Asset Price Bubbles and Bubbly Debt

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Andrzej Malawski Memorial Session

Understanding Asset Price Bubbles

- price $=$ fundamental value $+$ bubble.

- Economic Theory: Price bubbles are rare and exotic.

- Recent Bubbles:

  Japanese Bubble 1980s',

  Dot.com Bubble,

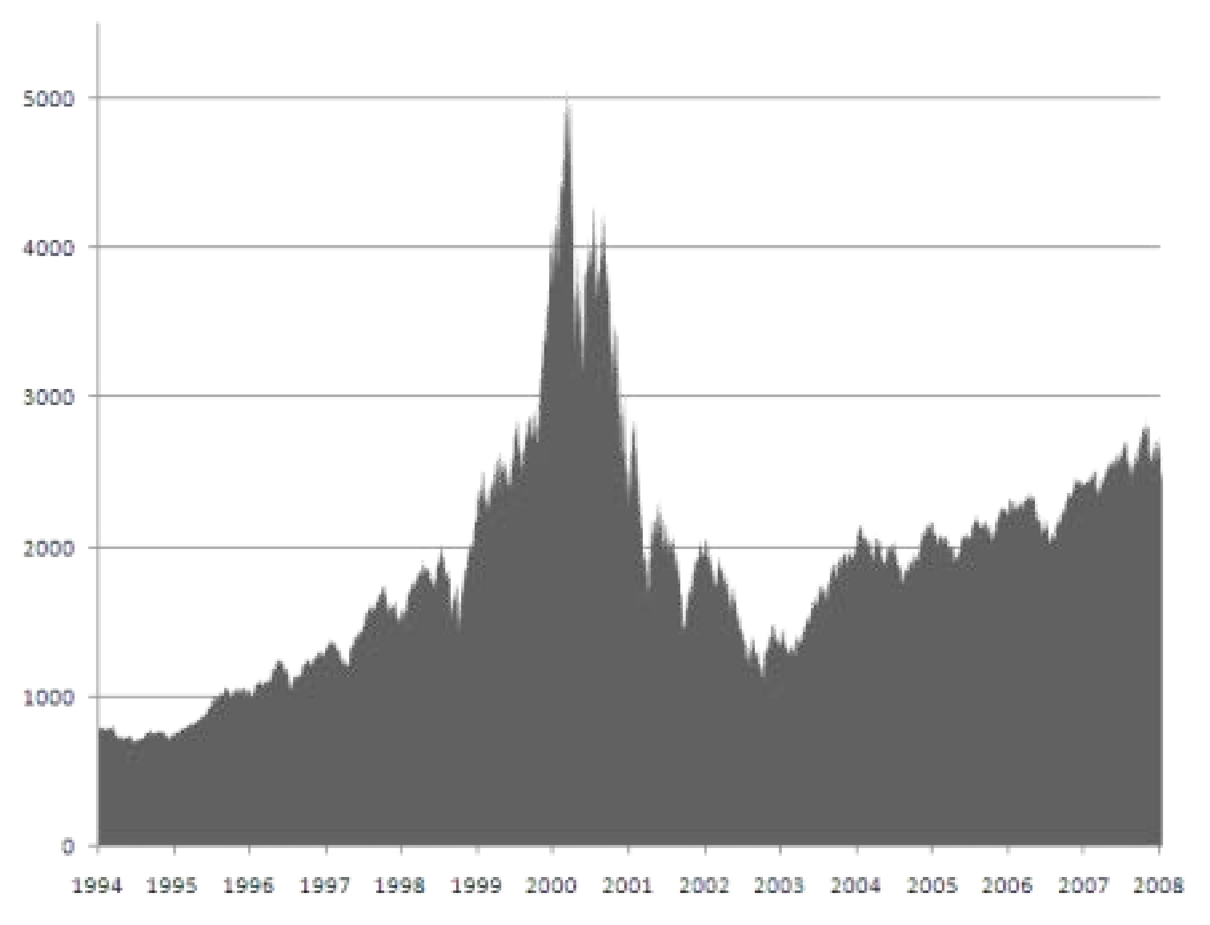
  US Housing Bubble,

  Bitcoin Bubble,

  Dow Jones at 23,000 (?).

Dot.com Bubble 1999-2001

- Nasdaq Index peaked on March 10, 2000, at 5048.
- More than 100% increase from year before.
- 1000 % return on internet stocks between February 1998 and early 2000.
- Wave of IPO's with no prospect of earnings. 89 % return on IPO's on the 1st day.


5000
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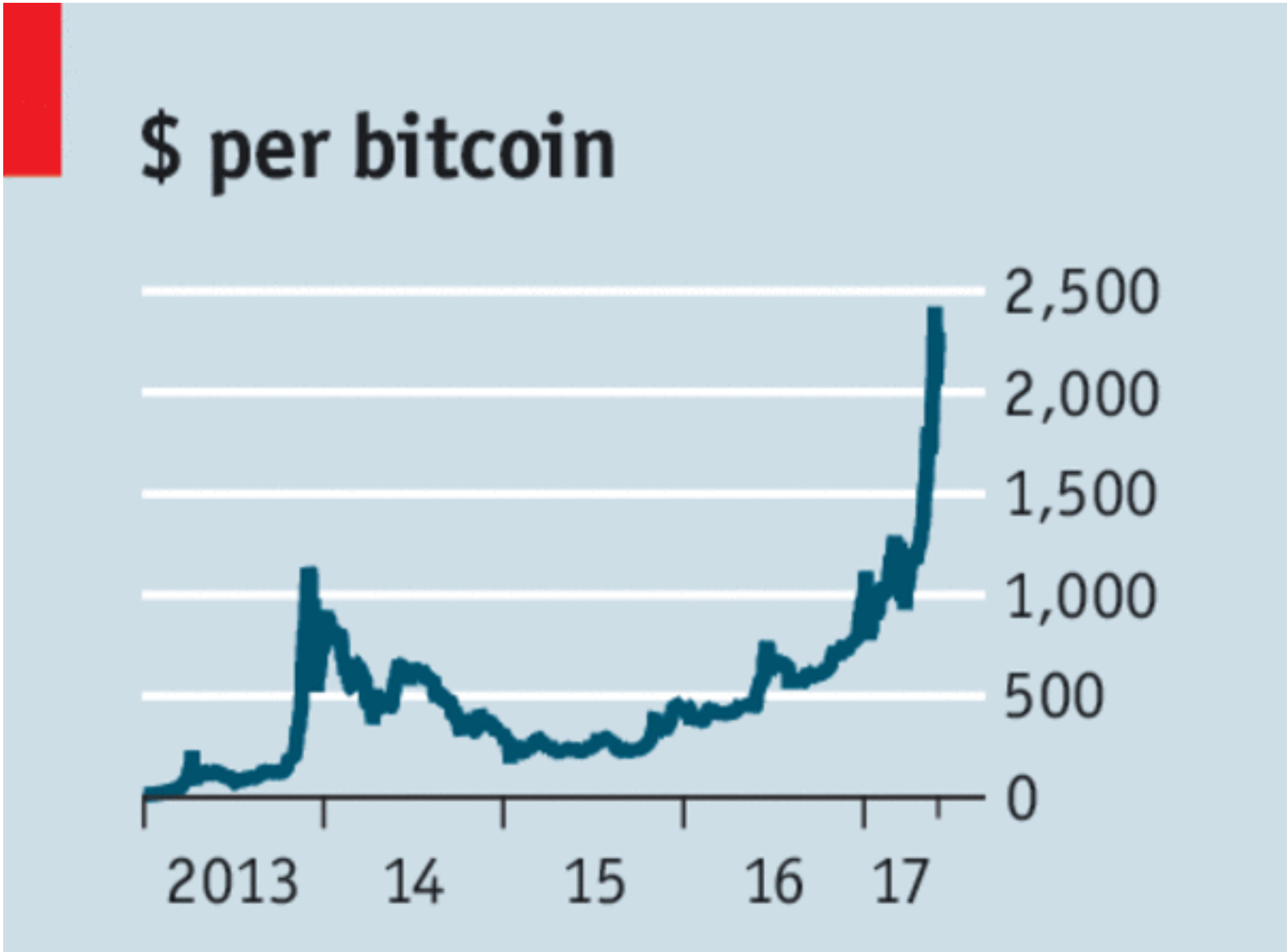
Other Bubbles

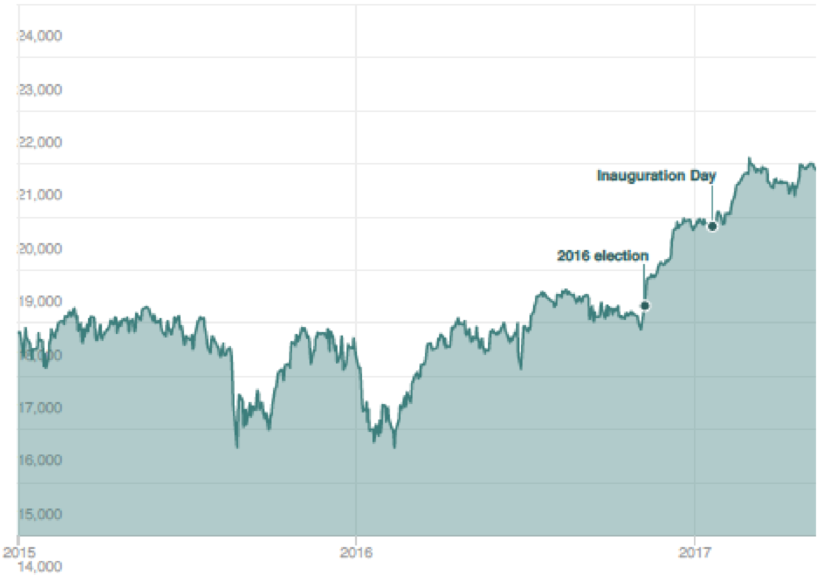
- Japanese Stock Market Bubble 1986-1991
  - 500 % rise of Nikkei index.
  - Capitalization of Japan stock market 1.5 times capitalization of US market.
- Bitcoin Bubble 2017: from $ 400 to $ 5,000 per bitcoin.
- Dow Jones at 23,000, Nasdaq at 6,000. Bubble?



Economist.com

Dow Jones Industrial Average, 2015-Present

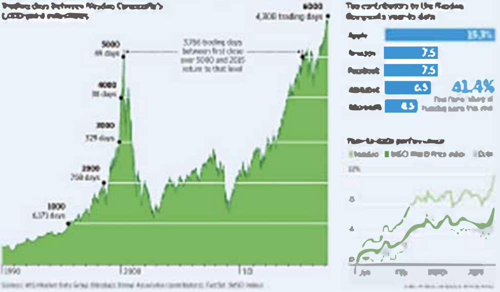
The Dow was at 23,002.20 as of 11:08 a.m. ET Tuesday.



Note: Historical data is as of market close.

Source: Yahoo Finance

Nasdaq Soars to New Heights as Global Stocks Rally



Understanding Asset Price Bubbles II

- What is the “fundamental value”?
  - I. Discounted present value of future dividends.
    Rational Price Bubbles
  - II. Agents’ marginal valuation of future dividends, that is, willingness to pay if obliged to hold the asset forever.
    Speculative Bubbles.
- Competing theories, or complementing theories?

Present Value

- The present value at date t of an asset with dividend stream $\{x_t\}$ is

$$PV_t(x) = \sum_{\tau=t+1}^{\infty} \frac{1}{R_t^\tau} E^*[x_\tau]$$

Discounted present value of future dividends.

  - $E^*(\cdot)$ is expectation under equivalent martingale measure, or pricing kernel.
  - R_t^τ is date-τ discount at t.

Rational Price Bubbles

- Price bubble is the difference between the price and the present value:
$$\sigma_t \equiv p_t - PV_t(x).$$
- Basic properties of rational bubbles:
  - positive:
  $$0 \leq \sigma_t$$
  - zero bubbles on finite maturity assets,
  - "discounted martingale" property:
  $$\sigma_t = \frac{1}{R_t^{t+1}} E_t^*[\sigma_{t+1}]$$

No-Bubble Theorem

- In assets markets with debt constraints
- **Theorem:** *In an equilibrium, if the present value of the aggregate endowment is finite,*

$$\sum_{\tau=t+1}^{\infty} \frac{1}{R_t^\tau} E^*[\bar{e}_\tau] < \infty, \qquad (FPV)$$

and assets are in strictly positive supply, then price bubbles are zero.

- *Santos and Woodford (1997), and LeRoy and Werner (2014).*

“Low” Interest Rates

- FPV means “high” discount rates.
- Price bubble can exist only if FPV is violated, that is INF-PV, or “low”discount rates,

$$\sum_{\tau=t+1}^{\infty} \frac{1}{R_t^{\tau}} E^*[\bar{e}_\tau] = +\infty \qquad (INF-PV)$$

- Are we not in a low-discount INF-PV world??

Self-Enforcing Debt

- A reason for INF-PV: DEBT.
- Self-enforcing debt limits: *Bulow and Rogoff (1989)*

  At any level of debt not-exceeding the limit, the agent is willing to repay her debt rather than default.

  Default: debt is forfeited but no more debt in the future.

  Debt limits are a commitment device against default, hence self enforcing.
- B&R question: **Can non-zero debt limits be self enforcing?**

Bubbly Debt

- Self-enforcing debt limits have the discounted martingale property:

$$D_t^i = \frac{1}{R_t^{t+1}} E_t^*[D_{t+1}^i]$$

Bubbly debt.

- Self enforcing debt limits are non-zero only if

INF-PV.

Hellwig and Lorenzoni (2009), DaRocha and Valiakis (2017).

Bubbly Debt and Price Bubbles

Shifting bubble between debt limits and asset prices:

- Theorem: *If p are equilibrium asset prices with self-enforcing debt D^i, and D^i is bounded away from zero, then for every small positive discounted martingale ϵ, prices $p + \epsilon$ are an equilibrium with self-enforcing debt, too.*

  Werner (2015)

Summary of Rational Bubbles

- Bubbly debt gives rise to equilibria with low discount rates and with rational price bubbles.

- Robert Shiller's present value calculations.

- Dow Jones at $23,000$

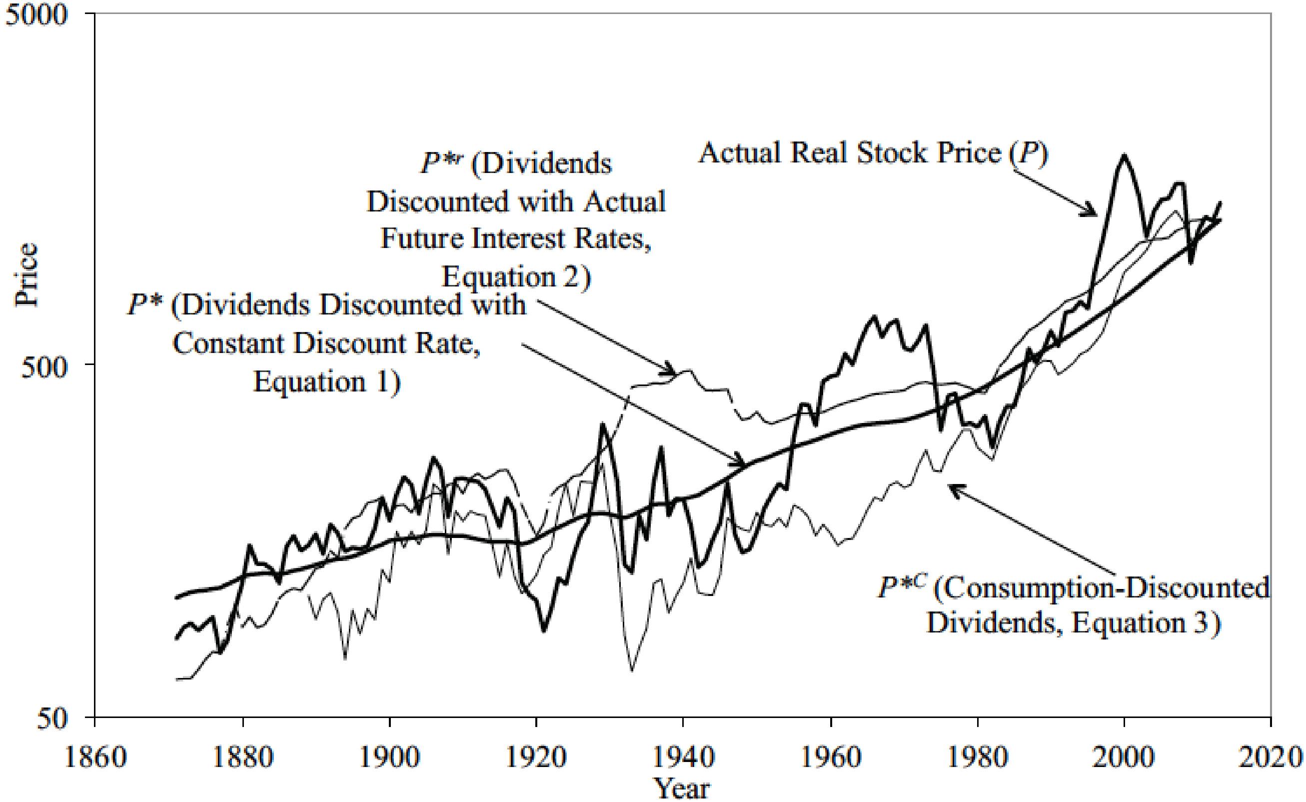


FIGURE 2. Real Standard & Poor's Composite Stock Price Index along with three present

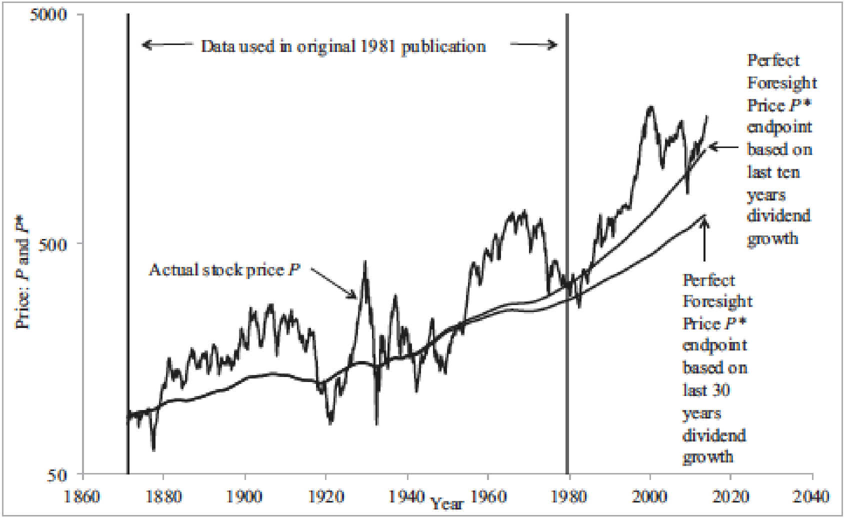


FIGURE 1. Real Standard & Poor's Composite Stock Price Index along with Present values with constant discount rate of subsequent real dividends accruing to the index 1871–1913. The two present values differ in their assumption about dividend growth after 2013.

Speculative Bubbles

- Fundamental value: marginal value of buying an additional share of the asset at date t and holding it forever

$$V_t^i(x) = \sum_{\tau=t+1}^{\infty} \beta^{\tau-t} E^i[\frac{u'(c^i_{\tau+1})}{u'(c^i_\tau)}\ x_\tau]$$

  $\frac{u'(c^i_{\tau+1})}{u'(c^i_\tau)}$ is the marginal rate of substitution between consumption in $\tau+1$ and τ.

- It holds $p_t \geq V_t^i(x)$
  with strict inequality if debt or short-sales constraints are binding at t.

Speculative Bubbles

- There is speculative bubble at date t if

$$p_t > \max_i V_t^i(x).$$

That is, asset price exceeds all agents' fundamental valuations.

- Agent who buys the asset pays more than his willingness to pay if obliged to hold it forever. Hence, speculative trade – buy in order to sell at a later date.

Heterogeneous Beliefs

- Agents have different probability beliefs and are risk neutral.
- Valuation is the discounted expected value of dividends under agent's i belief:

$$V_t^i(x) = \sum_{\tau=t+1}^{\infty} \beta^{\tau-t} E^i[x_\tau]$$

- Speculative bubble if asset price exceeds every agents discounted expected value of dividends.

Yes, persistent speculative bubbles can be in equilibrium in markets with short-sales restriction – Harrison and Kreps (1978).

Heterogeneous Beliefs?

- "Dogmatic" beliefs: *Harrison and Kreps (1978)*.
- Bias in belief updating, or overconfidence: *Scheinkman and Xiong (2003, 2006)*
- Heterogeneous priors with learning: *Morris (1996)*.
- Ambiguous (but common) beliefs: *Werner (2015)*.

Heterogeneous Priors and Learning

- There is a family of probability distributions P_θ of dividends $\{x_t\}$ parametrized by θ in some set Θ.
- Agent i has prior belief μ^i on θ in Θ.

  $\mu^i(\cdot|x^t)$ is agent's i posterior on Θ, $P_{\mu^i}(\cdot|x^t)$ is conditional distribution of future dividends given the past $x^t = (x_1, \ldots, x_t)$.

  Bayesian model of learning
- Question: What conditions on priors lead to speculative bubble and speculative trade?

Valuation Dominance and MLR Order

- If posterior valuations exhibit switching, then there is speculative bubble.
  Valuation switching: At every date t, there is no single agent i such that $V^i_\tau = \max_k V^k_\tau$ for all dates $\tau \geq t$.

- *If prior μ^i has density f_i on Θ, then μ_i dominates μ^j in the Maximium Likelihood Ratio order if*

$$\frac{f_i(\theta')}{f_i(\theta)} \geq \frac{f_j(\theta')}{f_j(\theta)} \qquad \text{for every } \theta' \geq \theta.$$

- Proposition: *If μ^i dominates μ^j in MLR order for every $j \neq i$, then agent i is valuation dominant.*
  Werner (2017)

Learning with i.i.d. Dividends

- $\{x_t\}$ is an i.i.d. process. Then

$$V_t^i(x) = \sum_{\tau=t+1}^{\infty} \beta^{\tau-t} E_t^i[x_{t+1}] = E_t^i[x_{t+1}] \frac{\beta}{1-\beta}$$

MLR-dominance among priors is equivalent to valuation dominance

- Example: $0-1$ dividends:
x_t can take values 0 or 1; $\theta \in [0,1]$ is probability of high dividend.
$E_t^i[x_{t+1}]$ equals posterior probability of high dividend.

i.i.d. Dividends

- Posterior $\nu^i(t,k)$ for k "successes" in t periods is
  - For uniform prior μ^i with $f_i \equiv 1$,

$$\nu^i(t,k) = \frac{(k+1)}{(t+2)}.$$

  - For Jeffreys prior μ^j with $f_j(\theta) = \frac{1}{\sqrt{\theta}(1-\theta)}$,

$$\nu^j(t,k) = \frac{(k+1/2)}{(t+1)}.$$

- Yes,there is valuation switching for μ^i and μ^j. There is speculative bubble in equilibrium.

Merging of Beliefs and Bubbles

- Blackwell and Dubins (1962) merging of opinions:
  If agents' priors are absolutely continuous with respect to each other, then conditional beliefs for the future given the past merge.

- If priors are Bayes consistent and absolutely continuous, then speculative bubble vanishes as time goes to infinity.

  Priors may be inconsistent and not absolutely continuous.
  Werner (2017)

Summary of Speculative Bubbles

- Different prior beliefs and learning are likely to give rise to speculative bubbles and speculative trade.

- Dot.com bubble: **E. Ofek and M. Richardson (2003)** attribute the bubble to stringent short sales restrictions and heterogeneity of investors' beliefs.
  Also Hong, Scheinkman, and Xiong (2006)

- Other speculative bubbles: Japan's stock market bubble, Bitcoin bubble.