2. Markets

- Double auction
- Robustness
  - Earnings inequalities, number of traders, culture, zero intelligence
- One-sided auction
- Bubbles in a stock market experiment

2. Competitive markets

- Assumptions
  - Agents are rational and selfish utility/profit maximizers
  - A homogeneous well defined good is produced and traded
  - There are numerous firms and consumers
  - Agents are price takers (auctioneer)
- These assumptions can be seriously questioned
  - People are boundedly rational
  - People often have interdependent utility functions
  - There are many markets with only few firms
  - In most markets there is no auctioneer but agents set prices

Questions

- Are these real-world deviations negligible frictions, or do they seriously challenge the predictive power of the competitive model?
- I.e., is the competitive equilibrium a robust prediction of price and quantity outcomes even for more “realistic” market institutions where these assumptions do not hold perfectly?
  - Answer is very important (e.g., for the first and the second welfare theorem).
- How do alternative market institutions differ with respect to, e.g., efficiency, convergence etc.?

The first (market) experiment: Chamberlin

- **Chamberlin (JPE, 1948)** conducted bilateral trading experiments with his graduate students at Harvard to "prove" the failure of the competitive model.
- He concluded:

  "… *economists may have been led unconsciously to share their unique knowledge of the equilibrium point with their theoretical creatures, the buyers and sellers, who, of course, in real life have no knowledge of it whatsoever*." (p. 102)

Response by Vernon Smith

- V. Smith, a former Harvard student changed Chamberlin's trading institution in the following way:
  - Instead of having the subjects circulate and make bilateral deals he used the oral double auction procedure.
  - He also implemented the method of "stationary replication", which is a sequence of trading days with stationary demand and supply schedules.
- The market equilibrium was reached.
- "These two changes seemed to me the appropriate modifications to do a more credible job of rejecting competitive price theory, which after all, was for teaching, not believing..." (Smith 1991, p. 155).

Details of the double auction
(homogeneous goods)

- Each buyer *i* is paid according to $B_i(x_i)-p_i$ where x_i denotes the number of goods bought.
- Each seller is paid according to $p_i-S_i(x_i)$.
- There is a limited time for trading per "market day". If trading ceases before the time limit is reached, the "day" ends. In a typical case, a day is 5 to 10 minutes.
- Within a market day a buyer can make price bids to the group of sellers for a specified quantity and/or accept a seller's price offer for a specified quantity at any point in time.
- Within a market period a seller can make price offers to the group of buyers for a specified quantity and/or accept a buyer's price bid for a specified quantity at any point in time.

Details...

- Improvement rule: A new bid must be better (higher) than the highest standing bid. A new offer must be better (lower) than the lowest standing offer.
- If a bid (offer) is accepted a binding contract is concluded.
- In general, individuals only know their own $B_i(x_i)$ or $S_i(x_i)$ values.

Is the outcome in the DA obvious?

"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)

Obvious… ?

- Demand and supply change during a trading period.
- Nothing ensures that trade will take place at the CE. Notice that the number of CE-trades is in general smaller than the number of economically feasible trades. In principle it might be possible that all feasible trades take place.
- There is no rigorous game theoretic prediction.

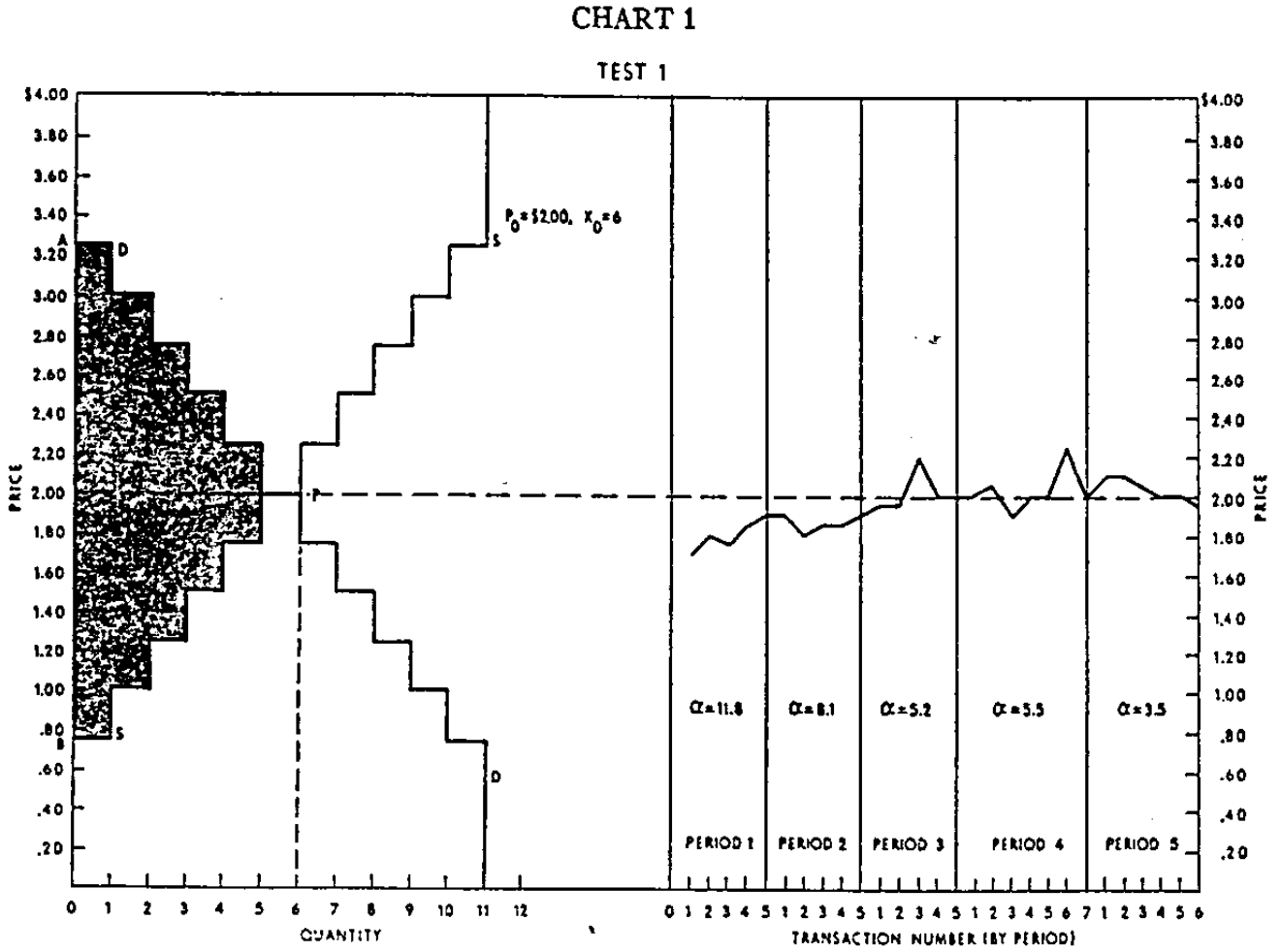
Hypotheses

- „Prices converge“
  - Def: α = standard deviation of the trading prices in a given period around the predicted equilibrium price.
  - α declines over time?
- „Efficiency is high“ = Sum of realized incomes divided by sum of possible incomes close to 1?

Results

- Main result:
  - Symmetric supply- and demand functions (Chart 1; Smith 1962)
  - Prices converge, i.e., α declines
- Further findings (less important and robust?)
  - Charts 2/3: better convergence for flat supply- and demand functions (range of offers!)
  - Chart 5: Quick reaction to changes in the supply- and demand functions
  - Charts 4/6/7: division of rents has an impact on the direction of convergence
    - Chart 4: Buyers are on short side, sellers earn almost nothing, prices come “slowly” from above
    - Chart 6/7: Sellers earn relatively high rents, buyers show resistance to pay high prices, convergence from below

Symmetric supply and demand functions



From: From: Smith (1962)

CHART 2

TEST 2

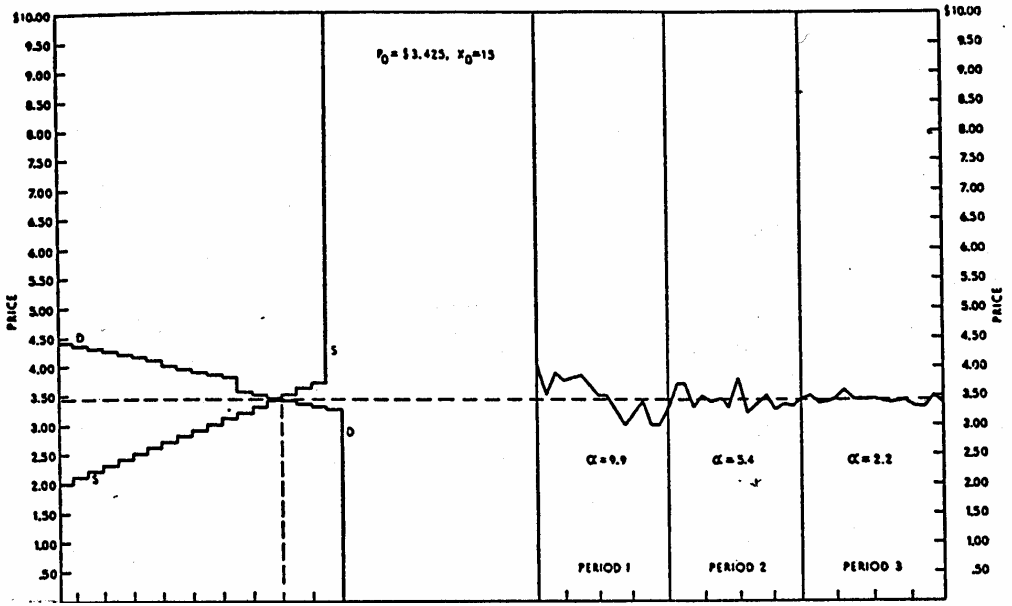
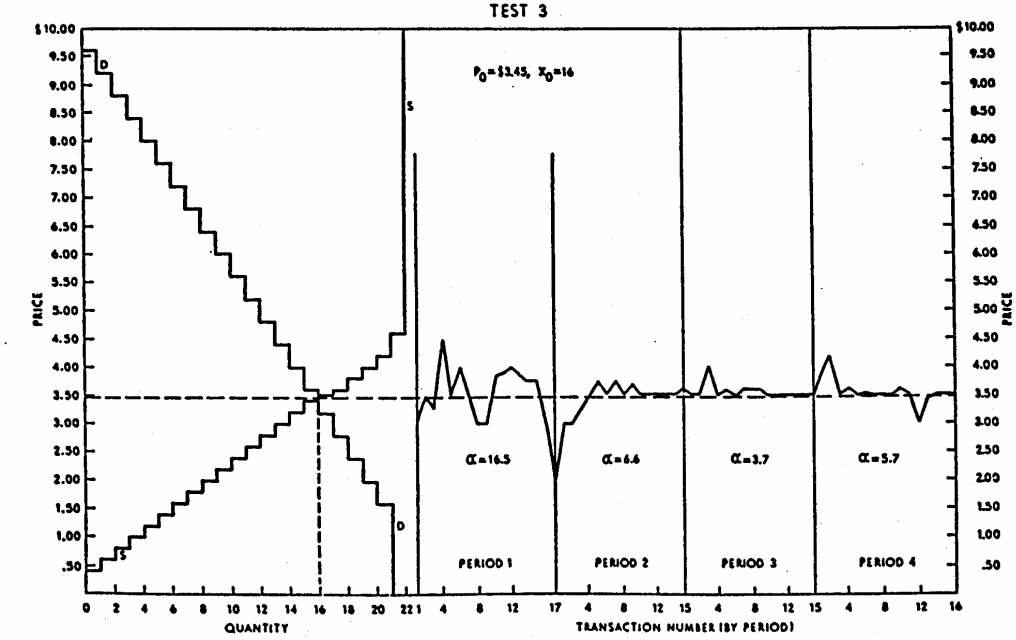


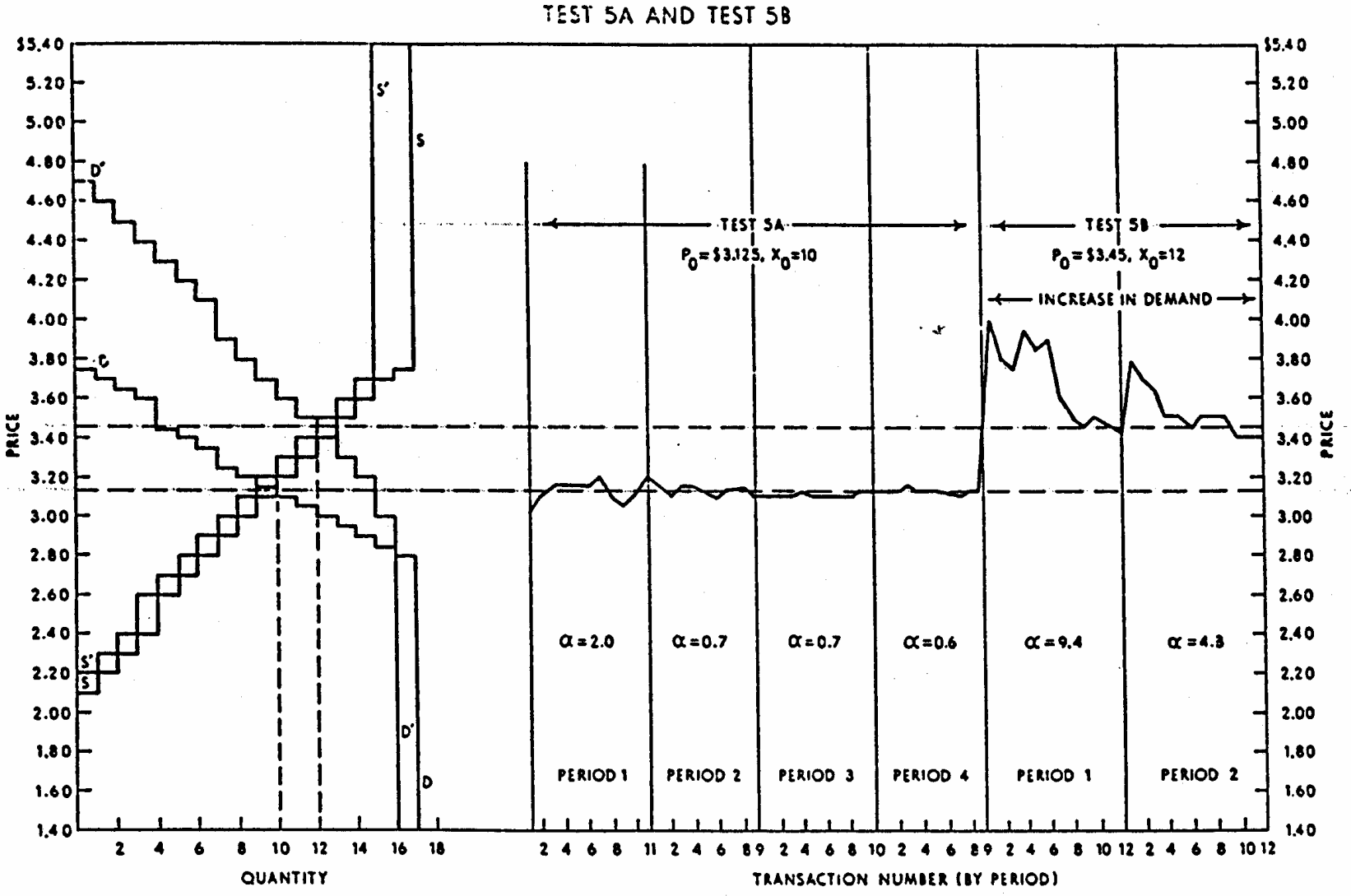
CHART 3

TEST 3



From: Smith (1962)

CHART 5



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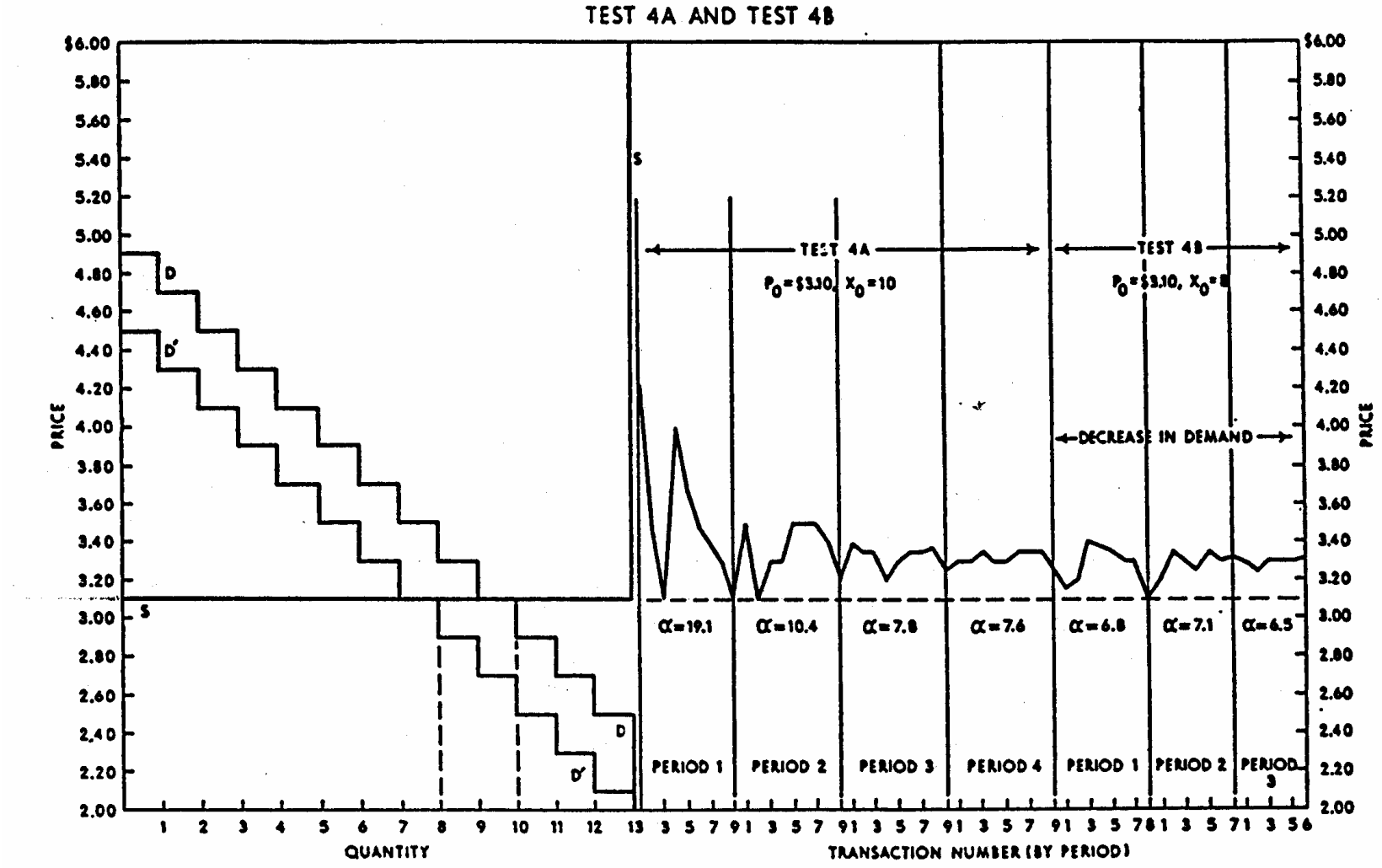


From: From: Smith (1962)

CHART 6

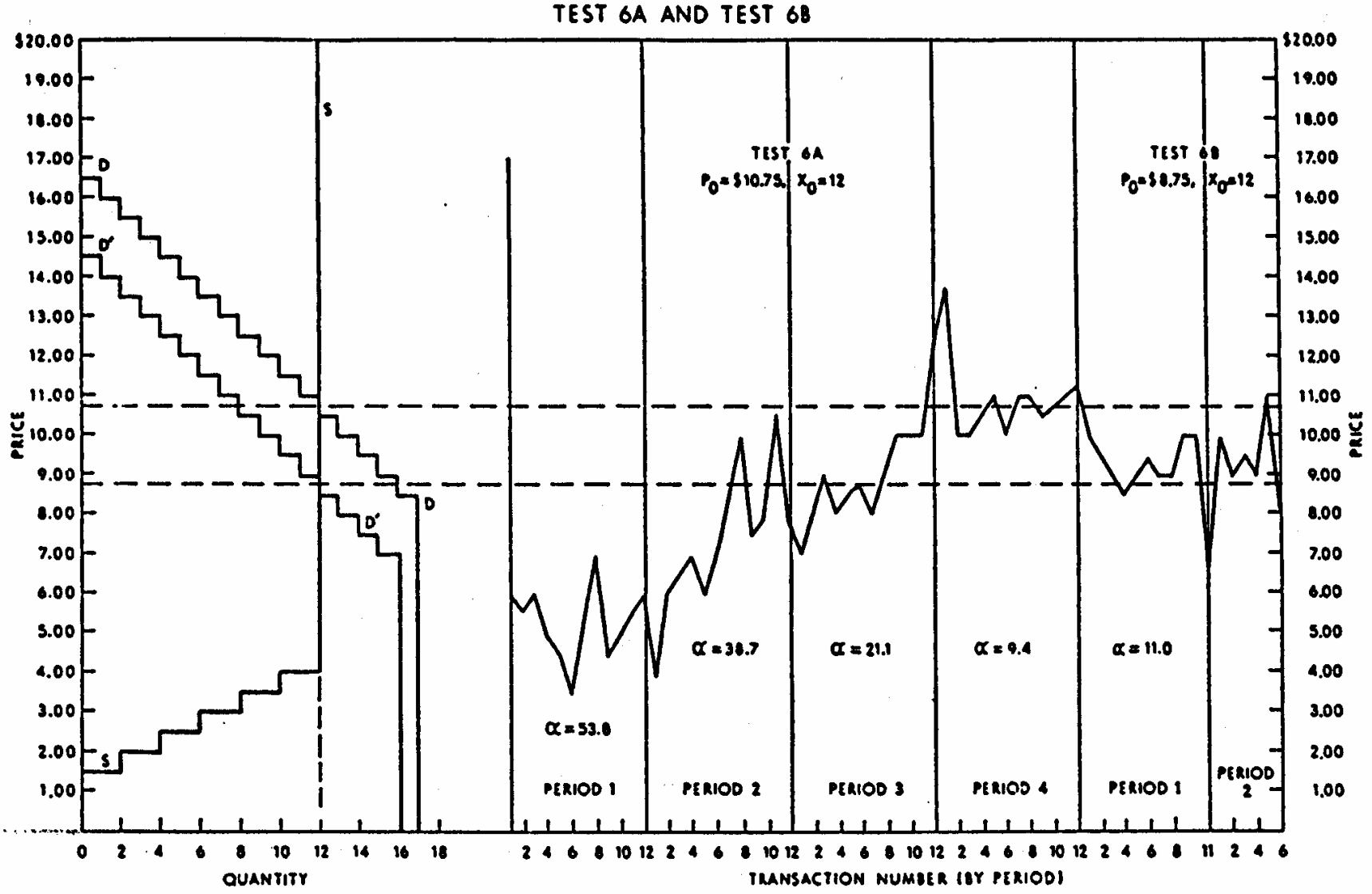
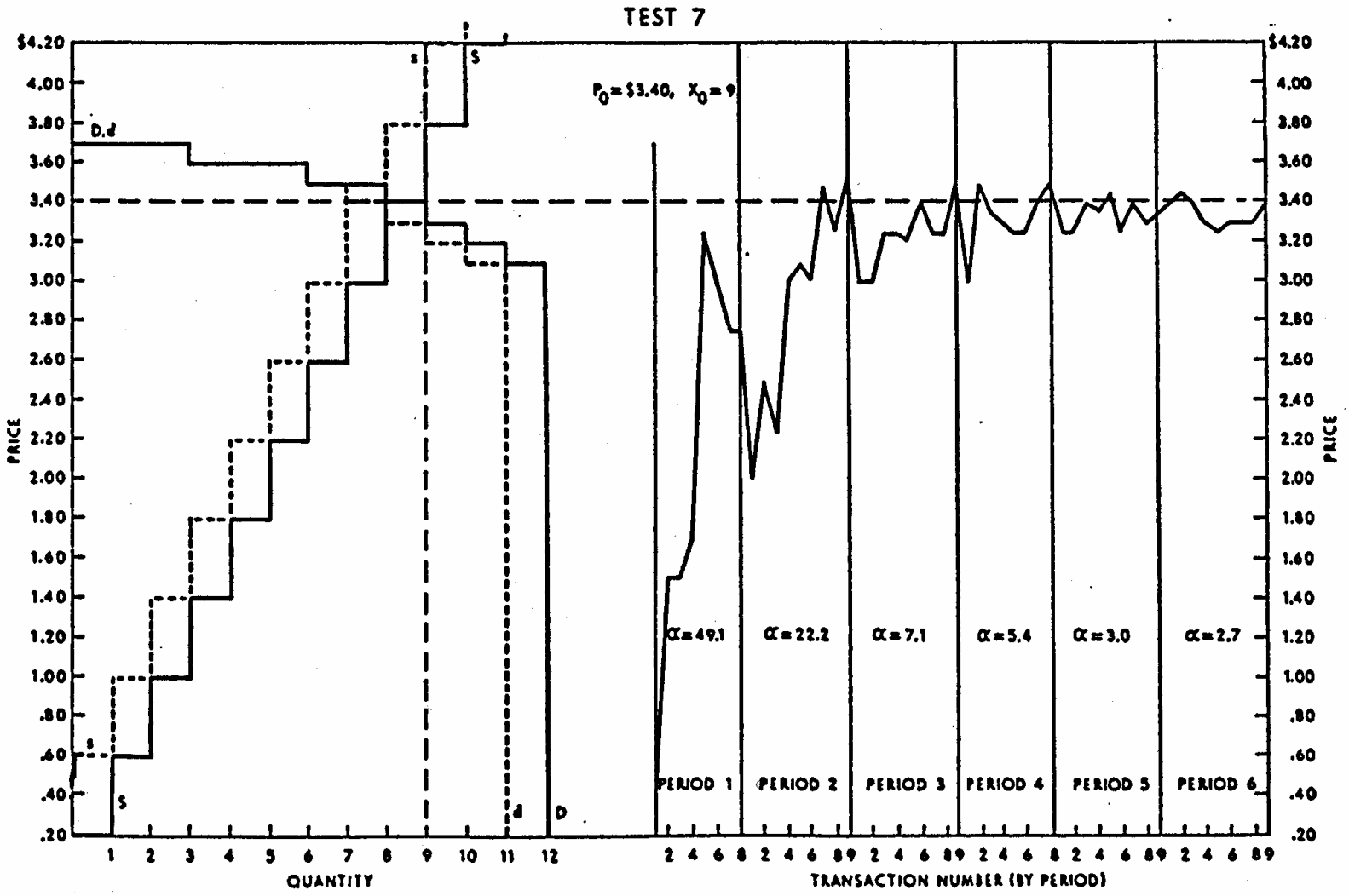

TEST 6A AND TEST 6B
TEST 6A
P_0=$10.75, X_0=12
TEST 6B
P_0=$8.75, X_0=12
D
D'
S
S
D
D'
PRICE
PRICE
$20.00
19.00
18.00
17.00
16.00
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
α = 53.8
α = 38.7
α = 21.1
α = 9.4
α = 11.0
PERIOD 1
PERIOD 2
PERIOD 3
PERIOD 4
PERIOD 1
PERIOD 2
0 2 4 6 8 10 12 14 16 18
QUANTITY
2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 11 2 4 6
TRANSACTION NUMBER (BY PERIOD)

CHART 7



20

From: Smith (1962)

Summary

- Relatively quick convergence of prices
  - Without knowledge of supply and demand functions
  - Few traders
  - Inexperienced traders, short time to learn
  - Trade without auctioneer, all traders are price makers and price takers
- Note: private information about supply and demand improves convergence, in particular if rents are shared very unevenly.

Reactions to these results

"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

- o remarkably little learning,
- o strict privacy, and
- o a modest number (of traders, A.F.),

inexperienced traders 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 behavior - 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)

- After long discussions with the referees and the editor the paper was finally published in the JPE in 1962.

How robust are the CE-outcomes in DAs?

- Extreme earnings inequality under private payoff information (Smith and Williams 1990)
- Initially there is a substantial excess supply (S=16, D=11) ; then, in period 6, subjects get the same induced values but the maximum quantities that can be bought or sold change, such that there is substantial excess demand (S=11, D=16).
- To control for sequence effects, also did sessions with order reversed.
- Figure 11 (and Figure 12) of S&W 1990 (10 cent commission)
- Figure 13 of S&W 1990 (zero commission); final rent to long side of market approx. 5-9 %

Trade commission

- To reach the theoretical prediction subjects sometimes receive a small trade commission, because subjects sometimes do not trade if they can earn only little amounts of money.
- “Advantage”
    - Theoretical prediction is reached better
- **But**
    - Commissions change the theoretical prediction, so not clear that it makes sense to use them.

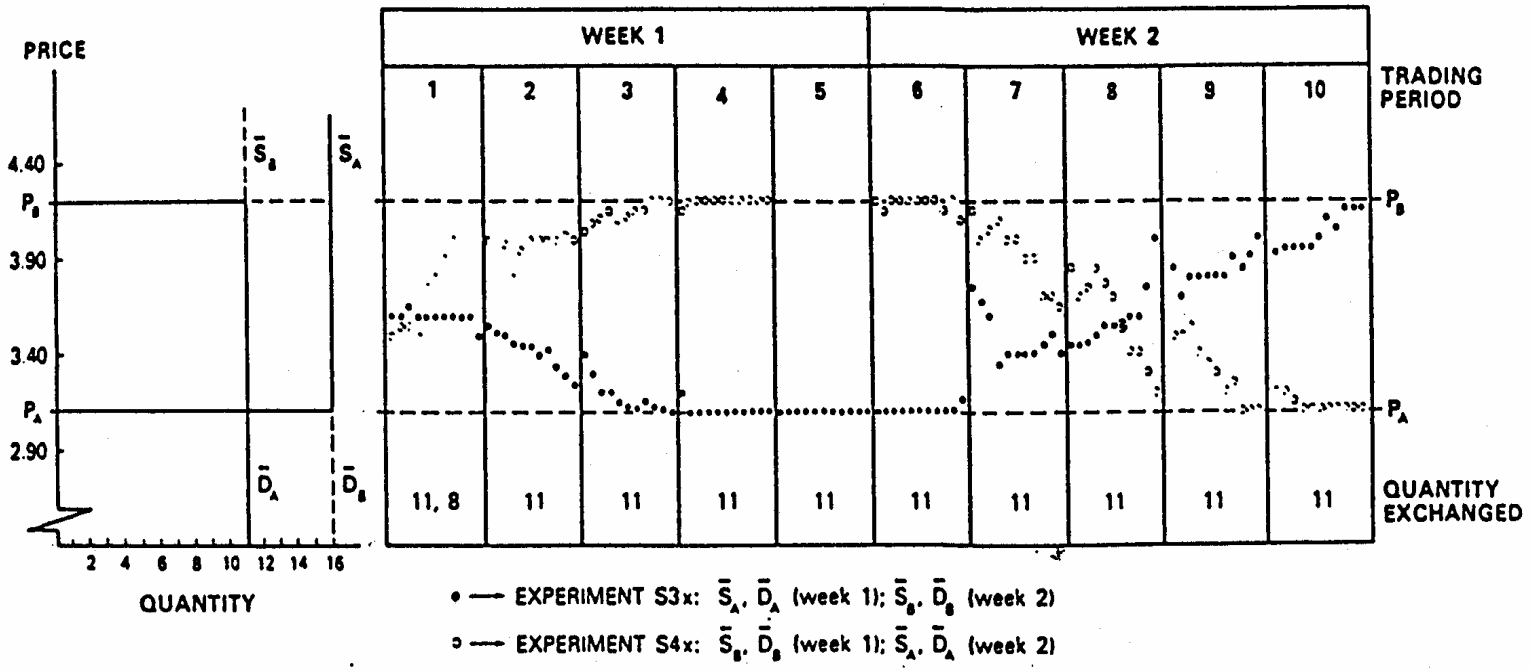


FIGURE 11. Swastika Experiments S3x and S4x: $.10 Commission

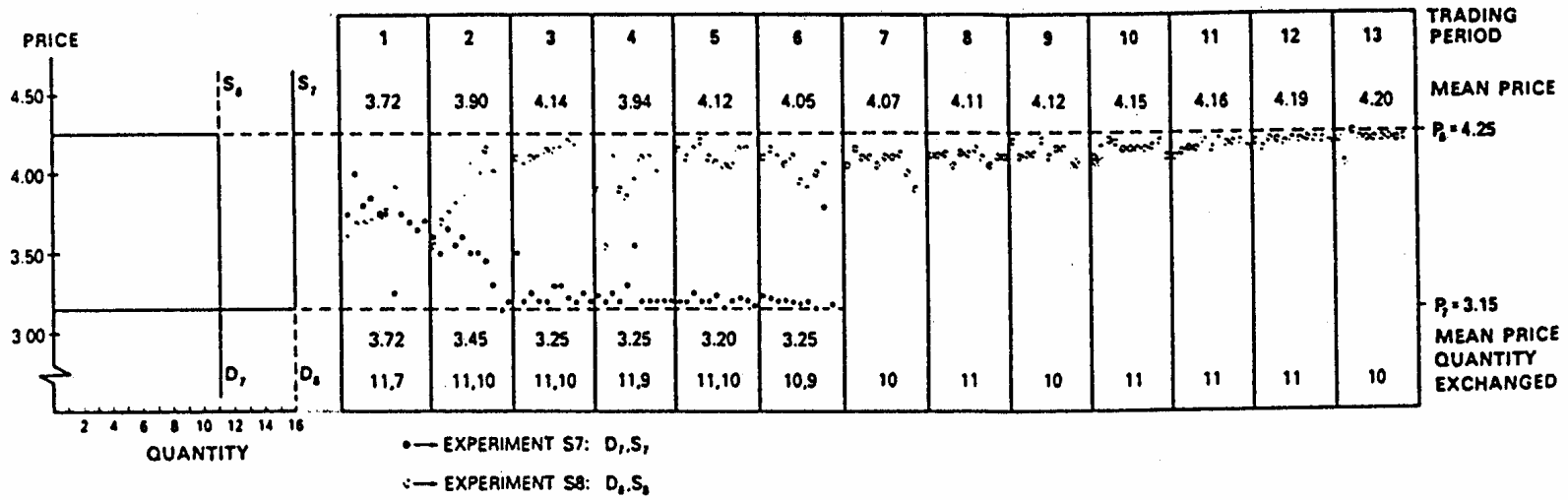


FIGURE 13. Swastika Experiments S7 and S8: Zero Commission

Robustness: Reducing the number of traders: Duopoly und Monopoly (Smith Williams 1989)

- Duopoly
  - Theoretical prediction: Bertrand competition, i.e., as in the CE
  - But both sellers could also coordinate on Monopoly solution and would earn more (see next slide)
  - Experiment: Only 2 sellers
  - Result: Even with only two sellers prices come close to the CE and aggregate welfare is most of the time well above 90 percent.

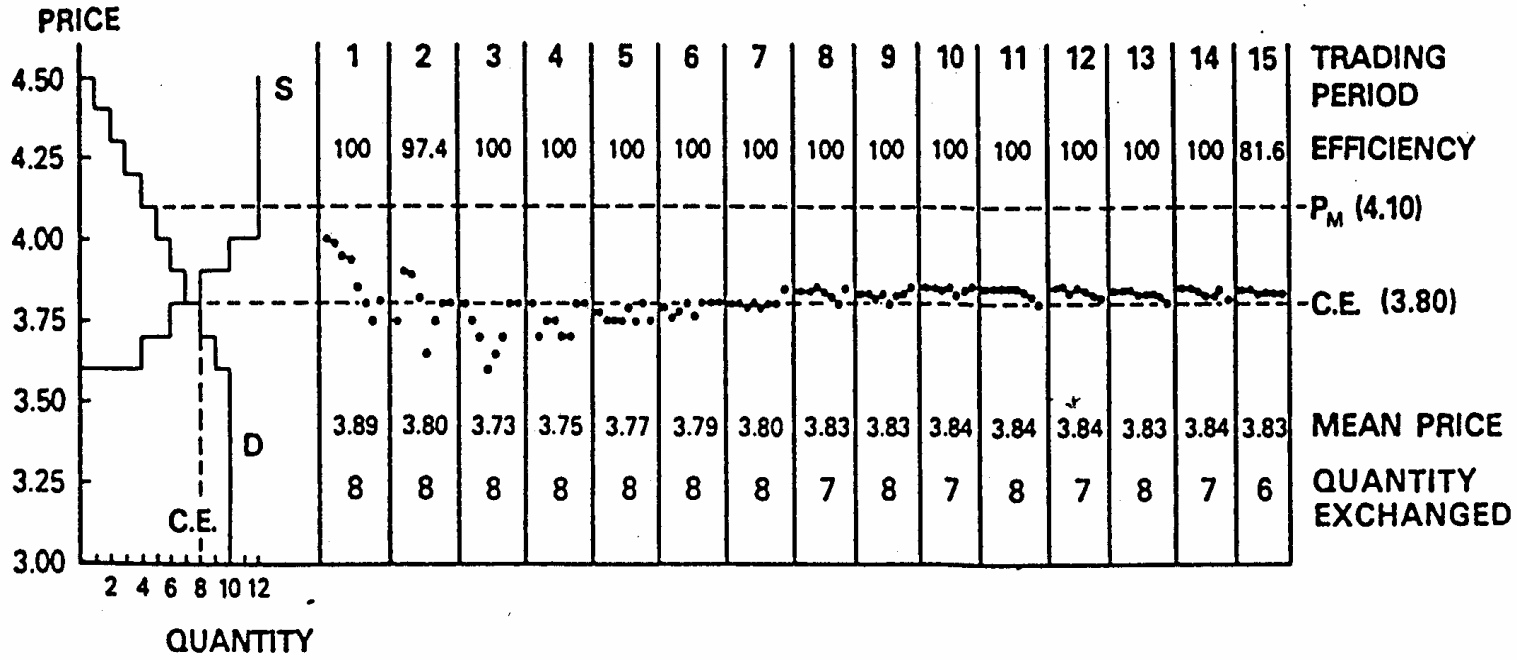


FIGURE 1. Duopoly Experiment D1

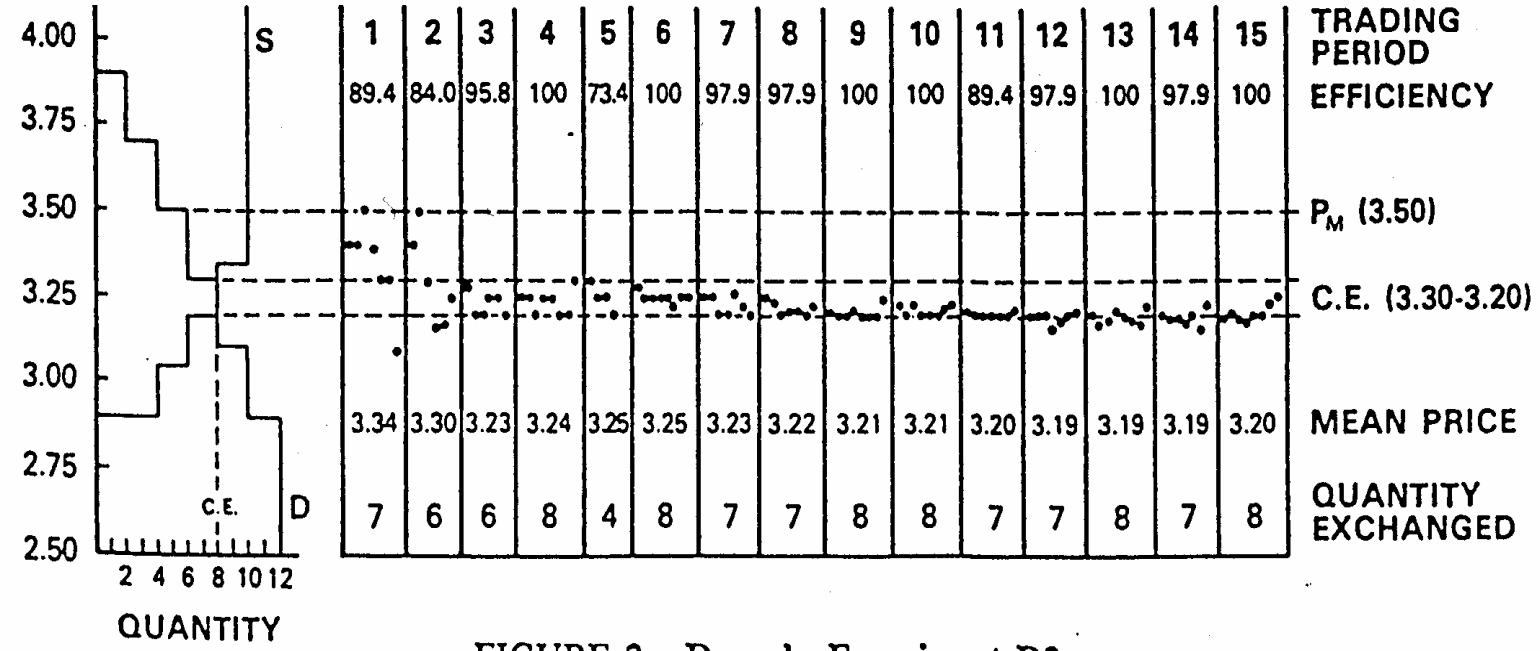


FIGURE 2. Duopoly Experiment D2x

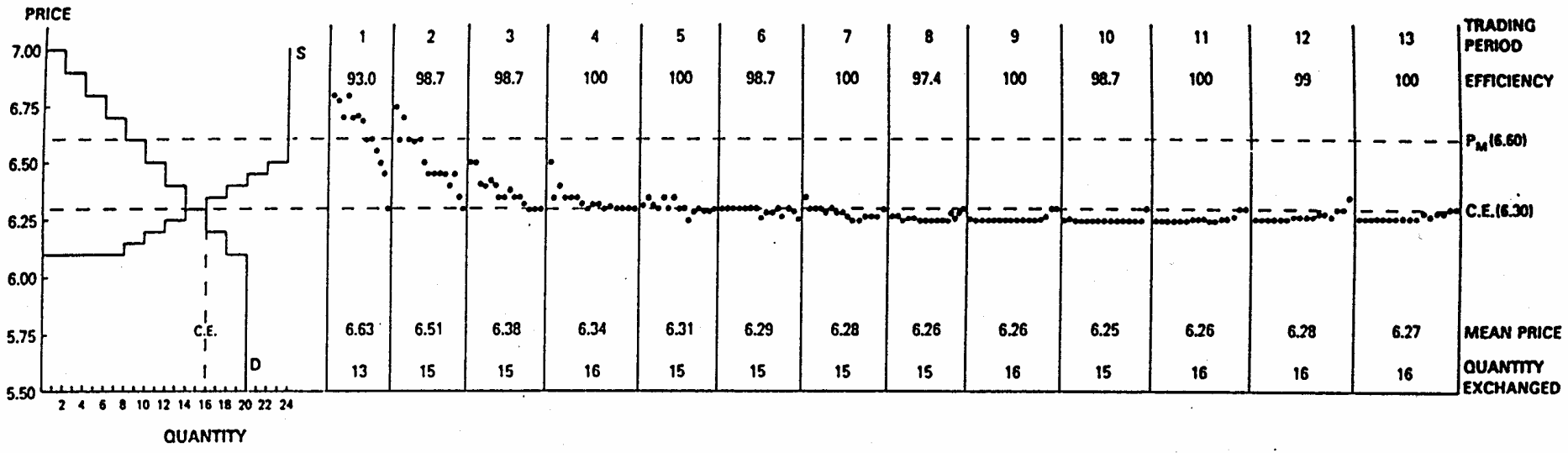


FIGURE 3. Duopoly Experiment D3x

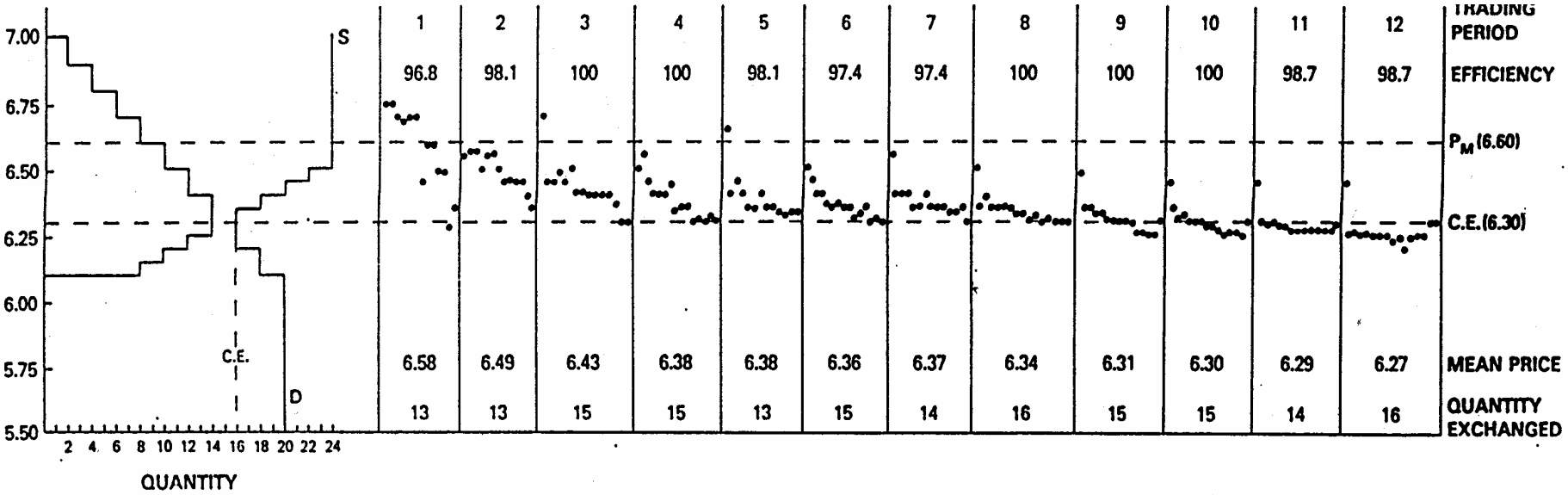


FIGURE 4. Duopoly Experiment D4x

Monopoly

- Monopoly (one seller)
- Theoretical prediction : Monopoly leads to higher price and lower quantity

- Results: Figures 5,6,8: Initial units sold close to the monopoly price, additional units are sold at successively lower prices; sometimes prices even go below CE for many periods (Fig. 8)
- Overall: Difference between CE and monopoly price not overwhelming.

- Attempts at price discrimination lead to CE price
- Price discrimination is an advantage in a static context but informs buyers that monopolists can make profitable gains at low prices: Discriminative price cutting in early periods raises buyers' resistance against monopoly prices
- Aggregate welfare in general rather high
- Monopoly effectiveness is general rather low (Table 2)
  - Monopoly effectiveness = $\frac{\text{(mean price – CE price)}}{\text{(Monopoly price – CE price)}}$
- M>0 (M<0) if seller profit is above (below) CE-prediction
- M>1 if discriminating monopoly profit is obtained

TABLE 1. Design Parameters for Duopoly (D) and Monopoly (M) Experiments

Experiment	Number of buyers	Commission per trade	Buyers' Profit per period at CE	Sellers' Profit per period at CE	Sellers' Profit per period at P_M
D1	5	\$.05	\$2.80	\$1.00 (\$.50 per seller)	\$2.40 (\$1.20 per seller)
D2x	6	\$0	\$2.80	\$1.90 (\$.95 per seller)	\$3.30 (\$1.65 per seller)
D3x D4x	10	\$.10	\$5.60	\$2.20 (\$1.10 per seller)	\$4.90 (\$2.45 per seller)
M1x M2x M3x M4xs M5x	5	\$.10	\$2.80	\$1.10	\$2.45

"x" experiment suffix denotes all experienced subjects.
"xs" experiment suffix denotes experienced seller only.
Profits are calculated exclusive of any trading commissions.
CE profits for D2x are calculated at the midpoint of the CE range.

Monopoly-Experiment

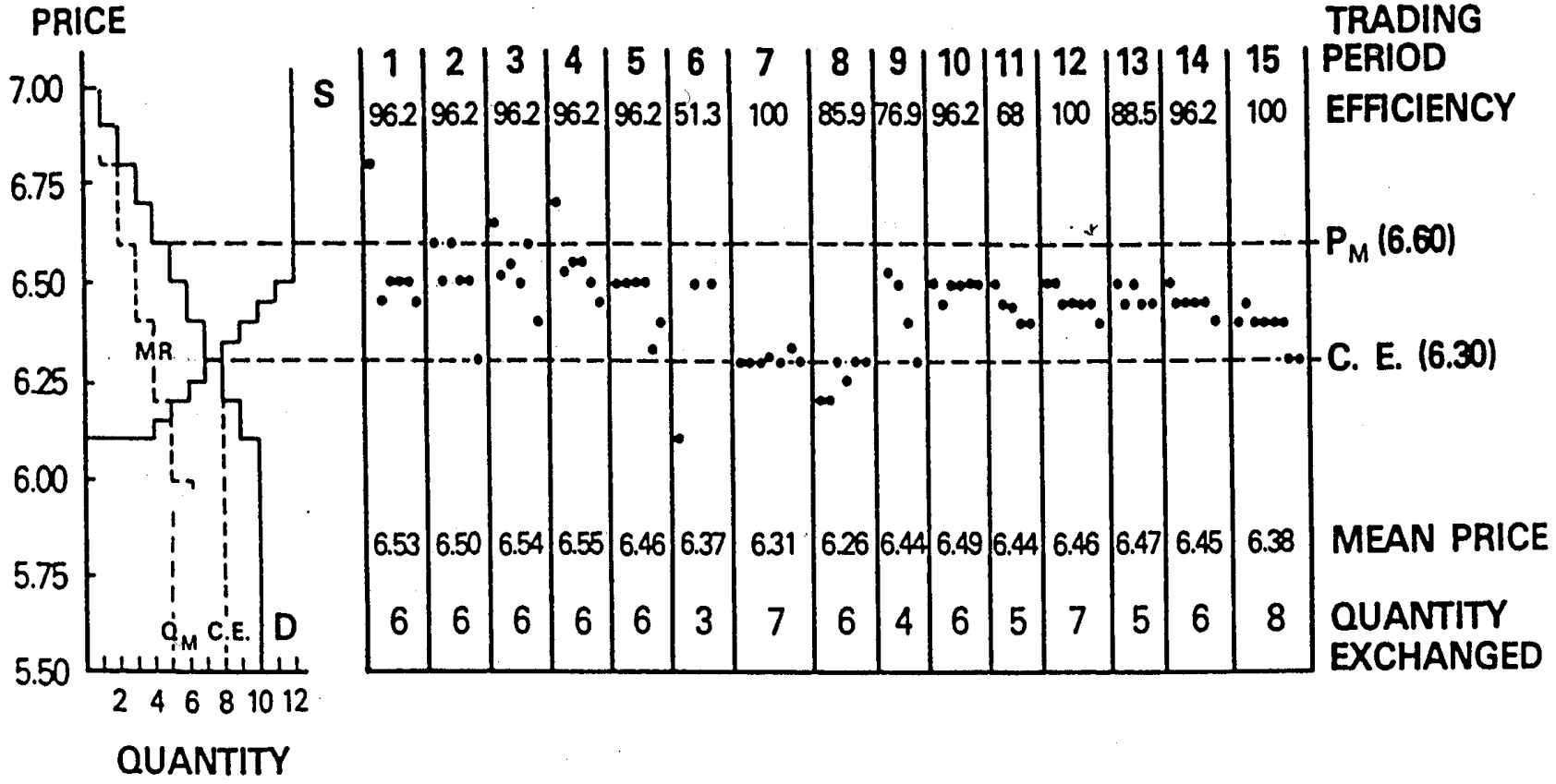


FIGURE 7. Monopoly Experiment M3x

Smith Williams 1990

Monopoly

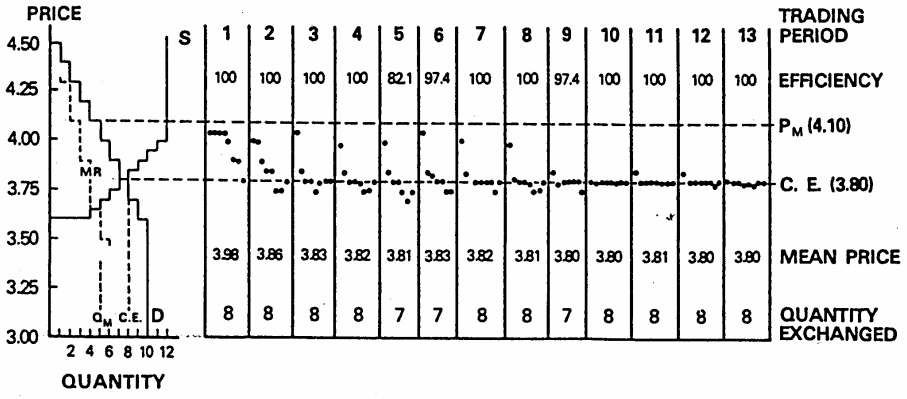


FIGURE 5. Monopoly Experiment M1x

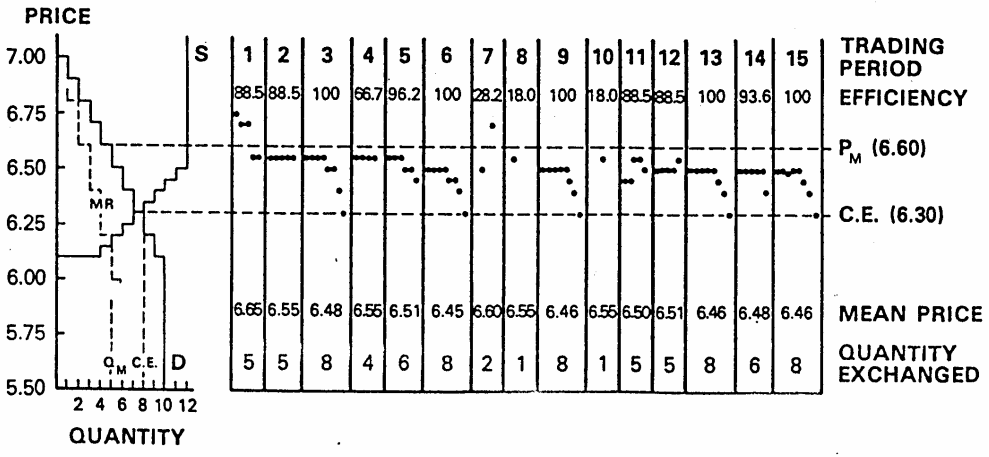


FIGURE 6. Monopoly Experiment M2x

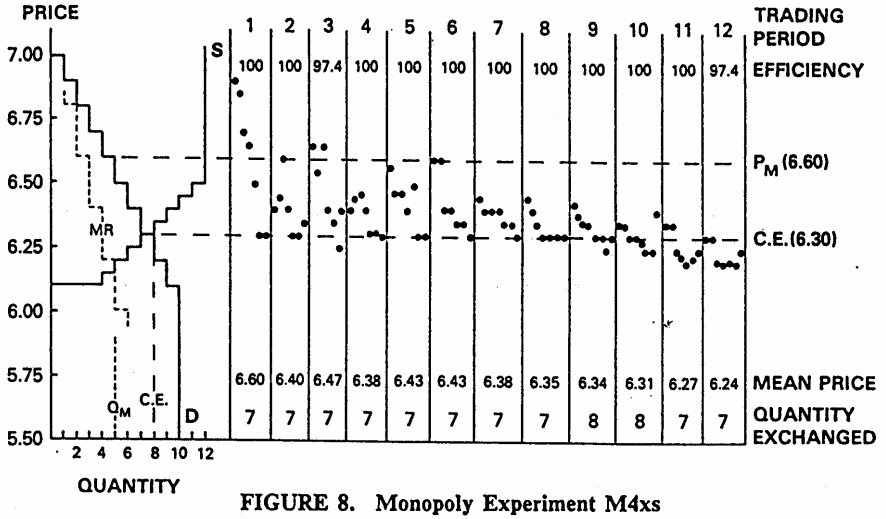


FIGURE 8. Monopoly Experiment M4xs

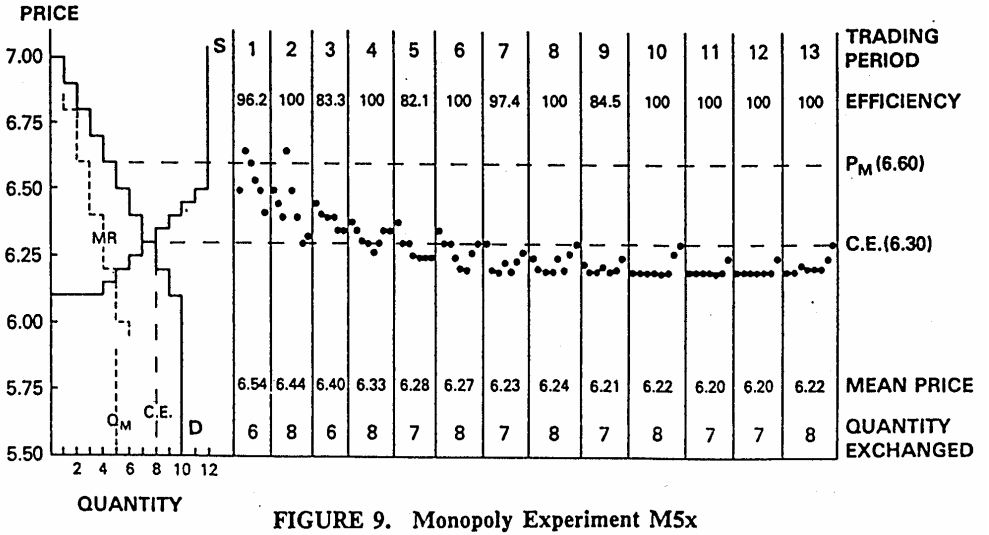


FIGURE 9. Monopoly Experiment M5x

Smith and Williams 1990

Monopoly

TABLE 2. Index of Monopoly Effectiveness

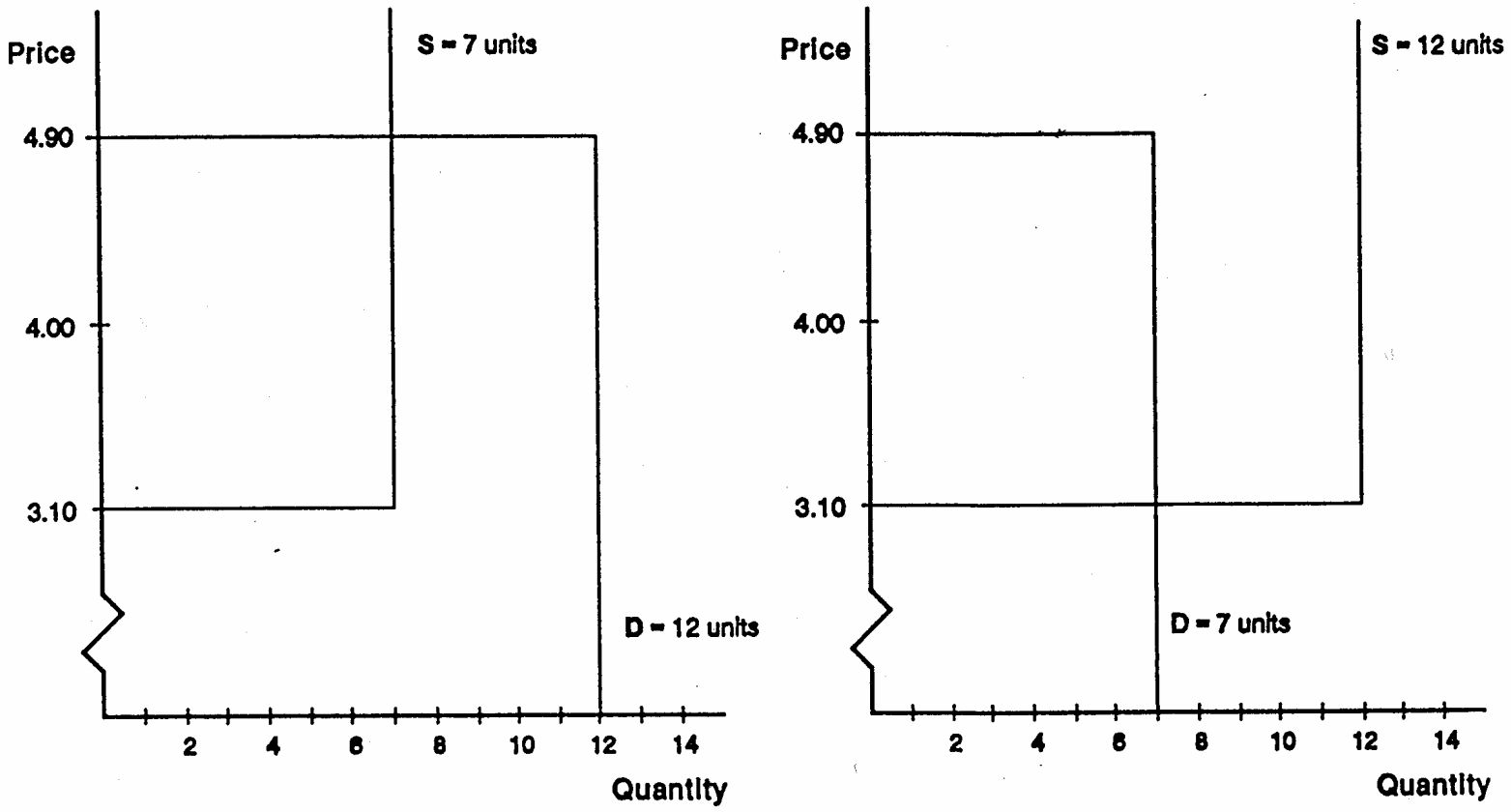
Trading Period	Duopoly Experiments				Monopoly Experiments				
	D1	D2x	D3x	D4x	M1x	M2x	M3x	M4xs	M5x
1	.49	.41	1.46	1.32	1.04	1.19	1.00	1.56	1.01
2	−.03	.01	1.13	.90	.38	.81	.86	.52	.84
3	−.43	−.16	.42	.71	.19	1.11	1.01	.86	.39
4	−.29	−.07	.22	.45	.10	.52	1.06	.42	.16
5	−.17	−.46	.03	.39	.04	.93	.65	.69	−.08
6	−.08	0	−.06	.31	.17	.89	−.22	.67	−.16
7	.02	−.15	−.09	.38	.15	−.07	.03	.41	−.35
8	.17	−.19	−.21	.24	.07	−.48	−.22	.25	−.37
9	.15	−.24	−.24	.06	−.01	.93	.19	.21	−.44
10	.22	−.22	−.26	0	−.01	−.48	.81	.07	−.48
11	.23	−.27	−.23	−.04	.04	.63	.40	−.18	−.50
12	.20	−.32	−.16	−.20	.03	.70	.81	−.31	−.49
13	.16	−.31	−.18		−.01	.93	.52		−.44
14	.18	−.32				.78	.63		
15	.07	−.26				.92	.48		
MEAN	.06	−.17	.14	.38	.17	.62	.53	.43	−.07

Smith Williams 1990

Cultural differences?

- Design by Kachelmeier and Shehata 1992

	China	Canada/US
Private payoff information	5 Double Auction markets	5 Double Auction markets
Public payoff information	5 Double Auction markets	5 Double Auction markets



Excess Demand Phase (Periods 1 - 11)

Excess Supply Phase (Periods 12 - 22)

Fig. 1. Laboratory market design.

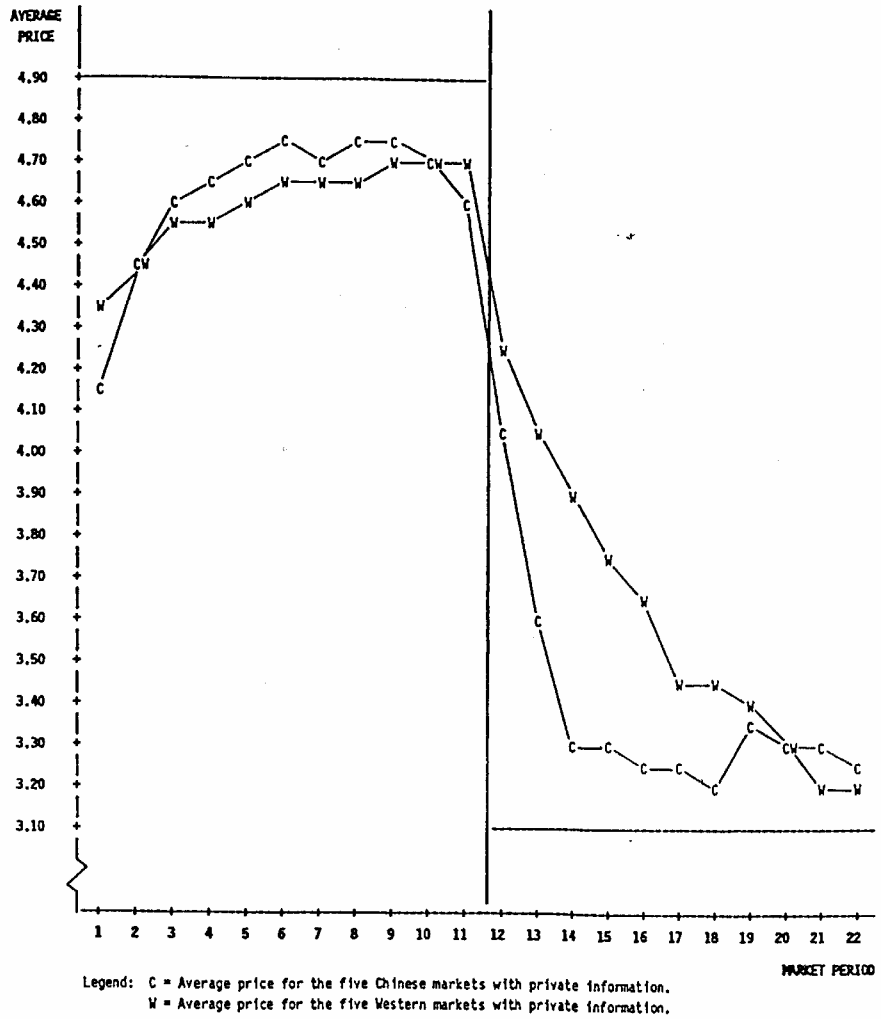


Fig. 2. Average negotiated prices in the private information markets.

S.J. Kachelmeier and M. Shehata, Culture and competition

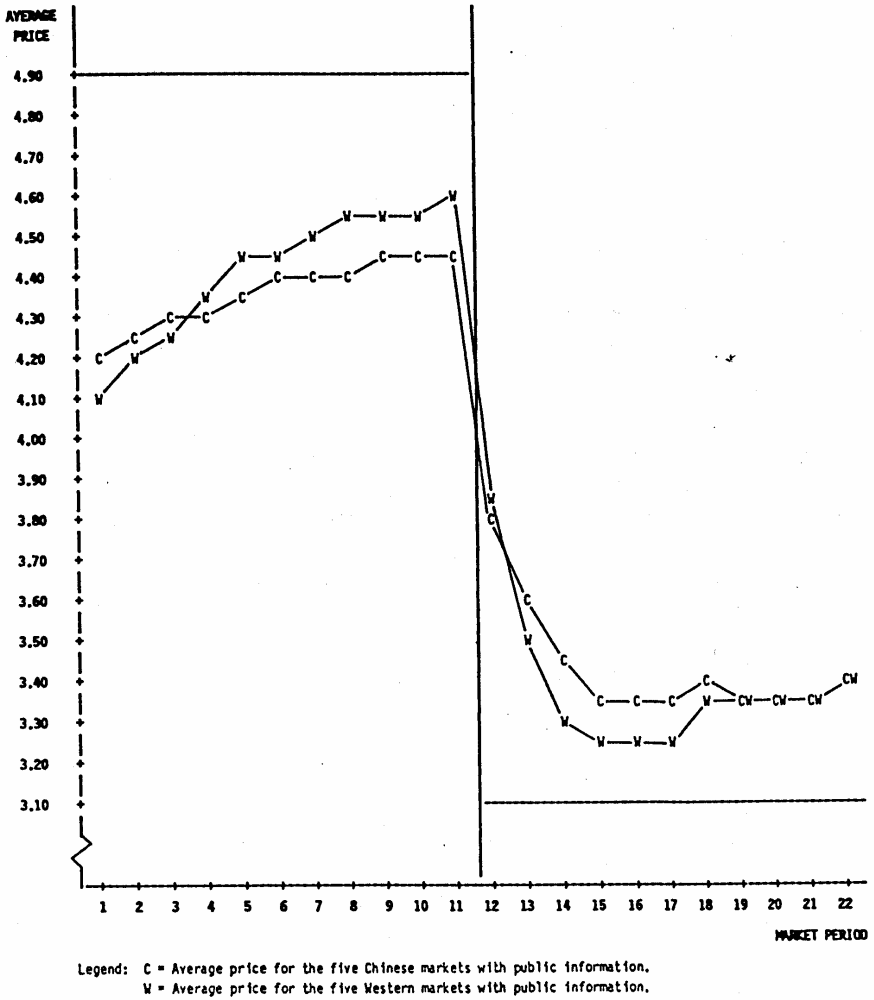


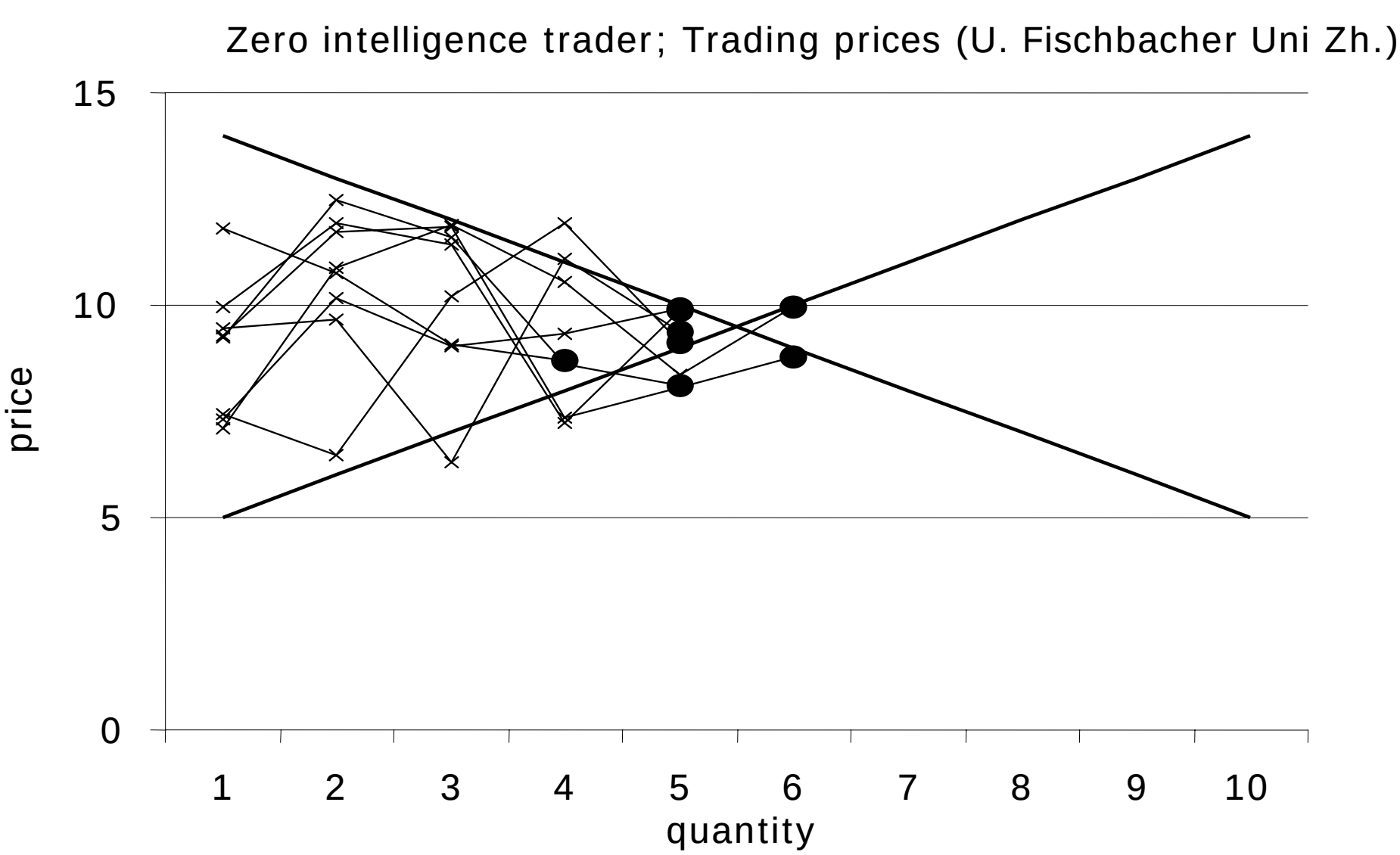
Fig. 3. Average negotiated prices in the public information markets.

- Figure 1: CE is very inequitable (like in S&W 1990)
- Figure 2: No cultural differences under private information. Final rent for the long side of the market between 6 and 11 % of the total rent.
- Figure 3: No cultural differences under public information. Final rent between 11 and 28 percent of the total rent.
- In the excess demand phase (1-11) prices under private information are significantly higher than prices under public information. Private information facilitates the speed of convergence and closeness to the CE (Fairness!).
- In the excess supply phase (12-22) public information seems to speed up adjustment in the early periods but to hinder adjustment towards the end.

Zero intelligence traders (Gode/Sunder 1992,1993)

- Simulation of traders with a simple algorithm
  - there are randomly generated offers, which are accepted if profit positive)
- -> Convergence to CE

- But:
  - Result is not really a mystery since Zero-Intelligence-Trader to the „left“ of the supply and demand curves have the highest chance to make a quick trade (they have the largest number of compatible trading partners).


Zero intelligence trader; Trading prices (U. Fischbacher Uni Zh.)
15
10
5
0
price
1
2
3
4
5
6
7
8
9
10
quantity

Alternative Market Institutions

- Important question:
  - How does changing the market institution affect convergence to CE, compared to, e.g. double auction.

- This can be answered with an experiment…

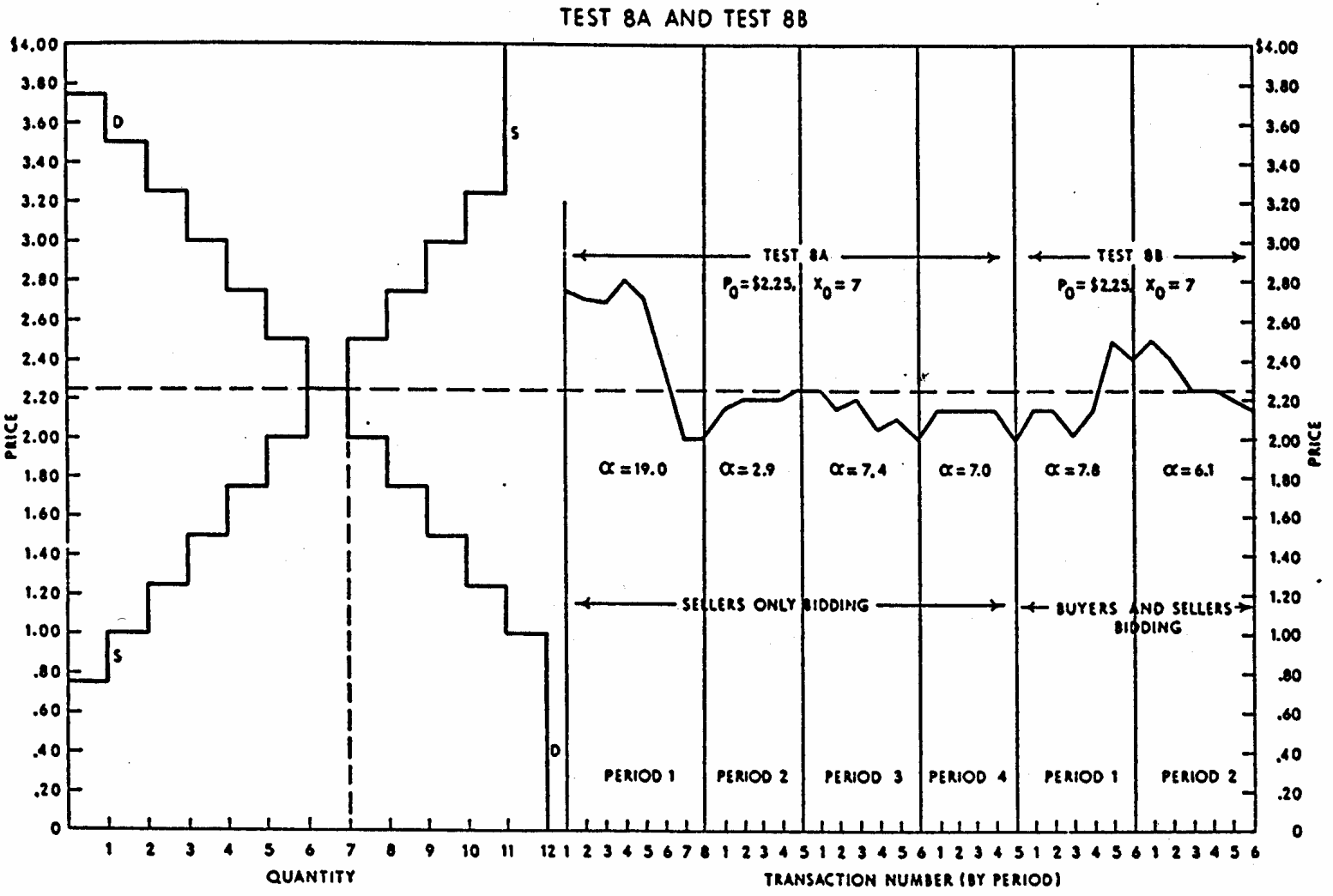
Posted offer market institution

- One side of the market (e.g., sellers) can make **one** price offer
- Subjects on the other side of the market are randomly selected one at a time, and can decide which offer, if any, to accept.
  - This side of the market is sometimes simulated, because the acceptance rule is fairly mechanical: accept the lowest price available, unless it exceeds your value.
- Posted offer market an important, pervasive institution: e.g, stores post prices, buyers can select the price they like, out of the items remaining.

- Comparison with Double Auction institution
  - Much simpler to conduct.
  - Less information available to sellers; buyers cannot signal as in the double auction.

- Results: Posted offer vs. Double auction
  - If sellers make offers: Convergence from above, i.e., sellers slowly lower prices (vice versa if buyers make offers)
  - Less competitive compared to the DA; reaching the CE needs usually more time.
  - Why is convergence slower? Buyers cannot signal…

CHART 8



From: Davis/Holt Experimental Economics

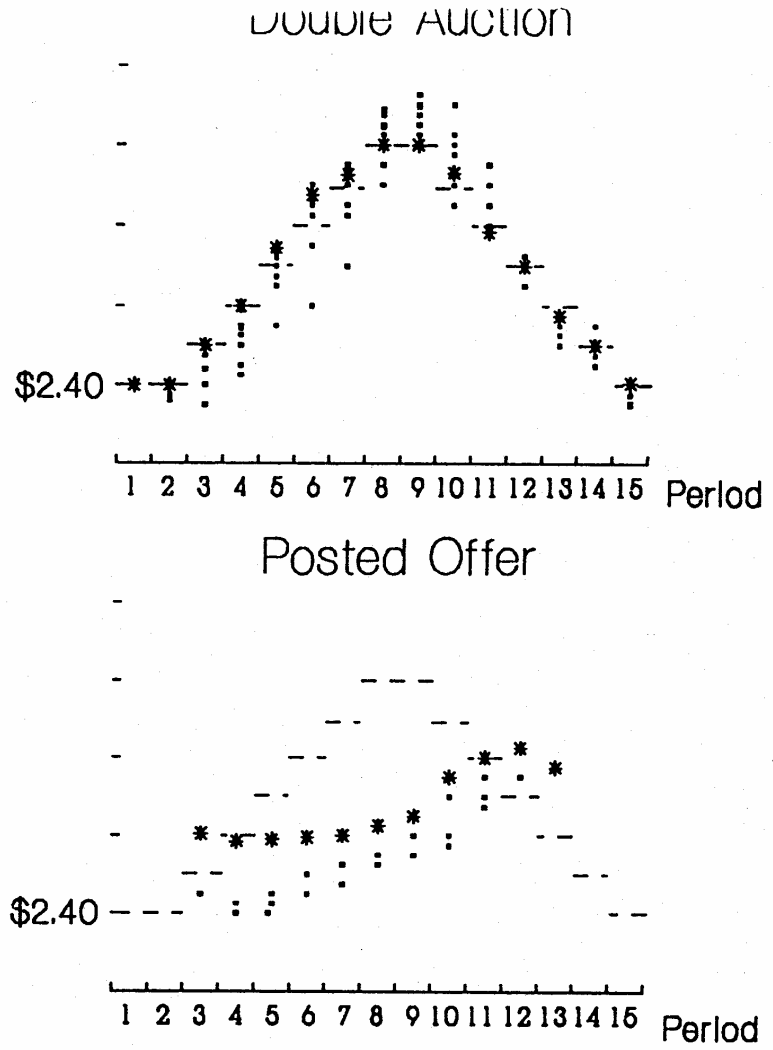


Figure 4.7 Double-Auction and Posted-Offer Contract Prices in a Design with Regular Demand Shifts (Source: Davis, Harrison and Williams, 1991) Key: contract prices: ·, Final contract prices: *, Equilibrium Price: --.

Stock market with irrational price bubbles (Smith et. al. 1988)

- One type of asset, market lasts 15 periods.
- In a given period, return on the asset is either $0.6, $0.28, $0.08, or $0.00, each with probability 1/4.
  - Expected per period return is $0.24.
  - EV of asset in period 1 is thus $0.24*15=$ 3.6; in period 15 it is just $0.24.
- There are 9 traders, endowed with units of the asset and with experimental cash.
- 3 of the traders have 3 units, 3 have two units, and 3 have one unit of the asset.
- Cash endowment is adjusted such that the expected value of everybody's portfolio is the same.
- Assets are traded for cash under the DA-institution.

More Details

- At the end of each period, after the DA, one of the four states of the world occurs, generating the corresponding return for the asset holders.
- Cash is transferred to future periods (real money earnings are equal to amount of cash at the end).
- Only assets that are owned can be sold, and assets have to be bought with cash-on-hand.

- Trade occurs if (1) traders have different risk attitudes, or (2) have different expectations regarding future asset values.
- Whatever the mix of risk attitudes, **rational expectations** of asset prices rule out price bubbles.
  - The fundamental value of the asset is clear.

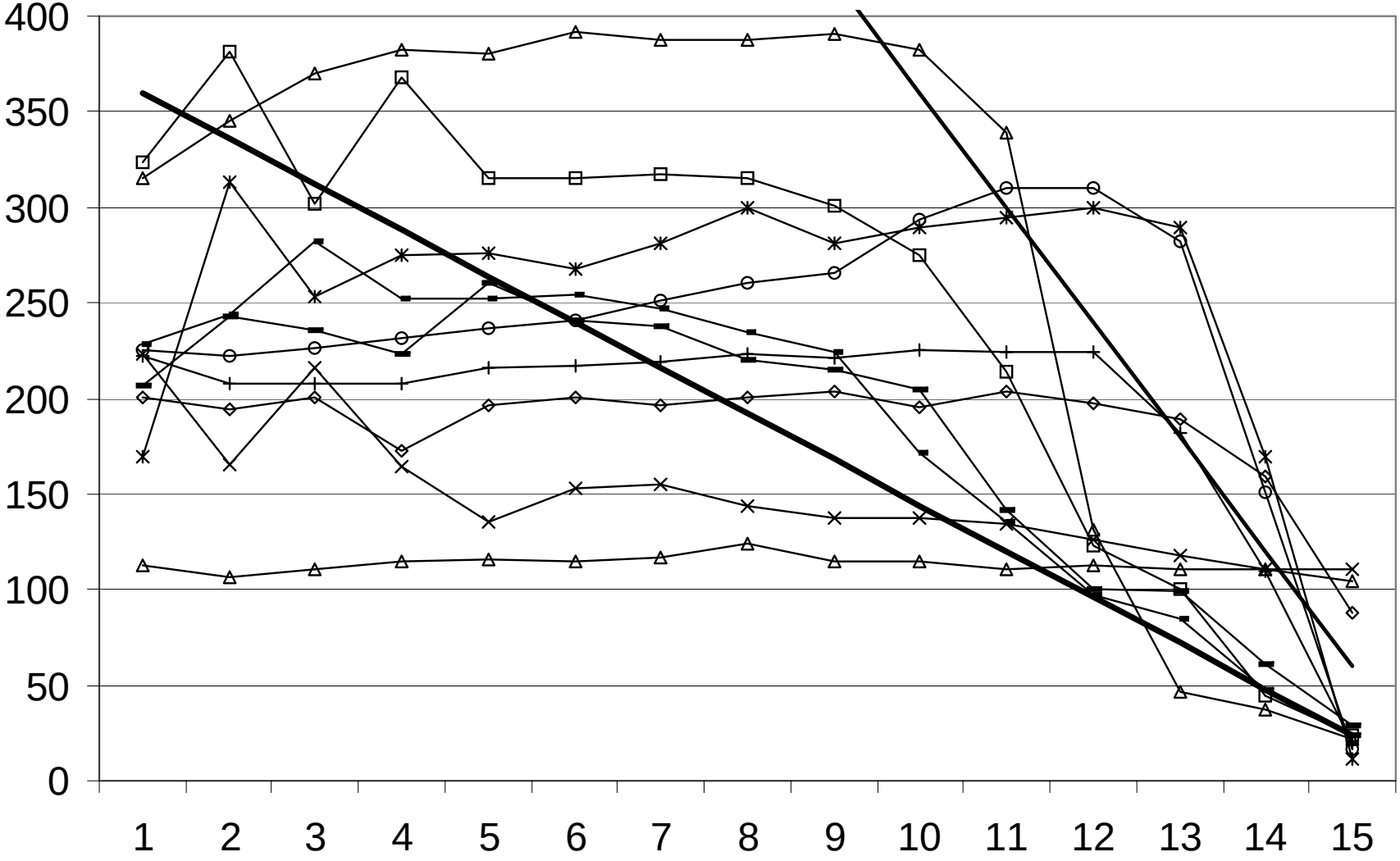
Predictions (if everybody is rational)

- In case of rational, risk neutral traders the asset value in any period is, by backwards induction, equal to the expected value of the asset.
- Therefore, only trades at the expected value should occur, it they occur at all. With near risk neutral agents we thus expect low trading volume, at prices near the expected value.
- Suppose that for risk loving agents the certainty equivalent of the asset is $.24 + \varepsilon$ ($\varepsilon>0$ but small) per period while for risk averse agents it is $.24 - \varepsilon$.
- Then, under rational expectations, the price in period 15 must be within the ε-neighbourhood of .24. The maximum price of the asset in t is then $(T-t+1)(.24 + \varepsilon)$.

Results

- Traders who participate the first time in the asset market (not in other DA-markets) trade a lot, at prices far above the fundamental value.
- Traders who participate the second time trade less, at lower prices, but still above the fundamental value.
- Twice experienced traders trade, if at all, at the fundamental value.

Participants of a course (economics) in Zurich (U. Fischbacher)



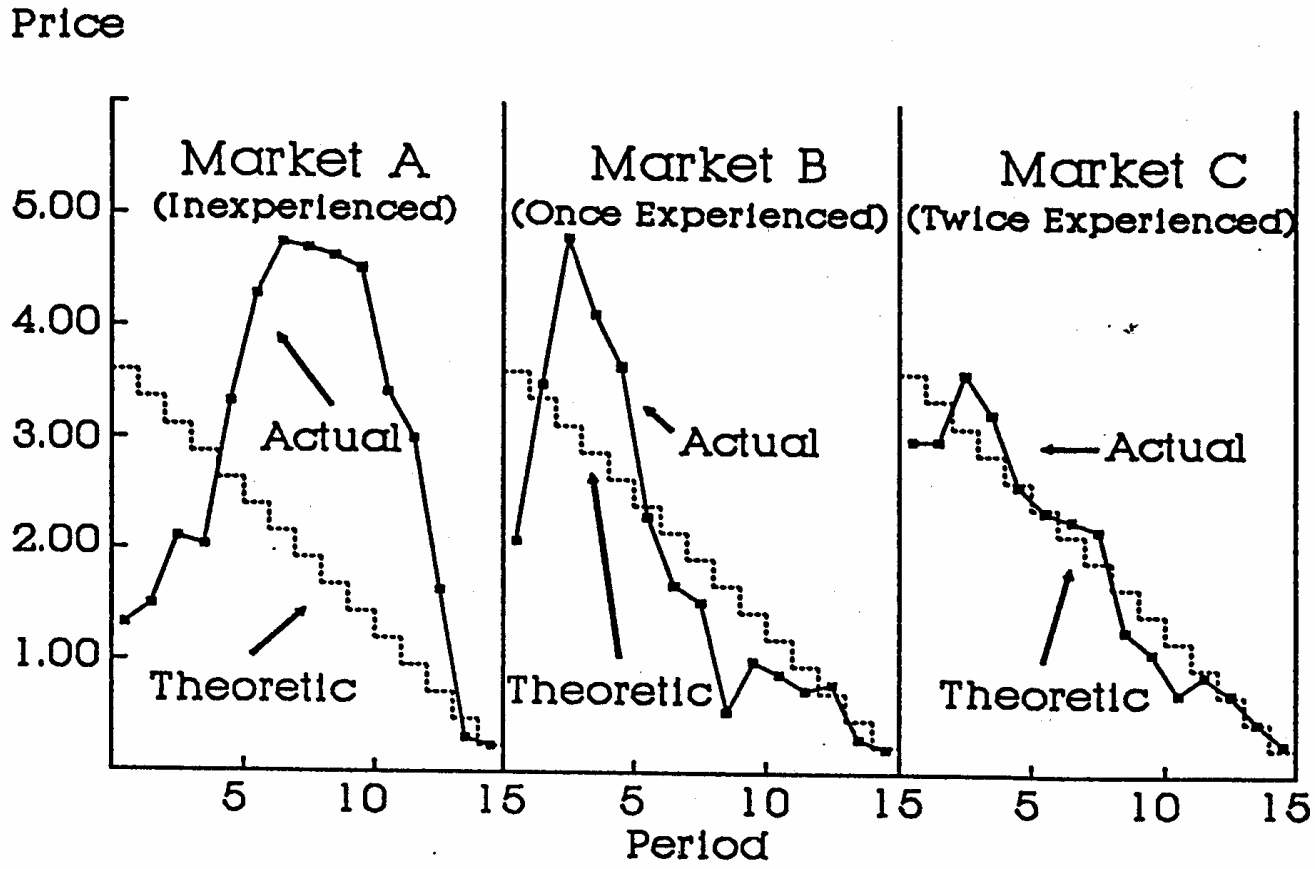


Figure 3.16 Intrinsic Value and Mean Prices in a Sequence of Three Double-Auction Asset Markets with the Same Participants (Source: Sessions 3pd295, 3pd296, and 3pd297, Peterson, 1991)

See: Davis/Holt Experimental Economics (Results published in JEBO)

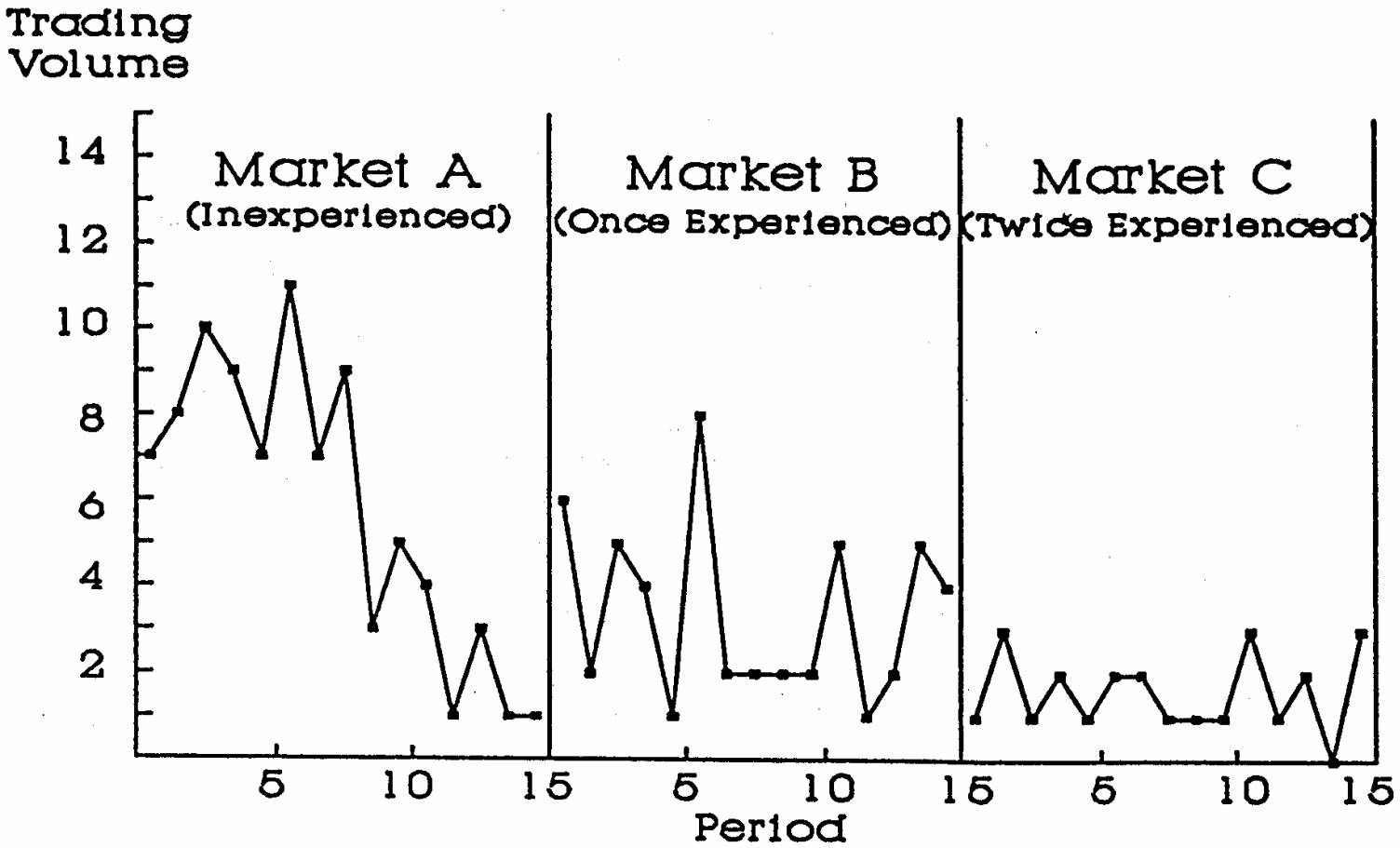


Figure 3.17 Transactions Quantities in a Repeated Series of Double-Auction Asset Markets (Source: Sessions 3pd295, 3pd296, and 3pd297, Peterson, 1991)

Final comments on price bubbles

- Business professionals create the “same” speculative bubbles.
- This is an often cited result in “Behavioral Finance”.
- DA does not generate “rational” outcomes per se (see also discussion about incomplete markets).
- Possible interpretation: Absence of common knowledge of rationality renders speculation profitable even for rational traders. Even if everybody is rational but assumes the existence of some irrational traders the bubble can occur.