Information and Markets

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Summer School – PIMS/UBC

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Lecture 4: Experimental Evidence

Lectures 1–3

1) REE as model of market sharing of information

2) critiques of REE
   - incentives to purchase information
   - incentives to reveal information

3) efficient incentive-compatible artificial mechanisms

4) auction-like mechanisms can be informationally efficient

5) informational efficiency in practice – not just theory?

Issues?

- do agents behave as in the theory?
- are agents intelligent enough?
- if not, does it matter?

Why Experiments?

historical data:

- closing prices of every stock on NYSE since 1925
- prices/volume of every transaction on NYSE since 1981

but not

- true distribution of asset returns
- information/beliefs held by agents
- choices of agents

In laboratory we

- determine true distribution of asset returns
- determine information held by agents
- observe choices of agents (bids, offers, choices)
- conduct counterfactual experiments

How could I discover/verify a correct theory of gravitation if I were confined to my desk chair and the only observations I could make were of objects falling past my office window?

Series of experiments address how the market distinguishes

- risk (known probabilities)
- ambiguity (unknown probabilities)

What are implications for

- pricing
- learning from prices
- learning from others

Ellsberg Paradox

Urn

- 1/3 red balls
- unknown fraction blue balls
- unknown fraction green balls

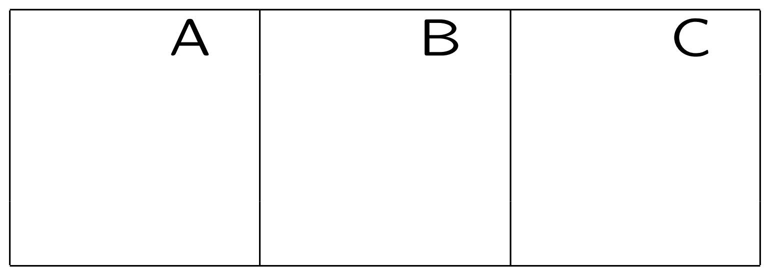
Bets with $1 payoffs

- bet on red $\succ$ bet on blue
- bet on red $\succ$ bet on green
- bet on (blue or green) $\succ$ bet (red or green)

Incompatible with expected utility
(violates sure thing principle)

Monty Hall Paradox

Three doors



Behind one door: large prize: luxury automobile, house, etc.

Behind other doors: joke prizes: goat, year's supply of soap, etc.

Contestant chooses a door

Monty – *who knows what is behind each door* – opens

another door, revealing joke prize

A	B	C
choice	goat	

Monty asks contestant: “Do you want to switch?”

What are true posteriors?

Monty has revealed *no information* $\Rightarrow$

Prob(A has big prize) = 1/3 , Prob (C has big prize) = 2/3

Correct behavior: switch

Few people get this right

Ellsberg Paradox in asset market?

Assets with \$1 dividend in given state(s)

- $p_R > p_B$
- $p_R > p_G$
- $p_R + p_G = p_{\{R+G\}} < p_{\{B+G\}} = p_B + p_G$

Arbitrage opportunity . . .
. . . violates law of one price

Experiments

State	R	G	B
Security R	100	0	0
Security G	0	100	0
Security B	0	0	100
Notes	100	100	100

Theory: expected utility

$$U(w) = \pi_R u(w_R) + \pi_G u(w_G) + \pi_B u(w_B)$$

FOC implication of expected utility

$$\frac{p_X/\pi_X}{p_Y/\pi_Y} \ < \ 1 \ \Leftrightarrow \ w_X^* > w_Y^*$$

Common priors $\Rightarrow$ true for all individuals, **hence** for aggregate

Theory: ambiguity aversion

$\pi_R = \pi$ known: π_B, π_G unknown

$$
\begin{aligned}
U(w) &= \pi u(w_R) \\
&\quad + \alpha \min_{\rho \in [0,1-\pi]} [\rho u(w_B) + (1-\pi-\rho)u(w_G)] \\
&\quad + \alpha \max_{\rho \in [0,1-\pi]} [\rho u(w_B) + (1-\pi-\rho)u(w_G)]
\end{aligned}
$$

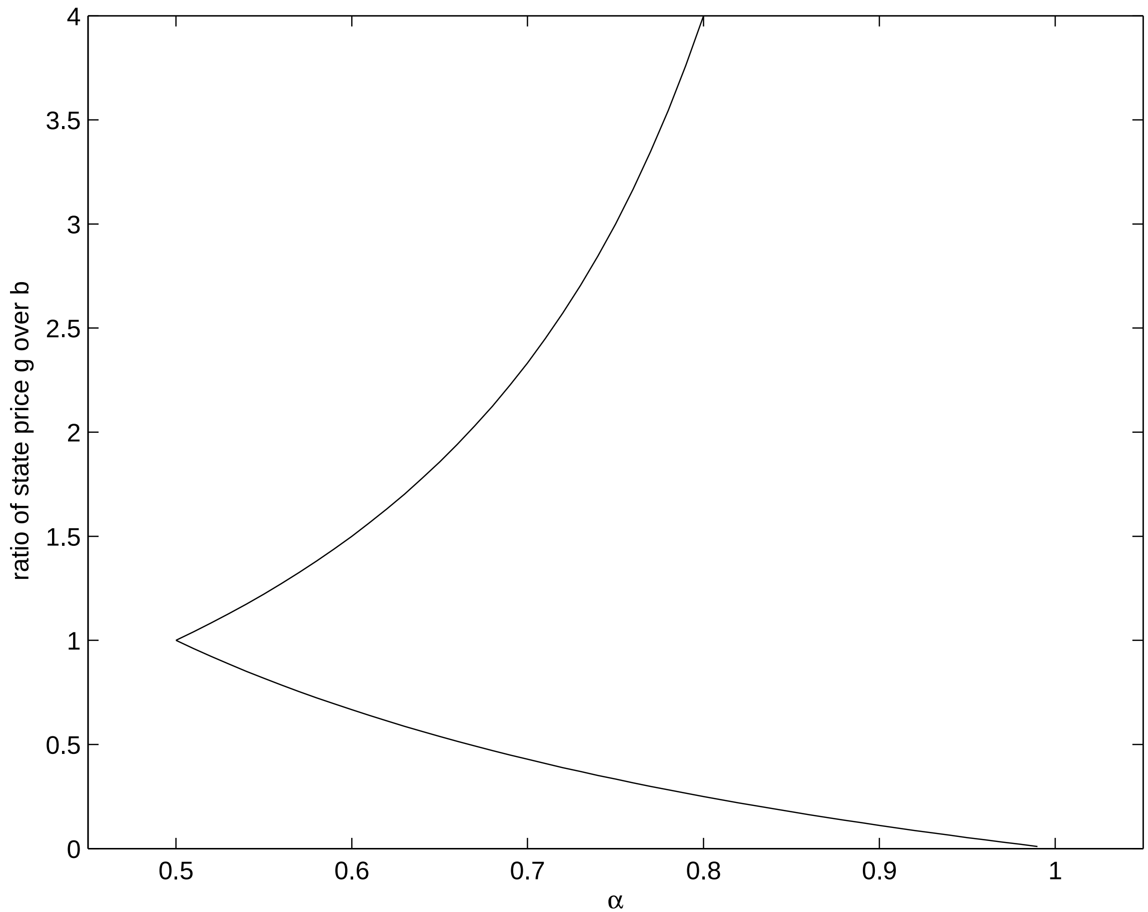
$\alpha = 1$ extreme ambiguity aversion (Gilboa–Schmeidler)
$\alpha = .5$ ambiguity neutrality = expected utility with uniform prior

FOC implication of ambiguity aversion

$$\frac{p_G}{p_B} < \frac{1-\alpha}{\alpha} \iff w_G^* > w_B^*$$

$$\frac{p_G}{p_B} > \frac{\alpha}{1-\alpha} \iff w_G^* > w_B^*$$

$$\text{reverse inequalities} \iff w_G^* = w_B^*$$



Refusing an ambiguous portfolio

Equilibrium implications
(assuming heterogeneous population)

- Market segmentation
  ambiguity-neutral agents hold ambiguous imbalance

- Pricing of risky securities
  all agents marginal

- Pricing of ambiguous securities
  only ambiguity-neutral agents marginal

- Possible wrong ranking of state price probabilities
  if supply of ambiguous securities large

Paired experiments

- Ambiguity $\leftrightarrow$ Pure Risk
- same endowment distribution
- same state distributions
- same sequence of draws
- same supplies: $X = 5 < Z = 10 < Y = 15$
- first pair: $Z = R$ risky (middle supply)
- second pair: $X = R$ risky (lowest supply)

Date	Urn (18 Total)			Subject Category (Number)	Signup Reward (franc)	Endowments			Loan (franc)	Exchange Rate cents/franc
	X	Y	Z			X	Y	Z		
040908	6	3	9	15	250	4	11	4	500	2
				14	250	1	4	6	375	2
030203	?	?	9	15	500	4	11	4	500	2
				14	500	1	4	6	375	2
041007	6	6	6	15	500	4	11	2	220	2.3
				14	300	1	4	8	375	2.3
020529	6	?	?	13	0	4	11	2	220	2.3
				13	0	1	4	8	300	2.3

Theory

- expected utility/ambiguity neutrality

  $\Rightarrow$ state price density ranks $p_X/\pi_X > p_Z/\pi_Z > p_Y/\pi_Y$

- SOME very ambiguity averse $\Rightarrow$ hold unambiguous portfolio

  $\Rightarrow$ supplies held by ambiguity neutral change order

  $\Rightarrow$ state price densities could have wrong order

  $\Rightarrow$ more likely when risky asset is in lowest supply

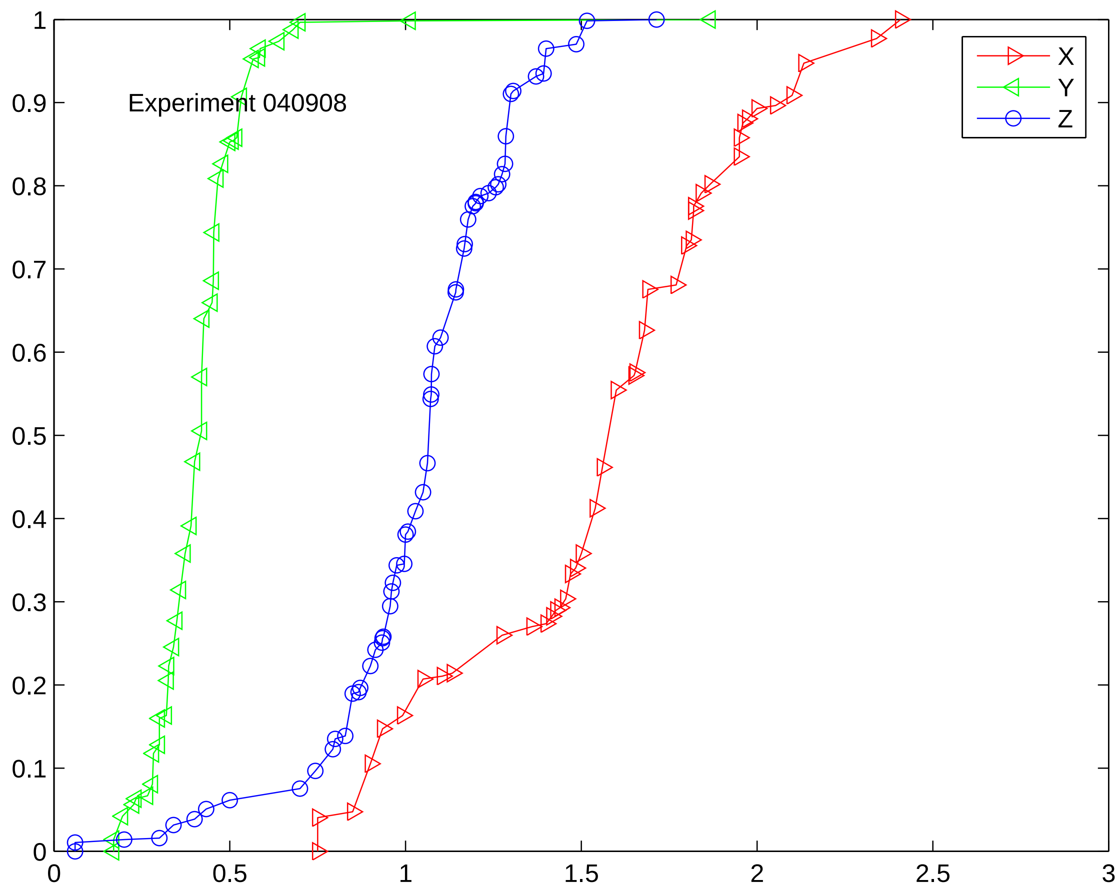
Implication for paired experiments

- Z risky $\rightarrow$ state price densities $p_X/\pi_X > p_Z/\pi_Z > p_Y/\pi_Y$
- X risky $\rightarrow$ anomalous ordering of p_X/π_X and p_Z/π_Z

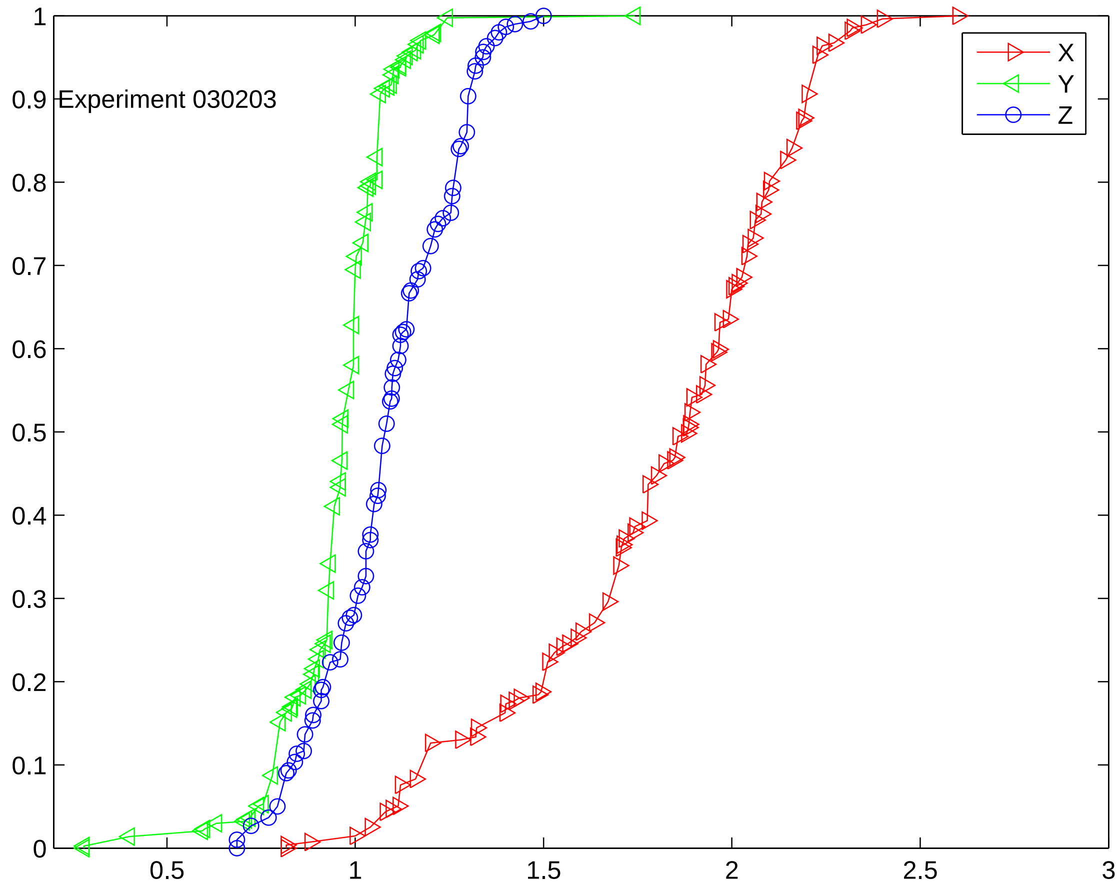
CDF's over whole experiment (every transaction) of state price densities p_X/π_X, p_Y/π_Y, p_Z/π_Z, updated from known distribution (pure risk case) or from uniform prior on ambiguous states (ambiguity case)

horizontal axis: state price densities

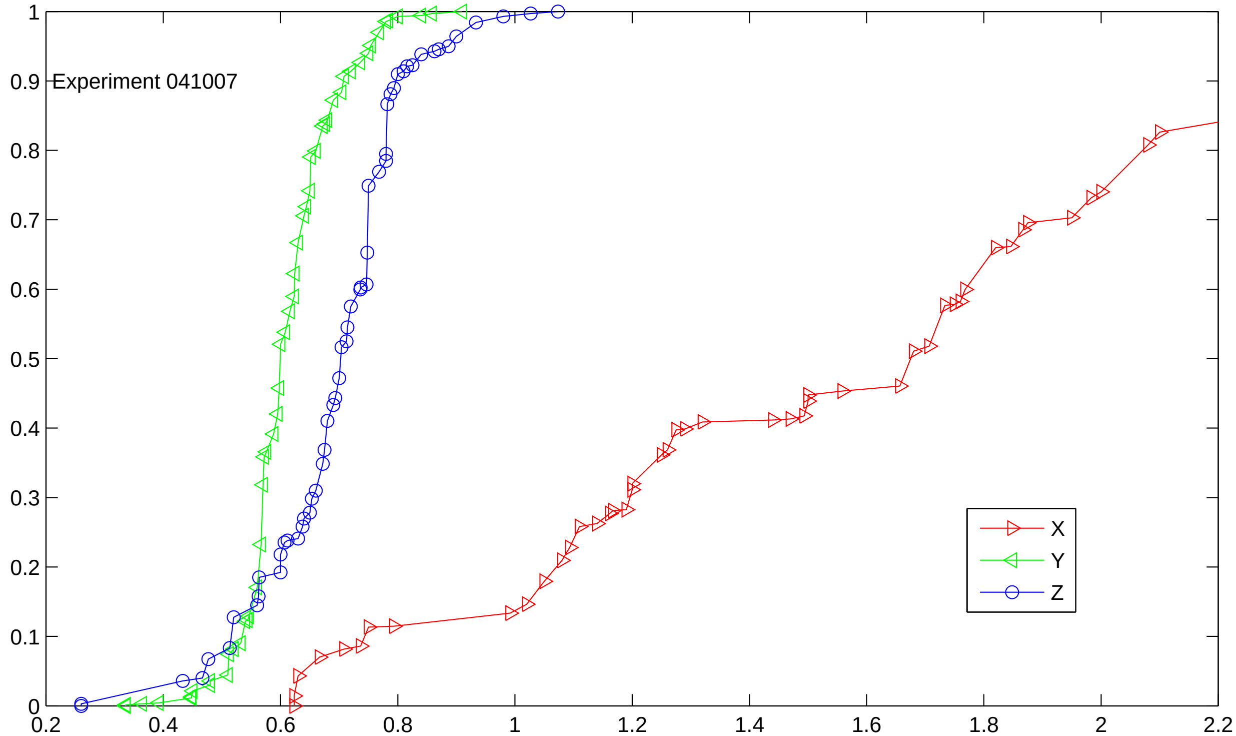
vertical axis: fraction of all transactions



Pure Risk

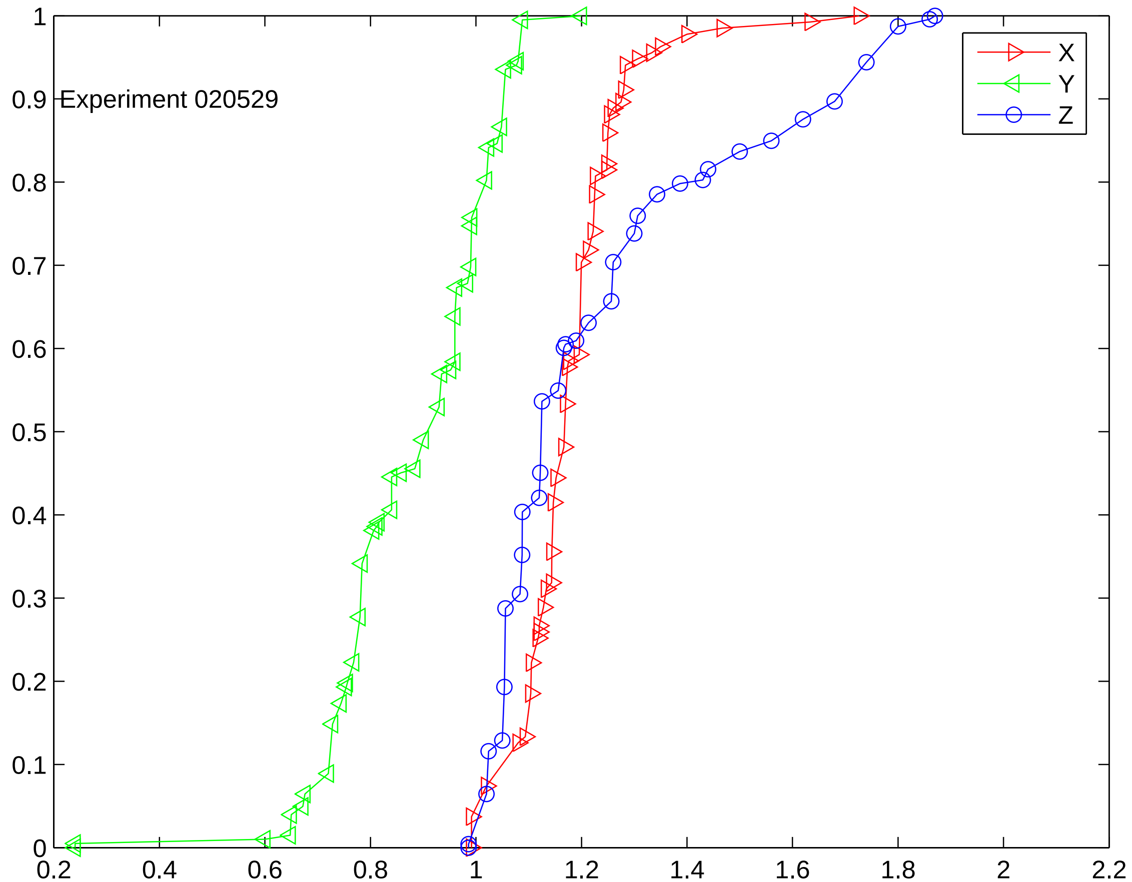


Ambiguity: Z risky, same sequence of draws



Experiment 041007
X
Y
Z
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2

Pure Risk



Ambiguity: X risky, same sequence of draws

Conclusions

- ambiguity matters
- heterogeneity matters

What does ambiguity aversion imply for learning?

Cognitive Biases

Agents learn from others (via prices) BUT

- cognitive biases $\rightarrow$ perceived ambiguity?
- $\rightarrow$ price-insensitivity?
- securities in equal supply

  $\Rightarrow$ cognitive biases may not affect equilibrium prices

Monty Hall

- Three securities: Red Stock, Black Stock, Notes.

- Red stock, Notes traded; Black Stock not traded

- Red/Black pay
  - $0.50 if "last card" is red/black
  - $0.00 otherwise

Information scenario I

- Initially: 4 cards spades, hearts, diamonds, clubs
- Discard one card
- Show and discard one card: NOT heart
- Choose one of last two cards: “last card”

Information scenario II

- Initially: 4 cards spades, hearts, diamonds, clubs
- Discard two cards
- Show and discard one card: NOT heart
- “last card”

Prices

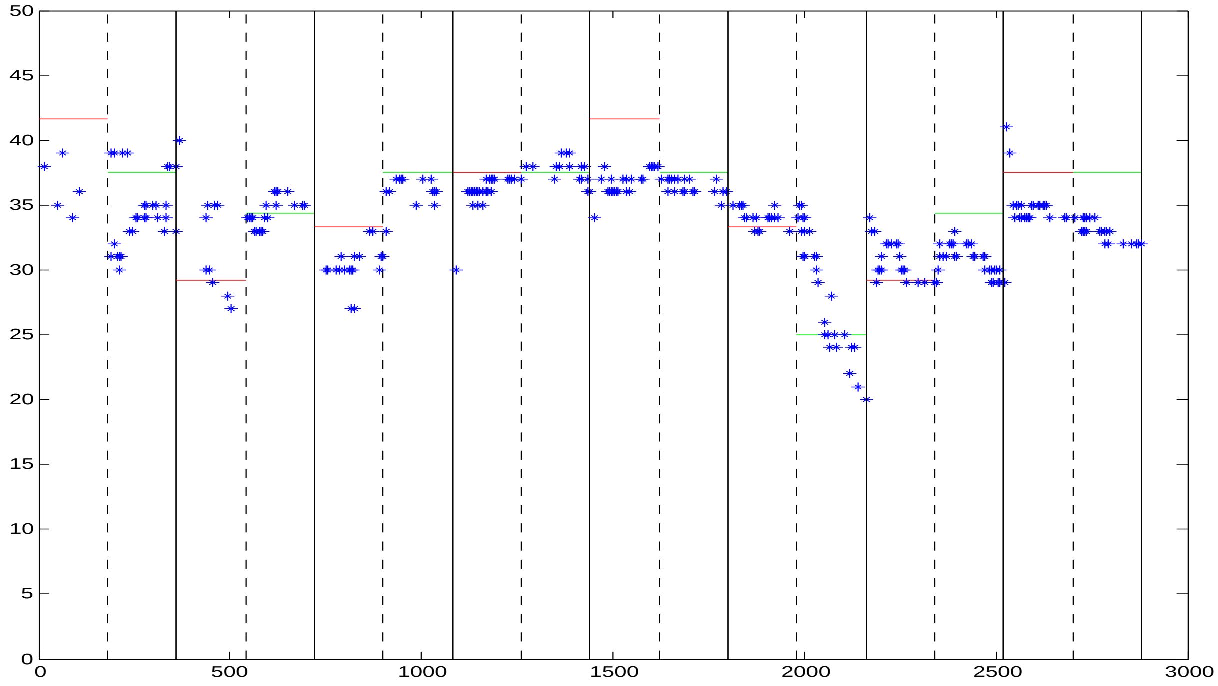
equal supply Black Stock, Red Stock

$\Rightarrow$ aggregate wealth constant across states

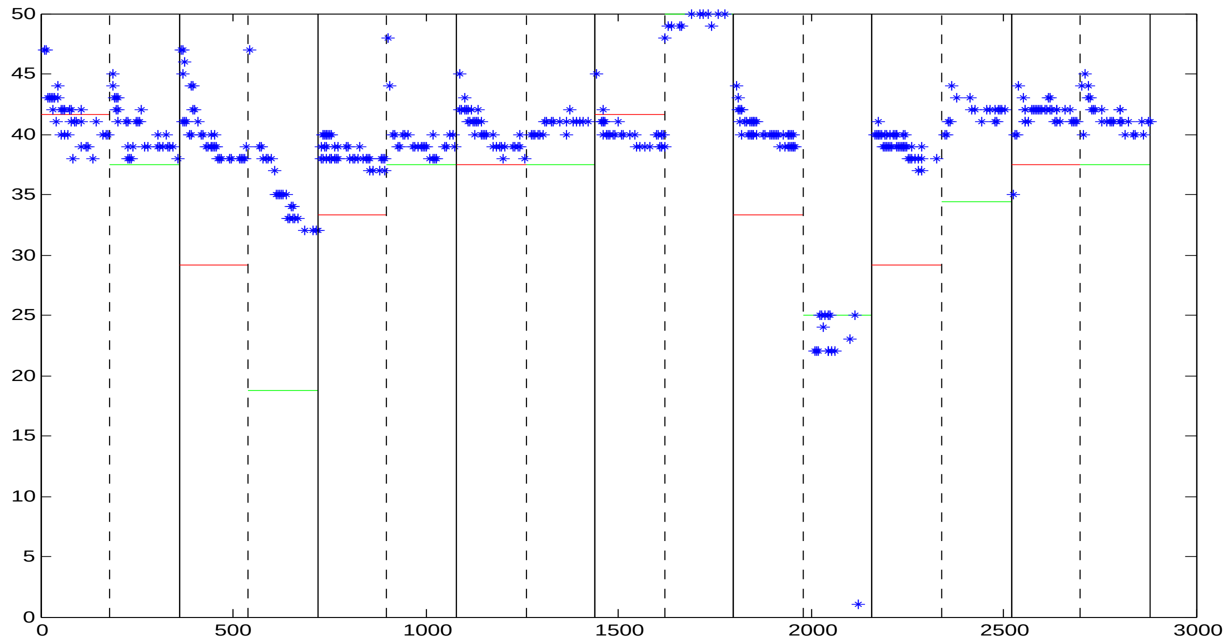
Standard theory

$\Rightarrow$ prices = payoffs x probabilities

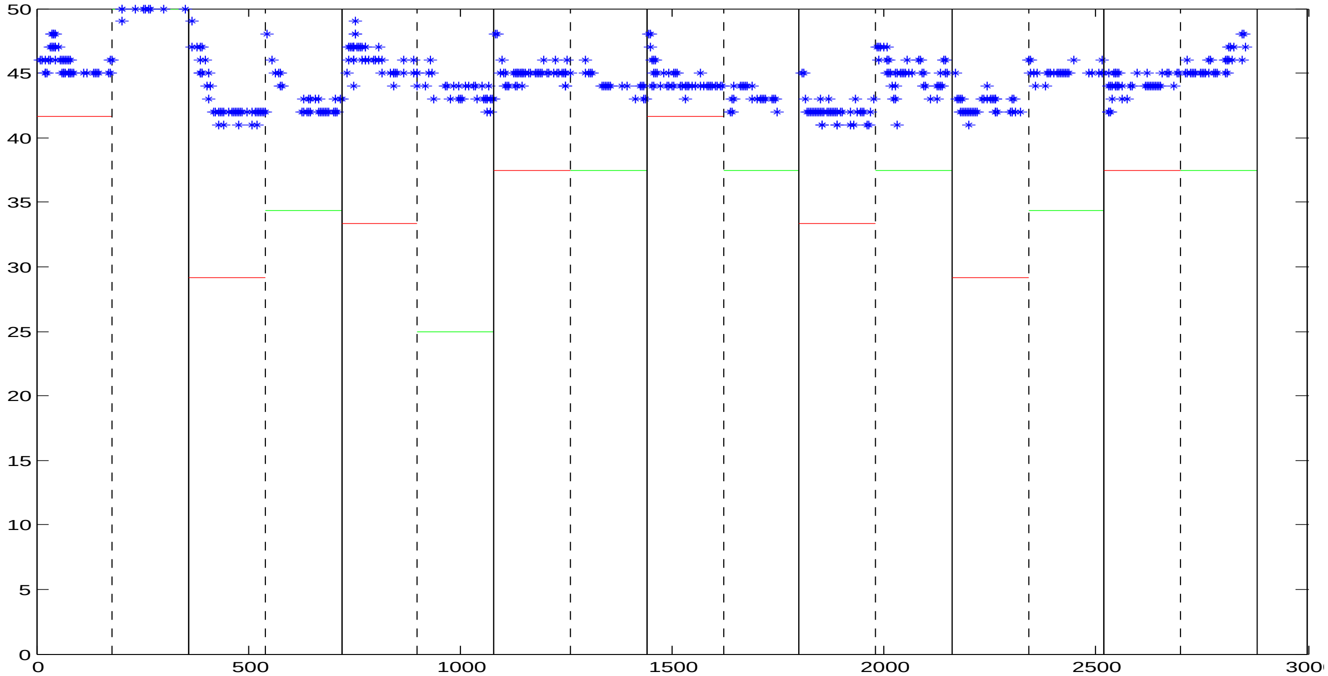
True probabilities change with information revelation



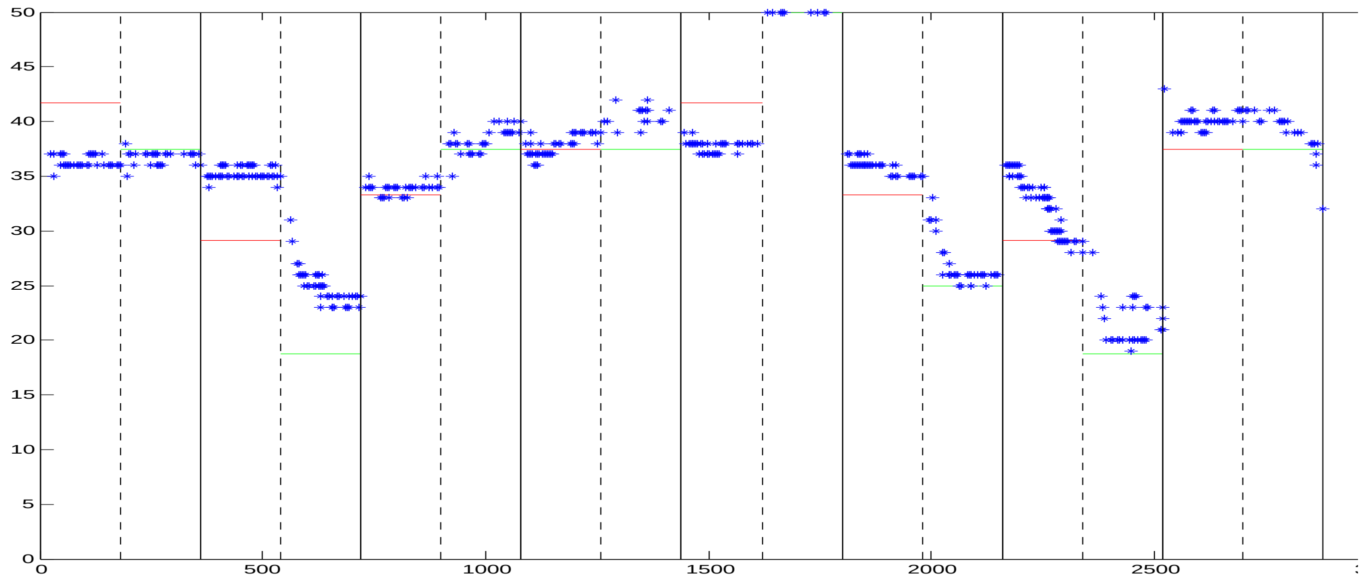
Caltech students only



UCLA students only



University of Utah students only



Majority: University of Utah students
Minority: Caltech students

Learning?

Correlation between *mispricing* and number of agents that *react significantly* to prices:

-0.40

(R^2s of projections of holding changes onto mispricing are also informative)

Conclusion

The effects of cognitive biases in financial markets

depend on perceptions of ambiguity,

and hence, on price sensitivity/insensitivity.

Are experimental findings in cognitive psychology

irrelevant for asset pricing?