Cheap Talk, Fraud, and Adverse Selection in Financial Markets: Some Experimental Evidence

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Source: *The Review of Financial Studies*, Autumn, 1999, Vol. 12, No. 3 (Autumn, 1999), pp. 481-518

Published by: Oxford University Press. Sponsor: The Society for Financial Studies.

Stable URL: https://www.jstor.org/stable/2646069

Cheap Talk, Fraud, and Adverse Selection in Financial Markets: Some Experimental Evidence

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We examine communication in laboratory games with asymmetric information. Sellers know true asset qualities. Potential buyers only know the quality distribution. Prohibiting communication, we document the degree of adverse selection. Then we examine two alternative communication mechanisms. Under "cheap talk," each seller can announce any subset of qualities. Under "antifraud," the subset must include the true quality. Both mechanisms improve market efficiency, but very differently. Relying on sellers' frequently exaggerated claims, buyers often overpay under cheap talk. Efficiency gains come at the buyers' expense. The antifraud rule improves efficiency further and eliminates the wealth transfer from buyers to sellers.

Typically the seller of a financial asset has better information about an asset's quality than any of its potential buyers. Left unchecked, this asymmetry can lead to adverse selection, with sellers of all but the lowest quality assets withdrawing from the market. To overcome this adverse selection problem, the seller's superior information needs to be communicated accurately to the buyer. In this article we examine the ability of two alternative communication mechanisms to mitigate the adverse selection observed in experimental markets.

Because of the efficiency gains that can be achieved by eliminating adverse selection and because of the obvious incentives sellers have to provide misleading information, regulators have focused considerable attention on communication between sellers and buyers. From the inception of the SEC,

We would like to thank the seminar participants at Universite Laval, Cornell University, Northwestern University, University of Iowa, and the Economic Science Association for their helpful comments. We would also thank Kerry Back (the editor) and an anonymous referee for their insight and assistance. Address correspondence and reprints requests to Thomas Rietz, Department of Finance, College of Business Administration, University of Iowa, Iowa City, IA 52242, or e-mail: Thomas-Rietz@uiowa.edu.

The Review of Financial Studies Fall 1999 Vol. 12, No. 3, pp. 481–518

the regulatory focus has been on eliminating the informational asymmetry between buyers and sellers. By mandating financial disclosures in registration statements, the SEC ensures that some standardized communication will take place. By creating an antifraud provision in the federal law, the SEC attempts to insure that both mandated and nonmandated disclosures are truthful. In addition, the SEC has attempted to protect buyers from sellers' communications that may escape federal antifraud provisions. For example, Section 5c of the Securities Act is effectively a prefiling "gag rule," prohibiting any sales-related communication from the seller to potential buyers before filing a registration statement with the SEC. In each instance, the SEC appears concerned with how communication affects market outcomes and buyer welfare. These regulations have created a communication mechanism that may overcome adverse selection.

The success of various communication mechanisms as remedies for adverse selection depends on the answers to several questions. If sellers can make any statement about their asset's quality in an unregulated environment, how often do they make exaggerated or fraudulent claims and how often do buyers rely on these statements? If regulations prohibit all communications between buyers and sellers, will adverse selection arise and are there differences between the outcomes and those observed when sellers are free to make fraudulent claims? Finally, does an antifraud rule provide an effective remedy to the adverse selection problem?

While the answers to these questions have substantial implications for financial economics, naturally occurring data are of little help in providing answers to them. We cannot observe the private information of parties at the time of a transaction. Neither can we measure the efficient transactions foregone due to the informational asymmetry. Nor can we manipulate the allowable communications between the seller and the buyer. A laboratory approach overcomes these difficulties.

In our laboratory sessions, a seller is endowed with one unit of an asset and knows the asset's quality with certainty. The asset's quality determines both the seller's reservation value for the asset and the buyer's valuation for the asset. The values are such that, if the buyer learns the asset's true quality, both parties can gain by trading it. While the seller knows the asset's quality, the buyer knows only the ex ante probability distribution of possible quality levels. The buyer and seller then play the extensive form of a game. We study three treatments. The first treatment approximates a presale "gag rule" under which no communication is allowed. This treatment shows what happens in a market without any communication, allowing us to assess the extent of the adverse selection problem caused by pure information asymmetry. Another treatment permits "cheap talk" by allowing the seller to make any statement (even a fraudulent one) about the asset's quality. This approximates a completely unregulated market and shows the extent of fraud without any regulatory controls. The third treatment imposes an antifraud rule. In it the seller can make any statement about the asset's quality as long as the statement includes the true quality. Thus the seller can make optimistic statements, but cannot engage in outright fraud. This approximates current SEC rules and case law.

We use the no communication treatment as a baseline. Economic theory predicts that adverse selection will lead to very inefficient outcomes in which only the lowest quality assets trade. This behavioral baseline may differ from the theoretical baseline of complete adverse selection because adverse selection is an equilibrium phenomenon. Buyers must anticipate that sellers with the highest quality assets may not be willing to trade if the prices bid only reflect the asset's ex ante average quality. Buyers must also realize that if the sellers of the highest quality assets withdraw from the market the expected value of the asset drops. This is not merely a statistical decision-making problem. Buyers must anticipate seller behavior in different states of nature. The extent of the adverse selection depends on how well traders solve this problem. Thus before we can examine the success of communication as a remedy to adverse selection, we need to establish empirically the level of adverse selection in the no-communication baseline. Although our results document considerable adverse selection, it is not nearly as severe as predicted by theory.

When sellers can engage in cheap talk, theory predicts the same outcomes as when no communication is allowed. This is because the incentives of the buyer and seller are never aligned, so the seller's communication should never be believed. However, we find considerable differences between these two treatments. In particular, buyers are frequently taken in by the seller's overoptimistic statements and bid too much for the asset. By purchasing the asset they significantly increase efficiency over the no-communication treatment, but they also transfer wealth to the sellers. What makes this result most surprising is that, in our experimental design, subjects alternate between being buyers and sellers. They also meet each other only once in each role and communicate anonymously through a computer network. Thus the buyer's gullibility is not due to a failure to understand the "other" side of the transaction, nor from an attempt at a multiperiod strategy, nor from promised side payments. The same subjects who are quite willing to lie when acting as sellers are quite gullible when acting as buyers. In fact, a subject's dishonesty when acting as a seller correlates positively with the same subject's gullibility when acting as a buyer — apparently a subject who is more likely to make fraudulent statements believes that others are less likely to make such claims.

The impact of cheap talk in our adverse selection setting has not been documented by previous experimental studies and it contrasts sharply with the behavior predicted by economic theory. The pervasiveness of gullible buyer behavior in the relatively transparent setting of our experimental markets lends credence to the SEC's concern about noncredible communication in markets with information asymmetry.

Theory predicts that the antifraud rule will result in fully efficient outcomes, with all assets trading at appropriate prices. In a sequential equilibrium, the seller makes a potentially vague statement about the asset's quality. However, the lowest quality stated should be the true quality of the asset. Upon hearing the seller's statement, a skeptical buyer should assume the asset is of the lowest quality level consistent with this statement and bid accordingly. We find that the antifraud rule significantly improves efficiency relative to the cheap talk treatments, and it largely eliminates the wealth transfer from the buyers to the sellers. However, efficiency remains considerably below 100%. Sellers do not always disclose their asset quality as predicted and buyers are not always sufficiently skeptical of their statements. Thus, while the antifraud rule mitigates the problem due to information asymmetry, it is less than a perfect remedy.

Previous experimental studies have examined credible communication mechanisms. Forsythe, Isaac, and Palfrey (1989) report an experiment where a seller can either disclose credibly the exact value of an asset to potential buyers or choose to "blind bid" the asset by making no disclosure. The asset is then sold via a first price sealed bid auction. They find evidence consistent with the sequential equilibrium in which sellers disclose their asset's quality, although they also find that a single optimistic buyer can cause a considerable reduction in the amount of disclosure. King and Wallin (1991) conduct a similar experiment, but manipulate the probability that a seller is informed about the asset's quality. In this situation, a buyer cannot distinguish between an uninformed seller and one who chooses not to disclose information. They find that the amount of disclosure decreases as the probability that the seller is uninformed increases, but they find little evidence supporting the point predictions of their model. Even when the seller is always informed, the full disclosure equilibrium is not observed.

These studies differ from ours in two important ways. First, in these experimental settings the seller cannot refuse to sell the asset. Thus the standard adverse selection result where the seller withdraws from the market is not possible. While the studies shed some light on voluntary disclosure, they are not designed to examine how communication serves as a remedy to adverse selection. Second, they do not contrast their results across communication mechanisms. They do not establish a benchmark level of adverse selection without communication nor do they examine how noncredible communication might influence results. Since their results only partially support the full disclosure equilibrium, it is hard to know if the achieved efficiency is significantly different from what could have been achieved with no communication or with cheap talk.[1] In contrast, we compare three different

[1] Another difference between our study and previous experimental work is that in the previous work the asset is sold via some type of auction institution (either oral or sealed bid). While this is consistent with many naturally occurring transactions, it presents a potentially distorted view of the buyer's belief about

communication remedies. We show that 19% of the achieved efficiency in the markets with an antifraud rule would have been achieved with no communications because of incomplete adverse selection. Further, 54% of the efficiency in the markets with an antifraud rule would have been achieved with noncredible communication because of the gullibility of buyers.

There have also been experimental studies in which subjects could make noncredible statements to one another. But none of the previous cheap-talk games consider settings where the preferences of the sender and the receiver are completely opposite, as is the case in our setting, and none consider settings where one party has an absolute information advantage over the other. Rather the literature studies how cheap talk might influence the strategy coordination between agents, either in the voluntary provision of public goods [Isaac and Walker (1988); and Palfrey and Rosenthal (1991)], in the collusive behavior among multiple sellers [Isaac, Ramey, and Williams (1984); Daugherty and Forsythe (1987a, b); and Davis and Holt (1990)], or in games with multiple equilibria, such as the battle of the sexes [Cooper et al. (1989)] or the coordination game [Cooper et al. (1992)]. In all of these games the communication is about what the sender will do, not about what he knows, and all subjects have common information about the uncertain elements of the game. The communication serves to coordinate the actions of the different agents when their incentives are aligned. What distinguishes our study from this work is that the cheap talk in our game is from a better informed party with incentives that are completely opposite from the opposing party, so the cheap talk should not influence the receiver's behavior. Somewhere between the previous cheap-talk literature and our study lies Dickhaut, McCabe, and Mukherji (1995), who document that a sender's message becomes less informative to the receiver as the preferences of the two players diverge. But this suggests that the cheap talk in our setting should not matter, in contrast to our findings.[2]

Finally, previous experimental work has examined the ability of costly signaling mechanisms to communicate information from an informed to an uninformed party. In a financial market context, Cadsby, Frank, and Maksimovic (1990) study the problem faced by the owner of a firm who can either

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the asset's value. For instance, a sealed bid auction is particularly sensitive to the winner's curse, so the most optimistic buyer will consistently win the auction. Alternatively, oral auctions may lead buyers to adapt their behavior in response to the behavior of other buyers. They may question why they are bidding a different amount than the other buyers and alter their responses to be consistent with the group. By conducting our experiment as a two-person game, we eliminate the potentially confounding effects of multiple buyer auction mechanisms that are commonly documented in the literature.

[2] Valley, Moag, and Bazerman (1995) and Valley et al. (1995) find that cheap talk in bargaining games with a two-sided informational asymmetry also increases the efficiency of outcomes. In these studies, the efficiency gains appear to be caused by increased cooperation between the two bargainers, who each possess information which is valuable to the other. In our setting, the seller has a distinct informational advantage over the buyer and the gains in efficiency we observe are accompanied by a significant wealth transfer from the buyer to the seller.

retain 100% ownership or sell some fraction to investors at an exogenously given price. They find support for a pooling equilibrium in which the fraction of the firm sold is invariant to the quality of the seller's asset. Cadsby, Frank, and Maksimovic (1994) add a "money-burning" mechanism to their original experiments and find that equilibrium dominance (also known as the intuitive criterion) is not a particularly robust equilibrium selection mechanism. Finally, Miller and Plott (1985) study a standard signaling game in which the seller of a high-value asset can add quality to his asset at a lower cost than the seller of a low-value asset, and the quality added is observable by the buyer (although the cost of doing so is unknown). They find general support for equilibria in which the signal serves to separate high-quality sellers from low-quality sellers, but they also document many divergent results, concluding that no single model can explain all their results. Taken together, these studies find only limited evidence that the availability of a costly signal to the seller will result in an equilibrium in which information is transferred from the informed party to the uninformed party. In contrast to the costly and indirect signals studied in these articles, we consider costless and direct communication from the seller to the buyer, and we examine how changes in the communication mechanism influence the resulting degree of adverse selection.

In the next section we present our model and derive testable predictions. In Section 3 we present a description of the laboratory games we conducted. Our results are described in Section 4. In Section 5 we provide a summary and some concluding remarks.

1. The Theory

Economists have long studied the effects of asymmetric information in markets. Lacking any mechanism that allows the seller to communicate credibly with buyers, the standard adverse selection model predicts that higher quality assets will not sell. This happens because a buyer's expected valuation for the asset does not exceed the seller's reservation price. In the extreme this leads to a pure "lemons" outcome [Akerlof (1970)] in which only the lowest quality assets sell. This prediction also holds in an unregulated "cheap-talk" environment that allows sellers to make costless, nonbinding claims since buyers would be foolish to rely on such claims. Similarly, this prediction holds under a gag rule or other tightly regulated environments that effectively prohibit communication between sellers and prospective buyers. Thus, absent any mechanism that allows the seller of an asset to disclose credibly its quality, theory predicts inefficient outcomes due to foregone gains from trade.

Grossman (1981), Milgrom (1981), and Milgrom and Roberts (1986) propose a simple remedy to the adverse selection problem: allow a seller to make statements about the quality of the asset, but prohibit the seller from committing outright fraud. This antifraud rule permits the seller to make either broad or narrow claims about the asset's quality, so long as the true quality is not excluded by these claims. Under such a rule, sellers' statements may be optimistic but they cannot be materially false. This rule approximates current securities laws on forward-looking statements and it gives an asset's seller a means to credibly communicate its quality. Under two of our parameter sets below, all sequential Nash equilibria to this game have the property that the seller's information is credibly communicated to the buyer and full efficiency is achieved.[3]

Our experiments were designed to follow theory very closely — subjects essentially played one of the extensive form games that represent each institutional setting we consider. Consequently, a careful description of the theory will do much to describe the experiments themselves.

Sellers are each endowed with one unit of an asset. The asset's quality, θ, can take three different values, low, medium, or high, and each is equally likely, that is, $\theta \in \{l, m, h\}$ and $P(l) = P(m) = P(h) = 1/3$.[4] Denote the buyer and seller valuations for the asset in each state as b_θ and s_θ, respectively. Let the transaction price be p_j, $j \in \{l, m, h\}$, where j is not necessarily equal to θ. Finally, let the buyer's endowment be e, which is invariant to the state of nature. If the asset does not trade, the buyer receives e and the seller receives s_θ. If the asset does trade, the buyer receives $e + b_\theta - p_j$ and the seller receives p_j.

The parameters we consider satisfy the restriction that, with complete information, there are gains from trade at each quality level. Further, the price corresponding to each quality level leads to strictly positive gains from trade by both parties (i.e., $s_\theta < p_\theta < b_\theta$ for all $\theta \in \{l, m, h\}$). The price corresponding to a quality level is also set so that both a buyer of a lower quality asset and a seller of a higher quality asset finds that price unattractive. The only ambiguous ordering is between b_l and s_m and between b_m and s_h. These parameter restrictions are summarized by the ordering:

$$0 \leq s_l < p_l < (b_l \text{ or } s_m) < p_m < (b_m \text{ or } s_h) < p_h < b_h. \qquad (1)$$

Finally, we restrict parameters so that $p_h > (b_l + b_m + b_h)/3$. This insures that bidding p_h (and receiving the expected value of all quality types in exchange) will be suboptimal.[5]

[3] In a third set, parameters allow for a second partial pooling equilibrium, which we will discuss below.

[4] We use three states of nature because the announcement strategies are trivial when there is an antifraud rule and only two states. The high-quality seller can do no better than disclose $\{h\}$, so any disclosure other than $\{h\}$ implies that the asset type is 1.

[5] This is somewhat more restrictive than we need, but insures that the suboptimality of bidding p_h is apparent by making its expected value less than zero. All we need for the adverse selection outcome is the slightly weaker, but less apparent, condition $p_h > \min\{(p_l + b_m + b_h)/3, (2p_m + b_h/3)$, which ensures that bidding p_h has a lower value than bidding p_m or bidding p_l.

Table 1
Experimental design and parameter sets

Panel A: Experimental design

Parameter set	Communication allowed: None	Cheap talk	Antifraud rule
I	NC1 & NC2	CT1 & CT2	AF1 & AF2
I′	NC3 & NC4	CT3 & CT4	AF3 & AF4
II	NC5 & NC6	CT5 & CT6	AF5 & AF6

Panel B: Parameter set parameters

	e	s_l	p_l	b_l	s_m	p_m	b_m	s_h	p_h	b_h
I	350	0	200	250	250	450	550	500	600	850
I′	350	0	200	250	250	300	550	500	600	850
II	400	0	150	250	200	400	450	450	650	750

Panel A shows the experimental design and designations for experimental sessions. "NC" refers to the no-communication treatment in which sellers could not communicate with buyers. "CT" refers to the cheap-talk treatment in which sellers could make any declaration to buyers. "AF" refers to the credible antifraud treatment in which sellers could not make fraudulent statements to buyers. Panel B shows the experimental currency values associated with each parameter set. The buyer's endowment is e. The buyer's valuations are denoted by b_l, b_m, and b_h for the low, medium, and high asset quality states, respectively. The seller's valuations are denoted by s_l, s_m, and s_h for the low, medium, and high asset quality states, respectively. Potential transaction prices are denoted by p_l, p_m, and p_h for low, medium, and high prices, respectively.

Panel A of Table 1 displays the three different communication settings we study, labeled NC for the no-communication treatment, CT for the cheap-talk treatment, and AF for the antifraud disclosure treatment. Panel B of Table 1 displays the three different parameter sets we use. Parameter set I serves as the baseline parameter set. Parameter set I′ allows us to verify that subjects were responding to the intended economic forces. By changing only p_m, it changes predicted buyer behavior in the no-communication and cheap-talk settings (by changing the optimal bid from p_l to p_m in the predicted equilibrium). Finally, parameter set II increases the cost of a frequently observed, suboptimal strategy (overbidding p_h) to buyers.

Next we describe the sequential Nash equilibria for each treatment. In each case, the equilibria are derived for a one-shot game since, as discussed in the next section, the experimental design mitigates reputation effects.

1.1 No communication, cheap talk, and adverse selection

Without communication, the buyer's information set is the ex ante distribution over states of nature. The buyer chooses a bid strategy, denoted as $B \in \{p_l, p_m, p_h\}$. Knowing the bid, the seller responds with a strategy, denoted $S(\theta|p_j) \in \{A, R\}$, where A and R represent accepting or rejecting the buyer's bid, respectively. Because the seller is informed and moves second, the seller's dominant strategy is to accept the bid price if it exceeds the seller's reservation value.

Under each parameter set there is a unique sequential equilibrium. For parameter sets I and II, the equilibrium is the low-trade equilibrium in which $B = p_l$ and $S(l|p_l) = A$, $S(m|p_l) = R$, and $S(h|p_l) = R$. Since the buyer is unwilling to pay more than p_l, a seller of a medium- or high-quality asset withdraws from the market. In parameter set I′, p_m is sufficiently low that the buyer attains the highest expected profit by bidding p_{m} in exchange for both low- and medium-quality assets.[6] Under parameter set I′, both low- and medium-quality assets trade. In this medium-trade equilibrium, $B = p_m$ and $S(l, p_m) = A$, $S(m, p_m) = A$ and $S(h, p_m) = R$.

Our no-communication treatment illustrates the most basic form of the adverse selection model. For parameter sets I and II the frequency of the low-trade equilibrium shows the extent of adverse selection. These results serve as benchmarks for our two disclosure treatments. Parameter set I′ also suffers from adverse selection in that the high-quality asset does not trade. The no-communication results still serve as a benchmark. However, I′ also allows us to determine whether bidders are willing to bid higher when it is optimal to do so.

In theory this game is fundamentally unaltered if cheap talk is permitted. Our cheap-talk treatment allows the seller to make a disclosure by announcing a subset of $\{l, m, h\}$ before the buyer's choice of price. This disclosure is nonbinding because the announced set need not contain the realized state. In this game, the seller can lie, tell the whole truth, or be vague. Under the assumptions of standard game theory (in particular, that utility is derived only from the final payoffs of the game), this type of cheap talk should have no impact — the equilibria are the same as in the no-communication treatment.[7] Intertreatment comparisons will tell us if the same equilibria actually arise when subjects play these games, or if such communication affects players and their actions.

1.2 Disclosure with an antifraud rule as a remedy

In this treatment, the seller moves first and makes a disclosure, $D(\theta)$, which consists of a subset of $\{l, m, h\}$. The antifraud rule constrains the disclosure to contain the true state of nature. Thus for low- and medium-quality assets, the seller may disclose the true state or the seller may exaggerate by including higher quality states in the disclosure. However, the seller cannot commit outright fraud by disclosing only states that are not true. Upon hearing the seller's disclosure, the buyer must choose a strategy, $B(D)$.

[6] The expected value of bidding p_l is $(e + b_l - p_l)/3 + 2e/3$ because only low-quality assets trade. The expected value of bidding p_m is $(e + b_l - p_m)/3 + (e + b_m - p_m)/3 + e/3$ because both low- and medium-quality assets trade. Thus bidders will bid p_m if $(e + b_l - p_l)/3 + 2e/3 < (e + b_l - p_m)/3 + e/3$. Rearranging gives $p_m < (p_l + b_m)/2$ as the parameter relationship that leads to this outcome.

[7] For example, Farrell (1987) shows that cheap talk can matter in other types of games, such as in the "battle of the sexes." However, in our setting the necessary conditions are not met. Theoretically, cheap talk matters under specific conditions. In particular, if it would be optimal for the seller to honor his announcement if the buyer believed the seller would honor it, then the announcement will be believed and honored. In our setting, the low-quality seller has a clear incentive to defect from such an arrangement.

For parameter sets I and II an argument very similar to proposition I of Matthews and Postlewaite (1985) can be used to show that the only sequential equilibria to this game have the property that the seller's announcement fully reveals the quality of the asset he has for sale.[8] To support this as an equilibrium strategy, buyers must adopt "assume the worst" beliefs. With these beliefs, the buyer assumes that the true quality of the asset for sale is the lowest quality level that the seller announces. So, in this equilibrium set, the seller announces a set with the truth as the minimum element, the buyer chooses the price associated with that state of nature, and the seller accepts. All three qualities of assets sell, achieving maximum efficiency.

This full disclosure equilibrium set also exists under parameter set I′. However, there is a second sequential equilibrium that may arise because p_m is sufficiently low. In this partial disclosure equilibrium the high-quality seller discloses $\{h\}$ and the medium- and the low-quality sellers disclose either $\{l, m\}$ or $\{l, m, h\}$. In response, the buyer bids p_h when $\{h\}$ is disclosed and p_m when $\{l, m\}$ or $\{l, m, h\}$ is disclosed. For any other disclosure the buyer bids the price associated with the minimum state in the disclosure, as in the fully revealing strategy above.[9] The medium-quality sellers are indifferent between disclosing $\{m\}$, $\{m, h\}$, $\{l, m\}$, or $\{l, m, h\}$ because all lead to a sale at p_m (and a profit of 50). However, this equilibrium may prove unstable. If the medium-quality seller believes that there is even a slight possibility that the buyer will bid according to the full disclosure equilibrium strategy (p_l in response to $\{l, m, h\}$ or $\{l, m\}$ disclosures), then, individually, he is no longer indifferent between disclosures. He will prefer to defect from the equilibrium strategy and disclose $\{m\}$ or $\{m, h\}$. Alternatively, Laffont and Maskin (1990) argue that the partial pooling equilibrium may be more reasonable than the full disclosure equilibrium in a related setting. They note that, in the partial disclosure equilibrium, a larger portion of the surplus goes to sellers on average (because of low-quality sellers selling at p_m). The experimental results are more consistent with full disclosure equilibria than with partial disclosure equilibria. (See note 14.)

2. The Experimental Setting

The subjects were undergraduate business students at the University of Iowa. Upon arrival, subjects were seated at separate computer terminals. Each received a set of instructions and record sheets. (These are reproduced

[8] While this is actually a set of equilibria with this common property, we will refer to the set as "an equilibrium."

[9] Buyers prefer bidding p_m to p_l in response to either $\{l, m\}$ or $\{l, m, h\}$, assuming the seller plays her equilibrium strategy. Buyers who bid p_l can expect a profit of 0.5 x 50 + 0.5 x 0 = 25 because only low-quality sellers will sell. Buyers who bid p_m can expect a profit of 0.5 x (-50) + 0.5 x 250 = 100. Thus buyer behavior can support this equilibrium. However, buyers would still prefer the full disclosure equilibrium overall.

in the appendix.) Since these instructions were read aloud, we assume that the information contained in them was common knowledge.

The experiment was conducted as a sequence of two-part periods. In the first part of a period, subjects were divided into pairs and played the extensive form of a game. The payoffs from the first part of the period ranged from 0 to 1000 points, where the number of points determined the probability of winning a cash prize of $1.50 in the second part of the period. A subject won the lottery prize if the number of points earned in the first part of the period was greater than or equal to the number on a lottery ticket drawn from a box containing 1000 tickets. The purpose of the lottery was to induce subjects to maximize the number of points they earn regardless of their attitudes toward risk [see Roth and Malouf (1979); Berg et al. (1986)].[10]

As the sequence of periods progressed, each subject was paired with each other subject twice, once as a seller and once as a buyer.[11] Subjects alternated between being a seller and a buyer each period. All pairing of subjects was done through the computer. Since subjects reported their choices through their computers, no subject knew the identity of the subject with whom they were paired, nor did they know the history of decisions made by any of the other subjects. We used random and anonymous subject pairings to mitigate reputation effects across periods. These pairings ensured that a seller could not meet again with previous buyers, nor was the seller's behavior observable by other subjects in the experiment. Because of this a subject could not exploit a reputation for being an honest seller. Having subjects alternate roles as buyer and seller helps ensure an equal understanding of both their own incentives and their opponent's incentives. We ran two sessions under each of three treatments and three parameter sets (discussed in more detail later). This gives us 6 sessions under each treatment, 6 sessions under each parameter set, and a total of 18 sessions. Table 1 shows the design. Each experimental session used 11 subjects (to meet the pairing constraints one subject sits out each period) and each session consisted of 22 periods. Finally, each subject participated in only one experimental session.

At the beginning of a period in each treatment, each subject's computer screen displayed the payoff table for each state of nature as separate red, white, and blue payoff tables. Figure 1 shows the display for parameter set I (without colors). The payoff tables for the seller (column player) are

[10] This procedure is commonly used in game theory experiments. To see why it works theoretically, let the probability of winning the prize be p and let the subject's utility be $u(x)$ for winning the prize and $u(y)$ for not winning the prize. Thus the subject's expected utility in the second part of the period is $EU = pu(x) + (1 - p)u(y)$. Because preference orderings based on expected utility are invariant to positive affine transformations of $u(\cdot)$, the value $u(x)$ can be normalized to 1 and the value $u(y)$ can be normalized to 0. With this, $EU = p$. Regardless of the subject's risk attitudes, he maximizes his expected utility by maximizing the probability of winning the prize.

[11] The instructions use the language "row player" and "column player" to refer to the buyer and seller, respectively. We will use the buyer-seller terminology in the text since we believe it provides additional clarity.

ROW PLAYER

33%	C1	C2
R1	400	350
R2	150	350
R3	0	350

Red Table

33%	C1	C2
R1	700	350
R2	450	350
R3	300	350

White Table

33%	C1	C2
R1	1000	350
R2	750	350
R3	600	350

Blue Table

PLAYER NUMBER 1 ________________________________ PERIOD NUMBER 1

The color of True table is Blue

COLUMN PLAYER

33%	C1	C2
R1	200	0
R2	450	0
R3	600	0

Red Table

33%	C1	C2
R1	200	250
R2	450	250
R3	600	250

White Table

33%	C1	C2
R1	200	500
R2	450	500
R3	600	500

Blue Table

Figure 1
The Column player's computer screen after the true table color is drawn

shown on the top half of the screen and the payoff tables for the buyer (row player) are shown on the bottom half of the screen. From these tables each player could determine the payoffs both players earn for each possible combination of action choices and states of nature. The computer randomly selected the state of nature for each pair of subjects (independently across pairs and periods). At the beginning of each period, the true table color was sent to the seller via the computer.

In the cheap-talk (CT) and antifraud (AF) treatments, each seller chose whether to declare a table color or set of table colors to the buyer. If a seller chose to make such a declaration, he was prompted for the table color or set of table colors he wished to declare and the buyer was sent the corresponding message. In the CT treatment, sellers' declarations were unconstrained (i.e., they need not contain the true table color). In the AF treatment, sellers' declarations were constrained so that, if the seller chose to send a message to the buyer, that message had to include the true table color. After receiving this message, the buyer then chose between prices p_l, p_m, and p_h, represented generically as choices R1, R2, and R3, respectively. In the no-communication (NC) treatment, the seller could not send any message to the buyer. Thus the buyer made this choice without receiving any message.

In all treatments the computer informed the seller of the buyer's choice by highlighting the appropriate row on each of the seller's payoff tables. The seller then chose whether to accept or reject, represented generically as choices C1 and C2, respectively. To aid in their decision making, the buyers could highlight the row corresponding to each choice across the different tables before making their choice. Similarly, the sellers could highlight the column corresponding to each action choice across the different tables before making their choice. Once the seller entered a choice, the true state of nature was revealed to the buyer, the intersecting row and column choices on the true table were highlighted on each player's screen, and the computer sent both players a message informing them of the number of points they received for the first part of the period.

3. Results

We begin with an overview of the outcomes in all three treatments. We follow that with a detailed analysis of each treatment to provide a better understanding of these outcomes. Recall that the NC treatment corresponds to a strict "no communication allowed" regulatory regime. The CT treatment allows sellers to declare subsets of payoff tables that need not contain the true table. This cheap talk corresponds roughly to an unregulated, single-shot market. In both treatments, theory predicts the "lemons" outcome in which only lower quality assets trade at correspondingly lower prices. Finally, the AF treatment corresponds to a less stringent "exaggeration allowed, but outright fraud prohibited" regulatory regime. In it, sellers can declare subsets of asset qualities but must include the true asset quality in their statement. In this treatment, theory predicts that the lowest quality asset declared is the true one and that a fully efficient allocation is achieved. Because we are interested in studying equilibrium behavior, most of the analysis focuses on the last 11 of the 22 periods in each session.

3.1 Overview of results

Table 2 gives the achieved efficiency for each session and also shows how it was distributed between the buyers and the sellers. The efficiency is measured relative to the full information outcome in which all units should trade. Since overall efficiency does not depend on the price paid by the buyer to the seller, we show separately the buyers' and sellers' shares of the efficiency. Further, since buyers can transfer some of their gains from trade to the sellers by paying more than the full information price for an asset, we also give the net transfer from buyers to sellers. Finally, we give adjusted efficiencies — both overall and for buyers and sellers separately. These adjusted efficiencies take into account that the low-quality (and, in parameter set I′, medium-quality) units should trade even with adverse selection.

Table 2 gives the efficiency data for all treatments. As an example, consider the last 11 periods of NC1. The achieved gains from trade are 26% of the maximum total possible, with buyers claiming 1% and sellers claiming 25%. The buyers transferred 6% of this maximum to the sellers by bidding prices higher than the associated quality. Of the 26% achieved gains, 19% are due to the trade of low-quality units, so the adjusted efficiency during the last half of this session is 7%. After subtracting the gains from trading low-quality units, the buyers' adjusted efficiency falls even further to −3%. (Buyers could have achieved a zero adjusted efficiency by always bidding p_l and receiving only low-quality units in return.)

Result 1. *The NC treatment leads to uniformly low adjusted efficiencies as predicted by theory.*

Panel A of Table 2 gives the efficiencies for the NC sessions, showing the effects of entirely prohibiting communication between buyers and sellers. The adjusted efficiencies for these sessions for each parameter set are all below 20% and uniformly lower than for the CT and AF treatments. Taking all the NC sessions together, the average adjusted efficiency during the last half of the sessions is only 7%. Buyers' adjusted efficiencies averaged −5% over these periods while sellers' adjusted efficiencies averaged 12%. Thus, on average, buyers transferred wealth to the sellers by overbidding for lower quality assets.

Result 2a. *The CT treatment results in significantly higher efficiencies than predicted by theory.*

Result 2b. *The CT treatment results in significantly higher efficiencies than in the NC treatment. However, buyers' adjusted efficiencies are the same across the two treatments. The increase in efficiency from allowing sellers to make unrestricted quality statements accrues completely to the sellers.*

Panel B of Table 2 gives the efficiencies for the CT sessions. Over the six CT sessions, the average adjusted efficiency during the last 11 periods is 20%, nearly three times the average in the NC sessions. Of this, 29% is the sellers' average adjusted efficiency and −9% is the buyers' average adjusted efficiency. Relative to the predicted equilibrium (which has a zero adjusted efficiency for both buyers and sellers), the outcome is more effi-

Table 2
Allocative efficiency for each market

Panel A: NC treatment

Parameter set	Session	Periods	Efficiency	Buyers' share	Sellers' share	Net transfer from buyer to seller	Eff. due to lows traded	Eff. due to meds traded	Adjusted efficiency	Buyer adjusted efficiency	Seller adjusted efficiency
I	NC1	All	.38	.01	.37	.12	.20	na	.18	−.03	.21
		Last 11	.26	.01	.25	.06	.19	na	.07	−.03	.10
	NC2	All	.44	.06	.39	.06	.33	na	.12	−.01	.12
		Last 11	.41	.03	.38	.07	.35	na	.06	−.04	.10
I′	NC3	All	.52	.15	.37	.10	.28	.20	.04	−.07	.11
		Last 11	.53	.13	.40	.12	.29	.20	.04	−.09	.13
	NC4	All	.47	.15	.32	.11	.21	.23	.03	−.09	.12
		Last 11	.49	.11	.38	.13	.25	.20	.04	−.10	.14
II	NC5	All	.45	.03	.42	.13	.35	na	.10	−.11	.20
		Last 11	.54	.08	.45	.12	.48	na	.05	−.11	.16
	NC6	All	.51(.44)	.26(.09)	.26(.35)	−.09(.07)	.31(.36)	na	.20(.07)	.13(−.05)	.07(.13)
		Last 11	.52(.46)	.21(.08)	.31(.39)	−.03(.10)	.36(.42)	na	.16(.04)	.07(−.09)	.09(.13)
Pooled averages		All	.46	.11	.36	.07	.28	.22	.11	−.03	.14
		Last 11	.46	.10	.36	.08	.32	.20	.07	−.05	.12

Table 2
(continued)

Panel B: CT treatment

Parameter set	Session	Periods	Efficiency	Buyers' share	Sellers' share	Net transfer from buyer to seller	Eff. due to lows traded	Eff. due to meds traded	Adjusted efficiency	Buyer adjusted efficiency	Seller adjusted efficiency
I	CT1	All	.55	.02	.53	.17	.33	na	.22	−.05	.27
		Last 11	.48	−.01	.49	.17	.32	na	.16	−.08	.24
	CT2	All	.49	−.07	.56	.22	.30	na	.19	−.12	.32
		Last 11	.57	−.11	.68	.29	.35	na	.22	−.18	.39
I′	CT3	All	.60	.15	.44	.15	.27	.21	.11	−.08	.18
		Last 11	.65	.12	.54	.22	.30	.22	.13	−.13	.26
	CT4	All	.60	.12	.48	.14	.35	.10	.15	−.04	.19
		Last 11	.70	.20	.50	.14	.34	.13	.24	.03	.21
II	CT5	All	.53	.06	.47	.12	.27	na	.26	−.05	.31
		Last 11	.48	.00	.48	.17	.23	na	.24	−.10	.34
	CT6	All	.47	.09	.38	.07	.26	na	.20	−.02	.22
		Last 11	.46	.03	.44	.14	.25	na	.21	−.07	.28
Pooled averages		All	.54	.06	.47	.15	.29	.16	.19	−.06	.25
		Last 11	.56	.04	.52	.19	.30	.18	.20	−.09	.29

Table 2
(continued)

Panel C: AF treatment

Parameter set	Session	Periods	Efficiency	Buyers' share	Sellers' share	Net transfer from buyer to seller	Eff. due to lows traded	Eff. due to meds traded	Adjusted efficiency	Buyer adjusted efficiency	Seller adjusted efficiency
I	AF1	All	.82	.28	.54	.06	.30	na	.52	.22	.30
		Last 11	.86	.28	.57	.05	.34	na	.52	.22	.30
	AF2	All	.82	.32	.50	.01	.31	na	.52	.26	.25
		Last 11	.90	.37	.53	.00	.36	na	.54	.30	.25
I′	AF3	All	.56(.61)	.25(.23)	.32(.38)	.05(.09)	.23(.26)	.16(.17)	.17(.17)	.07(.03)	.10(.14)
		Last 11	.61(.67)	.26(.25)	.35(.42)	.05(.09)	.27(.31)	.14(.17)	.19(.19)	.08(.05)	.11(.15)
	AF4	All	.71	.27	.43	.08	.34	.16	.21	.08	.14
		Last 11	.82	.32	.50	.11	.36	.22	.24	.06	.18
II	AF5	All	.53	.11	.43	.07	.28	na	.25	−.01	.26
		Last 11	.58	.11	.47	.08	.29	na	.29	−.01	.30
	AF6	All	.63	.15	.47	.06	.32	na	.30	.02	.28
		Last 11	.69	.13	.55	.09	.26	na	.43	.03	.40
Pooled averages		All	.68	.23	.45	.06	.30	.16	.33	.11	.22
		Last 11	.74	.25	.50	.06	.31	.18	.37	.11	.26

Panels A, B, and C give trading efficiencies for experimental sessions run under the no-communications (NC), cheap-talk (CT) and antifraud (AF) treatments, respectively, for all 22 experimental periods and the last 11 periods. Efficiency is measured as the actual gains from trade divided by the maximum possible gains from trade given the distribution of state outcomes. The buyers' share is the fraction of the maximum gains from trade earned by the buyers and sellers' share is the fraction of the maximum gains from trade earned by the seller (the two sum to the efficiency measure). The net transfer from buyer to seller is the amount the buyer gave up to the seller when the asset traded at a price exceeding its value, measured as a percent of the maximum gains to trade. The adjusted efficiency is the total efficiency (column 3) less the efficiency that results from trades that are predicted to occur in the adverse selection treatment. The buyers' and sellers' adjusted efficiencies are calculated analogously. In NC6, sellers failed to choose their dominant strategy of accepting or rejecting the buyers' bids eight times. In AF3, sellers failed to choose their dominant strategy of accepting or rejecting the buyers' bids seven times. The numbers in parentheses are the resulting statistics when these instances are removed from the data. All data from NC6 and AF3 are included in the pooled averages.

Table 3
Wilcoxon ranked sum tests for differences in adjusted efficiencies across treatments (last 11 periods of each session, $n = 6$ for each treatment)

Treatments compared	Adjusted efficiency z-statistic ($prob > \lvert z \rvert$)	Buyer adjusted efficiency z-statistic ($prob > \lvert z \rvert$)	Seller adjusted efficiency z-statistic ($prob > \lvert z \rvert$)
CT to NC	2.64*	−0.88	2.88*
	(0.0082)	(0.3785)	(0.0039)
AF to CT	2.08*	2.64*	0.32
	(0.0374)	(0.0082)	(0.7488)
AF to NC	2.88*	2.40*	2.40*
	(0.0039)	(0.0163)	(0.0163)

Shows Wilcoxon ranked sum tests for differences in adjusted efficiencies across treatments using the last 11 periods of each experimental session as a single observation. Adjusted efficiencies are defined as the actual gains from trade divided by the maximum possible gains from trade given the distribution of state outcomes minus the efficiency that results from trades that are predicted to occur even in the adverse selection treatment. An "*" indicates significance at the 5% level.

cient. However, this gain in efficiency comes at the expense of the buyers who, on average, transferred 19% of the overall surplus to the sellers through their overbidding. The sellers' false claims often deceive buyers, misleading them to purchase many assets at prices above their values.

Table 3 gives Wilcoxon tests for differences in adjusted efficiencies, buyers' adjusted efficiencies, and sellers' adjusted efficiencies during the last 11 periods across treatments (treating each session as a single observation). These tests show that the CT sessions have significantly higher adjusted efficiencies and sellers' adjusted efficiencies than the NC session, while showing no significant difference in buyers' adjusted efficiencies.

Result 3a. *The AF treatment results in significantly lower efficiencies than predicted by theory.*

Result 3b. *The AF treatment results in significantly higher overall efficiencies than in the CT treatment. Buyers' average adjusted efficiencies under the AF treatment are also significantly higher than under the CT treatment. However, sellers' adjusted efficiencies are the same across the two treatments. The increase in efficiency due to imposing the antifraud rule on otherwise unrestricted quality statements accrues completely to the buyers.*

Result 3c. *The AF treatment results in significantly higher overall efficiencies than in the NC treatment. The AF treatment significantly increases both the buyers' and the sellers' adjusted efficiencies relative to the NC treatment.*

Panel C of Table 2 gives efficiencies for the AF sessions, showing the effects of an antifraud rule. The overall and adjusted efficiencies for the AF sessions are relatively high. AF2, for example, achieves 90% efficiency during the last half of the session. The average efficiency for all six sessions during the last 11 periods is 74%. While this average is much less than 100%, it is significantly higher than the averages in the CT and NC treatments. In the last 11 periods of the AF sessions, the overall achieved efficiency is 29% higher and the adjusted efficiency is 30% higher than in the NC sessions. These efficiencies were 19% and 17% higher than in the CT sessions, respectively. The Wilcoxon statistics in Table 3 show that both buyers and sellers in the AF sessions enjoy significant gains in adjusted efficiency over those in the NC sessions. They also show that, while buyers' adjusted efficiencies under AF significantly exceed those under CT, sellers' adjusted efficiencies are not significantly different.

3.2 Summary of aggregate results

These aggregate results show a clear pattern with some surprises relative to the theoretical predictions of Section 2. First, the presence of cheap talk does permit sellers to earn additional profits at the expense of apparently gullible buyers. This is completely inconsistent with theory and it is particularly striking since, in our design, buyers and sellers are the same subjects, each alternating between being a buyer and a seller throughout the experiment. Second, the antifraud rule increases efficiency over that observed under cheap talk. This increase accrues wholly to the buyers. Two offsetting forces affect sellers' adjusted efficiencies. While they no longer gain at the buyers' expense from trades based on fraudulent, but believed, statements, they do gain from the general increase in efficiency from trades based on often exaggerated, but truth-revealing, statements. Third, while the AF treatment results in the highest efficiencies, they are still much lower than 100%.

In what follows, we will look at the details more closely to try to provide some explanation for these results. To do this, we begin by looking at the two most extreme treatments representing contrasting regulatory environments, NC and AF. Then we will study the CT treatment in detail. In essence, this treatment represents an environment with no regulation and it produced the most striking deviation from theory.

3.3 No communication treatment

This treatment may be interpreted as a "gag rule" that prevents all communications from a seller to a potential buyer. The theory predicts that adverse selection will result in very low efficiency. Under parameter sets I and II, we predict buyers will bid p_l, only sellers with low-quality assets will accept and, hence, only low-quality assets will trade. Because p_m is sufficiently low in parameter set I′, we predict both low- and medium-quality assets will trade at price p_m.

Result 4a. *Buyer behavior in the NC treatment is generally consistent with awareness of the adverse selection problem.*

Table 4
Prices chosen by buyers during the last 11 periods in the NC treatment

Parameter set	Session(s)	Occurrences of price p_l	p_m	p_h	Selten's measure of predictive success of equilibrium consistent prices: Low trade equilibrium	Medium trade equilibrium
I	NC1	44	8	3	0.47*	—
	NC2	46	7	2	0.50*	—
	NC1 & NC2 pooled	90	15	5	0.48*	—
I′	NC3	19	31	5	—	0.23*
	NC4	6	44	5	—	0.47*
	NC3 & NC4 pooled	25	75	10	—	0.35*
II	NC5	45	8	2	0.48*	—
	NC6	48	4	3	0.54*	—
	NC5 & NC6 pooled	93	12	5	0.51*	—

Shows the number of times each price (p_l for low, p_m for medium, or p_h for high) was chosen by buyers during the last 11 periods in the no-communication treatment sessions. Selten's (1991) measure is defined as the fraction of actual prices that are equilibrium consistent minus the fraction of admissible prices that are equilibrium consistent. In all cases the fraction of equilibrium consistent admissible prices is 1/3. The shaded regions indicate equilibrium predicted prices. An "*" indicates a number significantly different than the null hypothesis of random behavior at the 95% level according to two-sided binomial tests.

Result 4b. *Buyer behavior changes in the direction predicted across different parameter sets. When the equilibrium predicts only low-quality assets will trade at the price p_l (parameter sets I and II), most bids are at p_l. When the equilibrium predicts that low- and medium-quality assets will trade at the price p_m (parameter set I′), most bids are at p_m.*

Table 4 gives the frequency of low, medium, and high prices bid by the buyers during the last half of each NC session and then pools over sessions with common parameter sets. The shaded areas of the table show where the observations are consistent with the adverse selection, low-trade equilibrium (bidding only p_l) and the medium- trade equilibrium (bidding only p_m) for parameter set I′. Table 4 also gives Selten's (1991) measure of predictive success. Consider the first row of the table which gives the frequency with which buyers chose each price. Buyers chose p_l, the price consistent with the low-trade equilibrium, 80% of the time. Random choice would lead buyers to chose this price 33% of the time. The difference in these percentages, 47%, is Selten's measure of predictive success.

Under parameter sets I and II, the most frequent bid is p_l and this bid occurs significantly more often than predicted by random bidding (i.e., Selten's measure is significantly greater than zero). By the last half of each session, $90/110 = 82\%$ and $93/110 = 85\%$ of the bids were p_l for parameter sets I and II, respectively. Under parameter set I′, Selten's measure for the medium-trade equilibrium always significantly exceeds zero (implying buyers bid p_m more often than predicted by random bidding). These results demonstrate that the predictive success of the adverse selection model is not due to buyers naively bidding p_l. Instead, the bidding strategies change as predicted according to the parameter sets.

3.4 Antifraud treatment

This treatment corresponds to the theoretical remedy for adverse selection: an antifraud rule. The prediction for parameter sets I and II is that the minimum quality element in a seller's declaration will be the true state and buyers will bid the price associated with this state. If so, these markets will be efficient and all assets will trade at their complete information prices, benefiting both buyers and sellers. Under parameter set I′, there are two possible equilibria — a full disclosure equilibrium and a partial disclosure equilibrium. In the partial disclosure equilibrium, low- and medium-quality sellers disclose $\{l, m\}$ or $\{l, m, h\}$ while high-quality sellers disclose $\{h\}$. Thus the low- and medium-quality sellers pool and buyers pay p_m for both qualities.

Overall, sellers generally take advantage of the antifraud rule, exaggerating their announcements, but usually disclosing the true quality as the minimum announced quality. Buyers typically respond to vague disclosures with skepticism. This leads to significantly higher efficiency than in the NC and CT treatments. However, in the full disclosure equilibrium, sellers should completely reveal themselves and buyers should put no weight on anything other than the minimum disclosed state. The results fall short of this outcome.

Result 5. *In the AF treatment, sellers' "minimal" claims about their assets' qualities are generally consistent with the full disclosure prediction.*

Table 5 gives the frequency of different disclosure choices for each possible state outcome for the last half of each session. The shaded areas show the disclosures in which the minimum disclosed element is the true asset quality. These are the predicted disclosures for the full disclosure equilibrium. Seller behavior is generally consistent with the prediction. For example, in AF1, medium-quality sellers disclosed $\{l, m, h\}$ once, $\{m\}$ ten times, and $\{m, h\}$ seven times.[12] Thus the minimum state disclosed equals the true state $17/18 = 94\%$ of the time. For medium- and high-quality sellers, the minimum value of their disclosures equals the true state outcome 85% of the time for parameter set I and 71% of the time for parameter set II.[13]

[12] In the experiment, sellers were asked whether they wanted to send messages to buyers. If they responded affirmatively, they could not send the message $\{l, m, h\}$ since that message is equivalent to sending no message. For reporting purposes, however, we report a seller's choice to send no message as $\{l, m, h\}$ since this explicitly shows all states are possible and the minimal element of the set is l.

[13] There is no prediction for the low-quality state because, in the low-quality state, disclosures that do not include the low state are not allowed in the AF treatment.

Table 5
Frequency of sellers' announcements for each state outcome during the last 11 periods in the AF treatment

Parameter set	Session(s)	State	Seller's announcement {l}	{l,m}	{l,h}	{l,m,h}	{m}	{m,h}	{h}	Total
I	AF1	l	6	7	2	7	na	na	na	22
		m	na	0	na	1	10	7	na	18
		h	na	na	0	3	na	1	11	15
	AF2	l	5	2	3	13	na	na	na	23
		m	na	1	na	2	8	5	na	16
		h	na	na	0	1	na	1	14	16
	AF1 & AF2	l	11	9	5	20	na	na	na	45
	pooled	m	na	1	na	3	18	12	na	34
		h	na	na	0	4	na	2	25	31
I′	AF3	l	3	6	6	5	na	na	na	20
		m	na	1	na	2	5	5	na	13
		h	na	na	1	3	na	3	15	22
	AF4	l	1	6	7	9	na	na	na	23
		m	na	1	na	4	4	9	na	18
		h	na	na	0	2	na	0	12	14
	AF3 & AF4	l	4	12	13	14	na	na	na	43
	pooled	m	na	2	na	6	9	14	na	31
		h	na	na	1	5	na	3	27	36
II	AF5	l	2	1	6	8	na	na	na	17
		m	na	1	na	3	4	10	na	18
		h	na	na	1	7	na	4	8	20
	AF6	l	5	4	3	3	na	na	na	15
		m	na	1	na	4	8	9	na	22
		h	na	na	0	0	na	2	16	18
	AF5 & AF6	l	7	5	9	11	na	na	na	32
	pooled	m	na	2	na	7	12	19	na	40
		h	na	na	1	7	na	6	24	38

Shows the number of times each announcement set (l for low, m for medium, and h for high quality) was chosen by sellers during the last 11 periods in the antifraud treatment sessions. The shaded regions indicate announcements consistent with the full disclosure equilibrium. Entries labeled "na" were not applicable because the AF treatment did not allow these announcements.

A statistical analysis of the equilibrium-consistent announcements is given in Table 6. Here we give Selten's measure of predictive success for the conjecture that the minimum element announced is the true state (which supports the full disclosure equilibrium). In all but three cases (medium-quality sellers in AF3 and AF4 and high-quality sellers in AF5), Selten's measure is significantly positive. Thus sellers are consistently more likely to behave in a manner consistent with this equilibrium than not.[14]

[14] The data from parameter set I′ (AF3 and AF4) shows what happens to sellers' disclosures when either partial or full disclosure can be equilibrium strategies. The disclosure of the medium- and high-quality sellers are consistent with the full disclosure prediction $50/67 = 75\%$ of the time overall. The pooled results are consistent with the partial pooling equilibrium $61/110 = 55\%$ of the time. To see whether pooling or separating behavior is more prevalent, note that the full disclosure and partial disclosure equilibria make mutually exclusive predictions for medium-quality sellers under parameter set I′. The seller discloses either $\{m\}$ or $\{m, h\}$ in the full disclosure equilibrium but discloses either $\{l, m\}$ or $\{l, m, h\}$ in the partial disclosure equilibrium. The results favor the full disclosure equilibrium $23/31 = 74\%$ of the time and the partial disclosure equilibrium $8/31 = 26\%$ of the time. Pooling across sessions, there

Table 6
Tests for predictive success of the full disclosure (sequential) equilibrium in the AF treatment

		Predictive success of sequential equilibria			
		Seller behavior		Buyer behavior	
Parameter set	Session(s)	State	Equilibrium consistent announcements	Minimum element in announced set	Equilibrium consistent bid responses
I	AF1	l	—	l	0.55*
		m	0.44*	m	0.50*
		h	0.48*	h	0.67*
	AF2	l	—	l	0.67*
		m	0.31*	m	0.67*
		h	0.63*	h	0.67*
	AF1 & AF2 pooled	l	—	l	0.32*
		m	0.38*	m	0.46*
		h	0.56*	h	0.44*
I′	AF3	l	—	l	0.30*
		m	0.27	m	0.45*
		h	0.43*	h	0.33*
	AF4	l	—	l	0.33*
		m	0.22	m	0.28
		h	0.61*	h	0.58*
	AF3 & AF4 pooled	l	—	l	0.32*
		m	0.24*	m	0.40*
		h	0.50*	h	0.44*
II	AF5	l	—	l	0.43*
		m	0.28*	m	0.11
		h	0.15	h	0.42*
	AF6	l	—	l	0.42*
		m	0.27*	m	0.25*
		h	0.64*	h	0.25*
	AF5 & AF6 pooled	l	—	l	0.42*
		m	0.28*	m	0.18*
		h	0.38*	h	0.38*

For the AF treatment, Table 6 gives tests for predictive success of the full disclosure (sequential) equilibrium in which the minimal quality element in the seller's announcement set is the actual quality of the item and the buyer's bid price is consistent with this quality. Selten's (1991) measure is defined as the fraction of actual responses that are equilibrium consistent minus the fraction of admissible responses that are equilibrium consistent. An "*" indicates a number significantly different than the null hypothesis of random behavior at the 95% level according to two-sided binomial tests.

Result 6. *In the AF treatment, the prices bid by buyers in response to sellers' "minimal" announcements are generally consistent with the full disclosure equilibrium.*

Table 7 gives the frequency of buyers' low, medium, and high price bids for each possible disclosure received for the last half of each session. The shaded numbers are the prices that correspond to the minimum quality in the seller's disclosure, which is the predicted price for the full

is a significant tendency (at the 5% level) for medium-quality sellers to make announcements consistent with the full disclosure equilibrium instead of the partial disclosure equilibrium.

disclosure equilibrium. For example, in AF1, buyers responded to the disclosure of $\{l, m\}$ with five bids of the predicted price p_l and two optimistic bids of p_m. Overall the price predicted by the full disclosure equilibrium is bid $104/110 = 95\%$ of the time in parameter set I sessions and $73/110 = 66\%$ of the time in parameter set II sessions. Table 6 shows that Selten's measures of predictive success for the full disclosure equilibrium bidder responses are generally significantly positive. Thus, with two exceptions (announcements with minimal elements "m" in AF4 and AF5), buyers bid significantly more often in ways consistent with this equilibrium than not.[15]

3.5 Cheap-talk treatment

Three aspects of our design imply that, in theory, results under the CT treatment should mirror those under the NC treatment. First, announcements are nonbinding. Second, the randomized matching and anonymous communication do not allow for reputation formation. Third, sellers have a clear incentive to make false announcements. Taken together, these aspects imply that announcements should have no meaning and no effect on the buyers. However, we have already shown that cheap talk increases efficiency relative to no communication and these increases accrue mostly to the sellers at the expense of the buyers. Here we study the behavior leading to these results in more detail.

Overall, sellers display a slight tendency to reveal the true state as the minimum announced quality in their disclosures. As a result, buyers can rationally put some faith in these nonbinding announcements. However, sellers are also quite willing to lie and include only qualities higher than the actual qualities in their announcements. Buyers deceived by such announcements pay inflated prices relative to the asset's quality. Overall, buyers are overinfluenced by sellers' announcements. They end up losing because the announcements they appear to believe are much more likely to be fraudulent than truthful.

Result 7. *In the absence of the antifraud rule, sellers frequently make fraudulent announcements, including only qualities higher than the true quality. However, sellers' "minimal" announcements tend to correlate weakly with the true quality.*

[15] Tables 6 and 7 show whether buyer responses are more consistent with the full or partial disclosure equilibrium. For the sessions using parameter set I′, the partial disclosure equilibrium predicts that buyers will bid p_m in response to an $\{l, m\}$ or $\{l, m, h\}$ disclosure, while the full disclosure equilibrium predicts that buyers will bid p_l in this case. All other predictions are the same between the two equilibria. As seen in Table 7, $\{l, m\}$ or $\{l, m, h\}$ is disclosed 39 times in AF3 and AF4 combined and the results are consistent with the full disclosure equilibrium $23/39 = 59\%$ of the time. They are consistent with the partial disclosure equilibrium $13/39 = 33\%$ of the time. Combining these buyer responses to all disclosures, Table 6 shows support for the full disclosure equilibrium according to Selten's measure. There is no significant evidence that buyers bid as predicted by the partial disclosure equilibrium.

Table 7
Prices chosen by buyers given sellers' announcements during the last 11 periods in the AF treatment

Parameter set	Session(s)	Price	Seller's announcement {l}	{l,m}	{l,h}	{l,m,h}	{m}	{m,h}	{h}	Total
I	AF1	p_l	6	5	2	10	2	1	0	26
		p_m	0	2	0	1	8	7	0	18
		p_h	0	0	0	0	0	0	11	11
	AF2	p_l	5	3	3	16	0	0	0	27
		p_m	0	0	0	0	8	6	0	14
		p_h	0	0	0	0	0	0	14	14
	AF1 & AF2 pooled	p_l	11	8	5	26	2	1	0	53
		p_m	0	2	0	1	16	13	0	32
		p_h	0	0	0	0	0	0	25	25
I′	AF3	p_l	3	1	5	8	1	0	4	22
		p_m	0	5	2	2	4	7	1	21
		p_h	0	1	0	0	0	1	10	12
	AF4	p_l	1	4	5	10	1	3	1	25
		p_m	0	3	1	3	3	5	0	15
		p_h	0	0	1	2	0	1	11	15
	AF3 & AF4 pooled	p_l	4	5	10	18	2	3	5	47
		p_m	0	8	3	5	7	12	1	36
		p_h	0	1	1	2	0	2	21	27
II	AF5	p_l	2	1	6	13	1	8	1	32
		p_m	0	1	0	4	3	5	1	14
		p_h	0	0	1	1	0	1	6	9
	AF6	p_l	5	3	2	5	2	6	4	27
		p_m	0	2	0	2	6	5	1	16
		p_h	0	0	1	0	0	0	11	12
	AF5 & AF6 pooled	p_l	7	4	8	18	3	14	5	59
		p_m	0	3	0	6	9	10	2	30
		p_h	0	0	2	1	0	1	17	21

Shows the number of times each price (p_l for low, p_m for medium, or p_h for high) was chosen by buyers during the last 11 periods in the antifraud treatment sessions given the sellers' announcement sets (l for low, m for medium, and h for high quality). The shaded regions indicate price responses consistent with the full disclosure equilibrium.

Table 8 shows sellers' disclosures for each state outcome during the last half of the six CT sessions. The shaded region indicates the seller announcements that are fraudulent. As seen in the table, sellers definitely took advantage of not being constrained by an antifraud rule. In CT1, for example, the 21 low-quality sellers made 8 exaggerated, but not fraudulent, announcements (i.e., announcements that included states higher than the true state as well as the true state) and 13 fraudulent announcements (i.e., inflated announcements which excluded the truth). The 14 medium-quality sellers made 3 exaggerated, but not fraudulent, announcements and 11 fraudulent announcements. Overall, low- and medium-quality sellers made fraudulent announcements 47% of the time. There is considerable variation in this statistic over the six CT sessions, however. Low- and medium-quality sellers in CT2 made fraudulent claims 68% of the time while low- and medium-quality sellers in CT6 committed fraud in only 26% of their announcements. Pooling over the last half of all six CT ses-

Table 8
Frequency of sellers' announcements for each state outcome during the last 11 periods of the CT treatment

			Announcement							
Parameter set	Session(s)	State	{l}	{l,m}	{l,h}	{l,m,h}	{m}	{m,h}	{h}	Total
I	CT1	l	0	1	1	6	2	5	6	21
		m	0	0	1	3	0	0	10	14
		h	3	1	1	2	0	2	11	20
	CT2	l	0	1	1	4	5	2	10	23
		m	2	0	0	0	4	0	6	12
		h	1	2	0	1	0	0	16	20
	CT1 & CT2	l	0	2	2	10	7	7	16	44
	pooled	m	2	0	1	3	4	0	16	26
		h	4	3	1	3	0	2	27	40
I′	CT3	l	5	0	1	7	2	0	5	20
		m	0	1	1	3	0	3	9	17
		h	0	0	0	4	0	1	13	18
	CT4	l	2	0	0	6	4	2	8	22
		m	1	0	0	8	2	0	3	14
		h	1	0	0	1	0	0	17	19
	CT3 & CT4	l	7	0	1	13	6	2	13	42
	pooled	m	1	1	1	11	2	3	12	31
		h	1	0	0	5	0	1	30	37
II	CT5	l	3	1	0	5	1	1	3	14
		m	0	1	0	6	6	0	5	18
		h	1	0	0	8	0	0	14	23
	CT6	l	2	0	0	6	2	0	5	15
		m	2	2	0	5	6	2	2	19
		h	1	0	1	2	5	0	12	21
	CT5 & CT6	l	5	1	0	11	3	1	8	29
	pooled	m	2	3	0	11	12	2	7	37
		h	2	0	1	10	5	0	26	44

Shows the number of times each announcement (l for low, m for medium, and h for high quality) was chosen by sellers during the last 11 periods in the cheap-talk treatment sessions. The shaded regions indicate announcements that are fraudulent in the sense that minimum announced quality is strictly higher than the actual quality.

sions, the rank-order correlation between the minimum state in the seller's disclosure and the true state is .27, which is significant at the .0001 level (330 observations). It is therefore not completely irrational for buyers to place some faith in the sellers' claims. However, the correlation ranges from .16 in CT1 to .40 in CT3, so the relation is always far from fully revealing.[16]

Result 8. *Cheap talk influences buyers, inducing them to bid higher on average than they do with no communication. Increasing the costs of overbidding relative to the true quality does not reduce this tendency.*

[16] For comparison, the correlation between the minimum disclosed state and the true state in the AF treatment is .79, which differs significantly from zero (at the .0001 level).

Table 9 gives the buyers' bids for each seller announcement over the last half of the CT sessions. In theory, the announcement should not affect buyer behavior and buyers should bid p_l in the sessions with parameter sets I and II, as in the NC treatment. However, 39% (43/110) of the bids were higher than p_l in the parameter set I sessions and 37% (41/110) were higher than p_l in the parameter set II sessions. This is considerably more than in the NC sessions, where the parameter set I and parameter set II sessions had 18% and 15% of the bids higher than p_l, respectively. A chi-square test of the relative frequency of p_l bids between the NC and CT treatments using parameter sets I and II is significant at the .0001 level (440 observations). Similarly, for the sessions using parameter set I′ the bid should never be p_h, yet p_h was bid 25% of the time in the parameter set I′ CT sessions compared to only 9% of the time in the parameter set I′ NC sessions. A chi-square test of the relative frequency of p_h bids between the NC and CT sessions using parameter set I′ is significant at the .001 level (220 observations). Overall the bids are considerably higher in the presence of cheap talk than when communication was prohibited. Treating each session as an observation, the CT sessions have uniformly more p_m and p_h bids under parameter sets I and II and uniformly more p_h bids under parameter set I′; a Wilcoxon ranked-sum test is significant at the .001 level. Clearly the sellers' ability to make noncredible (and frequently fraudulent) announcements significantly influenced the buyers' bidding behavior.

Parameter set II was created to increase the cost to buyers, relative to parameter set I, of bidding p_h. With parameter set I, the buyer loses 50 by bidding p_h and receiving the average-quality asset in return; in parameter set II, the buyer loses 167 by doing this. Nonetheless, as seen in Table 9, the fraction of p_h bids varied little across the parameter sets. Of the 110 bids under each, 25% of the bids were p_h under parameter set I and 23% were p_h under parameter set II. (Both parameter sets resulted in 15% of the bids at p_m.) A chi-square test of the relative frequency of p_h bids between parameter set I and II is insignificant with a p-value of only .75 (220 observations). It appears that this more than threefold increase in the expected loss to bidding p_h had little effect on buyers' behavior.

Result 9. *The small correlation between sellers' "minimal" announcements and true qualities implies that buyers may have a small reason to believe sellers' statements. However, buyers are overly influenced by the (typically fraudulent) announcements.*

Given that there is a weak correspondence between the true state of nature and the sellers' disclosures in the CT treatment, it may not be irrational for the buyers to be influenced by them. Indeed, the rank-order correlation between the buyer's bid and the minimum state in the seller's disclosure is .34, pooling over the last half of all six CT sessions, which is significant at the .0001 level. However, the wealth transfer from the buyers to the

Table 9
Prices chosen by buyers given sellers' announcements during the last 11 periods in the CT treatment

Parameter set	Session(s)	Price	Seller's announcement {l}	{l,m}	{l,h}	{l,m,h}	{m}	{m,h}	{h}	Total
I	CT1	p_l	3	2	3	9	1	3	16	37
		p_m	0	0	0	1	1	2	2	6
		p_h	0	0	0	1	0	2	9	12
	CT2	p_l	3	2	0	4	2	1	18	30
		p_m	0	1	0	1	7	0	1	10
		p_h	0	0	1	0	0	1	13	15
	CT1 & CT2 pooled	p_l	6	4	3	13	3	4	34	67
		p_m	0	1	0	2	8	2	3	16
		p_h	0	0	1	1	0	3	22	27
I′	CT3	p_l	2	0	1	5	0	0	5	13
		p_m	3	1	1	8	1	3	12	29
		p_h	0	0	0	1	1	1	10	13
	CT4	p_l	3	0	0	7	2	0	11	23
		p_m	1	0	0	8	4	1	3	17
		p_h	0	0	0	0	0	1	14	15
	CT3 & CT4 pooled	p_l	5	0	1	12	2	0	16	36
		p_m	4	1	1	16	5	4	15	46
		p_h	0	0	0	1	1	2	24	28
II	CT5	p_l	3	2	0	16	3	0	9	33
		p_m	1	0	0	3	3	0	2	9
		p_h	0	0	0	0	1	1	11	13
	CT6	p_l	5	2	1	9	11	2	6	36
		p_m	0	0	0	4	1	0	2	7
		p_h	0	0	0	0	1	0	11	12
	CT5 & CT6 pooled	p_l	8	4	1	25	14	2	15	69
		p_m	1	0	0	7	4	0	4	16
		p_h	0	0	0	0	2	1	22	25

Shows the number of times each price (p_l for low, p_m for medium, or p_h for high) was chosen by buyers during the last 11 periods in the cheap-talk treatment sessions given the sellers' announcement (l for low, m for medium, and h for high quality).

sellers shown in panel B of Table 2 demonstrates that buyers are *overly* influenced by the sellers' disclosures. Although our setting is highly stylized, this evidence is consistent with the SEC's concern that presales "puffery" can generate unwarranted optimism in buyers' beliefs. The next section investigates individual behavior in more detail to provide further insights into how subjects can overstate their assets' values when acting as sellers and yet can be taken in by such disclosures when acting as buyers.

3.6 Dishonesty and gullibility under cheap talk

The results under the CT treatment are sufficiently intriguing to warrant further investigation. For example, it is possible that a few individual buyers are entirely responsible for the observed wealth transfer from the buyers to the sellers, and that, when acting as buyers, most of the subjects are not so easily misled. Similarly, it is possible that the correlation between the true outcome and the sellers' disclosures is driven by a few pathologically honest subjects. To investigate these possibilities we compute a gullibility index and a dishonesty index for each subject. The gullibility index is the number of times the subject, when acting as a buyer, bid more than p_l in response to a seller's disclosure that the asset quality is strictly better than the low (i.e., $\{m\}$, $\{m, h\}$, or $\{h\}$), divided by the number of times the subject observed this type of disclosure. It measures the subject's propensity to bid more than p_l when observing a disclosure that claims the asset to be strictly better than the lowest quality. The dishonesty index is the number of times the subject, when acting as a seller, had a low- or medium-quality asset to sell and made a disclosure whose minimum state exceeded the true state of nature, divided by the number of times the subject had a low- or medium-quality asset to sell. It measures the subject's propensity to lie outright about the quality of her asset when the asset is not of the highest quality. Both measures range between 0 and 1, with 1 representing the highest possible level of gullibility or dishonesty.

Result 10. *Dishonesty and gullibility levels are both widely and evenly distributed across subjects.*

The distribution of the gullibility index over the 66 subjects (6 cheap-talk sessions and 11 subjects per session) is close to uniformly distributed over the interval [0, 1]. Its 25th percentile is at .29, its median value is .5, and its 75th percentile is at .71. The dishonesty index's mass is also evenly distributed, but over a somewhat smaller and lower interval. Its 25th percentile is at .20, its median value is .40, and its 75th percentile is at .67. Thus subjects do not appear to sort neatly into honest/dishonest and gullible/skeptical categories. Further, the dishonesty and gullibility is not concentrated in just a few individuals; 15 of the 66 subjects have gullibility measures greater than .75 and 13 of them have dishonesty measures greater than .75.

Result 11. *Dishonesty and gullibility levels are positively correlated across subjects.*

Comparing each subject's level of gullibility to her level of dishonesty shows a significant relation between these two measures. The rank-order correlation between the measures is .31, which is significant with a p-value of .01. Subjects who are more inclined to lie to others are also more inclined to be influenced by others' disclosures. It is as if they believe they are the only ones capable of dishonesty. In some sense, this is a consistent belief; for lying to be profitable, a seller must believe that others will be taken in by false disclosures.[17]

[17] This observation caused one economist to summarize our findings as "There's half a sucker born every minute."

Result 12. *Subjects appear to learn to be less gullible after observing dishonesty in others. However, they do not appear to learn to be dishonest after observing gullibility in others.*

We investigate whether the level of a subject's gullibility or dishonesty is determined by the observed history of other subjects' behavior. To do this we compute what each subject empirically observed of other subjects' gullibility and dishonesty measures. That is, the observed gullibility index is the number of times the subject, when acting as a seller, observed a buyer bid more than p_l in response to a disclosure that the asset quality is strictly better than low (i.e., $\{m\}$, $\{m, h\}$, or $\{h\}$), divided by the number of times the subject made this disclosure. Similarly the observed dishonesty index is the number of times the subject, when acting as a buyer, observed a seller with a low- or medium-quality asset make a disclosure whose minimum state exceeded the true state of nature, divided by the number of times the subject interacted with a seller of a low- or medium-quality asset. We then compute the rank-order correlation between the subject's observed frequency of the gullibility and dishonesty of others during the first half of each session with the subject's own gullibility and dishonesty during the second half of each session. We find a significant negative correlation between the observed dishonesty during the first half of the session and the subject's own gullibility during the second half of the session; the correlation is $-.36$ and is significant at the .003 level. We find no significant correlation between the observed level of gullibility in the first half of the session with the subject's own level of dishonesty in the second half of the session. This suggests that subjects who are most frequently lied to are less gullible in the future, but that subjects who observe that others are particularly gullible do not exploit the observation with more lying.

4. Conclusions

We have studied issues surrounding informational asymmetry in financial markets along with a proposed remedy for the resulting adverse selection problem. Previous studies have not allowed sellers to withdraw from the market nor have they contrasted alternative communication mechanisms. With our design, we establish a benchmark for the extent of adverse selection when communication is prohibited and then study the effect of two types of communication on this environment. The first was unrestrained communication or "cheap talk." The second mechanism required all communication to obey an antifraud rule, where all statements made by sellers could not completely rule out the truth. By design we constructed a controlled environment that is far less complex than those found in existing financial markets or in any experimental asset market studies. This allows us to be as true to theory as possible in order to study the pure behavioral aspects of adverse selection. It is possible that in more complicated environments these findings would change. Such changes would not invalidate our results but could be used to isolate and identify the institutional and behavioral interactions that caused these different results.

In our no communication benchmark, adverse selection occurs, but not to the full extent that theory would predict. Further, the antifraud rule is largely, but not completely, capable of eliminating it. Surprisingly we also find that cheap talk significantly reduces adverse selection. In part, this arises because there is some truth in the sellers' communications. However, buyers are often fooled by untruthful seller disclosures and purchase assets at inflated prices. Although both effects increase the number of efficient trades, the latter effect transfers the gains from the buyers to the sellers. Imposing the antifraud rule improves allocations further, but it does not fully eliminate adverse selection. Of interest, the additional efficiency gains accrue to the buyers. The sellers are not significantly better off relative to the cheap-talk treatment.

The fact that noncredible communication — cheap talk — can have such a dramatic effect in our markets is inconsistent with existing theory. Its effect could also not have been anticipated from previous experimental studies. Most cheap-talk studies have looked at environments where players' preferences are aligned. The findings of the one study [Dickhaut, McCabe, and Mukherji (1995)] that varied the extent to which preferences diverged suggest that buyers should find cheap talk completely uninformative in our setting.

In our environment, subjects had no opportunity, and knew they would have no opportunity, to exploit any reputation effects. As sellers, they were matched with each other subject only once and all interaction was anonymous through a computer terminal. Further, to promote a better understanding of each player's role, subjects alternated between being a buyer and being a seller. It is therefore most surprising that subjects can make a dishonest claim to another subject in one period and then be so gullible in the next period as to be taken in by another subject's dishonest claim. Counter to what one might expect, we find that the subjects who are dishonest sellers tend to be gullible buyers.

Our results suggest that regulators' fears about the effect of noncredible communication on uninformed parties may be well founded. In situations where antifraud provisions cannot be applied, gag rules may be justified. In addition, there are three recent examples where our findings suggest there is some cause for concern. First, our results imply that there may be a basis for the concerns of the NASD and the SEC about the on-line stock forums available over the Internet. This concern arises since the identity and profession of an individual commenting in these forums is not verifiable. Because of this, an ordinary investor who participates in these forums may be taken advantage of since the investor cannot tell whether investment advice reflects the enthusiasm of other ordinary investors or is outright fraud by interested parties [Lohse (1996)].

Second, our results lend credence to the SEC's concern that internal memos written by investment houses evaluating IPOs are being leaked to some investors [Pulliam (1997)]. Such information can cause problems if investors are gullible because, being an internal document, underwriters can provide an overly optimistic outlook for an IPO.

Finally, the Justice Department recently brought charges against a number of individuals for manipulating the prices of thinly traded "microcap" stocks [Weiss (1997)]. Justice's case relies on the argument that cold-callers can prey on a gullible, uninformed public, getting them to purchase blocks of stocks at vastly inflated prices. Whereas a sophisticated, rational investor would simply ignore these unsubstantiated claims, our findings suggest that there may indeed be a need to protect such gullible investors.

Appendix

These are the instructions for the three different communication settings where the buyer chooses price. Text shown in braces { } is for the adverse selection setting only; text shown in brackets [] is for the cheap-talk *and* credible disclosure settings; text shown in double braces {{}} is for the cheap-talk setting only; text shown in double brackets [[]] is for the credible disclosure setting only. The rest of the text is common to all three settings.

INSTRUCTIONS

General

You are about to participate in an experiment in the economics of decision making. If you follow these instructions carefully and make good decisions, you might earn a considerable amount of money that will be paid to you in cash at the end of the experiment.

The experiment will consist of a series of separate decision making periods. Each period consists of two phases. In Phase I you will be paired with another person and, based upon your combined actions, you will be able to earn points. In Phase II, you will have the opportunity to earn dollars based upon the points you earn in Phase I. We begin by describing Phase II so that you understand how the points you earn affect the number of dollars you earn. Then, we describe Phase I in detail so that you understand how to earn points.

Phase II Instructions

At the end of Phase I, you will have earned between 0 and 1000 points according to the rules we will discuss below. The number of dollars you earn in Phase II will depend partly on the number of points you earned in Phase I and partly on chance. Specifically, we have a box which contains lottery tickets numbered 1 to 1000. In Phase II, a ticket will be randomly drawn from the box. If the number on the ticket IS LESS THAN OR EQUAL TO the number of points you have earned in Phase I, you WIN $1.50. If the number on this ticket IS GREATER THAN the number of points you have earned in Phase I, you WIN $0.00. For example, if you have 600 points, you will have a 60%

chance of winning $1.50. Notice that the more points you have, the larger will be your chance of winning the $1.50 prize.

Phase I Instructions

In each decision making period, you will be paired with another person. One of you will be designated the Column player and the other will be designated the Row player. You will alternate from being the Column player to being the Row player from one period to the next. Since there is not an even number of people participating in this experiment, you will occasionally be required to not participate during a particular period. At the beginning of each period you will be told via your terminal whether you are a Row or Column player or are sitting out this period. In your folder you will find a record/profit sheet. On this sheet you will indicate, based on the message previously received on your terminal, whether you are a Row or Column player or are sitting out this period.

During today's experiment you will play against each person twice — once as a Row player and once as a Column player. Each period, the computer randomly determines which player you are paired with. However, you will not know the identification of the person you are playing against in any period. Similarly, nobody in your decision making pair will know your identification in any period. Further, you will not be told who these people are either during or after the experiment.

Each period, the game will proceed as follows: First, the Column player will learn which one of three payoff tables is being used this period. {Next, the Row player selects an action and, after learning what action the Row player selected, the Column player selects an action.} [Next, if he or she chooses, the Column player can send a message to the Row player regarding which table was chosen.] {{If the Column player sends a message, it need not include the table that was actually drawn.}} [[If the Column player sends a message, it must include the table that was actually drawn.]] [Finally, the Row player selects an action and, after learning what action the Row player selected, the Column player selects an action.] The points earned by both players is determined by the actions each selects and actual payoff table being used.

More specifically, at the beginning of each period the payoff table is randomly chosen by the computer. Each table is equally likely and as such has a 1 in 3 (33%) chance of occurring each period. Further, the payoff table used by each pair of players is determined by a separate independent drawing. Since each payoff table is identified by a color, Red, White or Blue, the Column player will receive a message on his or her terminal stating the color of the "true" table for the period. The computer will not inform the Row player of the color of the table drawn.

{Next, the Row player will choose an action.} [The Column player need not send any message.] {{However, if the Column player does send a message, he or she can declare a table or a set of tables but is not required to include the color of the true table from the message.}} [[However, if the Column player does send a message, then he or she cannot exclude the color of the true table from the message. In other words, the color of the actual table must be included in the message which the Column player sends.]] [After the Column player sends a message or decides to not send a message, the Row player will choose an action.] The Column player will be told the Row player's action and will also be asked to select an action. The Row and Column players' combined actions and the payoff table determined by the color of the table drawn at the beginning of the period determines the number of points earned by both players.

In the next part of the instructions we will be referring to specific numbers of points. These numbers are the same as you will be using in today's experiment.

Specific Instructions to the Column Player
In those periods in which you are the Column player, you will first be told the color of the table drawn for the period. If, for instance, the White table was drawn, you would receive the following message:

The color of the true table is white

Record this information on your record sheet. The Row player will not be told the color of the table drawn.

[**Message Stage**
After the computer informs you of the color of the true table, you will be asked:

Do you wish to declare a table (Y/N)

Enter Y for yes if you wish to send a message to the Row player about which table or tables have occurred and enter N for no if you do not wish to send a message to the row player. You will then be given the opportunity to verify your response.

If you chose to declare a table you will then be asked:

Which Table(s) would you like to declare?

Red (Y/N)

After responding Yes or No to whether you wish to declare the Red table, you will be prompted to give a Yes or No response for the White and the Blue Table, each in turn.] [[Since you MUST include the color of the actual table in your message, the computer will automatically assume a Yes response to that table.]] [You may not respond Yes to all three tables nor may you respond No to all three tables. After deciding which tables you wish to declare, you will be asked to verify your response. After sending your message to the Row player, you will enter the action stage of Phase I.]

Action Stage
The Row player will then choose either action R1, action R2 or action R3. The Row player's action choice will be displayed on your terminal by highlighting the appropriate column on the true table. As the Column player, you may then either choose action C1 or action C2. The computer will send you the following message:

You may choose 1–2. Your decision?

Enter the number of the column (1 or 2) you wish to choose. A light bar will highlight your choice on the screen. You will then be given an opportunity to verify your choice.

The number of points earned by you is given by the following table for each pair of actions you and the Row player might select, and each possible color of the payoff table. (Note that these tables appear in the appropriate color on your screen: the Red table appears in red, the White table appears in white and the Blue table appears in blue.)

Number of points earned by the Column player

	Column player's action			Column's player action			Column player's action		
Row player's action	33%	C1	C2	33%	C1	C2	33%	C1	C2
	R1	200	0	R1	200	250	R1	200	500
	R2	450	0	R2	450	250	R2	450	500
	R3	600	0	R3	600	250	R3	600	500
	Red table			White table			Blue table		

To read these tables, notice first that the likelihood of a given table occurring appears in the upper left hand corner of each table. Since each table is equally likely, each has a 1 in 3 chance (33%) of occurring. Next, suppose the color of the payoff table drawn was red, you chose action C1 and the Row player chose action R2. You would then earn 450 points. Similarly, suppose the color of the payoff table drawn was white, you chose action C2 and the Row player chose action R3. You would then earn 250 points. In a like manner, you can use these tables to determine the number of points you would earn for all other combinations of your actions, the Row player's actions and colors of payoff tables. Recall that when you make your action choice you will know the color of the true payoff table and the Row player's action choice. The Row players also earn points depending upon the color of the payoff table, the action you select and the action they select.

Once both you and the Row player have selected actions and entered them into the computer, the computer will determine the number of points earned by you based on the table corresponding to the color of the payoff table that was drawn. The result is then sent to you via your terminal. The message will look like the one below:

You received _ points.

At the end of the period, you are to record your point earnings for Phase I on your record sheet. The computer will also inform you about the action taken by the Row player and the color of the payoff table drawn at the beginning of the period. You are also to record the color of payoff table, your action choice and the action choice of the Row player on your record sheet. Make sure you check your earnings in points against the computer's calculations.

Specific Instructions for the Row Player

{In those periods in which you are a Row player, you may choose either action R1, action R2 or action R3.} [In those periods in which you are a Row player, you will begin by receiving a message from the Column player. If the Column player has decided not to declare any tables you will receive the message:

The column player has not declared any tables.

If the Column player has decided to declare one or more tables then you will receive the appropriate message. For instance, if the true table was White and the Column player chose to declare the White and Blue Tables, you would receive the message:

The column player has declared
White Blue Table(s).]

{{Remember that the Column player does not have to include the color of the true table in his or her message.}} [[Remember that the color of the true table is always included in the Column player's message.]] [After receiving this message, you will choose an action. You may choose either action R1, action R2 or action R3.] After observing your action choice, the Column player may either choose action C1 or action C2. The number of points earned by you is given by the following table for each pair of actions you and the Column player might select, and each possible color of the payoff table. (Note that these tables appear in the appropriate color on your screen: the Red table appears in red, the White table appears in white and the Blue table appears in blue.)

Number of points earned by the Row player

	Column player's action			Column's player action			Column player's action		
Row player's action	33%	C1	C2	33%	C1	C2	33%	C1	C2
	R1	400	350	R1	700	350	R1	1000	350
	R2	150	350	R2	450	350	R2	750	350
	R3	0	350	R3	300	350	R3	600	350
	Red table			White table			Blue table		

To read these tables, notice first that the likelihood of a given table occurring appears in the upper left hand corner of each table. Since each table is equally likely, each has a 1 in 3 chance (33%) of occurring. Next, suppose the color of the payoff table drawn was red and you chose action R2 and the Column player chose action C1. You would then earn 150 points. Similarly, suppose the color of the payoff table drawn was white, you chose action R3 and the Column player chose action C2. You would then earn 350 points. In a like manner, you can use this table to determine the number of points you would earn for all other combinations of your actions, the Column player's actions and colors of payoff tables. The Column players also earn points depending upon the color of the payoff table, the action you select and the action they select.

When it is time for you to select an action, you will receive a message stating:

You may choose 1–3. Your decision?

Enter the number of the row (1, 2, or 3) you wish to choose. A light bar will highlight your choice on the screen. You will then be given an opportunity to verify your response.

Once both you and the Column player have selected actions and entered them into the computer, the computer will determine the number of points earned by you based on the table corresponding to the color of payoff table that was drawn. The result is then sent to you via your terminal. The message will look like the one below:

You received _ points.

At the end of the period, you are to record your point earnings for Phase I on your record sheet. The computer will also inform you about the action taken by the Column player and the color of the payoff table drawn at the beginning of the period. You are also to record the color of payoff table drawn, your action choice and the action choice of Column player on your record sheet. Make sure you check your earnings in points against the computer's calculations.

Phase II Recording Rules

After completing your Phase I record sheet for a given decision making period, you are to use your profit sheet to record the dollars you earn in Phase II. First, record your Phase I point earnings in the row corresponding to the number of the period that is currently being conducted. The person who sat out in this period will then be asked to draw a lottery ticket from the box. Before he/she returns the ticket to the box, the number on the ticket will be announced. You should record the number of the ticket in the second column of your profit sheet. If the number drawn IS LESS THAN OR EQUAL TO the number of points earned in Phase I, circle $1.50 in the next column; otherwise circle $0.00 in that column. Pay careful attention to what you circle. Any erasure will invalidate your earnings for the period. If you do make a mistake and circle the wrong number, call it to the experimenter's attention.

At the end of the experiment, add up your total profit in dollars and record this sum on your profit sheet. This is the amount of dollars you have earned in the experiment.

In summary, your earnings in the experiment will be the total of the amounts you win in all Phase II lotteries. The amount of money you earn will depend partly upon luck and partly upon whether you have made good decisions in Phase I. Notice that the more points you earn in Phase I, the more likely you will win in Phase II. Are there any questions?

References

Akerlof, G., 1970, "The Market for Lemons: Qualitative Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, 84, 488–500.

Berg, J. E., L. Daley, J. Dickhaut, and J. O'Brien, 1986, "Controlling Preferences for Lotteries on Units of Experimental Exchange," *Quarterly Journal of Economics*, 101, 281–306.

Cadsby, C., M. Frank, and V. Maksimovic, 1990, "Pooling, Separating, and Semiseparating Equilibria in Financial Markets: Some Experimental Evidence," *Review of Financial Studies*, 3, 341–367.

Cadsby, C., M. Frank, and V. Maksimovic, 1994, "Equilibrium Dominance in Experimental Financial Markets," working paper, University of Maryland.

Cooper, R., D. V. DeJong, R. Forsythe, and T. W. Ross, 1989, "Communication in Battle-of-the-Sexes Games: Some Experimental Results," *Rand Journal of Economics*, 20, 568–587.

Cooper, R., D. V. DeJong, R. Forsythe, and T. W. Ross, 1992, "Communication in Coordination Games," *Quarterly Journal of Economics*, 107, 739–771.

Daughety, A. F., and R. Forsythe, 1987a, "Regulation and the Formation of Reputations: A Laboratory Analysis," in E. Bailey (ed.), *Public Regulation: New Perspectives on Institutions and Policies*, MIT Press, Cambridge, Mass.

Daughety, A. F., and R. Forsythe, 1987b, "Regulatory-Induced Industrial Organization: A Laboratory Investigation," *Journal of Law, Economics, & Organizations*, 3, 397–434.

Davis, D., and C. Holt, 1990, "The Effects of Non-Binding Price Announcements in Posted-Offer Markets," *Economics Letters*, 34, 307–310.

Dickhaut, J., K. McCabe, and A. Mukherji, 1995, "An Experimental Study of Strategic Information Transmission," *Economic Theory*, 6, 389–403.

Farrell, J., 1987, "Cheap Talk, Coordination and Entry," *Rand Journal of Economics*, 18, 34–39.

Forsythe, R., R. M. Isaac, and T. R. Palfrey, 1989, "Theories and Tests of 'Blind Bidding' in Sealed-Bid Auctions," *Rand Journal of Economics*, 20, 214–238.

Grossman, S., 1981, "The Informational Role of Warranties and Private Disclosure About Product Quality," *Journal of Law and Economics*, December, 461–483.

Isaac, R. M., V. Ramey, and A. W. Williams, 1984, "The Effects of Markets Organization on Conspiracies and Restraint of Trade," *Journal of Economic Behavior and Organization*, 5, 191–222.

Isaac, R. M., and J. M. Walker, 1988, "Communication and Free-riding Behavior: The Voluntary Contribution Mechanism," *Economic Inquiry*, 26, 585–608.

King, R. R., and D. E. Wallin, 1991, "Voluntary Disclosures When Seller's Level of Information is Unknown," *Journal of Accounting Research*, 29, 96–108.

Laffont, J. J., and E. Maskin, 1990, "The Efficient Market Hypothesis and Insider Trading on the Stock Market," *Journal of Political Economy*, 90, 70–93.

Lohse, D., 1996, "Stock Regulators are Worried Dangers Lurk for Investors in On-Line Chat Sites," *The Wall Street Journal*, September 12, C1.

Matthews, S., and A. Postlewaite, 1985, "Quality Testing and Disclosure," *Rand Journal of Economics*, 16, 328–340.

Milgrom, P., 1981, "Good News and Bad News: Representation Theorems and Applications." *Bell Journal of Economics*, 12, 380–391.

Milgrom, P., and J. Roberts, 1986, "Rely on the Information of Interested Parties," *Rand Journal of Economics*, 17, 18–22.

Miller, R. M., and C. R. Plott, 1985, "Product Quality Signaling in Experimental Markets," *Econometrica*, 53, 837–872.

Palfrey, T., and H. Rosenthal, 1991, "Testing for the Effects of Cheap Talk in a Public Goods Game with Private Information," *Games and Economic Behavior*, 3, 183–220.

Pulliam, S., 1997, "'Cheat Sheets' on IPOs Raise Fairness Issue," *The Wall Street Journal*, December 31, C1.

Roth, A., and M. W. K. Malouf, 1979, "Game-Theoretic Models and the Role of Bargaining," *Psychological Review*, 86, 574–594.

Selten, R., 1991, "Properties of a Measure of Predictive Success," *Mathematical Social Sciences*, 21, 153–167.

Valley, K., J. Moag, and M. Bazerman, 1995, "Away with the Curse: Effects of Communication on the Efficiency and Distribution of Outcomes," working paper, Harvard University.

Valley, K., L. Thompson, R. Gibbons, and M. Bazerman, 1995, "Is Talk Really Cheap? Outperforming Equilibrium Models of Communication in Bargaining Games," working paper, Harvard University.

Weiss, G., 1997, "Investors Beware Chop Stocks," *Business Week*, December 15, 112–130.