Adjustment Dynamics During a Strategic Estimation Task

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Introduction

- Central issue in macro & finance: modeling how expectations are formed in strategic environments
  - *e.g.* pricing complementarities are important contributor to both amplification & persistence in monetary models

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- Central issue in macro & finance: modeling how expectations are formed in strategic environments
  - *e.g.* pricing complementarities are important contributor to both amplification & persistence in monetary models
- The rational expectations modeling standard:
  - economic agents are forward-looking & think through the consequences of their own actions and those of others
  - they incorporate optimally all information and make no systematic errors
  - they believe that all other agents behave in the same way

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  - used to acquire the knowledge needed for economic decisions
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- Alternative view: deviations from RE benchmark predictions occur because agents economize on cognitive resources
  - used to acquire the knowledge needed for economic decisions
  - and to think through the actions of others
- We use a controlled laboratory experiment to study
  - information processing, namely response to news about the fundamental
  - strategic sophistication, namely extent to which behavior incorporates attempts to predict the forecasts of other subjects in the session
  - eductive versus inductive reasoning

The Experiment

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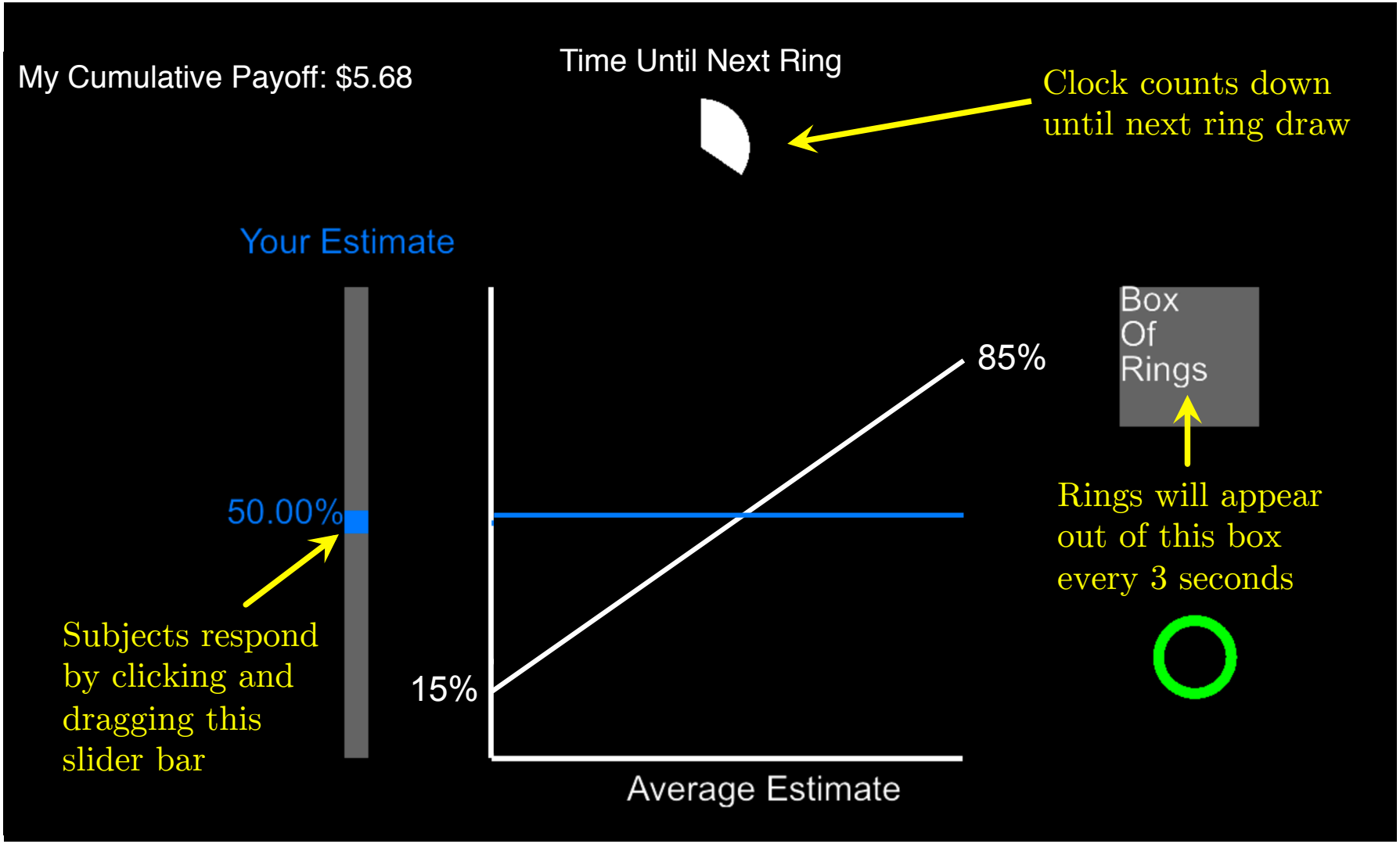
- We show subjects the optimal forecast as a function of their beliefs about other players' forecasts
- Subjects have all the info needed to compute the RE forecast
- We find that average and individual responses converge slowly to theoretical equilibria, and forecasts are noisy and biased
- Behavior is too heterogeneous to be described by single rule

The Experimental Task

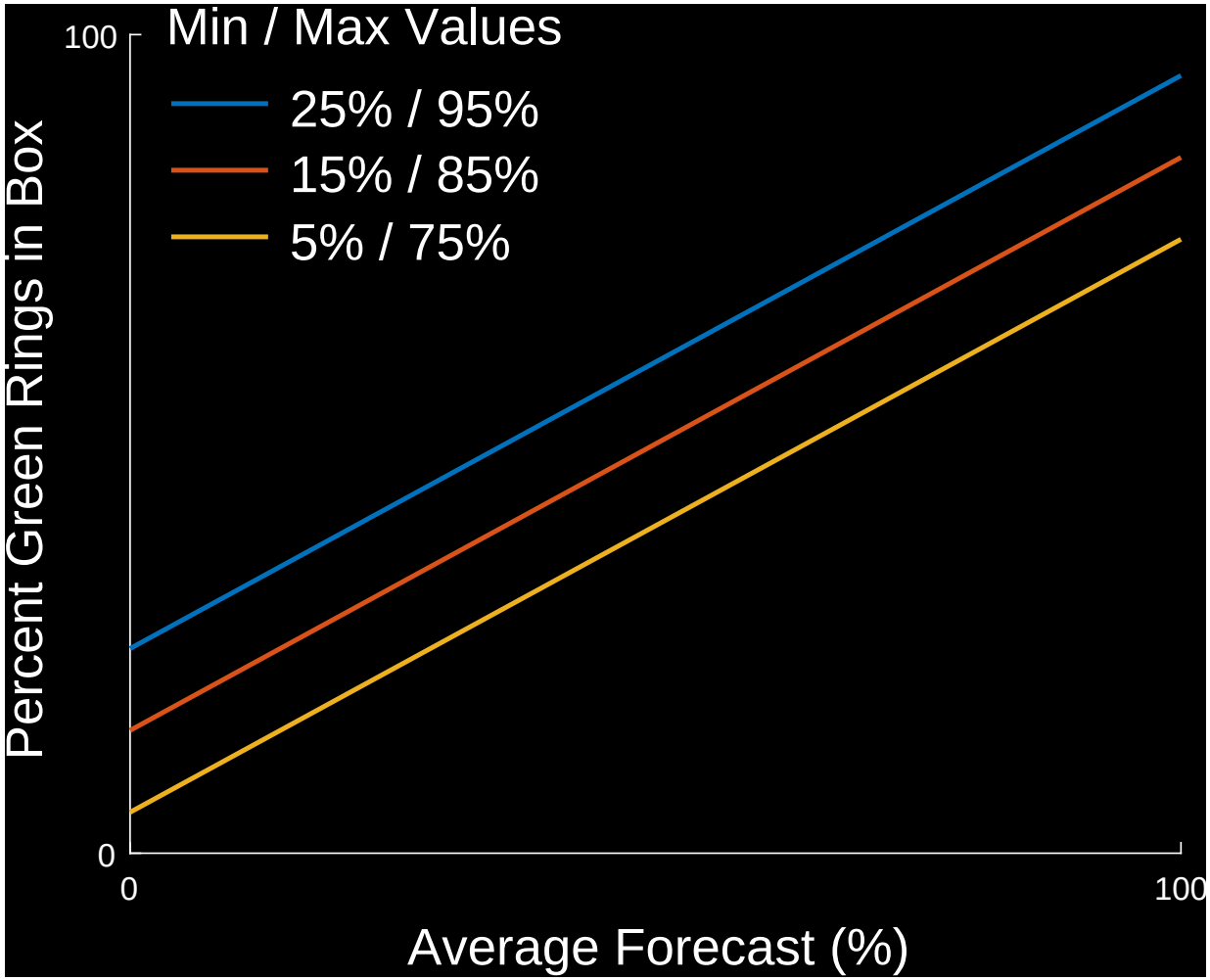


what the subjects see

Timing

1. An initial exogenous intercept z is realized
2. The best response function for the current value of z is displayed
3. Subjects have three seconds to adjust their forecasts
4. A virtual box is formed with the % of green rings given by the best response function shown and subjects' forecasts at the end of the 3-second interval
5. A ring is drawn from the box, and players' scores are updated
6. With probability $\delta = 0.005$, a new value of z is drawn and with probability $(1 - \delta)$, z remains unchanged, and the session continues with step 2

Data-Generating Process



possible states

Data-Generating Process

- Percentage of green rings depends in part on the average forecast of all players in the session

$$p = z + \alpha \widehat{P}$$

- Initial z drawn from uniform on $Z = \{0.05,\ 0.15,\ 0.25\}$
- After each ring draw, probability $\delta = 0.005$ of an intercept shift
  - if no shift, $z_{t+1} = z_t$
  - if shift, z_{t+1} is another independent draw from Z

Reward Function for Subjects

- Each time a ring is drawn, earn

$$1 - (s - \hat{p})^2 \text{ points}$$

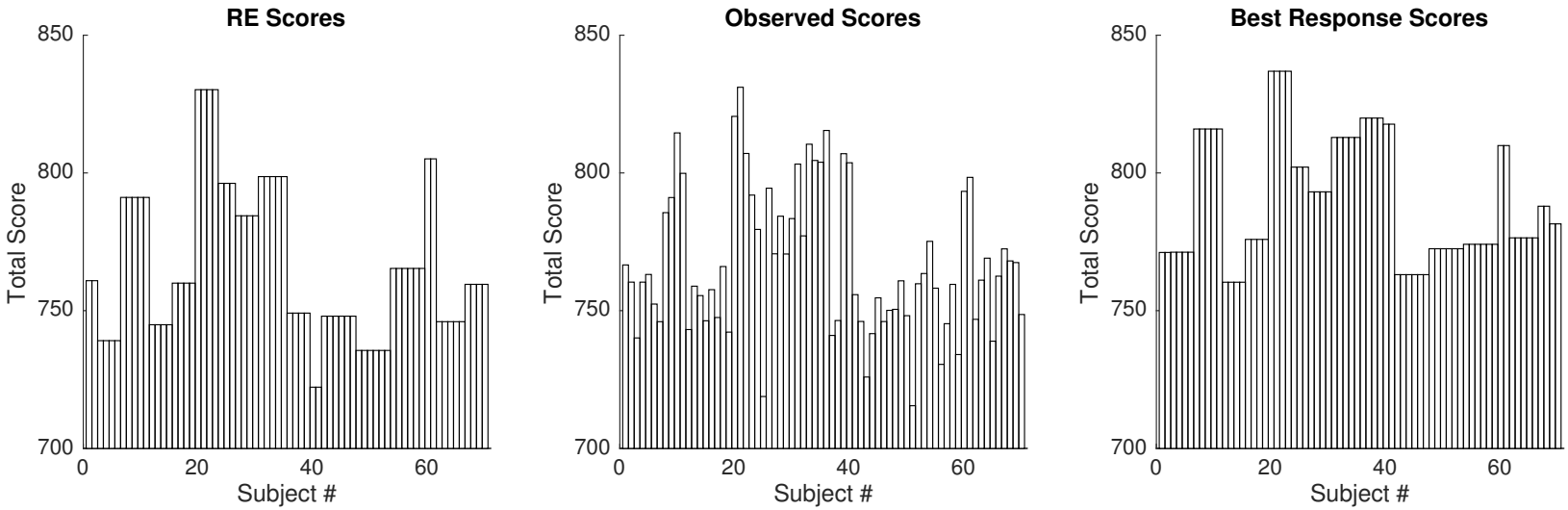
where s is the ring draw, equal to 1 if green and 0 if red and $\hat{p}$ is current slider position

- Implication: if believe that green ring will be drawn with probability p, max expected reward by setting

$$\hat{p} = p = \arg \max_r p[1 - (1 - r)^2] + (1 - p)[1 - r^2]$$

- Reward function & optimal decision rule are explained to subjects

Performance



RE: score of hypothetical RE subject given group behavior
Observed: score earned by our subjects
Best Response: score if knew the hidden proba, given group

Patterns of Adjustment

- RE model predicts that when the exogenous state changes
  - all subjects adjust immediately to new equilibrium
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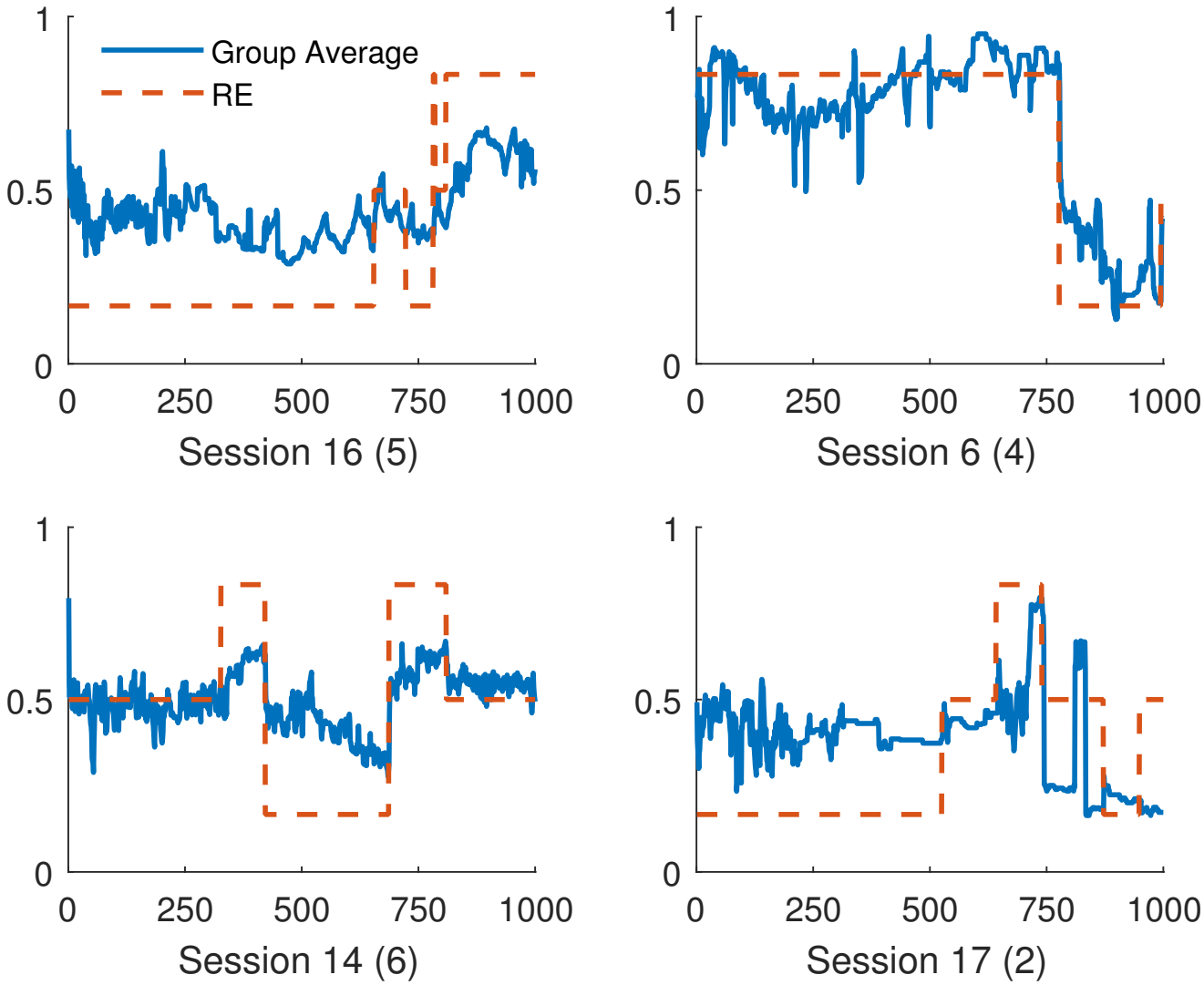
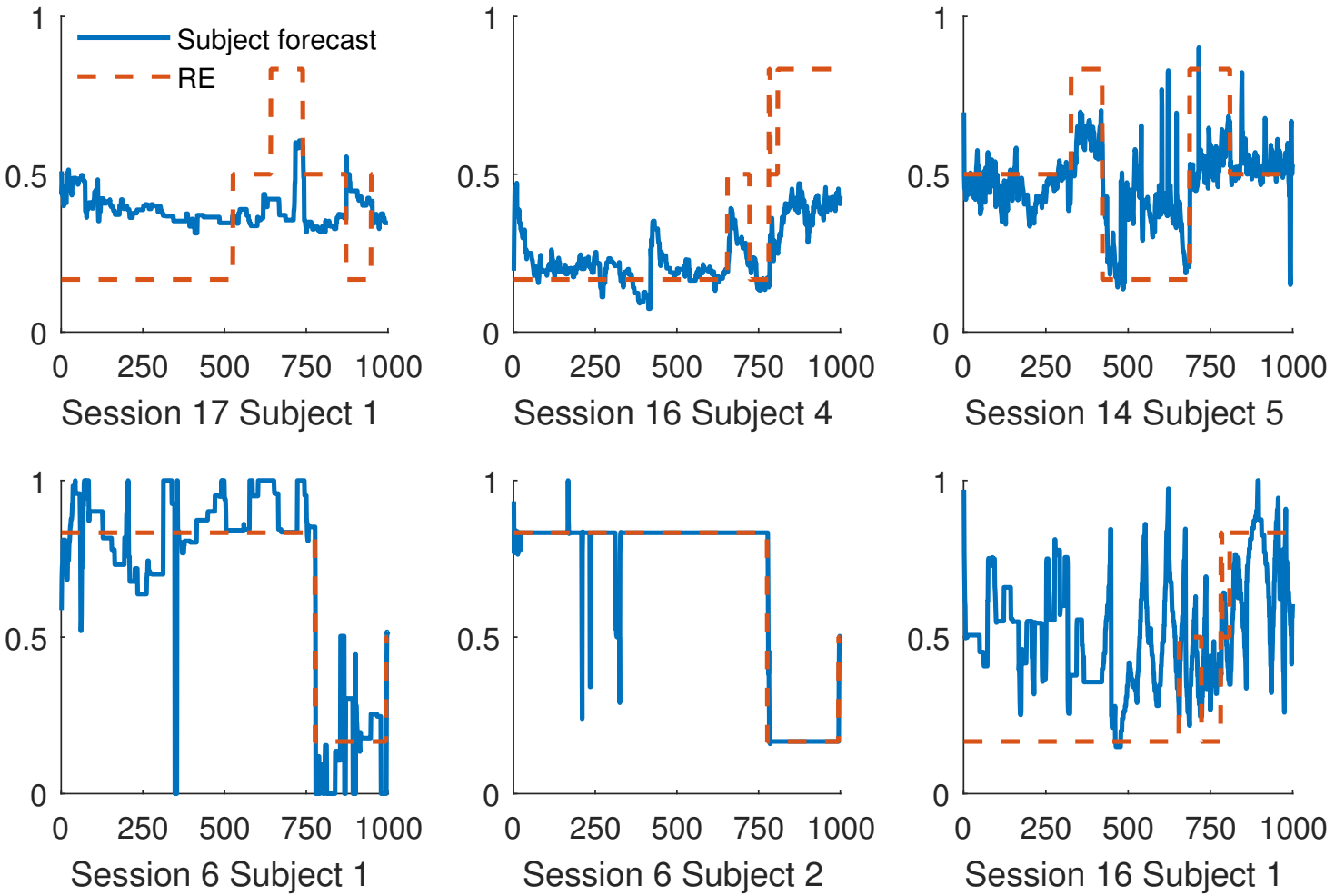
- RE model predicts that when the exogenous state changes
  - all subjects adjust immediately to new equilibrium
  - there is no further adjustment after the initial response
- Subjects are shown the intercept and the slope of the best response function
  - we can see if they use this information
  - we can analyze their beliefs about the forecasts of others

Examples of the Data: Group Averages



forecasts are noisy, biased, and respond incompletely

Examples of the Data: Individual Subjects

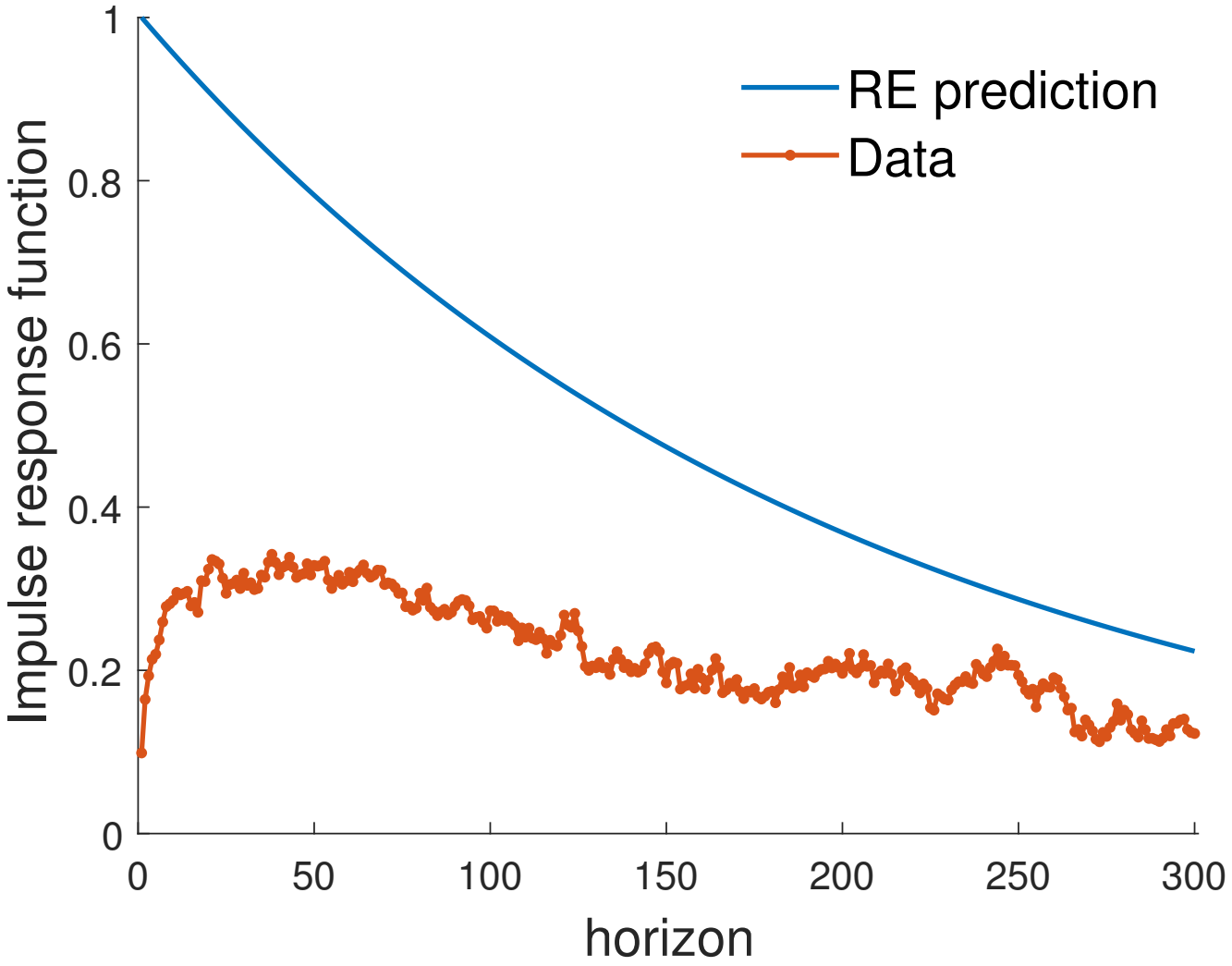


forecasts are noisy and heterogeneous

Summary Statistics

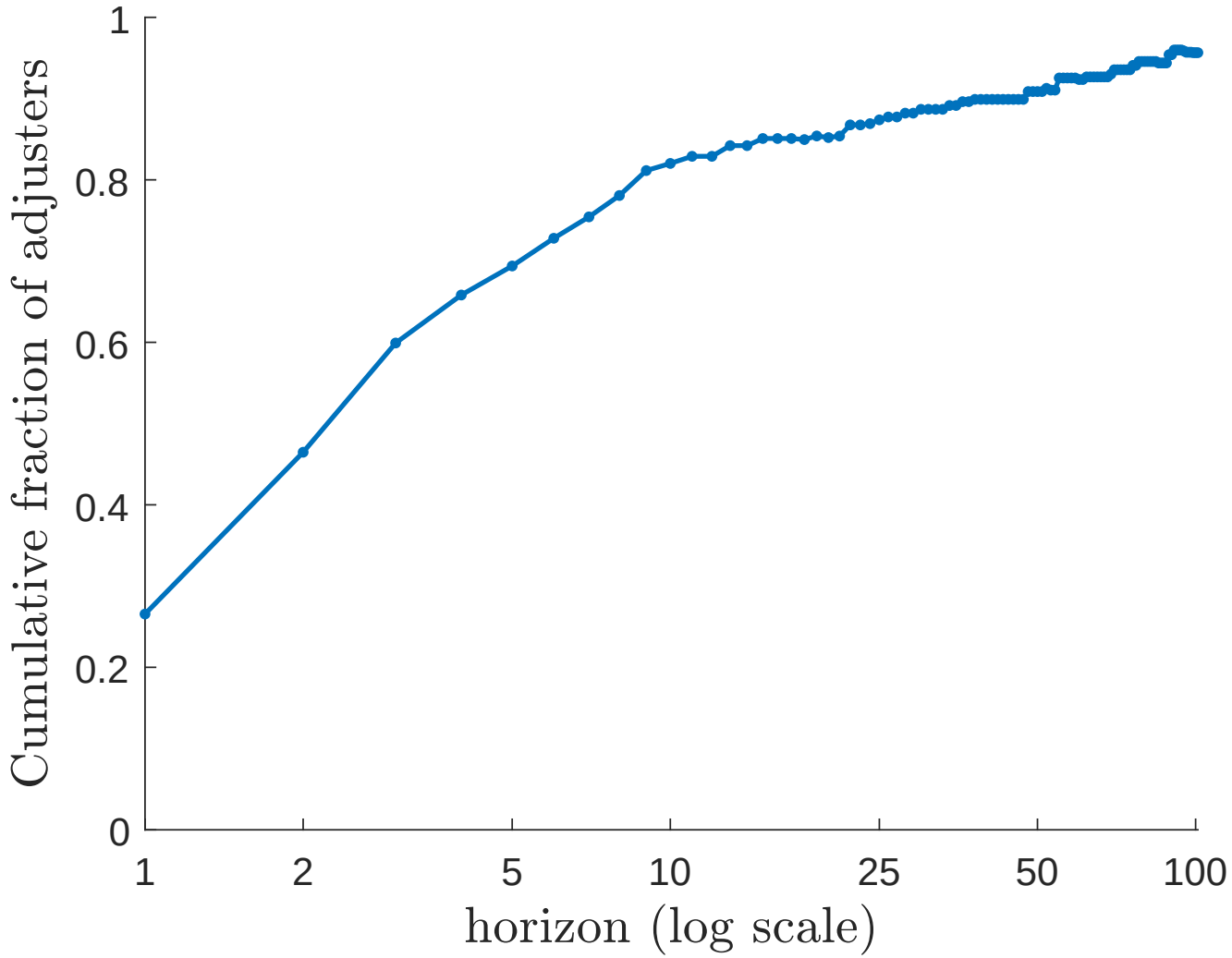
Mean size of gap between group forecast and RE forecast	8.5%
Mean absolute size of gap between group and RE forecast	16.5%
Mean absolute size of gap between individual and RE forecast	19.4%
Standard deviation of gap between individual and RE forecast	24.1%

Dynamics of Adjustment to Intercept Shift



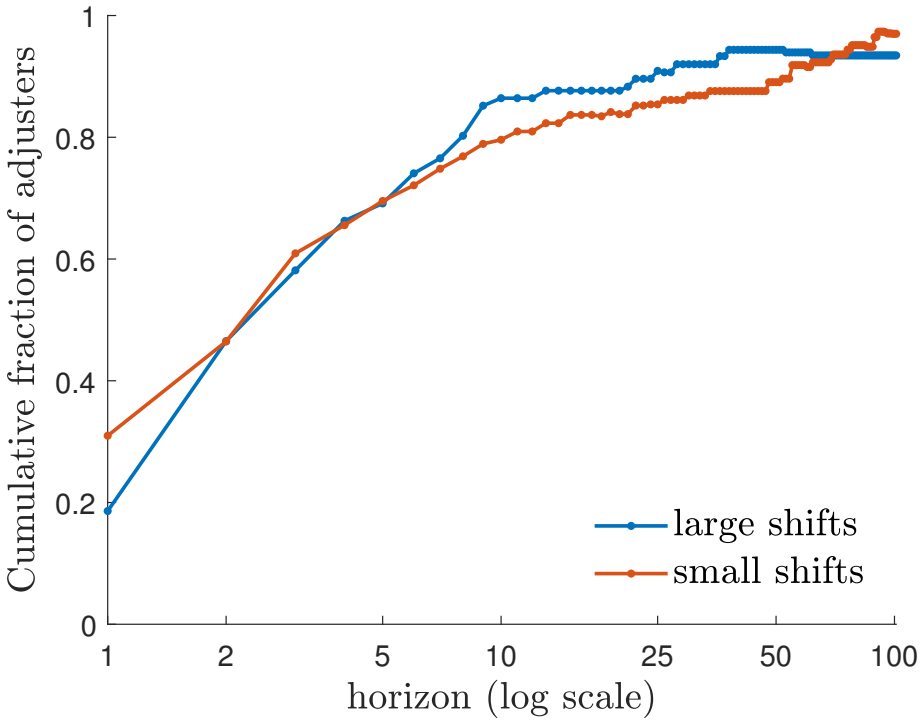
very incomplete, sluggish adjustment

Cumulative Fraction of Adjusters

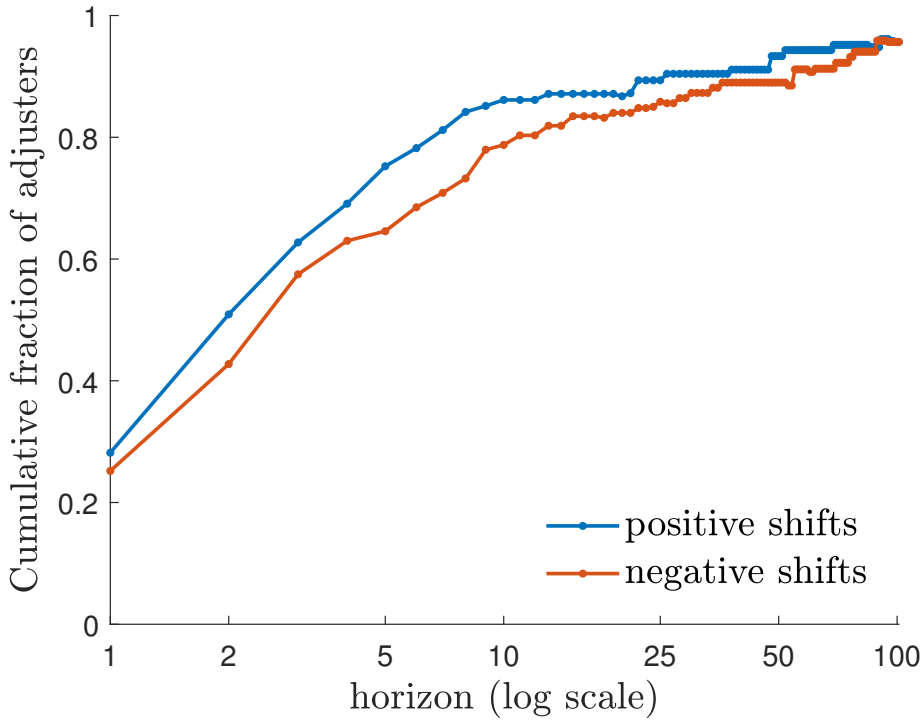


RE model predicts 100% on impact

Cumulative Fraction of Adjusters



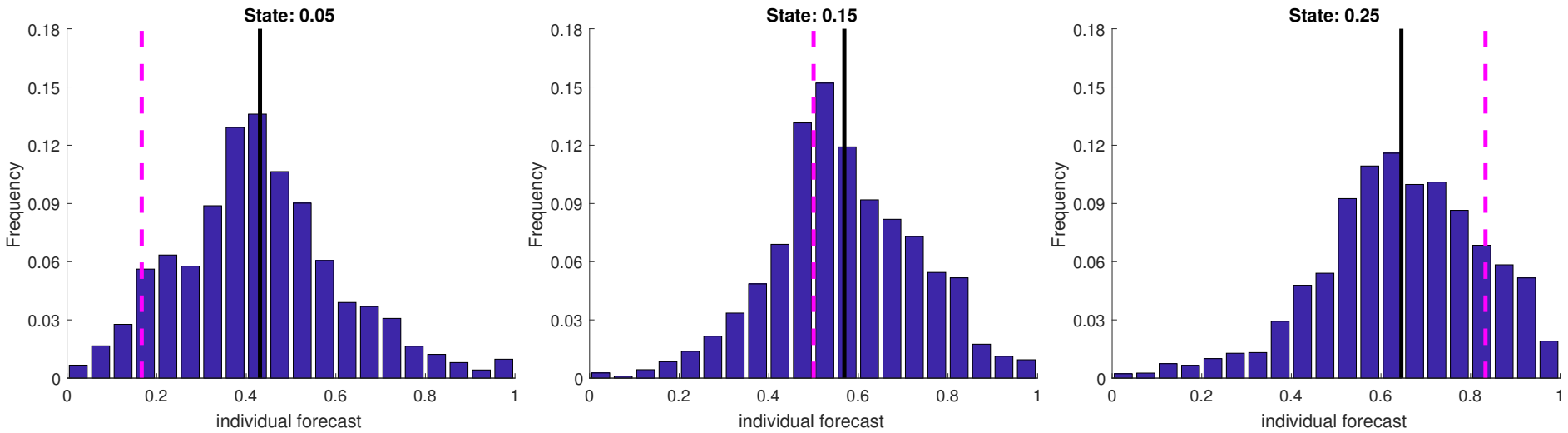
By size



By sign

slightly faster adjustment to large and to positive shocks

Forecast Dispersion Conditional on Adjustment



dispersed distribution of forecasts conditional on adjustment

black line is data average, magenta is RE forecast

Strategies for Responding to the Fundamental

- 64% of subjects: best fitting rule (minimizing MSE) is simple deductive level-0 rule
  - linear function of the history of ring realizations estimated at the subject level
  - no strategic considerations or discrete response to intercept shift
- The level-0 "ring watchers" generate gradual adjustment
- They exhibit large heterogeneity in the sensitivity to the ring history and hence a wide range of accuracy levels

Strategies for Responding to the Fundamental

- For 24% of our subjects the best fitting rule is level 1
  - respond to intercept but assume others set forecast based on history of rings
  - forecast of others based on subject-level estimate
  - most simplistic form of strategic thinking

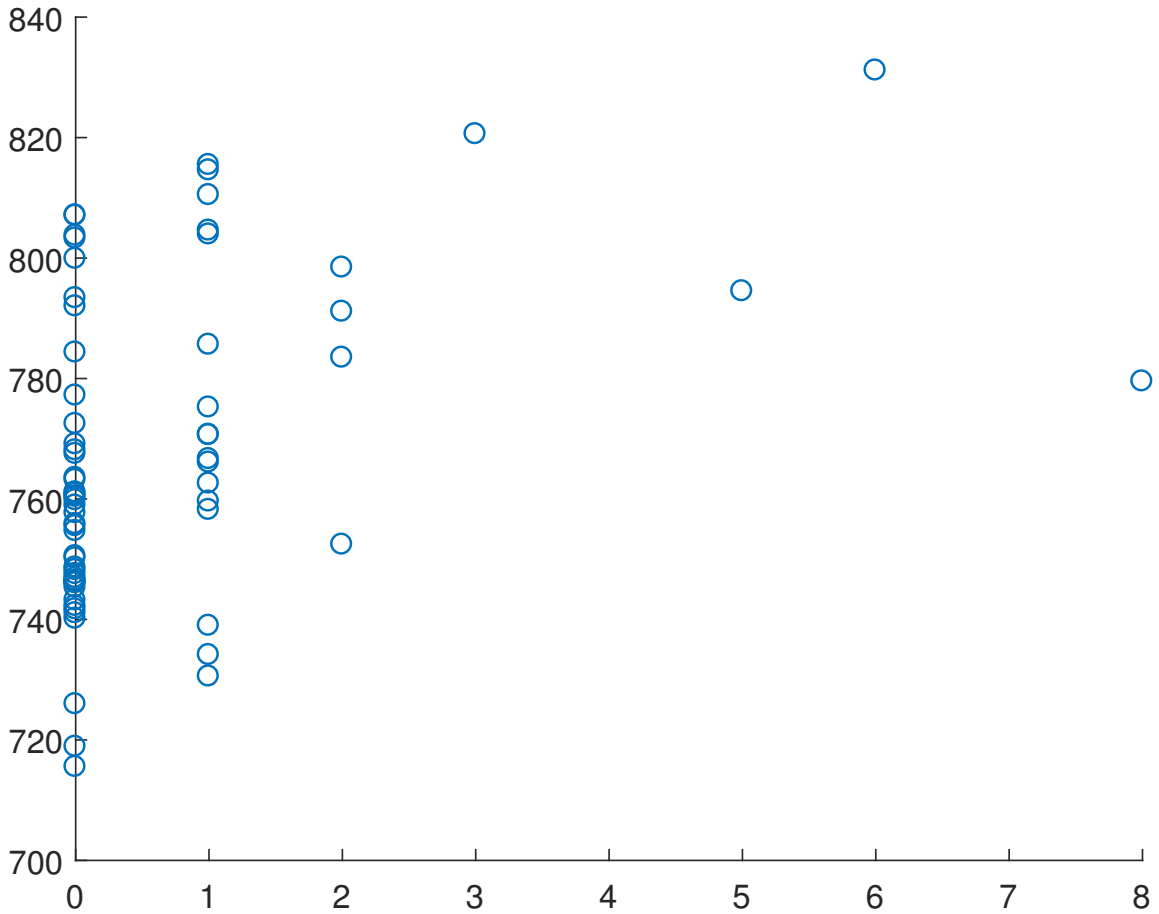
Strategies for Responding to the Fundamental

- For 24% of our subjects the best fitting rule is level 1
  - respond to intercept but assume others set forecast based on history of rings
  - forecast of others based on subject-level estimate
  - most simplistic form of strategic thinking
- For 12% of our subjects best fitting are levels 2 and above
  - 6% of the subjects are level 2
  - 4% of our subjects the best fitting rules are levels 3-6
  - 1 subject is essentially RE

Strategies for Responding to the Fundamental

Level	Number of Subjects	% Subjects
0	45	64.3%
1	17	24.3%
2	4	5.7%
3-6	3	4.3%
∞	1	1.4%

Strategies for Responding to the Fundamental



two dimensions of heterogeneity: observational and strategic

Conclusion

- Do subjects **optimize using rational expectations?**
  - less overall accuracy than that
  - inattentive and dispersed responses to change in the state
  - varying ability to track evolution of state among level-0 subjects
  - range of strategic sophistication for higher level subjects
- In the aggregate, adjustment is very sluggish reflecting large heterogeneity in strategies