Extrapolation and Bubbles

Barberis, Greenwood, Jin, and Shleifer (2018)

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Motivation

- Empirical evidence suggests a close relationship between extrapolation and bubbles (Case et al., 2012; Greenwood and Shleifer, 2014; Haruvy et al., 2007)
- It remains unclear whether extrapolation can help explain high trading volumes in bubbles and how bubbles evolve around cash flow news

Model Setup

- An economy in discrete time. $t = 0, 1, 2...T$
- Two assets
  - One risk-free asset
  - One risky asset with a fixed supply of Q shares and dividend payment on time T.
    $\tilde{D_T} = D_0 + \tilde{\epsilon_1} + ... + \tilde{\epsilon_T}$ where $\tilde{\epsilon_t} \sim N(0, \sigma_\epsilon^2)$
- In equilibrium, aggregate share demand for the risky asset equals supply.

Model Setup

- Two types of investors
  - Fundamental Investors:
    - Maximize CARA utility over next period's wealth
    - Boundedly rational: do not have a full picture of how others behave
  - Extrapolators:
    - Form demand by weighing a **growth signal** G_t (based on past prices) against a **value signal** V_t (based on fundamental evaluation of cash flow)
    - 'Wavering': random slight shifts in relative weights between the signals
- All investors are subject to short-selling constraints, i.e., non-negative demand.

Investor Demand

Fundamental Investor Demand:

$$\frac{D_t - \gamma\sigma_\epsilon^2(T-t-1)Q - P_t}{\gamma\sigma_\epsilon^2}$$

- Expected price change scaled by the trader's risk aversion and by her estimate of the risk

Investor Demand

Extrapolator Demand:

$$w_i \underbrace{\left(\frac{D_t - \gamma\sigma_\epsilon^2(T-t-1)Q - P_t}{\gamma\sigma_\epsilon^2}\right)}_{\text{Value signal } (V_t)} + (1-w_i) \underbrace{\left(\frac{X_t}{\gamma\sigma_\epsilon^2}\right)}_{\text{Growth Signal } (G_t)}$$

$$X_t = \theta X_{t-1} + (1-\theta)(P_{t-1} - P_{t-2})$$

- X_t (extrapolator enthusiasm): weighted average of past price changes, with more recent price changes weighted more heavily.

Wavering between value and growth

$$w_i \underbrace{\left(\frac{D_t - \gamma\sigma_\epsilon^2(T-t-1)Q - P_t}{\gamma\sigma_\epsilon^2}\right)}_{\text{Value signal } (V_t)} + (1 - w_i) \underbrace{\left(\frac{X_t}{\gamma\sigma_\epsilon^2}\right)}_{\text{Growth Signal } (G_t)}$$

- **Wavering** of w_i: slight shift of weights on signals
  - Intuition: extrapolators face a fear vs. greed dilemma
  - $w_{i,t} = \bar{w}_i + \tilde{u}_{i,t}$
  - $\tilde{u}_{i,t} \sim N(0, \sigma_u^2)$, i.i.d. over time and across extrapolators

Equilibrium Price

- Equilibrium Price:

$$P_t = D_t + \underbrace{\frac{\sum_{i \in I^*} \mu_i (1 - w_{i,t})}{\sum_{i \in I^*} \mu_i w_{i,t}} X_t}_{\text{Extrapolation component}} - \gamma \sigma_\epsilon^2 Q \frac{(\sum_{i \in I^*} \mu_i w_{i,t})(T - t - 1) + 1}{\sum_{i \in I^*} \mu_i w_{i,t}}$$

  - I^*: set of investors with positive demands at t
  - μ_i: Proportion of investor i among all investors

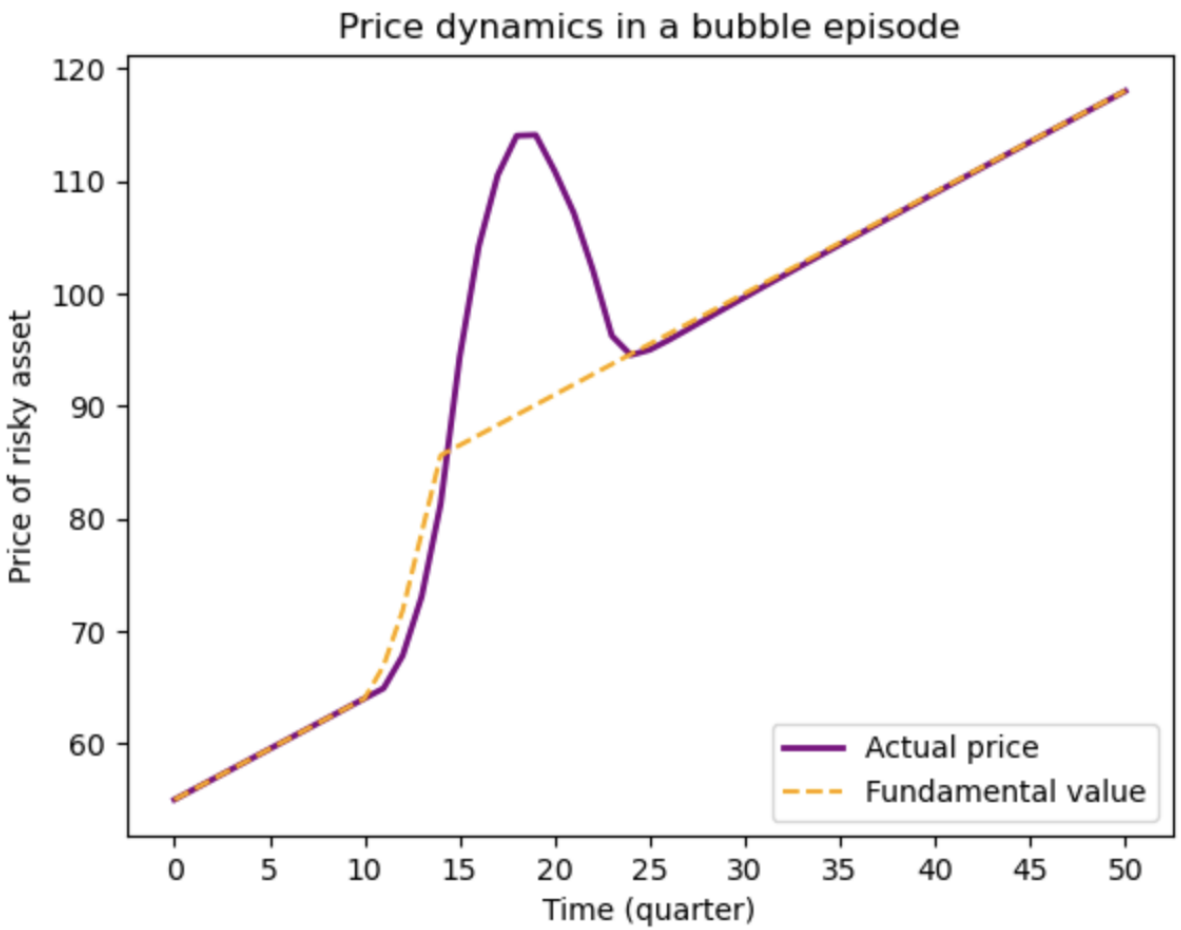
- Fundamental Value (price if no extrapolators):

$$D_t - \gamma \sigma_\epsilon^2 (T - t) Q$$

Replication: Numerical example of a bubble episode

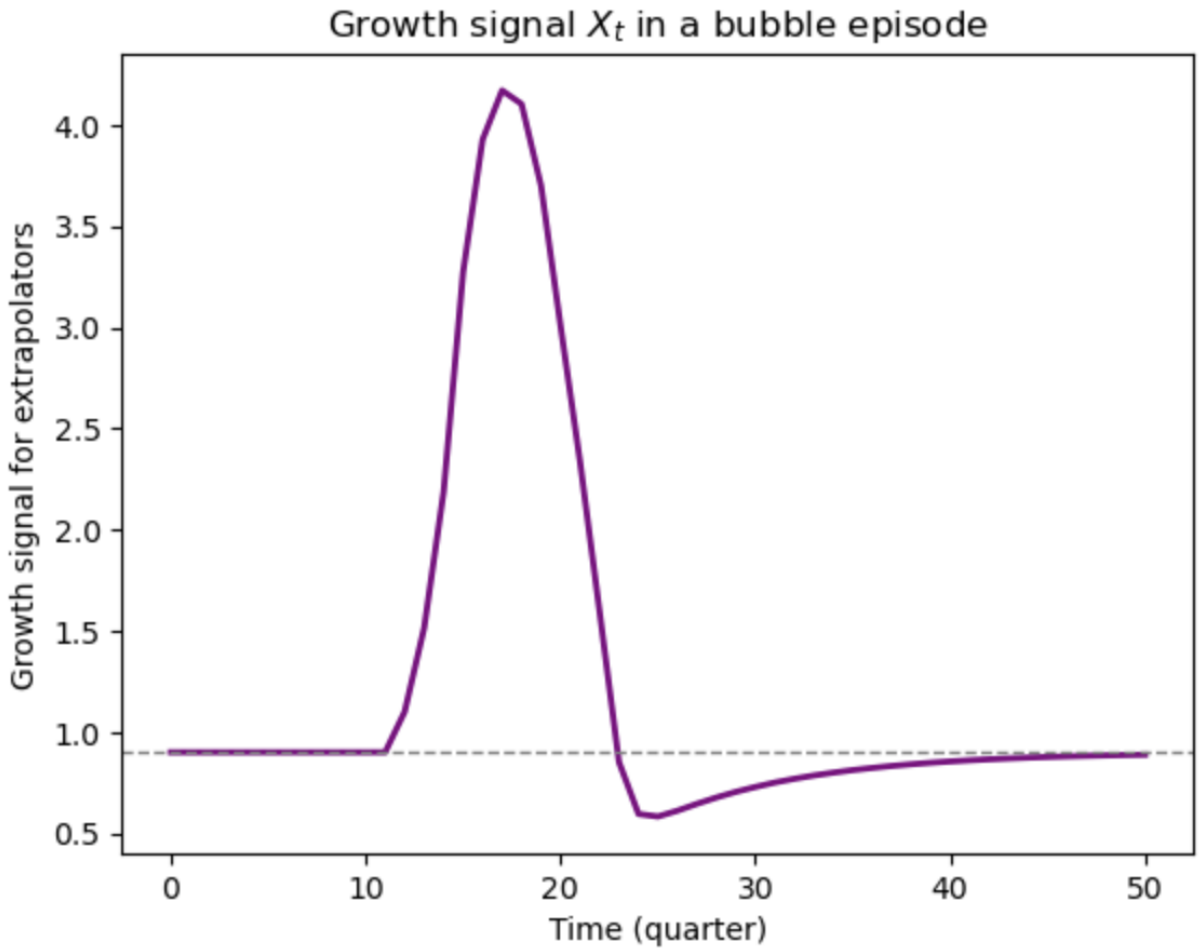
- 50 cash-flow shocks: 10 shocks of 0, followed by positive shocks of 2, 4, 6, 6, followed by 36 shocks of 0
- 30% of investors are fundamental traders and the reminders are extrapolators
- Extrapolators put base weight $\bar{w}_i = 0.1$ on a value signal and waver with $\sigma_u = 0.03$
- Other parameters: $D_0 = 100$, $T = 50$, $Q = 1$, $\sigma_\epsilon = 3$, $\gamma = 0.1$, $I = 50$, $X_1 = 0.9$

Replication: Price in a bubble episode



- The bubble emerges after a sequence of cash flow shocks and deflates as the news fades.

Replication: Extrapolator Enthusiasm in a bubble episode

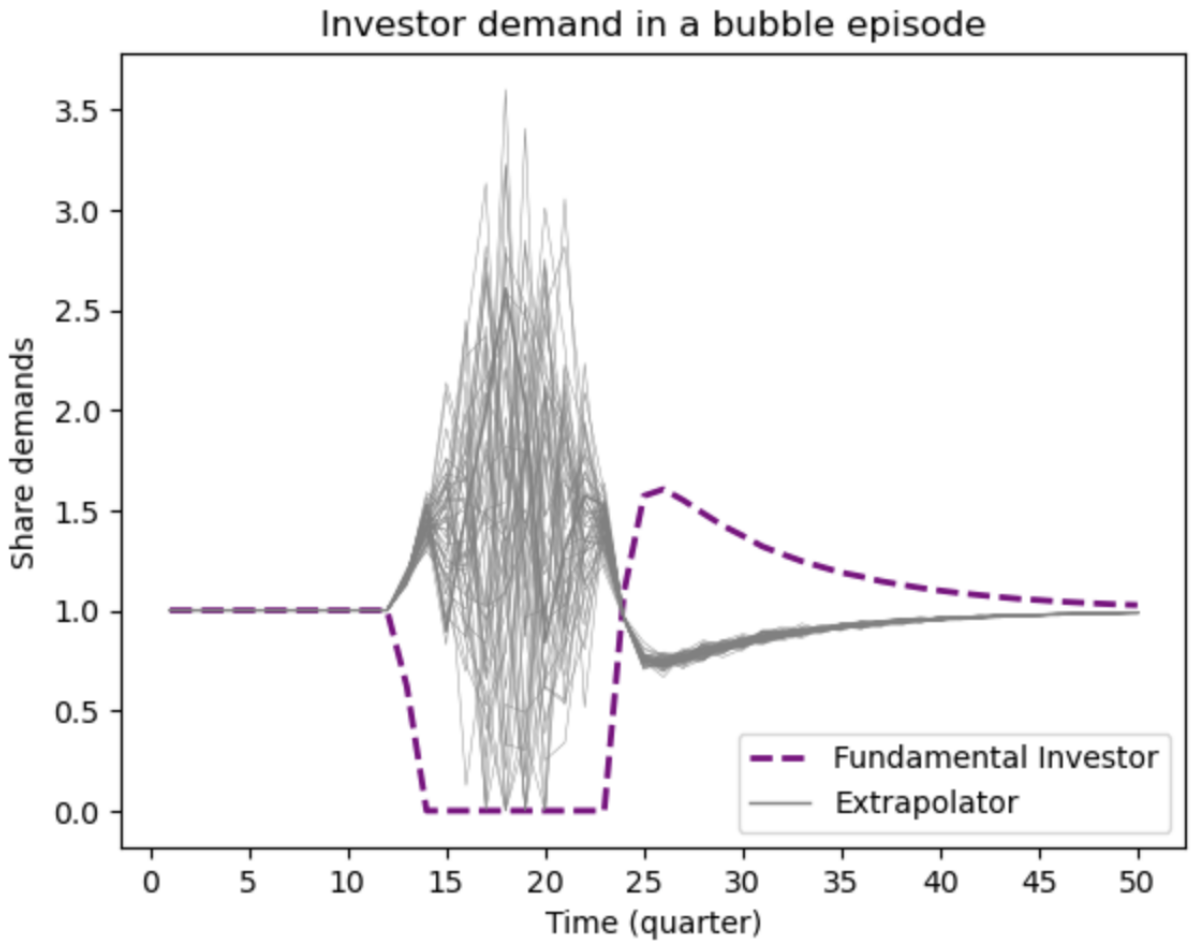


- Extrapolator enthusiasm is high during the bubble episode and decreases sharply as the price drops.

Intuition: Three stages of a bubble

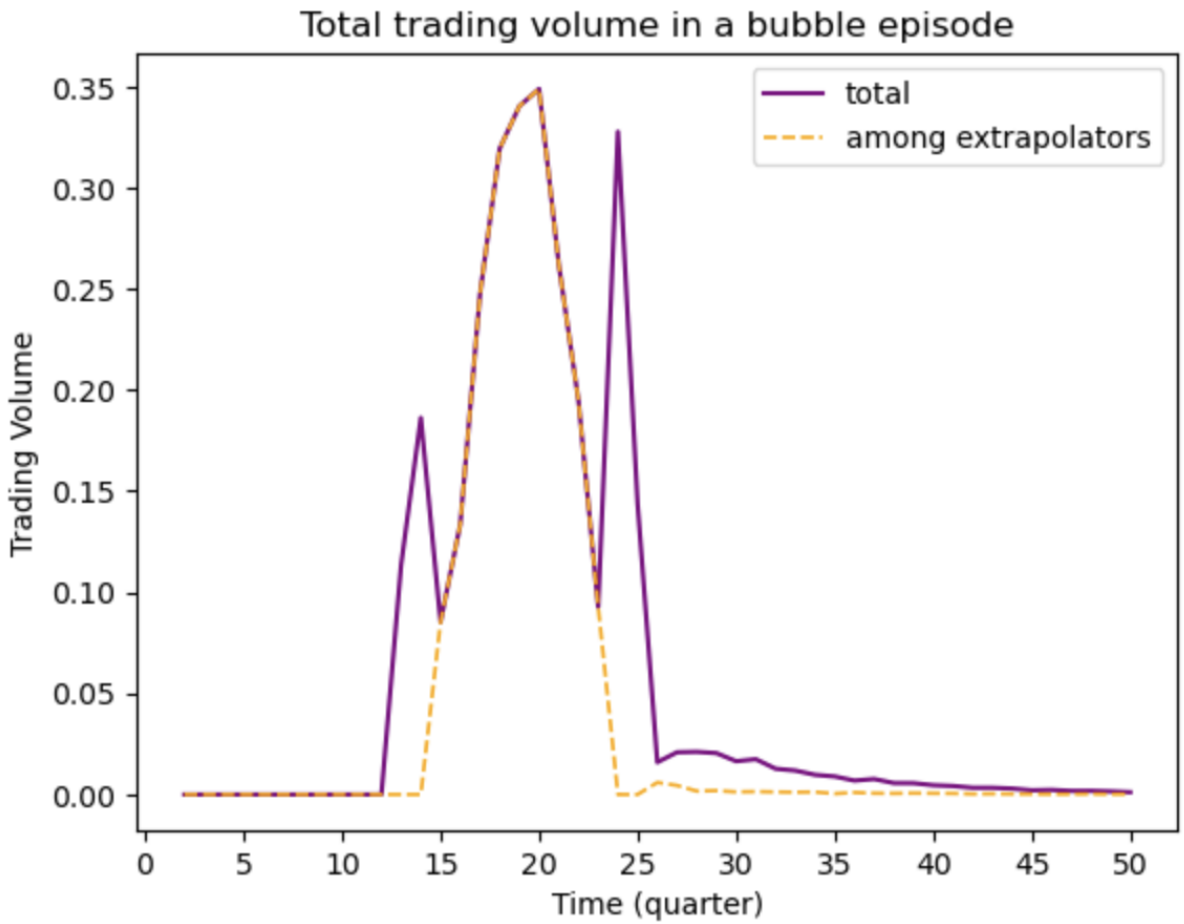
- First stage: emerge
  - Cash flow news pushes up the price of the risky asset
  - Extrapolators sharply **increase** the demand and buy from fundamental investors
- Second stage: evolve
  - High over-valuation makes fundamental investors **exit** the market
  - Extrapolators continue to trade due to wavering (more on this later)
- Third stage: deflate
  - Bubble begins to collapse as cash flow news subsides
  - Fundamental investors **re-enter** the market and buy from extrapolators

Replication: Demand in a bubble episode



- The role of **wavering**: during bubble periods, extrapolators face both high V_t and high G_t, even a slight change in weights can lead to large demand changes

Replication: Volume - the three peaks



- The role of **wavering**: during bubble periods, even a slight change in weights can lead to large demand changes $\rightarrow$ intense trading, i.e., high volume

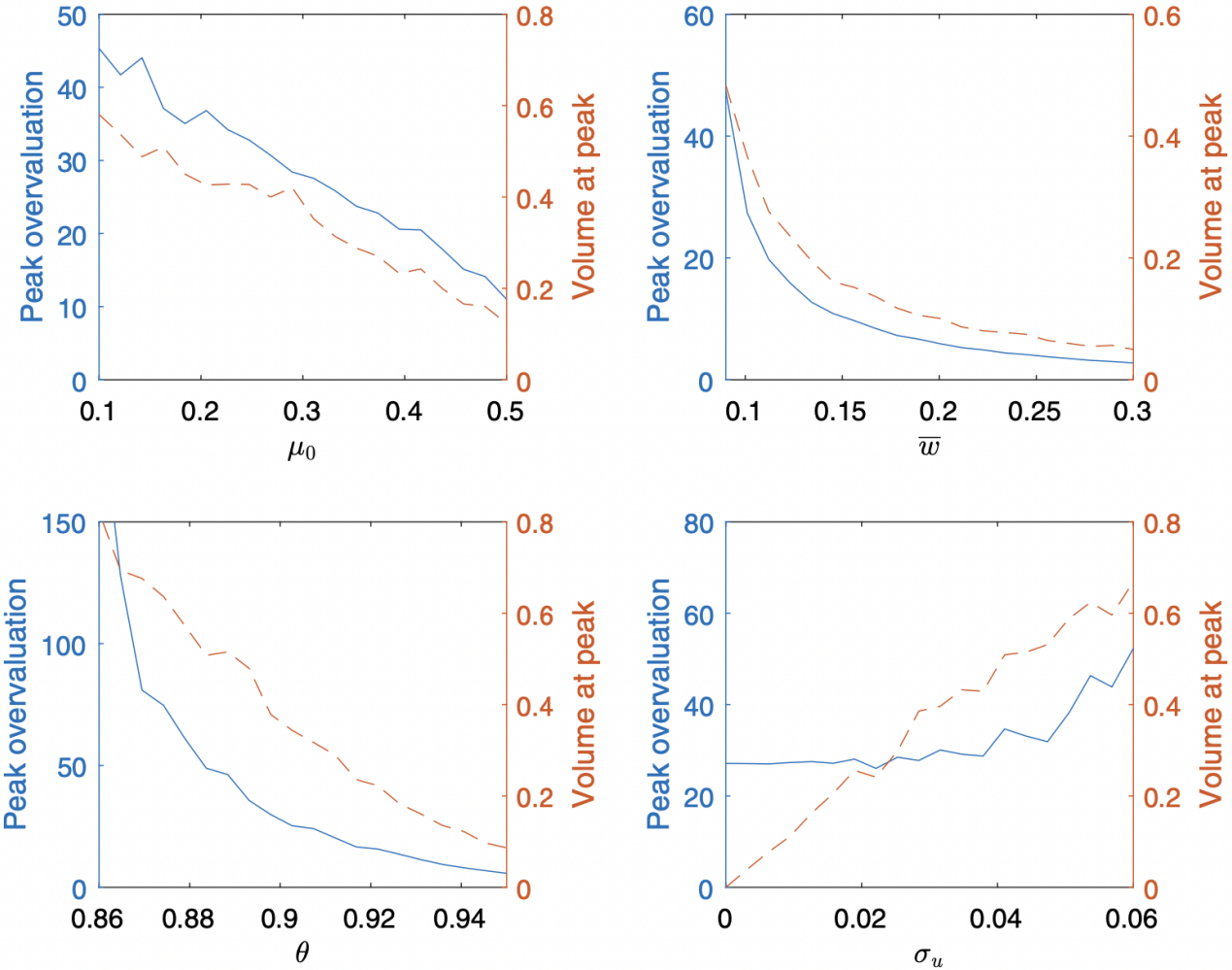
Discussion: key takeaways

- The model captures various **asset pricing patterns**
  - Formulation of bubbles: emerge after a series of intense cash flow news
  - Heavy trading volume: even during bubble episodes
  - Excessive volatility: price changes are more volatile compared to fundamental value
  - Return predictability: the difference between the price and the fundamental value predicts long-term price change
- The model provides a mechanism - **wavering** - to explain intense trading during bubbles:
  - alternative sources of heterogeneity among extrapolators, e.g., different θ and $\bar{w}_i$ do not generate as much trading volume as wavering.

Discussion: issues and possible extensions

- The model setup for investor behaviors seems a bit ad-hoc
- It remains silent on empirical facts such as rational investors 'riding the bubble' (Brunnermeier and Nagel, 2004)
- The model does not provide a concrete definition for bubbles or address their existence
- Is it realistic to assume i.i.d. wavering?
  $\rightarrow$ Perhaps extrapolators 'fear' more and thus put more weight on the value signal when the price is far from fundamental
- Can investors tell whether they are in a bubble episode?
  $\rightarrow$ If they can, we may want to model them differently in/out of a bubble

Appendix: Comparative Statics



Appendix: Why not fully rational traders?

The paper considers boundedly rational traders under short-selling constraints because this captures the main ideas in a simpler way than models with fully rational traders.
Another advantage is that it makes more realistic predictions about downturns - lower volume in 'negative bubbles'