How Do Market Price and Cheap Talk Affect Coordination?

by

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ABSTRACT

Crises, such as bank runs, currency crises, and debt crises have the common structure of a coordination problem. The goal of my dissertation is to examine the role of communication institutions and public information on such coordination problems. I conduct experiments on coordination games with heterogeneously informed agents under three experimental conditions. In the Control Condition, subjects are not allowed to communicate with each other. In the Market Condition, subjects can communicate through trading in a financial market with two state-contingent securities, whose dividend realizations are tied to the game outcome. In the Cheap Talk Condition, they can communicate through non-binding messages. The experimental results show that market price aggregates information, but price has a negative feedback effect on coordination. Cheap talk transmits information and improves the efficiency of coordination. Market prices reduce fundamental uncertainty, but coordination does not improve because strategic uncertainty intensifies. In contrast, cheap talk improves coordination as it reduces strategic uncertainty. Furthermore, I find that coarsening the cheap talk message space impacts coordination positively. The results shed light on the role of public information on coordination. In particular, transparency (i.e., efficient markets) in times of a crisis is not desirable for the efficiency of investor coordination.
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Chapter 1

1 Introduction

The underlying structures of bank runs, currency crises, and debt crises are strategic coordination problems. For example, bank runs can occur as a consequence of coordination failures (Diamond and Dybvig 1983). Panicking depositors withdraw money based on the expectation that other depositors will withdraw money and leave nothing for them if their bank fails. The beliefs are self-fulfilling, and the bank fails as a result of panic-driven withdrawals. The goal of my dissertation is to examine the role of communication institutions and public information on such coordination problems.

In a coordination game, agents face both fundamental and strategic uncertainty. *Fundamental uncertainty* is related to agents’ beliefs about exogenous states of nature, and *strategic uncertainty* is related to agents’ beliefs about other agents’ strategic choices. Recent studies suggest that public information that reduces fundamental uncertainty can sometimes exacerbate strategic uncertainty and lead to increased coordination failure (Morris and Shin 2004; Anctil et al. 2004; Anctil et al. 2010; Angeletos and Pavan 2004). In a controlled laboratory setting, I investigate the effect of two important sources of public information on coordination: market price and cheap talk (i.e., non-binding promises). By focusing on the influence of price and cheap talk information on fundamental and strategic uncertainty, this paper offers new evidence about the effect of public information on coordination and contributes to the debate on the role of accounting information in the recent financial crisis.

Studies on the recent financial crisis suggest that such panic-driven runs lead to the liquidity squeeze in the repo and asset-backed commercial paper market (Krishnamurthy
2009; Covitz, Liang, and Suarez 2009; Gorton and Metrick 2009; Gorton 2009b). Many argue that Bear Stearns, an investment bank which relies heavily on short term borrowing such as repo, might have failed as the result of coordination failures among lenders (Acharya and Gale 2009; Cox 2008; Morris and Shin 2008). Former Securities and Exchange Commission chairman Christopher Cox comments, “The fate of Bear Stearns was the result of a lack of confidence, not a lack of capital. . . . Bear Stearns’ capital, and its broker-dealers’ capital, exceeded supervisory standards. Counterparty withdrawals and credit denials, resulting in a loss of liquidity—not inadequate capital—caused Bear’s demise” (Cox 2008).

Public information can be a major driver of investor confidence. First, price is closely monitored by market participants, and for the case of Bear Stearns the credit default swap (CDS) market allowed the major Bear Stearns’ lenders to trade on their private assessments about the quality of Bear Stearns’s debt.¹ The CDS price, by aggregating this insider information (see Acharya and Johnson 2007), becomes an important source of public information to the lenders. Cheap talk among lenders generates a second source of public information. For example, immediately before the debacle of the Bear Stearns Asset Management Fund, its lenders managed to enter into nonbinding agreements not to foreclose on the fund (Cohan 2009). These agreements are cheap talk because of a lack of enforceability. Market prices and cheap talk provide two sources of public information to investors, but their impact on coordination is not well understood. In this paper we use

¹ A CDS is a swap contract in which the buyer of the contract makes periodic payments and, in return, receives a payment if a credit instrument defaults. For example, the bondholders of Bear Stearns can buy a CDS on Bear Stearns. If Bear Stearns goes bankrupt, the seller of the CDS will pay the bondholders. The prices of CDSs are barometers of the credit quality of a firm.
experimental methods to study the influence of market prices and cheap talk on coordination.

This paper studies the coordination problem as an investment game with exogenous fundamentals (Morris and Shin 2004). Similar games have been widely applied to study financial crisis (Goldstein and Pauzner 2004; Goldstein and Pauzner 2005; Marshall 1998; Rochet and Vives 2004; Fehr and Shurchkov 2006). Multiple agents have to decide individually whether to invest in a risky joint project. The success of the project depends on both an exogenous fundamental and agents’ strategic decisions. Each agent has only noisy private information about the project fundamental on which to base his or her investment decision. A project with a sound fundamental can fail if not enough agents invest due to a lack of confidence. Insufficient investment can trigger failure of a solvent project, which can be regarded as a liquidity crisis.

The experimental design consists of three main experimental conditions: the Control Condition, the Market Condition, and the Cheap Talk Condition. In the Control Condition, subjects play the investment game, and they are not allowed to communicate with each other. In the Market Condition, participants trade two state-contingent securities, whose dividend depends on the outcome of the coordination game, before they make their investment decisions. The price becomes a source of public information to all agents. In the Cheap Talk Condition, agents send nonbinding messages to the experimenter about their investment decisions. The experimenter then announces publicly how many of them intend to invest, which becomes a source of public information to agents before they make their final investment decisions.
The main results of this paper are the following. First, in the Control Condition, coordination failures occur as predicted. Solvent projects with weaker fundamental fail, although such projects can succeed if all subjects commit to invest. Second, price aggregates information about the fundamentals and predicts the game outcome. However, both individual and aggregate investments are significantly lower in the Market Condition compared to the Control Condition. Third, cheap talk messages convey information about the fundamentals and subjects condition their decisions on the messages. Both individual and aggregate investments in the Cheap Talk Condition are significantly higher than in the Control Condition. Overall, cheap talk outperforms the market in that the efficiency of the coordination game is significantly higher in the Cheap Talk Condition than in the Market Condition. Furthermore, there is a significant correlation between public information and decisions in the coordination game. The more optimistic the public information, the more likely subjects choose to invest.

The results seem surprising in that competitive markets produce worse outcomes than pure cheap talk. We can better understand the economic forces behind this result by looking at the effects of public information on fundamental and strategic uncertainty separately. Market prices aggregate private information and reduce fundamental uncertainty, but experimental data indicate that strategic uncertainty increases, especially for relatively good states. Cheap talk provides noisier information about exogenous states. Although it doesn’t reduce fundamental uncertainty as much as the market, it allows players to communicate directly their intended choice, which reduces strategic uncertainty, especially for relatively good states. Cheap talk makes sure that coordination failures don’t occur for relatively good states.
In a coordination game with multiple Pareto-ranked equilibria, expectations play a critical role in equilibrium selection. Market generates public signals from a highly competitive (non-cooperative) mechanism whereas cheap talk generates public signals from a more “cooperative” mechanism. In a standard competitive Rational Expectations Equilibrium (REE), agents rationally expect that coordination failures may occur and such pessimistic expectations are reflected in the price. Price, as a source of public information, further influences the agents’ beliefs. Therefore, pessimistic expectations are self-fulfilling. In contrast, cheap talk provides a mechanism for agents to communicate which equilibrium they wish to achieve. The communication of the willingness to play a better equilibrium combining with the reduction in strategic uncertainty drive agents’ expectations and shift the economy to a more desirable equilibrium.

This paper contributes to our understanding of the role of public information on investor coordination. The importance of coordination problems cannot be overstated. Gorton (2009a) emphasizes that the banking crises that started from 2007 are essentially “bank runs” in the traditional sense. For example, the sharp rises in repo haircuts are equivalent to capital withdrawals from the financial institutions that heavily rely on the short-term repo market for funding. Moreover Gorton (2009b) argues that common knowledge created by market prices, such as the ABX Index, aggregates information about subprime risks and speeds up the meltdown of the subprime market. Like the CDS on Bear Stearns’s debt, the ABX is a CDS on a basket of subprime home loans, which aggregates information about subprime risk. My experimental results demonstrate that information

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2 A repo, or repurchase agreement, is a transaction in which one party sells some securities to another party (the repo lender) in exchange for cash and simultaneously agrees to buy those securities back at a predetermined (higher) price at some date in the near future.
from markets similar to the ABX can increase strategic uncertainty and reduce investor confidence in the presence of coordination problems.

Understanding the feedback effect of market information on real investment decisions has implications for accounting. The increasing use of market information in accounting valuation is based on the belief that informationally efficient prices facilitate decision making and improve investment efficiency. As an example, the ABX Index is the preferred input to value subprime mortgage-related assets such as CDOs. Banks were forced to take large write-offs and report depressed financial results as the result of declines in the ABX. Many argue that such mark-to-market accounting practices have resulted in a loss of market confidence that has further exacerbated the crisis (Joseph-Bell, Joas, and Bukspan 2008). The proponents of mark-to-market accounting believe that providing more transparent information to investors can reduce investor uncertainty and improve investment efficiency. One important factor that has been overlooked in this debate is the role of price information on strategic uncertainty. If coordination underlies the investment problem in a time of financial crisis, as argued by Gorton (2009a), then price information can have unexpected effects on strategic uncertainty, which may diminish investor confidence.

The remainder of the dissertation is organized as follows. Section 2 reviews the relevant literature. Section 3 describes the model of coordination and discusses how cheap talk or asset markets affect coordination. I also develop a model of cheap talk under simplified assumptions to guide my analysis of experimental data. Section 4 describes the experimental designs and procedures. Section 5 reports and analyzes the experimental
results. The last section concludes the paper and discusses limitations and future research directions.

Chapter 2

2 Literature Review

Four streams of literature are relevant to my paper: the value of information in multiple-person settings with strategic dependence, the global game theory, the feedback effect of market prices on real investment decisions, and the cheap talk literature.

This paper is closest to the stream of literature studying the role of information in multiple-person settings with strategic dependence. In single-person decision-making settings, the value of additional information is strictly nonnegative, as stated in Blackwell’s theorem. In a multiple-person world, the value of information is no longer so straightforward. Baiman (1975) illustrates that information value can be negative or positive in an exogenously specified two-person noncooperative game. Players’ payoffs are determined not only by exogenous states, but also by their opponents’ decisions. If player A adopts a finer information system, player B may change his decision in anticipation that player A will make decisions based on finer information. Therefore more information can sometimes lead players to play an equilibrium that makes both worse off. In a moral hazard setting, Arya, Glover, and Sivaramakrishnan (1997b) find that the value of information depends on the nature of the strategic interaction between players. In their setting, both the principal and the agent exert effort, and public information arrives after the agent selects effort but before the principal selects effort. This information can help the principal to fine-tune her effort choice, but it can worsen the control problem because the agent will adjust his effort in anticipation that the principal will change effort. The value of
information depends on whether the principal’s and agent’s efforts are strategic complements or substitutes.

My paper also shows that public information can have an unexpected effect on economic efficiency in the presence of a strategic interdependency, but the underlying economic forces are different. A strategic dependency arises in the coordination game because the outcome of the coordination game depends not only on exogenous states, but also on joint choices of agents. Agents face not only fundamental uncertainty, but also strategic uncertainty. Changes in the information environment affect both types of uncertainty, and the effect of the changes on the equilibrium rests on the interplay between the two types of uncertainty (Morris and Shin 2004). Therefore we have to evaluate the effect of information on both types of uncertainty to measure the value of information on the efficiency of coordination.

The most closely related paper is ADKS, which provides experimental evidence on the impact of changes in the precision of private information on strategic uncertainty and coordination. In ADKS setting, multiple creditors individually decide whether to roll over or foreclose a risky project with three possible states (solvent, uncertain, or bankrupt). If the state is solvent (bankrupt), then the project always succeeds (fails) regardless of the creditors’ decisions. However, if the state is uncertain, the project outcome depends on the number of creditors that roll over. If a sufficient number of creditors commit to the project, the project succeeds; otherwise, it fails. Each creditor has a private clue (low, medium, or high) about the true state. ADKS vary the precision of private clues in such a way that as the precision of the private clue increases (fundamental uncertainty decreases), creditors receiving “medium” are more likely to infer that the true state is uncertain, in which state
multiple equilibria exist (strategic uncertainty increases). ADKS’s experimental evidence supports the risk dominance principle as the equilibrium selection criterion (Harsanyi and Selten 1988). Sometimes the risk-dominant equilibrium is Pareto inferior, and therefore the increases in private information fail to improve economic efficiency. My paper also studies the effect of changes in the information environment on coordination, focusing on interactions between fundamental and strategic uncertainty. The major difference between this paper and ADKS is that ADKS exogenously manipulates the information environment by varying the precisions of private information (see Walther 2004), whereas in this paper, the public information varies across experimental conditions. Moreover, the public information arises endogenously through players’ communication in the Cheap Talk Condition and the Market Condition.

converges to the unique equilibrium with private information. Heinemann, Nagel, and Ockenfels (2004) test a speculative attack model by Morris and Shin (1998) under two informational treatments: perfect public information and noisy private information about the fundamental. Their results show that the predictability of outcomes is similar under the two information conditions and they conclude that public information doesn’t have a destabilizing effect. Consistent with their results, I also find that price, as a source of public information, doesn’t reduce predictability of outcomes. My experimental design is closely related to Fehr and Shurchkov (2006), who test a dynamic global game. My experiments in the Control Condition are similar to the first stage of their games. Consistent with their paper, I also find that subjects’ behavior is more aggressive than theoretical predictions. Duffy and Ochs (2009) compare a static and dynamic global game and find no difference. Previous experimental papers focus on test of either static or dynamic global game theory, whereas the goal of our paper is to understand how economic institution can alleviate or exacerbate coordination failures.

The experiments in the Market Condition is closely related to the literature on feedback effects of prices on real investment decisions (e.g., Kanodia 1980; Angeletos and Werning 2006; Angeletos, Lorenzoni, and Pavan 2007; Ozdenoren and Yuan 2008). The traditional literature on market efficiency focuses on the information aggregation role of prices (e.g., Grossman 1976; Hellwig 1980; Grossman and Stiglitz 1980). These papers prove that price can be a sufficient statistic for diverse private information, but the role of prices on real production is not considered. Kanodia (1980) incorporates the effects of market prices on firms’ investment decisions and shows that prices play not only an information aggregation role, but also a resource allocation role. My paper also incorporates the resource allocation
role of prices beyond its information aggregation role. The underlying coordination game can be regarded as a production problem, and market prices can affect production through its informational role.

Angeletos and Werning (2006) present a theoretical model that is most closely related to the Market Condition in my paper. In their model, dividends of financial assets are determined by outcomes of a coordination game with privately informed agents. In a rational expectation equilibrium framework, they show that price is an endogenous source of public information that aggregates diverse private information. Price information changes the information structure of the coordination game, and sometimes it can increase strategic uncertainty by introducing multiple equilibria to the coordination game; furthermore, price itself can exhibit multiplicity.

In the experimental asset market literature, most studies also focus on the information aggregation role of markets. Securities dividends are usually determined by exogenous state variables. Plott and Sunder (1982) find that information held by traders who are perfectly informed about true states can be disseminated to uniformed traders. Plott and Sunder (1988) show that asset markets with complete sets of state-contingent securities are able to aggregate diverse private information. Lundholm (1991) and O’Brien and Srivastava (1991) find that the ability of markets to aggregate information is weakened as complexity in the information environment increases. O’Brien (1990) suggests that ex post disclosure of public accounting information can help coordinate agents with adaptive expectations on the rational expectations equilibrium. The novelty of my study is that security dividends are determined not only by exogenous states, but also by endogenous investment decisions. In a rational expectation equilibrium, price not only aggregates
information about fundamentals, but also influences investment decisions through its impact on the information environment. This paper is among the first to incorporate real investment decisions in an experimental asset market. Kogan, Kwasnica, and Weber (2008) also conduct experiments studying the impact of the asset market on coordination. They use a coordination game with complete information, and fundamental uncertainty plays no role in their paper.

My experiments in the *Cheap Talk Condition* add to the experimental literature on cheap talk. In a two person coordination game, Cooper et al. (1990) find that the Pareto inferior equilibrium is often selected. Allowing subjects to communicate though cheap talk lead them to choose the Pareto dominant equilibrium more often (Cooper et al. 1992). Blume and Ortmann (2007) find that costless messages can facilitate participants’ coordination on the Pareto-dominant equilibrium in Minimum and Median games, but communication improves coordination more effectively in the Median game than the Minimum game. My experiments show that in a coordination game with incomplete information and varying fundamentals, cheap talk improves coordination, but only for the game with relatively strong fundamentals. The presence of incomplete information and private information in my experimental setting implies that cheap talk can also transmit information. In strategic information transmission literature (Crawford and Sobel 1982), an informed party sends a message to an uninformed party who chooses an action that affects both parties’ payoffs and the incentives of the two parties may be misaligned. In my experiments, everyone is informed and each takes an action that jointly determines the game outcomes and hence their payoffs. The experimental results suggest that informative and responsive equilibria are played and cheap talk improves efficiency. A closely related
paper is Palfrey and Rosenthal (1991) who investigate the effect of binary message cheap talk on contribution level of a public goods game with incomplete information. They find that cheap talk messages transmit information but communication fails to improve efficiency. The difference between coordination game and public goods game may result in the different results about efficiency.

Chapter 3

3 Model and Predictions

3.1 Coordination Game with Incomplete Information

There is a continuum of agents indexed by \( i \), each of whom has to decide whether to rollover their investment on a project, \( a_i \in \{ \text{invest, not invest} \} \). The project outcome depends on the aggregate investment \( A \), which is the proportion of agents who choose to invest, and a state variable \( \theta \), related to the project fundamental. The project succeeds if \( A \geq \theta \), and fails otherwise. If an agent chooses not to invest, his payoff is \( \lambda \) (\( \lambda > 0 \)), irrespective of the project outcome, which can be regarded as the opportunity cost of investment. If the agent chooses to invest, his payoff depends on the project outcome: \( R \) \((R > \lambda)\) if the project succeeds, and 0 if it fails. The payoffs are summarized in the following table.

<table>
<thead>
<tr>
<th>Investment Game Payoff</th>
<th>( A \geq \theta ) ((\text{Success}))</th>
<th>( A &lt; \theta ) ((\text{Failure}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a_i = \text{invest} )</td>
<td>( R )</td>
<td>0</td>
</tr>
<tr>
<td>( a_i = \text{not invest} )</td>
<td>( \lambda )</td>
<td>( \lambda )</td>
</tr>
</tbody>
</table>
The variable \( \theta \) is the hurdle of aggregate investment for the project to succeed. If the aggregate investment is less than the hurdle, the project fails, and those who have chosen to invest are penalized with zero payoffs. Such beliefs can be self-fulfilling and lead more agents to refrain from investing, which leads to the failure of the project even if it is fundamentally sound. In the case of bank runs, an interpretation of the model is the following: a bank failure is triggered if the total funding to the bank \((A)\) is not enough to meet the bank’s liquidity needs \((\theta)\). As \( \theta \) increases, the amount of total investment that is required for the bank to survive increases. Large \( \theta \) represents weak economic fundamental. If \( \theta > 1 \), the bank is insolvent, and there is no chance for the bank to succeed.

Agents’ decisions are influenced by their knowledge of \( \theta \). Consider for a moment the case in which \( \theta \) is common knowledge. The equilibrium of this game is the following. If \( \theta \leq 0 \), the dominant strategy is for all to invest; if \( \theta > 1 \), the dominant strategy is for all not to invest; if \( 0 < \theta \leq 1 \), there are two pure-strategy symmetric Nash equilibria: either everyone invests or no one invests. In my experiments, agents have heterogeneous information about \( \theta \). They have a common prior that \( \theta \) is drawn from a normal distribution, \( \theta \sim N(y, 1/ \alpha) \), where \( \alpha \) is the precision of the prior information and \( y \) is the expected value of \( \theta \). In addition, each agent receives a private clue \( S_i = \theta + \varepsilon_i \), where \( \varepsilon_i \sim N(0, \frac{1}{\beta}) \) is independently and identically distributed (i.i.d.) across agents and independent of \( \theta \) and \( y \), and \( \beta \) is the precision of the private clues. Assuming that \( \beta \geq \frac{\alpha^2}{2 \pi} \), there is a unique equilibrium in this game as shown by Morris and Shin (2004).

Assuming that there is a continuum of agents, we can derive the equilibrium of the coordination game under the Control Condition. Agents have a common prior about the

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3 See Morris and Shin (1998, 2004) for proofs. A brief derivation of the equilibrium is provided in Appendix A.
state variable $\theta \sim N(y, 1/\alpha)$, where $\alpha$ is the precision of the prior information and $y$ is the expected value of the state variable. In addition, each agent has a private signal about the state, $S_i = \theta + \varepsilon_i$, where $\varepsilon_i \sim N(0, 1/\beta)$ and $\beta$ is the precision of private signals.

Furthermore, $\varepsilon_i$ are i.i.d. across agents and independent of $\theta$ and $y$. Given the prior and their private signal, agents update their beliefs about $\theta$. Their posterior is $\varphi = \frac{\alpha y + \beta S_i}{\alpha + \beta}$. The strategy of an agent maps his private clue onto one of the two actions. Because it is strictly dominant to invest for sufficient low signals and not to invest for sufficient high signals, one possible strategy is a monotone threshold strategy: invest if the private signal is smaller than $S^*$ and do not invest otherwise. Given this strategy, the measure of agents who invest is given by $A(\theta) = \Pr(S < S^*|\theta) = \Phi(\sqrt{\beta}(S^* - \theta))$, where $\Phi$ is the cumulative distribution function of the standard normal distribution. If agents adopt this threshold strategy, the outcome of the project is deterministic. The project succeeds if and only if $\theta \leq \theta^*$, where $\theta^*$ solves $\theta^* = A(\theta^*)$. This gives us the first equilibrium condition:

$$\theta^* = \Phi(\sqrt{\beta}(S^* - \theta^*)) = \Phi(\sqrt{\beta} \left(\frac{\alpha + \beta^*}{\beta} - \frac{\alpha}{\beta} y - \theta^*\right))$$ (1)

In equilibrium, agents are indifferent between “invest” and “not invest”, which gives us the second equilibrium condition:

$$R\Phi(\sqrt{\alpha + \beta}(\theta^* - \varphi^*)) = \lambda$$ (2)

The left-hand side is the expected payoff if an agent chooses to invest. The right-hand side is the payoff if an agent chooses not to invest. The posterior probability of project success given a signal $S$ is $\Pr(\theta \leq \theta^*|S)$, which equals $\Phi(\sqrt{\alpha + \beta}(\theta^* - \varphi))$. Combining equations

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4 It is assumed here that agents are risk-neutral.
(1) and (2), we can derive the equilibrium pair \((S^*, \theta^*)\), where \(\theta^*\) is the implicit solution of equation (3):

\[
\theta^* = \Phi \left( \frac{\alpha}{\sqrt{\beta}} \left( \theta^* - \frac{\sqrt{\alpha + \beta \Phi^{-1}(\frac{S^*}{R})}}{\alpha} - y \right) \right)
\]  

(3)

The threshold state \(\theta^*\) is obtained as the intersection between the 45° line and a cumulative normal distribution with mean \(\frac{\sqrt{\alpha + \beta \Phi^{-1}(\frac{S^*}{R})}}{\alpha} + y\) and variance \(\frac{\beta}{\alpha^2}\). To ensure the existence of a unique solution to equation (3), the slope of the right-hand side of equation (3) must be smaller than 45°. Differentiating the right-hand side with respect to \(\theta\), we derive the slope of the CDF function: \(\phi(\cdot) \frac{\alpha}{\sqrt{\beta}}\), where \(\phi(\cdot) = \Phi' \left( \frac{\alpha}{\sqrt{\beta}} \left( \theta_{p^*} - \frac{\sqrt{\alpha + \beta \Phi^{-1}(\frac{S^*}{R})}}{\alpha} - y \right) \right)\). The slope must be smaller than 1 to ensure a unique solution for equation (3) because \(\phi(\cdot)\) is bounded by \(\frac{1}{\sqrt{2\pi}}\). Therefore, the condition \(\frac{\alpha}{\sqrt{\beta}} < \sqrt{2\pi}\) is needed, or equivalently, \(\beta \geq \frac{\alpha^2}{2\pi}\).

This condition requires that the precision of the private signal must be sufficiently larger than the precision of the public signal. The iterated deletion of strictly dominated strategies ensures that when the monotone equilibrium is unique, there is no other equilibrium.\(^5\) The equilibrium investment strategy \(S^*\) can be expressed as a function of \(\theta^*\).

The experimental parameters are \(y=0.5\), \(R=1000\), \(\lambda =500\), \(\beta=25\), and \(\alpha=1\). Assuming that agents are risk-neutral, the predicted equilibrium is \(S^* = 0.5\) and \(\theta^* = 0.5\). Assuming that agents are risk-averse (negative exponential utility with risk aversion coefficient \(0.001\)), the predicted equilibrium is \(S^* = 0.693\) and \(\theta^* = 0.628\). Assuming that agents are risk-loving (negative exponential utility with risk aversion coefficient \(-0.001\)), the

predicted equilibrium is $S^* = 0.307$ and $\theta^* = 0.372$. Figure A1 plots the predicted aggregated investment $A$ for the three cases respectively. We can see that investment decreases as agents become more risk averse.

3.2 Information Conditions and Predictions

There are three experimental treatments: the Control Condition, the Market Condition, and the Cheap Talk Condition. In the Control Condition, agents are not allowed to communicate with each other, and they only have the common prior and private clue about the fundamental. In the Market Condition, agents have access to a market and can trade two state-contingent securities: Stock A, which is referred to as “Success” stock; Stock B, which is referred to as “Failure” stock. The “Success” stock pays a dividend if the project succeeds and pays no dividend if the project fails; the “Failure” stock pays a dividend if the project fails and pays no dividend if the project succeeds. Price is publicly available as the market is organized as a double-auction market with an open order book. Agents play the coordination game after trading in this market. Their total earnings consist of trading profits and game payoffs. In the Cheap Talk Condition, agents are asked to send a message to the experimenter about their intended choices: invest or not invest. The experimenter then announces publicly how many intend to invest, and agents play the coordination game afterward. Agents’ messages are nonbinding; that is, they can make a choice different from their stated intentions. There is no cost for agents to send messages, and the messages have no effect on their payoffs.

Public information endogenously arises in the Market Condition and Cheap Talk Condition. In a REE, stock price aggregates private information about the fundamental. Previous experiments show that markets with state-contingent securities can aggregate
dispersed private information (Plott and Sunder 1988). Field studies also provide evidence that such markets can aggregate private information and predict future uncertain events (Berg et al. 2008). If prices aggregate information about $\theta$, we should be able to find a correlation between the prices of stocks and $\theta$. As success is more likely if the fundamental is strong ($\theta$ is small), price of “Success” stocks is predicted to be decreasing in $\theta$; the prices of “Failure” increasing in $\theta$. Price changes the information structure of the coordination game. Angeletos and Werning (2006) derive the equilibrium of a two-stage game with a stock that settles on the outcomes of the coordination game. Their analysis shows that price changes the structure of the information environment by increasing the precision of public information $\alpha$, and the condition for the existence of a unique equilibrium $\beta \geq \alpha^2 / 2\pi$ can be violated because prices increase the precision of the public information $\alpha$. As the ability of price to aggregate information increases, multiple equilibria are reintroduced. I will analyze the experimental data to see if price aggregates information and how the equilibrium in the game is affected by price.

Cheap talk messages may also contain information about fundamental. There are multiple equilibria in the two stage game with pre-play cheap talk. One of the equilibria is a babbling equilibrium, in which agents send random messages and ignore other agents’ messages. In this equilibrium, the aggregate message is uninformative and agents are not responsive to the message. Other informative and responsive equilibria also exist, in which messages are correlated with private signal and agents’ choices are influenced by aggregate messages. In a simplified theoretical example with two players and uniform distributed noise structure, I find that there is a continuum of such informative and responsive
equilibria. I will analyze the experimental data to determine whether subjects play the uninformative equilibrium, or instead engage in informative cheap talk.

3.3 Simplified Model of Cheap Talk

To guide the analysis of cheap talk experiments, I develop an analytical model of cheap talk in a coordination game with incomplete information in this section. The model is not the same as the experimental setup, but captures the main characteristics and provides a theoretical structure for me to analyze the experimental data.

To solve the equilibrium with cheap talk, I make several simplifications. I assume there are two players. Each player has one private signal $S_i$ about the true state $\theta$ and their signals are independent from each other. The true state $\theta$ is the average of the two players’ signal. In my experiments, the average of all players’ signals is approximately equal to the true state. Players choose either 0 (not invest) or 1 (invest). The aggregate action is the sum of the two actions. The aggregate action $A$ can be 0, 1, or 2. The outcome of the game is success if the aggregate action is equal or larger than the true state and failure otherwise. The payoff from choosing 1 depends on the game outcome. If the outcome is success, the payoff is the highest, which is normalized to be 1. If the outcome is failure, the payoff is 0. The payoff from choosing 0 is a constant $\lambda$, a number between 0 and 1.

<table>
<thead>
<tr>
<th>$a_i$</th>
<th>$A \geq \theta$ (Success)</th>
<th>$A &lt; \theta$ (Failure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_i = 1$</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>$a_i = 0$</td>
<td>$\lambda$</td>
<td>$\lambda$</td>
</tr>
</tbody>
</table>

I assume players’ signals are uniformly distributed between 0 and 3. Therefore, the true state $\theta$ is also between 0 and 3. The choice of lower and upper bound is to make sure that there is a nontrivial coordination problem. There are also ranges where players have a
dominant strategy to choose 0 or 1. If \( \theta \) is equal or less than 1, then the dominant strategy is to choose 1. If \( \theta \) is larger than 2, then the dominant strategy is to choose 0. If the state \( \theta \) is between 1 and 2, there is a coordination problem. If the state is common knowledge, there are two equilibria, either both choose 0 or both choose 1 are equilibrium. Since players have noisy signals about the state, we can apply global game technique to solve the equilibrium of this game without communication. In the following analysis, I assume agents are risk neutral.

**Case 1: No Communication**

I restrict to symmetric monotone threshold strategies. Each agent adopts a threshold strategy based on their private signals. The strategy is to choose 1 if the private signal is less or equal to \( S' \) and choose 0 otherwise. At the equilibrium threshold \( S' \), an agent is indifferent between choosing 0 or 1. This leads to the equilibrium condition

\[
E(\pi|a_i = 1, S_i = S') = E(\pi|a_i = 0, S_i = S')
\]

The expected payoff of choosing 1 equals the probability of the outcome to be success. The payoff of choosing 0 is a constant. Therefore, the above equation becomes

\[
\text{pr}(A \geq \theta|a_i = 1, S_i = S') = \lambda
\]

Given the private signal \( S' \), an agent expects is uniformed distributed between \( \frac{S'}{2} \) and \( \frac{S'+3}{2} \). He has no information about the other agent’s signal, but he knows that his opponent adopts same threshold strategy. Therefore, he conjectures that the probability that the other agent choosing 1 is \( \frac{S'}{3} \). The left hand side of the above equation becomes

\[
\frac{S'}{3} \text{Pr}(\theta \leq 2) + \left(1 - \frac{S'}{3}\right)\text{Pr}(\theta \leq 1) = \lambda
\]
Assuming \( \lambda = \frac{1}{2} \), the solution to the above equation is \( \frac{3}{2} \). Under this strategy, an agent chooses 1 if he receives a signal equal or less than \( \frac{3}{2} \), and chooses 0 if he receives a signal larger than \( \frac{3}{2} \).

We can calculate the ex ante expected payoffs for each player without communication.

\[
E(\pi^{nc}) = \frac{1}{2} E(\pi | a_i = 0) + \frac{1}{2} \left( \frac{1}{2} E(\pi | a_i = 0, a_j = 0) + \frac{1}{2} E(\pi | a_i = 0, a_j = 1) \right) = \frac{37}{72}
\]

\[
= 0.514
\]

As a benchmark, we can calculate the expected payoffs in the first best. In the first best case, the true state is publicly known and agents choose 1 if the state is equal or less than 2 and choose 0 if the state is larger than 2, the expected ex ante payoffs is

\[
E(\pi^{fb}) = \frac{7}{9} \cdot 1 + \frac{2}{9} \cdot \frac{1}{2} = \frac{48}{54} = 0.889
\]

We can see that the expected payoff is lower in the no communication case than in the first best. The loss of efficiency comes from two sources: first, agents have noisy information about the true state because their signals only tell them half of the information about the state. Second, agents don’t trust other agents and they are conservative in that they choose 1 only when their expected true state is equal or less than \( \frac{3}{2} \). If they trust each other, their threshold is 2.

**Case 2: Cheap Talk**

As in the experiments, agents can send a binary message about their intended actions in the cheap talk stage. The messages can be 0 or 1. I also restrict myself to symmetric monotone reporting strategies. The reporting strategy is to report 1 if and only if the private signal is equal or less than the reporting threshold \( S^r \). In the game stage, players’
action will depend on not only the private signals but also the public signal, which is the cheap talk message. In the two player case, a player knows the other agent’s message. Hence, his action strategy depends on the other player’s report. I also restrict myself to symmetric monotone action strategies. There are two action thresholds depending on the other agent’s message: $S_1$ and $S_0$. That is, given the other agent reports 1 (0), an agent will choose 1 if his private signal is equal or less than $S_1(S_0)$.

The task is to solve the reporting threshold $S^r$ and two action thresholds $S_1, S_0$. I restrict to the case that $S_1 \geq S_0$. This is intuitive because an agent will be more willing to choose 1 if the other agent reports 1 than if the other agent reports 0. Furthermore, I restrict to the case that $S^r \geq S_1$. This implies that an agent is more willing to report 1 than he actually wants to choose 1. If he reports 0, he will choose 0 for sure. If he reports 1, it is possible that he will change his mind and switch to 0 depending on the other agent’s report.

First, at the equilibrium threshold $S_0$, an agent is indifferent between choosing 0 or 1. This leads to the following equilibrium condition.

$$E(\pi | a_i = 1, m_j = 0, S_i = S_0) = E(\pi | a_i = 0, m_j = 0, S_i = S_0)$$

Given the reporting strategy, $m_j = 0 \Rightarrow a_j = 0$. The above equation is simplified to

$$\text{pr}(1 \geq \theta | m_j = 0, S_i = S_0) = \lambda$$

The posterior about the state based on $m_j = 0$ and $S_i = S_0$ is that $\theta \sim \mathcal{U}\left[\frac{S_0 + S^r}{2}, \frac{S_0 + 3}{2}\right]$. Therefore, the above equation becomes

$$1 - \frac{S_0 + S^r}{S_0 + 3} - \frac{S_0 + S^r}{2} = \lambda$$

If we assume $\lambda = \frac{1}{2}$, the above equation gives us
\[ S_0 = \frac{1-S^r}{2} \tag{4} \]

Second, at the equilibrium threshold \( S_1 \), and an agent is indifferent between choosing 0 and 1, which leads to the second equilibrium condition.

\[ E(\pi|a_i = 1, m_j = 1, S_i = S_1) = E(\pi|a_i = 0, m_j = 1, S_i = S_1) \]

First, we know that \( m_j = 1 \Rightarrow S_j \leq S^r \). Second, we know that \( a_j = 1 \) if and only if \( S_j \leq S_1 \). Therefore, the probability that \( a_j = 1 \) is \( \frac{S_1}{S^r} \). This allows us to simplify the equilibrium condition,

\[ \frac{S_1}{S^r} pr(2 \geq \theta|m_j = 1, S_i = S_1) + (1 - \frac{S_1}{S^r}) pr(1 \geq \theta|m_j = 1, S_i = S_1) = \lambda \]

The posterior about the state given the message from j and the private clue \( S_1 \) is that \( \theta \sim U \left[ \frac{S_1+0}{2}, \frac{S_1+S^r}{2} \right] \). Therefore, the above equation becomes

\[ \frac{S_1}{S^r} \cdot \frac{2-S_1+0}{S_1+S^r} \cdot \frac{S_1+0}{S_1+S^r} + \left(1 - \frac{S_1}{S^r}\right) \cdot \frac{1-S_1+0}{S_1+S^r} \cdot \frac{S_1+0}{S_1+S^r} = \lambda \]

If we assume \( \lambda = \frac{1}{2} \), the above equation gives us

\[ S_1 = \frac{\frac{1}{2}S^r - 2S^r}{2-S^r} \tag{5} \]

At the equilibrium reporting threshold, an agent will choose 0 since we assume \( S^r \geq S_1 \). No matter what the other agent chooses, the agent’s payoff is a constant.

Therefore, there is no binding equilibrium condition for \( S^r \). It can be any number between \( S_1 \) and the upper bound 3 as long as equation (4) and (5) are satisfied.
We can solve a few special cases.

1. Babbling equilibrium: $S^r = 3$, and $S_1 = \frac{3}{2}$. In this case, no matter what signal an agent receives, he always report 1. Therefore, his report has no information and will be ignored. The action threshold is the same as the case without communication.

2. Most efficient equilibrium: $S^r = S_1 = \frac{8}{3}$ and $S_0 = -\frac{5}{6}$. In this case, an agent reports 1 if his signal is equal or less than $\frac{8}{3}$. If the other agent reports 1, an agent always chooses 1. If the other agent reports 0, an agent always chooses 0. Note that agents’ actions are perfectly coordinated through the message. We can also calculate the ex ante expected payoff.

$$E(\pi^{ct})$$

$$= \frac{1}{9} E(\pi|a_i = 0) + \frac{8}{9} \left( \frac{1}{9} E(\pi|a_i = 0, a_j = 0) + \frac{8}{9} E(\pi|a_i = 0, a_j = 1) \right) = \frac{43}{54}$$

$$= 0.796$$

We can see that there is a significant increase in efficiency compared to the no communication case. It is still less than the first best. Players can’t achieve first best in cheap talk because the message space is restricted to be binary. The binary messages can only imperfectly communicate information. Cheap talk improves efficiency because it allows players to signal to each other that they should trust each other to coordinate on a more efficient equilibrium.

3. A continuum of equilibria exists between the above two cases: $S^r$ in the range between $\frac{8}{3}$ and 3. Note that both $S_0$ and $S_1$ are decreasing in $S^r$.

Asymmetric equilibria
I also find asymmetric equilibria, in which one agent babbles but responds to the other’s message, while the other agent sends informative message but ignores his opponent’s report. Assume $i$ babbles but responds to messages and $j$ sends informative messages but ignores the other agent’s messages. We need to solve the action strategy for $i$ given $j$’s report. Define the action threshold to be $S_i^0$ if the other agent reports 0 and $S_i^1$ if the other agent reports 1. We also need to solve the reporting strategy for $j$. Let us define the reporting threshold to be $S_j^r$. In addition, we need to find the action strategy for $j$. As $j$ ignores the other’s report, we only need to solve one action threshold, define it to be $S_j^a$.

Among such asymmetric equilibria, I solve one equilibrium in which $S_j^r = S_j^a$. That is, $j$ truthful reports his intention. He will choose 0 if he reports 0 and choose 1 if he reports 1. In this equilibrium, $j$ knows that the other agent will use his report but the other agent’s message doesn’t affect $j$’s action. Given $j$’s strategy, we can solve for $i$’s strategy.

First, at the equilibrium threshold $S_i^0$, he is indifferent between choosing 0 or 1.

$$E(\pi|a_i = 1, m_j = 0, S_i = S_i^0) = E(\pi|a_i = 0, m_j = 0, S_i = S_i^0)$$

Given $j$’s reporting strategy, $m_j = 0 \Rightarrow a_j = 0$. The above equation is simplified to

$$\text{pr}(1 \geq \theta|m_j = 0, S_i = S_i^0) = \lambda$$

The posterior about the state based on $m_j = 0$ and $S_i = S_0$ is that $\theta \sim U[\frac{s_i^0 + s_j^r}{2}, \frac{s_i^0 + s_j^r}{2}]$.

Therefore, the above equation becomes $\frac{1 - s_i^0 + s_j^r}{s_i^0 + s_j^r + s_j^r} = \lambda$.

If we assume $\lambda = \frac{1}{2}$, the above equation gives us

$$S_i^0 = \frac{1 - s_j^r}{2} \quad (6)$$
Second, at the equilibrium threshold $S_i^1$, he is also indifferent between choosing 0 or 1.

$$E(\pi|a_i = 1, m_j = 1, S_i = S_i^1) = E(\pi|a_i = 0, m_j = 1, S_i = S_i^1)$$

Given $j$’s reporting strategy, $m_j = 1 \Rightarrow a_j = 1$. The above equation is simplified to

$$\text{pr}(2 \geq \theta|m_j = 1, S_i = S_i^1) = \lambda$$

The posterior about the state based on $m_j = 1$ and $S_i = S_i^1$ is that $\theta \sim \mathcal{U}[\frac{S_i^1}{2}, \frac{S_i^1 + S_i^f}{2}]$.

Therefore, the above equation becomes

$$\frac{2 - \frac{S_i^1}{2}}{\frac{S_i^1 + S_i^f}{2} - \frac{S_i^1}{2}} = \lambda.$$

After rearrangement, we get

$$S_i^1 = \frac{8 - S_i^f}{2} \tag{7}$$

Third, for agent $j$, at the equilibrium threshold $S_j^a$, he is indifferent between choosing 0 or 1.

$$E(\pi|a_j = 1, S_j = S_j^a) = E(\pi|a_j = 0, S_j = S_j^a)$$

At $S_j^a$, $j$ reports $m_j = 1$. Therefore, the probability that $a_i = 1$ is $\frac{S_i^1}{3}$ and the probability that $a_i = 0$ is $1 - \frac{S_i^1}{3}$. The posterior about the state based on $S_j = S_j^a$ is that $\theta \sim \mathcal{U}[\frac{S_j^a}{2}, \frac{S_j^a + 3}{2}]$.

The equilibrium condition above becomes

$$\frac{S_i^1}{3} \cdot \frac{2 - \frac{S_j^a}{2}}{\frac{S_j^a + 3}{2} - \frac{S_j^a}{2}} + \left(1 - \frac{S_i^1}{3}\right) \cdot \frac{1 - \frac{S_j^a}{2}}{\frac{S_j^a + 3}{2} - \frac{S_j^a}{2}} = \lambda.$$

Given $S_j^a = S_j^f$, the above equation becomes the following after arrangement.

$$S_i^1 = \frac{6S_j^f - 3}{4} \tag{8}$$
Combining equation (7) and (8), we get $S_i^I = \frac{45}{16}$ and $S_i^R = \frac{19}{8}$. We can also calculate the ex ante expected payoffs for each agent.

$$E(\pi_j^{asy})$$

$$= \frac{5}{24} E(\pi | a_j = 0)$$

$$+ \frac{19}{24} \left( \frac{45}{48} E(\pi | a_i = 1, a_j = 1) + \frac{3}{48} E(\pi | a_i = 0, a_j = 1) \right)$$

$$= \frac{5}{24} \cdot \frac{1}{2} + \frac{19}{24} \left( \frac{45}{48} \Pr (\theta \leq 2 | S_j \in \left[ \frac{19}{8}, \frac{45}{16} \right], S_j \in \left[ 0, \frac{45}{16} \right]) \right) = 0.768$$

$$E(\pi_i^{asy}) = \frac{5}{24} E(\pi | a_i = 0) + \frac{19}{24} \left( \frac{45}{48} E(\pi | a_i = 1, a_j = 1) + \frac{3}{48} E(\pi | a_i = 0, a_j = 1) \right)$$

$$= \frac{5}{24} \cdot \frac{1}{2} + \frac{19}{24} \left( \frac{45}{48} \Pr (\theta \leq 2 | S_j \in \left[ \frac{19}{8}, \frac{45}{16} \right], S_j \in \left[ 0, \frac{45}{16} \right]) + \frac{3}{48} \cdot \frac{1}{2} \right) = 0.793$$

In this asymmetric equilibrium, the agent who babbles but uses information from cheap talk message has slightly less payoffs than in the symmetric equilibrium. The player who sends informative message but knows that the other player babbles has much lower payoffs than in the symmetric equilibrium because this player doesn’t get information from the other player about the true state.

The simple model described above suggests that there are multiple equilibria in the two stage game with cheap talk. It is an empirical question which equilibrium is played. Informative and responsive equilibria can improve the efficiency of coordination. The analysis of the experimental data can inform us about equilibrium selection and efficiency impact of cheap talk.
4 Experimental Details

4.1 Experimental Procedure

Thirteen sessions of computerized experiments were run at a computer lab at Carnegie Mellon University in fall 2008 and spring 2009. Each session had 12 subjects. No subject could participate in more than one session. In total, 156 undergraduate students recruited from the Tepper Research Participation Pool participated. The experiment was conducted using the Financial Trading System (FTS). The coordination game was run by FTS sender/receiver software, and the security market was run by FTS market software.

The Market Sessions lasted 2 hours, and other sessions lasted 1 hour. In the experiments, participants were individually seated, and their desks were separated by dividers. Prior to the experiment, they received written instructions, including the relevant payoff tables. Subjects read the instructions by themselves and then completed a short quiz testing whether they understood the experimental instructions. The answers to the quiz were then announced publicly by the instructor. Throughout the experiment, subjects were not allowed to communicate with each other. After the experiment, the subjects filled out a questionnaire about their game strategy and provided comments on the experiment. Afterward, they were paid in cash. Their total experimental points were converted into dollars at a predetermined exchange rate of 1000 points = 50¢. The average payment for the 2-hour sessions was $24, and the average payment for the 1-hour sessions was $12. In addition, subjects were also rewarded 1 credit for each hour of participation, which could be converted into course credits, according to the rules of the Tepper Research Participation Pool.

4.2 Parameterization and Session Design
The parameters are chosen under the guidance of the theory. The payoff for investing in a successful project is 1000 points, and the payoff for investing in a failed project is 0. The payoff is 500 points if a subject chooses not to invest. This payoff scheme is chosen for its simplicity for the theory and for the ease of the experimental participants. The prior is that θ is normally distributed with mean 0.5 and standard deviation 1 (precision parameter α is 1). The private clues are drawn from a normal distribution with mean θ and standard deviation 0.2 (precision parameter β is 25). The equilibrium uniqueness condition $\beta \geq \frac{\alpha^2}{2\pi}$ is satisfied under this parameterization. To avoid the complexity of dealing with fractions in the experiment, the values of θ and private clues $S_i$ are rescaled by a factor of 100. In the remainder of the paper, both θ and $S_i$ are referred to by their rescaled values.

I conducted four types of experimental session: the Control Session, the Cheap Talk Session, the Market Session, and the Modified Cheap Talk Session. In the Control Sessions, subjects first play the first 20 rounds of coordination games under the Control Condition and then play 20 rounds of games in the Cheap Talk Condition. In the Cheap Talk Sessions, the order is reversed. In the Market Sessions, subjects only play 20 rounds of games in the Market Condition. The Modified Cheap Talk Sessions are similar to the Cheap Talk Sessions, except that message spaces are different (details will be provided in the following section). Following is a summary of the experimental sessions.

<table>
<thead>
<tr>
<th>Experimental Session Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sessions (Code)</td>
</tr>
<tr>
<td>Control Session (C1-C4)</td>
</tr>
<tr>
<td>Cheap Talk Session (T1-T4)</td>
</tr>
</tbody>
</table>

$^a$ In one Market Session, only 15 rounds are run due to time constraints.
4.3 Timeline of Events in Experiments

Each experimental session consists of multiple rounds. The following schematic illustrates the timeline of events in one round. At the beginning of each round, the server computer generates a random \( \theta \) and a set of clues \( S_i \). It then transmits the private clues to subjects. After the communication stage, subjects enter their game decisions: 1 or 0. Subjects’ inputs are gathered and processed by the server computer. At the end of each round, subjects receive feedback, which includes the realization of \( \theta \), the game outcome, and their payoffs. Each round \( \theta \) is freshly drawn, and the draw is independent of other rounds.

Timeline of Events in an Experimental Round

7 In the experiments, subjects are asked to choose a number 0 or 1, where 0 represents “not invest” and 1 represents “invest”.

---

\[\text{Cheap Talk (with History) Condition}\]

\[\text{Control (with History) Condition}\]

---

\( a \) This is referred to as the \textit{Cheap Talk (with History) Condition} in the rest of the paper.

\( b \) This is referred to as the \textit{Control (with History) Condition} in the rest of the paper.

---

<table>
<thead>
<tr>
<th>Market Session (M1-M4)</th>
<th>Market Condition</th>
<th>N/A</th>
<th>4</th>
<th>48</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified Cheap Talk (MT)</td>
<td>Modified Cheap Talk</td>
<td>Control Condition</td>
<td>1</td>
<td>12</td>
</tr>
</tbody>
</table>
The communication stage represents the major difference among the various experimental conditions. In the **Control Condition**, there is no activity at the communication stage. In the **Market Condition**, subjects trade two stocks: “Success” and “Failure”. The market lasts for 2 minutes. If the game outcome is success, the “Success” stock pays 1 point of dividend per share and the “Failure” stocks pay nothing; if the game outcome is failure, the “Failure” stock pays 1 point of dividend per share and the “Success” stock pays nothing. In each round, subjects are endowed with 300 points cash loan and 10 shares of each stock. Subjects can both make market and take market, and short selling is allowed. In the **Cheap Talk Condition**, subjects send a message to the experimenter about their intent: 1 or 0. The experimenter announces the number of subjects who intend to invest. In the **Modified Cheap Talk Condition**, subjects are asked to send to the experimenter a message about their estimated probability (a number between 0 and 1) that the game outcome will be success. The experimenter announces the average messages.

5 **Experimental Results**

This section reports the experimental results. First, I examine the three main experimental conditions to evaluate the impact of different institutions on game decisions. I also analyze the information content of the endogenous public information in the market and cheap talk settings. Second, I discuss the relation between public information and investment decisions. Last, I compare the efficiency of coordination under various experimental conditions.

5.1 **Analysis of Individual Condition**

In the following analysis, the main dependent variables are the investment decisions, either at the individual decision $a_i$ (a binary choice variable with 1 representing invest and
0 representing not invest) or at the aggregate level $A$ (percent of subjects that choose to invest). The main explanatory variables are $\theta$ and private clue $S$. Table 1 provides the descriptive statistics for the variables.

5.1.1 **Investment Decisions**

The global game theory provides predictions for the *Control Condition*. It prescribes that agents adopt a cutoff strategy: invest if $S \leq S^*$, and do not invest otherwise. I apply a simple error model to examine whether subjects follow a cutoff strategy. First, I assume an arbitrary threshold for each subject. Then I classify decisions that are inconsistent with this threshold strategy as an error, for example, invest above this threshold or not invest below this threshold. I calculate the error rate for each arbitrary threshold and choose the threshold that minimizes the error rate. If the threshold is not unique, I take the average of the maximum and minimum of all thresholds that have the minimal error rates. The error rate measures the degree of the use of threshold strategy at the individual basis. Table 2 summarizes the estimated threshold based on the simple error model for the *Control Condition* in the Control Sessions and Cheap Talk Sessions. The average threshold is 56.44 and the average error rate is small (0.08). I also estimated the thresholds separately for the first and last 10 rounds. The average estimated threshold is stable over time: the average threshold is 56.63 for the first 10 rounds and 56.86 for the last 10 rounds. The average error rate reduces from 0.056 to 0.027 from the first 10 rounds to the last 10 rounds, which suggests that the convergence of behavior toward the threshold strategy through learning.

*Finding 1:* *In the Control Condition, subjects adopt threshold strategies based on their private clues.*
Table 2 also reports the estimated threshold using logistic regression. I run logistic regressions with the individual choices as the dependent variable and the private clues as the explanatory variables. The regression model is as follows:

\[
\Pr(a_i = 1) = \Pr(S_i \leq S^*) = \frac{1}{1 + e^{-(\alpha - \beta S_i)}}.
\]

The fitted model gives the estimated probability of choosing to invest for a given private clue \(S\). The estimated threshold \(S^*\) is \(\hat{\alpha} / \hat{\beta}\), and the dispersion of the estimated threshold is \(\pi / (\sqrt{3} \hat{\beta})\). The average estimated threshold for the Control Condition is 55.58.

Figure 1 compares the observed aggregate investment level with the predicted level. We can see that the aggregate investment \(A\) is decreasing in \(\theta\). The aggregate investment is close to the theory prediction for \(\theta\) less than 50 (projects with relatively strong fundamentals), but higher than the theory prediction for \(\theta\) larger than 50 (projects with weaker fundamentals). Using the session level data and the Wilcoxon-mann-Whitney test, we can reject the null hypothesis that observed aggregate investment is the same as the predicted level for \(\theta\) in the range 50-75 (\(p = 0.02\), two-tailed test) and 75-100 (\(p = 0.004\), two-tailed test). The finding that subjects are more aggressive than theory predicted is consistent with previous experimental tests of global games (see Heinemann, Nagel, and Ockenfels 2004, Fehr and Shurchkov 2006, and Duffy and Ochs 2009).

The investment decisions differ systematically across the three main experimental conditions. Figure 2 panel A plots the investment at the individual level. We can see that the investment frequency is decreasing with private clues in all conditions. The investment frequency in the Market Condition is lower than the Control Condition, and the investment frequency in the Cheap Talk Condition is higher than the Control Condition. Figure 2 panel B shows that the same pattern holds at the aggregate level. To test the significance of
the difference between investment decisions in the three conditions, I run a logistic regression with the individual choice as the dependent variable, private clues and two dummy variables D1 and D2 as the independent variables. D1 is set to 1 for the Control Condition or Cheap Talk Condition and 0 for the Market Condition. D2 is set to 1 for the Cheap Talk Condition and 0 otherwise. D2 measures the difference between the Cheap Talk Condition and the Control Condition and D1 measures the difference between the Control Condition and the Market Condition. Results of the regression are reported in Table 3. Both coefficients on D1 and D2 are significantly positive. Similar results are obtained if I only use the data of last ten rounds. This confirms that subjects are most likely to invest in the Cheap Talk Condition and least likely to invest in the Market Condition controlling for the private clue.

**Finding 2:** Controlling for private clues, subjects are less likely to invest in the Market Condition than the Control Condition; subjects are more likely to invest in the Cheap Talk Condition than the Control Condition.

I also examine the second moment, the standard deviation of investment, which provides a measure of the predictability of outcomes. Larger standard deviation implies lower predictability of outcomes. Figure 3 panel A shows that the standard deviation of aggregate investment in the Market Condition is similar to the Control Condition. Using the session level data and the Wilcoxon-Mann-Whitney test, we can’t reject the null hypothesis of no difference between the two. This suggests that the predictability of outcomes is not reduced by the introduction of market. Panel B of figure 3 shows that the standard deviation of aggregate investment in the Cheap Talk Condition is higher than the Control Condition. Using the session level data and the Wilcoxon-mann-Whitney test, we can reject the null hypothesis that the standard deviation of aggregate investment is the same in the Cheap Talk and Control Condition for θ in the range 40-60 (p = 0.10, two-
tailed test) and 60-80 ($p = 0.04$, two-tailed test). The predictability of outcomes is lower in the *Cheap Talk Condition*, possibly because of the existence of multiple equilibria.

**Finding 3:** *The standard deviation of aggregate investment in the Market Condition is not significantly different from the Control Condition; the standard deviation of aggregate investment in the Cheap Talk Condition is higher than the Control Condition.*

### 5.1.2 Market Price

In this section, I analyze the information content of price and how price affects decisions in the game. I use the average of last five trades in each period as the measure of market prices.\(^8\) Price is very informative about the fundamentals. There is a significant negative (positive) relation between prices of the “Success” (“Failure”) stock and θ. The linear regression with the price of “Success” stock as the dependent variable and θ as the explanatory variable has the coefficient $-0.01$ ($p = 0.0007$). The linear regression with the price of “Failure” stock as the dependent variable and θ as the explanatory variable has the coefficient $0.009$ ($p = 0.0063$).\(^9\)

**Finding 4:** *The price of “Success” is negatively correlated to θ; the Price of “Failure” is positively correlated to θ.*

In the following analysis, I summarize the information in two stocks by the variable *Price_Success*, which is defined as the price of “Success” stock divided by the sum of the prices of the two stocks.\(^10\) Figure 4 panel A shows that there is a negative relationship between *Price_Success* and θ. Figure 4 panel B plots the standard deviation of *Price_Success*. The standard deviation has an inverse U-shaped pattern. Prices are more volatile for the states around 50 where strategic uncertainty is high. In a REE, price

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\(^8\) Similar results are obtained if I use the last prices, and last two prices.

\(^9\) In these regressions, θ is adjusted in the following way: θ is set to 0 if it is less than 0, and θ is set to 100 if it is more than 100.

\(^10\) Prices are very noisy in the first few rounds as subjects experience learning about trading. Therefore in the following analysis related to price we exclude data from the first five rounds of each session.
multiplicity arises when there are multiple equilibria in the game and vice versa (Angeletos and Werning 2006). Figure 6 panel B shows the standard deviation of price and the standard deviation of aggregate investment. We can see that the patterns in the standard deviation of price tracks the pattern of the standard deviation of aggregate investment. Both vary with the state variable $\theta$. This indicates that price volatility is consistent with the variation of game outcomes, confirming the prediction of REE.

Table 4 reports the results of linear regressions with $price\_Success$ as the dependent variable. It confirms the significant negative relation between prices and $\theta$. In addition, prices are also positively related to the aggregated investment $A$. After controlling for information in $\theta$, the coefficient on the aggregated investment is still significant. This suggests that prices provide information not only about $\theta$, but also about investment choices in the game. Figure 6 panel A plot price and aggregate investment in the same graph. We can see that price tracks aggregate investment closely. Prices can be used to predict game outcomes with a high degree of accuracy. One simple rule to predict the game outcome based on prices is to predict success (failure) if the price of “Success” stock is higher (lower) than “Failure” stock. This forecast rule based on prices generates correct predictions in 90.7% of experimental rounds.

Angeletos and Werning (2006) find that agents also adopt a threshold strategy in the game stage, but the threshold is a function of stock price. Ideally we shall estimate investment threshold $S^*$ for price. Due to limited observations, I estimate the threshold for three subsamples based on $Price\_Success$: High (>0.8), Low (<0.2), and Med (between 0.2 and 0.8). The estimated investment threshold is 51.48 with dispersion 23.91 for the high price sample, the estimated threshold is 45.75 with dispersion 28.1 for the medium price
sample, and the estimated threshold is 31.41 with dispersion 41.4 for the low price sample. Figure 5 panel A plot the investment frequency for each subsample for various clue intervals. We can see that higher prices lead to higher investment frequency. This indicates that price affects individual investment decisions.

In a REE, the individual demand for each stock depends on the private clues. Table 5 panel A shows the results of linear regressions with the net changes in the holdings of each stock as the dependent variable and \textit{Price\_Success} as the explanatory variables. There is a significant negative (positive) relation between clues and demand for “Success” (“Failure”) stock. This suggests that subjects’ private clues affect their portfolio holdings. Another property of rational expectations equilibrium is that trading decisions and investment decisions are consistent with each other. The Probit regression results reported in table 5 panel B confirms that the probability of choosing to invest increases (decreases) in the holdings of “Success” (“Failure”) stocks.

**Finding 5:** The holdings of “Success” are decreasing in the private clue and the holdings of “Failure” are increasing in the private clue. The probability of choosing to invest increases in the holdings of “Success” stock and decreases in the holdings of “Failure” stock.

### 5.1.3 Cheap Talk Messages

The analysis of messages in the \textit{Cheap Talk Condition} suggests that informative and responsive equilibria are played. In the \textit{Cheap Talk Condition}, subjects submit messages to the experimenter whether they intend to invest and the experimenter announces how many intend to invest. I define cheap talk messages as the percentage of subjects who intend to invest, which is between 0 and 1. Figure 4 panel C shows that the cheap talk message is informative about the state. There is a negative relation between the state and aggregate message. The larger the state, the less the percentage of subjects intends to invest. A linear
regression of the cheap talk message on the state has a negative coefficient -0.003 (p<0.0001). Compared to price, cheap talk messages are less informative about the state. Figure 4 panel D plots the standard deviation of the cheap talk message and compares it with the standard deviation of price. We can see that price is more volatile for relatively good states, whereas cheap talk messages are more volatile for relatively bad states.

**Finding 6: The percentage of subjects that intend to invest decreases as θ increases.**

Subjects’ decisions are responsive to cheap talk messages. In the informative cheap talk equilibria, agents also adopt a threshold investment strategy, but threshold is a function of messages. Ideally we should run a logistic regression for each realization of messages. Due to limited data, I run regressions for three subsamples by the total number of subjects that intend to invest: High (> 9), Low (<6) and Med (6-9). I estimated the threshold of investment for the three subsamples. The estimated threshold is 122.52 with dispersion 48.4 for the high sample. The estimated threshold is 73.41 with dispersion 31.69 for the medium sample. The estimated threshold is 35.21 with dispersion 27.59 for the low sample. Figure 5 panel B plots the investment frequency for the three subsamples respectively. We can see that subjects’ decisions are very responsive to cheap talk messages.

**Finding 7: The individual investment decisions are responsive to cheap talk messages.**

My simplified cheap talk model predicts that agents will also adopt a threshold strategy in the cheap talk stage. That is, they intend to invest if their clue is less than a cutoff and not invest otherwise. I apply the simple error model to estimate the cheap talk threshold. There are 8 out of 96 subjects with minimum error larger than 0.2. I classify those subjects who don’t follow the cutoff strategy. Table 6 reports the estimated threshold for subjects who follow the cutoff strategy. The average threshold is 83.86 and the mean error rate is
0.07. Figure 7 plots the distribution of estimated cutoffs. 26% of subjects have cutoffs higher than 100. Very few subjects (0.07%) have cutoffs less than 50. The rest has cutoffs less than 100 but higher than 50. The distribution shows that individual thresholds are dispersed, which indicate the cheap talk strategy is likely to be asymmetric. Furthermore, there is evidence that the cheap talk thresholds are affected by the history of play. In the Control Sessions, subjects have the experience of playing the game in the Control Condition before they can cheap talk. In the Cheap Talk Sessions, subjects have no past experience. The estimated cheap talk threshold is 79.14 for the Control Sessions, which is significantly lower than the estimated thresholds for the Cheap Talk Sessions 88.60 ($p = 0.07$, one tailed t-test). This indicates that past experience of play the game without communication reduces the cheap talk threshold.

I also examine the consistency of messages and actual choices at the individual level. 80% of cases that subjects intend to invest actually choose to invest. 72% of cases that subjects intend to not invest actually follow their intention. For the cases in which actual choices differ from intentions, subjects change their decisions because they take into account the public information announced by the experimenter. One simple way to use this information is to form a conjecture about the game outcome: success if the total percentage of subjects who intend to invest is equal to or larger than a subject’s private clue, and failure otherwise. Indeed, in 84% of the cases in which subjects announce “invest” but choose “not invest,” the conjectured outcome is failure. Similarly, in 71% of the cases in which subjects announce “not invest” but choose “invest,” the conjectured outcome is “Success”. This indicates that a majority of subjects did not to follow their intentions.

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11 E.g., suppose that 6 out of 12 subjects intend to invest; then $E(A) = 50$. A subject who receives a signal 30 estimates that $E(\theta) = 30$. This subject would conjecture that the outcome will be success because $E(A) = 50 > E(\theta) = 30$. 

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because they took into account the announced public information. To summarize, cheap talk messages convey information, and subjects take into account this information.

5.2 Public Information and Investment Decisions

The above analyses show that both price and cheap talk aggregate information and the information affects decisions in the game stage. To explore the link between public information and investment decisions, I run a linear regression with the aggregate investment as the dependent variable and public information as the explanatory variable. In the Cheap Talk Condition, the public information is percentage of subjects that intend to invest. In the Market Condition, the public information is the prices of “Success” stocks. In the Modified Cheap Talk Condition, the public information is the average estimated probability of success. The regression results in table 7 show that there is a strong positive relation between the aggregate investment and the level of the public information. The variation in the public information explains a large portion of the variations in the observed aggregate investment after controlling for θ.

Finding 8: The aggregate investment is positively correlated with public information.

The Market Condition and the Cheap Talk Condition are not directly comparable to each other. Market price predicts the probability of the outcome to be success, but cheap talk messages is about the intended actions. To make market and cheap talk comparable, I run a Modified Cheap Talk Session, in which subjects submit their estimated probability of project success to the experimenter in the Modified Cheap Talk Condition. The average estimated probability of success is comparable to the price of “Success” stock. Figure 8 panel A compares the public information in the two conditions. Cheap talk messages are more optimistic than market prices. For θ between 40 and 60, cheap talk messages
indicates the probability of success is about 70%, and market price indicates that the
probability of success is only about 40%. The REE market price is pessimistic than cheap
talk and the aggregate investment level is much lower in the Market Condition than the
Modified Cheap Talk Condition as shown in Figure 8 panel B.

The history effect can also be explained by the difference in the public information.
Figure 9 panel A shows that the cheap talk messages in the Cheap Talk Condition in the
Cheap Talk Sessions are much more optimistic than the messages in the Cheap Talk
Condition in the Control Condition. Subjects are less likely to announce that they intend to
invest if they have experienced playing the game in the Control Condition. As a result,
they are less likely to choose to invest as shown in figure 9 panel B.

This difference in public information can also explain the different investment
decisions in the Modified Cheap Talk Condition compared to the Cheap Talk Condition.
The difference between the two conditions is the message space. In the Cheap Talk
Condition, the message space is restricted to either “invest” or “not invest”. In the
Modified Cheap Talk Condition, the message is a continuous number between 0 and 1.
Figure 10 panel A shows that the messages in the Modified Cheap Talk Condition are less
optimistic than the messages in the Cheap Talk Condition. Figure 10 panel B confirms that
subjects are less likely to choose “invest” in the Modified Cheap Talk Condition compared
to the Cheap Talk Condition. Restricting agents to reporting “invest” or “not invest” has
the effect of generating optimistic public information. An agent who has decided to invest
with at least 50% probability will report that he intends to invest. If the agent is allowed to
report the probability, then the average message will be lower than if he were restricted to

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12 In the post experiment questionnaires, subjects indicate that they are less likely to say they intend to invest
in the Cheap Talk Condition in the Control Sessions because they have experienced the game in the Control
Condition and they expected others will not cooperate.
report “invest” or “not invest”. This result suggests that there is a benefit to restricting message spaces of communication. Previous literature also finds benefits to restricting message spaces in communication. In a capital budgeting setting, Arya, Glover, and Sivaramakrishnan (1997a) and Arya et al. (2000) illustrate that restricting message spaces of informed managers can serve as the commitment device for the uninformed principal. In my setting, coarsening communication by restricting message space exogenously seems to be able to reduce strategic uncertainty.

5.3 Coordination Efficiency

5.3.1 Frequency of Success

The first measure of efficiency is the frequency of success for solvent projects ($\theta \leq 100$). Table 8 reports the frequency of project failures for various ranges of $\theta$. In the three main experimental conditions, the project success rate is 100% for $\theta \leq 40$ and the success rate is 0 for $\theta \geq 70$. In the intermediate range, the success rates are nonzero and decrease with $\theta$. There is coordination failure in all three conditions. There are fewer incidences of coordination failures in the Cheap Talk Condition and more incidences of coordination failures in the Market Condition. The success rates in the Cheap Talk Condition (the Market Condition) are higher (lower) than the Control Condition.

5.3.2 Frequency of Miscoordination

The other source of inefficiency in a coordination game is that players’ choices are not perfectly coordinated. For example, players who have not chosen to invest to a successful project lose the opportunity to profit and players who have chosen to invest to a failed project lose their investment. I define a dummy variable Miscoordination to measure this type of inefficiency. Miscoordination equals 1 if the game outcome is success but the
choice is “not invest” or the game outcome is failure and the choice is “invest”. Figure 10 compares the frequency of miscoordination in the three main conditions. In the Control Condition, the frequency of miscoordination has an inverse U–shaped pattern. The frequency of miscoordination is the largest for \( \theta \) around 50. Figure 10 panel A shows that the frequency of miscoordination is higher in the Market Condition than in the Control Condition for relatively strong fundamentals. Figure 10 panel B shows that the frequency of miscoordination is lower in the Cheap Talk Condition than the Control Condition.

5.3.3 Game Payoffs

Table 9 summarizes the average game payoff per round for each subject in each experimental condition. It also reports the efficiency ratios, which are calculated as the ratio between the total payoffs and the highest payoffs that subjects can earn under the first best solution.\(^{13}\) The average efficiency ratio is 68.50% in the Control Condition; it increases to 74.70% in the Cheap Talk Condition and decreases to 64.57% in the Market Condition. Using the session level data and the Wilcoxon-mann-Whitney test, we can reject the null hypothesis of no difference in the efficiency ratio between the Cheap Talk Condition and the Control Condition (\( p = 0.07 \), two-tailed test) and between the Cheap Talk Condition and the Market Condition (\( p = 0.03 \), two-tailed test). The efficiency ratio in the Market Condition is not significantly different from the Control Condition (\( p = 0.37 \), two-tailed test).

Finding 9: The payoff efficiency in the coordination game in the Cheap Talk Condition is higher than the Market Condition and the Control Condition.

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\(^{13}\) Under the first best, subjects will invest if \( \theta \leq 100 \) and their payoffs will be 1000 points. Subjects will not invest if \( \theta > 100 \) and their payoffs will be 500 points.
Chapter 4

6 Conclusion and Discussion

The role of information on fundamental uncertainty is well studied in the accounting literature, but the role of information on strategic uncertainty is rather new. This paper provides empirical evidence of the importance of strategic uncertainty on investment decisions in a coordination game. I study the impact of two important sources of public information on coordination: market price and cheap talk. The experimental results suggest that market price aggregates information about exogenous fundamental but has negative impact on investment confidence. Cheap talk also aggregates information but the information is coarser than information in the price. I find that the efficiency of coordination is significantly higher in the Cheap Talk Condition than the Market Condition.

My experimental results suggest that more information may not necessarily improve efficiency in a coordination setting. Further analysis reveals that price reduces fundamental uncertainty but increases strategic uncertainty, whereas cheap talk allows players to communicate their intentions and reduces strategic uncertainty. From information economics perspective, information in price provides much finer partitions about the exogenous fundamentals. There is an almost one to one mapping between price and the fundamentals and agents can infer from the level of price which states have realized. However, the uncertain about other agents’ strategic choices is still unresolved. Price reflects such strategic uncertainty through its volatility. Cheap talk messages provide a coarser partition of the exogenous fundamentals. Agents can learn less information about the fundamentals, but they can infer information about other agents’ strategic choices. Agents are able to achieve better outcome because the resolution of strategic uncertainty
increases confidence. The conventional wisdom that more information is better breaks down in a coordination setting because of the subtle effect of information on strategic uncertainty. As pointed out by Baiman (1975), in a multiple person decision making setting, the role of information on efficiency is no longer as straightforward as in a single person decision making setting.

My experiments in the Market Condition are designed to test the prediction of a REE in which price has a feedback effect on real investment decisions. Previous experimental asset market only focuses on the ability of price to aggregate information about exogenous states. There is only fundamental uncertainty, which is uncertainty about an exogenous state variable. Usually the experimenter can observe the true state and also be able to control the level of fundamental uncertainty by manipulating the precisions of private signals. In my experiments, dividends are not only a function of states but also a function of agents’ investment decisions. In a coordination game, strategic uncertainty endogenously arises because of the strategic nature of the game. This type of uncertainty can’t be controlled by the experimenter. In a REE, price not only aggregates information about fundamental uncertainty, but also reveals information about strategic uncertainty. Price reflects strategic uncertainty through its volatility. I find that the standard deviation of price varies with the states. Moreover, the pattern of the standard deviation of price is consistent with the standard deviation of the aggregate investment.

In a coordination game, expectations play a significant role in determining game outcome. In a REE, market will anticipate the equilibrium that will be selected in the game and such expectation is self-fulfilling. In contrast, cheap talk relaxes the rational expectation constraint and allows agents to signal their willingness to play a better
equilibrium. The optimistic signals affect agents’ beliefs and they can achieve better outcomes.

The results in this paper suggest that information aggregation properties of a market can sometimes lead to unexpected consequences on resource allocation. Price can increase strategic uncertainty by aggregating information about a fundamental and making it publicly available. The anecdotal evidence of the failure of Bear Stearns seems to be consistent with this argument. The CDS spreads measuring the default risk on Bear Stearns debt rocketed from 246 to 792 basis points in a single day on March 13, 2008. All market participants observing the spike knew that other participants were also observing the spike. This may have caused the confidence of lenders to evaporate suddenly, and the resulting panic-driven withdrawals triggered the failure of Bear Stearns.

Understanding the role of strategic uncertainty has implications for the debate on mark-to-market accounting. Under mark-to-market accounting, banks are required to value their subprime mortgage securities using the ABX Index; at the same time, banks are also the major traders in this market as they hedge their exposure to the subprime risk through the ABX market. Their hedging activities drive down prices, but ironically, they have to use the depressed prices to value their subprime-related assets, which forces banks to take large write-offs. If there is hedging activity in the market, market prices will be even more depressed, and investment may be further reduced. In addition to the information effect on strategic uncertainty, marking-to-market assets using the ABX may further exacerbate the underlying coordination problem by introducing an additional feedback effect. Ryan (2008) discusses about this potential feedback effect of mark-to-market accounting using the ABX Index on the index itself and he calls for behavioral-experimental type of research on this
topic. In future experiments, financial reporting can be introduced to the coordination game to study this effect.

The experimental results of this paper are consistent with the findings from recent empirical studies. For example, Hertzberg, Liberti, and Paravisini (2009) find that sharing lenders’ private information about their common borrowers through a public credit registry increases defaults and causes a permanent decline in debt. Their results are consistent with my experimental findings in that the credit registry is a similar information channel to a market, through which lenders’ private information is aggregated and disseminated in public. Brunner and Krahnen (2008) document that moderate-sized “bank pools” have a positive impact on the success of distressed loan workout in Germany. Bank pools are cheap talk in that they are formed to allow multiple creditors to communicate with each other through nonbinding guarantees. Their findings also suggest a positive impact of cheap talk on coordination. Chen, Goldstein, and Jiang (2009) find that mutual funds that hold illiquid assets exhibit stronger sensitivity of fund outflows to bad performance than funds that hold liquid assets. However, such a difference disappears for the sample in which the investor base comprises large investors. One possibility is that the large investors are able to communicate through cheap talk.

Coordination problems also exist within decentralized organizations, and this study also has implications for managerial accounting. For example, suppose a firm undertakes a project that requires the input of multiple divisions. Each division must decide whether to commit scarce resources to the project. A division may hold back its investments because of a lack of confidence about other divisions’ commitment. Participative budgeting, which is widely applied in decentralized organizations, shares common attributes with cheap talk.
In the participative budgeting process, each division submits its future plan, and the head office aggregates and publishes the plan. Luft and Shields (2007, p35) show that decentralization increases participative budgeting. My paper suggests that participative budgeting may play a role in facilitating coordination among divisions in decentralized firms.

Recently, internal markets called “prediction markets” have been explored as an innovative way of aggregating information within organizations (Wolfers and Zitzewitz 2004). For example, Microsoft opened a prediction market to predict an internal product ship date. In this market, software developers and testers traded state-contingent securities such as NOV, DEC, JAN, and so on. If the actual ship date was in January, then the JAN share had a $1 payoff, and the others had a $0 payoff. Such prediction market generates useful information for project management as prices aggregate diverse information. My paper cautions companies against the potential negative effect of prediction markets relative to more traditional mechanism for coordination such as participative budgeting.

There are limitations of the current study, and several related extensions may be helpful in addressing those limitations. First, only insiders who play the coordination game participate in the trading in the current market experiment. Future experiments can allow outsiders to trade. Future studies can also vary the relative payoffs from the market and the game. Second, future experiments can study other cheap talk procedures such as committee meetings or repeated cheap talk. Third, the payoff structure is exogenously specified in this paper. Future experiments can vary the payoffs and study how changes in the payoff parameters affect coordination and whether such changes affect the impact of price and cheap talk on coordination. Last, it may also be interesting to study the combined effect of
cheap talk and an asset market on coordination. If strategic uncertainty can be managed through cheap talk, can investors take advantage of the information revealed in the market?

In this paper, public information is generated through communication among investors. In practice, there are other exogenous channels of public information, such as public accounting reports, credit ratings, public news, and media announcements. Future research can study the impact of such information channels on coordination. Also, these public disclosures may contain biases, such as the conservative bias of accounting or an optimistic bias in managerial disclosure. Future research can study how such biased information affects coordination.

The strategic interdependence among agents in a coordination setting can make the role of public information counterintuitive. As public information plays a significant role in coordinating beliefs, it is rational for agents to overweight public information relative to private information. As a result, the noise in the public information can be amplified, and social efficiency can be adversely affected by public information disclosure (Morris and Shin 2002). Accounting information is the most important source of public information to play a significant role in coordination. Understanding the role of public information on coordination is necessary and useful for both accounting theory and policy design.
7 Appendix: Experimental Instructions

This is an experiment in decision making under uncertainty. If you follow the instructions carefully and make decisions wisely, you will receive a considerate amount of money. You will be paid in cash at the end of the experiment.

If you have any questions during the experiment, please raise your hand and wait for an experimenter to come to you. Please do not talk or try to communicate with other participants during the experiment. *Participants intentionally violating the rules may be asked to leave the experiment and will not be granted credit.*

You are one of 12 people who interact with each other during the experiment. The experiment has two parts, and each part consists of several rounds. Your earnings are measured in points, and your points are summed up over all rounds. Your objective is to maximize your total points. We will convert your points into dollars at 1000 points = 50 cents.

[Game Instructions]

- **Your Choice x**
  In this experiment, your task is to choose a number $x$. You may choose 0 or 1.

- **Group Choice X**
  *The group choice $X$ is the percentage of participants that choose 1.* For example, if 6 out of 12 participants choose $x = 1$, the number $X$ is 50. $X$ is in the interval $[0,100]$. The table below provides the number of people that choose 1 and the corresponding $X$.

<table>
<thead>
<tr>
<th># of subjects</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>8.3</td>
<td>16.7</td>
<td>25.0</td>
<td>33.3</td>
<td>41.7</td>
<td>50.0</td>
<td>58.3</td>
<td>66.7</td>
<td>75.0</td>
<td>83.3</td>
<td>91.7</td>
<td>100</td>
</tr>
</tbody>
</table>

- **Your Payoff**
  - **If you choose 0**, you get 500 points. Your payoff doesn’t depend on others’ choices.
  - **If you choose 1**, you might get 1000 or 0 points depending on the group choice $X$ and an unknown number $Y$.

- **Unknown Number Y**
  *Y is the minimum percentage of people that must choose 1* to guarantee you 1000 points if you choose 1. Suppose you choose 1. If the percentage of people that choose 1 is equal to or greater than the selected number $Y$, you can get 1000 points. Otherwise, you get 0. For each round, the computer will randomly select a real number $Y$. Your payoff is summarized below.

<table>
<thead>
<tr>
<th>Your choice is $x = 1$</th>
<th>If $X \geq Y$, your payoff is 1000</th>
<th>If $X &lt; Y$, your payoff is 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your choice is $x = 0$</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>
Y can be a negative number, in which case you can get 1000 points by choosing 1 by yourself. It can also exceed 100, in which case you can never get 1000 points. The computer selects the number Y at the beginning of each round from a normal distribution with an average value of 50 and a standard deviation of 100. This means that the average value of Y is 50, but the number Y drawn may deviate from the average value in a round. Positive and negative deviations are equally probable. The distribution (standard deviation) of the number Y was chosen in such a way that there is approximately a 33% probability that Y lies between -50 and 50 and an equal probability of approximately 33% that Y lies between 50 and 150.

- Private Clues about Y
  Each participant will receive one private clue about Y. The clues are independently drawn from a normal distribution with mean Y and a standard deviation of 20. How can you interpret your clue? Suppose your clue is Z, then approximately 68 out of 100 times, Y falls in the interval \([Z-20, Z+20]\). And 95 out of 100 times, Y falls in the interval \([Z-2\times20, Z+2\times20]\).

An Example: Suppose the computer randomly selects \(Y = 23.8\). The clue numbers are drawn from a normal distribution with mean 23.8 and a standard deviation of 20. For example, the clues might be 35, 22.8, 66, 45 . . . You might receive a private clue 35. It tells you that Y is in the interval \([15, 55]\) 68 out of 100 times. 95 out of 100 times, Y is in the interval \([-5, 75]\). In rare cases, Y is smaller than -5 or bigger than 75.

- Feedback Information
  Once all participants submit their choices, you will receive the feedback information:

<table>
<thead>
<tr>
<th>Username</th>
<th>subject01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selected number: Y</td>
<td>23.8</td>
</tr>
<tr>
<td>Your Choice</td>
<td>1</td>
</tr>
<tr>
<td>(X \geq Y?) (X is percentage of people that choose 1)</td>
<td>Yes</td>
</tr>
<tr>
<td>Your Payoff</td>
<td>1000</td>
</tr>
</tbody>
</table>

For example, the above feedback screen shows that the selected number by the computer is 23.8. The percentage of people that choose 1 is greater than 23.8 percent. Subject01 chooses 1 and his payoff is 1000.

[Cheap Talk Instructions]

The second part of the experiment is the same as the first part, except that you can announce your intention of play first. That is, you can announce what choice you intend to make, either 0 or 1. You can do so by typing your intention into the cell marked with “?” and clicking enter.

<table>
<thead>
<tr>
<th>Username</th>
<th>subject01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Clue about Y</td>
<td>5.4</td>
</tr>
<tr>
<td>You intend to choose (0 or 1)</td>
<td>?</td>
</tr>
</tbody>
</table>

The experimenter collects the announcement of intentions and informs everyone of the total number of subjects that intend to choose 1.
After that, you make your game choice. You can do so by typing your game choice into the cell marked with “??” and clicking enter.

<table>
<thead>
<tr>
<th>Username</th>
<th>subject01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Clue about Y</td>
<td>5.4</td>
</tr>
<tr>
<td>Your Choice (0 or 1)</td>
<td>??</td>
</tr>
</tbody>
</table>

Once all participants submit their choices, the game outcome is realized and feedback information is sent out. **Note that your announcement is not binding. You can choose to follow your announcement or not. Your payoff is not determined by your announcement of your intention, but by your actual game choice.**

**[Market Instructions]**

Before you play the game, you can trade in a market. The market has two securities, which are “**Stock A** (X ≥ Y)” and “**Stock B** (X < Y)”. If the game outcome is X ≥ Y, one unit of Stock A pays 1 point dividend and Stock B pays nothing. If the game outcome is X < Y, one unit of Stock B pays 1 point dividend and Stock A pays nothing.

At the beginning of each trading round, you will be endowed with 10 units of each security and 300 points as initial cash to purchase securities. During the trading period, you may buy and sell units of security. To initiate a trade, you can submit offers: Ask (your offer to sell) and Bid (your offer to buy). Alternatively, you can accept the existing bid or ask. That is, you can Buy from an existing ask or Sell to an existing bid. Operational details will be explained in a moment.

Your trading profits are calculated as:

\[
\text{Trading profits} = \text{cash received for selling securities} - \text{cash paid for purchasing securities} + \text{dividend per unit} \times \text{final holdings in each security}
\]

**Example:** Suppose you purchased 10 units of security “Stock A” at the average price of 0.8 and sold 5 units of security “Stock B” at the average price of 0.4 during the trading period. How much are your trading profits if the game outcome is X ≥ Y?

**Answer:**

- Change in cash = –10×0.8 (purchase “Stock A”) + 5×0.4 (sell “Stock B”) = –6;
- Final holdings of “Stock A” = 10 (initial shares) + 10 = 20 units;
- Final holdings of “Stock B” = 10–5 = 5 units;
- Trading profits = –6+1 (“Stock A” dividend) × 20 units + 0 (“Stock B” dividend) × 5 units = 14.

The market will open for two minutes. Once the market is closed, you will make your game decision. The prices of the two securities are public information. Markets for each round are independent of each other. You will start fresh with an initial endowment of cash and securities at the beginning of trading, and your trading profits will not be carried over to the next round.

**Trading Window**

We only use a few functions of the trading program. **Please just focus on those features** and ignore others. The example trading window below is used to demonstrate those features.
A. **Information Area:** This area shows basic information about the current trading round. Most importantly, it shows your profits.

1) **Grade:** the trading profits for the current trial. The trader in the above screen earns 10.26 points trading profits for the current trial.
2) **Cash:** your cash balance. The trader above has a cash balance of 310.27. This includes his initial endowment of 300 points.

B. **Security Area:** This area shows the security information.

1) **Security Name:** there are two stocks in the market. If you want to trade a stock, single click the security’s name first so that the system knows that you are trading that stock.
2) **Bid:** this column shows the highest price offered to buy a stock (Price/Quantity). A star indicates that you are the one who makes that offer. In our example, the trader submits an offer to buy 1 unit of Stock A at 0.21. Someone else makes an offer to buy 1 unit of Stock B at 0.87. If your offer price is not the highest, it will be stored in an order book. You can view all orders from a pop-up window by clicking a stock’s name.
3) **Ask:** this column shows the lowest price offered to sell a stock (Price/Quantity). In our example, someone offers to sell 1 unit of Stock A at 0.32. The trader above offered to sell Stock B at 0.89. You can view all ask offers from the pop-up window if you single click a stock’s name.
4) **Position:** this column shows the number of units of security you currently hold. For example, the trader above has 9 units of Stock A and 11 units of Stock B.
5) **Last:** this column shows the most recent market transaction price. For example, one unit of Stock A has just been sold at 0.22 and one unit of Stock B has just been bought at 0.95.
6) **Payoff:** this column shows the dividend of each security. In this example, the game outcome is X<Y; therefore each unit of Stock A pays 0 and Stock B pays 1.

C. **Trading Area:** This area is where you can make offers to buy or sell units of the security. How can you trade?

1) **You can submit your offers (Bid or Ask):** How can you make offers? First, click the stock you want to trade. Specify a price in the space next to “Price” and a quantity in the box next to “Quantity.” Then click on the button “Bid” or “Ask.”
For example, suppose you want to buy 1 unit of Stock A at the price of 0.22. First click the security name “Stock A,” and then type 0.22 in the price box and type 1 in the quantity box. Finally, click the button “Bid.” Your bid will show up in the bid column as 0.22/1*. If your bid is lower than the current best bid 0.21, then it won’t show up in the trading screen but will be stored in the order book.

2) **You can accept existing offers (Buy or Sell):**
   If there are offers available in the market, you can take those offers. How can you do that? First, click the stock you want to buy or sell. Specify a quantity in the box next to “Quantity,” and then click on “Buy” or “Sell.”

   For example, suppose you want to buy 1 unit of Stock A. First click the security name “Stock A” and type in “1” in the quantity box. Then click the button “Buy.” Your “Buy” order is matched with the current best ask offer. In the screen shot above, the best ask offer for Stock A is 0.32. Your cash account reduces by 0.32 and your position in Stock A increases by 1. The price 0.32 will show up as the most recent transaction price in the column “LAST.” Your “Sell” orders are matched with the highest bid offer, which is shown in the column “Bid” in the security information area.

   **To simplify the trading, we restrict to trading one unit at a time. The “Quantity” must be 1. The price range for each security is [0, 1].**
8 References

Ashcraft, A. B., and J. A. C. Santos. 2009. Has the CDS Market Lowered the Cost of Corporate Debt? : SSRN.


9 Figures

Figure 1: Actual and Predicted Aggregate Investment in the Control Condition

The above figure depicts the aggregate investment in the Control Condition compared with the aggregate investment predicted by the global game under the assumption that there is a continuum of risk neutral agents.
Figure 2: Individual and Aggregate Investments

Panel A: Individual Investment and Private Clues

Panel B: Aggregate Investment $A$ and State $\theta$

Figure 3: Standard Deviation of Aggregate Investment

Panel A: Market Condition vs. Control Condition

Panel B: Cheap Talk Condition vs. Control Condition
Figure 4: Information from the Stock Prices and Cheap Talk Messages

Panel A: Mean of Price_Success

Panel B: Standard Deviation of Price_Success

Panel C: Mean of Cheap Talk Messages

Panel D: Standard Deviation of Cheap Talk Messages

Panel A depicts the average prices of the “Success” stock. I use the last five trades in each period as the measure of market prices. “Price_Success” is the prices of “Success” stocks rescaled by the sum of the “Success” and “Failure” prices. Panel B depicts the standard deviation of the prices for the “Success” stock. Data from the first five rounds of each session are excluded. Panel C depicts the average percentage of subjects that intend to invest and compares it with Panel A. Panel D depicts the standard deviation of the cheap talk messages and compares it with panel B.
Figure 5: Public Information and Individual Investment

The figure above depicts investment frequencies in the Market Condition and Cheap Talk Condition by the level of public information. In Panel A data in the Market Condition are divided into three subsamples by the prices of the rescaled “Success” stock: Low (price lower than 0.2), Med (price between 0.2 and 0.8), and High (price larger than 0.8). In Panel B data in the Cheap Talk Condition are divided into three subsamples by the number of subjects that intend to invest: High (more than 9), Med (between 6 and 9), and Low (less than 6).
Figure 6: Public Information and Aggregate Investment

Panel A: Market Condition

Panel B: Market Condition (Standard Deviation)

Panel C: Cheap Talk Condition

Panel D: Cheap Talk Condition (Standard Deviation)

Panel A depicts the average rescaled “Success” stock price (Price) and the percentage of subjects that choose to invest (Choice). Panel B depicts the standard deviation of price and the standard deviation of aggregate investments. Panel C depicts the average percentage of subjects that intend to invest and the percentage of subjects that choose to invest. Panel D depicts the standard deviation of cheap talk messages and aggregate investments.
Figure 7: Distribution of Estimated Cheap Talk Thresholds

The figure above depicts the distribution of the estimated individual cheap talk threshold. The threshold is estimated by a simple error model using data from *Cheap Talk Condition*. If the minimum error for an individual is larger than 0.2, we define that this individual doesn’t hold threshold strategy. The figure above excludes these individuals.

Figure 8: Comparison between Market Condition and Modified Cheap Talk Condition

Panel A: Public Information

In the Market Condition, the public information is price_success. In the Modified Cheap Talk Condition, the public information is the average estimated probability of success.
Figure 9: Comparison between *Cheap Talk Condition* in Control Sessions and Cheap Talk Sessions

Panel A: Public Information (Message)

Panel B: Aggregate Investment

Figure 10: Comparison between *Cheap Talk Condition* and *Modified Cheap Talk Condition*

Panel A: Public Information

Panel B: Aggregate Investment

In the *Cheap Talk Condition*, public information is the percentage of subjects that intend to invest. In the *Modified Cheap Talk Condition*, the public information is the average estimated probability of success.
The figure above depicts average frequency of miscoordination. Miscoordination is defined to be 1 if game outcome is success and subjects’ choices are “Not Invest” or if game outcome is failure and subjects’ choices are “Invest”. Otherwise, miscoordination is defined to be 0.

Figure A1: Predicted Aggregate Investments

Depicts the predicted aggregate investment for the experimental parameters: $\gamma = 0.5$, $R = 1000$, $\lambda = 500$, $\beta = 25$, $\alpha = 1$, under the assumption that there is a continuum of agents. The aggregate investment $A$ is the percentage of subjects who invest. The solid line is the predicted aggregate investment under the assumption that agents are risk-neutral. The dashed line is the predicted aggregate investment under the assumption that agents are risk-loving (negative exponential utility with risk aversion coefficient $-0.001$). The dotted line is the predicted aggregate investment under the assumption that agents are risk-averse (negative exponential utility with risk aversion coefficient 0.001).
### 10 Tables

#### Table 1: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control Sessions</th>
<th>Cheap Talk Sessions</th>
<th>Market Sessions</th>
<th>Modified Cheap Talk</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Cheap Talk</td>
<td>Control</td>
<td>Market</td>
<td>Modified Cheap Talk</td>
</tr>
<tr>
<td>Min $\theta$</td>
<td>-58.6</td>
<td>-51.9</td>
<td>-51.9</td>
<td>-58.6</td>
<td>-51.9</td>
</tr>
<tr>
<td>Max $\theta$</td>
<td>144.5</td>
<td>143.4</td>
<td>143.4</td>
<td>144.5</td>
<td>143.4</td>
</tr>
<tr>
<td>Mean $\theta$</td>
<td>51.5</td>
<td>51.6</td>
<td>50.7</td>
<td>51.5</td>
<td>50</td>
</tr>
<tr>
<td>Min $S$</td>
<td>-87.2</td>
<td>-102.6</td>
<td>-102.6</td>
<td>-74.3</td>
<td>-74.3</td>
</tr>
<tr>
<td>Max $S$</td>
<td>179.9</td>
<td>163.9</td>
<td>163.9</td>
<td>179.9</td>
<td>163.9</td>
</tr>
<tr>
<td>Mean $S$</td>
<td>50.44</td>
<td>51.51</td>
<td>51.14</td>
<td>50.5</td>
<td>49.5</td>
</tr>
<tr>
<td>Mean choice</td>
<td>0.54</td>
<td>0.6</td>
<td>0.65</td>
<td>0.55</td>
<td>0.46</td>
</tr>
<tr>
<td>% of success</td>
<td>0.49</td>
<td>0.53</td>
<td>0.59</td>
<td>0.51</td>
<td>0.45</td>
</tr>
<tr>
<td>Average game payoff</td>
<td>641.67</td>
<td>690.63</td>
<td>728.65</td>
<td>659.90</td>
<td>615.56</td>
</tr>
<tr>
<td># of subjects</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
</tr>
</tbody>
</table>

Variable $\theta$ is the exogenous state variable. The prior about $\theta$ is that it is normally distributed with mean 50 and standard deviation 100. $S$ is the private clue received by the individual, which is drawn from a normal distribution with mean $\theta$ and standard deviation 20. Choices $a_i$ are either 0 or 1. In the experiment, subjects are asked to choose between 0 (not invest) and 1 (invest). If the percentage of subjects choosing 1 is equal to or greater than $\theta$, the outcome is success. Otherwise, the outcome is failure. The average payoffs are payoffs per round measured in game points.
Table 2: Estimated Threshold $S^*$ for the Control Condition

<table>
<thead>
<tr>
<th>Session (Code)</th>
<th>Condition</th>
<th>Estimated Threshold$^a$ (Standard Deviation)</th>
<th>Mean Error Rate</th>
<th>Logistic Regression$^b$ (Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (C1)</td>
<td>Control</td>
<td>46.00 (14.07)</td>
<td>0.08</td>
<td>43.08 (31.92)</td>
</tr>
<tr>
<td>Control (C2)</td>
<td>Control</td>
<td>53.25 (9.35)</td>
<td>0.08</td>
<td>53.90 (23.61)</td>
</tr>
<tr>
<td>Control (C3)</td>
<td>Control</td>
<td>70.08 (22.00)</td>
<td>0.05</td>
<td>67.40 (26.54)</td>
</tr>
<tr>
<td>Control (C4)</td>
<td>Control</td>
<td>58.83 (13.80)</td>
<td>0.09</td>
<td>57.55 (24.40)</td>
</tr>
<tr>
<td>Cheap Talk (T1)</td>
<td>Control</td>
<td>61.08 (9.42)</td>
<td>0.04</td>
<td>62.77 (16.09)</td>
</tr>
<tr>
<td>Cheap Talk (T2)</td>
<td>Control</td>
<td>52.38 (10.46)</td>
<td>0.03</td>
<td>54.28 (11.27)</td>
</tr>
<tr>
<td>Cheap Talk (T3)</td>
<td>Control</td>
<td>59.63 (15.15)</td>
<td>0.06</td>
<td>56.32 (21.82)</td>
</tr>
<tr>
<td>Cheap Talk (T4)</td>
<td>Control</td>
<td>50.29 (8.01)</td>
<td>0.06</td>
<td>49.36 (16.74)</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>56.44 (9.05)</td>
<td>0.06</td>
<td>55.58 (9.05)</td>
</tr>
</tbody>
</table>

$^a$ The average individual threshold estimated by a simple error model. First, we assume an arbitrary threshold for a subject. Then we classify decisions that are inconsistent with this threshold strategy as an error, for example, invest above this threshold or not invest below this threshold. We can calculate the error rate for each arbitrary threshold. Finally we choose the threshold that minimizes the percentage of errors. If the threshold is not unique, we take the average of the supremum and infimum of all thresholds that have the minimal error rates. The error rate measures the degree of usage of threshold strategy at the individual basis.

$^b$ The estimated threshold using run logistic regression $\Pr(\text{Choice} = \text{Invest}) = 1 / [1 + e^{-(\alpha/\beta + S^*)}]$. The estimated threshold is $\hat{\alpha}/\hat{\beta}$ and the dispersion of the estimated threshold is $(\pi/\sqrt{3})\hat{\beta}$.
Table 3: Logistic Regression of Individual Choices on Clues

<table>
<thead>
<tr>
<th>Dependent Variable: Choice $a_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$S$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>D1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>D2</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td># of observations</td>
</tr>
<tr>
<td>(all rounds)</td>
</tr>
</tbody>
</table>

Significance level: * $p<10\%$, ** $p<5\%$, *** $p<1\%$

The above table reports results of logistic regressions with individual choices as the dependent variable. Choice equals 1 if “Invest” and choice equals 0 if “Not Invest.” The explanatory variables include private clue $S$, two dummy variables: “D1” is a dummy variable that equals 1 if data are from the Control Condition or Cheap Talk Condition. “D2” is a dummy variable that equals 1 if data are from the Cheap Talk Condition. Numbers in parentheses are standard errors clustered at the experimental session level.

<table>
<thead>
<tr>
<th></th>
<th>Market Condition</th>
<th>Control Condition</th>
<th>Cheap Talk Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>D2</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
The table above reports results of a linear regression with “price_Success” (the price of the “Success” stock divided by the sum of the prices of “Success” and “Failure” stocks) as the dependent variable. The explanatory variables include θ and the aggregated investment $A$ (the percentage of subjects who choose to invest). First 5 rounds of each session are excluded.

<table>
<thead>
<tr>
<th></th>
<th>Dependent Variable: Price_Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.91***</td>
</tr>
<tr>
<td></td>
<td>0.086</td>
</tr>
<tr>
<td></td>
<td>0.4**</td>
</tr>
<tr>
<td></td>
<td>(0.099)</td>
</tr>
<tr>
<td></td>
<td>(0.039)</td>
</tr>
<tr>
<td></td>
<td>(0.123)</td>
</tr>
<tr>
<td>State 0</td>
<td>−0.008***</td>
</tr>
<tr>
<td></td>
<td>−0.003*</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
</tr>
<tr>
<td>Aggregate investment $A$</td>
<td>0.81***</td>
</tr>
<tr>
<td></td>
<td>0.523***</td>
</tr>
<tr>
<td></td>
<td>(0.077)</td>
</tr>
<tr>
<td></td>
<td>(0.101)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>0.74</td>
</tr>
<tr>
<td># of observations</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>55</td>
</tr>
</tbody>
</table>

Significance level: * $p<10\%$, ** $p<5\%$, *** $p<1\%$
Table 5: Portfolio Holdings

Panel A: Linear Regression of Stock Holdings on Clues

<table>
<thead>
<tr>
<th></th>
<th>Dependent Variable</th>
<th>Net Change in “Success” Stock Position</th>
<th>Net Change in “Failure” Stock Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.342**</td>
<td>-2.071**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.129)</td>
<td>(0.411)</td>
<td></td>
</tr>
<tr>
<td>Clue S</td>
<td>-0.079**</td>
<td>0.038**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.008)</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.017</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td># of observations</td>
<td>660</td>
<td>660</td>
<td></td>
</tr>
</tbody>
</table>

Panel B: Probit Regression of Investment Choices on Stock Holdings

<table>
<thead>
<tr>
<th></th>
<th>Choice=1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Change in “Success” Stock Position</td>
<td>0.015***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td></td>
</tr>
<tr>
<td>Net Change in “Failure” Stock Position</td>
<td>-0.009***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td></td>
</tr>
<tr>
<td># of observations</td>
<td>660</td>
<td>660</td>
</tr>
</tbody>
</table>

Significance level: * p<10%, ** p<5%, *** p<1%

Panel A reports estimates of linear regressions with the net change in the holdings of two stocks as the dependent variable. Each individual has 10 units of initial endowment of each stock. The net change in stock holdings is the final position minus the initial holdings. Panel B reports estimates of Probit regressions with individual investment choice as dependent variable. Choice equals 1 if subjects choose to invest and 0 if subjects choose not to invest. Numbers in parentheses are standard errors clustered at the experimental session level.
Table 6: Estimated Thresholds for Cheap Talk Messages

<table>
<thead>
<tr>
<th>Session (Code)</th>
<th>Condition</th>
<th>Estimated Threshold</th>
<th>Standard Deviation</th>
<th>Mean Error Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (C1)</td>
<td>Cheap Talk</td>
<td>71.96</td>
<td>38.53</td>
<td>0.07</td>
</tr>
<tr>
<td>Control (C2)</td>
<td>Cheap Talk</td>
<td>80.95</td>
<td>31.65</td>
<td>0.10</td>
</tr>
<tr>
<td>Control (C3)</td>
<td>Cheap Talk</td>
<td>94.91</td>
<td>19.41</td>
<td>0.06</td>
</tr>
<tr>
<td>Control (C4)</td>
<td>Cheap Talk</td>
<td>69.55</td>
<td>26.90</td>
<td>0.04</td>
</tr>
<tr>
<td>Session Average</td>
<td></td>
<td>79.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheap Talk (T1)</td>
<td>Cheap Talk</td>
<td>82.96</td>
<td>32.32</td>
<td>0.05</td>
</tr>
<tr>
<td>Cheap Talk (T2)</td>
<td>Cheap Talk</td>
<td>85.55</td>
<td>18.81</td>
<td>0.03</td>
</tr>
<tr>
<td>Cheap Talk (T3)</td>
<td>Cheap Talk</td>
<td>98.35</td>
<td>29.73</td>
<td>0.09</td>
</tr>
<tr>
<td>Cheap Talk (T4)</td>
<td>Cheap Talk</td>
<td>88.63</td>
<td>36.51</td>
<td>0.09</td>
</tr>
<tr>
<td>Session Average</td>
<td></td>
<td>88.60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table above reports estimated threshold for subjects to announce that they intend to invest using a simple error model. First, we assume an arbitrary threshold for a subject. Then we classify decisions that are inconsistent with this threshold strategy as an error, for example, intend to invest above this threshold or intend not to invest below this threshold. We can calculate the error rate for each arbitrary threshold. Finally we choose the threshold that minimizes the percentage of errors. If the threshold is not unique, we take the average of the supremum and infimum of all thresholds that have the minimal error rates. The error rate measures the degree of usage of threshold strategy at the individual basis. Estimated individual thresholds with minimum error rates greater than 0.2 are excluded.

Table 7: Linear Regression of Aggregate Investment on Public Information

<table>
<thead>
<tr>
<th></th>
<th>Dependent Variable: Aggregate Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.913***</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
</tr>
<tr>
<td>State θ</td>
<td>-0.666***</td>
</tr>
<tr>
<td></td>
<td>(0.020)</td>
</tr>
<tr>
<td>Public Information</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.58</td>
</tr>
<tr>
<td># of observations</td>
<td>255</td>
</tr>
</tbody>
</table>

Significance level: * p<10%, ** p<5%, *** p<1%

The table above reports the results of linear regression using data from sessions with public information: Cheap Talk Condition, Market Condition, and Modified Cheap Talk Condition. Public information is the percentage of subjects that intend to invest in the Cheap Talk Condition, the scaled price of Success stock in the Market Condition, and the average probability of success in the Modified Cheap Talk Condition.
Table 8: Frequency of Project Success

<table>
<thead>
<tr>
<th>State $\theta$</th>
<th>Market Condition</th>
<th>Control Condition</th>
<th>Talk Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-40</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>40-55</td>
<td>0.40</td>
<td>0.58</td>
<td>0.87</td>
</tr>
<tr>
<td>55-70</td>
<td>0.10</td>
<td>0.25</td>
<td>0.41</td>
</tr>
<tr>
<td>70-100</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 9: Average Game Payoffs per Round

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>SD</th>
<th>Average Efficiency Ratio_FB $^a$</th>
<th>Average Efficiency Ratio_GG $^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Condition</td>
<td>650.78</td>
<td>450</td>
<td>800</td>
<td>70.85</td>
<td>68.50%</td>
<td>103%</td>
</tr>
<tr>
<td>Market Condition</td>
<td>616.15</td>
<td>425</td>
<td>750</td>
<td>64.24</td>
<td>64.57%</td>
<td>95%</td>
</tr>
<tr>
<td>Cheap Talk Condition</td>
<td>709.64</td>
<td>600</td>
<td>825</td>
<td>47.21</td>
<td>74.70%</td>
<td>110%</td>
</tr>
</tbody>
</table>

The table above reports the summary statistics for the average game payoffs per round. The game payoffs are measured in game points. For each condition in each experimental session, I calculate average game payoffs per round for each subject.

$^a$The average efficiency ratio measured relative to the first best. Under the first best, a subject chooses to invest as long as $\theta \leq 100$.

$^b$The average efficiency ratio measured relative to the global game prediction. Under the global game, a subject chooses to invest as long as $S \leq 50$. 