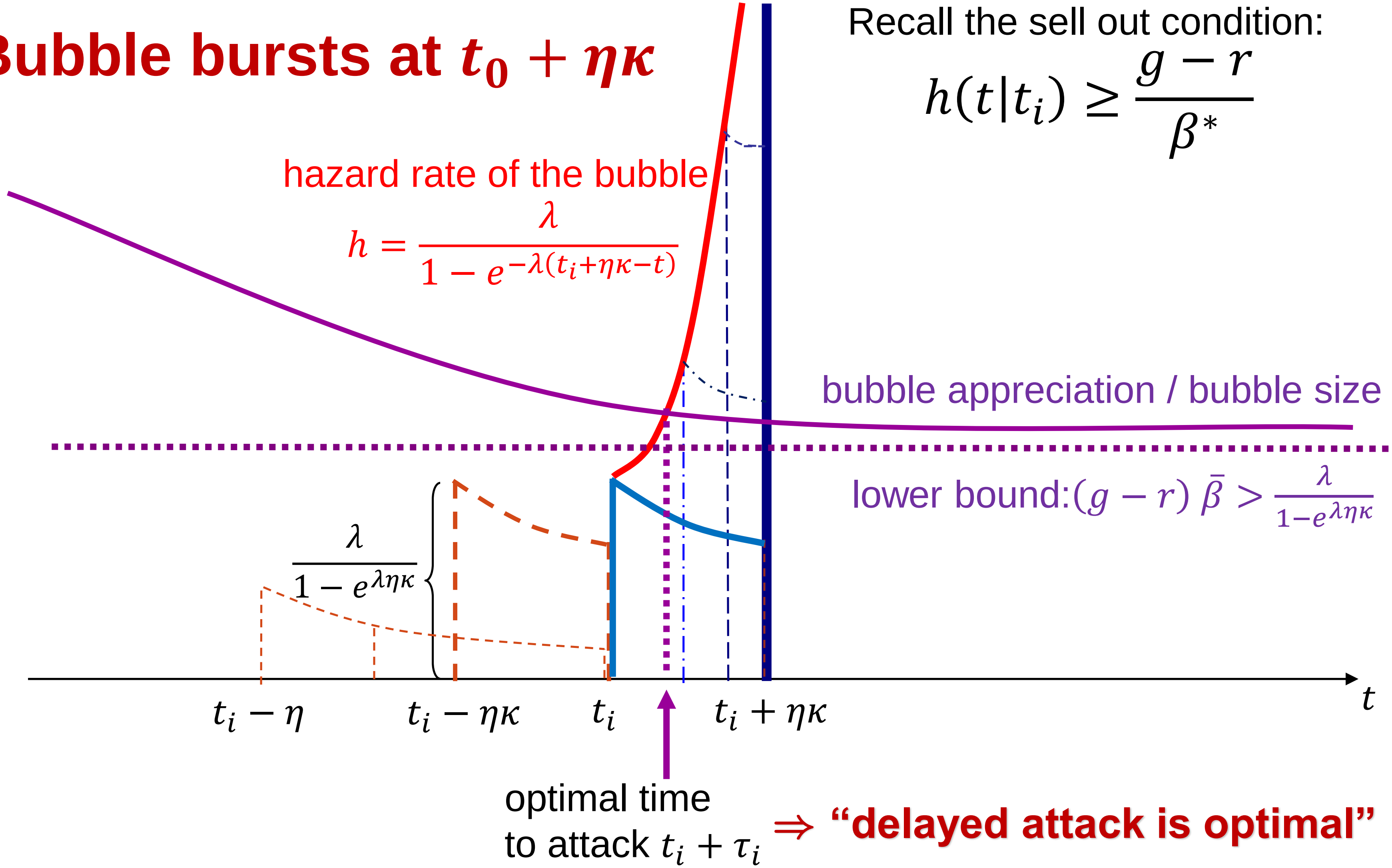


$\Rightarrow$ **"delayed attack is optimal"**

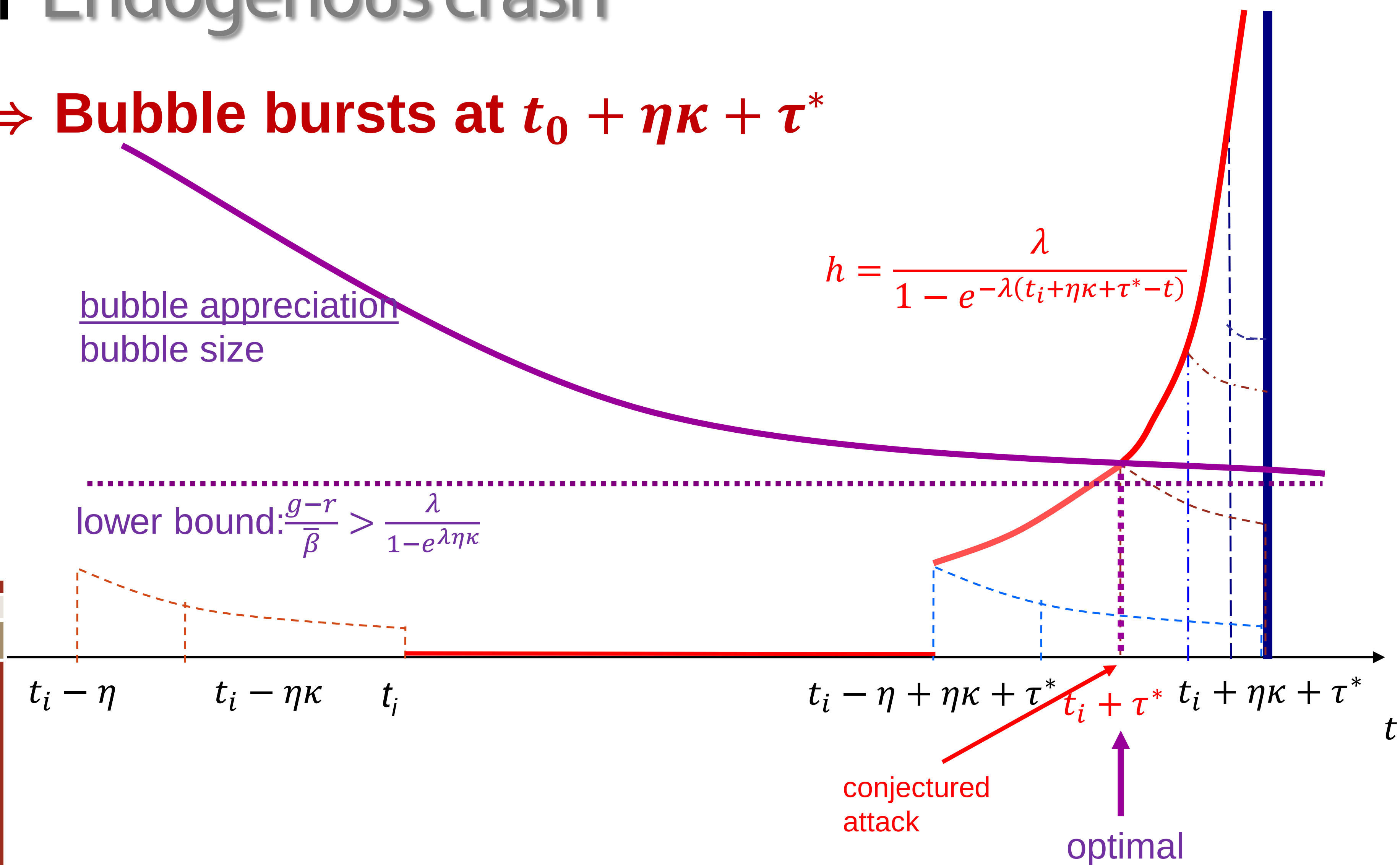
Endogenous Crash for large enough $\bar{\tau}$ (i.e. $\bar{\beta}$)

- 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 τ^* 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 crash

$\Rightarrow$ Bubble bursts at $t_0 + \eta\kappa + \tau^*$

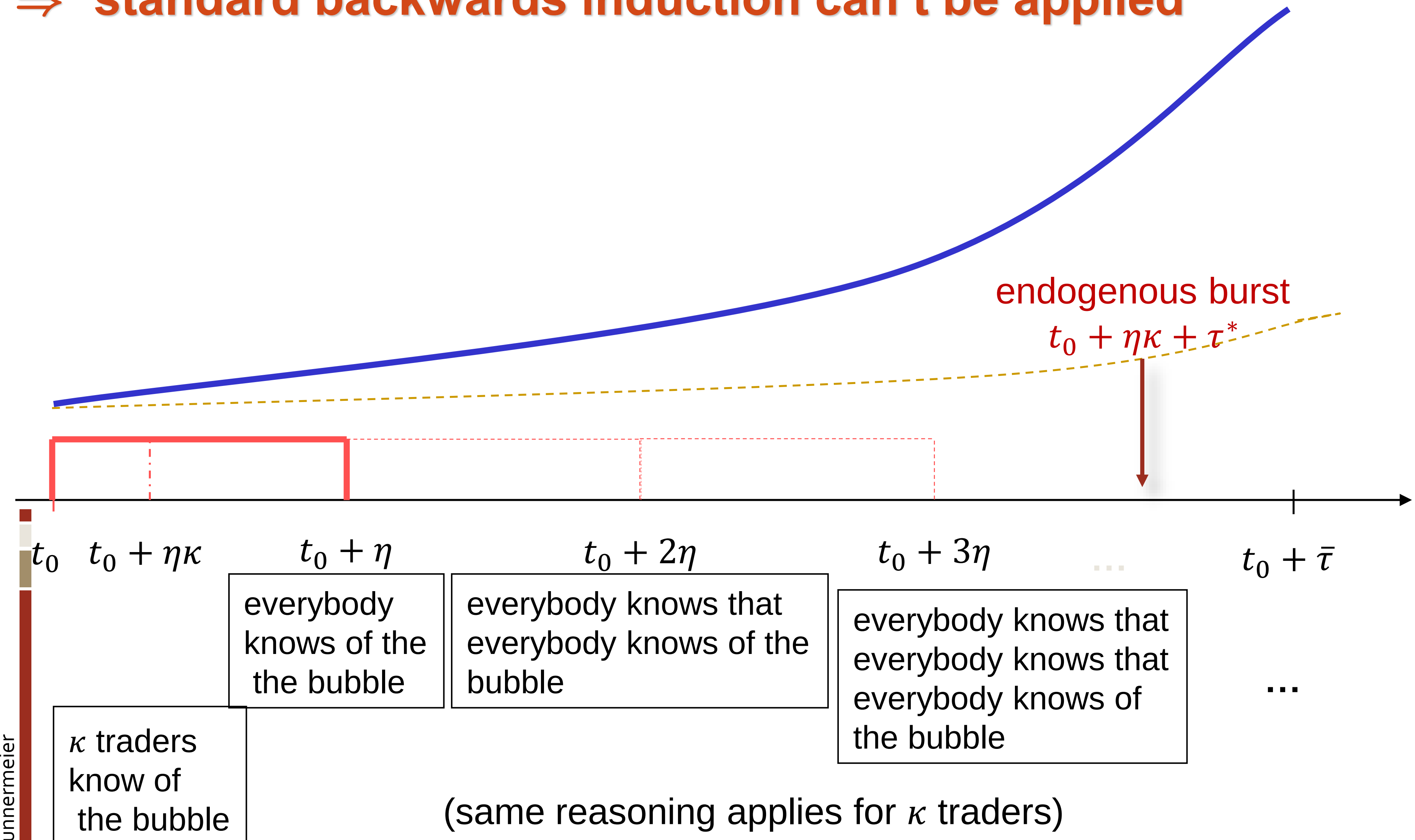


Exogenous crash for low $\bar{\tau}$ (i.e. low $\bar{\beta}$)

- Proposition 2: Suppose $\frac{\lambda}{1-e^{-\lambda\eta\kappa}} \leq \frac{g-r}{\bar{\beta}}$.
  - Unique trading equilibrium
  - Traders begin attacking after a delay of $\tau^1 < \bar{\tau}$ periods.
  - Bubble does not burst due to endogenous selling pressure prior to $t_0 + \bar{\tau}$.

Lack of common knowledge

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



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 attach" fails, then the bubble is temporarily strengthened

Setting with synchronizing events

- Focus on news with no info content (sunspots)
- Synchronizing events occur with Poisson arrival rate
  - Note that pre-emption argument does not apply since event occurs with zero probability
- Arbitrageurs who are aware of the bubble become increasingly worried about it over time.
  - Only traders who became aware of the bubble more than τ_e periods ago observe (look out for) this synchronizing event.

Synchronizing events – market rebounds

- Proposition 5: In 'responsive equilibrium'
  Sell out a) always at the time of the public event t_e,
  b) after $t_i + \tau^{**}$ (where $\tau^{**} < \tau^{*}$)
  except after a failed attack at , re-enter the market
  for $t \in (t_e, t_e - \tau_e + \tau^{**})$.

- Intuition for re-entering the market
  - For $t_e < t_0 + \eta\kappa + \tau_e$ attack fails, agents learn $t_0 > t_e - \tau_e - \eta\kappa$
  - Without public event, they would have learnt this only at $t_e + \tau_e - \tau^{**}$
  - Density that bubble burst for endogenous reasons is zero

Conclusion of Bubbles and Crashes

- Bubbles
  - Dispersion of opinion among arbs causes a synchronization problem which makes coordinated price correction 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 synchronization device.
- Rebound
  - Can occur after a failed attack which temporarily strengthens the bubble

Hedge Funds & the Technolgy Bubble

Markus Brunnermeier and Stefan nagel

Princeton University and Stanford University

Hedge Funds and the Technology Bubble

With Stefan Nagel

- Quarterly 13F filings to SEC
- Mandatory for all institutional investors
  - With holdings in U.S. stocks of more than $ 100 million
  - Domestic and foreign
  - At manager level
- Caveat: No short positions

- 53 managers with CDA/Spectrum data
  - Excludes 18 managers b/c mutual business dominates
  - Incl. Soros, Tiger, Tudor, D.E. Shaw etc.
- Hedge fund performance data
  - HFR hedge fund style indexes

Did hedge funds ride the bubble?

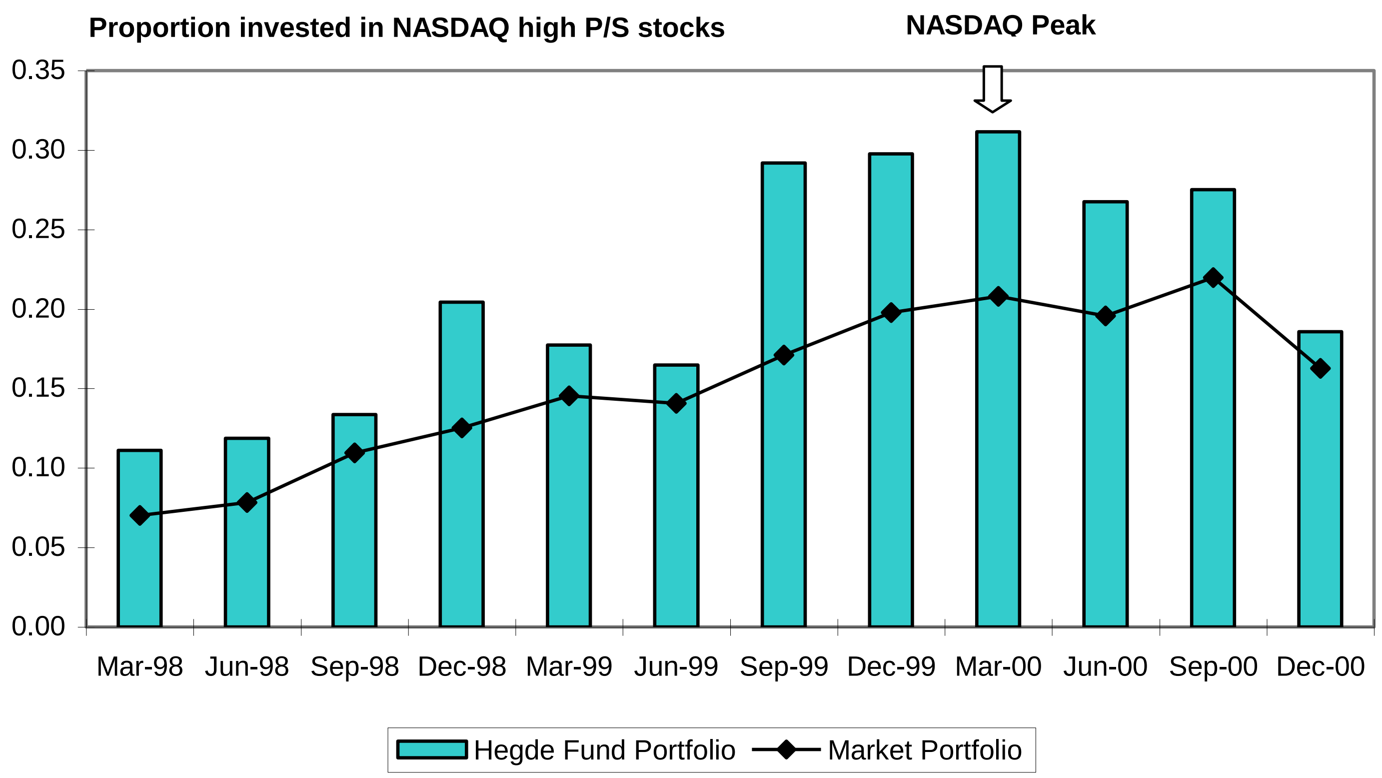


Fig. 2: Weight of NASDAQ technology stocks (high P/S) in aggregate hedge fund portfolio versus weight in market portfolio.

Did Soros ride the bubble?

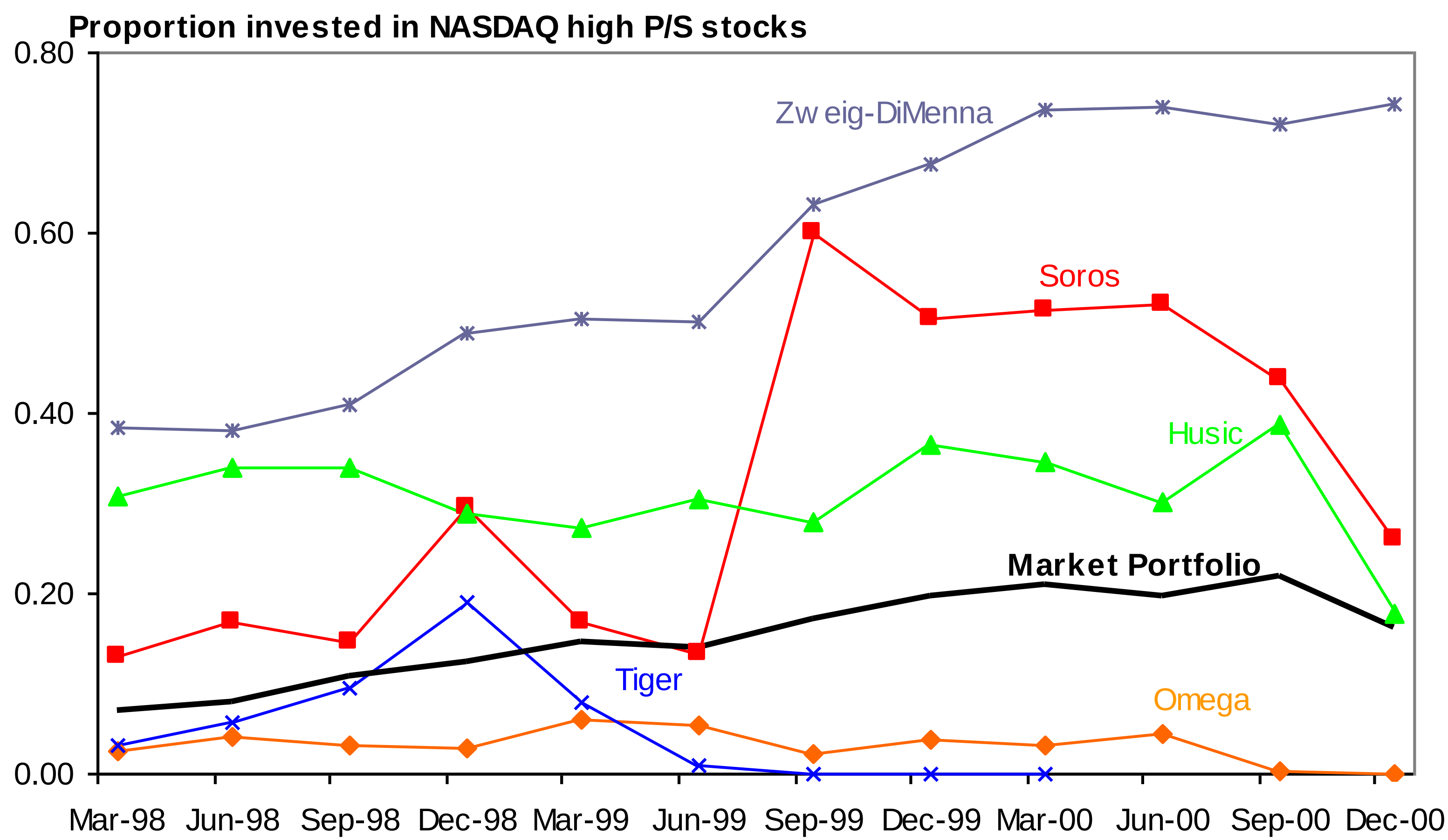
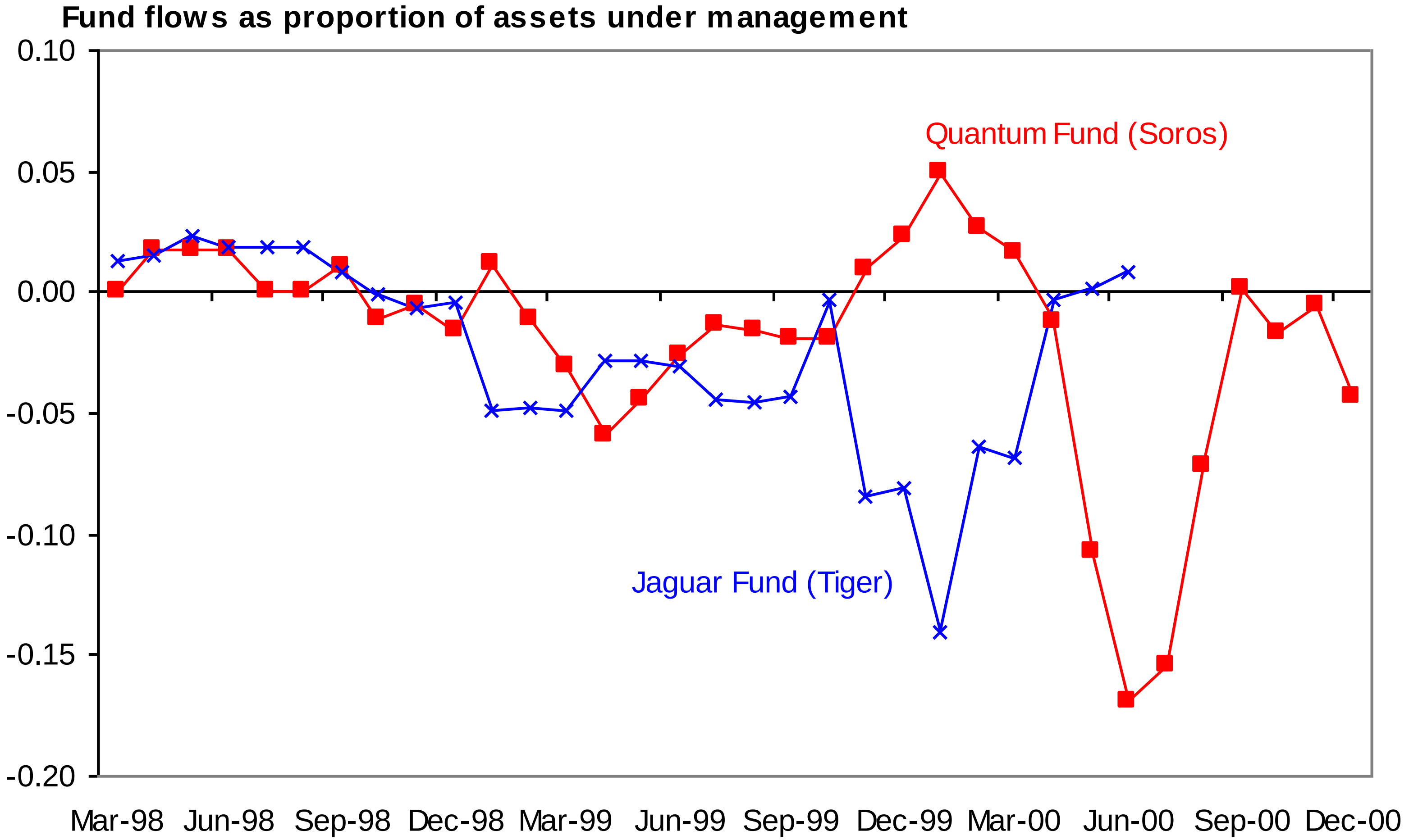


Fig. 4a: Weight of technology stocks in hedge fund portfolios versus weight in market portfolio

Fund in- and outflows



Did hedge funds time stocks?

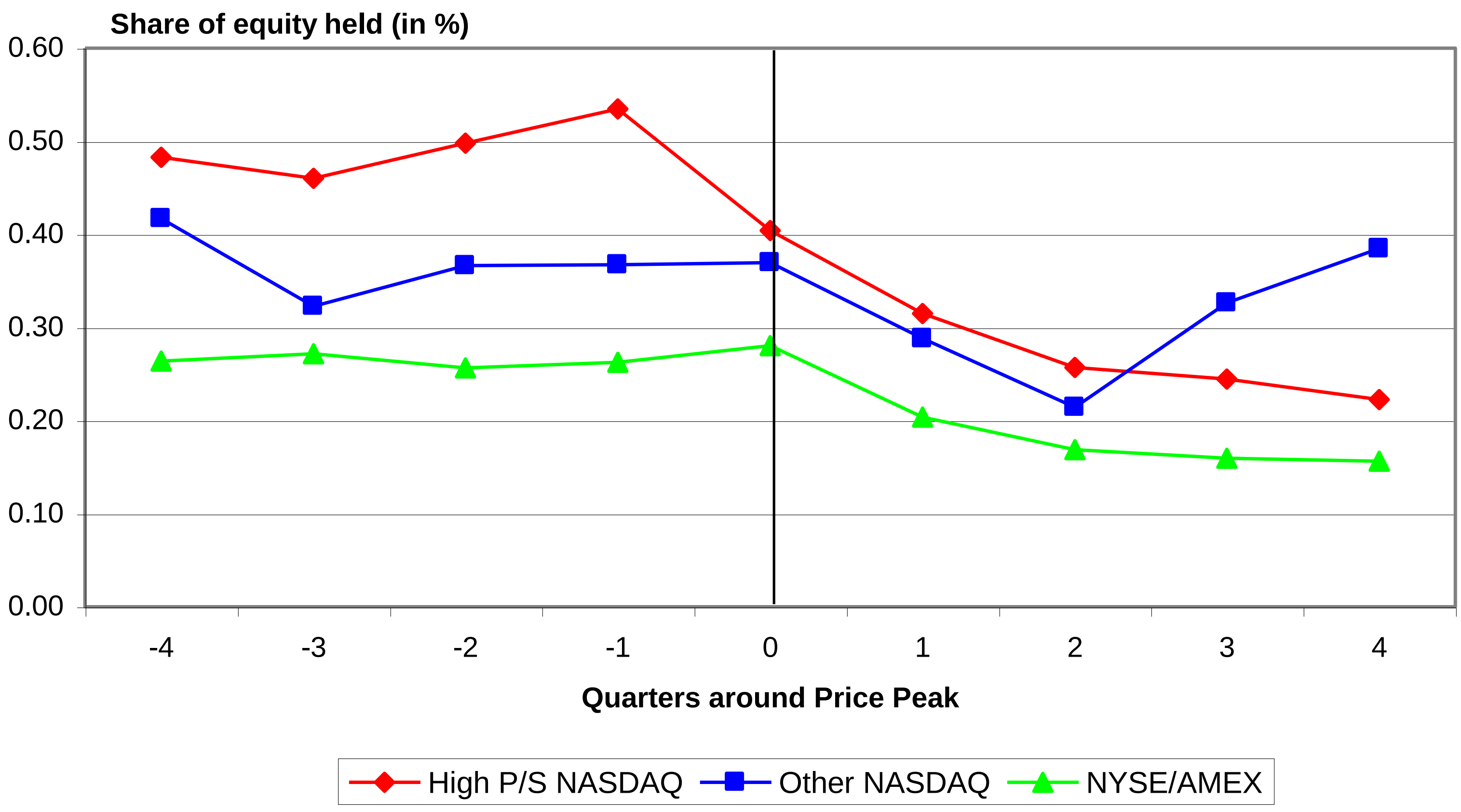


Figure 5. Average share of outstanding equity held by hedge funds around price peaks of individual stocks

Did hedge funds' timing pay off?

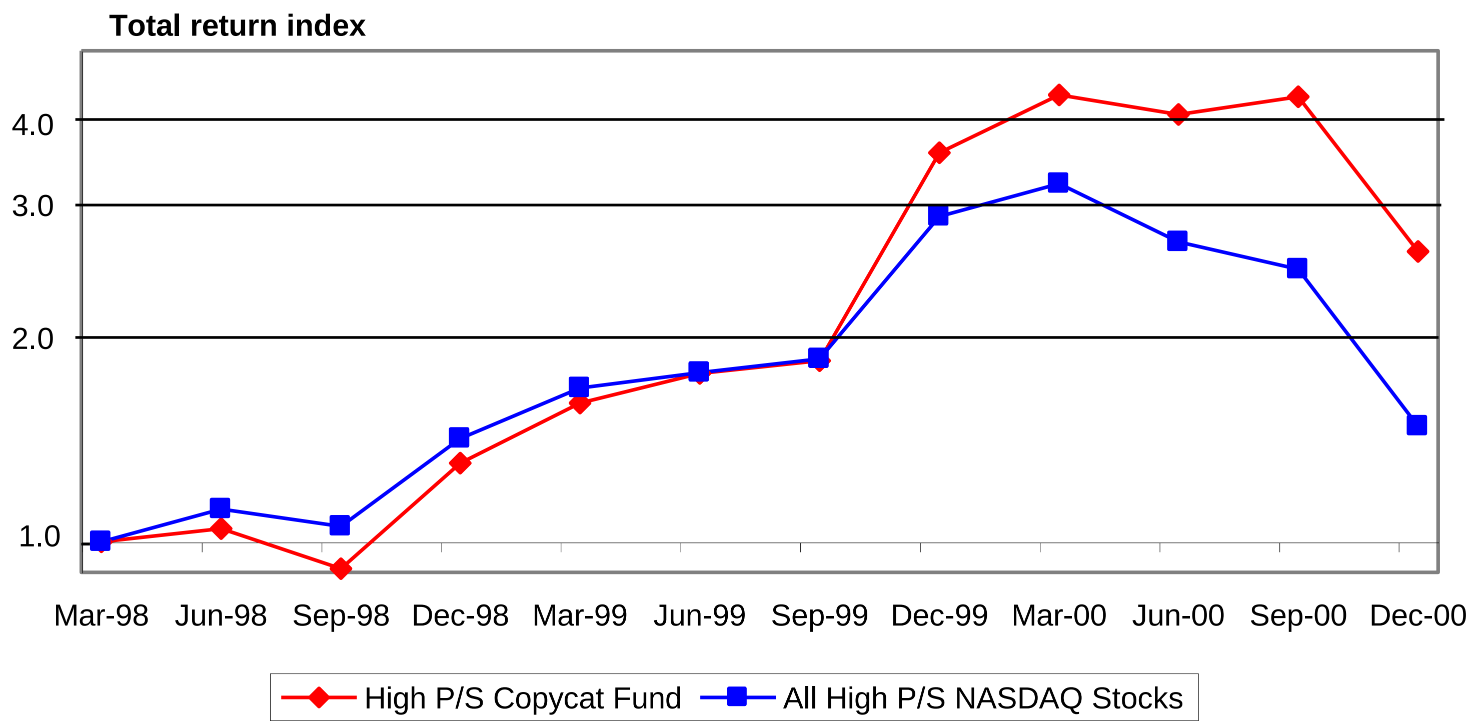


Figure 6: Performance of a copycat fund that replicates hedge fund holdings in the NASDAQ high P/S segment

Conclusion

- Hedge funds were riding the bubble
  - Short sale constrains and "arbitrage" risk are not sufficient to explain this behavior.
- Timing best of hedge funds were well placed. Outperformance!
  - Rues out unawareness of bubble
  - Suggests predictable investor sentiment. Riding the bubble for a while may have been a rational strategy

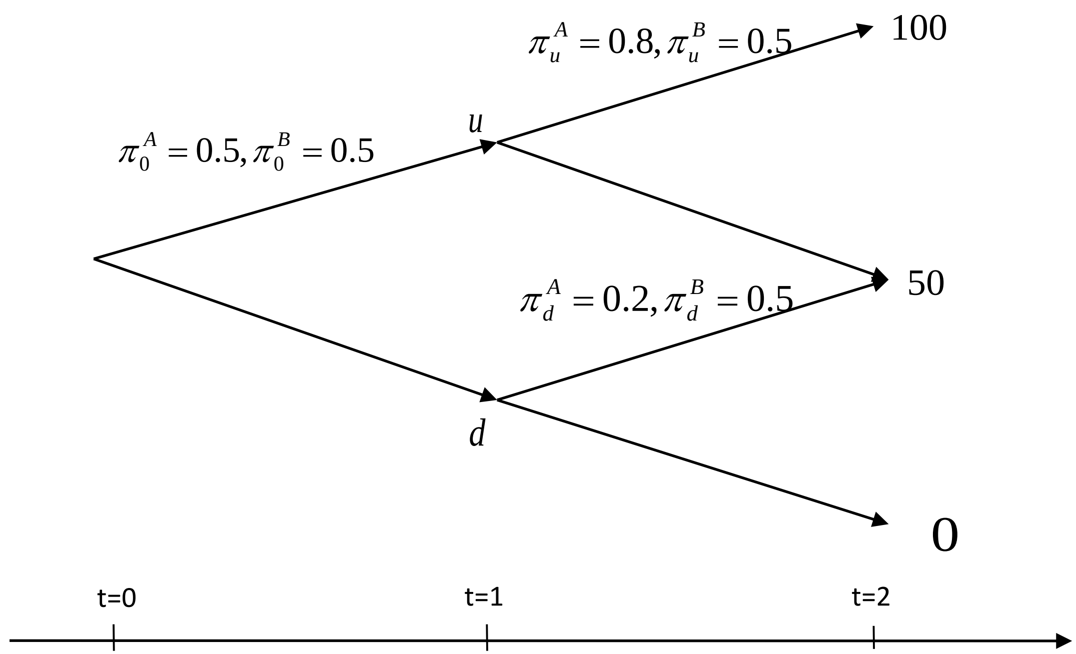
⇒ Supports 'bubble-timing' models

Heterogeneous Beliefs Bubbles

Harrison and Kreps, Scheinkman and Xiong

Bubbles with Trading Cost – simplified example

- Two risk-neutral agents: A and B.
  - An asset with fixed supply, 1 unit equally divided bw A & B.
  - Heterogeneous beliefs; short-sales prohibited.
  - Harrison and Kreps (1978), Morris (1996), Scheinkman and Xiong (2003).



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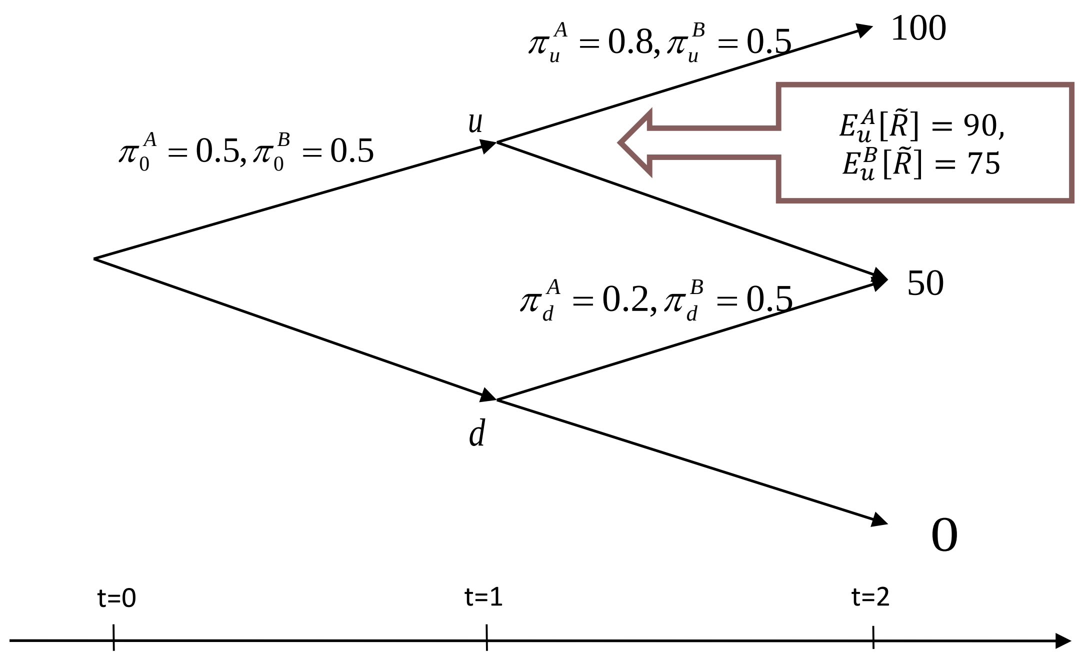

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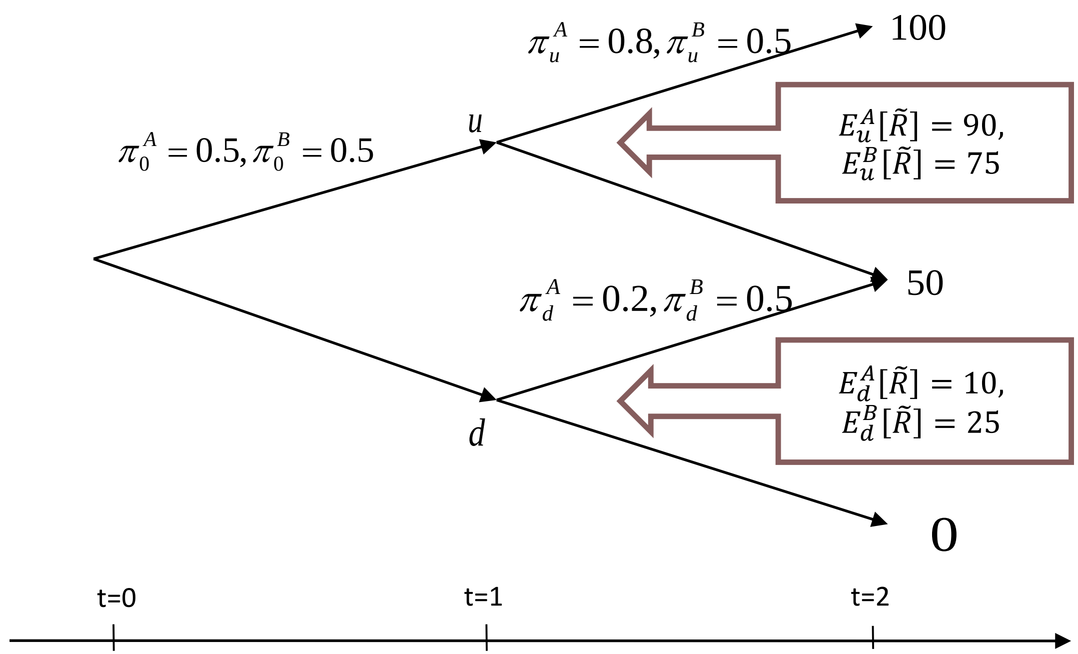

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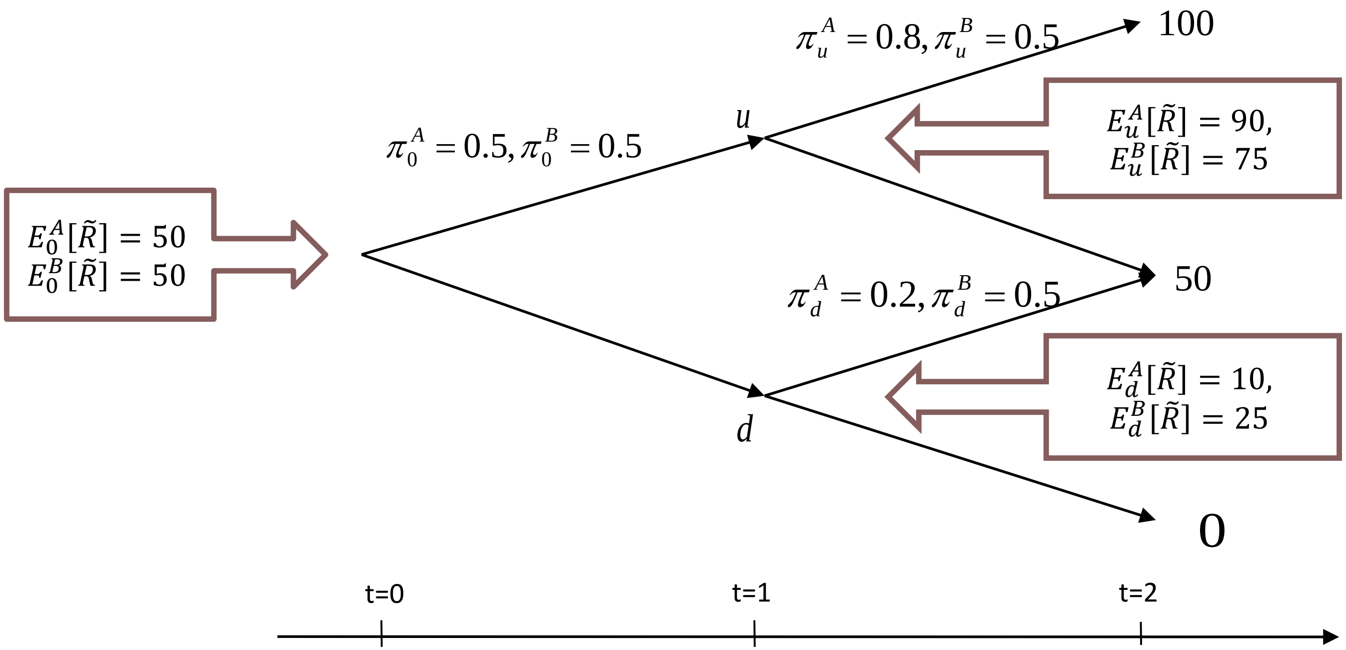

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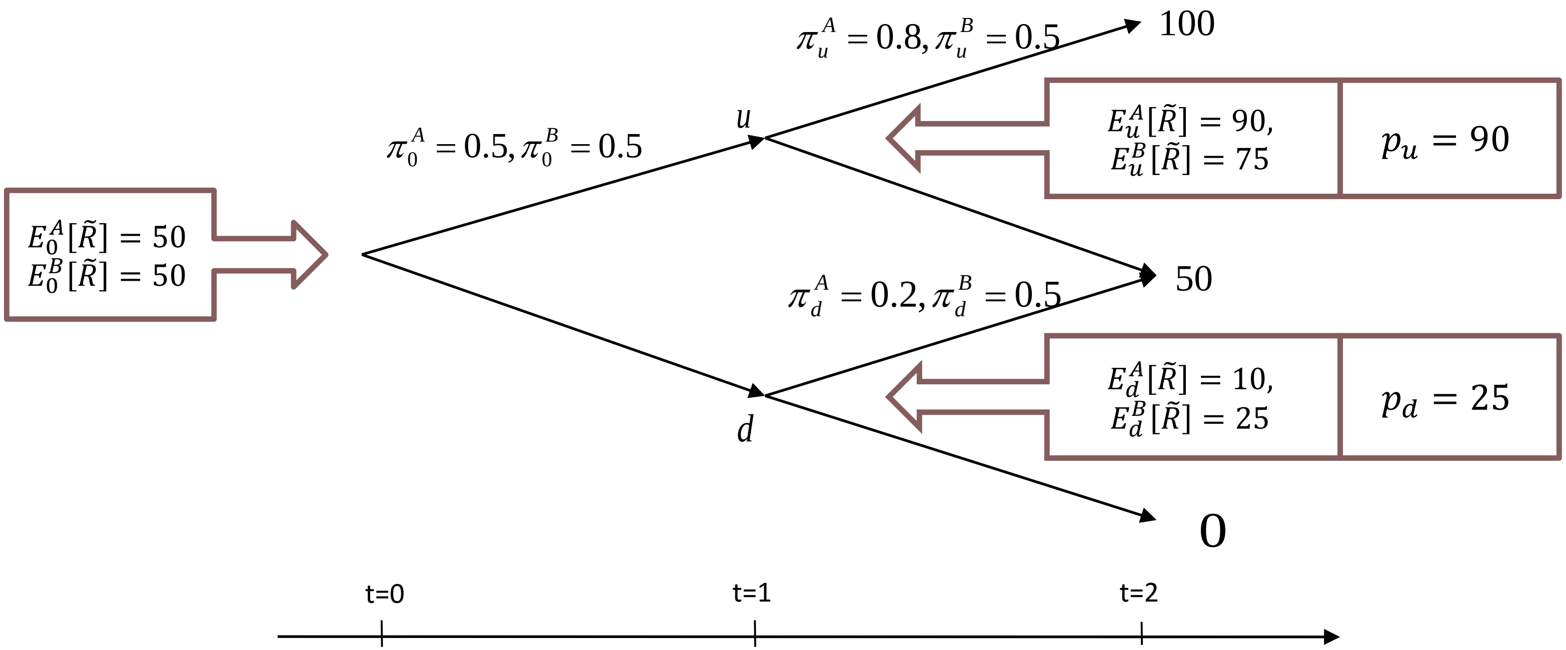

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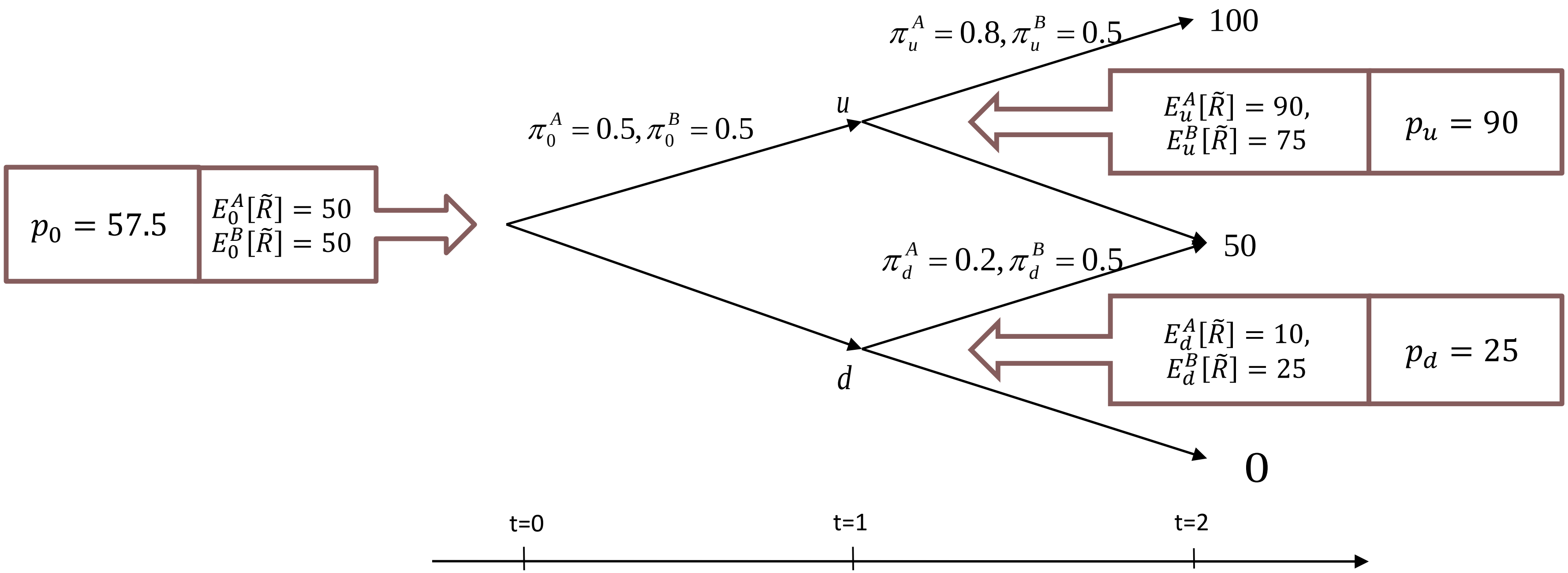

Welfare criterions heterogeneous beliefs

Brunnermeier & Xiong 2011

- Given a social welfare function W, allocation $x \succcurlyeq_W x'$ if
  - $E^A\left[W\left(u^A(x), u^B(x)\right)\right] \geq E^A\left[W\left(u^A(x'), u^B(x')\right)\right]$ AND
  - $E^B\left[W\left(u^A(x), u^B(x)\right)\right] \geq E^B\left[W\left(u^A(x'), u^B(x')\right)\right]$
- Back to Bubble example
  - Assume linear and symmetric social welfare function:
    $$W(u_A, u_B) = u(c_A) + u(c_B) = c_A + c_B.$$
  - At the status quo:
    $$E_0^j[W(u_A, u_B)] = E_0^j[\tilde{R}] = 50, \forall j \in \{A, B\}.$$
  - Suppose that trading costs k per share.
    - $k < 15$ so that trading occurs.
  - In the equilibrium:
    $$E_0^j[W(u_A, u_B)] = E_0^j[\tilde{R}] - \frac{k}{2} = 50 - \frac{k}{2}, \forall j \in \{A, B\}.$$