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Discussion of 'Stock Market Volatility and Learning' by Klaus Adam, Albert Marcet and Juan Pablo Nicolini

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► To cite this version:

Philippe Weil. Discussion of 'Stock Market Volatility and Learning' by Klaus Adam, Albert Marcet and Juan Pablo Nicolini. Monetary policy, asset markets and learning, European Central Bank, Nov 2006, Frankfurt am Main, Germany. hal-03569517

HAL Id: hal-03569517

<https://sciencespo.hal.science/hal-03569517>

Submitted on 12 Feb 2022

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“Stock Market Volatility and Learning”

by K. Adams, A. Marcet & J.P. Nicolini

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Conference on Monetary Policy, Asset Prices and Learning ECB
November 6-7, 2006

Introduction

▷ Introduction

Comments

Under the hood

Fundamentals

Conclusion

- Ambitious project

Introduction

▷ Introduction

Comments

Under the hood

Fundamentals

Conclusion

- Ambitious project
- *A parti pris* of simplicity.

Introduction

▷ Introduction

Comments

Under the hood

Fundamentals

Conclusion

- Ambitious project
- *A parti pris* of simplicity.
- Nothing exotic or non-standard in the model.

Introduction

▷ Introduction

Comments

Under the hood

Fundamentals

Conclusion

- Ambitious project
- *A parti pris* of simplicity.
- Nothing exotic or non-standard in the model.
- Avoid freeing up too many parameters.

Introduction

▷ Introduction

Comments

Under the hood

Fundamentals

Conclusion

- Ambitious project
- *A parti pris* of simplicity.
- Nothing exotic or non-standard in the model.
- Avoid freeing up too many parameters.
- An determined attempt to take learning models into the mainstream of macro.

Introduction

▶ Comments

Objectives

Caveats

Gripes

Under the hood

Fundamentals

Conclusion

General comments

Objectives of the paper

Introduction

Comments

▷ Objectives

Caveats

Gripes

Under the hood

Fundamentals

Conclusion

- Show that during the (slow) process of convergence to rational expectations, an OLS learning model generates data that closely match the behavior of actual stock markets.

Objectives of the paper

Introduction

Comments

▷ Objectives

Caveats

Gripes

Under the hood

Fundamentals

Conclusion

- Show that during the (slow) process of convergence to rational expectations, an OLS learning model generates data that closely match the behavior of actual stock markets.
- Mechanism: beliefs affect prices and prices affect beliefs \implies possibility of **momentum** effect

Objectives of the paper

Introduction

Comments

▷ Objectives

Caveats

Gripes

Under the hood

Fundamentals

Conclusion

- Show that during the (slow) process of convergence to rational expectations, an OLS learning model generates data that closely match the behavior of actual stock markets.
- Mechanism: beliefs affect prices and prices affect beliefs \implies possibility of **momentum** effect
- Key result: this effect is strong during the transition to R.E., yet weak close to it.

Caveats

Introduction

Comments

Objectives

▷ Caveats

Gripes

Under the hood

Fundamentals

Conclusion

- The name of the game remains the somewhat mechanical characterization of the behavior of a stochastic non-linear difference equation.

Caveats

Introduction

Comments

Objectives

▷ Caveats

Gripes

Under the hood

Fundamentals

Conclusion

- The name of the game remains the somewhat mechanical characterization of the behavior of a stochastic non-linear difference equation.
- OLS learning rule is intuitive, has desirable properties, yet remains arbitrary. At the very least, the exogeneity of the gain sequence is problematic.

Gripes

Introduction

Comments

Objectives

Caveats

▷ Gripes

Under the hood

Fundamentals

Conclusion

- Hard to disentangle which results are general, and which are specific to the OLS learning rule

Gripes

Introduction

Comments

Objectives

Caveats

▷ Gripes

Under the hood

Fundamentals

Conclusion

- Hard to disentangle which results are general, and which are specific to the OLS learning rule
 - ▷ What is the respective contribution to the results of the paper of *each* of the essential ingredients (pricing equation, OLS learning rule)?

Introduction

Comments

Objectives

Caveats

▷ Gripes

Under the hood

Fundamentals

Conclusion

- Hard to disentangle which results are general, and which are specific to the OLS learning rule
 - ▷ What is the respective contribution to the results of the paper of *each* of the essential ingredients (pricing equation, OLS learning rule)?
 - ▷ What is the implication of the auxiliary assumption that agents have RE about dividends, and learning is only about prices?

Introduction

Comments

Objectives

Caveats

▷ Gripes

Under the hood

Fundamentals

Conclusion

- Hard to disentangle which results are general, and which are specific to the OLS learning rule
 - ▷ What is the respective contribution to the results of the paper of *each* of the essential ingredients (pricing equation, OLS learning rule)?
 - ▷ What is the implication of the auxiliary assumption that agents have RE about dividends, and learning is only about prices?
- No attention paid to the fact that, in this model, the *fundamental* value of the asset can be perfectly computed by all investors

Introduction

Comments

▶ Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

Under the hood

Simplifications

Introduction

Comments

Under the hood

▷ Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

- No dividend uncertainty: everyone knows $D_t = 1$ for all t (\implies focus on learning about *prices*).

Simplifications

Introduction

Comments

Under the hood

▷ Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

- No dividend uncertainty: everyone knows $D_t = 1$ for all t (\implies focus on learning about *prices*).
- Continuous time (\implies no exotic dynamics due to discrete time)

Simplifications

Introduction

Comments

Under the hood

▷ Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

- No dividend uncertainty: everyone knows $D_t = 1$ for all t (\implies focus on learning about *prices*).
- Continuous time (\implies no exotic dynamics due to discrete time)
- Timing: observe $p(t)$, compute $p^E(t + dt)$, observe $p(t + dt)$ etc.

Simplifications

Introduction

Comments

Under the hood

▷ Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

- No dividend uncertainty: everyone knows $D_t = 1$ for all t (\implies focus on learning about *prices*).
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- Timing: observe $p(t)$, compute $p^E(t + dt)$, observe $p(t + dt)$ etc.
- Interest rate: $r = \delta$

Simplifications

Introduction

Comments

Under the hood

▷ Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

- No dividend uncertainty: everyone knows $D_t = 1$ for all t (\implies focus on learning about *prices*).
- Continuous time (\implies no exotic dynamics due to discrete time)
- Timing: observe $p(t)$, compute $p^E(t + dt)$, observe $p(t + dt)$ etc.
- Interest rate: $r = \delta$
- No rational bubbles (e.g., Ramsey model)

Pricing equation

Introduction

Comments

Under the hood

Simplifications

▷ Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

Under risk neutrality

$$\frac{1 + \dot{p}^E}{p} = r$$

Rational expectations

Introduction

Comments

Under the hood

Simplifications

Pricing equation

▷ Rational expectations

Irrational expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{1 + \dot{p}^E}{p} = r$$

Rational expectations

Introduction

Comments

Under the hood

Simplifications

Pricing equation

▷ Rational expectations

Irrational expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{1 + \dot{p}^E}{p} = r$$

- Perfect foresight on prices: $\dot{p}^F = \dot{p}$.

Rational expectations

Introduction

Comments

Under the hood

Simplifications

Pricing equation

▷ Rational expectations

Irrational expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{1 + \dot{p}^E}{p} = r$$

- Perfect foresight on prices: $\dot{p}^F = \dot{p}$.
- If there are no bubbles, the RE price is $p = 1/r$.

Rational expectations

Introduction

Comments

Under the hood

Simplifications

Pricing equation

▷ Rational expectations

Irrational expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{1 + \dot{p}^E}{p} = r$$

- Perfect foresight on prices: $\dot{p}^F = \dot{p}$.
- If there are no bubbles, the RE price is $p = 1/r$.
- Investors rationally expect

$$\dot{p}^E / p = 0$$

Irrational expectations

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

▷ Irrational
expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{1 + \dot{p}^E}{p} = r$$

Irrational expectations

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

▷ Irrational
expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{1 + \dot{p}^E}{p} = r$$

- Assume that people irrationally expect

$$\dot{p}^E / p = \beta, \quad \beta < r.$$

Irrational expectations

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

▷ Irrational
expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{1 + \dot{p}^E}{p} = r$$

- Assume that people irrationally expect

$$\dot{p}^E / p = \beta, \quad \beta < r.$$

- Then $p = 1/(r - \beta)$.

Irrational expectations

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

▷ Irrational expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{1 + \dot{p}^E}{p} = r$$

- Assume that people irrationally expect

$$\dot{p}^E / p = \beta, \quad \beta < r.$$

- Then $p = 1/(r - \beta)$.
- Actual price growth is

$$\dot{p} / p = p \dot{\beta} = \dot{\beta} / (r - \beta).$$

Irrational expectations

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

▷ Irrational expectations

Two important results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{1 + \dot{p}^E}{p} = r$$

- Assume that people irrationally expect

$$\dot{p}^E / p = \beta, \quad \beta < r.$$

- Then $p = 1/(r - \beta)$.
- Actual price growth is

$$\dot{p} / p = p\dot{\beta} = \dot{\beta} / (r - \beta).$$

- Hence both the *level* and *rate of change* of price-growth expectations determine actual growth. **General result**

Two important results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

▷ Two important
results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{\dot{p}}{p} = p\dot{\beta} = \frac{1}{r - \beta}\dot{\beta}$$

- Price growth generated by the learning model exceeds the fundamental growth rate ($\dot{p}/p > 0$) if growth expectations are increasingly bullish ($\dot{\beta} > 0$).

Two important results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

▷ Two important
results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{\dot{p}}{p} = p\dot{\beta} = \frac{1}{r - \beta}\dot{\beta}$$

- Price growth generated by the learning model exceeds the fundamental growth rate ($\dot{p}/p > 0$) if growth expectations are increasingly bullish ($\dot{\beta} > 0$).
- If the current price is high (β close to r), then even a small degree of bearishness ($\dot{\beta} < 0$) can cause a huge price collapse. When the current price is low, $\dot{\beta}$ does not have a large influence on prices.

Two important results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

▷ Two important
results

Learning rule

More results

Moral

Fundamentals

Conclusion

$$\frac{\dot{p}}{p} = p\dot{\beta} = \frac{1}{r - \beta}\dot{\beta}$$

- Price growth generated by the learning model exceeds the fundamental growth rate ($\dot{p}/p > 0$) if growth expectations are increasingly bullish ($\dot{\beta} > 0$).
- If the current price is high (β close to r), then even a small degree of bearishness ($\dot{\beta} < 0$) can cause a huge price collapse. When the current price is low, $\dot{\beta}$ does not have a large influence on prices.

But these are simply **results 1 and 4** in the paper!

Two important results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

▷ Two important
results

Learning rule

More results

Moral

Fundamentals

Conclusion

- They do not depend on the OLS learning rule, on the randomness of dividends or on discrete time.

Two important results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

▷ Two important
results

Learning rule

More results

Moral

Fundamentals

Conclusion

- They do not depend on the OLS learning rule, on the randomness of dividends or on discrete time.
- They can be for sure be extended to a stochastic discount factor.

Two important results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

▷ Two important
results

Learning rule

More results

Moral

Fundamentals

Conclusion

- They do not depend on the OLS learning rule, on the randomness of dividends or on discrete time.
- They can be for sure be extended to a stochastic discount factor.
- They are **general**.

Learning rule

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

▷ Learning rule

More results

Moral

Fundamentals

Conclusion

- Assume β is updated according to

$$\dot{\beta} = \theta \left(\frac{\dot{p}}{p} - \beta \right) \quad \theta > 0.$$

Learning rule

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

▷ Learning rule

More results

Moral

Fundamentals

Conclusion

- Assume β is updated according to

$$\dot{\beta} = \theta \left(\frac{\dot{p}}{p} - \beta \right) \quad \theta > 0.$$

- Now remember that from the pricing condition

$$\frac{\dot{p}}{p} = \frac{1}{r - \beta} \dot{\beta}.$$

Learning rule

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational expectations

Two important results

▷ Learning rule

More results

Moral

Fundamentals

Conclusion

- Assume β is updated according to

$$\dot{\beta} = \theta \left(\frac{\dot{p}}{p} - \beta \right) \quad \theta > 0.$$

- Now remember that from the pricing condition

$$\frac{\dot{p}}{p} = \frac{1}{r - \beta} \dot{\beta}.$$

- Hence

$$\dot{\beta} = -\theta' \beta, \quad \theta' = \frac{\theta}{1 - \frac{\theta}{r - \beta}}$$

More results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

▷ More results

Moral

Fundamentals

Conclusion

$$\dot{\beta} = -\theta' \beta, \quad \theta' = \frac{\theta}{1 - \frac{\theta}{r - \beta}}$$

More results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

▷ More results

Moral

Fundamentals

Conclusion

$$\dot{\beta} = -\theta' \beta, \quad \theta' = \frac{\theta}{1 - \frac{\theta}{r-\beta}}$$

- In the *long run*, the gain θ is small, so $\theta' \approx \theta > 0$: convergence to RE ($\beta \rightarrow 0$).

More results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational expectations

Two important results

Learning rule

▷ More results

Moral

Fundamentals

Conclusion

$$\dot{\beta} = -\theta' \beta, \quad \theta' = \frac{\theta}{1 - \frac{\theta}{r - \beta}}$$

- In the *long run*, the gain θ is small, so $\theta' \approx \theta > 0$: convergence to RE ($\beta \rightarrow 0$).
- But in the *short run*, the gain θ is large so that we can have $\theta' < 0$ if

$$r > \beta > r - \theta.$$

More results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational expectations

Two important results

Learning rule

▷ More results

Moral

Fundamentals

Conclusion

$$\dot{\beta} = -\theta' \beta, \quad \theta' = \frac{\theta}{1 - \frac{\theta}{r - \beta}}$$

- In the *long run*, the gain θ is small, so $\theta' \approx \theta > 0$: convergence to RE ($\beta \rightarrow 0$).
- But in the *short run*, the gain θ is large so that we can have $\theta' < 0$ if

$$r > \beta > r - \theta.$$

- If this inequality is verified, anything that throws β off its (zero) SS RE value is reinforced in the short run by self-referential learning: **momentum, bubbles.**

More results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

▷ More results

Moral

Fundamentals

Conclusion

- The paper assumes $\beta_0 = 0$ and relies on small dividend shocks to move β away from zero right away (big initial gain).

More results

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

▷ More results

Moral

Fundamentals

Conclusion

- The paper assumes $\beta_0 = 0$ and relies on small dividend shocks to move β away from zero right away (big initial gain).
- The alternative (followed here) is to eliminate shocks and allow $\beta_0 \neq 0$.

Moral

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

▷ Moral

Fundamentals

Conclusion

- What does the stripped-down model teaches us about the paper?

Moral

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

▷ Moral

Fundamentals

Conclusion

- What does the stripped-down model teaches us about the paper?
 - ▷ Results 1 and 4 are very robust.

Moral

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

▷ Moral

Fundamentals

Conclusion

- What does the stripped-down model teaches us about the paper?
 - ▷ Results 1 and 4 are very robust.
 - ▷ Other results (momentum, bubbles) intimately linked to shape of learning rule, i.e. more fragile.

Moral

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

▷ Moral

Fundamentals

Conclusion

- What does the stripped-down model teaches us about the paper?
 - ▷ Results 1 and 4 are very robust.
 - ▷ Other results (momentum, bubbles) intimately linked to shape of learning rule, i.e. more fragile.
- What the stripped-down model teaches us more generally about learning and stock prices?

Moral

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

▷ Moral

Fundamentals

Conclusion

- What does the stripped-down model teaches us about the paper?
 - ▷ Results 1 and 4 are very robust.
 - ▷ Other results (momentum, bubbles) intimately linked to shape of learning rule, i.e. more fragile.
- What the stripped-down model teaches us more generally about learning and stock prices?
 - ▷ Short- and long-run stability properties of learning rules may differ a lot.

Moral

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

▷ Moral

Fundamentals

Conclusion

- What does the stripped-down model teaches us about the paper?
 - ▷ Results 1 and 4 are very robust.
 - ▷ Other results (momentum, bubbles) intimately linked to shape of learning rule, i.e. more fragile.
- What the stripped-down model teaches us more generally about learning and stock prices?
 - ▷ Short- and long-run stability properties of learning rules may differ a lot.
 - ▷ Crucial role of decreasing gain.

Introduction

Comments

Under the hood

Simplifications

Pricing equation

Rational expectations

Irrational
expectations

Two important results

Learning rule

More results

▷ Moral

Fundamentals

Conclusion

- What does the stripped-down model teaches us about the paper?
 - ▷ Results 1 and 4 are very robust.
 - ▷ Other results (momentum, bubbles) intimately linked to shape of learning rule, i.e. more fragile.
- What the stripped-down model teaches us more generally about learning and stock prices?
 - ▷ Short- and long-run stability properties of learning rules may differ a lot.
 - ▷ Crucial role of decreasing gain.
 - ▷ The shape of the learning rule is key to understanding how small dividend shocks interact, on impact, with learning to produce big movements in prices.

Introduction

Comments

Under the hood

▶ Fundamentals

Crashes

Bubbles

Conclusion

Fundamentals

Crashes

Introduction

Comments

Under the hood

Fundamentals

▷ Crashes

Bubbles

Conclusion

- The model predicts that stock market crashes are possible.

Crashes

Introduction

Comments

Under the hood

Fundamentals

▷ Crashes

Bubbles

Conclusion

- The model predicts that stock market crashes are possible.
- Problem: the price cannot fall below its fundamental value $1/r$:

Crashes

Introduction

Comments

Under the hood

Fundamentals

▷ Crashes

Bubbles

Conclusion

- The model predicts that stock market crashes are possible.
- Problem: the price cannot fall below its fundamental value $1/r$:
 - ▷ Proof: stock = ownership of dividends + right to resell. Value of the latter non-negative under free disposal.

Crashes

Introduction

Comments

Under the hood

Fundamentals

▷ Crashes

Bubbles

Conclusion

- The model predicts that stock market crashes are possible.
- Problem: the price cannot fall below its fundamental value $1/r$:
 - ▷ Proof: stock = ownership of dividends + right to resell. Value of the latter non-negative under free disposal.
 - ▷ Hence the fundamental (**which the paper assumes can be calculated**) is a lower bound on prices.

Crashes

Introduction

Comments

Under the hood

Fundamentals

▷ Crashes

Bubbles

Conclusion

- The model predicts that stock market crashes are possible.
- Problem: the price cannot fall below its fundamental value $1/r$:
 - ▷ Proof: stock = ownership of dividends + right to resell. Value of the latter non-negative under free disposal.
 - ▷ Hence the fundamental (**which the paper assumes can be calculated**) is a lower bound on prices.
 - ▷ The argument goes through for any holding period T (e.g., in an OLG model). We must have

$$p_t \geq \int_t^{t+T} e^{-r(s-t)} D_s ds.$$

Crashes

Introduction

Comments

Under the hood

Fundamentals

▷ Crashes

Bubbles

Conclusion

- The model predicts that stock market crashes are possible.
- Problem: the price cannot fall below its fundamental value $1/r$:
 - ▷ Proof: stock = ownership of dividends + right to resell. Value of the latter non-negative under free disposal.
 - ▷ Hence the fundamental (**which the paper assumes can be calculated**) is a lower bound on prices.
 - ▷ The argument goes through for any holding period T (e.g., in an OLG model). We must have

$$p_t \geq \int_t^{t+T} e^{-r(s-t)} D_s ds.$$

- Moral: to understand price crashes, one needs a model in which the fundamental i) must be learned and ii) can crash.

Bubbles

Introduction

Comments

Under the hood

Fundamentals

Crashes

▷ Bubbles

Conclusion

- Uneasy feeling about bubble-like phenomena in the model.

Bubbles

Introduction

Comments

Under the hood

Fundamentals

Crashes

▷ Bubbles

Conclusion

- Uneasy feeling about bubble-like phenomena in the model.
- The Timmerman and Cogley-Sargent *projection facility* ($\dot{\beta} = 0$ when $\beta > r$) that is used to keep $\beta < r$ and prices positive is ad hoc:

Bubbles

Introduction

Comments

Under the hood

Fundamentals

Crashes

▷ Bubbles

Conclusion

- Uneasy feeling about bubble-like phenomena in the model.
- The Timmerman and Cogley-Sargent *projection facility* ($\dot{\beta} = 0$ when $\beta > r$) that is used to keep $\beta < r$ and prices positive is ad hoc:
- Justification: eliminates “crazy” actions and phenomena.

Bubbles

Introduction

Comments

Under the hood

Fundamentals

Crashes

▷ Bubbles

Conclusion

- Uneasy feeling about bubble-like phenomena in the model.
- The Timmerman and Cogley-Sargent *projection facility* ($\dot{\beta} = 0$ when $\beta > r$) that is used to keep $\beta < r$ and prices positive is ad hoc:
- Justification: eliminates “crazy” actions and phenomena.
 - ▷ Rationality is creeping in through the backdoor.

Bubbles

Introduction

Comments

Under the hood

Fundamentals

Crashes

▷ Bubbles

Conclusion

- Uneasy feeling about bubble-like phenomena in the model.
- The Timmerman and Cogley-Sargent *projection facility* ($\dot{\beta} = 0$ when $\beta > r$) that is used to keep $\beta < r$ and prices positive is ad hoc:
- Justification: eliminates “crazy” actions and phenomena.
 - ▷ Rationality is creeping in through the backdoor.
 - ▷ Dangerous argument: why don’t agents compare price growth (which is hard to predict) to dividend growth (which is easy to predict)? Why don’t they know it is “crazy” that prices move more than dividends?

Bubbles

Introduction

Comments

Under the hood

Fundamentals

Crashes

▷ Bubbles

Conclusion

- Uneasy feeling about bubble-like phenomena in the model.
- The Timmerman and Cogley-Sargent *projection facility* ($\dot{\beta} = 0$ when $\beta > r$) that is used to keep $\beta < r$ and prices positive is ad hoc:
- Justification: eliminates “crazy” actions and phenomena.
 - ▷ Rationality is creeping in through the backdoor.
 - ▷ Dangerous argument: why don’t agents compare price growth (which is hard to predict) to dividend growth (which is easy to predict)? Why don’t they know it is “crazy” that prices move more than dividends?
- Moral: use economic arguments instead (TVC condition probably rules out equilibria with $\dot{p}^E / p = \beta > r$).

Introduction

Comments

Under the hood

Fundamentals

▶ Conclusion

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Fundamentals

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Introduction

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Under the hood

Fundamentals

Conclusion

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Introduction

Comments

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Fundamentals

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- A thought-provoking paper that tries to play the asset pricing game without affording itself extra degrees of freedom.
- It should be possible to go further by disentangling what is general from what is specific to the learning rule and what comes from auxiliary modeling assumptions.
- Generalize H-J bounds to learning economies?