Disclosure and Financial Markets Lecture 9

Cheap Talk

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Overview

- Cheap-talk models consider a situation in which a sender can costlessly say whatever they want.
  - The question we will ask is: what, if anything, can be communicated?
- They consider a “sender” (e.g., the firm) and a “receiver” (e.g., the market).
- While they appear to be reflective of many scenarios, they can lead to quirky equilibria.
- Key feature: since there are no costs, the precise message sent is arbitrary – all firms might say “tea” or “coffee” each with a 50/50 chance, as long as the receiver interprets these appropriately.

Overview

Applications to public firm disclosure are limited:

- Examples might include MD&A, press releases, annual meetings, social media disclosures, etc.

- But distorting communication in these settings is unlikely to be costless
  - Litigation risk suggests they might be closer to costly reporting bias models.
  - However, legally, plaintiff has to prove that they responded to the communication and incurred a loss. Thus, if you can unravel bias, it doesn't influence your action, and you can't litigate.
  - Fits into Fischer and Verrecchia, but then costs and incentives would be related: a cost is only incurred when the manager manipulates the investor's action, which occurs only when their random incentive x is above expectations. See Bertomeu and Cheynel "Truth and Deception" for an analysis.
  - Liability insurance is also very common. See Caskey (2014) for an analysis of this.

Overview

Some other applications:

- Communication between traders
  Information sharing at investor conferences
- Communication from journalists/market "gurus" to the market (Benabou and Laroque (1992))
  e.g., SeekingAlpha. Presence of a position must be disclosed but otherwise not much scrutiny
- Communication from analysts to the market (e.g., Morgan and Stocken (2003)).
  Incentives to appease management but also appear accurate
- Communication from the CEO to the board (e.g., Adams and Ferreira (2007))
  e.g., empire-building incentives

Agenda

1. Misaligned incentives benchmark
2. Partial incentive alignment: binary state, continuous action
3. Partial incentive alignment: binary action, continuous state
4. Continuous action and state: Crawford and Sobel (1982)
5. Multiple audiences; Gigler (1994)

Misaligned Incentives Benchmark

- Suppose that a sender wants to maximize the action taken by a receiver.
- The sender observes a fundamental $\tilde{\theta} \in [0, 1]$ and sends an arbitrary message m to the receiver.
- The receiver chooses their action $a \in \mathbb{R}$ to minimize a “quadratic loss function”: $E\left[\left(a - \tilde{\theta}\right)^2 \middle| m\right]$, which implies $a = E\left[\tilde{\theta}|m\right]$.

Theorem

In any equilibrium, the firm's price always equals $E\left[\tilde{\theta}\right]$.

Proof.

Suppose by contradiction that there was an equilibrium in which at least two messages were sent in equilibrium, m_1 and m_2, that lead to different actions $E\left[\tilde{\theta}|m_1\right] > E\left[\tilde{\theta}|m_2\right]$. Then, any sender that sends m_2 would prefer to send m_1, a contradiction. □

Often referred to as a “babbling” equilibrium.

Misaligned Incentives Benchmark

- Note in some sense that there are infinitely many babbling equilibria.
  - As mentioned: the message sent is arbitrary.
  - As a result, we distinguish equilibria in cheap-talk models by the induced distribution of actions/prices.
  - Sometimes, attention is placed on a “literal” message space, which is the set of possible states (in the present case, $[0, 1]$).

- Equilibria could be “informative” in that they reveal something about the payoff, as long as all messages yield the same actions.
  - This feature needs to be orthogonal to the firm’s objective.
  - For example, suppose $\tilde{\theta}$ is uniform. Then, there is an equilibrium in which types $[0, z] \cup [1 - z, 1]$ say tea and types $(z, 1 - z)$ say coffee, for $z < 1/2$.
  - See Chakraborty and Harbaugh (2010, AER) for a related analysis.

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Partial Incentive Alignment: Assumptions

- We will next discuss the case of partial incentive alignment, as summarized in Stocken's review. Following Stocken, I will refer to the action as $P(m)$.

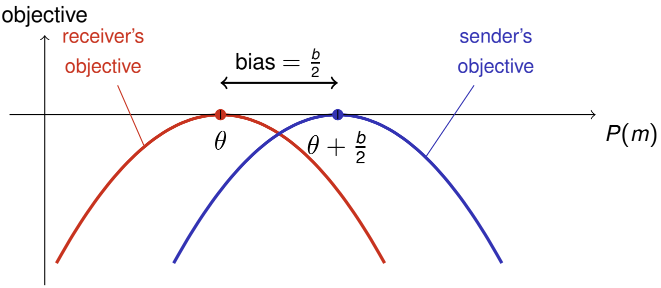
- Suppose instead that the sender maximizes:

$$U\left(m, \tilde{\theta}, b\right) = -\left(P\left(m\right) - \left(\tilde{\theta} + \frac{b}{2}\right)\right)^2$$

- Note this utility function exhibits "partial incentive alignment."
  - Sender's optimal action given $\tilde{\theta}$ is no longer ∞.
  - The ideal action is $\tilde{\theta} + \frac{b}{2}$, and the sender's loss function is symmetric around this.

Partial Incentive Alignment: Ideal Points

- Both players have quadratic-loss objectives in the receiver's action $P(m)$, so each is an inverted parabola peaked at that player's **ideal action**.
- The receiver wants to match the true state, $P = \theta$; the sender prefers $P = \theta + \frac{b}{2}$. The horizontal gap between the peaks is the bias $\frac{b}{2}$.



Partial Incentive Alignment: Equilibrium

$$U\left(m, \tilde{\theta}, b\right) = -\left(P\left(m\right) - \left(\tilde{\theta} + \frac{b}{2}\right)\right)^2$$

What capital market settings might this objective function capture?

- Analysts perhaps trade-off a greater price, which the manager likes, against a less accurate report (see next slide).
- Managers might want a higher price, but not too high.
  - Say, some loss of credibility in the future if it comes out you lied.
  - While this is reasonable, we would ideally formally model this, by using “honest types” (see Sobel 1985).
  - Moreover, this looks like a cost to different messages and thus more closely resembles manipulation models.

Partial Incentive Alignment: Equilibrium Concept

Note we can rewrite the sender's objective function as follows:

$$
\begin{aligned}
& \arg\max_m -\left(P(m) - \left(\tilde{\theta} + \frac{b}{2}\right)\right)^2 \\
= \quad & \arg\max_m -\left(P(m) - \tilde{\theta}\right)^2 + b\left(P(m) - \tilde{\theta}\right) - \frac{b^2}{4} \\
= \quad & \arg\max_m \underbrace{bP(m)}_{\text{bias incentive}} \underbrace{-\left(P(m) - \tilde{\theta}\right)^2}_{\text{accuracy incentive}}
\end{aligned}
$$

where the final line eliminates terms that do not depend upon m.

An equilibrium consists of a receiver action function $P(m)$ and sender reporting strategy $m(\theta)$ such that:

(i) $P(m) = E[\tilde{\theta}|m]$ for all m where there exists a θ such that $m(\theta) = m$; and

(ii) $m(\theta)$ is the solution to $\max_{m \in M} E[bP(m) - (P(m) - \tilde{\theta})^2|m]$ for all $m \in M$.

Partial Incentive Alignment: Babbling Equilibrium

"Babbling" equilibria always continue to exist: the manager's message is uninformative, for example independent of type.

- Equilibrium condition (i) yields that the action in such an equilibrium is simply the prior, given any message: $E[\theta|m] = E[\theta]$.
- As such, equilibrium condition (ii) is trivially satisfied: any message yields the same exact action.
- Technically, we have to specify that the off-path beliefs are such that the manager does not want to shift to another message not sent in equilibrium.
  - Can assume that the beliefs for each possible off-path message m' is such that $E[\theta|m'] = E[\theta]$.
- These equilibria are often ignored; focus is often on the equilibria that lead to the most communication.
  - When the action is unconstrained, these are Pareto preferred, maximizing utility of both the sender and receiver. Why?

Partial Incentive Alignment: Binary State Example

- Suppose now that $\tilde{\theta} \in \{L, H\}$. When does there exist an equilibrium in which the sender truthfully conveys θ?
- We would need:

$$\overbrace{-\left(P(L) - L - \frac{b}{2}\right)^2}^{\text{u(low state, low message)}} > \overbrace{-\left(P(H) - L - \frac{b}{2}\right)^2}^{\text{u(low state, high message)}} \text{ and}$$

$$\underbrace{-\left(P(H) - H - \frac{b}{2}\right)^2}_{\text{u(high state, high message)}} > \underbrace{-\left(P(L) - H - \frac{b}{2}\right)^2}_{\text{u(high state, low message)}}$$

- But, note in such an equilibrium $P(L) = L$ and $P(H) = H$. So, the conditions reduce to:

$$-\frac{b^2}{4} > -\left(H - L - \frac{b}{2}\right)^2 \text{ and}$$

$$-\frac{b^2}{4} > -\left(L - H - \frac{b}{2}\right)^2.$$

Partial Incentive Alignment: Binary State Example

- Note that both conditions simplify to:

  $$|b| < H - L.$$

  So, for many possible biases, full communication is possible.
  Hence, the sender is not successful at distorting the receiver's action.

- The condition says the sender doesn't always prefer the same action among $\{H, L\}$.

- Again, there are also babbling equilibria.

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Partial Incentive Alignment: Binary Action Example

- Suppose next that $a \in \{0, 1\}$ and $\tilde{\theta} \sim U[0, 1]$.
  - Examples include voting and discrete investments.

- Note the receiver takes action 1 when $E\left[\tilde{\theta}|m\right] > \frac{1}{2}$ and action 0 otherwise.

- Sender prefers action 1 if and only if the sender's "ideal action" $\theta + \frac{b}{2}$ is closer to 1 than 0.
  - Formally, $1 - \theta - \frac{b}{2} < \theta + \frac{b}{2} \Leftrightarrow \theta > \frac{1}{2} - \frac{b}{2}$.
  - Follows by the symmetry of the sender's objective function around her ideal point.

- I will focus on equilibria with exactly two messages sent in equilibrium.

- Conjecture an equilibrium in which there is precisely one message (M_1) leading to $a = 1$ and precisely one message (M_0) leading to $a = 0$.
  - Upon observing $\tilde{\theta} > \frac{1}{2} - \frac{b}{2}$, the sender sends M_1.
  - Upon observing $\tilde{\theta} < \frac{1}{2} - \frac{b}{2}$, the sender sends M_0.

Partial Incentive Alignment: Binary Action Example

We have:

$$E\left[\tilde{\theta}|M_1\right] = \frac{1+\frac{1}{2}-\frac{b}{2}}{2} = \frac{3}{4} - \frac{b}{4};$$
$$E\left[\tilde{\theta}|M_0\right] = \frac{\frac{1}{2}-\frac{b}{2}}{2} = \frac{1}{4} - \frac{b}{4}.$$

Thus, this is an equilibrium if and only if the receiver finds it optimal to take action 1 upon observing M_1 and action 0 upon observing M_0:

$$\frac{3}{4} - \frac{b}{4} > \frac{1}{2} \quad \Leftrightarrow \quad b < 1 \quad \text{and}$$
$$\frac{1}{4} - \frac{b}{4} < \frac{1}{2} \quad \Leftrightarrow \quad b > -1.$$

So, we always have an informative equilibrium, unless the sender's preferences are "state independent" i.e., regardless of the state θ she prefers one of the actions.

Partial Incentive Alignment: Binary Action Example

Note the receiver takes action 1 with probability

$$1 - \left(\frac{1}{2} - \frac{b}{2}\right) = \frac{1}{2} + \frac{b}{2}.$$

Without information, she would take action 1 with probability $\frac{1}{2}$.

So, the sender is successful at distorting the receiver's action.

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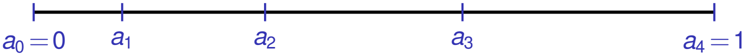
Crawford and Sobel (1982)

Suppose $\tilde{\theta} \sim U[0,1]$ and a can be selected as any value in $\mathbb{R}$.

Proposition 3.1. All equilibria are partition equilibria in which the support of the sender's private information $[0,1]$ is partitioned into N elements

$$\{a_0(N) = 0, \ldots, a_i(N), \ldots, a_N(N) = 1\},$$

where $1 \leq N \leq N(b)$ and $N(b)$ is a positive integer. The sender who privately observes $\theta \in (a_i(N), a_{i+1}(N))$ sends a message $m \in M$ that induces the receiver to take an action $P(m) = (a_i(N) + a_{i+1}(N))/2$.



Example equilibrium.

Crawford and Sobel (1982): Equilibrium

Proof. Consider a partition $a = \{a_0, \ldots, a_i, \ldots, a_N\}$ of the unit interval with N elements where $a_{i-1} < a_i$ for $i = 1, 2, \ldots, N$. Since θ is uniformly distributed, $E[\tilde{\theta}|\theta \in (a_i, a_{i+1})] = (a_i + a_{i+1})/2$. Given the concavity of the sender's objective function in Equation (3.1), when $\theta = a_i$, in equilibrium the sender must be indifferent between adjacent actions $E[\tilde{\theta}|\theta \in (a_{i-1}, a_i)]$ and $E[\tilde{\theta}|\theta \in (a_i, a_{i+1})]$; that is,

$$b\frac{(a_i + a_{i+1})}{2} - \left(\frac{(a_i + a_{i+1})}{2} - a_i\right)^2$$

$$= b\frac{(a_{i-1} + a_i)}{2} - \left(\frac{(a_{i-1} + a_i)}{2} - a_i\right)^2 \tag{3.2}$$

for $i = 1, \ldots, N - 1$; because the sender's payoff is declining in $(P(m) - \theta)$, the sender will strictly prefer the receiver actions $(a_i(N) + a_{i+1}(N))/2$ and $(a_{i-1}(N) + a_i(N))/2$ when $\theta = a_i$ to any of the other actions in the set of possible receiver actions. After

Crawford and Sobel (1982): Full Model Equilibrium

simplification, observe that the equilibrium incentive compatibility condition (Equation (3.2)) can only hold if

$$a_{i+1} = 2a_i - a_{i-1} + 2b \quad \text{for } i = 1, \ldots, N-1.$$

Given $a_0 = 0$, this recursive expression can be rewritten as

$$a_i = ia_1 + i(i-1)b \quad \text{for } i = 1, \ldots, N. \tag{3.3}$$

To determine the maximum number of elements in the partition, set $a_1 = 0$ in Equation (3.3). $N(b)$ is then the largest positive integer such that $a_N = N(N-1)b < 1$. Thus, $N(b)$ is given by

$$N(b) = \left\lfloor -\frac{1}{2} + \frac{1}{2}\sqrt{1 + \frac{4}{b}} \right\rfloor,$$

where $\lfloor x \rfloor$ denotes the smallest integer greater than or equal to x.

Finally, it remains to characterize the partition. Given Equation (3.3) and $a_N = 1$, it follows that $a_1 = 1/N + (1-N)b$. Substituting a_1 into Equation (3.3) yields

$$a_i = \frac{i}{N} + i(i-N)b \quad \text{for } i = 0, 1, \ldots, N. \qquad \square$$

Crawford and Sobel (1982): Equilibrium Features

Equilibrium features:

- If there exists an equilibrium with N partitions, then there also exists one with $N-1$ partitions.

- Information communicated in the "most informative" equilibrium decreases in bias.

- For bias $\geq \frac{1}{2}$, no information is communicated.

- Distance between partition elements grows. *Thus, the firm provides more precise information when it performs poorly!*

- How can we think about such equilibria?
  - Buy/hold/sell recommendations.
  - "Vague/imprecise" language. For example, a manager might say, "the project is going well" without providing details.

Crawford and Sobel (1982): Assumptions

- Note the original Crawford and Sobel paper analyzes general “supermodular” utility functions with arbitrary distributions.

- The overall nature of the proof is essentially the same. However, the precise locations of the partition endpoints will vary with the distribution and utility function.

- We won’t talk about the general case but the analytical results in C&S are elegant and very readable, so a theorist should go through it.

Multiple Senders: Battaglini (2004)

- **Battaglini (2004):** when there are multiple senders, you can often get full communication.
- The idea is that, if the senders send two messages that disagree, the receiver's off-equilibrium-path belief is specified to be such that both senders are worse off than reporting the truth.
- This equilibrium only works if, for any realization of the state, there is some level of the fundamental, and associated action choice, that makes both senders worse off than the action given the truth.
- However, he shows the equilibrium is not robust to a stability refinement.

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Multiple Audiences: Gigler (1994)

- Gigler (1994) analyzes a model in which partial incentive alignment arises endogenously.

- The manager has two audiences: the capital market and the product market.

- Disclosing that demand is higher:
  - Increases the firm's price by increasing beliefs about the firm's value.
  - Decreases the firm's value by increasing the competitor's production.

Gigler (1994): Assumptions

- Two firms choosing quantities. Gigler focuses on one of the firm's disclosures, assuming it observes the intercept of the inverse demand curve:

$$p(q_1, q_2, t) = t - q_1 - q_2.$$

- Firm 1 observes $\tilde{t}$, which is a random variable with support on $[t_L, t_U]$, where $t_U > t_L > 0$.

- At the beginning of the game, the manager chooses a message m to send to both the market and the competitor.

- Then, there is Cournot competition between the firms.

Gigler (1994): Assumptions

- Let $\pi_1(q_1, q_2, t)$ denote the firm's realized profits.
- Prior to production, the firm must raise K dollars by selling stock. The stock's price equals expected profits.
  - Let $\alpha(m) = \frac{K}{E[\pi_1(q_1(m,t), q_2(m), t)|m]}$ denote the fraction of the firm sold.
- The manager solves:

$$\arg\max_{m, q_1} \underbrace{(1 - \alpha(m))}_{\text{equity retained}} * \underbrace{\pi_1(q_1, q_2(m), t)}_{\text{expected firm profit}}$$

- Observe that q_2 depends upon m, but not q_1. This is because (i) the message is sent prior to production choice; (ii) there is Cournot, not Stackelberg competition.
- We see that the firm's objective has two components: maximize equity retained and maximize expected profits.

Gigler (1994): Production Equilibrium

Solve the model via backwards induction, starting with the production stage. Given m: Firm 1 knows $\tilde{t}$ and thus solves:

$$q_1^* = \arg\max_{q_1} q_1 * (t - q_1 - q_2^*) \Leftrightarrow q_1^* = \frac{t - q_2^*}{2}.$$

Firm 2 does not know t, but knows m. It thus solves:

$$q_2^* = \arg\max_{q_2} q_2 * E\left[\tilde{t} - q_1\left(\tilde{t}\right) - q_2 | m\right] \Leftrightarrow q_2^* = \frac{E\left[\tilde{t} - q_1^*\left(\tilde{t}\right)|m\right]}{2}$$

In a Nash equilibrium, we have:

$$q_1^* = \frac{1}{2}\left(t - \frac{E\left[\tilde{t} - q_1^*\left(\tilde{t}\right)|m\right]}{2}\right).$$

Solving this, we obtain $q_1^* = \frac{3t - E\left[\tilde{t}|m\right]}{6}$, $q_2^* = \frac{E\left[\tilde{t}|m\right]}{3}$.

Even though firm 1 knows t, its production still depends on m.

Gigler (1994): Firm Profits

Substituting and simplifying, we find:

$$\pi_1\left(q_1^*, q_2^*(m), t\right) = \frac{1}{4}\left(t - q_2^*(m)\right)^2 = \frac{1}{4}\left(t - \frac{E\left[\tilde{t}|m\right]}{3}\right)^2.$$

Note the market does not observe t, but just m. From its perspective,

$$\begin{aligned}
E\left[\tilde{\pi}_1|m\right] &= E\left[\frac{1}{4}\left(\tilde{t} - \frac{E\left[\tilde{t}|m\right]}{3}\right)^2 \middle| m\right] \\
&= E\left[\frac{1}{4}\left(\tilde{t}^2 - \tilde{t}\frac{2E\left[\tilde{t}|m\right]}{3} + \frac{E\left[\tilde{t}|m\right]^2}{9}\right) \middle| m\right] \\
&= \frac{9E\left[\tilde{t}^2|m\right] - 5E\left[\tilde{t}|m\right]^2}{36} \\
&= \frac{9Var\left[\tilde{t}|m\right] + 4E\left[\tilde{t}|m\right]^2}{36}.
\end{aligned}$$

Gigler (1994): Pure Cheap Talk

Proposition 1. *There can be no information communicated* ***privately*** *to either the competitor or the capital market in equilibrium.*

- This proposition is analogous to the fully misaligned incentive problem considered earlier.
- Consider the capital market case first. The manager wants to minimize:

$$\alpha(m) = \frac{K}{E[\tilde{\pi}_1|m]} = \frac{36K}{9\,Var\left[\tilde{t}|m\right] + 4E\left[\tilde{t}|m\right]^2}$$

  But, this implies that all messages must lead to the same level of $\alpha(m)$, which means no *effective* communication. however, there can still be two messages m_1, m_2 that are informative but set $\alpha(m_1) = \alpha(m_2)$

- The product market case is similar, since the manager's profit always declines in $q_2(m)$:

$$\frac{\partial}{\partial q_2}\pi_1(q_1^*, q_2) = \frac{\partial}{\partial q_2}\frac{(t-q_2)^2}{4} = \frac{q_2 - t}{2} \propto -q_1.$$

  There appears to be an unstated assumption that firm-1 production cannot go negative, so that the above is negative. (Though the paper is not clear about this.)

Gigler (1994): Reducing the Manager's Objective Function

Substituting the firm's profit function and the equilibrium share price into the "type $t = \tau$" manager's objective function yields:

$$\begin{aligned} \Pi(m, \tau) &= (1 - \alpha(m)) * \pi_1(q_1, q_2(m), \tau) \\ &= (1 - \alpha(m)) * \frac{(\tau - q_2(m))^2}{4} \\ &= \left[1 - \frac{36K}{9Var[t|m] + 4E[t|m]^2}\right] \frac{\left(\tau - \frac{E[t|m]}{3}\right)^2}{4}. \end{aligned}$$

Gigler (1994): Communication Equilibrium

Lemma 3. *If m' and m'' are two messages sent in equilibrium, then:*
(i) $\alpha(m') = \alpha(m'') \Leftrightarrow q_2(m') = q_2(m'')$*;*
(ii) $\alpha(m') > \alpha(m'') \Leftrightarrow q_2(m') < q_2(m'')$.
Intuition: if not, types ubiquitously prefer one message to the other.

Proposition 2. *Any equilibrium reporting strategy $m(t)$ results in a nondecreasing outcome. That is:*

$$t'' > t' \implies \alpha(t'') < \alpha(t'), q_2(t'') \geq q_2(t').$$

Intuition: Higher firm types are more incentivized to retain equity than they are to reduce production. In part, because a reduction in production is not as valuable when t is higher (there's enough demand to go around).

Gigler (1994): Communication Equilibrium

Note there can never be an interval of types $[l, u]$ that fully reveal their information.

In this case, we would have that, by reporting as if they were type t, the manager of type $\tau \in [l, u]$ would obtain a payoff of:

$$\Pi(m, \tau) = \frac{36K}{4t^2} \frac{\left(\tau - \frac{t}{3}\right)^2}{4}.$$

But,

$$\frac{\partial}{\partial t}\left(\frac{36K}{4t^2} \frac{\left(\tau - \frac{t}{3}\right)^2}{4}\right) = \frac{3}{2}\frac{K}{t^3}\tau(t - 3\tau),$$

which is generally non-zero when $\tau = t$. This tells us equilibria must be of a partition nature.

Gigler (1994): Communication Equilibrium

Proposition 4. *All public disclosure equilibria are partition equilibria. That is,* $\forall t \in (t_i, t_{i+1})$*, equilibrium outcomes are characterized by:*

$$q_2(t) = \frac{E[t|t \in (t_i, t_{i+1})]}{3} \quad \text{and}$$

$$\alpha(t) = \frac{36K}{4E[t|t \in (t_i, t_{i+1})]^2 + 9Var[t|t \in (t_i, t_{i+1})]},$$

where the partition endpoints satisfy the indifference condition:

$$(1-\alpha(t'))\frac{(t_i - q_2(t'))^2}{4} = (1-\alpha(t''))\frac{(t_i - q_2(t''))^2}{4}.$$

- K in an intermediate range is sufficient to ensure existence of such an equilibrium.
- Equilibrium cannot be solved for in closed form (not even in uniform case).

Summary

The cheap talk models we have studied provide the following insights:

1. When talk is cheap, communication requires some degree of incentive alignment.
2. The more aligned incentives are, the more that can be communicated.
3. Senders can distort receiver actions when these actions are constrained, but not when they are unconstrained
4. Agents may be able to precisely communicate more in states of the world that they view as *less* favorable.
5. Multiple senders can aid in communication as their messages can be compared, imposing discipline on deviations from the truth.
6. Multiple audiences who respond in opposing fashions to a sender's message can render "public" communication more informative.