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MARKET FOR INFORMATION: EXPERIMENTAL EVIDENCE[1]

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Predictions of the noisy rational expectations equilibrium (REE) model are found to be relatively accurate for both asset and information markets in the laboratory. When information about an asset's uncertain dividend is sold to a fixed number of highest bidders, prices, allocations, efficiency, and distribution of profit predictions of the full revelation REE model in the asset market dominate the predictions of the Walrasian model; demand for information shifts to the left and its price declines close to zero. When the price of information is fixed at a relatively high level, the number of informed agents and the informativeness of the asset market tends to adjust to permit the informed agents to recover their investment in information.

KEYWORDS: Noisy rational expectations, costly information, experimental economics, efficient capital markets.

1. INTRODUCTION

THIS PAPER PRESENTS the results of an empirical test of the proposition that in a competitive market equilibrium, asset prices reveal information in such a way that net returns to production of information are zero. The test is conducted in laboratory markets for a one-period asset. Theoretical models, e.g., Grossman and Stiglitz (1980), suggest that an equilibrium level of noise in asset markets must permit the producers of costly information to recover their costs by allowing them to earn greater than normal gross profits if production of costly information is to persist. These predictions of the noisy rational expectations equilibrium model about markets for assets and information are generally supported by the data.

The idea that market prices are not merely determined by endowments and preferences of traders but also, in part, determine these preferences has received much attention from economic theoreticians during recent years. In a world of uncertainty, price and other market variables have the potential of transmitting information from trader to trader, and could even aggregate diverse information in the possession of individual traders and transmit it to all traders. Predictions of the rational expectations equilibrium, which obtains when traders no longer wish to recontract after observing market behavior, are quite different from the predictions of the Walrasian model in which traders are

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assumed not to utilize information contained in prices and other market variables in choosing their actions.[3]

Empirical verification and testing has lagged behind the development of theoretical models of value of information in competitive markets, primarily because of the practical difficulties of such testing. Experimental work conducted in laboratory settings supports the plausibility of the rational expectations model as a description of behavior of certain markets. Plott and Sunder (1982) found that a double oral auction market is capable of promptly transmitting information from informed to uninformed traders and, in certain markets, the rational expectations model provides a better description of market behavior than the Walrasian model does. In a second study, Plott and Sunder (1988) found that the double oral auction market is capable of simultaneously aggregating diverse information in the possession of different traders and transmitting it to all traders. The ability of markets to do so, however, is influenced by the completeness of the market and investors' knowledge of the preferences of other investors. In both these studies, information was distributed to some or all traders at zero cost to them.

Application of the concept of rational expectations to markets in which agents have to pay for their private information yields interesting results. If the asset market is capable of aggregating information in the possession of individual traders and revealing all of it to the traders through asset price or other market variables (e.g., bids, offers, timing, and identity of traders), such observables will carry information which is equal or superior to the private information in the possession of all individual traders. Since all traders have free access to market variables, and therefore to superior information, incentives to acquire costly private information are destroyed.

Grossman and Stiglitz (1980) argued that an asset market mechanism that reveals all costly information produced privately by traders cannot attain equilibrium; for the market to attain equilibrium, costly private information can be only imperfectly revealed through prices or other market observables.

The primary purpose of this paper is to test whether the noisy rational expectations models can describe the behavior of asset markets with costly information. Specifically, several conjectures proposed by Grossman and Stiglitz about the implications of the rational expectations model concerning demand for information, informativeness of prices, and distribution of wealth among traders are tested. Plott and Sunder's (1982, 1988) designs for asset markets, whose behavior is known to be described well by the REE model, constitute the point of departure for markets examined in this paper. In Plott and Sunder (1982, 1988), the identity of traders who received information was determined exogenously and the cost of information was zero. In the economies examined in this paper, the decision to buy information is endogenous and either the price of information (when the number of traders allowed to buy information is fixed)

[3] See Lucas (1972), Green (1973), Grossman and Stiglitz (1980), Grossman (1981), and Hellwig (1980, 1982).

or the number of traders who buy information (when the price is fixed) is determined endogenously in the market for information.

The structure of experimental markets used in this study is described in the following section. Economic hypotheses under scrutiny are described and discussed in the third section. Empirical results and analysis are presented in the fourth, followed by discussion and conclusions. A summary description of market procedures and instructions are given in the Appendix. A complete set of instructions and the raw data are available from the author.

2. DESIGN OF MARKETS

Seven markets, numbered 1 through 7 in chronological order, were studied. Each market was conducted for several periods. In each period securities which had one-period lives were traded. Each security paid a single dividend to its holder at the end of the period. This dividend depended on a randomly drawn state of nature and differed across traders in all except two markets (Nos. 6 and 7). Differences among dividends and expectations about the state of nature led to the existence of gains from trade. Security Markets 1–5 were organized as oral double auctions,[4] and Markets 6 and 7 were organized as computer double auctions on PLATO.

Subjects were graduate and undergraduate students, mostly in business administration at Universities of British Columbia, Minnesota, and Arizona during 1983–86. Subjects in Markets 1, 2, 4, and 6 were inexperienced, having never participated in a laboratory market. Subjects in Markets 3, 5, and 7 had participated in one or more of the prior markets. Most experiments lasted for about three hours of which about 60 minutes for inexperienced subjects and 15 minutes for experienced subjects was spent on instructions. Subjects were paid their earnings, amounting to about $20 to $30 for each session, in cash.

Instructions, procedures for training subjects, the method of inducing preferences, and other details of experimental procedure were similar to those used in Plott and Sunder (1982, 1988). Subjects' preferences for experimental securities were induced using the procedures developed by Smith (1976) and Plott (1979). During each period each individual i was assigned a dollar redemption function of the following form:

$$R_i = \gamma_i\left[a_i + d_i(\theta)q_i + \sum_s P_s^i - \sum_p P_p^i + c_i - I_i\right],$$

$$a_i < 0, \qquad d_i(\theta) \geq 0, \qquad \gamma_i > 0, \qquad q_i \geq 0, \qquad \text{and} \qquad I_i \geq 0,$$

[4] Any buyer (seller) is free to make an oral bid (offer) to buy (sell) one security at a specified price. All bids and offers are publicly announced and recorded. Only the latest and highest bid (lowest offer) is outstanding at any time. Sellers (buyers) are free to accept any outstanding bid (offer) at any time to close a transaction.

where

R_i = dollar earnings of individual i,
q_i = number of securities held by i at the end of the period ($q_i \geq 0$ because short sales were prohibited) is the sum of initial endowment of securities $\bar{q}_i$ plus purchases less sales in the period,
γ_i = conversion rate of francs into dollars,
a_i = fixed cost each period in francs,
$\theta \in \Theta = \{x, y, z\}$ = possible states of nature,
$d_i(\theta)$ = dividend rate per security in francs for individual i, expressed as a function of the state of nature θ.
$\Sigma_s P_s^i$ = revenue to trader i from sales of securities in the period,
$\Sigma_b P_b^i$ = cost to trader i of securities bought in the period,
c_i = initial endowment per period of working capital (cash) in francs, and
I_i = cost of information purchased by individual i in the period.

As long as a trader's utility is increasing in money, he or she would prefer a larger R_i and the derived demand for experimental securities can be used as a parameter in the model of the security market.

The following constraints were placed on traders. The trader's initial endowment of working capital, c_i, was sufficiently large never to be binding. At the beginning of each period, a trader was endowed with $\bar{q}_i$ securities. The trader could take a short position during trading, but negative holding of securities at the end of a trading period was prohibited through imposition of a substantial penalty. Since a trader could, at most, sell his or her initial endowment of securities through trading, the total supply of securities was fixed at $\Sigma_i \bar{q}_i$.

The information structure of all markets was the same. Traders saw the state of nature determined each period on the basis of a ball drawn from a bingo cage and they knew the relative proportion of balls in the cage that yielded x and y states respectively. (Summary instructions and procedures are given in the Appendix.) In Market 1 and in the first ten periods of Market 3 (referred to as Market 3A) traders were invited to submit sealed bits for the purchase of information with the proviso that the four highest bidders would receive information (whether the realized state of nature for the period is x or y) at the fifth highest bid price (uniform price or nondiscriminatory auction). The price at which information was sold to the four highest bidders was publicly announced but the identity of the buyers of information was not revealed. Markets 1 and 3A constituted Series A. In Series B markets numbered 2, 4, 5, 6, 7, and in the last eight periods of Market 3 (referred to as Market 3B), the price of information was fixed and announced by the experimenter at the beginning of each period. Information was sold to all those who wished to buy at this price. The identity of buyers was not revealed. The number of traders who bought information was publicly announced in Markets 2, 3B, 6, and 7, and remained undisclosed in Markets 4 and 5. Thus in Series A markets the supply of

TABLE 1

DESIGN OF MARKETS
(Each market session lasted for approximately three hours)

(1) Mkt	(2) Location & Subj. Exper.	(3) Trader Divid. Type	(4) # of Trad.	(5) Initial Endowment Certific. and Fr.	(6) Fixed Cost (Fr.)	(7) $ per Fr.	(8) Dividend in Fr. x	y	z	(9) Prior Prob. x	y	z	(10) Expected Dividend with no Info.	(11) Supply of Information about State	(12) Distr. of Info. about Info. Purchase
1	UBC (inexper.)	I	6	2 10,000	10,000	0.004	400	100		0.4	0.6		220	4 highest bidders recd. info. at 5th highest bid price	Mkt. clearing Price of info. announced
		II	6	2 10,000	10,000		125	175					155		
2	UM (inexper.)	I	6	2 10,000	10,000	0.003	400	100		0.4	0.6		220	Price fixed: Mkt. 2 Per. 1–4 @60 fr, Per. 5–13 @100 fr.	No. traders buying info. announced in Mkt 2, not in Mkt 4
		II	6	2 10,000	10,000		125	175					155		
4	UA (inexper.)													Mkt 4 @100 fr.	
3	UM (exper. in Mkt. 2)	I	6	2 10,000	10,000	0.002	430	115		0.4	0.6		241	A.4 highest bidders recd. info. at 5th highest bid price	3A. Mkt clear. Price of info. announced
		II	6	2 10,000	10,000		40	210					142	B. Price fixed: per. 11–12 at 50 fr. per. 13–18 at 100 fr.	3B No. traders buying info. announced
5	UA (exper.)	I II	4 4											Mkt. 5: 100 fr.	5. Not announced
6	UA (inexper.)	I	7	2 1,000	1,000	0.0033	100	140	300	1/3	1/3	1/3	180	100 fr	Announced
7	UA (exper.)	I	6	2 2,500	2,500	0.0033	150	315	110	1/3	1/3	1/3	192	100 fr	Announced

UBC = University of British Columbia.
UM = University of Minnesota.
UA = University of Arizona.

information was fixed each period at 4 traders, the price of information was determined by the market; in Series B markets 2, 3B, and 4–7 the price of information was fixed each period and the number of buyers of information was determined endogenously.

Traders did not know the dividends of others though they knew that others may have different dividends. Twelve traders in Markets 1–4 and eight in Market 5 were partitioned into two types, I and II, according to their dividends given in Table I. In Market 1, for example, investor type I received a dividend of 400 francs if state x occurred and 100 francs if y occurred; x and y dividends of type II investors were 125 and 175 francs, respectively. In Markets 6 and 7 all traders had identical dividends and there were three possible states of the world, x, y, and z (see Table I). Column 10 of Table I gives the expected dividend of securities for each type of investor based on the prior probabilities.

The difference between the markets reported on here and those reported in Plott and Sunder (1982, 1988) lies not in the setting of asset markets themselves (which are similar) but in the market for information. In Plott and Sunder no market for information existed; costless distribution of information was arranged exogenously across various investor types to ensure that informational monopolies did not exist in any class of investors. In contrast, in markets reported here, distribution of information through purchases by individuals is endogenous and no particular distribution of information can be guaranteed. In Series A markets information is supplied to the four (out of twelve) highest bidders; in Series B markets all those who wish to, may buy information at a fixed price. In all markets it is possible for all buyers of information to be on the same (buying or selling) side of the asset market. Furthermore, the purpose of analysis here is to examine equilibria in asset *and* information markets; the latter market does not exist in the Plott and Sunder studies.

3. RATIONAL EXPECTATIONS MODEL

In rational expectations equilibrium traders condition their expectations about the state of nature on the equilibrium values of variables endogenous to the market and such behavior, in turn, results in those equilibrium values. For the two- and three-state settings of our experimental markets, we use as a benchmark the version of REE models in which prices fully reveal the state of nature. Predictions of this model are given in Table II. Since REE prices in states x and y (and z in Markets 6 and 7) are different, they enable uninformed individuals to infer the state of nature from market behavior.

3.1. *Market for Information*

The full revelation REE model implies that if any one or more traders buy information, it will be revealed to all market participants and everyone will benefit equally from it. Information would have social value, but no private value. If the information market has a fixed supply, the leftward shift in the

TABLE II

ASSET PRICE AND ALLOCATION PREDICTIONS OF THE FULL REVELATION REE MODEL

Market	No. of Info. Traders	State of Nature: x Price	x Allocation to Trader Type	y Price	y Allocation to Trader Type	z Price	z Allocation to Trader Type
1,2,4	0	220	I	220	I		
	≥ 1	400	I	175	II		
3,5	0	241	I	241	I		
	≥ 1	430	I	210	II		
6*	0	180	—	180	—	180	—
	≥ 1	100	—	140	—	300	—
7*	0	192	—	192	—	192	—
	≥ 1	150	—	315	—	110	—

* In Markets 6 and 7 all traders have identical dividends and the RE model makes no prediction about allocation of securities among them.

private demand for information (as full revelation RE equilibrium becomes established in the asset market) will move the price of information toward zero. With a fixed supply of information there is no danger that no one in the market will have access to information. Thus, even as the price of information converges to zero, information will continue to be available in the market and full revelation RE equilibrium in the asset-information markets is given as follows for Market 1:

In state x: asset price 400, assets allocated to type I traders, information price zero, allocation of information indeterminate.

In state y: asset price 175, assets allocated to type II traders, information price zero, allocation of information indeterminate.

When the price of information is fixed at some positive level, full revelation RE equilibrium does not exist. As traders learn to extract information from observation of state-price correspondence in the asset market, the demand for information shifts to the left until the quantity of information demanded is reduced to zero and there is no information in the market to be revealed. REE with no information for Market 1 is: asset price 220, asset allocated to type I, in both states x and y. However, when no one buys information each trader has private incentives to acquire information and the demand for information shifts to the right. Thus the full revelation REE model predicts that in a market with the price of information fixed at a positive level, the demand for information will be unstable and the quantity demanded will not converge to a fixed amount.

In a noisy rational expectations equilibrium, prices do not fully reveal the information produced by the informed traders and thus allow them the opportunity to recover their costs of producing it. In the double auctions reported in this study, each contract is for a single security and is final with no opportunity for Walrasian recontracting. Unlike the Walrasian auction, the transaction price for each unit may vary in a double auction. Even if the transaction price ultimately reveals the information to the uninformed, variation of prices leaves

open the opportunity for the informed to recover their costs through transactions at favorable prices during early parts of a trading period. Grossman and Stiglitz (1980) and others employed exogenous supply shocks to produce noisy rational expectations equilibrium in which prices allow only a part of costly information to be revealed to the uninformed. The inherent variability of all observables in a double auction, and the sequential nature of transactions suggest that explicit introduction of such exogenous supply noise may not be necessary to attain a noisy REE with cost information in double auctions. Hellwig (1982) constructs a rational expectations equilibrium in which the informed traders enjoy a small timing advantage that permits them to earn returns on their investment in information.

In Series B markets (Nos. 2, 3B, 4, 5, 6, and 7) information was sold to all traders who wished to buy it at the announced price. Several conditions which are potentially relevant to the informativeness of these markets were manipulated to examine the robustness of noisy equilibrium. First, the number of traders who acquired information was publicly announced in Markets 2, 3B, 6, and 7 before trading started in the asset market; this number remained undisclosed in Markets 4 and 5. Second, traders had diverse preferences in Markets 2, 3B, 4, and 5 and uniform preferences in Markets 6 and 7. Finally, the number of possible states was increased from 2 (x and y) in Markets 2, 3B, 4, and 5 to 3 (x, y, and z) in Markets 6 and 7.

4. RESULTS

The time series of asset transaction prices for all periods of the seven markets are shown in Figures 1 through 7. Price predictions of the full revelation REE model in asset markets are shown by a thin horizontal line for each period. Each dark rectangle represents one asset market transaction at the specified price in chronological order. The market price of information in fixed supply information markets of Series A (Markets 1 and 3A) is shown by a horizontal broken line; and the number of traders who bought information in the fixed-price-of-information markets of Series B (Markets 2, 3B, and 4–7) is shown in a thick horizontal line. Summary statistics for each market (average asset price and asset market efficiency) are also given.

Conclusions from the data are developed in the following paragraphs. Briefly, the behavior of both asset and information markets converges toward the predictions of the fully revealing rational expectations equilibrium when the supply of information is fixed (Series A): the price of information drops simultaneously with convergence of the asset market toward fully revealing a rational expectations equilibrium as assessed by asset prices, allocations, and efficiency. As predicted by simultaneous application of the rational expectations model to the information and asset markets, distribution of net (of cost of information) profit across traders also converges toward equality. When the price of information is fixed (Series B), the behavior of asset markets conforms to predictions of the noisy rational expectations model. Informativeness of the

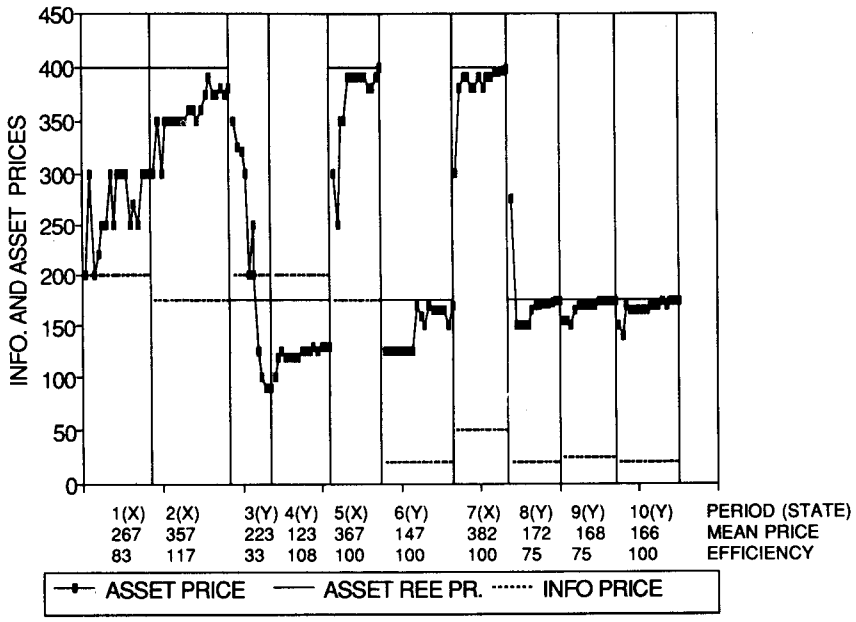

FIGURE 1.—Market 1: Transaction record for information and asset markets (quantity of information fixed).

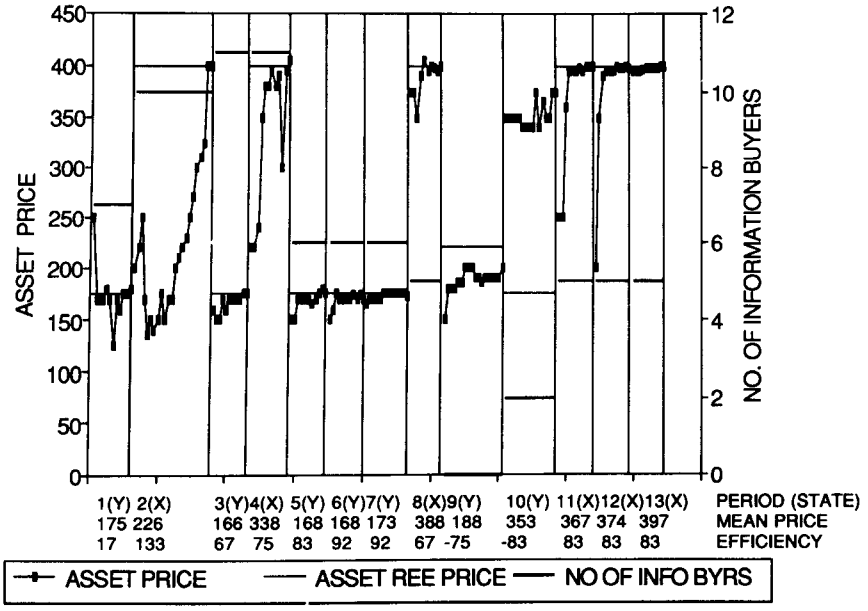

FIGURE 2.—Market 2: Transaction record for information and asset markets (price of information fixed).

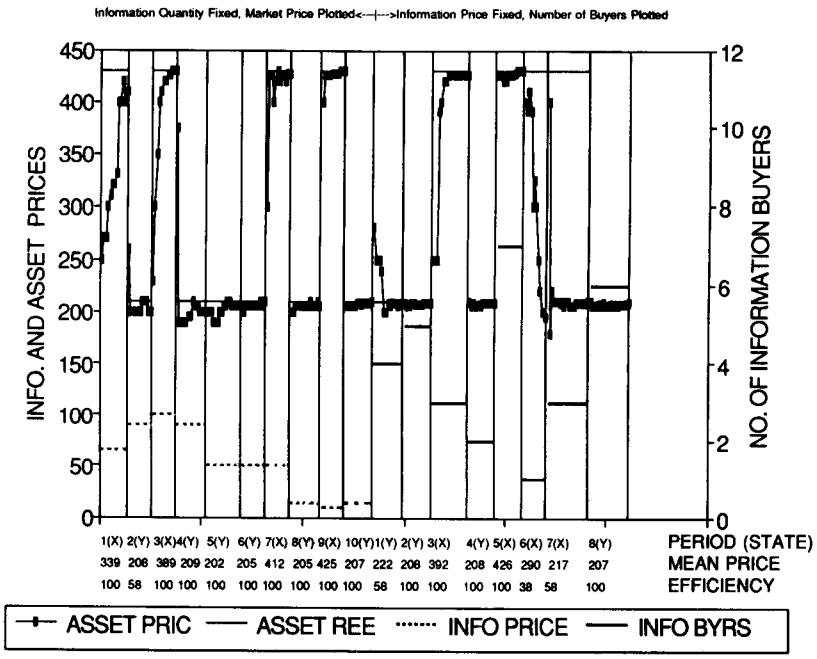

FIGURE 3.—Market 3: Transaction record for information and asset markets (3A, Periods 1–10: quantity of information fixed; 3B, Periods 1–8: price of information fixed).

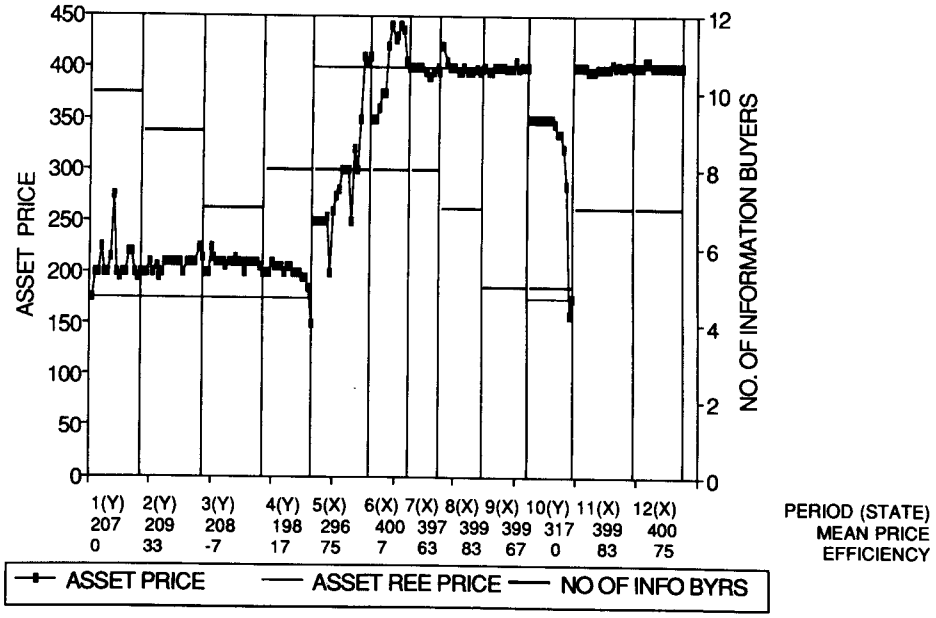

FIGURE 4.—Market 4: Transaction record for information and asset markets (price of information fixed).

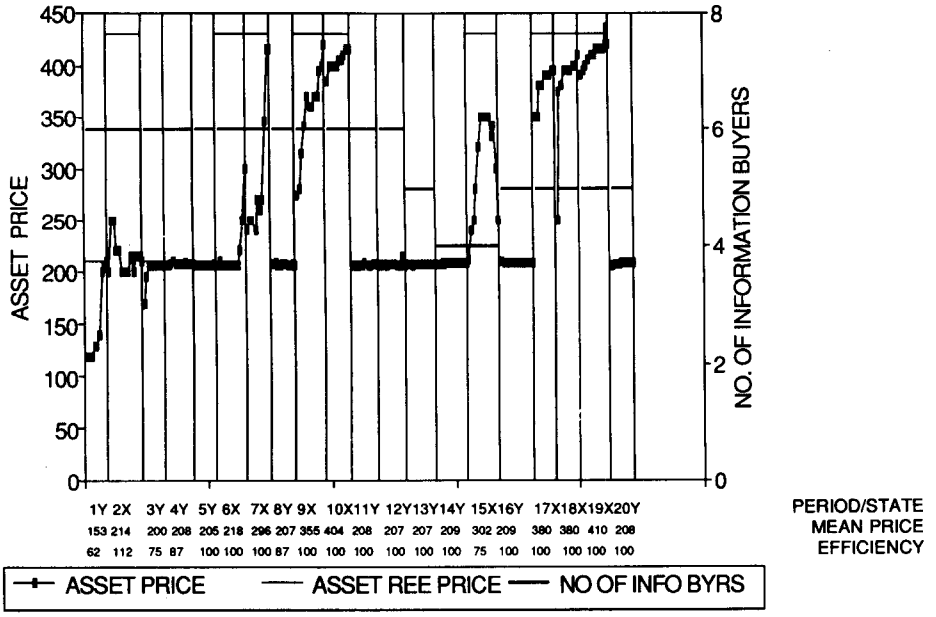

FIGURE 5.—Market 5: Transaction record for information and asset markets (price of information fixed).

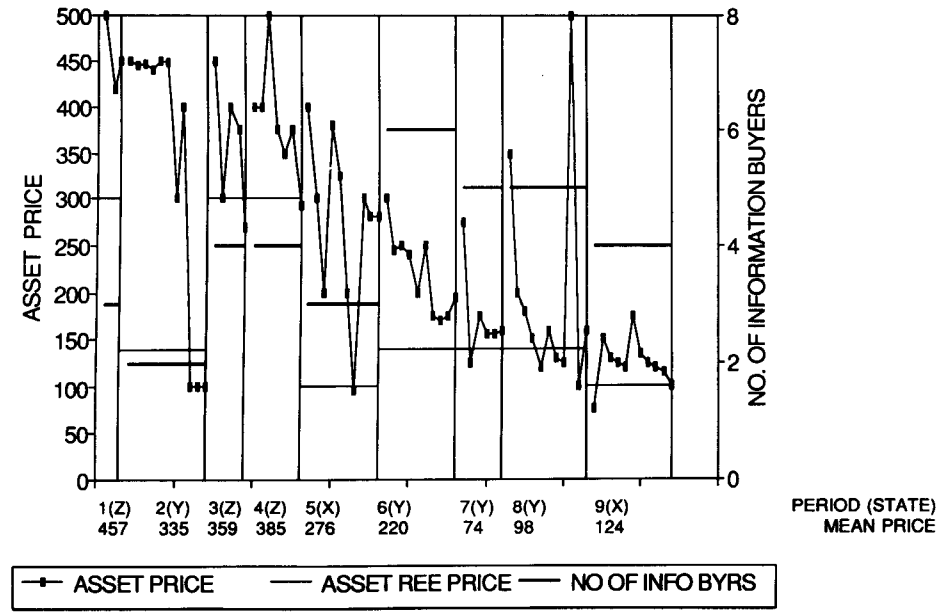

FIGURE 6.—Market 6: Transaction record for information and asset markets (price of information fixed).

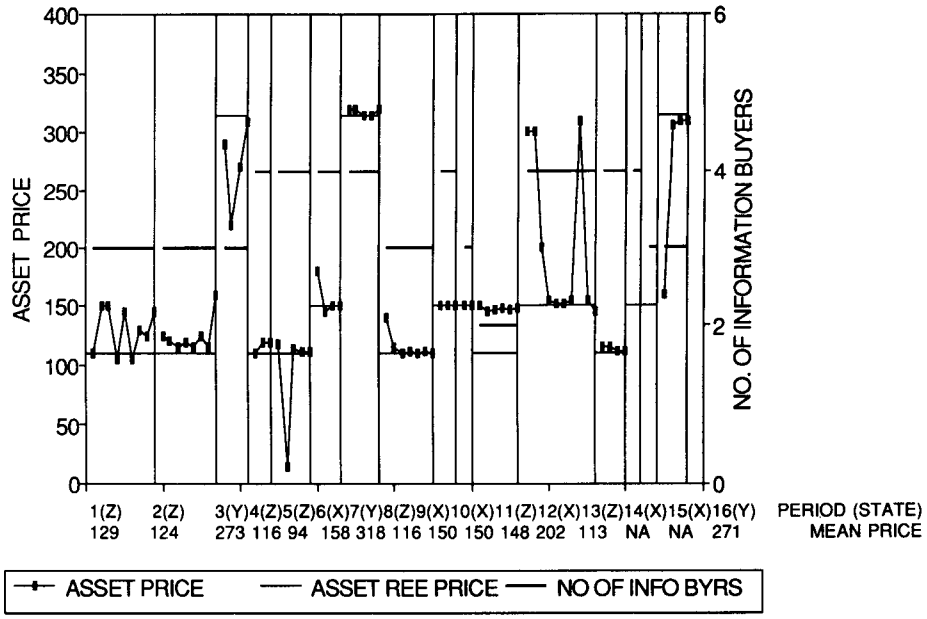

FIGURE 7.—Market 7: Transaction record for information and asset markets (price of information fixed).

asset market, as measured by prices, profit distribution, and efficiency is lower; average gross profits of the informed are higher but their net profits are statistically indistinguishable from the profits of the uninformed. When the number of informed traders is small, prices sometimes converge to a level corresponding to a wrong state of nature (i.e., a state of nature other than the realized state).

Sections 4.1 and 4.2 present the results for Series A and B respectively. Exploratory analysis of data with respect to individual information purchases and occasional convergence of markets to wrong prices is given in Sections 4.3 and 4.4 respectively.

4.1. *Markets with the Supply of Information Fixed (Series A)*

CONCLUSION 1: *Asset prices in Series A markets converge to REE predictions.*

In both Markets 1 and 3A, asset prices predicted by REE and Walrasian equilibrium are distinct when state y occurs. The observed level of prices is much closer to the predictions of REE. Out of 12 occurrences of state y in these two markets, mean deviations of transaction prices from predicted prices are smaller for the REE model in 11 periods. The same is true of mean absolute and for mean squared deviations. Furthermore, out of 140 nonzero price changes during these two markets, 96 changes were in the direction of the REE

price.[5] Since only one half of these changes would be expected to be in the direction of the REE price by random chance, the observed behavior has less than .001 probability of being realized under the null hypothesis of random walk. Unlike Plott and Sunder (1982), the identity of informed traders changed from period to period but this variation made little difference to the convergence of prices to the REE predictions.[6]

CONCLUSION 2: *Price of information in Series A markets converges close to zero.*

In Market 1, the price of information declines from 200 francs in period 1 to 20 francs in period 10. In simple regression of price on time, the slope coefficient has a t statistic of -5.3 which is significant at $\alpha = .0005$. The average price of information in the first five periods exceeds the average price in the last five by 163 francs. The null hypothesis of equality of the two averages is rejected in favor of a lower price in later periods at $\alpha = 0$. Similarly, in Market 3A, the price of information declines from 65 francs in period 1 to 15 in period 10. The slope coefficient of time regression has a t statistic of -5.0 (significant at $\alpha = 0.0005$) and the difference between the average price of information during the first and last five periods is significant at $\alpha = 0.000$.

Figure 8 confirms that this decline in price is due to a leftward shift in demand for information. Demand functions based on bids submitted by traders for the purchase of information at the beginning of each period of Markets 1 and 3A are plotted in Figure 8.

CONCLUSION 3: *Allocation of assets in Series A markets converges to REE predictions.*

As can be seen in Table III, only 7 percent of the certificates (17 out of 240) in 10 periods of Market 1 were held by traders who were not predicted to hold them by the REE model. Figures for the experienced-trader Market 3A are even more striking at 2 percent. Average efficiency (percent of total potential gains from trading actually exploited) was 89 percent in Market 1 and 96 percent in Market 3A (see numbers given in Figures 1 and 3).

CONCLUSION 4: *Allocation of information in Series A markets moves in the direction of the REE predictions.*

The Walrasian model predicts traders of type I, whose dividends are more variable across the states of nature, buy information because they derive greater

[5] The number of price changes in the direction of the Walrasian equilibrium price is also 96. However, since the level of price is explained much better by the REE, this conclusion from the data is appropriate.

[6] Banks (1985) exogenously varied the identity of investors in the Plott and Sunder (1982) research design but found that the prices still converge to the REE predictions.

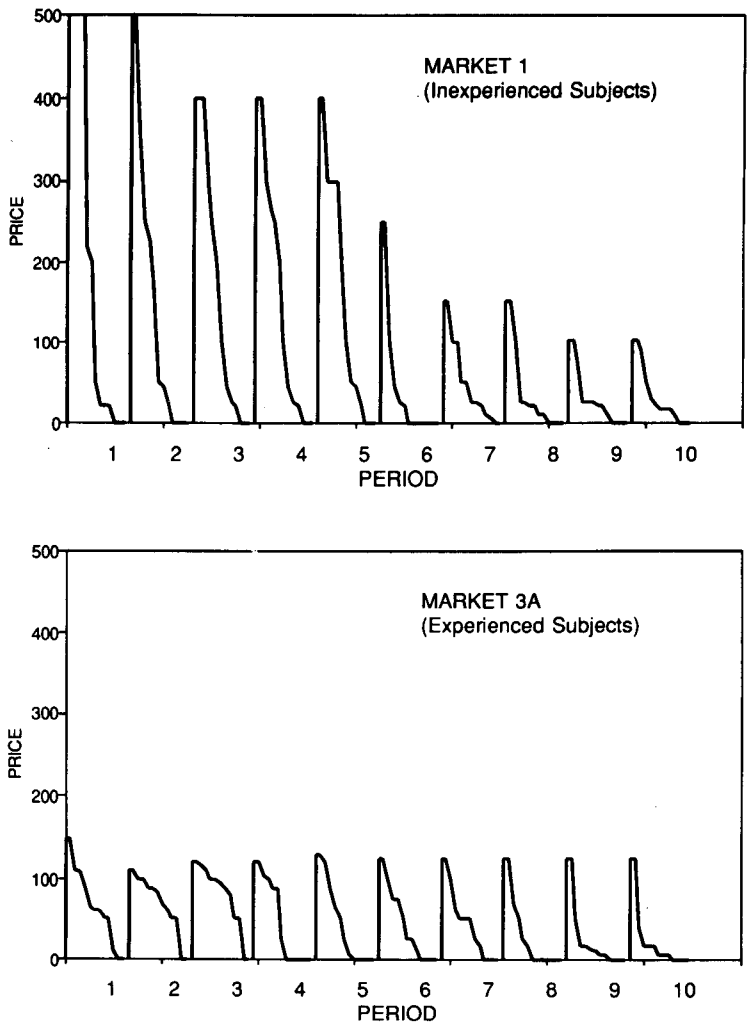

FIGURE 8.—Demand functions for information constructed from individual bids for information (fixed supply of information).

value from it; in REE, the value of information is zero to all traders and therefore buyers of information are expected to be distributed randomly across the two types of traders. During the first five periods of Market 1, only one out of twenty buyers of information is a type II trader and information purchase conforms closely to the predictions of the Walrasian model. In the last five periods, as traders gain experience and REE is established, information purchases are more evenly distributed among the two types of investors (14 type I and 6 type II buyers). In Market 3A, conducted with experienced subjects, information purchases are evenly distributed among type I and II traders (20 each). (See Table IV for data on purchase of information.)

TABLE III

MISALLOCATION OF SECURITIES RELATIVE TO THE PREDICTIONS OF THE REE*

		Period																				Total and Percent Misallocation
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Market 1	State	*x*	*x*	*y*	*y*	*x*	*y*	*x*	*y*	*y*												17/240 =
	No.	2	0	8	1	0	0	3	3	0												7 percent
Market 2	State	*y*	*x*	*y*	*x*	*y*	*y*	*y*	*x*	*y*#	*y*	*x*	*x*	*x*								56/312 =
	No.	10	0	4	3	2	1	1	4	3	22	2	2	2								18 percent
Market 3A	State	*x*	*y*	*x*	*y*	*y*	*y*	*x*	*y*	*x*	*y*											5/240 =
	No.	0	5	0	0	0	0	0	0	0	0											2 percent
Market 3B	State	*y*	*y*	*x*	*y*	*x*	*x*	*x*	*y*													30/192 =
	No.	5	0	0	0	0	15	10	0													16 percent
Market 4	State	*y*	*y*	*y*	*y*	*x*	*x*	*x*	*x*	*x*	*y*	*x*	*x*									84/288 =
	No.	12	8	13	10	3	11	4	2	4	12	2	3									29 percent
Market 5	State	*y*	*x*	*y*	*y*	*y*	*x*	*x*	*y*	*x*	*x*	*y*	*y*	*y*	*y*	*x*	*y*	*x*	*x*	*x*	*y*	9/320 =
	No.	3	0	2	1	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	3 percent

* In markets 6 and 7, all traders have identical dividends and the REE model makes no prediction about the allocation of securities among them.

\# No trader chose to purchase information in Period 9 of Market 2.

The convergence of asset prices to the REE predictions and convergence of the price of information to zero are related to each other. Transactions away from the REE price transfer wealth across traders, allowing informed traders to extract private value from their information. As the variability of prices declines and prices reveal the state more precisely, the price of information declines and the cross-sectional variation of profits declines.[7] These findings are stated in the following conclusion.

CONCLUSION 5: *Distribution of profit across traders in Series A markets converges to the predictions of the REE model.*

The REE model predicts all investors earn the same profit irrespective of their dividend type and decision to purchase information. Since the REE price of information is zero, gross and net profit predictions are identical. Convergence to equality of profit across investors in Markets 1 and 3A can be seen through reduction in cross-sectional standard deviations of net profit (Figure 10), and through reduction in the difference between average profit of informed and uninformed traders (Figure 11).[8] This is true of both gross and net (of

[7] This conclusion is consistent with Grossman and Stiglitz' (1980) conjecture 5: "The greater the magnitude of noise, the less informative will the price system be, and hence the lower the expected utility of uninformed individuals. Hence in equilibrium, the greater the magnitude of noise, the larger the proportion of informed individuals." Since the supply of information was restricted to 4 traders in Markets 1 and 3A, greater noise was associated with a higher price for information.

[8] Though not reported here (results are available from the author), difference between the profits of informed and uninformed traders predicted to be buyers (and between those predicted to be sellers) according to the FR benchmarks declines. Because of a flat demand function used in these asset markets, traders who happen to be buyers make more money on average than the sellers. In order to examine the effect of information purchase on profits, it is useful to control for whether each trader is on the buying or selling side of the market during each period.

TABLE IV

RECORD OF INFORMATION PURCHASES AND RUNS TESTS FOR MIXED STRATEGY

Market No.	Trader No. and Type	Info. Purchase Sequence Over Periods*	# of Runs	Critical Region Lower to Upper		Randomness Rejected**	
	State	*x x y y x y x y y y*		$\alpha = 0.05$	$\alpha = 0.25$	$\alpha = 0.05$	$\alpha = 0.25$
1	1 I	− − − − − + + + + +	2	2–10	3–9	Yes	Yes
	2 I	+ + + − + + + − − +	5	2–	3–	No	No
	3 II	− − − − − − − − − −	1	NA	NA	—	—
	4 II	− − − − − − − − − −	1	NA	NA	—	—
	5 I	− + − + + − + − − +	8	2–10	3–9	No	No
	6 I	+ − + + + − + + + +	5	NA	2–	—	No
	7 II	− − − − − + − + + −	5	2–	3–	No	No
	8 II	− − − − − − − − − −	1	NA	NA	—	—
	9 I	− + + + − − − − − −	3	2–	3–	No	No
	10 I	− + + + + − − − − −	3	2–9	3–8	No	No
	11 II	− − − − − − − − − −	1	NA	NA	—	—
	12 II	+ − − − − + − + + −	6	2–9	3–8	No	No
	Total # of Purchases	3 4 4 4 4 4 4 4 4 4					
	State	*y x y x y y y x y y x x x*					
2	1 I	+ + + + + + + − − + + + +	3	NA	2–	—	No
	2 I	+ + + + + + + + − − − + −	4	3–	4–9	No	Yes
	3 II	− + + + − − − + − − − − −	5	3–	4–9	No	No
	4 II	+ + + + − − − − − − − − −	2	3–	4–9	Yes	Yes
	5 I	+ + + + + + + + + − − + − +	5	2–	3–	No	No
	6 I	− + + + + + + + + − − + + +	4	2–	3–	No	No
	7 II	+ + + + − − − − − − − − − −	2	3–	4–9	Yes	Yes
	8 II	− − + + + + + − − − − − − −	3	3–11	4–10	Yes	Yes
	9 I	+ + + + + + + + + − − + + +	3	NA	2–	—	No
	10 I	+ + + + − − − − − + + + +	3	3–11	4–10	Yes	Yes
	11 II	− + + + − − − − − − − − −	3	2–	3–	No	No
	12 II	− − − − − − − − − − − − −	1	NA	NA	No	Yes
	Total # of Purchases**	7 0 1 1 6 6 6 5 0 2 5 5 5					
	State	*x y x y y y x y x y y y x y x x x y*					
3	1 II	− − − − − − − + − − + + + + + + + +	4	5–15	7–13	Yes	Yes
	2 II	+ − − − − − − + + − − − − − + − − −	6	3–	5–	No	No
	3 I	+ + − + − + + − + − + + − + − − + +	13	5–14	6–13	No	Yes
	4 I	− − − + − − − − − + − + − − + − − +	10	4–	5–11	No	No
	5 II	− − − − + + − − − + − − − − + − + +	8	4–13	6–12	No	No
	6 II	− − + + + + + + + + − − − − − − − −	3	5–15	7–13	Yes	Yes
	7 I	− − − − − − − − − − − − − − − − −	1	NA	NA	—	—
	8 I	− + + − − − − − − − − − − + − − +	6	3–	5–	No	No
	9 II	+ + + − − − + − − − − − − − − −	4	3–	5–	No	Yes
	10 II	− − − − − − − − − − − − − − − −	1	NA	NA	—	—
	11 I	− − + + + + + + + + + + − + − − +	6	4–	5–11	No	No
	12 I	+ + − − + − − − − − + + + − + − − −	8	5–14	6–13	No	No
	Total # of Purchases	4 4 4 4 4 4 4 4 4 4 4 4 5 3 2 7 1 3 6					

	State	y y y y x x x x x y x x		$\alpha = 0.05$	$\alpha = 0.25$	$\alpha = 0.05$	$\alpha = 0.25$
4	1 I	+ + + + + + + + + + + +	1	NA	NA	—	—
	2 I	+ + + + + + + + − − + +	3	NA	2−	—	No
	3 II	+ + − + + + + + + + + +	3	NA	NA	—	—
	4 II	− + − − − − − − − − − −	3	NA	NA	—	—
	5 I	+ + + + + + + + − + + +	3	NA	NA	—	—
	6 I	+ − − + + + + + + + + +	3	NA	2−	—	No
	7 II	+ + + + + + + + + + + +	1	NA	NA	—	—
	8 II	+ + + − − − − − − − − −	2	2−	3−	Yes	Yes
	9 I	+ + + + + + + + + − − + −	4	2−	3−	No	No
	10 I	+ − − − − − − − − − − +	3	NA	2−	—	No
	11 II	− − − − − − − − − − − −	1	NA	NA	—	—
	12 II	+ + + + + + + + − − − −	2	3−	4–9	Yes	Yes
	Total # of Purchases**	0 9 7 8 8 8 8 7 5 5 7 7					

	State	y x y y y x x y x x y y y y x y x x x y					
5	1 I	− + + + + + + + + + + + + − − − − − − −	3	6–16	7–14	Yes	Yes
	2 II	+ + + + + + + + + + + + + + + + + + + +	1	NA	NA	—	—
	3 I	+ + + + + + + + + + + + + + + + + + + +	1	NA	NA	—	—
	4 II	− − − − − − − − − − − − − − − − − − − −	1	NA	NA	—	—
	5 I	+ + + + + + + + + + + + − − − + + + + +	3	3−	4−	Yes	Yes
	6 II	+ + + + + + + + + + + + + + + + + + + +	1	NA	NA	—	—
	7 I	+ + + + + + + + + + + + + + + + + + + +	1	NA	NA	—	—
	8 II	+ − − − − − − − − − − − − − − − − − − −	2	NA	NA	—	—
	Total # of Purchases	6 6 6 6 6 6 6 6 6 6 6 6 5 4 4 5 5 5 5 5					

	State	z y z z x y y y x					
6	1 I	+ − + + − + + + +	5	NA	2−	—	No
	3 I	− − − − − − − − −	1	NA	NA	—	—
	4 I	− − + + + + + + +	2	NA	2−	—	Yes
	5 I	− − + − − + − − −	5	NA	2−	—	No
	6 I	+ + − + + + + + −	4	NA	2−	—	No
	7 I	− − − − − + + + +	2	2–9	3–8	Yes	Yes
	8 I	+ + + + + + + + +	1	NA	NA	—	—
	Total # of Purchases	3 2 4 4 3 6 5 5 4					

	State	z z y z z x y z x x z x z x x y					
7	1 I	− − − − − − − − + − − − − − − −	3	NA	NA	—	—
	2 I	− − − − − − − − − − − − + + − −	3	2−	3−	No	Yes
	3 I	− − + + + + + + + + + + + + + +	2	2−	3−	Yes	Yes
	4 I	+ + − + + + + + + + + + + + + +	3	NA	NA	—	—
	6 I	+ + + + + + + + + + + − + + + +	3	NA	NA	—	Yes
	7 I	+ + + + + + + + − − − − + − − − −	4	4–14	6–12	Yes	—
	Total # of Purchases	3 3 3 4 4 4 4 3 4 3 2 4 4 4 3 3					

Rejections of the Null Hypothesis of Mixed Strategy	14	22
Failure to Reject the Null Hypothesis of Mixed Strategy	21	23
Insufficient Data for Testing	34	24
Total	69	69

* + = bought information; − = did not buy information. Underscore on a digit indicates that the number of information buyers is 10 plus that digit.

** The null hypothesis of randomness is rejected if the number of runs is less than or equal to the lower limit of the critical region or greater than or equal to the upper limit.

information cost) profits. As the price of information declines toward zero, so does the difference between gross and net profits, fulfilling the no-arbitrage condition.

The above results suggest that the REE model is not only able to provide a good approximation of certain asset markets with asymmetric information (as previously shown by Plott and Sunder (1982)) but is also able to provide a good approximation of certain asset *and* information markets operating simultaneously.

4.2. *Markets with the Price of Information Fixed (Series B)*

Six experiments of Series B were designed to examine whether the variables endogenous to the stock market—the number of traders who choose to produce information and the informativeness of the asset market—adjust robustly to a variety of exogenously controlled market conditions in such a way as to eliminate opportunities for arbitrage. These exogenous variables are subject experience, diversity of subject preferences, size of the state space, total number of traders in the market, and the public announcement about the number of informed traders in the market. Variation of these conditions across markets has been described earlier in the design section of this paper.

Reduction in informativeness of these markets takes the form of increased variability of market observables, as measured against the full revelation (FR) benchmarks. In discussing Series B markets, we replace REE by FR as a label for these benchmark predictions because these predictions do not constitute an equilibrium for markets where the price of information is fixed at a positive level.

CONCLUSION 6: *Series B markets are less informative than Series A markets.*

In Conclusion 1 and in the first and third panels of Figure 9 it is seen that prices in Series A markets converge to FR levels (which are also REE for these markets). In contrast, Panels 2, 4, 5, 6, 7, and 8 of Figure 9 show that the convergence of transaction prices to FR levels is erratic. Even after many periods of trading experience, transaction prices are close to the FR levels in some periods and far from the FR levels in other periods.[9] Asset price levels in these markets are less reliable indicators of the realized state of the world.

If asset markets fully revealed information, the number of traders who choose to buy information at a positive price would converge to zero (analogous to Conclusion 2 above for Series A). Instead, the number of buyers of information in Series B markets fluctuates, sometimes widely, but shows no signs of converging to zero (see thick horizontal lines for each period in Figures 2, 3B, 4, 5, 6, and 7). Association between lower informativeness of these markets and the

[9] This behavior of mean absolute deviation is virtually identical to the behavior of root mean squared deviations not shown here.

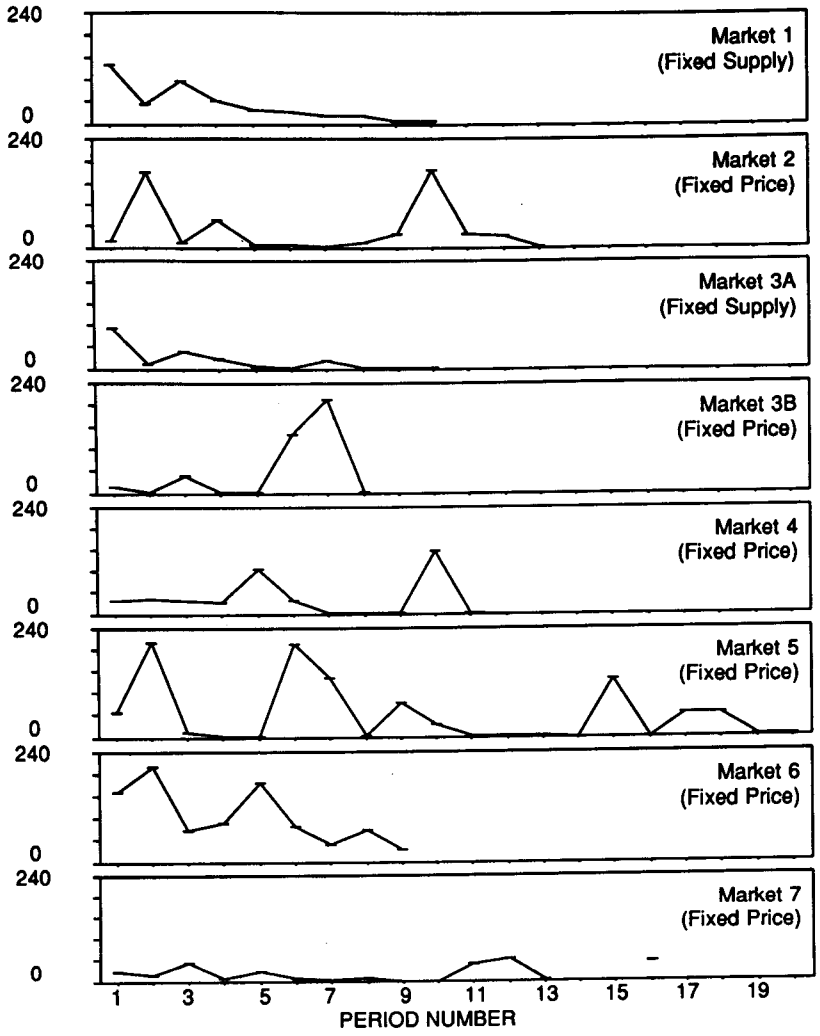

FIGURE 9.—Mean absolute difference between transaction and FR prices.

higher proportion of informed buyers is consistent with the Grossman and Stiglitz' (1980) conjecture (see Footnote 5).

FR benchmarks for allocation of assets among traders are given in Table II, and observed deviations from these benchmarks are given in the last column of Table III. On average, the percent of assets misallocated in Series B markets is higher than for Series A markets (18, 16, 29, and 3 percent versus 7 and 2 percent for the respective series). Average efficiency is also lower (55, 82, 42, and 95 percent versus 89 and 96 percent for the respective series). Conclusion 3 does not hold for Series B markets. Note that in Series B markets, periods of low or zero number of misallocated assets (and therefore high efficiency) are

interspersed with periods in which this number is large (and efficiency is low). This variability also supports the low informativeness of markets of this series.

Under full revelation, distribution of information purchases across type I and type II traders is diffuse. While Series A markets converge to this distribution (see Conclusion 4), type I persistently buy more information than type II traders in Series B markets. Seventy-five percent of information in Market 2, 61 percent in Market 3B and 4, and 63 percent in Market 5 was bought by type I traders (calculated from Table IV data). Further, information buying behavior exhibits no signs of being distributed equally between the two types of traders in the later periods of these markets.

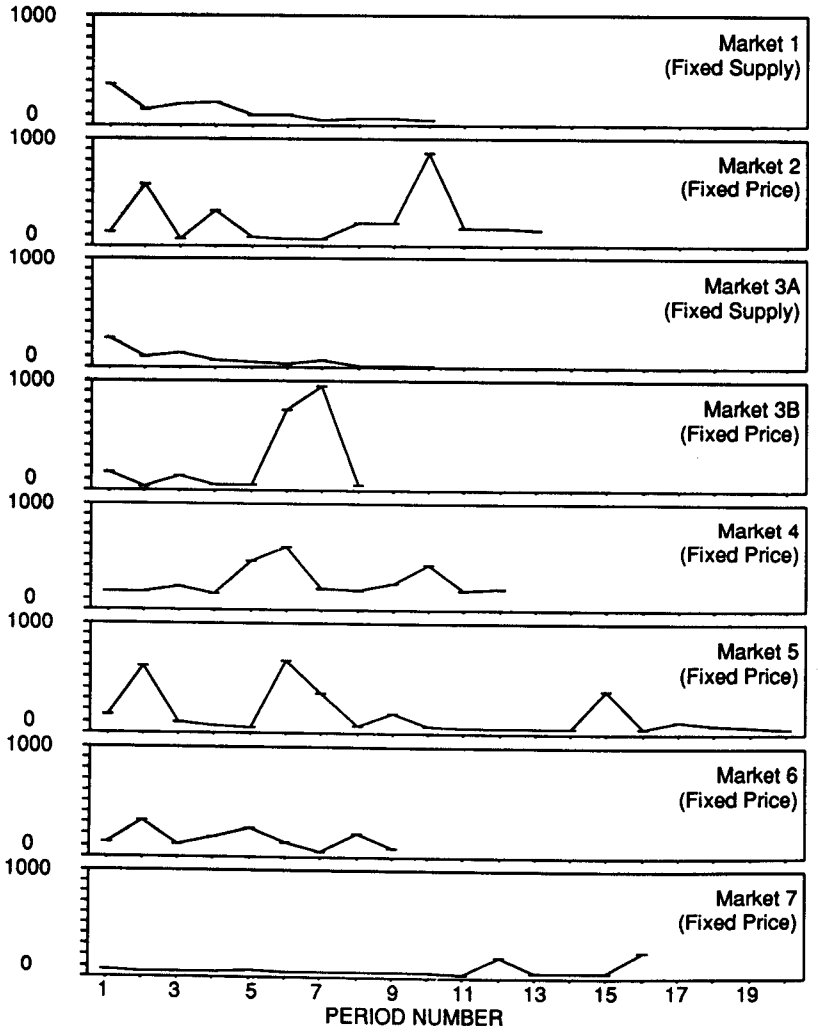

FIGURE 10.—Standard deviation of profits across traders.

Finally, while Series A converges to the FR benchmarks with respect to distribution of profits across traders (see Conclusion 5 and Figure 10), Series B markets exhibit no such tendency. Periods of low cross-sectional dispersion of profits are punctuated by periods of large dispersion, even after considerable trading experience.

All observable aspects of market behavior (asset prices and allocations, information purchase and allocations, profit distribution and market efficiency) point toward lower informativeness of Series B markets as compared to Series A markets.

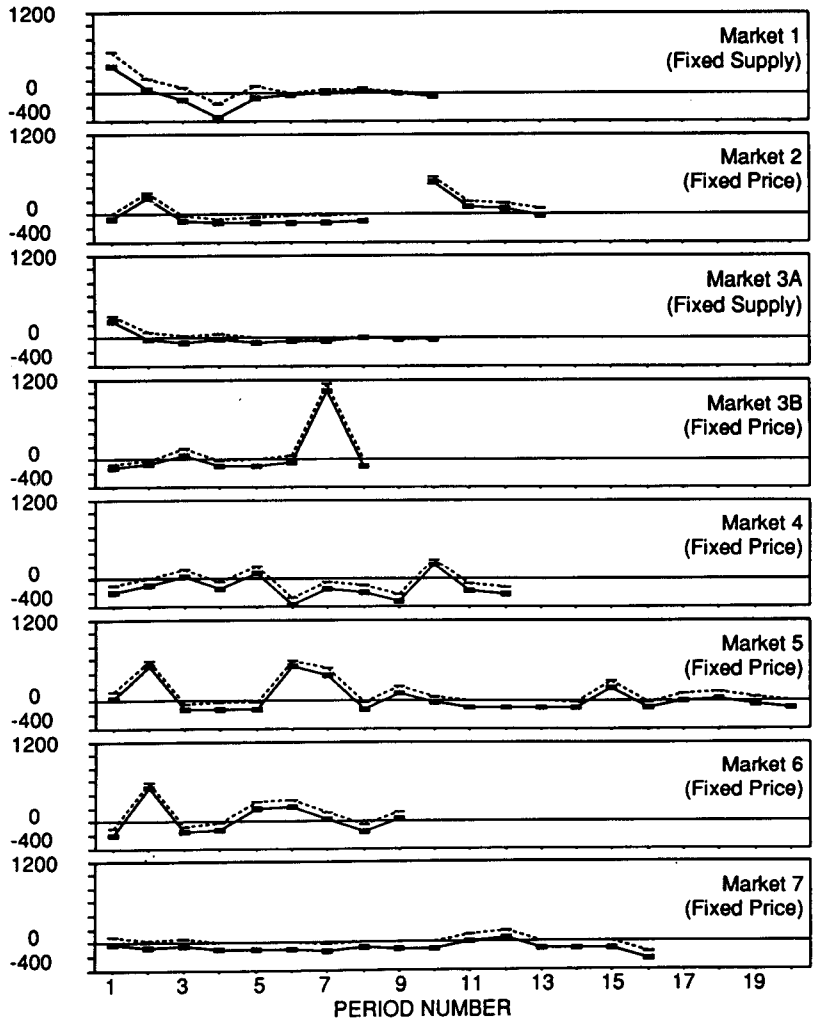

FIGURE 11.—Average profits of informed over uninformed traders (gross: dotted upper line; net: solid lower line).

TABLE V

AVERAGE NET PROFIT OF INFORMED OVER UNINFORMED TRADERS

	Market															
	1		2		3A		3B		4		5		6		7	
Period	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net
1	599	399	3	−57	311	246	−61	−111	−87	−187	136	36	−99	−198	81	−18
2	229	54	311	251	82	−8	−4	−54	14	−86	598	498	594	495	33	−66
3	97	−103	−27	−87	37	−63	164	64	149	49	−31	−131	−57	−156	52	−47
4	−144	−344	−59	−119	73	−17	−3	−103	−44	−144	−19	−119	−9	−108	0	−99
5	109	−66	−32	−132	6	−59	8	−92	197	97	−6	−106	303	204	−1	−100
6	17	−3	−26	−126	4	−46	52	−48	−270	−370	597	497	321	222	4	−95
7	72	22	−23	−123	−3	−53	1138	1038	−35	−135	480	380	132	33	−9	−108
8	71	51	2	−98	18	3	4	−96	−95	−195	−24	−124	−39	−138	19	−80
9	42	17			0	−11			−218	−318	223	123	138	39	0	−99
10	−27	−47	573	473	−2	−17			310	210	73	−27			0	−99
11			203	103					−69	−169	0	−100			108	9
12			176	76					−119	−219	7	−93			159	60
13			89	−11							1	−99			8	−91
14											−2	−102			0	−99
15											290	190			0	−99
16											−3	−103			−140	−239
17											109	9				
18											131	31				
19											53	−47				
20											−1	−101				
Summary for Net:																
Mean		−2		12.5		−2.5		74.7		−122		30.6		43.6		−79
Std. Devn.		173.		178.		85.7		367.		160.		199.		214.		61.8
t value		−0.0		0.24		−0.0		0.57		−2.6		0.68		0.60		−5.1
Summary for Gross:																
Mean	106.		99.1		52.6		162.		−22.		130		142.		19.6	
Std. Devn.	187.		181.		91.0		373.		160.		199		214.		61.8	
t value	1.79		1.89		1.82		1.22		−0.4		2.9		1.99		1.26	

CONCLUSION 7: *Average gross profit of informed traders exceeds the average gross profit of the uninformed but their net profits are statistically indistinguishable.*

No-arbitrage condition of equilibrium means that the producers of costly information should be able to recover their costs and that their profits, net of the cost of information, should be equal to the profits of the uninformed traders. Figure 11 shows the difference between the average profits of the informed and the uninformed trades. Separate lines are shown for differences between gross and net profits. A period-by-period comparison of the average gross profits of the informed and the uninformed traders in Table V and Figure 11 shows that the null hypothesis of equal gross profits is rejected for three out of six Series B markets (2, 5, and 6) at $\alpha = 0.05$ in favor of the alternative that the informed traders have higher gross profits. The null hypothesis of equal net profits is not rejected for any of the Series B markets in favor of the alternative that informed traders have higher net profits. The data provide at least weak support for the predictions of the noisy REE.

In Series B markets, periods of large numbers of informed traders and high market informativeness are punctuated at irregular intervals with high mean absolute deviation (MAD) of prices from FR and high standard deviation of profits. Generally, informed traders incur net losses in periods of low MAD and make up the difference in periods when MAD is high. The unreliability of prices in revealing information allows those traders who buy information the opportunity to make a profit when, on occasion, asset trades are made at prices which are quite different from FR prices. This is especially true when asset prices converge to the wrong FR benchmark, a topic I return to later.

A comparison of price charts (Figures 1 through 7) and the profit chart (Figure 11) shows that a second reason the informed traders are able to earn extra gross profits is because they enjoy a timing advantage over the uninformed, even in periods where transaction prices and asset allocations do converge to the static FR benchmarks at the end of the period (see, for example, Period 2 of Market 2, Period 3 of Market 3B, Period 5 of Market 4, Periods 7 and 9 of Market 5, and Periods 2 and 5 of Market 6). This timing advantage of the informed traders is consistent with Hellwig's (1982) model of private incentives to produce information in revealing environments.

Beyond these seven conclusions, it is useful to conduct some exploratory analysis of the data to extract some guidance for future research. The following paragraphs concern two such issues: purchase of information by individuals, and the tendency of the asset market to converge to the wrong price in certain periods when only a small number of traders are informed.

4.3. *Purchase of Information by Individuals*

A mixed strategy implies a random sequence of buy/don't buy decisions over the experimental periods by each subject. Nonstationarities induced by learning across periods (see Conclusions 2 and 4 above) make it difficult to conduct

reliable statistical tests to determine if the data are consistent with a mixed strategy. A one-sample runs test (see Siegel (1956, pp. 52–58)) for the null hypothesis of randomness of the information purchase sequence of each subject yields ambiguous results.[10] Table IV provides the number of runs for each subject and the number of runs that define the critical region for rejection of the null hypothesis of randomness at $\alpha = 0.05$ and $\alpha = 0.25$. The null hypothesis is rejected for 14 out of 35 subjects at 0.05 level and for 22 out of 45 subjects at the 0.25 level. On the whole, the frequencies of rejection of the null hypothesis are higher than the respective values of α, but they are not high enough for a decisive rejection of the mixed strategy hypothesis. The purchase sequences for individual traders given in Table IV might be helpful in exploring new explanations of individual information purchase behavior that could be subjected to more powerful tests when longer data series can be gathered.

4.4. *Convergence of Market to Wrong Price*

In period 10 of Market 2, asset prices were close to the FR price for state x when, in fact, the realized state was y. Similarly, in Periods 6 and 7 of Market 3B, asset prices were close to the FR price for state y when in fact state x had been realized in both periods. To understand this behavior, it seems useful to consider the inter-period and intra-period dynamics of learning in these markets.

Convergence to wrong prices occurred in later periods of these markets when many traders seem to have become accustomed to being able to infer state from price. In all these markets relatively few traders—one to three—had information. With only one exception (in Market 3B, Period 7) all informed traders were on the selling side and they became inactive after selling their endowment of two certificates because of the restriction on short sale. Other traders had no way of knowing that the informed traders had become inactive. Knowing that at least some trader(s) in the market had perfect (and therefore superior to their own) information, the informed seemed willing to rely on the market to learn the state from prices. The blind leading the blind, they arrived at the wrong conclusion in these three cases.[11] The only other occasion when these conditions occurred was Period 4 in Market 3B in which price was close to the FR price corresponding to the realized state y.

These observations suggest that after traders have learned to infer state from observing the market, if all active traders in the market have reason to believe that their own private information can add nothing to the information they can discern from the market, any of the prices in the range of state-price correspondence may be observed in any state. This was possible in our markets because

[10] More powerful tests would require ex ante specification of the probability of information purchase which, in this case, must be estimated from the data themselves.

[11] The informed investor on the buying side in period 7 of market 3B was a monopolist who had little reason to want to push the asset price up to the FR benchmark corresponding to state x. Accordingly, this trader bought heavily in this period at a very low price and made a large profit.

(1) the informed traders had perfect information, while the uninformed had none; (2) the asset trading environment was such that when enough traders were informed, the uninformed were always able to infer information from the market; (3) the existence of short sale restrictions caused the informed traders on the selling side of the market to become inactive after a few transactions in the early part of the trading period; and (4) this inactivity of the informed traders in such cases could not be known to the other traders. When its price is fixed, demand for information shifts leftward when traders learn to read the market for information, fewer traders purchase information, and there is a greater chance that all the buyers of information also happen to be on the selling side of the asset market (type II in state x and type I in state y), and that no more than one trader on the buying side of the asset market (type I in state x and type II in state y) has the knowledge of the state of nature. If this happens, the informed sellers will generate only two sale transactions each, which may be insufficient to fully reveal the information to the market.[12] Since the uninformed traders do know that some traders in the market know the state of nature, they are tempted to rely on their observation of market variables to infer the state. This situation provides opportunity for the market to converge to a wrong price. However, more extensive modelling of intra-period learning (e.g., Hellwig (1982)) and testing must precede definitive conclusions in this respect.

When the above-mentioned phenomenon occurs, asset market behavior deviates markedly from FR benchmark in asset allocations and profit distribution. A sharp rise in the cross-sectional standard deviation of profits in Period 10 of Market 2 and Periods 6 and 7 of Market 3B (Figure 10), higher profits of the informed over the uninformed (Figure 11), and sharply higher misallocation of assets in these periods (Table III) have already been discussed under Conclusion 6. Thus the information free ride for the uninformed is not free at all; failure of the market to be perfectly informative means that, on occasion, relying on the market for information leads the uninformed investors to make wrong, money-losing decisions. As we have already seen in Conclusion 7, the net profits *averaged over time* are about the same for the informed and uninformed traders. In markets with fixed price of information, it is difficult to attain equality of net profits across informed and uninformed traders on a *period-by-period* basis because the trading mechanism requires all traders to make their information purchase decisions simultaneously and independently, allowing no opportunity for cross-trader coordination.

5. SUMMARY

Predictions of the noisy REE model hold not only in the asset markets but also in the simultaneously run markets for information about the asset dividends. Interaction between the asset and information markets is essentially as

[12] Penalties on being caught short at the end of a trading period made it risky for traders to try to push the price toward the FR benchmark by engaging in speculative trading.

predicted in the theoretical literature on rational expectations, even down to the details such as occasional convergence of the market to the wrong price when the number of informed traders is small. The "warts and all" picture that emerges from these experiments provide strong support for the view that rational expectations is a useful way of thinking about the functioning of economic systems: economic agents are capable of learning from what they observe in the market, and when they do learn in this manner, their demand for information from alternative sources declines. These data help document and classify the role of noise (see Black (1986)) in operating orderly markets in a world of costly information.

The results are specific to the market setting used here and their generalization to other market structures is an open issue. The simple information structure of these markets addresses dissemination of information among traders. It does not address more complex issues concerning aggregation of costly diverse information (see Hellwig (1980)). How market variables come to reveal information is beginning to be understood,[13] and that issue is not explored in this paper. While much theoretical attention has been focused on price as the key variable that conveys information, many other market variables such as bids, offers, their timing, and allocation of assets are observable in the market setting used here. The speed at which prices adjust to information suggests that nonprice variables may play an important role in the dissemination of information.

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APPENDIX

Summary of Procedures and Instructions

Markets were conducted in three steps: (1) training with the mechanism used to draw the states of nature, (2) explanations of procedures and rules of the market, and (3) conduct of markets for several periods.

Step 1: Training with the Mechanism Used to Draw the States of Nature

Instruction Set 1 (see summary below) was distributed and read out. Subjects had the opportunity to observe the operation of a bingo cage with 40 balls kept on a table between them and the experimenter. The subjects were asked to predict the outcome of 10 draws, one at a time, with replacement and received announced rewards ($0.25 for correct and −$0.10 for incorrect predictions). No mention was made of probabilities.

[13] See Hellwig (1982), Blume, Bray, and Easley (1982), Bray (1982), Jordan (forthcoming), and Dubey, Geanakoplos, and Shubik (1983) for attempts to model the process by which information gets incorporated into price.

Step 2: Explanation of Procedures and Rules of the Market

Instruction Set 2 (see summary below) was distributed and read out. The experimenter illustrated a sequence of hypothetical transactions on the blackboard so each subject would understand how transactions were to be recorded on the record sheet and how his/her profit would be reckoned. The example was designed to minimize its normative effect on subsequent bidding behavior. The importance of accurate records of all transactions was emphasized. Instruction Set #2 was modified in Markets 1 and 3A to allow for the sale of information to a fixed number of traders through a sealed bid auction. In PLATO computer auctions (Markets 6 and 7), a part of instruction Set #2 was substituted by PLATO online instructions for double auctions.

Step 3: Conduct of Markets

Five minutes were permitted for each period with warning at four minutes. The experimenter drew a ball from the bingo cage. In Markets 1 and 3A, sealed bids for information were gathered from all traders; after tallying the bids, information was recorded on the bidding forms of four winning bidders, bidding forms were returned to all traders, and the price at which information was sold (i.e., fifth highest bid) publicly announced. In Markets 2, 3B, 4, 5, 6, and 7, the experimenter announced the price of information, collected information purchase order forms from all traders, recorded information on appropriate forms, and returned all forms to traders. The bingo cage was operated in full view of the subjects. A running log of bids, offers, and transactions of the current and previous few periods was maintained on the blackboard. A cumulative table of trading activity of each period showing the following data was also maintained on the blackboard: period, opening price, closing price, high price, low price, average price, number of transactions, realized state, price of information, and the number of traders who had bought information.

SUMMARY OF INSTRUCTION SET #1

The bingo cage has 40 balls numbered 1 through 40. If the ball drawn is numbered 1 through 16, outcome of the draw is called X; if a ball numbered 17 through 40 is drawn, the outcome is called Y.

You have to predict the outcome of each draw before it is announced. If your prediction is correct you win $0.25, if wrong you lose $0.10.

Number	Circle One Decision		Outcome X or Y	Circle One Win ($)	Circle One Lose ($)
1.	X	Y	_____	0.25	−0.10
2.	X	Y	_____	0.25	−0.10
⋮	⋮	⋮	⋮	⋮	⋮

Total winnings $_____
Total losses $_____
Net winnings/losses $_____

SUMMARY OF INSTRUCTION SET #2

General

This is an experiment in decision-making. The instructions are simple, and if you follow them carefully and make good decisions, you might earn a considerable amount of money which will be paid to you in cash.

In this experiment a market for buying and selling certificates will be operated over a sequence of market years. The attached Information and Record Sheet will help you determine how much money you make from your decisions. The information contained in it is your private information.

All trading and earnings will be in terms of francs. Each franc is worth_dollars to you. At the end of the experiment your francs will be converted to dollars at this rate.

Specific Instructions

At the beginning of each year you are provided with an initial holding of certificates. This is recorded on row 0 of the year's information and record sheet. Within the following rules, you are

free to buy and sell certificates. Your profits come from two sources—from collecting earnings on the certificates you hold at the end of the year *and* from buying and selling certificates.

The certificate earning each period will be one of the two numbers of francs listed on row 26 of your information and record sheet. The method by which one of the two numbers is selected each year is explained later. Note that earnings may be different for different investors. At the end of each year all your holdings are automatically sold to the experimenter at a price of 0.

In addition, at the beginning of each year you are provided with an initial amount of francs on hand. This is also recorded on row 0 of each year's information and record sheet. You may use it to purchase certificates. At the end of the year, you must return this amount to the experimenter and the rest is your profit for the year.

Information About Dividends

Whether the dividend you receive from the certificate you hold is the X dividend or the Y dividend shown on row 26 is determined by the experimenter at the beginning of the year by drawing a ball from a bingo cage containing 40 balls numbered 1 through 40. If the ball drawn is numbered 1–16, X dividend is paid; if the ball drawn is numbered 17–40, Y dividend is paid.

Before the market opens for trading each year you have the opportunity to buy information about whether X or Y dividend would be paid in that year. The experimenter will declare the price of information and invite you to submit your purchase order. Information will be distributed to all who wish to purchase information. The number of traders who purchase information, but not their identity, will be announced by the experimenter.

Trading and Recording Rules

(1) All transactions are for one certificate at a time.

(2) After each transaction you must calculate and record your new holdings of certificates and your new francs on hand. Your holdings of certificates must not be below zero at the end of the period. For every certificate "short," a fine must be paid equal to the highest price at which any unit is sold during the period plus 500 francs.

(3) At the end of the experiment add up your total profit on your profit sheet and enter this sum on row 21 of your profit sheet. To convert this number into dollars, multiply by the number on row 22 and record the product on row 23. The experimenter will pay you this amount of money.

Market Organization

The market will be conducted in a series of periods. Each period lasts for 5 minutes. Anyone wishing to purchase a certificate is free to raise his or her hand and make a verbal bid to buy one certificate at a specified price, and anyone with certificates to sell is free to accept or not accept the bid. Likewise, anyone wishing to sell a certificate is free to raise his or her hand and make a verbal offer to sell one certificate at the specified price. If a bid or offer is accepted, a binding contract has been closed for a single certificate, and the contracting parties will record the transaction on their information and record sheets. Any ties in bids or acceptance will be resolved by random choice. Except for the bids and their acceptance, you are not to speak to any other subject. There are likely to be many bids that are not accepted, but you are free to keep trying. You are free to make as much profit as you can.

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