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Risk Aversion and Information Structure: An Experimental Study of Price Variability in the Securities Markets

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ABSTRACT

This study investigates the differences in the behaviors between the speculative investors and the conservative investors in two separate experimental markets. Although the market for speculators shows greater price volatility in both bid/ask spread within a trade as well as with intraperiod variances, it exhibits several desirable properties. Specifically, the price patterns tend to converge closer, and at a greater speed to either the prior information equilibrium price or the rational expectation equilibrium price. It also achieves better allocational efficiency. And, it is also less likely to be misled by potentially "false" price information.

THE PURPOSE OF THIS PAPER is to investigate experimentally whether the price variability of securities can be caused by the risk aversion behavior of investors and/or the particular type of information structure they possess.

The nature of security price variability has become a subject of research interest in recent years, e.g., Shiller [15], and LeRoy and Porter [11]. Risk aversion has been cited by several authors, e.g., Grossman and Shiller [4], and LeRoy and LaCivita [10] as a source of "excessive" price variability. Unfortunately, as pointed out by LeRoy and LaCivita, useful insights into this question cannot be obtained from the empirical data on security prices since risk aversion measures must necessarily be imputed from the same price data. Thus, for valid variability tests, risk aversion measures must be obtained independently of the security price data.

Our approach to this problem is to utilize the experimental economics methodology.[1] This methodology allows us to first measure the degree of risk aversion of the market participants (traders), and second, to segregate these traders into two separate markets, one consisting of relatively speculative investors and the other of relatively conservative investors. Any differences in the behavior of the two markets, where the remaining relevant factors are controlled, enables us to understand how risk aversion affects price formation as well as its volatility.

An important control variable in our experiment is the information available to the market. We are not solely interested in the difference in the way speculative and conservative investors respond to the type of information; e.g., the absence

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[1] See Smith [17], Plott [12], and Plott and Sunder [13] for a review and justification for experiments in economics.

versus the presence of superior or inside information, but also in how they respond to an environment where potentially "false" information is present. The latter issue is of interest since it addresses the alternative, but less frequently asked question of market efficiency: If, in an efficient market, market price responds to all relevant information, does it follow that market price does not respond to irrelevant information? For instance, if the market can economize information in the Hayekian sense (e.g., Grossman and Stiglitz [5], Smith [16], and Plott and Sunder [13]) where price is a sufficient statistic in the presence of informed traders, can the market also mistakenly take price as a signal when there is not common knowledge that all traders possess the same information? An investigation of this question has bearing on a related topic in the study of price variability, which is the phenomenon of price bubbles, e.g., Ackley [1] and Harrison and Kreps [6].

The remainder of this paper is outlined as follows: Section I discusses how risk aversion and information structure may affect price variability. The details of the experimental design is described in Section II. Section III reports the results, and our conclusions are presented in Section IV.

I. The Influence of Risk Aversion and Information Structure on Stock Prices

A. Risk Aversion

There are at least two diverse views on how the risk aversion of investors may affect asset prices and specifically, their volatility. The first holds that the less risk averse investors, commonly called speculators, cause stock prices to be more volatile. Since speculators thrive in a market with large fluctuations in prices, they are less concerned with the intrinsic value of the asset, and large deviations from intrinsic value are more probable. From the economic efficiency viewpoint, this effect of the speculator is rather dysfunctional. On the other hand, recent theoretical economic models predict a diametrically different result. For instance, LeRoy and LaCivita [10] theorize that increases in risk aversion will increase asset price variability since the more risk averse investors tend to widen the dispersion of prices. Grossman and Shiller [4], in a simulation study based on their theoretical model of asset valuation, found that the coefficient of relative risk aversion had to increase to 4 ($A = 0$ for risk neutrality) in order to approximate the range of price volatility from 1889 to 1979. In this view, it is the risk averse (or the conservative) investors that cause greater price variability. A proper analysis of this conflict cannot be conducted by examining price series empirically, because prices cannot simultaneously be used for: (1) inferring the degree of risk aversion of the investors, at least in the aggregate; (2) determining the appropriateness of the particular valuation model employed; (3) testing the efficiency of the asset market; and (4) measuring the appropriate amount of price variability. Thus, an experimental study where treatment variables such as risk aversion and the type of available information can be controlled is a reasonable alternative to this impasse.

B. Information Structure

The effect of information on the behavior of asset prices has been receiving increasing attention in recent years. For example, the study of the pattern and speed of prices in reaction to a piece of new information has evolved into an active industry (the event study) in financial and accounting research. However, very little is known about how information affects price variability. Event studies, for instance, often attribute the greater price variability around the event date to the "greater uncertainty" underlying the new information. This analysis is incomplete since it fails to address the more fundamental issue of whether higher variability helps or hinders the absorption of new information into prices. In other words, the relevant issue is: In the presence of new information, does high variability perform a useful economic function? It is reasonable to expect the answer to this question may, in part, depend upon the degree of risk aversion of the investors.

C. Research Questions

Although experimental economics offers researchers the ability to control the economic environment and allows for the replication of results, the testing of formulated hypotheses is not well developed. As a consequence, Forsythe et al. [3] had to caution against the interpretation of their test statistics.[2] Because prices have a high serial correlation both within and across periods, the standard assumption of independent and identically distributed samples drawn from a stationary normal distribution is usually not satisfied. As a result, most of the interesting inferences from experimental studies are derived from a close examination of the patterns of transaction prices.[3] Thus, hypotheses in this context are probably better described as relevant research questions to be addressed. Under this interpretation, the focus of our market experiments are:

A. Is there a difference in the behavior of prices between a market of speculators and a market of conservative investors? In particular, will the speculative investors induce greater price volatility into the market? Engage in more trades?
B. Which of the two types of investors appears to be more rational? For instance, will the conservative investors adjust faster to relevant informa-

[2] A representative statement to this testing problem comes from Forsythe et al. [3, p. 549]: "In dealing with the data we face some open problems that are being encountered in almost all experimental work where the cost of conducting experiments places a significant constraint on the number of observations. As will be obvious in the figures, the high degree of serial correlation of prices in a given experiment, both within and across periods, suggests the simultaneous interaction of the learning process by individuals and convergence process by the market. Yet, without a theory about these processes, our statistical statements suffer from an inability to use all the data available to us. Furthermore, the statistical tests we report should be regarded more as measures than classical hypothesis tests. Fortunately, the data from these experiments show sufficient regularities so that this should cause no problems"

[3] This is, in spirit, the experimental analog to the empirical study of the microstructure of securities markets (e.g., see Cohen et al. [2]).

tion? Will the speculative investors be more likely to respond to false information? Which of the two types exhibits a longer memory toward past information; i.e., adaptive expectations? Which uses no past history in forming rational expectations?

C. Is price volatility dysfunctional or functional to the process of price formation? Will a wide dispersion of bid/ask prices as well as a high variability between transaction prices transmit more or less information?

II. The Experimental Design

The underlying strategy of the experiment is to observe the differences in the resulting market prices, including their time paths and volatility, for two physically separated markets. The first market consists entirely of the "less risk averse" investors, while the second is made up of the "more risk averse" investors. For ease of exposition, they are imprecisely called the "speculative" and the "conservative" investors, respectively. An analysis of any differences in the behavior of prices between the two markets may allow us to gain some understanding and eventually predict how asset markets will perform when there is a change in the risk preference of investors.

A. Information Design

Aside from the differences in risk aversion of the participants, these markets are identical in their institutional setting as well as the type and timing of the information received. There are five information regimes in the experiment:

A. No insider information, common knowledge:
All of the traders have the same prior probabilities of the future states, and they are aware that all other traders have the same probability information also.

B. Imperfect insider information, common knowledge:
Some traders (the insiders) receive superior but probabilistic forecasts of the future states. All traders are aware that some traders possess superior imperfect information.

C. No imperfect insider information, not common knowledge:
No trader receives superior information, but the market may suspect some traders possess imperfect insider information.

D. Perfect insider information, common knowledge:
Some traders receive perfect (certain) information as to which state is to occur. All traders are aware that some traders possess superior perfect information.

E. No perfect insider information, not common knowledge:
No trader receives superior information, but the market may suspect some traders possess perfect insider information.

The first regime of no insider information provides a benchmark with which to compare the price behavior between the two markets as well as with subsequent information regimes. Regimes B and D are "true" information regimes; they

serve to contrast how the speculative and conservative investors repond to economically profitable information. Regimes C and E are the constructed "false" information regimes.

Due to the tautological nature of rational expectations, there is no such thing as false or irrelevant information. All of the information available at time t, whether it is subsequently proven to be true or false, will be incorporated into price. Thus, a piece of potentially false information (intentionally introduced to the traders in an experimental market) is still by definition a perceived "true" information, and will therefore be incorporated into price. We induced false information within regimes "C" and "E" by creating an illusion. In particular, if the market participants, who are aware that superior information has been distributed in the last information regime, suspect that superior information is also being distributed in the current trading period while in fact there is none, an illusion that someone has insider information is created. Because of this illusion, some market participants may ignore their own prior information and attempt to infer from the bid/ask and contacted prices in the initial trades of the trading period as to the nature of the supposedly superior information. Here, the traders are tricked into generating whatever false information they may conjure.

B. Institutional Framework and Environment

The interaction of the first treatment variable (risk aversion) and the second treatment variable (information structure) constitute the underlying basis for the design of the experiment. The details of the design involve the following components:

1. General Market Design
   a. A double auction market similar to that used on the floor of the New York Stock Exchange is utilized. This is a familiar auction process utilized in experimental economics (see Plott and Sunder [13] and others)
   b. Each market has 20 trading periods.
   c. Each trading period is composed of six minutes with opening, warning (at 5 and 5½ minutes), and closing bells.
   d. During the six-minute trading periods, traders can observe the bid/ask and transacted prices for the ten latest contracts which are being continuously updated.
2. The Information Design
   a. Each of the five information regimes prevails over four consecutive trading periods.
   b. At the beginning of each trading period, each trader is given a probability estimate of each of the three possible states of nature that can occur.
   c. After the first four trading periods (information regime A), additional (inside) information is distributed to certain traders via clue cards. All traders receive clue cards, but only cards of insiders contain information. This procedure (see Plott and Sunder [13]) is followed in order to disguise the identity of the insiders. All insiders receive the same information. When all traders receive blank cards, no insiders exist, but the distribu-

tion of the cards creates an illusion that some traders may have superior information. The identity of the insiders varied from period to period.

d. The equilibrium prices (prior information and rational expectations prices) are not stationary. The number of informed traders, the common knowledge about the existence of informed traders, and the information held by the informed traders are all subject to change (see Appendix Table A1).

3. The Classification of Traders

There are initially 70 business students at the Florida State University recruited for the experiment. Each person is given two psychological tests on preference taking behavior: the Jackson Personality Inventory (JPI) and the Jackson, Hournay, and Vidmar (JHV) tests.[4] Those persons who score in the top 12, signifying the least risk averse, and the bottom 12, or the most risk averse, are invited to participate in the second stage of the experiment. These students are designated as traders in Markets 1 and 2, respectively.

4. The Payoff (Dividend) Design

a. The traders' dollar compensation for their participation in the experiment depends upon their individual portfolio trading performance. At the beginning of each period, each trader is endowed with two shares which pays a liquidating dividend at the end of each trading year.

b. The amount of the liquidating dividend depends upon both the trader type and the realized state.

c. The 12 traders in each of the two markets are classified into three traders types which determines the size of their liquidating dividend for each state (see Appendix Table A2). This is to allow for differences among traders such as in tax brackets and in time consumption preferences so that gains from exchange are possible. The existence of various trader types also induces trading due to portfolio adjustments.

d. The traders are told that outcomes are determined probabilistically similar to that of a bingo game. The realized state is announced at the end of the six-minute trading period.

e. The traders' actual compensation in dollars is defined by the following profit function.

$$P(i) = y[d(i, j)x + (R - C)] \tag{1}$$

where:

$P(i)$ = dollar profit per period for a trader i. It consists of both dividend income and trading profits (losses)

y = the conversion rate of francs into dollars, at the rate of 0.001 dollar per franc.

$d(i, j)$ = the dividend paid in francs to trader i given that state j occurs

x = number of shares held at the end of the period.

R = revenue in francs for shares sold during the period.

C = costs in francs for shares purchased during the period.

[4] Note that we utilize an ordinal (not a cardinal) measure of risk aversion (see Schwarz [14, pp. 74–78] for a more elaborate discussion of these tests as well as Jackson [7, 8], Jackson et al. [9]).

f. A fixed cost for each trader is set equal to his (her) initial endowment of 10,000 francs.[5] The endowment is large enough to remove the possibility that trading may be inhibited by a budget constraint.

In summary, the environment in this experiment is made uncertain by the following features: (1) the market equilibrium prices are not constant over successive periods, which in effect reduces the repetitive environment reported as necessary for price convergence in some earlier experimental markets. (2) The payoffs to trader types are not constant across periods. (3) There are three possible states of nature instead of the often utilized two. (4) All trader types have the same preference for the future state of nature, and (5) the identity of the inside traders is not the same between periods. These factors act to increase uncertainty and are expected to produce less ideal convergent results vis-à-vis other studies.

III. Results and Analysis

The experiments for the two markets were conducted simultaneously in two different locations. For each market, there was an auctioneer, a recorder of displayed bid/ask prices, and a third person who permanently recorded the information for analysis. Each trader recorded the number and the price of all his (her) transactions in each period. To insure that all the traders were experienced, a trial run on a previous day was made in order to familiarize the traders with the rules of the experiment and the decision making process. The actual experiment, involving 20 trading periods, took two to three hours per market to complete.

After the completion of the experiment, the following data was collected and stored in data files for analysis:

1. The bid, ask, and transacted prices for each trade in all 20 trading periods. The identification of the trader making each bid and ask price was also recorded.
2. The profit and ending portfolio for every trader in each trading period.

The transacted prices are plotted in Figure 1 (for Market 1 which consists of the speculative investors) and Figure 2 (for Market 2 which consists of the conservative investors). Prices are ploted on the vertical axis, and the sequence of trades as well as the trading periods are indicated on the horizontal axis. The bid/ask prices for each trade are plotted along a vertical line and is similar to the information in a specialist's book. The length of the vertical line indicates the range of price divergence among the different traders. Since the initial endowments, prior probabilities, distribution of state prices, and superior information in the two markets were identical, the difference in the price range between the two markets should indicate how risk aversion can induce valuation differences. Transaction prices in each trading period are connected by a solid line. The

[5] Francs have been used successfully as the monetary units in other laboratory experiments (e.g., Plott and Sunder [13] and Forsythe et al. [3]). This is to avoid the technical problem of dealing with too small dollar amounts.

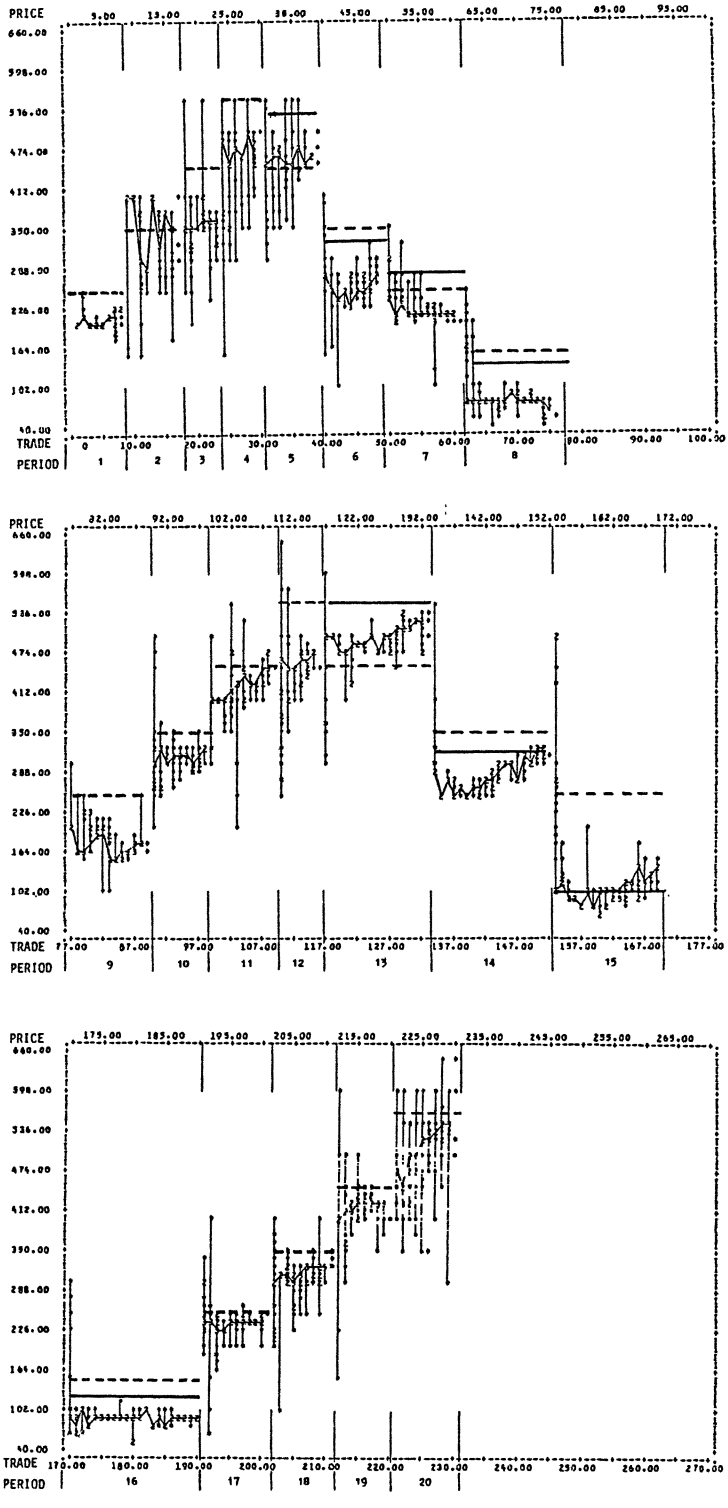

Figure 1. Bids, Offers, and Contracted Prices (Market 1, Speculators)

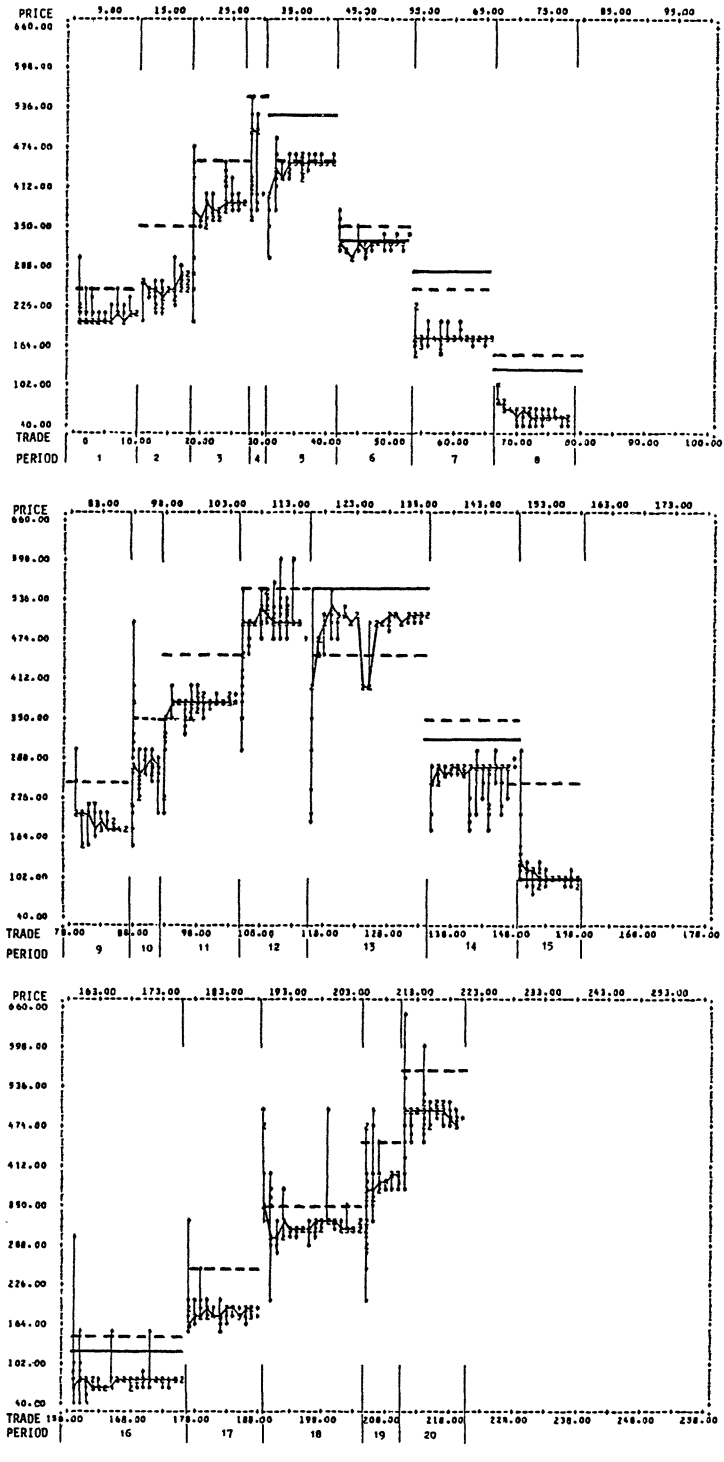

Figure 2. Bids, Offers, and Contracted Prices (Market 2, Conservatives)

horizontal dashed line is the prior information equilibrium price (see Plott and Sunder [13]),

$$PIE = \underset{i}{\text{Max}}\ E(P_j,\ d(i,\ j)) \tag{2}$$

where $d(i, j)$ is the liquidating dividend to trader i given that state occurs. P_j is the posterior probability for the occurence of state j. In the case of insiders, it will be different from their prior probabilities depending upin the nature of their superior information. When the nature of the inside information is such that a lower expected payoff is expected by the inside traders, the noninsiders do not adjust their prior probabilities due to any market information, and therefore some of the noninside traders would support a higher price.

Contrary to the above price determination by noninsiders, the rational expectations equilibrium price theory (see Plott and Sunder, [13]) predicts that in markets where certain traders have superior information, the equilibrium price is determined by the knowledge of those insiders. In particular,

$$REE = \underset{i}{\text{Max}}\ D_i^* \tag{3}$$

where D_i^* is the expectation of dividend income for trader i given *all* information present among the traders. In the case of perfect insider information, it represents a certain dividend return. The REE price is represented by the solid horizontal line in Figures 1 and 2.

In the absence of insider information, the *PIE* and *REE* prices are equal. Therefore, only during the insider information regimes of B and D do the two equilibrium prices differ. Plott and Sunder [13] provide support for the *REE* price during periods containing insider information. Using these equilibrium values, we define the risk premium as the difference between the contracted prices and the equilibrium prices. In the case of risk neutrality, these equilibrium prices serve as the reference price to which the sequence of transaction prices in a trading period approaches.

A close examination of the data in Figures 1 and 2 gives the following observations:

A. Price Variability

The market with speculative investors has demonstrated greater price variability in two ways: (1) The range for bid/ask prices is much wider throughout the sequence of prices in a trading period. In contrast, the market dominated by the conservative investors only shows large dispersion on bid/ask prices almost exclusively in the first transaction of each trading period. (2) The intraperiod standard deviation calculated from the possibly correlated contracted price sequence shows that Market 1 (speculative investors) has greater price volatility in 14 of 20 trading periods (see Table I). In particular, the speculative market also reports greater price variability in 7 of 8 periods in both "false" information regime.

In spite of greater price volatility in Market 1, there is no significant difference in the total trading volume between the two markets. Market 1 has 10.7 shares (or 214 shares in 20 periods) traded per trading period

compared to 10.35 shares (or 207 shares in 20 periods) in Market 2. It is notable that both classes of traders increased their trading volume when insider information was introduced (see Table I). The greater the certainty of the information (regime D versus regime B), the greater the trading volume.

The experimental results presented here do not support the prediction of some economic models; e.g., LeRoy and LaCivita [11], and Grossman and Shiller [4], that greater risk aversion is associated with greater price volatility. In fact, the opposite is observed. To find explanations and possible implications of this finding, we turn to an analysis of the differences in price behavior.

B. Information Structure and Price Behavior

A comparison of Figures 1 and 2 reveals the following differences:

1. Price patterns in Market 2 are mostly flat, while those in Market 1 converge toward the *PIE* or *REE* prices.This is especially true in the two "false" information regimes (trading periods 9–12 and 17–20) where traders may suspect the presence of inside information since blank clue cards are given to all traders immediately after a "true" information regime. Prices in Market 1, except for the first trading period in each of the two "false" information regimes, tend to converge toward the *PIE* prices. Thus, speculators may be fooled briefly by the appearance of possible inside information, but eventually, equilibrium prices based upon prior information prevails. On the other hand, the price patterns for the same 8 trading periods in Market 2 remains consistently flat, and there is very little exchange of information via subsequent bid/ask prices.
2. The risk premium, calculated as the difference between contracted price and either the PIE (no information case) or the REE (with information case) is 13 francs or 30% higher in the market for conservative investors (see Table II). In particular, the mean risk premium in Market 2 is either greater or equal (1 tie) in all five information regimes. This result provides support to our method of classifying investors into the two groups.

There are two observations concerning risk premiums that demand further explanations: The first is the existence of three negative risk premiums in Table I. Two of these occurred in period 15 in both markets and the other in period 2 of Market 1. In the first instance, informed traders in period 15 have the certain information that the worst state (z) will occur. Due to their limited short sale ability, the active informed traders are not able to exert enough downward pressure on transaction prices. Thus, contracted prices are higher than the low REE prices. In the second instance, transaction prices exhibit a rare damped oscillation around the PIE price (see period 2 in Figure 1). Consequently, the small negative risk premium does not appear to be as important as the fact that prices are converging toward the equilibrium value.

The second observation is concerned with the change in risk premiums between the two markets. The question here is whether the conservative or the speculative

Table I

Variability and Trading Volume of Transacted Prices

		Tracing Period																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A.	Market 1 (Speculative Investors)																				
	Std. deviation	5	46	7	19	7	13	9	6	15	7	18	10	15	24	19	6	7	12	10	36
	No. of trades	7	8	6	6	8	9	11	14	12	9	10	6	16	18	17	21	10	9	8	0
	Regime total			27				42				37				72				36	
B.	Market 2 (Conservative Investors)																				
	Std. deviation	6	8	12	0	17	7	2	7	10	9	9	9	40	10	10	4	6	10	9	8
	No. of trades	10	7	9	2	10	11	13	11	8	5	11	10	19	13	9	17	11	16	6	9
	Regime total			28				45				34				58				42	

Table II

Risk Premiums*

	Trading Period																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A. Market 1 (Speculative Investors)																				
Std deviation	45	−4	92	75	68	71	60	60	77	39	28	88	51	40	−7	35	15	33	32	37
Mean for information regime			52				65				58				31				29	
Overall mean											43									
B. Market 2 (Conservative Investors)																				
Std. deviation	46	95	68	50	80	6	96	79	61	75	76	46	61	51	−6	49	68	33	63	54
Mean for information regime			65				65				65				39				55	
Overall mean											56									
C. Market 1 minus Market 2																				
Std. deviation	−4	−99	24	25	−12	65	−36	−19	16	−36	−48	−42	−10	−9	−1	−14	−53	0	−31	−17
Mean for information regime			−13				0				−7				−8				−26	
Overall mean											−13									

* Calculated using REE prices.

investors are more likely to utilize past price history in forming current price expectations. One way to examine this is to compare the change in risk premiums between trading periods when the revealed state in the previous trading period is either the best state (x) or the worst state (z). There are three instances of z and nine instances of x. Of these, Market 2 (the conservatives) shows an increase in risk premiums in 2 of the 3 trading periods following the worst state (z) with an average increase of 23 francs, (a "once bitten" effect).[6] It also shows a decrease in risk premiums in 7 of 9 trading periods following the best state (x). However, the same pattern is not observed in Market 1. In the three trading periods immediately following a revealed (z) state, risk premiums increase in one, slightly decrease in 1, and do not change in the third. Similarly, in the nine trading periods following an (x) state, risk premiums increase in five and decrease in four instances. These results indicate that the conservative investors tend to have longer memories of previous price history, especially when the past outcome is unfavorable. One interpretation of this observation is that the degree of risk aversion, i.e., the parameter in the utility function, is a function of the investors' wealth. When wealth decreases due to a previously unfavorable outcome, risk aversion increases and the situation reverses given a previous wealth increasing outcome. An alternative interpretation is that the conservative investors are adoptive in forming their expectations. Further experiments are needed to discriminate between these two interpretations.

C. *Resource Allocation*

A criteria in assessing the economic efficiency of different market institutions in experimental studies, e.g. Smith [16], is to examine how much of the available asset supply ends up in the right hands, i.e., with those traders who place the highest value on the share. Recall that there are three types of traders in each market and, each type is initially endowed with 8 shares for a total supply of 24 shares. Ideally, all 24 shares should, via trading, end up with one trader type. Table III presents the share holdings in each trading period of the two markets. In general, the correct trader type does accumulate more shares (from the initial eight), and the number of shares owned increases with the amount of superior information. As expected, the informed traders (half of each trader type) also accumulates more shares (share holdings in parentheses). Most importantly, efficiency as measured by correct resource allocation is greater in Market 1. There are more shares in the right hands in all of the information regime except

[6] There are two major explanations for the failure of period 8 (market 2) to exhibit a "once bitten" effect. First, period 8 represents the fourth and last period of sequentially decreasing equlibrium prices. The REE of 138 francs is the lowest seen so far by the traders (the highest so far is the REE of 550 francs in period 4). Consequently, it is difficult for prices which are already substantially under REE to go much lower. This is especially true in light of the second point. In period 7, when state (z) occurred, the size of the risk premium was at its highest level, an extraordinary 96 francs. Given an REE of only 138 francs in period 8, it is easy to see why the risk premium could not remain at 96 francs. In fact, it might be considered extraordinary that the risk premium remained at 79 francs, the fourth largest for all periods of Market 2.

Table III

Number of Shares Owned by Trader Type

Trader Type	Trading Period																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A. Market 1 (Speculative Investors)																				
I	14			11			13 (9)			14			19(16)			21(7)			13	
II		10			13(9)			18(13)			17			18(11)			16			19
III			13			9(4)			18			12			8(0)*			12		
Information regime totals		48				53 (35)				61				66 (34)				60		
B. Market 2 (Conservative Investors)																				
I	12			10			16(9)			11			23(19)			20(16)			13	
II		9			10(8)			7(3)			13			17(15)			12			13
III			15			19(8)			14			15			11(6)*			18		
Information regime totals		46				52 (28)				53				71 (56)				56		

Notes: This table assumes REE prices. The numbers in parentheses indicate the number of shares in the hands of the informed traders in the group. The total supply of shares in the market is 24.

* Negative risk premiums existed in these periods (see Table I). Since the worst state "Z" is known to occur, the theoretical allocation with short sale constraint is zero.

regime D.[7] The difference in allocation between the two markets is greater in the two "false" information regimes, 61 shares versus 53 shares in C, and 60 shares versus 46 shares in E. Furthermore, when certain information indicated that the unfavorable state (z) would occur (period 15), the informed speculative traders are able to get rid of all their holdings while the conservative traders fail to do so.

In sum, we have observed that, although the speculative investors may induce a more volatile market, they also achieve greater convergence to equilibrium prices as well as a better allocation of resources. Thus, the role of speculators may not be entirely dysfunctional nor is greater price volatility necessarily harmful.

V. Conclusions

This study investigates the differences in the behaviors between the less risk averse (speculative) investors and the more risk averse (conservative) investors in two separate experimental markets. The conservative investors, as expected, report greater risk aversion by demanding higher risk premiums. They are also slower in adjusting their portfolio to information, thereby possibly reflecting a longer memory toward past price history or a dependence on current wealth level. On the other hand, the market for speculators shows greater price volatility in both bid/ask spread within a trade as well as with intraperiod variances. This experimental result contradicts the prediction from the theoretical models of LeRoy and LaCivita [11] and Grossman and Shiller [4]. Furthermore, contrary to popular belief, it is found that the greater price volatility caused by the speculators is not necessarily dysfunctional. The market for the speculative investors exhibits several desirable properties. Specifically, the price patterns tend to converge closer, and at a greater speed to either the prior information equilibrium price or the rational expectation equilibrium price. It also achieves better allocational efficiency. And, it is also less likely to be misled by potentially "false" price information.[8] Thus, the experimental evidence here suggests that it may be premature to relate price volatility with irrational price bubbles. Volatil-

[7] A probable explanation for this exception is the limited short sale ability of the traders, in particular the insiders of Type III. These insiders knew that the worst state (z) would occur and therefore sold off all of their shares (in Market 1). However, they were unable to force prices lower thereby resulting in a negative risk premium. As a consequence the inside Type III traders of Market 1 did not hold any shares even though, under REE, they had the highest valuation. It is apparent that had prices fallen lower, these traders would have repurchased many if not all of the shares held for sale. In essence, the limitation on short selling has prohibited prices from continuing their movement towards the REE price and consequently caused a misallocation of assets.

[8] As to the question ". . .does it follow that market price does not respond to irrelevant information?" We think the answer is yes. The critical factor in our experiment and we believe in the real world is not that there exists irrelevant information, but that we do not know whether other traders actually do possess good information. Therefore, we do not know how much reliance to put on prices for information. As a consequence, we are faced with two problems as a noninformed trader. First, we must conclude whether others possess superior information. Then, we can go to the second problem, and that is to try and infer from prices what the nature of this information is.

ity, including the bid/ask range, may be a valuable mechanism in which market participants exchange and learn new information.

Finally, a caveat of this study is in order since the results here are derived from the study, albeit in a more uncertain environment, of a single period market. Thus, the focus is in how well the investors of different risk aversions process the information within one trading period. The potential for trading (or speculative) profit is not as great as in a multiperiod model. The difference in the behaviors between the speculative and conservative investors in a multiperiod experiment will be reported in another paper.

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Appendix

Table A1

Information Design: Markets 1 and 2

Information Regime	Period	No. of Agents Informed	Common Knowledge About Informed Agents			Information Held By Informed Agents				
			How Many	Who	What He Knows	Information on Card	Posterior Probability			Actual State
							X	*Y*	*Z*	
1 & 2	1	None	Yes (0)	No	Yes	No card	0.4	0.4	0.2	*Y*
	2	None	Yes (0)	No	Yes	No card	0.4	0.4	0.2	*X*
	3	None	Yes (0)	No	Yes	No card	0.4	0.4	0.2	*X*
	4	None	Yes (0)	No	Yes	No card	0.4	0.4	0.2	*Y*
	5	6 (two of each type)	No	No	Yes (Imperfect)	*XXXYXXXXYX*	0.8	0.2	0	*X*
	6	6 (two of each type)	No	No	Yes (Imperfect)	*YYYXYZXYYZ*	0.2	0.6	0.2	*Y*
	7	6 (two of each type)	No	No	Yes (Imperfect)	*XYXZXZXXYX*	0.6	0.2	0.2	*Z*
	8	6 (two of each type)	No	No	Yes (Imperfect)	*YYYYXZXYYY*	0.2	0.7	0.1	*Y*
	9	None	No	No	Yes (Imperfect)	None	0.4	0.4	0.2	*X*
	10	None	No	No	Yes (Imperfect)	None	0.4	0.4	0.2	*Y*
	11	None	No	No	Yes (Imperfect)	None	0.4	0.4	0.2	*X*
	12	None	No	No	Yes (Imperfect)	None	0.4	0.4	0.2	*X*
	13	6 (two of each type)	No	No	Yes (Perfect)	*X*	1.0	0	0	*X*
	14	6 (two of each type)	No	No	Yes (Perfect)	*Y*	0	1.0	0	*Y*

15	6 (two of each type)	No	No	Yes (Perfect)	*Z*	0	0	1.0	*Z*
16	6 (two of each type)	No	No	Yes (Perfect)	*Y*	0	1.0	0	*Y*
17	None	No	No	Yes (Perfect)	None	0.4	0.4	0.2	*X*
18	None	No	No	Yes (Perfect)	None	0.4	0.4	0.2	*Z*
19	None	No	No	Yes (Perfect)	None	0.4	0.4	0.2	*X*
20	None	No	No	Yes (Perfect)	None	0.4	0.4	0.2	*Z*

Table A2

Dividend Design: Markets 1 and 2

Period	Trader Type	Dividend State			Prior Probability			$E(D)$	Period	Trader Type	Dividend State			Prior Probability			$E(D)$
		X	Y	Z	X	Y	Z				X	Y	Z	X	Y	Z	
1	I	350	225	100	0.4	0.4	0.2	250*	11	I	450	325	200	0.4	0.4	0.2	350
	II	300	175	50	0.4	0.4	0.2	200		II	550	425	300	0.4	0.4	0.2	450*
	III	250	125	00	0.4	0.4	0.2	150		III	500	375	250	0.4	0.4	0.2	400
2	I	350	225	100	0.4	0.4	0.2	250	12	I	600	475	350	0.4	0.4	0.2	500
	II	450	325	200	0.4	0.4	0.2	350*		II	550	425	300	0.4	0.4	0.2	450
	III	400	275	150	0.4	0.4	0.2	350*		III	650	525	400	0.4	0.4	0.2	550*
3	I	500	375	250	0.4	0.4	0.2	400	13	I	550	425	300	0.4	0.4	0.2	450*
	II	450	325	200	0.4	0.4	0.2	350		II	450	325	200	0.4	0.4	0.2	350
	III	550	425	300	0.4	0.4	0.2	450*		III	500	375	250	0.4	0.4	0.2	400
4	I	650	525	400	0.4	0.4	0.2	550*	14	I	400	275	150	0.4	0.4	0.2	300
	II	600	475	350	0.4	0.4	0.2	500		II	450	325	200	0.4	0.4	0.2	350*
	III	550	425	300	0.4	0.4	0.2	450		III	350	225	100	0.4	0.4	0.2	250
5	I	500	375	250	0.4	0.4	0.2	400	15	I	250	125	00	0.4	0.4	0.2	150
	II	550	425	300	0.4	0.4	0.2	450*		II	300	175	50	0.4	0.4	0.2	200
	III	450	325	200	0.4	0.4	0.2	350		III	350	225	100	0.4	0.4	0.2	250*
6	I	350	225	100	0.4	0.4	0.2	250	16	I	250	125	00	0.4	0.4	0.2	150*
	II	400	275	150	0.4	0.4	0.2	300		II	175	75	00	0.4	0.4	0.2	100
	III	450	325	200	0.4	0.4	0.2	350*		III	75	50	00	0.4	0.4	0.2	50
7	I	350	225	100	0.4	0.4	0.2	250*	17	I	250	125	00	0.4	0.4	0.2	150
	II	250	125	00	0.4	0.4	0.2	150		II	350	225	100	0.4	0.4	0.2	250*
	III	300	175	50	0.4	0.4	0.2	200		III	300	175	50	0.4	0.4	0.2	200
8	I	175	75	00	0.4	0.4	0.2	100	18	I	400	275	150	0.4	0.4	0.2	300
	II	250	125	00	0.4	0.4	0.2	150*		II	350	225	100	0.4	0.4	0.2	250
	III	75	50	00	0.4	0.4	0.2	50		III	450	325	200	0.4	0.4	0.2	350*
9	I	300	175	50	0.4	0.4	0.2	200	19	I	550	425	300	0.4	0.4	0.2	450*
	II	250	125	00	0.4	0.4	0.2	150		II	500	375	250	0.4	0.4	0.2	400
	III	350	225	100	0.4	0.4	0.2	250*		III	450	325	200	0.4	0.4	0.2	350
10	I	450	325	200	0.4	0.4	0.2	350*	20	I	550	425	300	0.4	0.4	0.2	450
	II	400	275	150	0.4	0.4	0.2	300		II	650	525	400	0.4	0.4	0.2	550*
	III	350	225	100	0.4	0.4	0.2	250		III	600	475	350	0.4	0.4	0.2	500

* Indicates the trader group with the highest expected value given the prior probability.