Chapter 3: Asset Market Experiments

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Disclaimer. I survey a sample of papers on experimental finance. Whilst the sampled is inevitably biased towards my opinions, I believe that the reader can benefit from the broad discussions of approaches to modelling asset markets in the laboratory.

Outline

1. Introduction

2. Single period market experiments
   - Genesis
   - zero-intelligence traders
   - Individual judgement errors and market equilibrium
   - Understanding price dynamics
   - Information mirage

3. Multiperiod market experiments
   - Why the SSW paradigm is attractive
   - Measuring bubbles
   - Why bubbles occur?

4. Learning to Forecast experiments

Introduction

- Financial market experiments can be informative even if it does not match exactly the real world.
  - Test a model given its central assumption.

- experiments provide a controlled environment to test economic principles about markets as well as a "sandbox" to evaluate economic policy interventions.

What is a stock?

A stock is a certificate that represents the ownership of a fraction of a company. The stock owner is entitled to a proportion of the company's assets and profits (paid in *dividends*) equal to how much stock they own. A stock is sometimes also referred to as an "asset" or a "security".

We will focus on two-sided markets (as opposed to one-sided) in this lecture.

Figure: NYMEX "pit" 2007

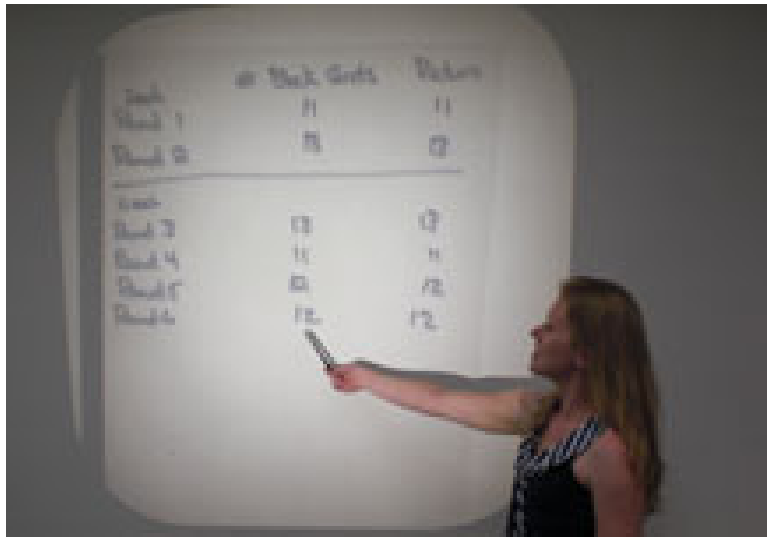


Figure: A classroom market experiment

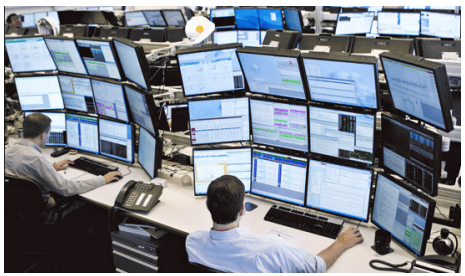


Figure: A trader's desk

Figure: A six asset trading market experiment

Owen Powell has a nice webpage that keeps track of asset market experiments
`https://sites.google.com/site/opowell/assetmarketexperiments`

Single period market experiments

Markets in economics

- Basic assumptions
  - Agents are rational and selfish utility or profit maximisers
  - A homogeneous well defined good is traded
  - There are numerous firms and consumers
  - Agents are price takers
- However....
  - In many instances people are boundedly rational
  - People often have interdependent utility functions
  - There are many markets with only a few firm.
  - In most markets there is no auctioneer but agents set prices.

Challenges to economic thinking

- Do these deviations from the assumptions constitute negligible frictions or do they seriously challenge the predictive power of the model?
- Are there "real" market institutions for which the competitive equilibrium is a good predictor of price and quantity outcomes?

Genesis

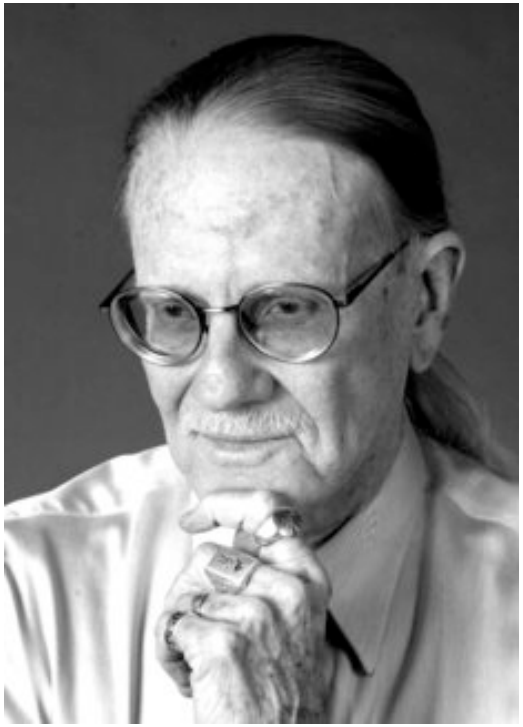


Figure: Vernon Smith

"The mere fact that … supply and demand schedules exist in the background of a market does not guarantee that any meaningful relationship exists between those schedules and what is observed in the market they are presumed to represent.

All the supply and demand schedules can do is set broad limits on the behaviour of the market. … In fact, these schedules are modified as trading takes place.

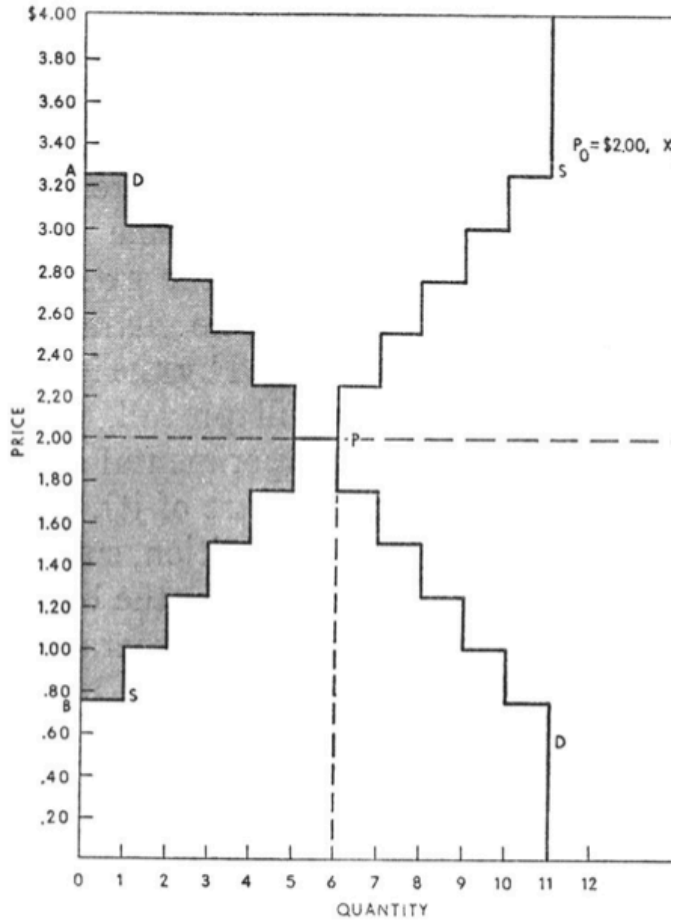
Whenever a buyer and a seller make a contract and "drop out" of the market, the demand and supply schedules are shifted to the left in a manner depending on the buyer's and seller's position on the schedules.

Hence the supply and demand functions continually alter as the trading process occurs.

It is difficult to imagine a real market process which does not exhibit this characteristic." —(Smith 1991, p. 12)

Competitive markets in the classroom (Smith, 1962, JPE)

- Students randomly assigned a card $\Rightarrow$ valuation or cost for a commodity, depending on whether they are a buyer or seller
  - buyer profit: $v - p$
  - seller profit: $p - c$
- You can construct the relevant supply and demand curves.
- Students shout out their
  - Buyers (bid): how much I'm willing to pay
  - Sellers (ask): how much I'm willing to sell
- Transaction occurs when a bid/ask is accepted.



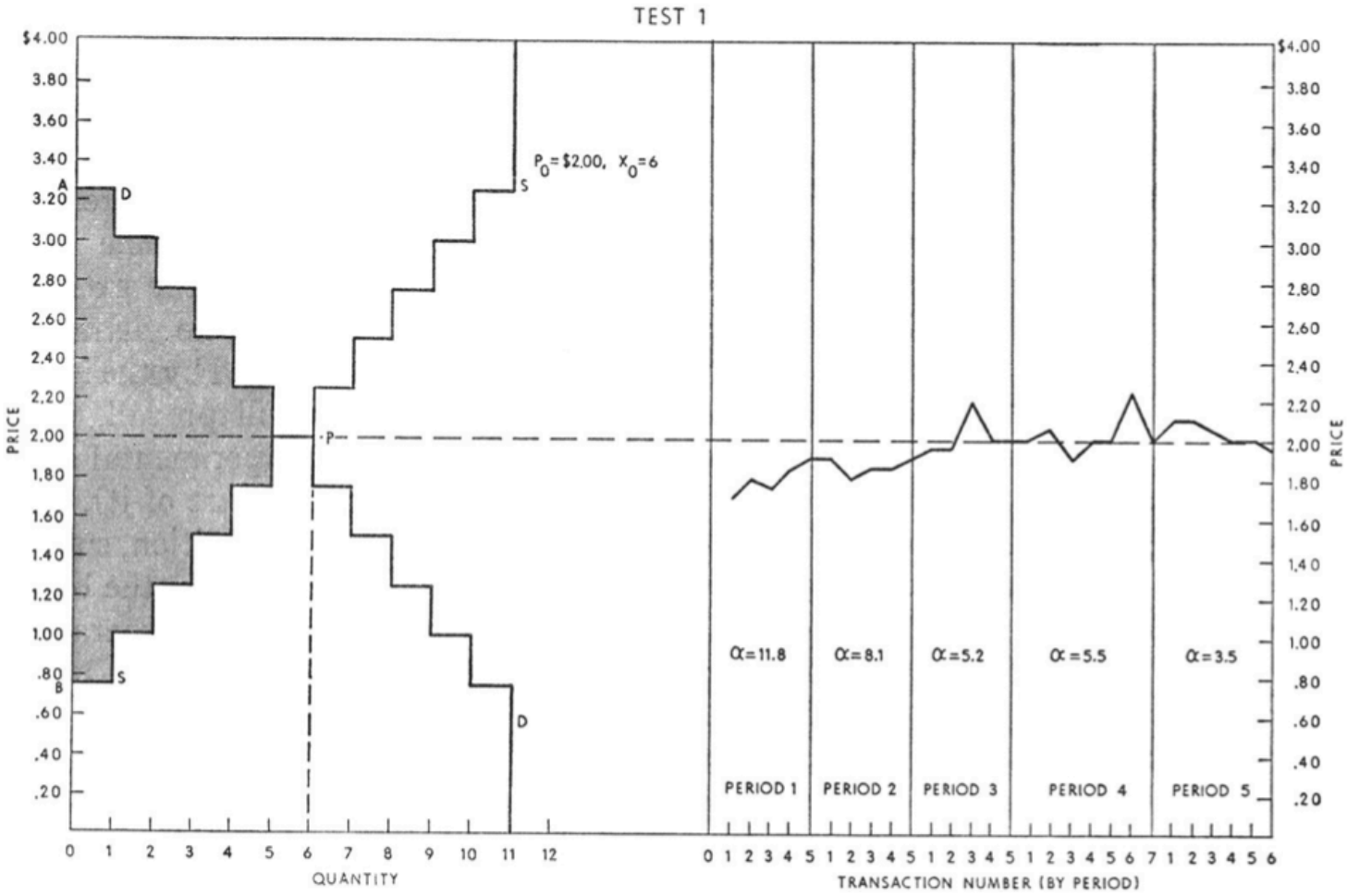


Figure: Smith 1962, Test 1

where α is a measure of price deviations from the equilibrium.

It can't be true!

"I am still recovering from the shock of the experimental results. The outcome was unbelievably consistent with competitive price theory. ... But the result can't be believed, I thought.

It must be an accident, so I will take another class and do a new experiment with different supply and demand schedules."— (Smith 1991, p. 156)

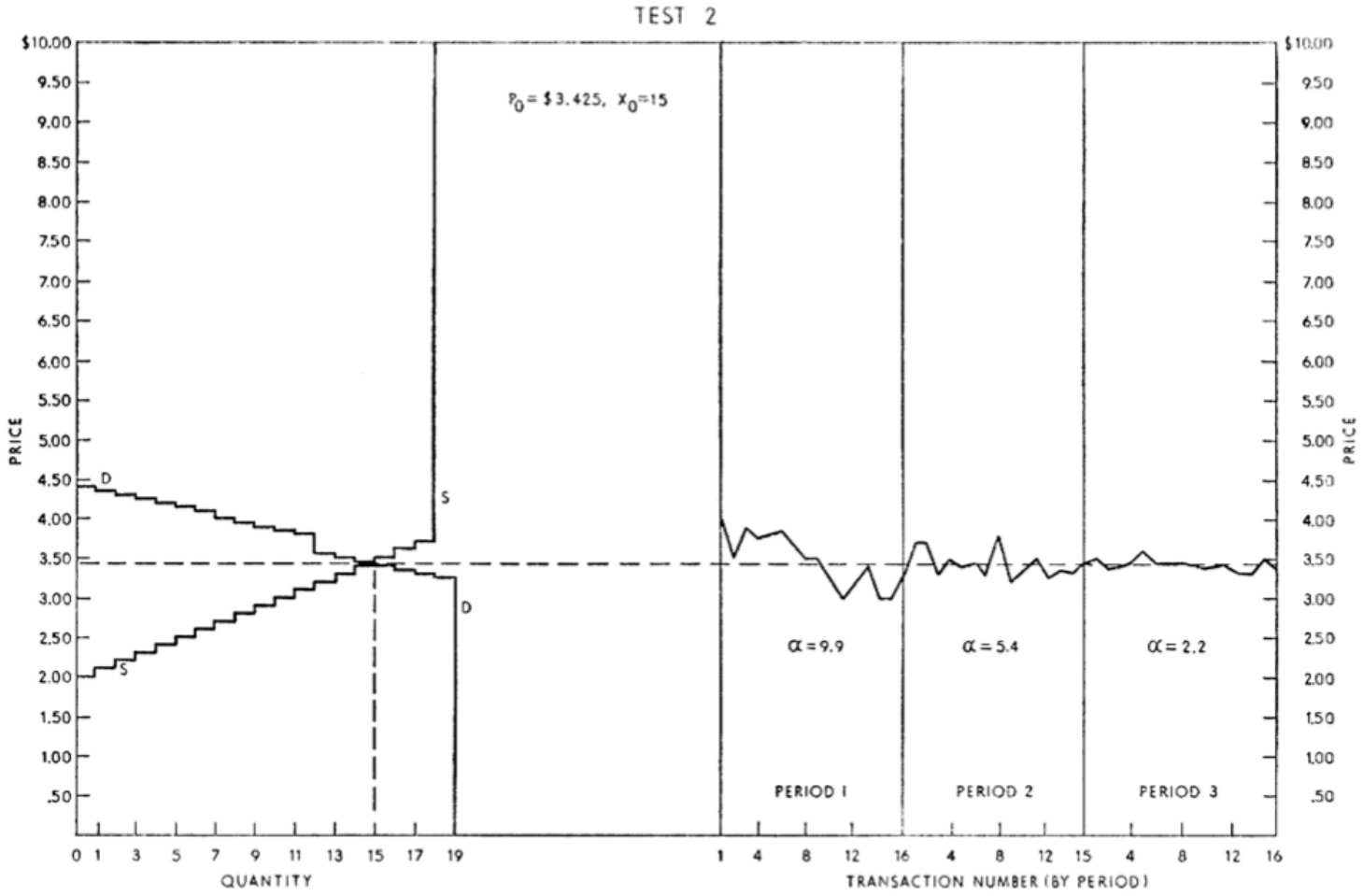


Figure: Smith 1962, Test 2

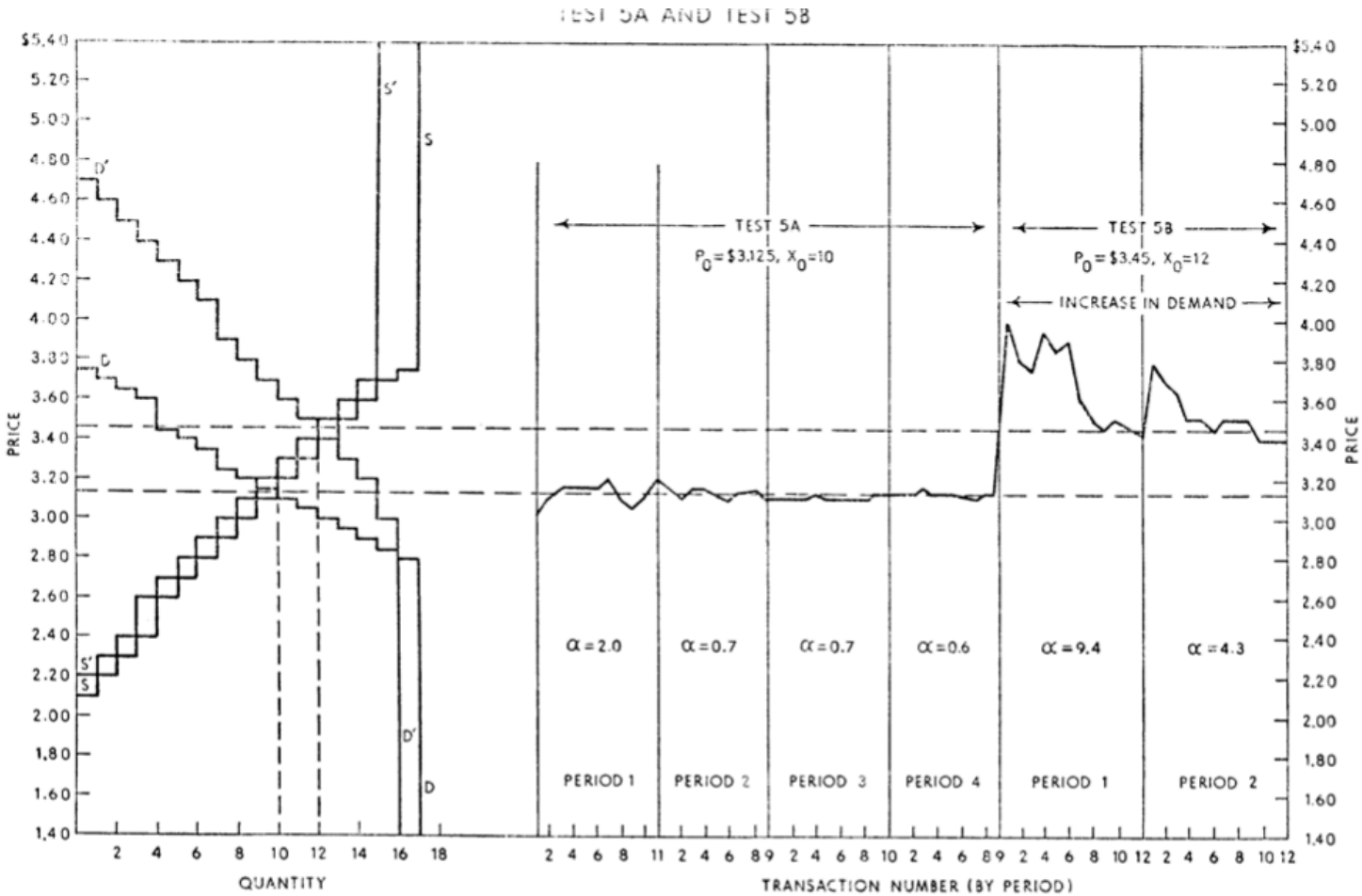


Figure: Smith 1962, Test 5

The demand/supply curves are changed in period 5 onwards.

Reflections of an experimental economist

"In 1960 I wrote up my results and thought that the obvious place to send it was the Journal of Political Economy.

It's surely a natural for those Chicago guys, I thought. What have I shown? I have shown that with converge rapidly to a competitive equilibrium under the double auction institution mechanism.

The market works under much weaker conditions than had traditionally been thought to be necessary.

- *You didn't have to have large numbers.*
- *Economic agents do not have to have perfect knowledge of supply and demand.*
- *You do not need price-taking behaviour—everyone in the double auction is a price maker as much as a price taker.*

A great discovery, right? Not quite, as it turned out. At Chicago they already knew that markets work. Who needs evidence?"— (Smith, 1991, p. 157)

Markets with zero-intelligence traders.

"Standard economic theory is built on two specific assumptions: utility-maximizing behavior and the institution of Walrasian tâtonnement.

Becker showed that the market-level predictions of economic theory are consistent with individual behaviors more general than utility maximization,

whereas Smith showed that such predictions are consistent with trading mechanisms more general than Walrasian tâtonnement." — (Gode and Sunder, 1993)

Qn. Can a non-walrasian market mechanism sustain high levels of allocative efficiency even if agents do not seek to maximise profits?

Gode and Sunder (1993, JPE)

- Human treatment as per Smith (1963)
- Unconstrain Zero-Intelligence (ZI-U) traders
  - Buyers: Bid randomly within a known interval
  - Sellers: Ask randomly within a known interval
- Constrained Zero-Intelligence (ZI-C) traders
  - Buyers: cannot bid more than their valuation
  - Sellers: Cannot ask less than their values
- non-walrasian market mechanism = Continuous double auction.
- 5 x market sessions (12 traders per market)

Notice that. Unlike the human traders, the zero-intelligence traders have no incentive to maximise profit.

see `http://people.brandeis.edu/~blebaron/classes/agentfin/GodeSunder.html` for the python code for generating zero-intelligence traders' behaviour.

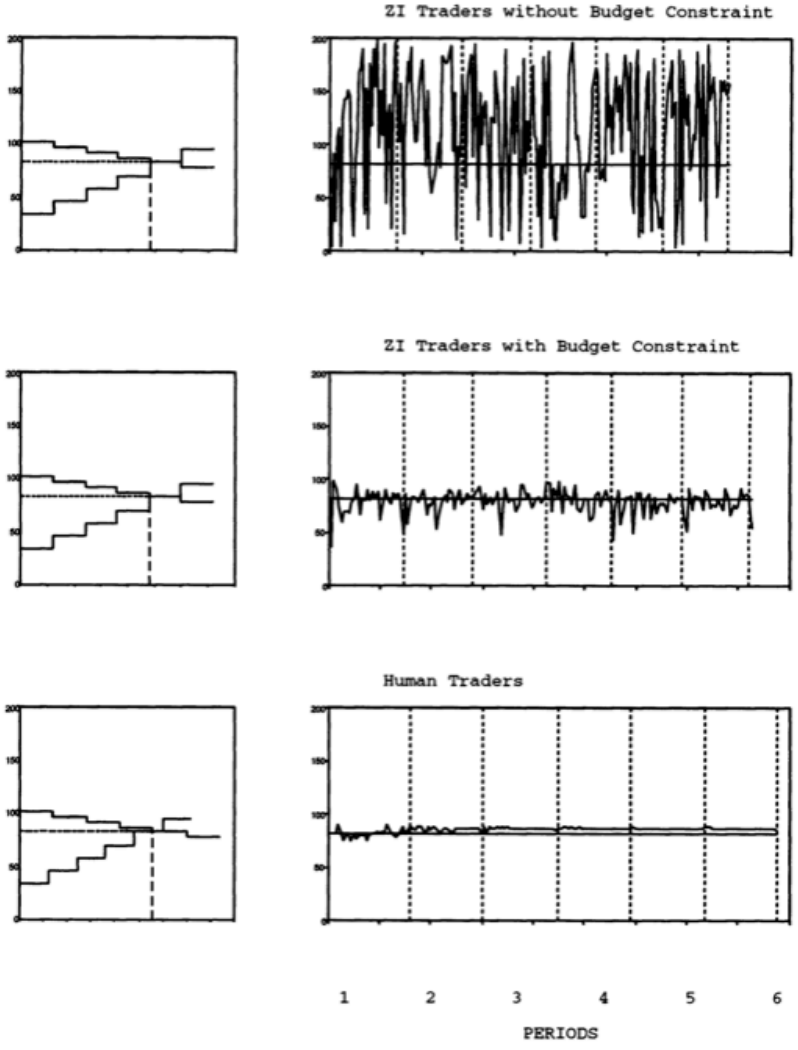


Figure: price dynamics in market 1

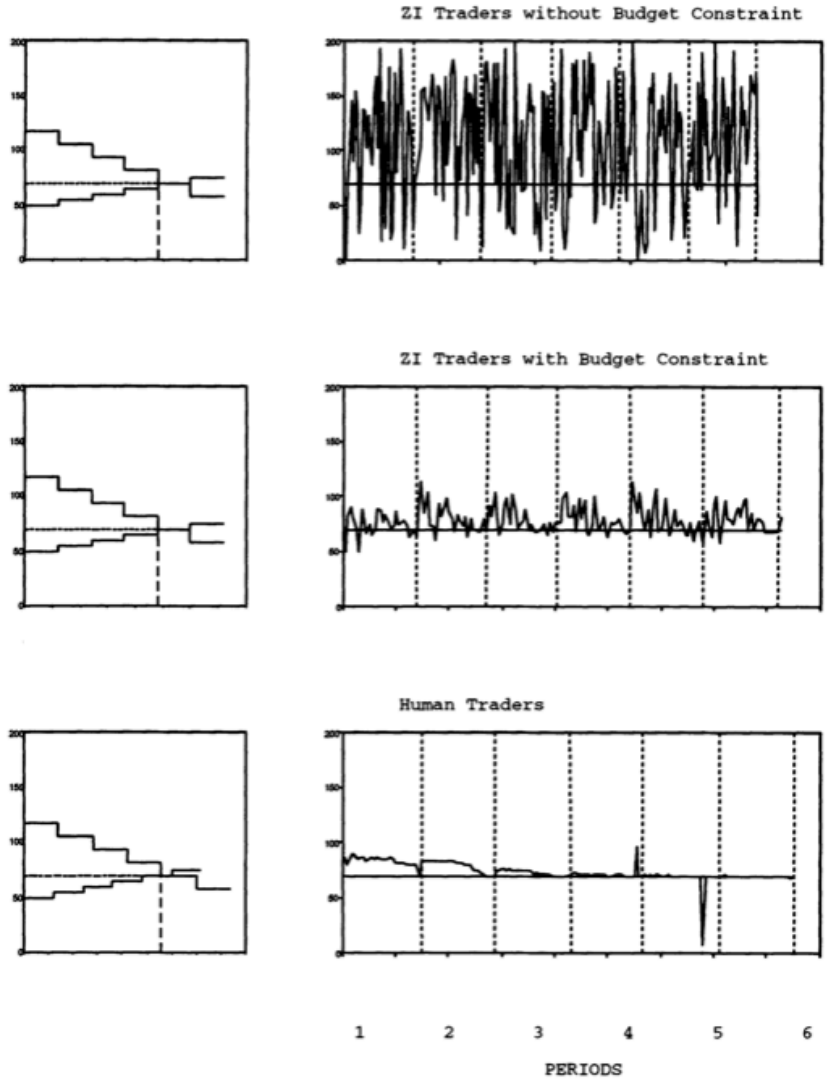


Figure: price dynamics in market 2

$$\text{efficiency} = \frac{\text{Total profit earn by all traders}}{\text{Maximum total profit that can be earned by all traders}}$$

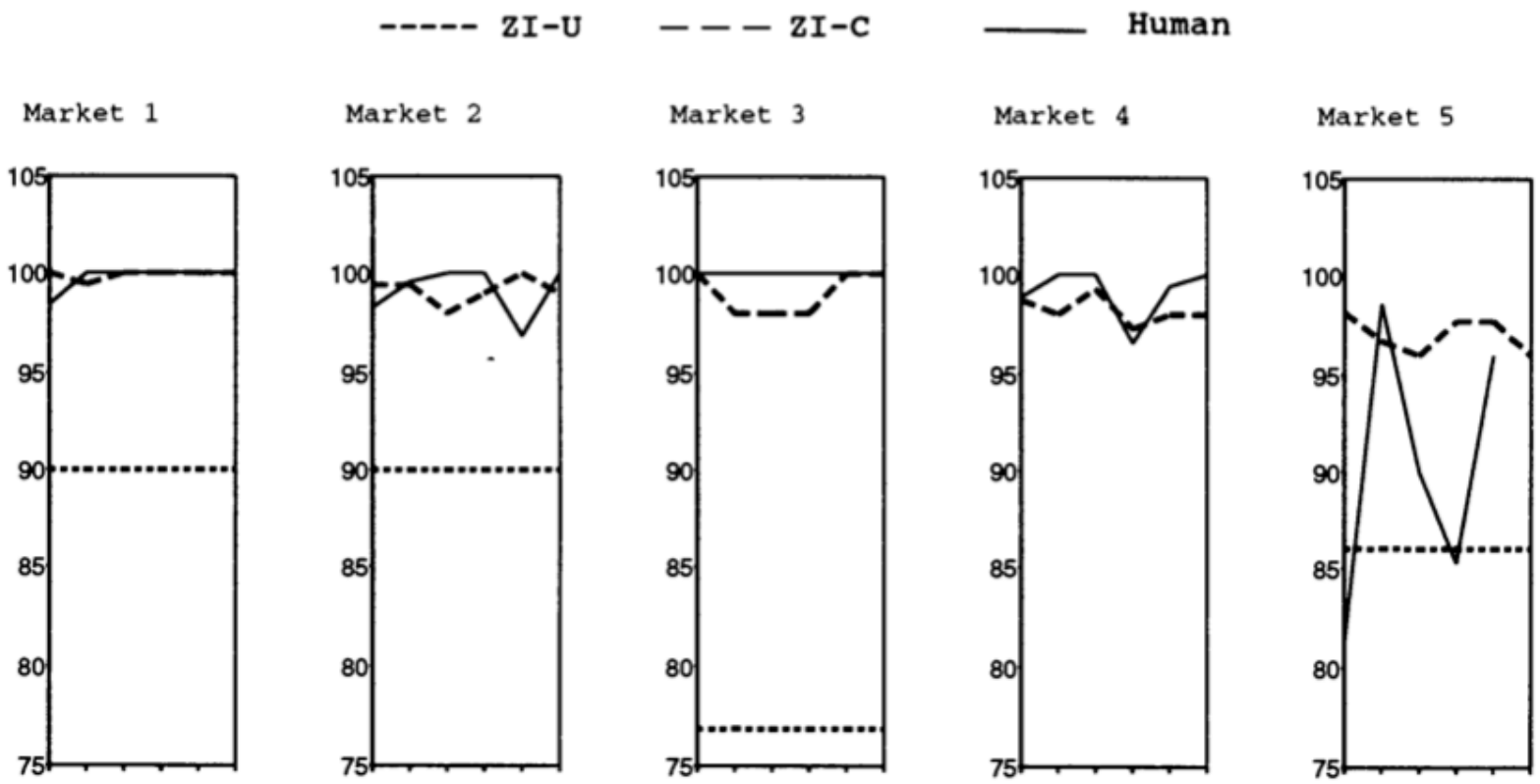


Figure: Efficiency measure in each market

The very last paragraph of their paper.....

"Finally, our results may help reconcile the predictions of neoclassical economic theory with its behavioral critique.

Economic models assume utility-maximizing agents to derive market equilibria and their welfare implications. Since such maximization is not always consistent with direct observations of individual behavior, some social scientists doubt the validity of the market-level implications of models based on the maximization assumption.

Our results suggest that such maximization at the individual level is unnecessary for the extraction of surplus in aggregate.

Adam Smith's invisible hand may be more powerful than some may have thought: when embodied in market mechanisms such as a double auction, it may generate aggregate rationality not only from individual rationality but also from individual irrationality." — Gode and Sunder (1993, p.136)

Individual judgement errors and market equilibrium

"Some adherents of behavioral finance begin sensibly enough with the results of convincing experiments that show human beings are irrational in certain specific systemic ways.

But then comes the hand waving as they try to extend the results to the much more complex, long-lasting, repetitive and subtle environment of the market.

This extension requires a big leap of faith." — *Rubinstein (2001)*

Kluger and Wyatts (2004, Journal of Finance)

RQ Are judgment errors observed in the individual experiments are reflected in market prices and allocations?

- Embed the "Monty hall problem" into asset markets.
- Though experiment. Suppose that there exist an asset that allows you to switch doors in the monty hall problem (the prize door is worth \$100).
  - Biased traders. Believe that there is only a 50% chance of the prize with switching doors and value the asset at \$50.
  - Rational traders. Believe that there is a 67% chance of the prize with switching doors and value the asset at \$67.
- Conducted 12 sessions (6 traders per session) with multiple stages.
  - Individual task: played 12 rounds of the monty hall game alone
  - All-or-Nothing market: traded the rights to switch door. Then they can choose switch all their doors or none.

Which sessions had “rational pricing” in the markets

Table IV

Average Prices for the Market Trials by Session and by Treatment

The prices are averages of transaction prices during the double auctions as well as the transaction prices in the second-price sealed bid auctions. P sessions contain the partial conversion treatment. B sessions contain the both assets treatment.

Trial	Treatment Session	Average Price											
		P1	P2	P3	P4	P5	P6	B1	B2	B3	B4	B5	B6
1	No conv	50.57	23.25	48.13	27.27	52.50	34.60	33.60	50.67	41.00	45.00	40.80	46.75
6	No conv	49.88	25.67	44.57	37.56	51.67	30.50	33.00	51.25	41.33	47.40	29.17	52.86
8	No conv	46.48	22.67	35.33	36.60	52.86	29.00	30.33	50.40	31.75	43.67	26.60	58.67
10	No conv	50.73	22.75	28.13	33.27	40.83	30.83	30.33	49.63	30.22	30.75	25.83	56.00
Avg.	No conv	49.42	23.59	39.04	33.68	49.47	31.23	31.82	50.49	36.08	41.71	30.60	53.57
2	All or none	50.56	29.50	45.83	54.80	44.83	36.43	34.14	54.71	49.00	52.67	59.29	53.44
4	All or none	50.00	25.00	51.38	64.00	52.00	35.50	34.00	51.40	62.10	54.00	68.80	58.50
9	All or none	51.08	22.75	41.80	64.36	56.83	40.00	27.67	51.30	62.08	39.75	71.20	69.64
11	All or none	50.30	26.33	40.13	60.22	58.43	47.60	28.00	49.30	62.09	31.67	72.30	66.56
Avg.	All or none	50.49	25.90	44.79	60.85	53.02	39.88	30.95	51.68	58.82	44.52	67.90	62.04
3	Partial	52.45	31.40	55.00	66.50	40.29	48.67						
5	Partial	52.18	33.50	64.00	65.67	55.67	53.40						
7	Partial	52.44	36.67	65.00	69.31	68.40	51.75						
12	Partial	52.50	38.14	70.40	65.38	70.90	55.00						
Avg.	Partial	52.39	34.93	63.60	66.72	58.82	52.21						

What determines whether a session has rational pricing — link to the individual task

Table IX

Table of Frequencies of Sessions Classified According to Whether Market Prices Reflected Judgment Errors

In Panel A the frequencies are also classified according to the number of participants with a conversion rate of 88% or more (seven or more of eight) in the last eight trials of the corresponding individual sessions. In Panel B the frequencies are also classified according to the number of participants with both a conversion rate of 88% or more (seven or more of eight) in the last eight trials of the corresponding individual sessions and a conversion rate of 88% or more shares converted in the all-or-none treatment of the market experiments.

Number of Participants with 88% or More Conversion Rate	Rational Pricing	Prices Reflecting Judgment Error	Total
	Panel A		
None	0	5	5
One	0	3	3
Two	2	1	3
Three	1	0	1
Total	3	9	–
Likelihood ratio chi-square = 9.677 Probability = 0.02			
	Panel B		
Less than two	0	9	9
Two or more	3	0	3
Total	3	9	–
Likelihood ratio chi-square = 13.496 Probability = 0.0002		Fisher's exact test probability = 0.0045	

"When at least two bias-free subjects are present, securities pricing does not reflect the cognitive bias seen at the individual level. Competition among two bias-free subjects is sufficient to drive prices to correct levels despite the presence of twice as many subjects who exhibit probability judgment errors."
— Kluger and Wyatts (2004, p.995)

However.....

"Kluger and Wyatt show that if at least two out of six traders are rational Bayesians, the market typically prices the two assets close to their fundamental value. However, this seems to be a rather rare event that is only observed in 25 percent of the groups. Thus, there is clearly no "market magic" at work. If almost all traders are biased, market outcomes reflect the bias." — Fehr and Tyran (2005)

Understanding price dynamics

"Differences among some models turn on the role played by price itself in conveying information about the state of nature.

On one hand are fully revealing rational-expectations (RE) equilibria (see Lucas 1972 and Green 1973) in which prices in equilibrium reveal the state because they must be consistent with the expectations individuals have about the state of nature when they face those prices.

On the other hand are the prior-information (PI) equilibria which hold that individuals do not condition expectations upon price.

Instead, expectations are exogenous to the price formation process with individuals utilizing whatever prior information they might have at their disposal.

With expectations formed, prices are determined by a straightforward application of the principles of demand and supply as in a Walrasian system." — *(Plott and Sunder, 1982, p.664)*

Competitive markets information aggregation (Plott and Sunder, 1982, JPE).

Design: Suppose that the state of the world is uncertain (X, Y or Z). There is an asset which dividend payment depends on the true state.

Market and Investor Type	Investors (N)	Initial Endowment		Fixed Cost*	Dollar per Franc	Dividends*			Prior Probability			Expected Dividend
		Certificate	Francs			X	Y	Z	X	Y	Z	
1:												
I	3	2	10,000	10,000		150	350	...				283.3
II	3	2	10,000	10,000	.002	250	300	...	⅓	⅔	...	283.3
III	3	2	10,000	10,000		300	100	...				166.7
2:												
I	4	2	10,000	10,000		100	350	...				266.7
II	4	2	10,000	10,000	.002	200	300	...	⅓	⅔	...	266.7
III	4	2	10,000	10,000		240	175	...				196.6
3:												
I	4	2	10,000	10,000		400	100	...				220
II	4	2	10,000	10,000	.003	300	150	...	.4	.6	...	210
III	4	2	10,000	10,000		125	175	...				155
4:												
I	4	2	10,000	10,000		375	100	...				210
II	4	2	10,000	10,000	.003	275	150	...	.4	.6	...	200
III	4	2	10,000	10,000		100	175	...				145
5:												
I	4	2	10,000	10,000		120	170	320				212.5
II	4	2	10,000	10,000	.003	155	245	135	.35	.25	.4	169.5
III	4	2	10,000	10,000		180	100	160				152

* In francs.

Suppose that in each market, 3-6 insiders know the true state.

- Prior-information (PI): Prices will converge to the intersection of all traders' demand and supply.
- Rational expectations (RE): Prices will converge to value of the true state.

TABLE 5

PRICE AND ALLOCATION PREDICTIONS: PRIOR INFORMATION (PI) VERSUS RATIONAL EXPECTATIONS (RE)* WITH RISK NEUTRALITY

MARKET AND MODEL	INFORMATION OF INSIDERS							
	Price				Type of Agent Holding Certificates in Equilibrium			
	None	X	Y	Z	None	X	Y	Z
2:								
PI	266	266†	350	...	I and II	I and II uninformed†	I insiders†	...
RE	266	240†	350	...	I and II	III†	I†	...
3:								
PI	220	400	220†	...	I	I insiders†	I uninformed†	...
RE	220	400	175†	...	I	I†	III†	...
4:								
PI	210	375	210†	...	I	I insiders†	I uninformed†	...
RE	210	375	175†	...	I	I†	III†	...
5:								
PI	212	212†	245	320	I	I uninformed†	II insiders†	I insiders†
RE	212	180†	245	320	I	III†	II†	I†

* In market 1 information given to insiders was probabilistic. Predictions are not given here in order to save space.
† The two predictions differ here.

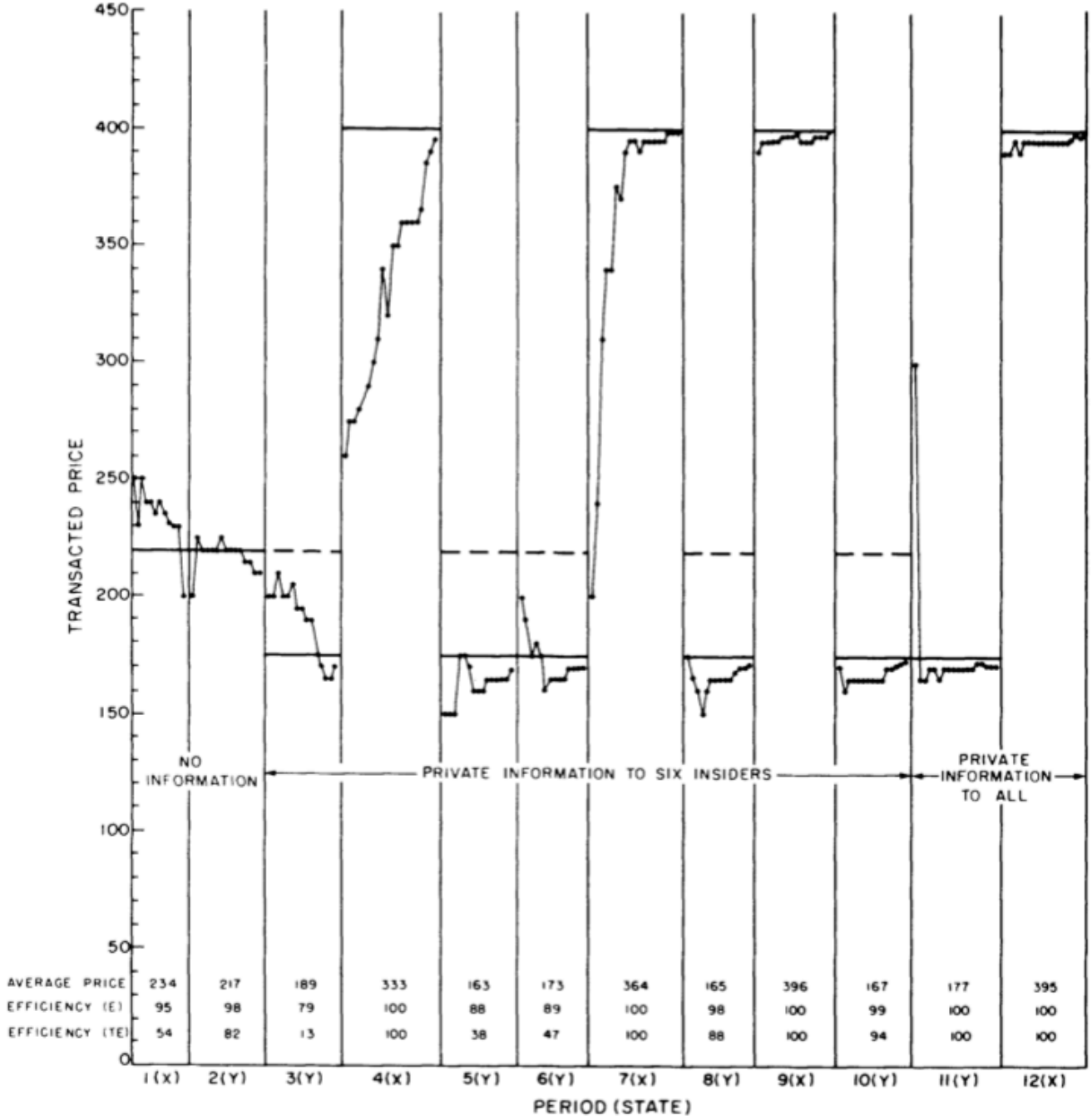


FIG. 4.—Market 3. Time series of contract prices

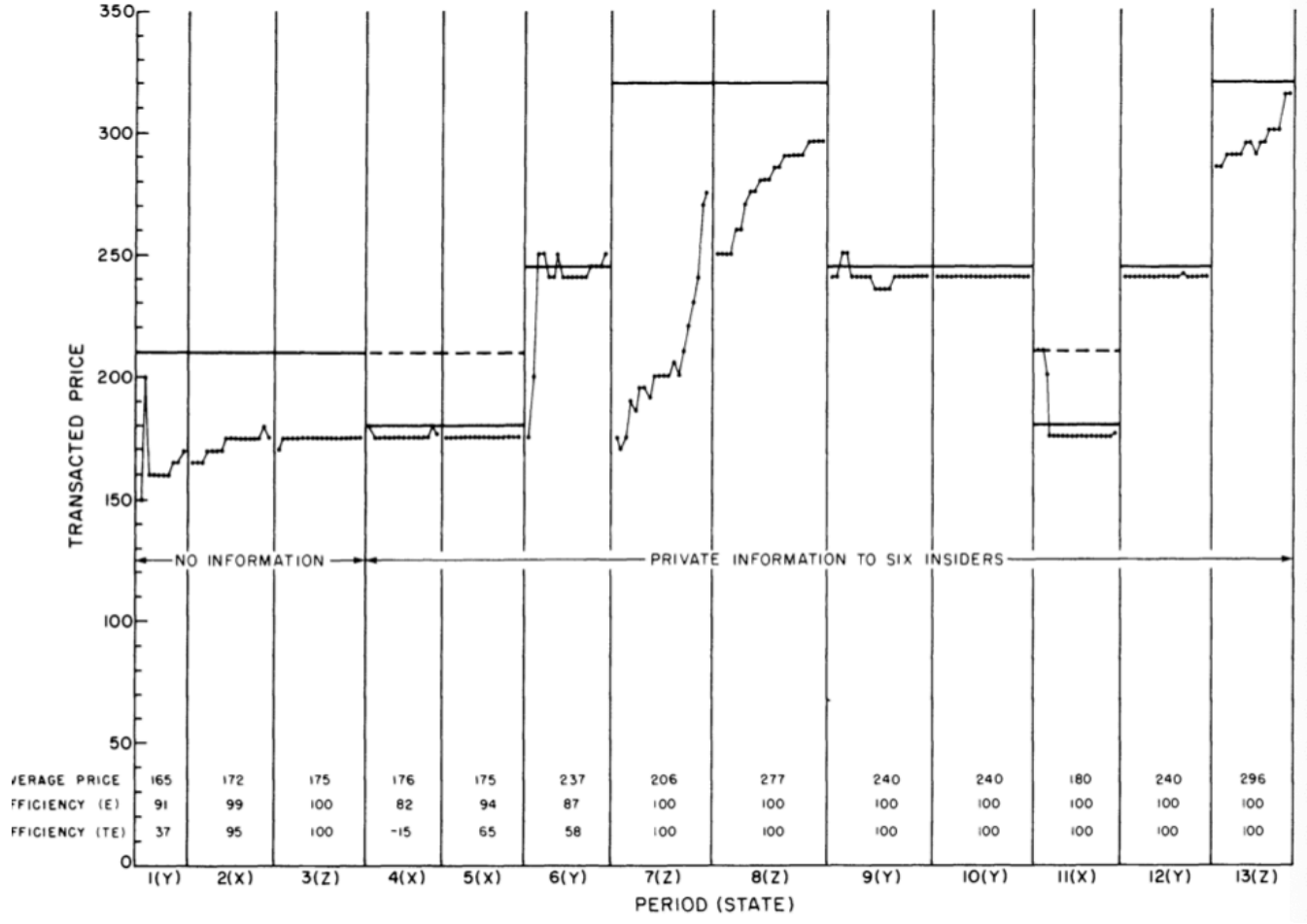


Figure: Market 5

Information mirage

Stylised observation: Asset prices are also much more volatile when markets are open for trading than when markets are closed (Oldfield and Rogalski 1980; French and Roll 1986).

> *"Imagine that the market opens in the morning and, just by chance, the first ten orders are on the sell side. Other traders, who have no information about the asset except that the first ten orders were to sell, might draw the reasonable conclusion that something bad has happened to the company. They might be induced to sell also and, if they are, the market price should fall. The price drop might attract the attention of other traders who extrapolate its recent path and sell, which attracts other traders who sell, and so on"—(French and Roll 1984, p. 17).*

> *"Ex-post, we label an event a panic when a group of investors has shifted out of equities for noninformational reasons, and this shift has caused substantial numbers of other investors to shift out of equities because they think that the price has moved for informational reasons"— (Grossman 1989, pp. 7-8).*

Information mirage in market (Camerer and Weigelt, 1991, Journal of Business).

Experiment sets out to see if information mirage can be replicated in the lab.

- In each period, the state of the world could be Good (G) or Bad (B) with a known probability.
- At each period, there is a 50% chance probability that some traders might have inside information about the true state.
- Information mirage occurs when no traders have inside information but the market behaves as if some traders have inside information.

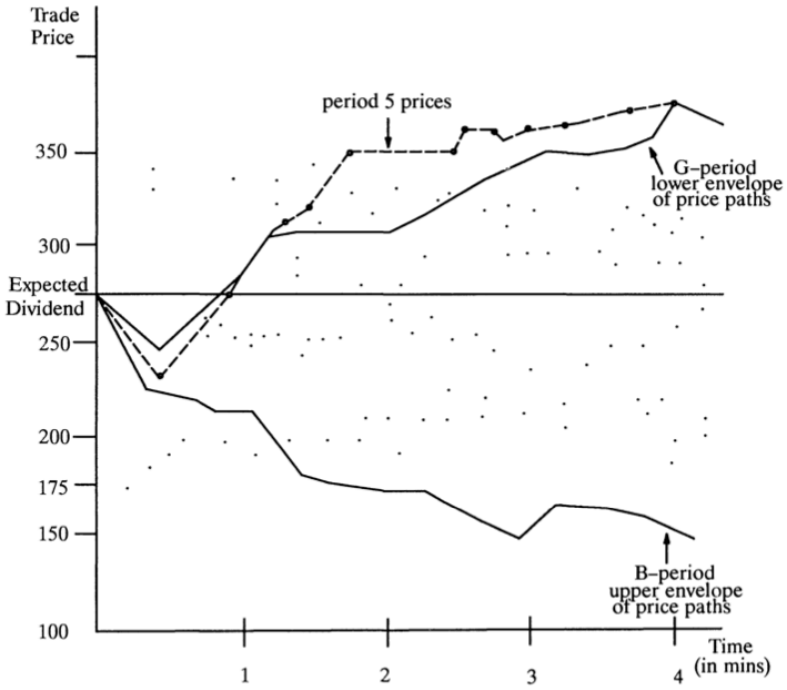


FIG. 8.—A sustained mirage price path (period 5, state *N*, in session 4). Unconnected points indicate time and price of trades in *all N* periods (except period 5) in session 4.

Figure: Mirage where market thinks it's a G state

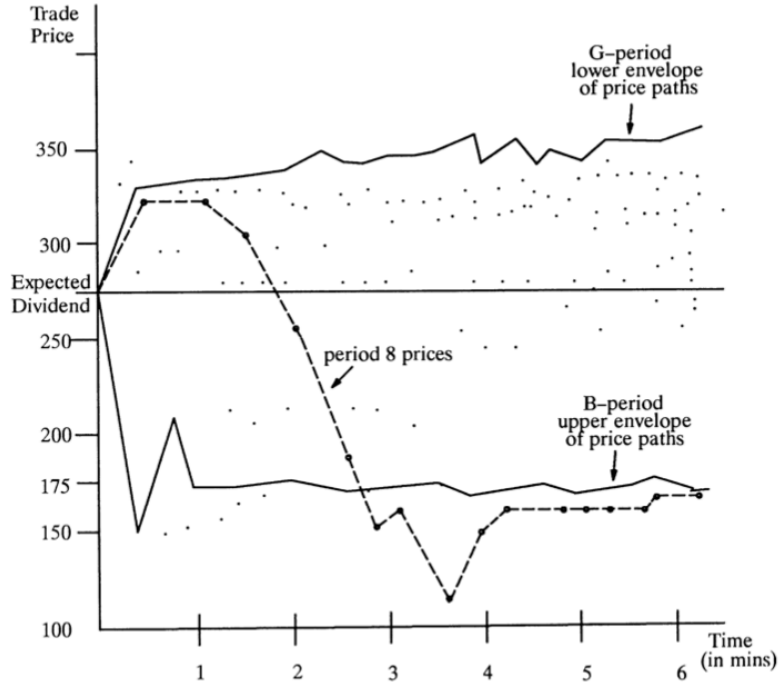


FIG. 9.—A sustained mirage price path (period 8, state *N*, in session 3). Unconnected points indicate time and price of trades in *all N* periods (except period 8) in session 3.

Figure: Mirage where market thinks it's a B state

"I can calculate the motions of the heavenly bodies, but not the madness of people" — Issac Newton

Multiperiod market experiments (asset market bubble experiments)

Classical theory

- Classical asset pricing theory: A stock's current value is the (risk-adjusted) discounted presented value of its future expected dividend stream.

$$p_t = \frac{\mathbb{E}(D_{t+1}|I_t) + \mathbb{E}(p_{t+1}|I_t)}{(1+r)}$$

  where D_{t+1} is the dividend at period $t+1$, I_t is the information at period t and r is the discount rate.

- Efficient markets hypothesis (Fama, 1970): Stock prices should only change when there is new information that influences traders' expectations.
  - $\Rightarrow$ all available information are incorporated into prices.
  - $\Rightarrow$ no *arbitrage* opportunities.
  - $\Rightarrow$ no opportunities for traders to make *supernormal* profits.

Possible that derivations from the equilibrium price can be due to different time horizons, discount rates or liquidity needs.

Bubbles and the Rational Expectation Hypothesis

> *"investors exhibit speculative behavior if the right to resell [an] asset makes them willing to pay more for it than they would pay if obliged to hold it forever." (Harrison and Kreps, 1978, Journal of Economic Theory)*

Rational expectations hypothesis (Muth, 1961, Econometica) posits that traders are able to make inferences about the profitability of their trade from market prices. They also use market prices and their private information to condition their demand for assets.

Qn: Can there be speculative behaviour when traders have *rational expectations?*

> *"unless traders have different priors about the value of an asset or are able to use the market for insurance purposes, this market does not give rise to gains from trade. Thus, speculation relies on inconsistent plans that are ruled out by rational expectations." (Tirole, 1982, Econometrica)*

Motivation

Evidence for price bubbles in closed-end funds.

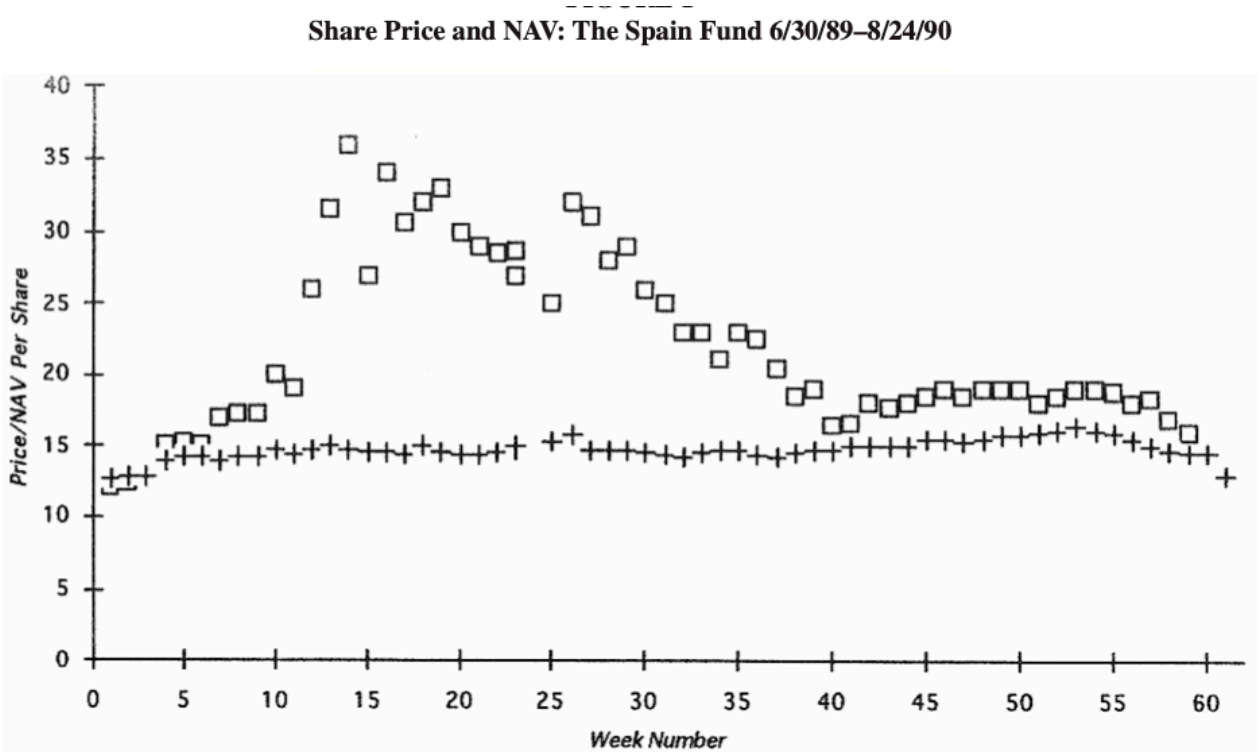


Figure: Porter and Smith 2003, Journal of Behavioral Finance.

□Price per share and $^{+}$Net asset value per share

The canonical SSW design

- There is an asset that can last for 15 periods.
- In each period t, the asset pays a dividend of 0, 8, 28 or 60 with equal chance.
- Traders begin the experiment with some money and assets.
- At each period t, they trade they asset for money over a continuous double auction market (computerised or oral).
- After period $t = 15$ the asset is worthless and traders keep their money.

Qn. What is the rational expectation price (or expected dividend) of this asset at each period t?
$\Rightarrow$ Some researchers call this the *fundamental value*.

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Price (eq.)	360	336	312	288	264	240	216	192	168	144	120	96	72	48	24

Table: Rational expectation price of asset.

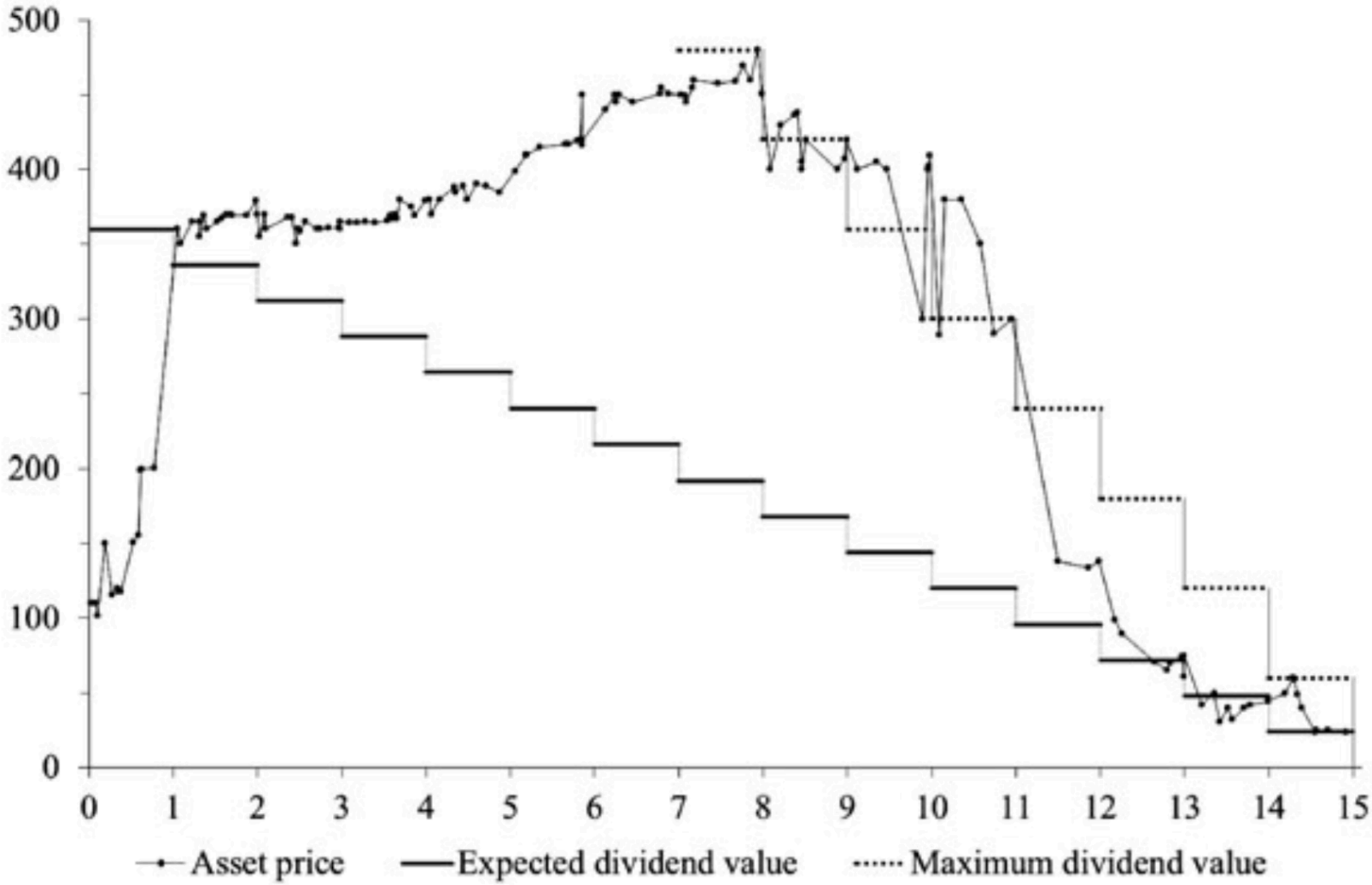


Figure: Typical price pattern (Palan, 2013, J. Econ. Surveys).

Maybe students are not as sophisticated as real world business men or women.

Arizona business executives

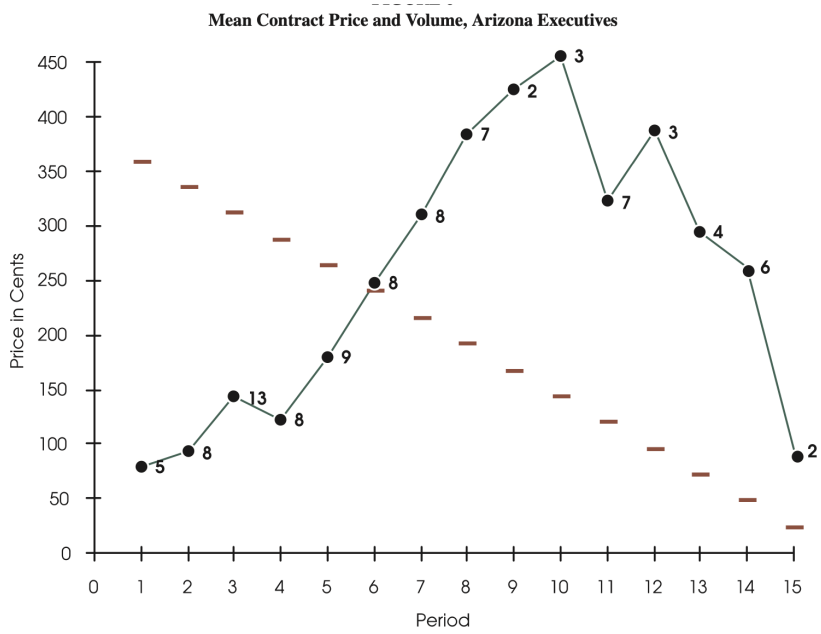


Figure: Porter and Smith, 2003, Journal of Behavioural Finance

OTC traders +"insiders" (i.e., people who were informed about the equilibrium)

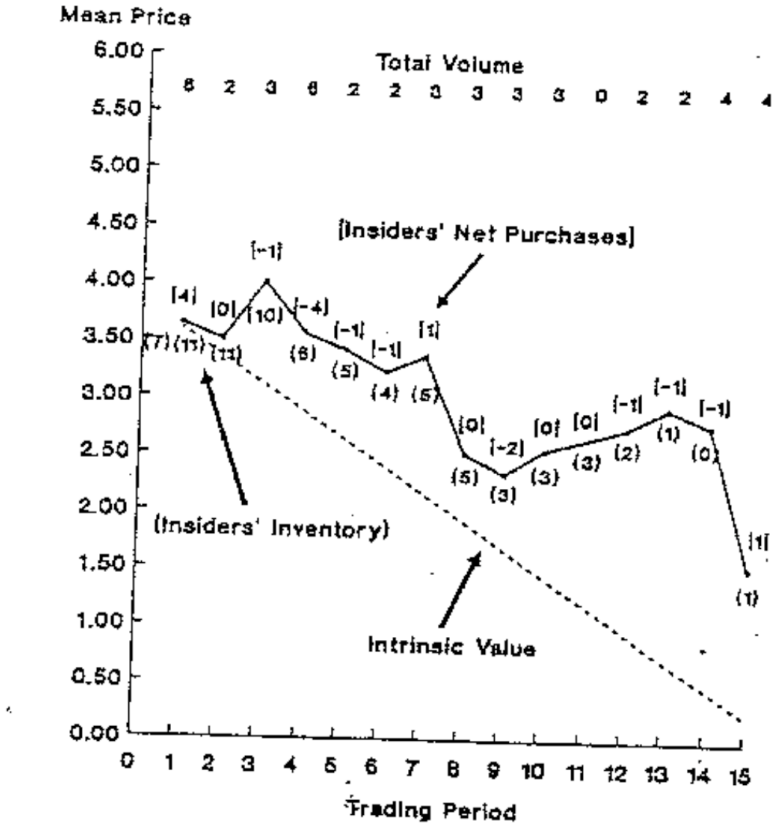


Figure: King, Smith, Williams and van Boening, 1993

Experience matters

Experience (i.e., repeated experiments) can reduce price bubbles in SSW (1988) type markets.

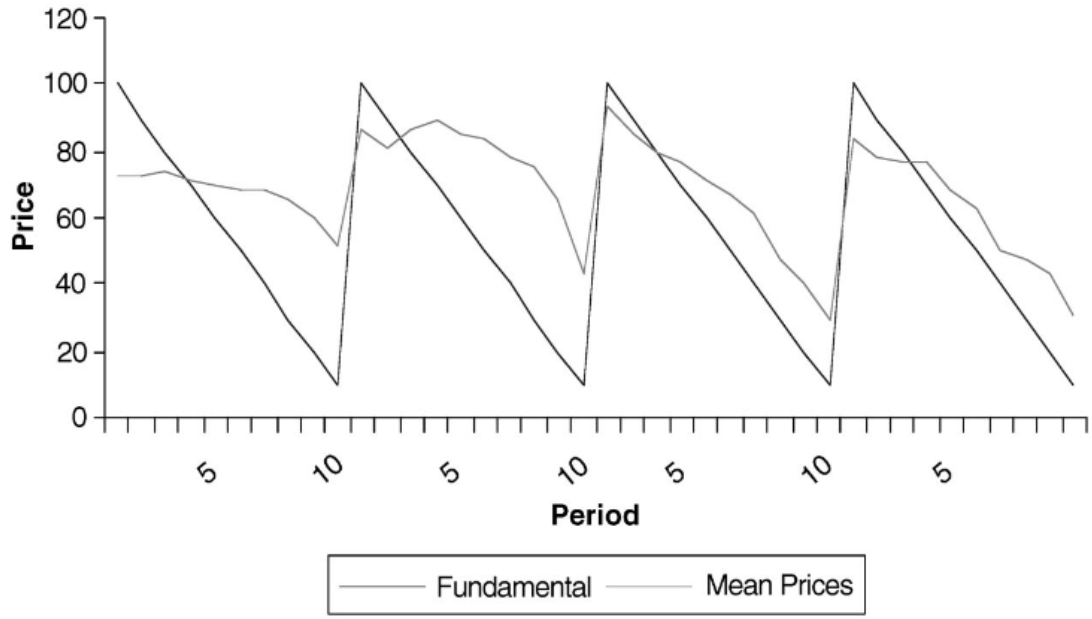


FIGURE 1. OBSERVED MEAN PRICES AND FUNDAMENTAL VALUES

Figure: Dufwenberg, Lindqvsit and moore, 2005, AER

Also see SSW (1988), King et al. (1993) and van Boening et al. (1993).

Why the SSW paradigm is attractive to experimental research

The SSW paradigm also experimenters to shed light on how institutional changes can affect asset market price bubbles (Some examples)

- individual vs. team: trading in a team (2 participants) as opposed to an individual can reduce price bubbles (Cheung and Palan, 2012).
- market size: Market size does not seem to affect price bubbles (Williams and Walker, 1993; Williams, 2008).
- short sales: The ability to short-sell can reduce but not eliminate price bubbles (Akert et. al, 2006; Haruvy and Noussair, 2006).
- Asset-to-cash ratio: Higher amounts of cash relative to the value of the assets lead to larger bubbles.
- public message: Public message such as "the price is too high" and "the price is too low" has mixed effects on prices (Corgnet et. al, 2010).

See Palan (2013, J. Econ. Surveys) for more examples.

Incentives

James and Isaac (2000, AER).

- Motivation: Many organisations use tournament incentives to motivate traders. Does, such incentives create price bubbles.
- Baseline (B): Paid as per normal
- Tournament(T): Paid twice as per normal if payoff is above the average. Paid a fixed amount if payoff is below the average.
- 6 sessions (9 traders per session).
- Sequence of each session was $BBTTBT$

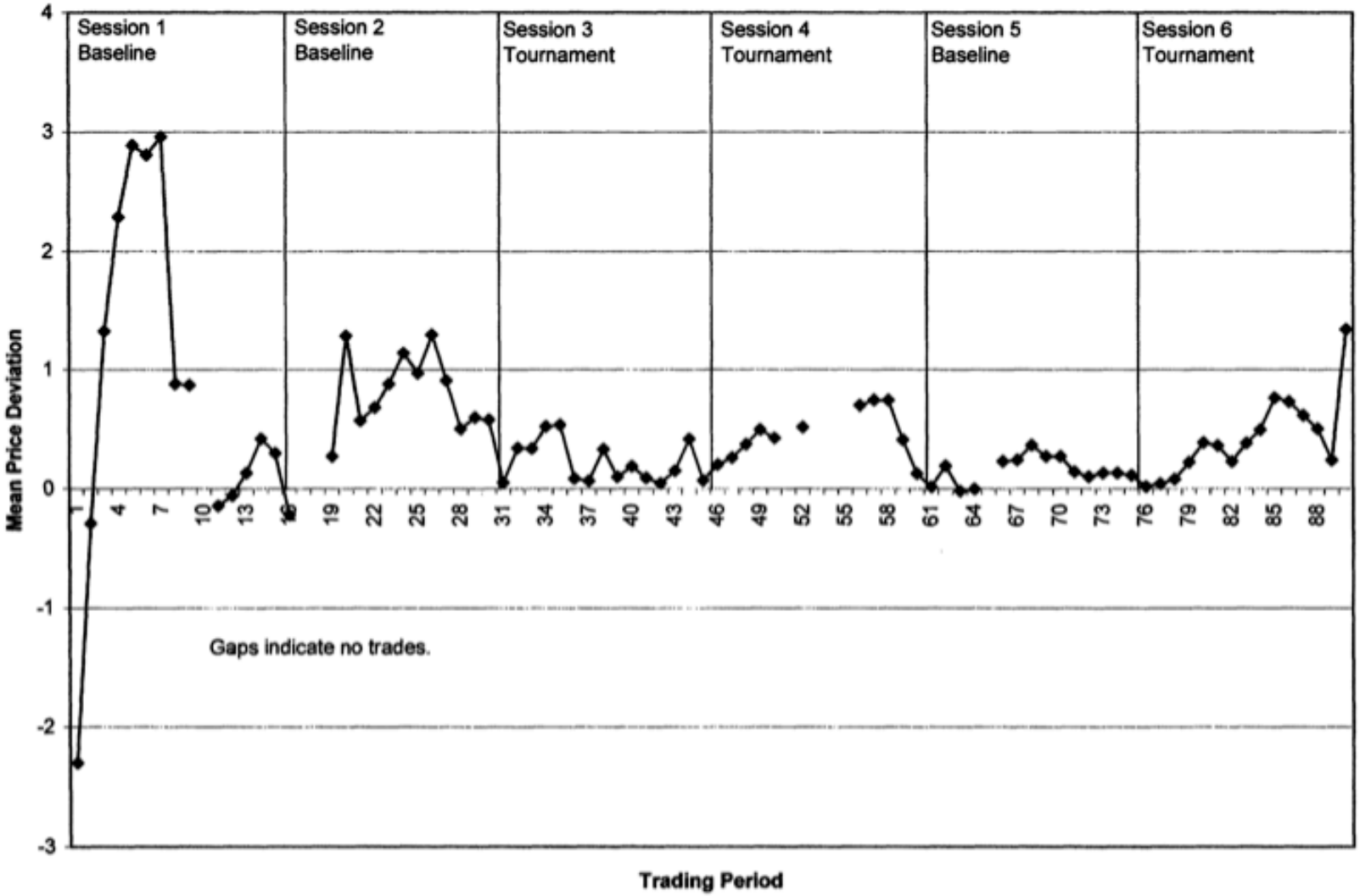


Figure: Mean prices over periods

Emotions

Andrade, Odean and Lin (2016, Review of Finance)

- 55 experimental sessions (9 subjects per session)
- Use movie clips (5mins): told subjects that it was a time-filler as they prepared the experiment.
  - Excitement. *Knight and Day* and *Mr and Mrs. Smith*
  - Fear. *Hostel* and *Salem's Lot*
  - Calm. *Franklin* and *Peace in the water*
- End-of-experiment questionnaire found that only 2.2% corrected guessed the purpose of the experiment.
- Use a separate group of subjects ($n = 85$) to verify that movie clips triggered the intended emotions.

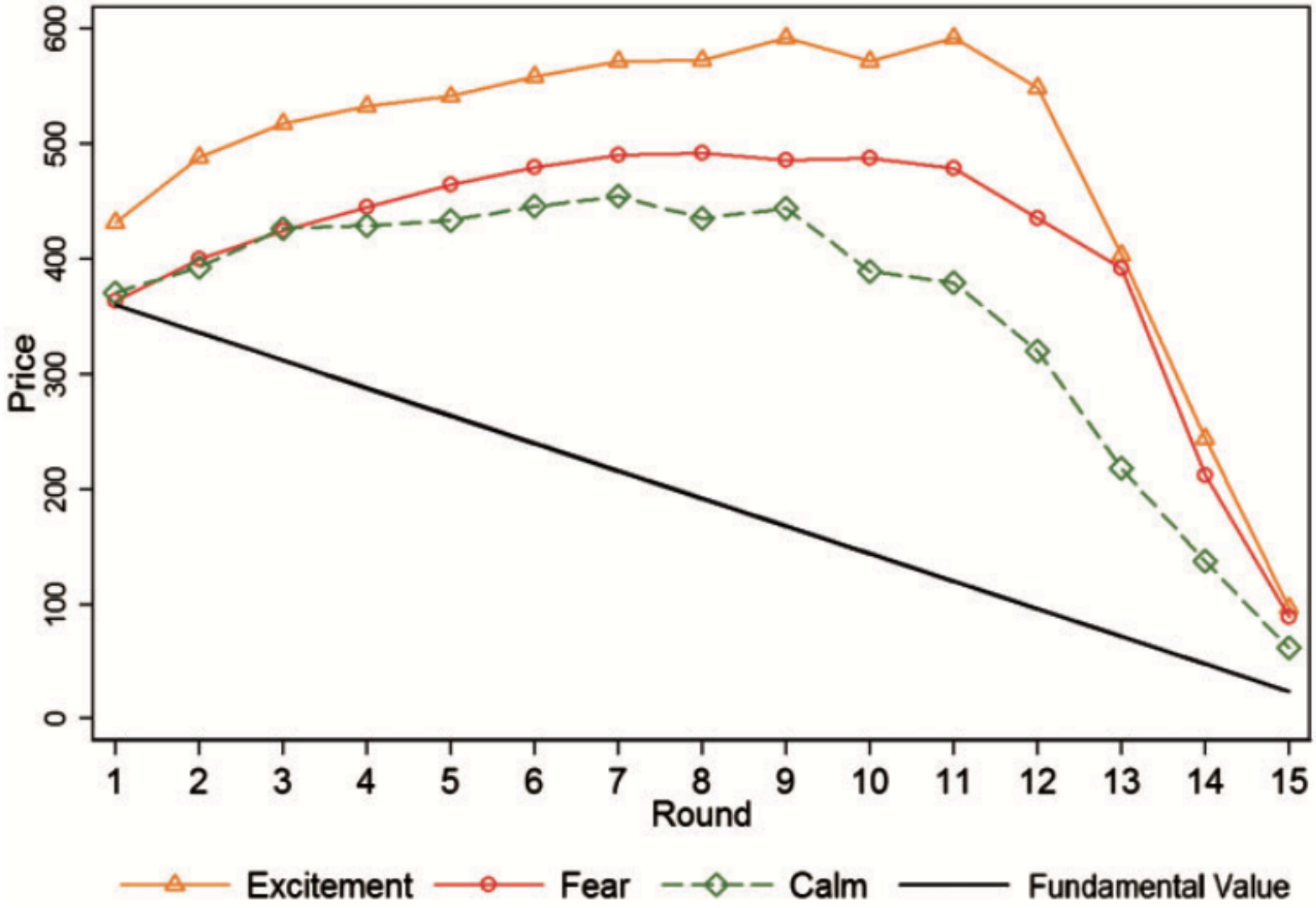


Figure 1. Average prices by round for each treatment (excitement, fear, and calm). The average trading prices are plotted round-by-round for twenty-four "Excitement" markets, sixteen "Fear" markets and fifteen "Calm" markets. The downward sloping straight line plots the declining fundamental values over fifteen rounds of trading.

Regular bubble measures in the literature

- **Price Amplitude**. Measures the trough-to-peak change in market price relative to the fundamental value and is normalised by the initial fundamental value.

$$PA = \frac{\max \bar{P}_t - FV_t}{FV_1} - \frac{\min \bar{P}_t - FV_t}{FV_1}$$

- **Total dispersion**. sum of all period absolute deviations of median prices from FV.

$$TD = \sum_{t=1}^{T} |\text{Median } P_t - FV_t|$$

- **Average biases**. averages the sum of all median price deviations from FV.

$$AB = \frac{\sum_{t=1}^{T} (\text{Median } P_t - FV_t)}{T}$$

- **Duration**. maximum number of consecutive periods within a market that the price deviations from FV increase

$$DUR = \max(N : \bar{p}_t - FV_t < \bar{p}_{t+1} - FV_{t+1} < ... < \bar{p}_{t+(N-1)} - FV_{t+(N-1)})$$

Desirable properties of bubbles measures (Stöckl, Huber and Kirchler, 2010, ExpEcon)

(i). relate FV and price.

(ii). monotone in the difference between FV and prices.

(iii). invariant to nominal changes in the experimental setting and thus comparable across different settings

The authors proposed:

$$RAD = \frac{\sum_{t=1}^{T} |\bar{p}_t - FV_t|}{|\bar{FV}|}$$

$$RD = \frac{\sum_{t=1}^{T} (\bar{p}_t - FV_t)}{|\bar{FV}|}$$

Criteria	(i)	(ii)	(iii)
Price amplitude	YES	NO	YES
Total dispersion	YES	NO	NO
Average biases	YES	YES	NO
Duration	YES	NO	NO
RAD	YES	YES	YES
RD	YES	YES	YES

Does the type measure influence interpretations?

Table 2 Experimental treatments

Treatment	Reference	FV-process	$E(FV_1)$	$E(FV_N)$	Periods	Information distribution
SSW_FV50	Huber et al. (2009)	dividend-based, Δ FV deterministic	50	0	10	symmetric
SSW_FV100	Sutter et al. (2009)	dividend-based, Δ FV deterministic	100	0	10	asymmetric
SAVE_N10	Kirchler et al. (2009)	Random-Walk without drift, no dividends	50	50	10	symmetric
ASYMM_N24	Kirchler (2009)	Random-Walk with drift, no dividends	40	45.1	24	asymmetric

Notes: $E(FV_1)$ ($E(FV_N)$) stands for the expected FV in period 1 (at the end) of the experiment

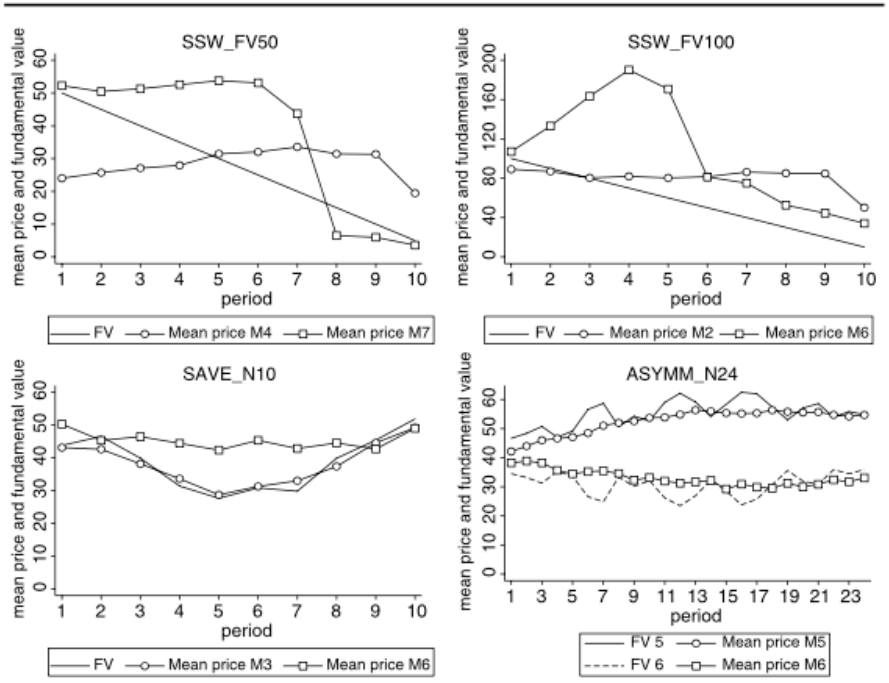


Fig. 1 FVs and mean prices for selected paths. M_i indicates market i of a treatment

Table 3 Bubble measures for selected paths

Treatment	Market	PA	TD	AB	HR^2	DUR	RAD	RD
SSW_FV50	M4	0.946	139.493	0.901	0.024	8	0.507	0.033
$E(FV_1) = 50$; $N = 10$	M7	0.732	126.094	9.825	0.681	5	0.459	0.357
SSW_FV100	M2	0.757	284.505	25.655	0.293	8	0.517	0.466
$E(FV_1) = 100$; $N = 10$	M6	1.130	501.815	50.182	0.543	3	0.912	0.912
SAVE_N10	M3	0.162	19.220	−0.535	0.961	2	0.050	−0.014
$E(FV_1) = 50$; $N = 10$	M6	0.401	79.783	6.624	0.353	3	0.206	0.171
ASYMM_N24	M5	0.233	80.796	−2.728	0.552	3	0.061	−0.049
$E(FV_1) = 40$; $N = 24$	M6	0.434	88.356	2.274	0.081	3	0.120	0.074

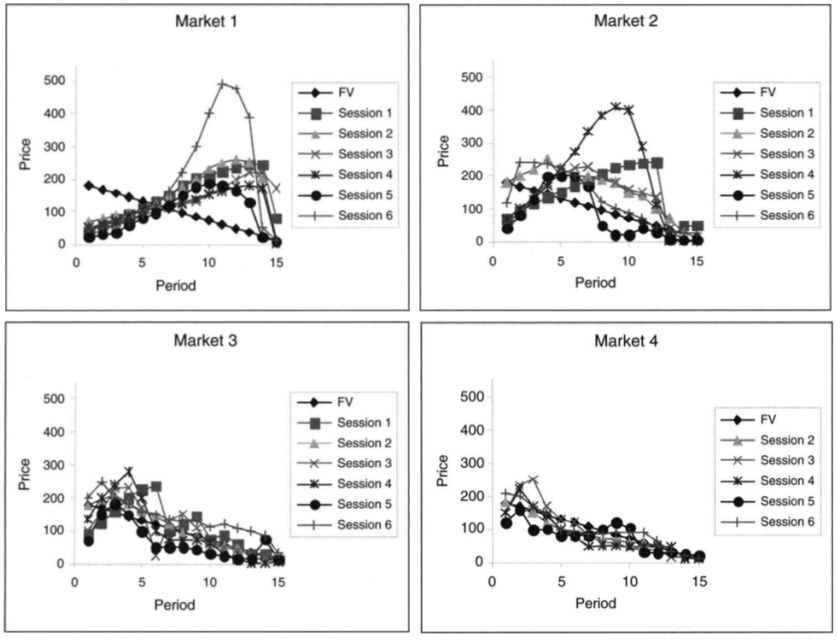
Notes: $E(FV_1)$ stands for the expected FV in period 1 of the experiment, N for the total number of periods in the experiment

Why do bubbles occur: Do traders expected price bubbles?

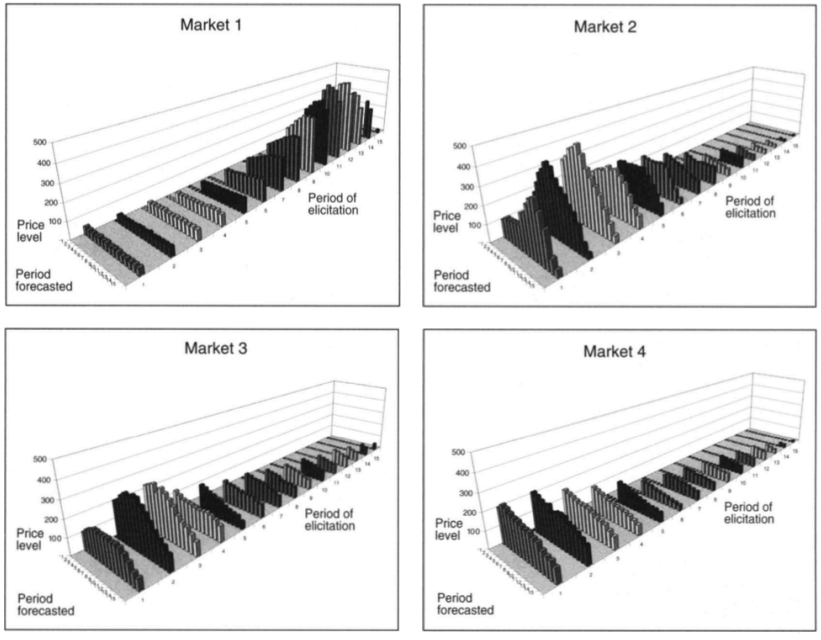
Haruvy, Lahav and Noussair (2007, AER)

- Conducted 6 experimental sessions (9 subjects per session)
- Each session participated 4 times in the SSW markets (1^{st}, 2^{nd},...,4^{th} market)
- In period t of each market, traders had to forecast prices for periods $t+1$, $t+2$, and so forth.
  - forecast within 10% accurate = 5 points
  - forecast within 25% accurate = 2 points
  - forecast within 50% accurate = 1 point

Prices in all sessions



Forecast in session 6



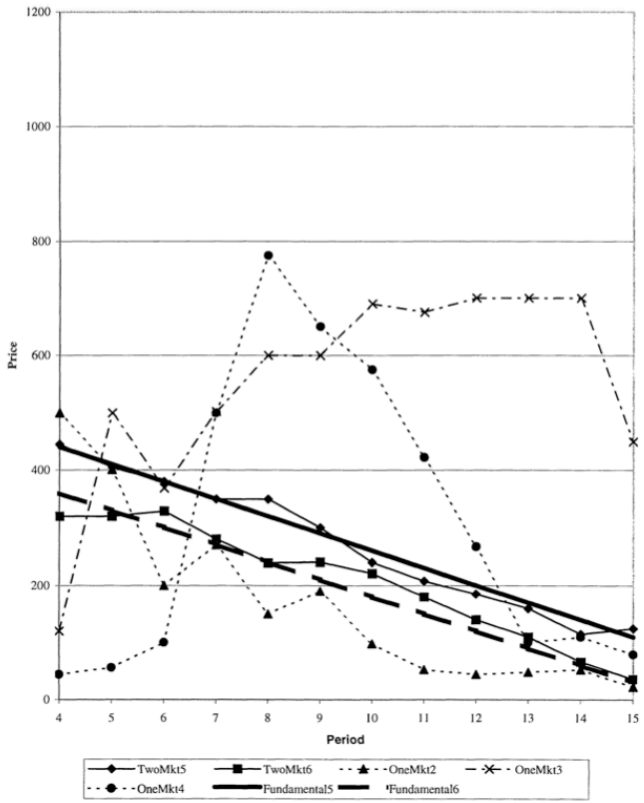
Forecast suggest that inexperienced traders to not expect prices to decrease!

Why do bubbles occur? Active participation hypothesis

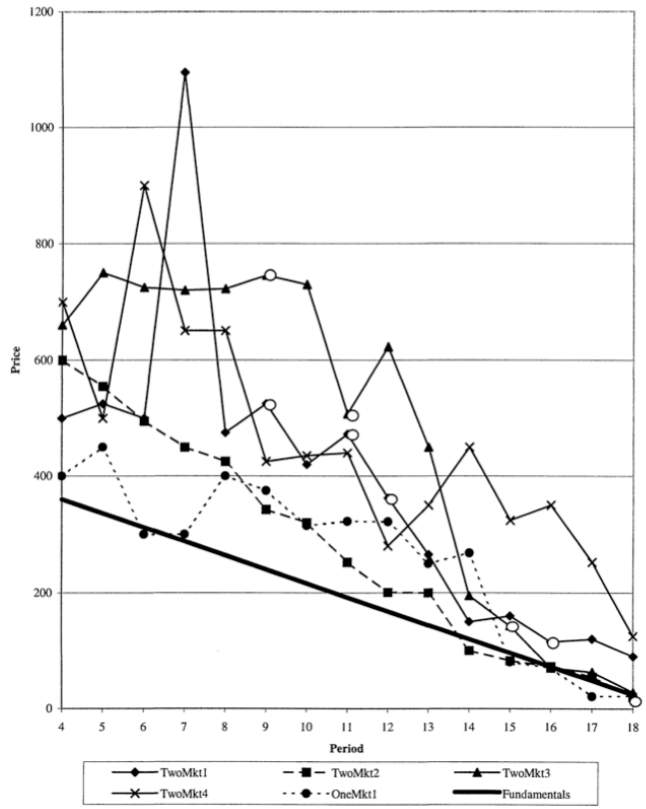
Subjects trade simply because they have no other activity to occupy their time and because of an experimenter demand effect (Lei, Noussair and Plott , 2001, Econometrica).

- Allow subjects to trade in Two markets as opposed to One market ⇒ Transactions should be lower in the two market setup and possibly, bubbles will be smaller.

12 period market



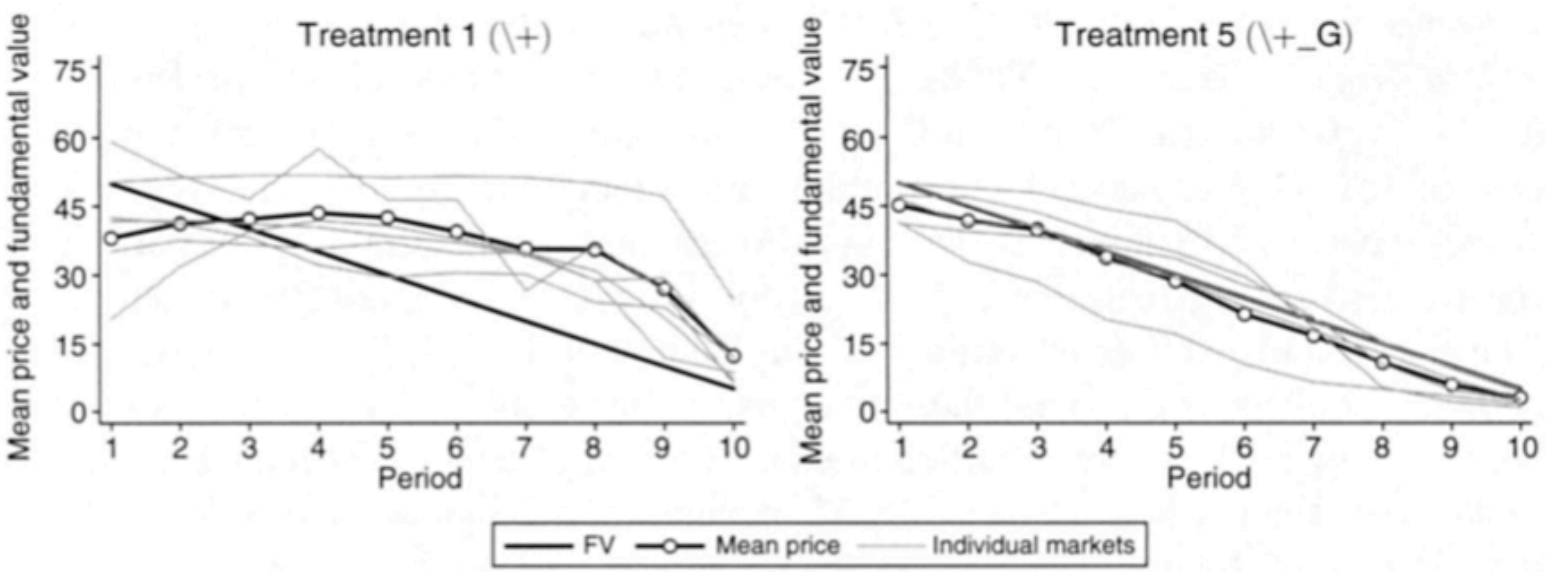
15 period market



Why do bubbles occur? Subject confusion

Kirchler, Huber, and Stöckl (2012, AER)

- Treatment (\+). Framed as stock market
- Treatment ($\backslash +_G$). Framed as a gold mine shareholding.



Baghestanian and Walker (2015, JEBO) argue that the gold mine framing does not reduce confusion but increases "focalism" on the FV.

Perhaps not all subjects are equal

Bosch-Rosa, Meissner and Bosch-Domeǹech (2018, ExpEcon) screened for subjects' cognitive abilities before admitting them into the SSW.

- Screening stage
  - Cognitive reflective test score (Frederick, 2005)
  - Guessing Game (Nagel, 1995) against oneself.
  - Race to 60 (Gneezy et al. 2010; Levitt et al. 2011) for 12 rounds against the computer.
- Scoring stage: Create a sophistication score (S_i) for each subject.
- Selection stage:
  - LOW: Lower 30% of the S_i distribution
  - HIGH: Lower 30% of the S_i distribution
- SSW experiment: 3 x (15 period) rounds + forecast at each period.

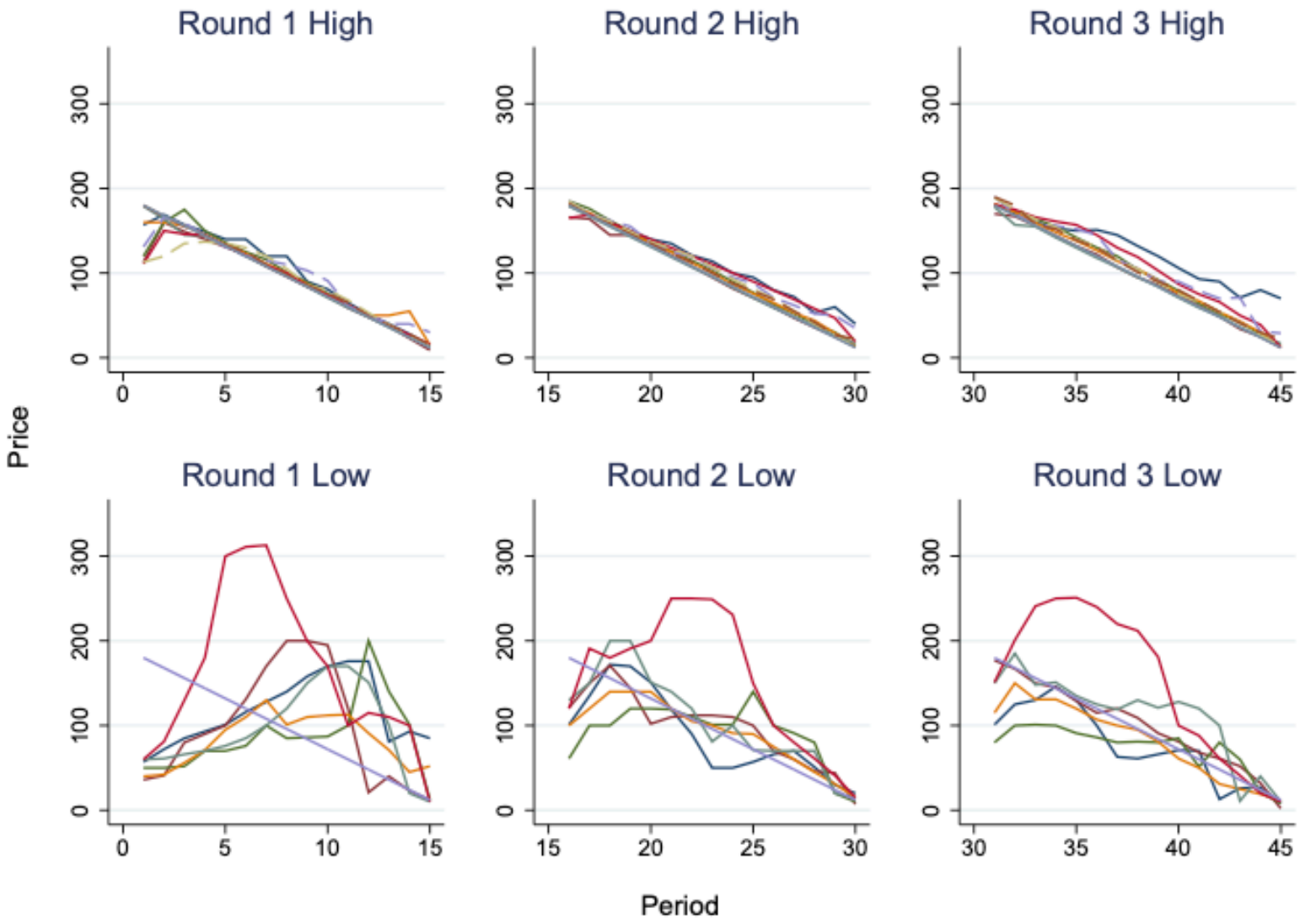


Figure: Mean prices in the LOW and HIGH treatments

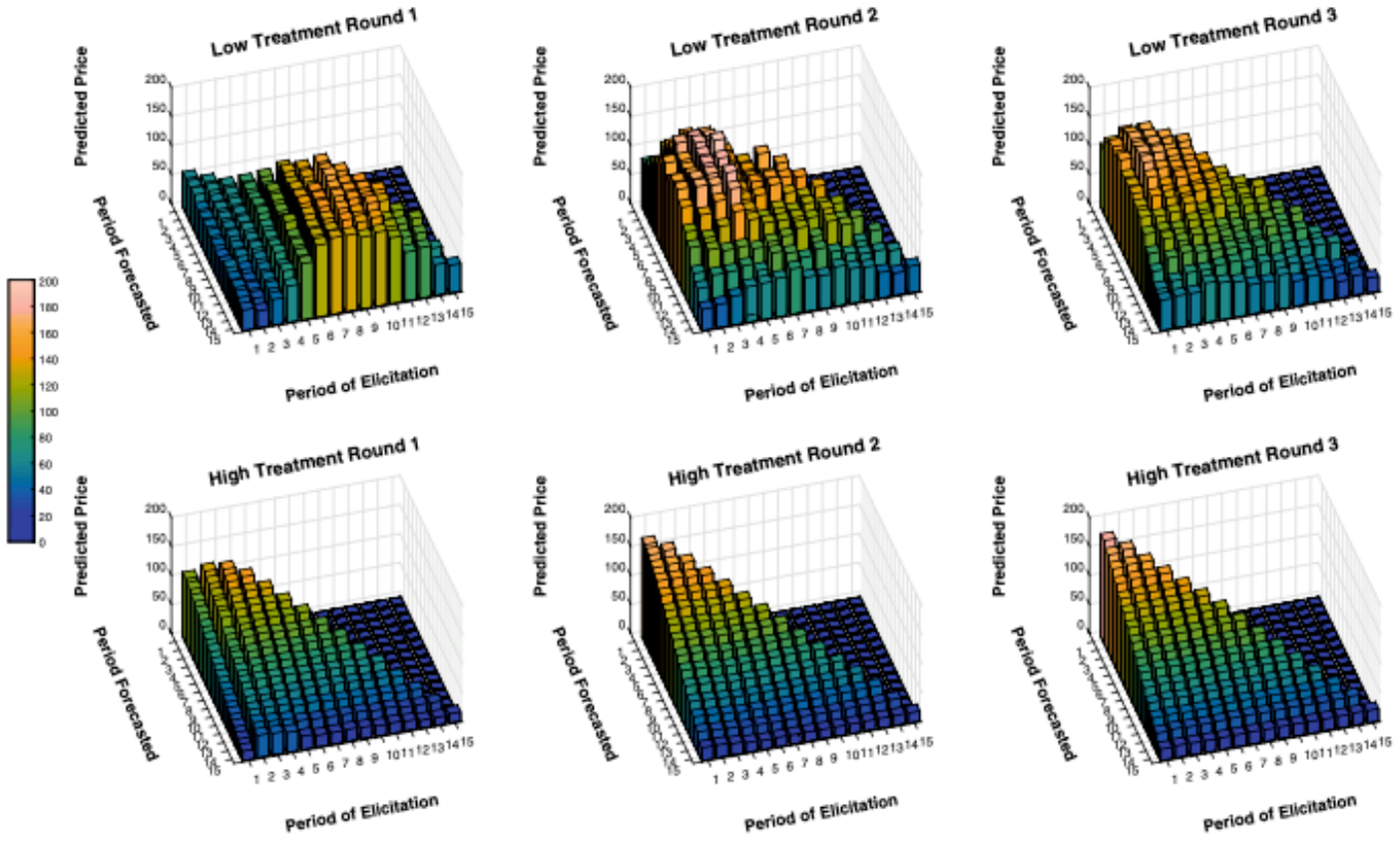


Fig. 3 Average price predictions for Low (*above*) and High Sophistication treatments (*below*) in the three rounds. "Period of Elicitation" indicates the period in which the price predictions are made. "Period Forecasted" indicates the periods for which the predictions are made. The *colors* of the *bars code* for the average prices predicted, from beige for high prices to *dark blue* for low ones. (Color figure online)

Figure: Mean forecast (price predictions) in the LOW and HIGH treatments

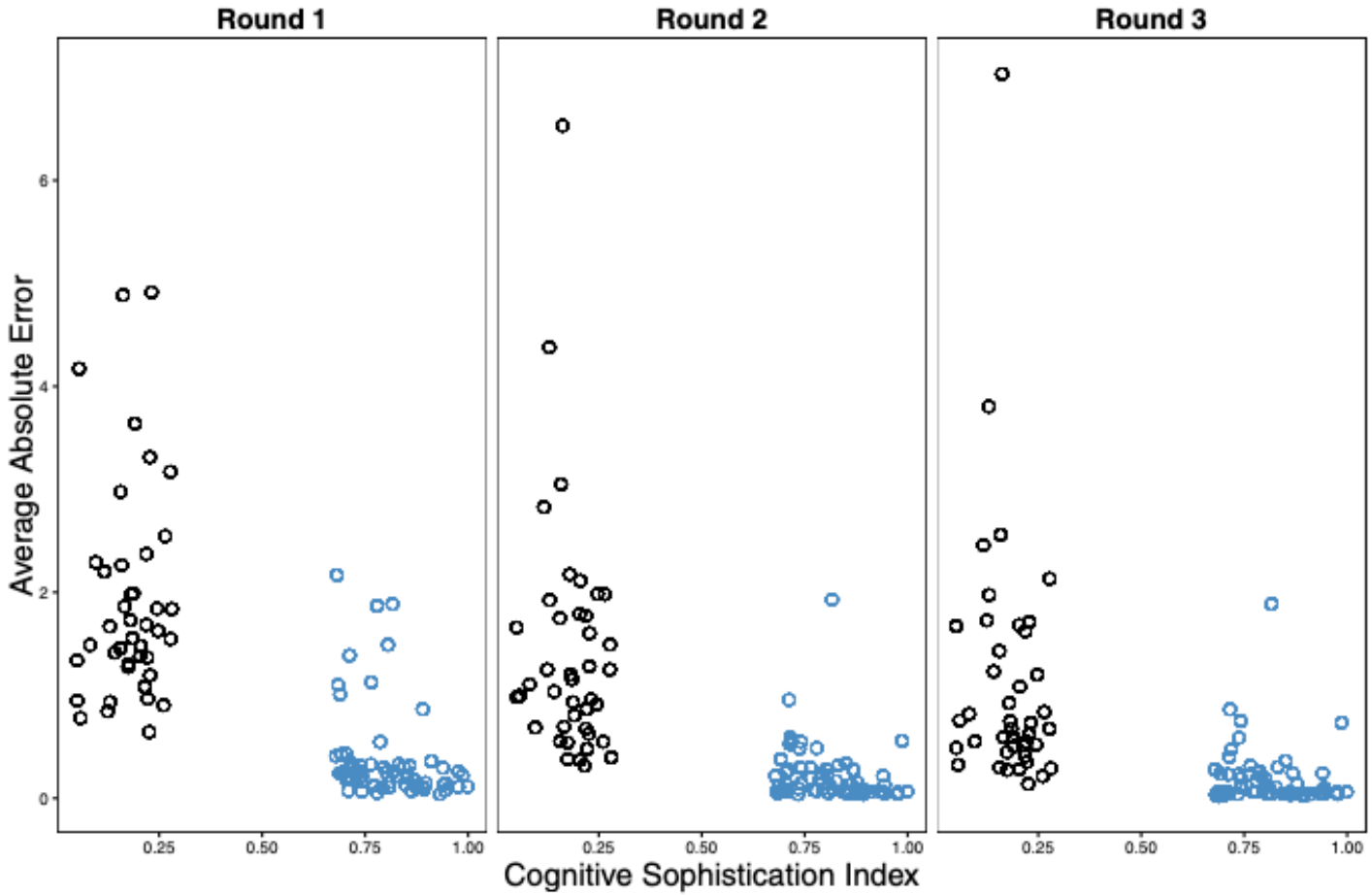


Fig. 4 Average absolute error in rounds 1 to 3 on the *vertical axis* with the corresponding Index of Cognitive Sophistication, S_i, on the *horizontal axis*. *Black dots* correspond to Low Sophistication sessions while *blue dots* refer to High Sophistication sessions. (Color figure online)

Figure: Mean forecasting error by sophistication index S_i

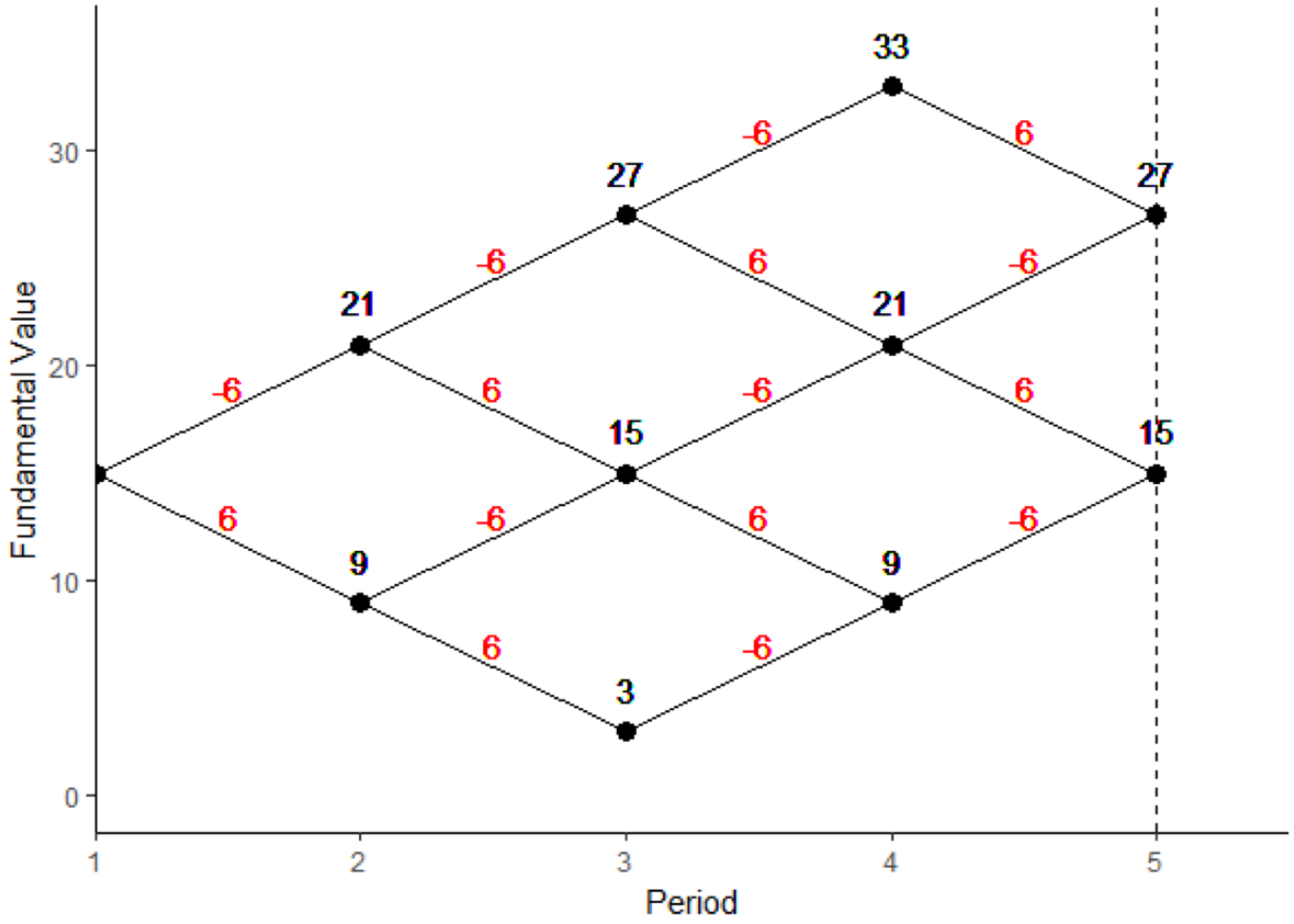
non-monotonic fundamental value

Is there a natural manner to generate a non-monotonic price path (Bossaerts, Shachat and Xie, 2008, WP)?

- There is an asset that "lives" for 5 periods.
- At the end of the 5th period, the asset is worth \$21.
- At each period the asset pays a dividend that is randomly drawn from the set

$$\{-6, -6, -6, 6, 6\}$$

  without replacements.
- what is the fundament value of the asset at each period t?


33
27
27
21
21
15
15
9
9
3
-6
6
Fundamental Value
30
20
10
0
1
2
3
4
5
Period

Learning to Forecast experiments (LtFE)

"in which the competitors have to pick out the six prettiest faces from 100 photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole: so that each competitor has to pick, not those faces that he himself finds prettiest, but those that he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point of view.....We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practise the fourth, fifth, and higher degrees" – *Keynes*

Hommes, Sonnemans, Tuinstra and van de Velden (2005, Review of Financial studies)

- Traders' decision are based upon their expectations and beliefs about the future state of the market, and thus generate a expectation feedback mechanism.
- Self-confirming nature. If many traders expect the price of an asset to increase, their demand for the asset increases, which by the law of demand and supply, increases the price of the asset.
- Many industry commentators speak about the *psychology of the market* (e.g., Benjamin Graham's Mr. Market).

Q. How to observe information about traders' expectations?
Q. How are expectations formed?
Q. Do expectations converge?

Each market consist of

- 6 traders and some computerised "fundamentalist"
- Risk free asset that pays returns $R = 1 + r$ where r is the discount rate.
- infinitely lived risky asset that pays the stochastic returns y_t at each period t. The returns are i.i.d with mean $\bar{y}$.

Task. At each period t, subject h predict the next period risky asset price $(p^e_{h,t+1})$—they do this before observing p_t.

- subjects only know that the price will be determined by some market equilibrium that takes into account the supply and demand for the asset, but DO NOT KNOW the exact underlying equilibrium.
- The payment to subject h in period t is

$$e_{ht} = \max\left\{1300 - \frac{1300}{49}(p_t - p^e_{ht})^2, 0\right\}$$

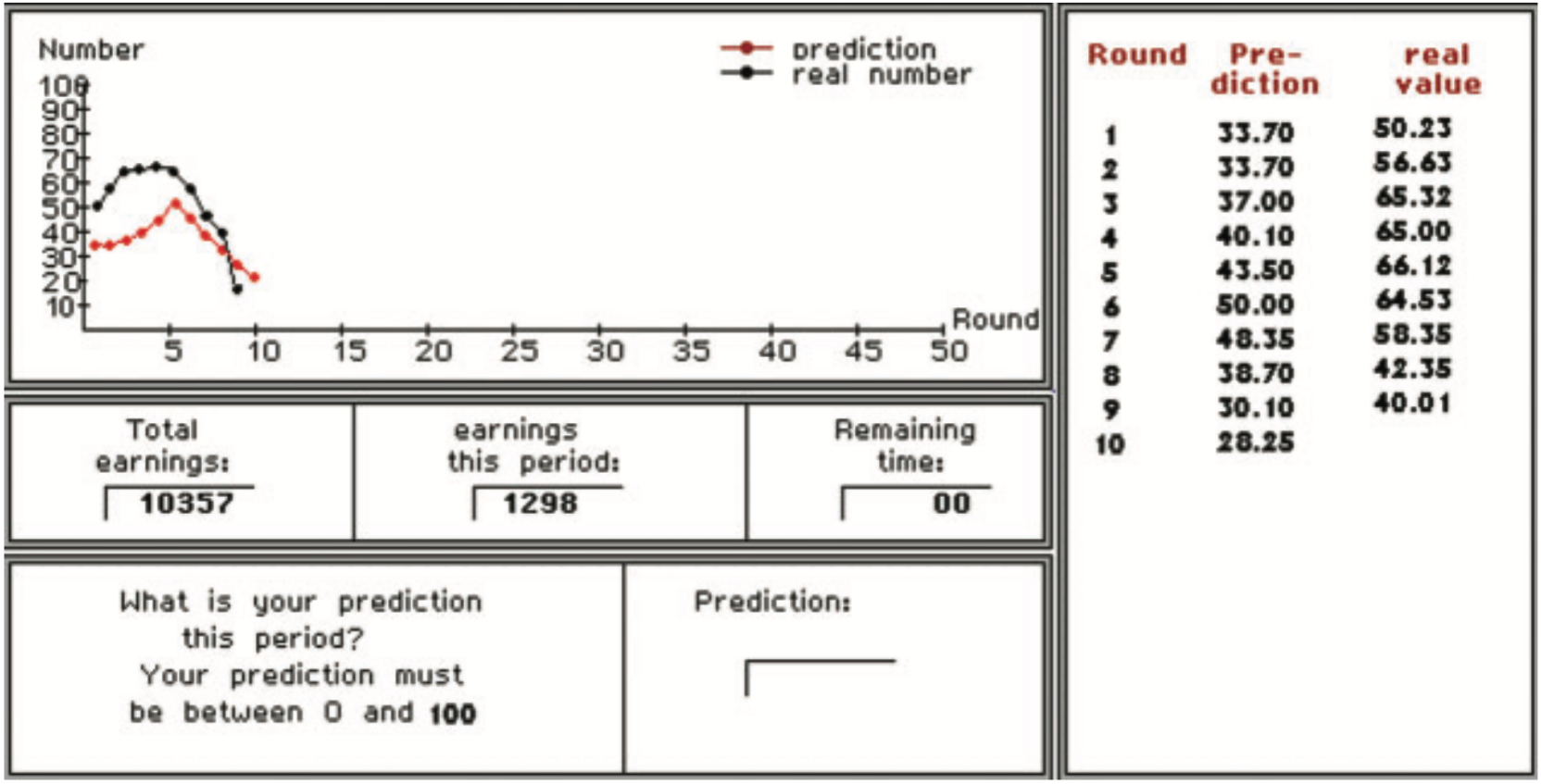


Figure: How subjects submit their predictions

The market clearing conditions (Brock and Hommes, 1998) for the risky asset

$$p_t = \frac{1}{1+r}\left[(1-n_t)\bar{p}^e_{t+1} + n_t p^f + \bar{y} + \epsilon_t\right]$$

where $p^f = \bar{y}/r$ is the "fundamental value", $\epsilon \sim \mathcal{N}(0, 0.25)$ is some stochastic shock, and

$$\bar{p}^e_{t+1} = \frac{1}{6}\sum_h p^e_{h,t+1}$$

is the average forecast of all traders, and

$$n_t = 1 - \exp\left(-\frac{1}{200}|p_{t-1} - p^f|\right)$$

is the weight of fundamentalist (computer traders) on price.

Models of price movements

- *Rational expectations.*

$$p^e_{h,t+1} = p^f$$

- *Naive expectation.*

$$p^e_{h,t+1} = p_{t-1}$$

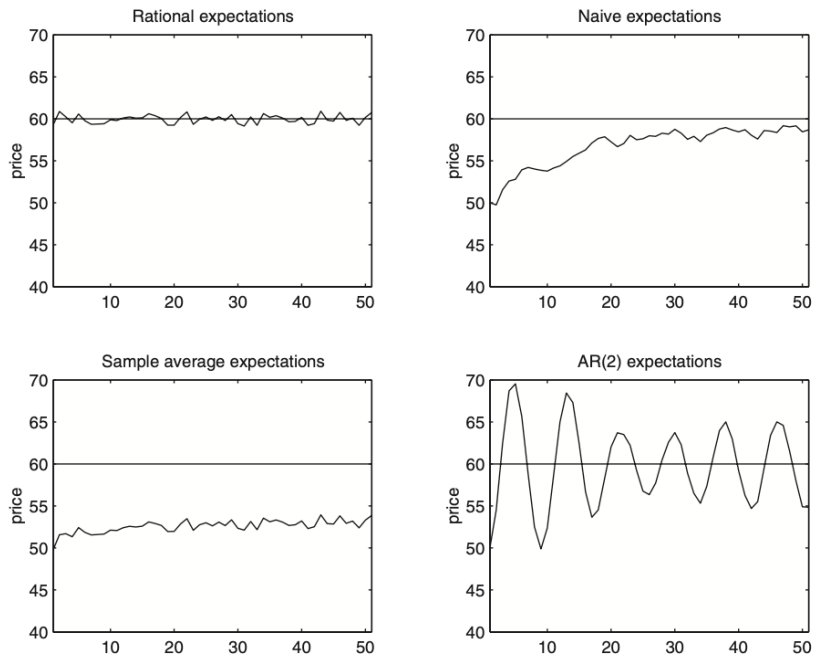
- *Adaptive expectations.*

$$p^e_{h,t+1} = \omega p_{t-1} + (1-\omega) p^e_{h,t}, \quad \omega \in (0,1)$$

- *Autoregressive (AR) 2.*

$$p^e_{h,t+1} = \alpha_h + \beta_{h,1} p_{t-1} + \beta_{h,2} p_{t-2}$$

Assume that $p^f = 60$,



Qn. Do prices converge to the Rational expectations (p^f)?

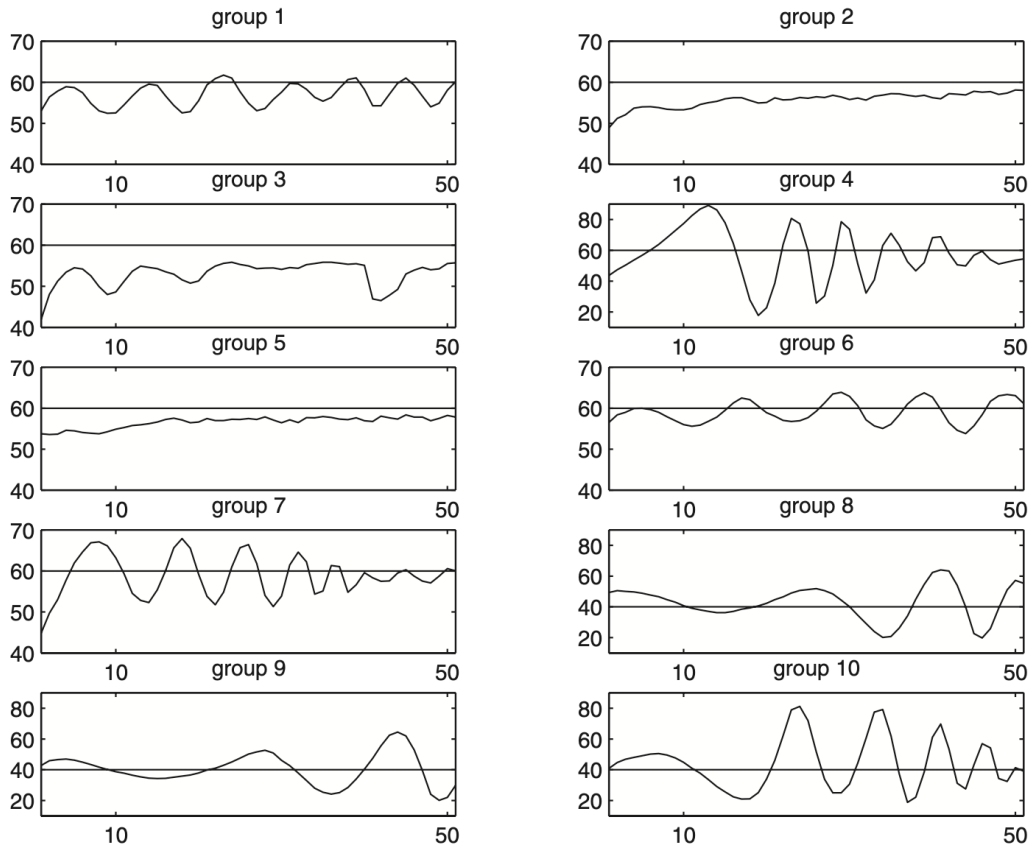


Figure: Market prices (10 sessions of 6 traders with 51 periods each)—the horizontal line details p^f)

Qn. Do traders' expectations converge?

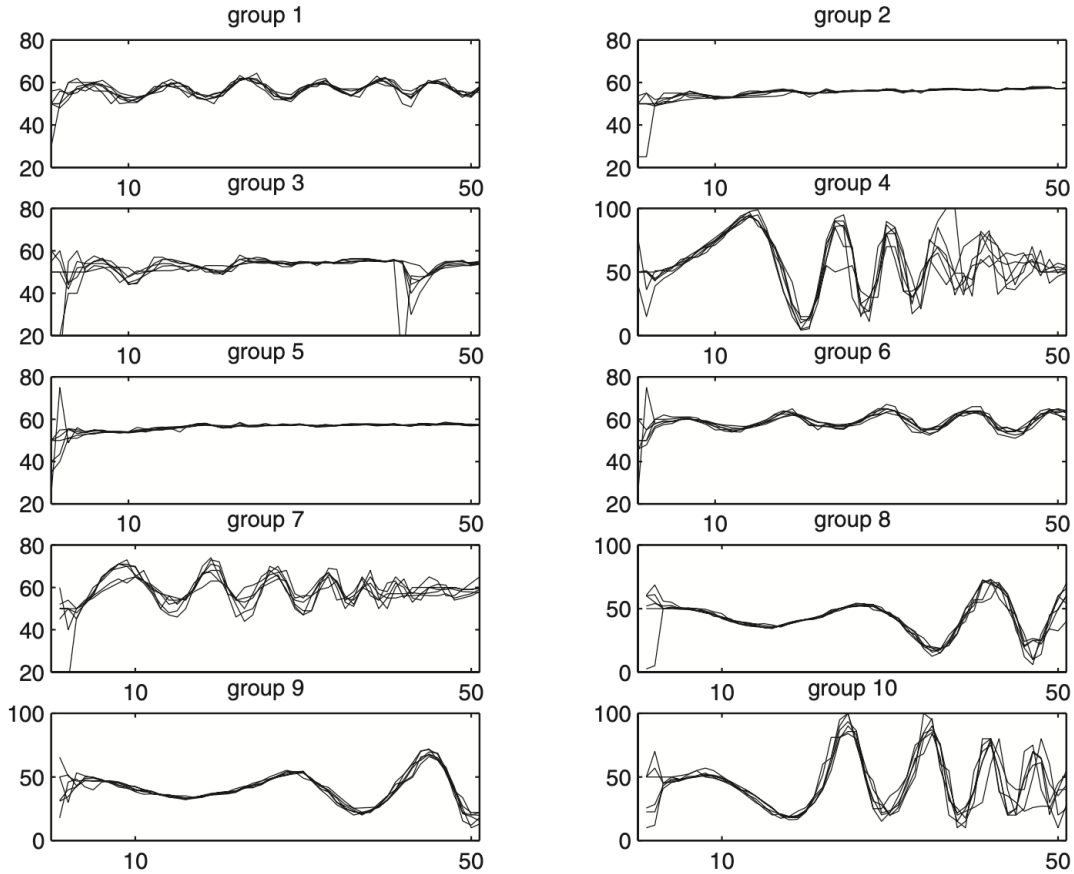


Figure: Traders' predicted prices

Qn. What happens to prices and expectations when there are no fundamentalist traders?

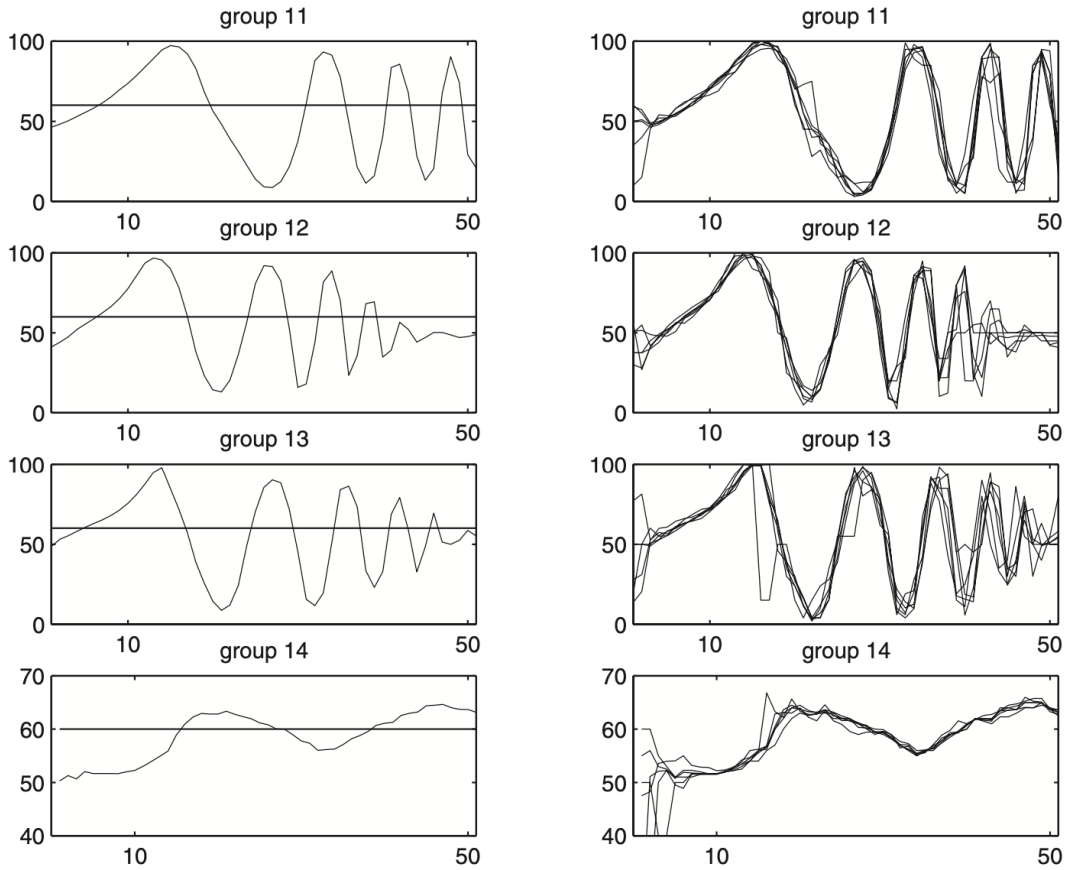


Figure: Prices (left column) predicted prices (right column) is 4 additional sessions without fundamentalist traders

End of chapter 2