EFFICIENCY OF EXPERIMENTAL SECURITY MARKETS WITH INSIDE INFORMATION

by

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The use of experimental markets in economics is relatively new. Experiments are conducted for a variety of reasons and I shall briefly mention these objectives in order to clarify the objective of our own study on insider information in security markets.[1]

Simulation comes to mind most readily when one talks about experiments. When a policy is going to be imposed on a social system an experiment seeks to recreate that social situation on a smaller scale in order to provide decision makers with some experience with how the situation might evolve. For example, when the railroads, worried about competition from barges on the Mississippi River, requested the Interstate Commerce Commission (ICC) to require the barge carriers to post their prices, the ICC commissioned an experimental study. A small-scale model of dry bulk barge market was created and examined under the existing form of a telephone market and the proposed form of a posted price market. While the railroads had pleaded that requiring the barge carriers to post their prices would benefit the shippers, the reader would probably not be surprized that the study found the average price in the posted price market to be higher than in the telephone market. This probably explains why railroads submitted their request in the first place. In any case the simulation study gave the ICC at least a crude idea of what might happen to the dry bulk barge market if they required the barge carriers to post prices.

[1] For a more detailed treatment see Plott [1980].

Process design is a second possible objective of experiments. Here an experimenter is a social engineer, and experiment is like a pilot plant. Existing theories may have suggested to the scientist that a particular approach to a social decision is preferable, but theory is devoid of operational detail and experiments can be useful to develop new social institutions. How, for example, could we implement the Clarke tax solution to the classic public goods problem. Experimental research done on mechanisms for allocating airport slots among airlines also falls into this category.

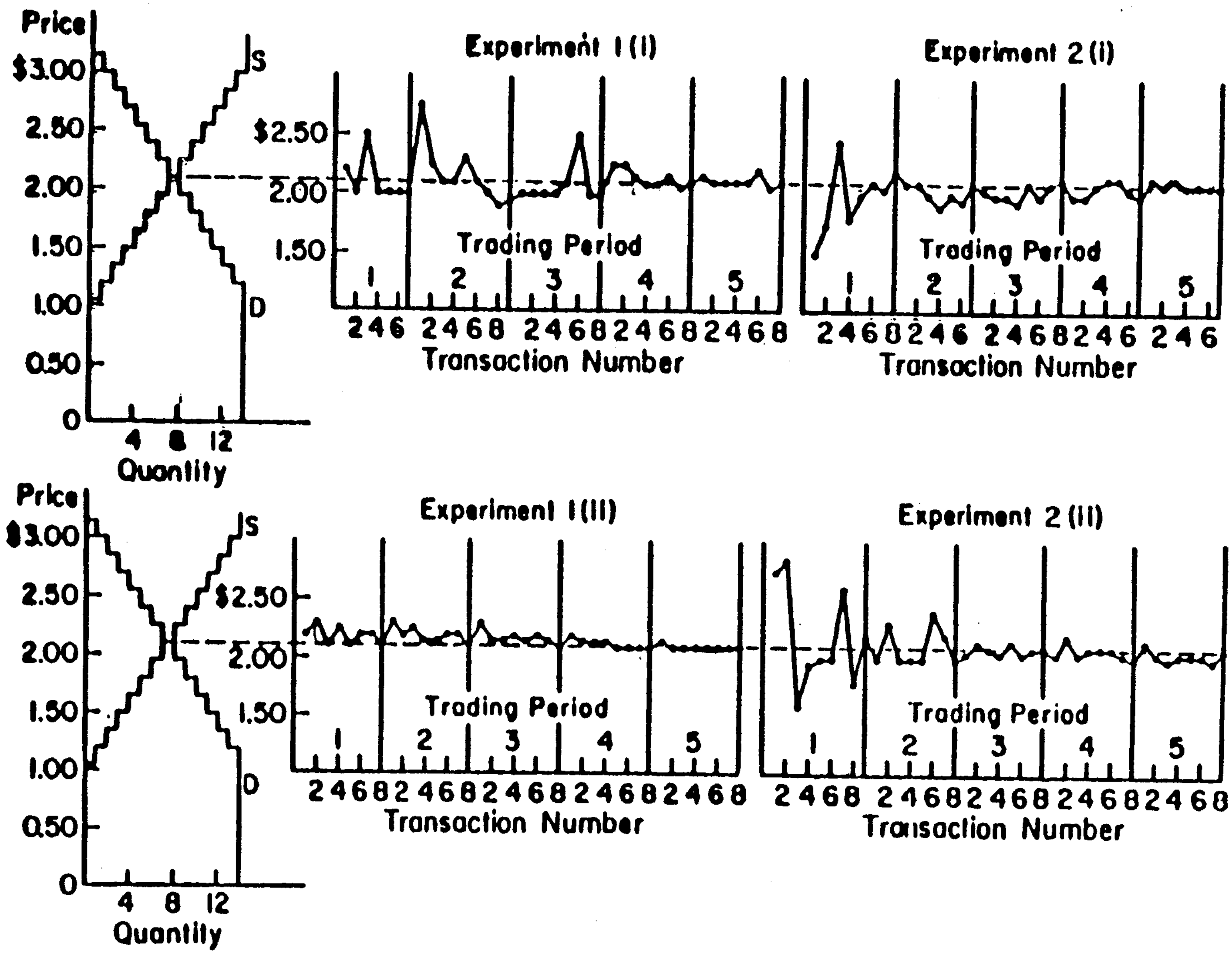
Measurement, a third objective of experiments, involves estimation of numerical value of parameters in economic models. For example, a large scale field experiment was conducted to measure the response of the labor supply to a program of income maintenance. The idea was to find out what would happen to the labor supply if negative income tax were introduced. Similar experiments have been conducted to estimate the elasticity of demand for health services and different medical insurance plans.

Fourth, experiments can play a useful role in theory rejection. Because models or theories are defended as reasonable representations of reality and not as being literally true, even the most ridiculous theories are sometimes difficult to refute in a convincing manner. Experiments can help accelerate the sifting process. The trick is to create a simple situation and see if the model predicts well. If a model does not explain the behavior of a simple situation designed to give it the best chance, its applicability to a complex situation becomes immediately suspect.

Vernon Smith tested the supply and demand models by the induced preference theory. Not only did the induced preference theory work well, but the supply and demand model performed amazingly well. Figure 1 illustrates the results.

In this experiment Smith created a situation where given the demand and supply functions in Figure 1, the standard economic theory predicts an equilibrium price of $2.10 and the equilibrium trading quantity to be eight units. These markets were double oral auction markets in which any trader could raise his/her hand and bid or offer to sell or buy for one unit of the good. The time series of transaction prices is shown in the figure. Notice that in the first period the price is not too far from the equilibrium price, the volume is six units as compared to the eight units

FIGURE 1

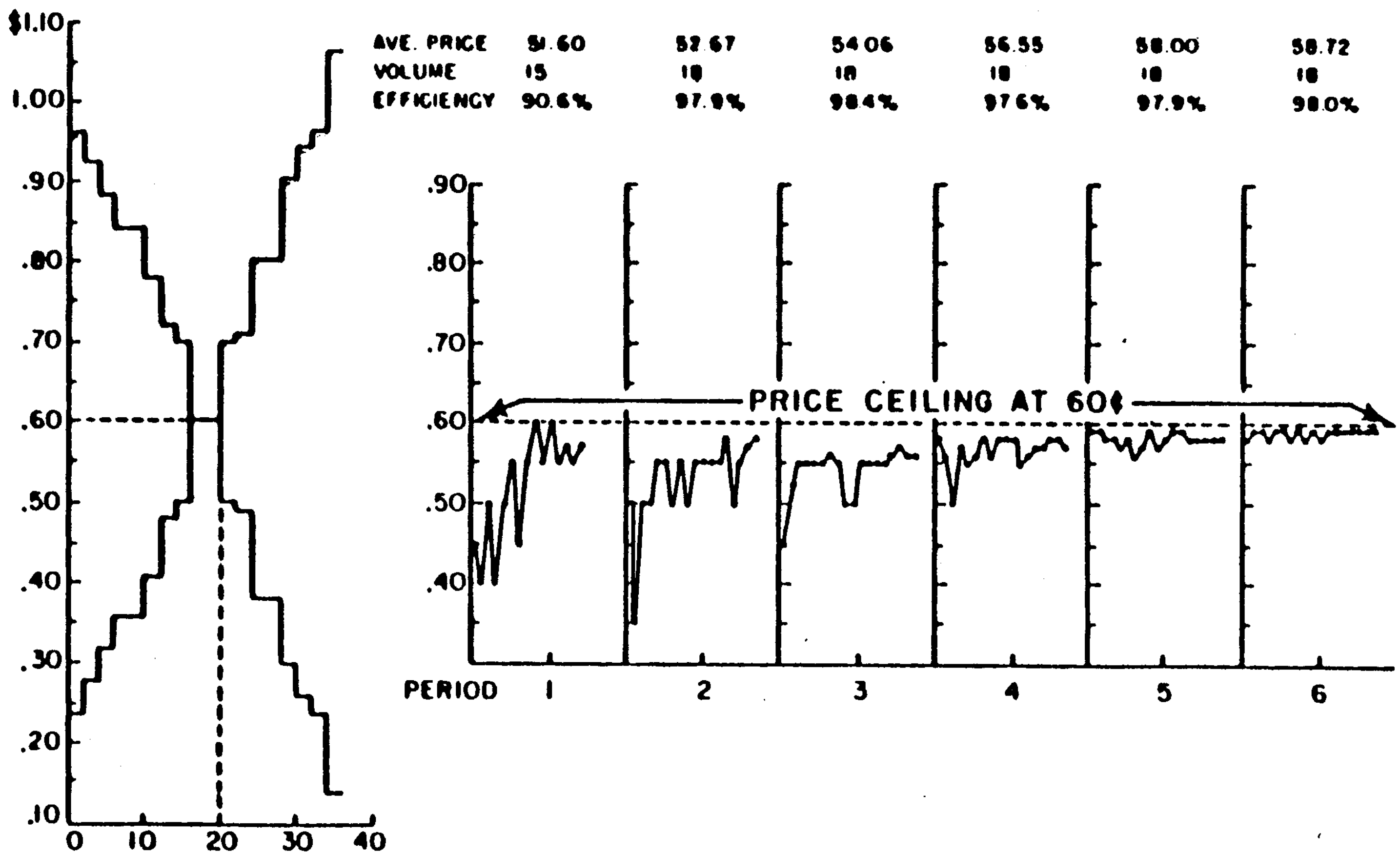


Source: Smith, Vernon L. "Relevance of Laboratory Experiments to Testing Resource Allocation Theory". In Evaluation of Econometric Models, edited by J. Kmenta and J. Ramsey. New York: Academic Press, 1978.

predicted by the standard demand and supply model. In the second period the first trade takes place way above the equilibrium price. Trading quantity is exactly equal to the prediction made by the demand supply model. The price levels are not exactly at the equilibrium price. Upon repetition, almost all trades are within a few pennies of the equilibrium price by the fifth period, the trading volume is exactly equal to the predicted volume and these markets are 100 percent efficient in their allocative efficiency. In another experiment, shown at the bottom of the figure, transactions are practically at equilibrium price by fifth period. Repetition of these experiments with independent subjects and situations has provided strong evidence that the standard supply and demand models in economics are robust and hold up in a variety of situations.

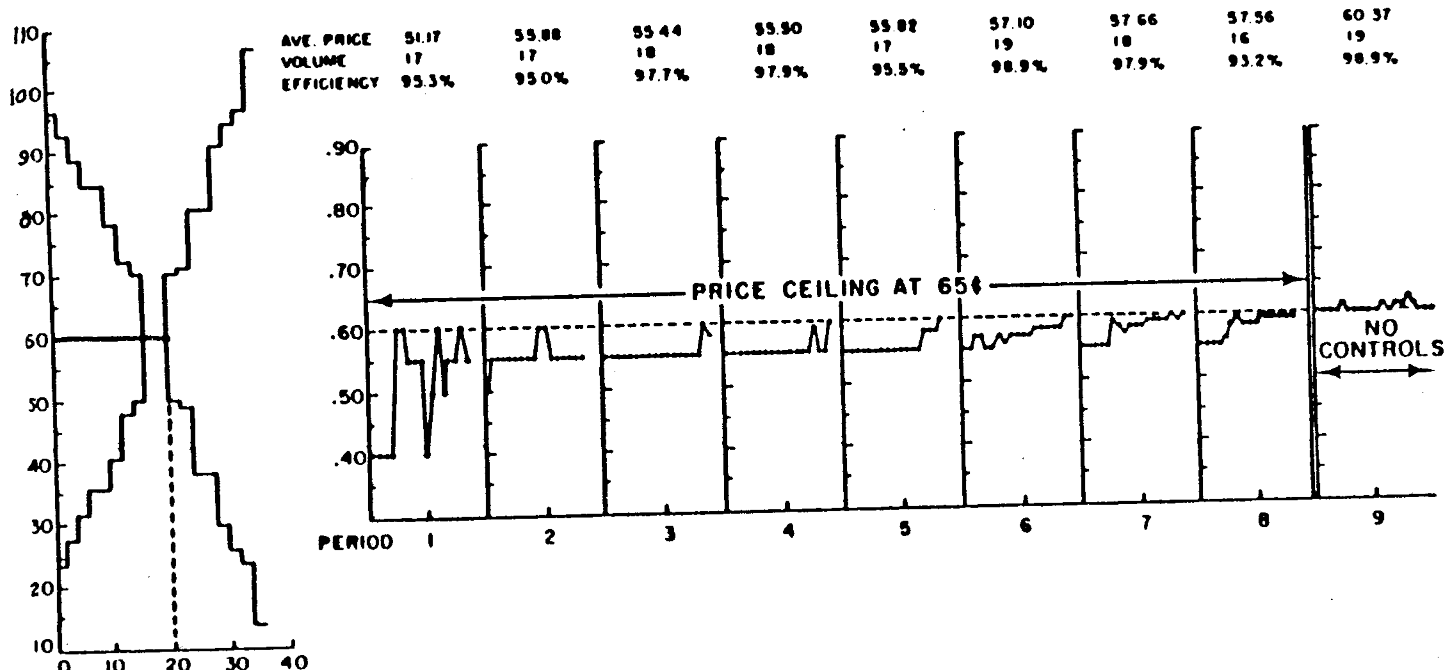
Robustness of social processes to change in institutions or parameters can also be tested by experimental methods and is a fifth possible objective of experiments. Performance of social mechanism can change substantially when an institution or parameter is changed. For example, presence of a non-binding price ceiling or price floor effects a price behavior which is contrary to the standard theory. Figure 2 shows an example from a study of price controls by Isaac and Plott. Equilibrium price is sixty cents and the equilibrium volume is twenty units. This too is a double oral auction market and it opens way below the equilibrium price. Notice that there is a price ceiling at the equilibrium price. Since the ceiling is at the equilibrium price one view is that it should make no difference to the behavior of this market. However, one obvious effect of the price ceiling is that convergence to equilibrium price takes place from below because trades above this price are ruled out. Further, it gets fairly close to this equilibrium price on replication but doesn't quite get there. When the price ceiling is removed in the last period the price adjusts to the equilibrium price exactly. In a second experiment, Isaac and Plott imposed a price ceiling at sixty-five cents when the equilibrium price was sixty cents (Figure 3). Certain theories of collusion in the market suggest that non-binding price ceilings might be used by suppliers as a means of implicit collusion. In this case the convergence to equilibrium price takes place from below and does not converge tightly to the equilibrium price. The moment price control is removed,

FIGURE 2



Source: Isaac, R. M. and C. R. Plott. "Price Controls and the Behavior of Auction Markets: An Experimental Examination". Social Science Working Paper no. 253. Pasadena: California Institute of Technology, February 1979.

FIGURE 3



Source: Isaac, R. M. and C. R. Plott. "Price Controls and the Behavior of Auction Markets: An Experimental Examination". Social Science Working Paper no. 253. Pasadena: California Institute of Technology, February 1979.

however, the price moves exactly to the equilibrium price. They showed very convincingly that non-binding price floors and price ceilings do have an effect on the behavior of the market under certain conditions.

There have been studies of the effect of single versus double oral auction markets, auction versus posted price institutions, and oral versus computer market, to find how the institutional detail affects the efficiency of these market institutions.

Finally, the sixth objective of experiments is theory competition. It is often not possible to distinguish between competing theories on the basis of historical data. Experimental methods have been useful in resolving disputes among competing theories of electricity pricing, for example, and more interestingly, the method of auctioning off Treasury bills. The Treasury uses a discretionary price auction in that each accepted bid is paid for at the bid price. Twenty years ago Milton Friedman suggested that the Treasury switch to a uniform or single price auction which requires that all accepted bids for Treasury bills be paid for at the lowest accepted price. He argued that a single priced auction would yield a greater total revenue to the Treasury, a result that appears to be counterintuitive. More recently, Harris and Raviv showed that in a world of risk averse buyers discriminatory price auctions should yield greater revenues. The experimental research suggests that it depends on the slope of the demand function. When the demand function is relatively steep, the discriminatory price auction yields high revenue; when the demand function is flat the uniform price auction yields the high revenue. Our own purpose in conducting these two studies that I shall discuss in this paper was this last one--theory competition.

The first experiment on asset markets was conducted by Forsythe, Palfrey and Plott. The asset in question existed for two periods and at the end of each period it paid a predetermined dividend to those who had the asset at the end of the period. The dividend was different for different investors to reflect different tax rates and attitudes toward risks and was known privately to each person. The dividend table is given in Figure 4. There are three different types of investor. To Invester 1 the security paid a dividend of 300 francs in the first period. (The franc/-dollar conversion ratio was announced at the outset.) In the second period a dividend of 50 francs was paid. Notice that the security paid a

FIGURE 4

INVESTOR TYPE	DIVIDENDS PERIOD 1	PERIOD 2	TOTAL
I	300	50	350
II	50	300	350
III	150	250	400*

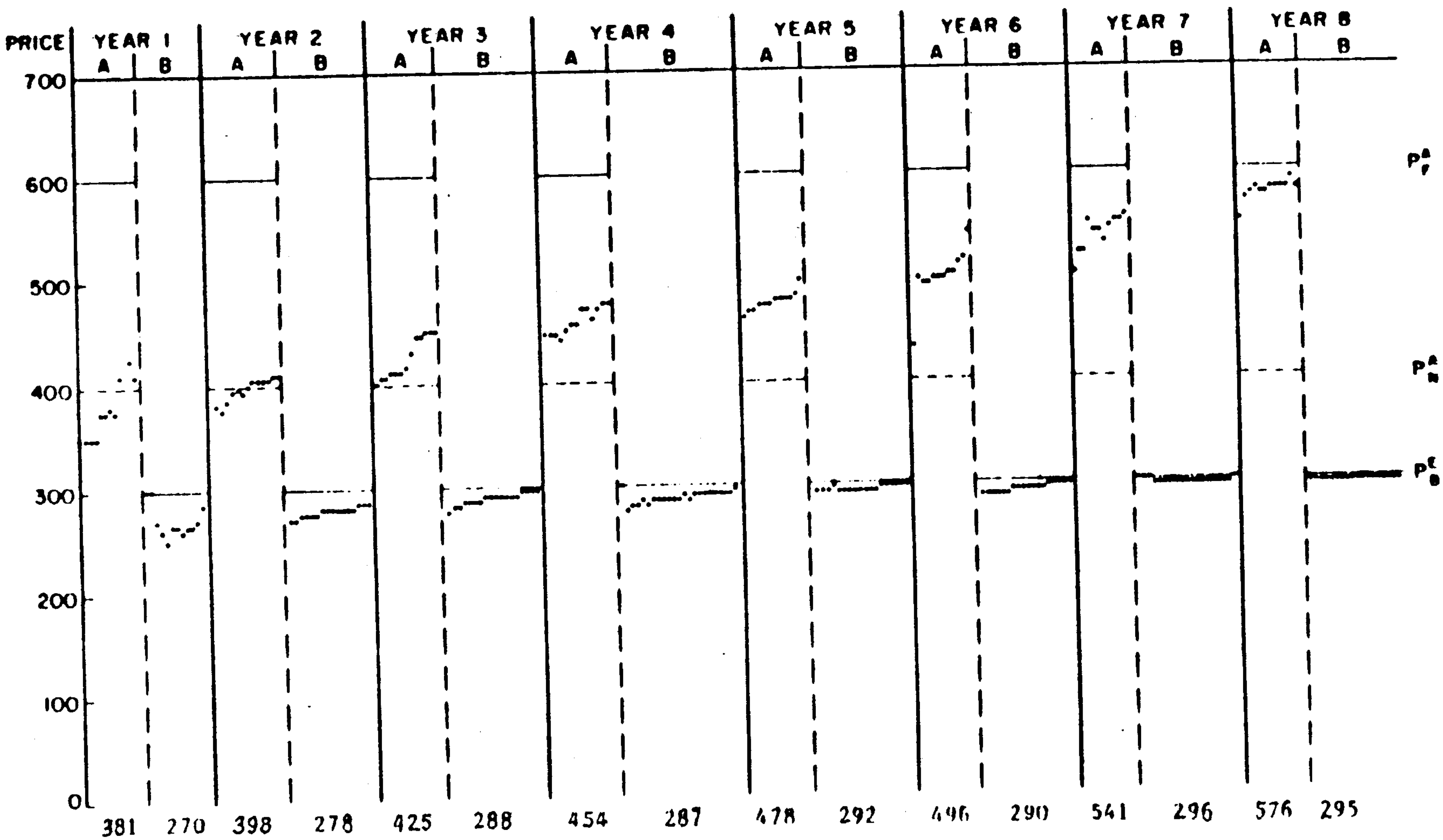
Period 1	Naive Equilibrium Price	=	400
	Perfect Foresight Equilibrium Price	=	600
Period 2	Naive Equilibrium Price	=	300
	Perfect Foresight Equilibrium Price	=	300

Source: Forsythe, Robert, Thomas Palfrey and Charles R. Plott. "Asset Valuation in an Experimental Market". Social Science Working Paper no. 299, Pasadena, California: California Institute of Technology, 1980. From Table 1.

total of 350 francs to Investor 1 over two periods. The second investor was paid 50 francs in the first period and 300 in the second period for a total of 350. The third investor received a dividend of 150 in the first period and 250 in the second period for a total of 400. There are two equilibrium concepts for this asset. One is a naive equilibrium price which is the maximum of the total value of the security over the two periods to each investor. This equilibrium price given a fixed equilibrium supply and a flat demand function should be 400 francs. That is a naive equilibrium price. However, if we allow trading between these two periods then there is another concept of equilibrium that applies to the pricing of these assets, the perfect foresight equilibrium. If Type 1 investors held the security in period 1 and sold it to Type 2 investors at the beginning of period 2, each could extract a dividend of 300 francs and the price of the security in the first period would be 600 francs. So in the first period, under the perfect foresight equilibrium the price of the security in the first period should be 600 and not 400; and in period 2 both equilibrium concepts give us the price of 300. Prices in this market are shown in Figure 5. Initially prices are bunched around the naive equilibrium price of 400 francs for the first period.

In the third year prices begin to move above the naive equilibrium price because investors are now beginning to learn that in the second period the securities are going to be worth 300. They can afford to pay more for it in the first period. By the eighth year the prices reach the perfect foresight equilibrium for the first period. The market is aggregating this information in a perfect fashion. The second period prices converge to their equilibrium level before the first period prices converge to their equilibrium level. It is a kind of phenomema that we see in the dynamic programming models, where the last period is optimized first. The adjustment is not instantaneous. It takes some time. In Figure 6, introduction of a futures market for the second period security radically changes the behavior of the spot market for the first period security. The perfect foresight equilibrium is attained much faster and there was no activity at all in the second period spot market. All the second period activity has been transferred from the spot to the futures market and there is a significant speed-up in efficiency of these markets due to introduction of the futures trading mechanism.

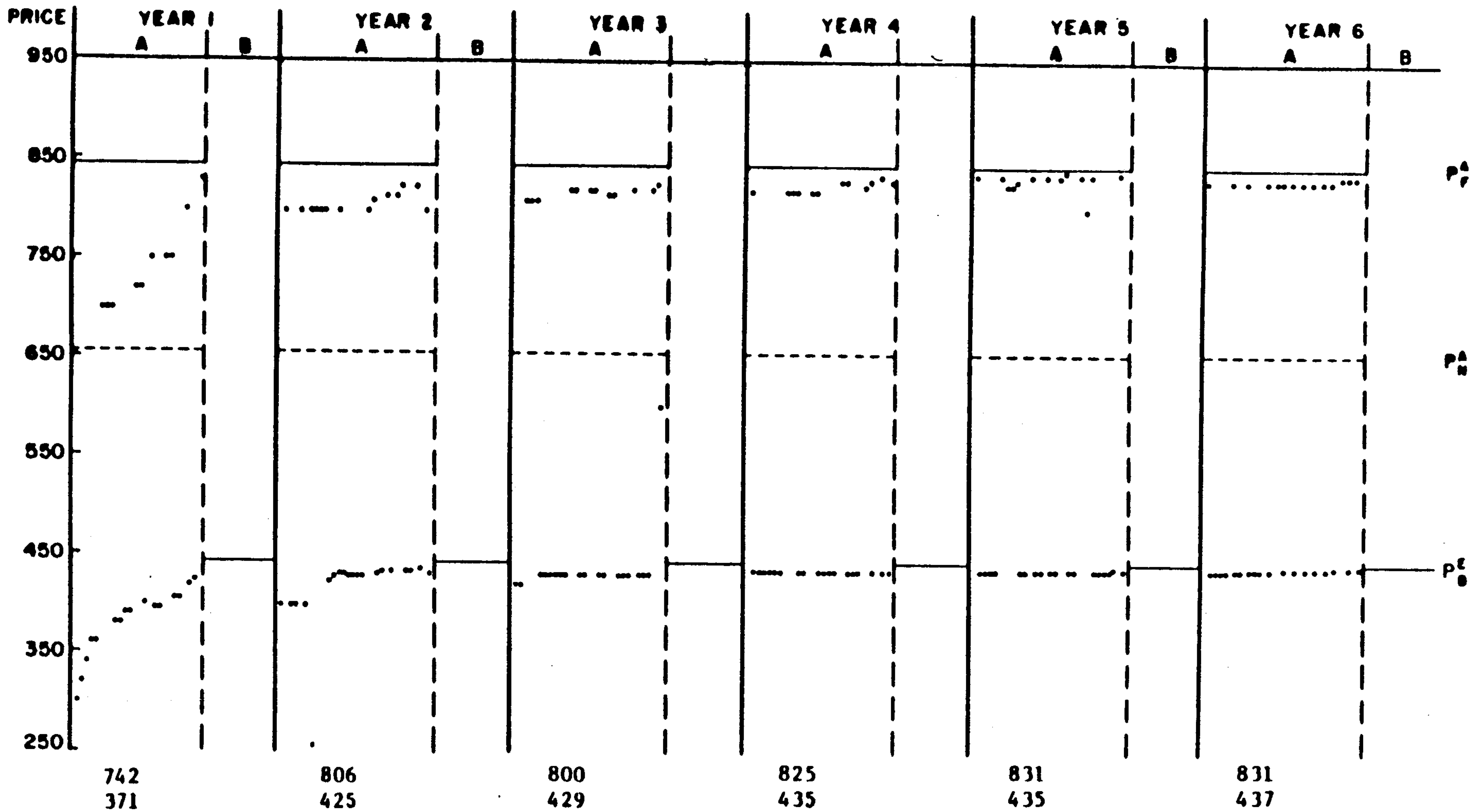
FIGURE 5: Experiment 1



AVERAGE PRICES

Source: Forsythe, Robert, Thomas Palfrey and Charles R. Plott. "Asset Valuation in an Experimental Market". Social Science Working Paper no. 299, Pasadena: California Institute of Technology, 1980. From Table 1.

FIGURE 6: Experiment 5



Average Prices

(upper = period A spot; lower = period B futures)

Source: Forsythe, Robert, Thomas Palfrey and Charles R. Plott. "Asset Valuation in an Experimental Market". Pasedena: California Institute of Technology, 1980. From Table 1.

Note that the observed prices are those predicted by the economic theory and that there is no trace of speculative bubbles suggested by those who think that asset prices can become delinked with their underlying economic returns.

While the Forsythe, Palfrey and Plott study examined the behavior of a two-period security under certainty, the next study I will discuss investigated the behavior of a single period security in an environment of uncertainty and this allowed us to address the question of insider information. The object of trading in these markets was a single period asset with an end-of-period dividend which depended not only on who held the asset (there were three different types of investor with different dividends) but also on which of the two random states of the world was realized in that period.

In Figure 7 the dividends for the security are given. There are three types of investors. For example, Type 1, had a dividend of 400 in state x and of 100 in state y. Everybody knew the relative frequencies (40 percent for x and 60 percent for y) of these states. The expected value of the security to Type 1 investor was 220, and 210 and 155 for Types 2 and 3 respectively. Thus, the security had an uncertain payoff. Half of the traders (there were twelve traders, four of each type) were informed of what the state was. Therefore, two traders of each type were uninformed. The traders could not communicate in any way except by making or accepting bids and offers.

There are two distinct economic theories that try to predict what will happen in a market of this type. First is the naive or prior information theory which says that all traders enter the market with their respective information, which is no information in the case of uninformed traders and perfect information in the case of informed traders, and trade on the basis of that information without learning anything from the prices they see in the marketplace. Suppose the state is x. There are some people in the market who know it is x . Informed Type 1 put a value of 400 on the security, informed Type 2 have a value of 300 and informed Type 3 have a value of 125. Uninformed people have expected values given in the last column of Table 7. The maximum of these six numbers, 400, is the naive equilibrium price. Similarly, under state y, the security is worth 100, 150 and 175 respectively to perfectly informed individuals in the

FIGURE 7

Type of Investor	DIVIDENDS State X ('4)	State Y ('6)	Expected Div.
I	400	100	220
II	300	150	210
III	125	175	155
No Information Equilibrium Price			220
Naive Equilibrium Price	400	220	
Rational Expectation Equilibrium Price	400	175	

Source: Plott, C. R. and Shyam Sunder. "Efficiency of Controlled Security Markets with Insider Information: An Application of Rational Expectation Models". Forthcoming in Journal of Political Economy.

market but there are also uninformed people who think it is worth 220 to them. Therefore, Type 1 uninformed people will outbid the rest and the naive equilibrium price under state y is 220.

Under the rational expectations theory, on the other hand, it is predicated that information possessed by only a few people soon belongs to all. The market informs everybody of the state. If we presume that everybody will get the information and there will be no uninformed people in the market the rational expectations equilibrium price under x is 400 and under y is 175 instead of 220 as predicted by the naive theory. These theories also make specific and distinct predictions about which investors hold the securities in equilibrium. In state x most theories predict that Type 1 investors will hold the security. In state y, the naive theory predicts that Type 1 investors should hold the security, and rational expectations theory predicts that Type 3 investors should hold the security. These are testable predictions of prices and allocations. The prices observed in this market are plotted in Figure 8.

In the first period no information was given to any investor. When everyone is uninformed and bases his trading on the base of expected values the equilibrium price is 220. In Figure 8 you can see that the transaction prices were somewhat above the equilibrium price at first and then came nearer. During the second period trading started out below the equilibrium price and goes up a little bit, and then comes down fairly close to the expected value. In the next two periods we informed half the investors that the state y . For state y, the naive theory predicts a price of 220 and the rational expectations theory predicts a price of 175. The actual prices in Figure 8 get very close to the rational expectations equilibrium price and not close to the naive equilibrium price.

Note that in this market there are some individuals whose expected value is 220, the security is trading at a price well below that expected value but they are not buying. Why aren't they buying? Probably because they have probably learned the state by observing the market action.

In the next period the state was x . Both theories predict the same equilibrium price. The market price moves all the way up to within a few pennies of the equilibrium price. In the next period (5) the state was y and the price of the very first transaction is close to the rational expectations equilibrium and not even close to the naive equilibrium.

Within three or four periods of trading these investors learned to almost perfectly read the market. Uninformed investors are behaving like informed investors. Remaining periods of the experiment confirm this observation. In the later periods there is no disequilibrium trading at all.

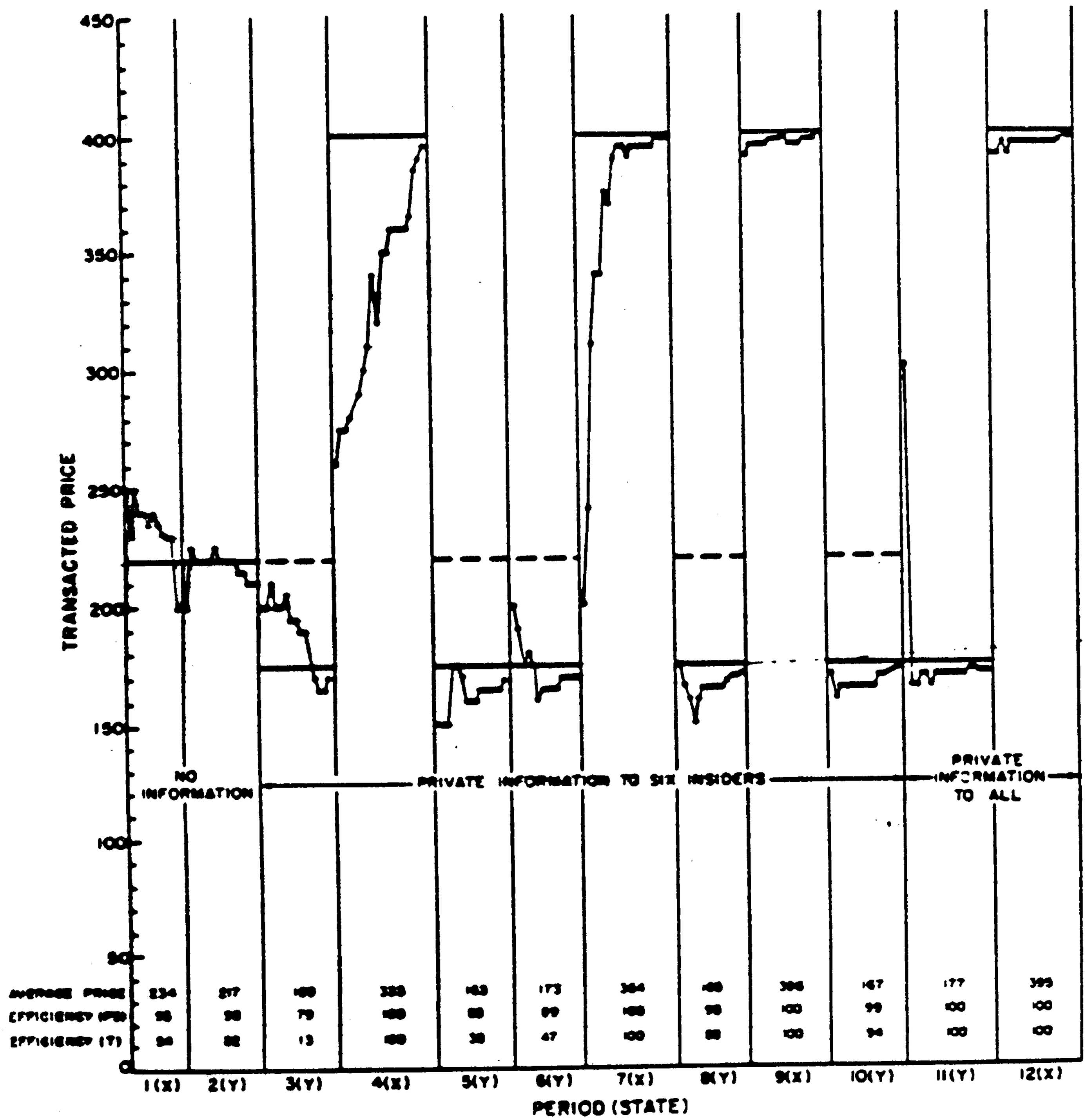
These markets are almost perfectly efficient in terms of the allocation of resources to those who have the best value for those resources. Their efficiency is shown at the bottom of Figure 8. We have already shown that price adjustment takes place instantaneously and these results hold up in a three state model also.

We might speculate that in the process of learning information the uninformed will suffer losses. We found that after only a little experience the uninformed make almost as much money as the informed people. They lose money only in the beginning when they are learning. The ratio of money made by informed people to money made by uninformed people is greater than one in the early periods. This ratio declines until the two groups make about equal money.

Because the opening price in these markets is very close to the rational expectations equilibrium, it is clear that the price above could not be the mechanism that carries the information in these markets. At this stage of research, we can only speculate that it is probably the unaccepted bids and offers that play the crucial role of conveying the information. In early stages of trading the informed traders seem to dominate the action, and that domination seems to leak the information out to the uninformed people. In the very first market action, that is, the very first bid or offer given in the market place, seventy-five percent of the traders were insiders. Non-insiders sat back a bit and watched what the informed traders did. The insiders get into the market first but in the process of trying to make money early they give away that information very quickly.

Next, we tested if these markets are fair game. Even though it may not seem so from the time series we just looked at, it is almost impossible to beat the buy-and-hold strategy in these markets. Mechanical filters of various sizes are not able to beat the buy-and-hold strategy. We would not have expected this result after looking at the prices, but when we tried to find mechanical rules of making money in this market we found it almost impossible.

FIGURE 8: Market 3



Source: Plott C. R. and Shyam Sunder. "Efficiency of Controlled Security Markets with Insider Information: An Application of Rational Expectation Models". Forthcoming in <u>Journal of Political Economy</u>.

Finally, the transaction-to-transaction relative price changes in these markets, have fat-tail distributions. We do not know why, but they do. Relative price changes are not normal.

More recently, we have examined the effect of contingent claims and option type securities on allocative efficiency of market mechanisms but that probably will be a story for another time. (Plott and Sunder, 1981b).

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