# Can Cheap Talk Overcome Information Disclosure in Buyer-Seller Communication?

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**Abstract**

We compare two types of strategic costless communication, *cheap-talk* and *information disclosure*, in a buyer-seller interaction where the buyer has private information about his ideal location in the product space and the seller is entitled to make a take-it-or-leave-it offer comprising a product location and a price. We show that cheap-talk can overcome information disclosure in terms of seller's payoff and, generally, in terms of total welfare. Under information disclosure, the buyer garbles the signal compared to the one in a cheap-talk equilibrium to persuade a lower price which inevitably reduces profits. However, information disclosure may also reduce product attractiveness and, thus, welfare.

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# 1 Introduction

Ann is a designer of personalized products (e.g., apparel designer or architect) and she is about to design a product to Bob. Designing a product that fits with Bob's ideal one, Ann increases his willingness to pay for her design. Consequently, matching Bob's preferences she can charge a higher price. However, Bob's preferences are private information and, anticipating Ann's incentives to increase the price, he may be strategic when communicating them (even at the cost of reducing product attractiveness). In an informal meeting, Bob may talk vaguely to persuade her to lower the price. If a big set of pictures and certifications (e.g., hard information) were available, Bob would also disclose them strategically (e.g., reveal/conceal). Anticipating that there always exists a strategic behavior, what is the best communication environment Ann should use to learn about Bob's preferences? can informal meetings, where messages are unverifiable, overcome a bunch of verifiable certifications that may be disclosed selectively? Formally, we are interested to know whether strategic information transmission (or *cheap talk*) can be superior to strategic information disclosure in terms of Ann profits and welfare. We prove that cheap talk overcomes information disclosure in terms of Ann profits and, likely, welfare. This, maybe, striking result suggests that a receiver (Ann) may prefer cheap talk over information disclosure as means of communication.

To answer these questions, we study a buyer-seller interaction where a buyer (Bob) has private information about his ideal location in the product space and the seller (Ann) is entitled to make a take-it-or-leave-it offer. The buyer is allowed to provide information about his preferred location to the seller. After receiving a message, the seller with zero production and location costs makes a take-it-or-leave-it offer comprising a product location and a price. The communication structure to persuade the seller can be either strategic information transmission (also known as *cheap talk*) (Crawford and Sobel, 1982) or strategic information disclosure (Kamenica and Gentzkow, 2011; Rayo and Segal, 2010). We compare them and we discuss which communication environment would be preferred by the seller.

Additional to the buyer-seller interaction, there are other cases where comparing these strategic communication environments is relevant. Within firms, agency problems shape capital budgeting practices (Stein, 2003, p. 145). Local managers have better information than the CEO about project prospects but also have empire building preferences. Suppose a CEO must choose both a project (among many) and its budget to be implemented by a local manager, but there is uncertainty about project costs, where some projects have lower cost than others. If the local manager has private information, he will try to manipulate the information transmitted to the CEO to maximize the net budget, budget minus actual cost, for empire building activities (Wulf, 2009). In this scenario, the CEO may have the power to shape the communication process, choosing informal meetings (cheap talk) or hard information disclosure (strategic information disclosure), but she cannot influence the strategic behavior when information about project prospects is transmitted. These strategic conflicts within organizations go beyond capital budgeting, and learning its implications results essential when thinking the organizational design (Mookherjee, 2006; Rantakari, 2013).

Alternatively, a bank (or a lender) may need information about borrower's financial behavior or investment projects in order to design the best financial contract. The bank may require financial credentials, scores, and credit history or the bank may base his decision on informal communication.[1] Even when this financial case may be modeled as vertically differentiated market, studying what communication environment dominates is important for banks/lenders.

In our environment, the buyer faces a simple trade-off that is present in any communication structure. On one hand, disclosing accurate information about his preferences allows the seller to choose a product location that is closer to the buyer's ideal one. On the other hand, it prompts the seller to charge a higher price as the product meets the buyer's preferences. Consequently, communicating imperfectly his ideal location in the product space, the buyer finds a balance between price and product attractiveness. With this trade-off in mind we proceed to describe the *cheap talk* and the *selective information disclosure* environments.

We first characterize the cheap talk equilibria and then we compare them with the one under disclosure. As it is usual in cheap talk communication, an equilibrium requires that players satisfy the incentive constraints to tell the truth and make actions that are consistent with players beliefs using Bayes rule. In spite of these constraints that limit the informativeness of messages, an (informative) cheap talk equilibrium allows the buyer and seller to avoid those situations where there is no trade and to increase product attractiveness, improving welfare.[2] As it is common in the literature on cheap talk, there is multiplicity of equilibria differing on the signal's informativeness (number of partitions), buyer's and seller's expected payoffs, and welfare loss. In every informative equilibrium, there is trade with probability one and an inefficiency arises when the product location does not coincide with the buyer's ideal.[3]

Information disclosure provides verifiability (and commitment) in buyer's signal, allowing the buyer to choose among a much richer set of signal distributions. Actually, the set of distributions that can be part of an equilibrium under cheap talk is a subset of the set of feasible distributions under disclosure. Consequently, the buyer is better off under information disclosure. Additionally, for any cheap talk equilibrium there are pareto superior signals distributions under information disclosure. However, it is not clear whether the buyer chooses a signal distribution that improves both players' payoff and welfare upon a cheap talk equilibrium. Actually,

[1]Historically, in the U.S. small business has mainly relied on informal meetings with local banks and lenders as the communication device to learn about investment projects (Petersen and Rajan, 2002).

[2]Informative communication means all but pure babbling. A babbling equilibrium is defined by a completely noisy communication where no information is transmitted, which is equivalent to no communication in our setup.

[3]There are two exceptions: First, in a babbling equilibrium there may be no trade. Second, there also exists a perfect informative equilibrium where there is no welfare loss (our results hold also here). However, these equilibria are not intereseted and/or plausible because the babbling equilibrium is pareto dominated by another equilibria and the perfect informative equilibrium would not survive as the buyer prefers not to talk instead of revealing his preferences.

we prove that under disclosure, the buyer strategically persuades the seller to charge a price lower than the price in any informative cheap talk equilibria. The buyer achieves this better deal by garbling the signal distribution which may reduce product attractiveness and welfare. Consequently, disclosing information selectively without restrictions gives the speaker too much degree of freedom, hurting the receiver and welfare in comparison with an informal and non-verifiable talk; concluding, the cheap talk results to be superior than information disclosure in terms of seller surplus and welfare.

Our main contributions are to find a general communication setup where it is possible to compare both communication structures and to prove that cheap talk may be superior to other communication structures in terms of seller surplus (receiver) and welfare. Since the seminal paper of Crawford and Sobel (1982), a vast literature has grown assuming ad-hoc strategic information transmission (i.e., cheap talk), as a natural communication framework when contracts are incomplete. Disclosure has also been extensively analyzed and, recently, several papers has pointed out its power for strategic persuasion (Milgrom, 1981).[4] However, the literature has always focused on strategic disclosure or cheap talk separately.[5] This gap may be based probably on the higher costs associated with information disclosure or on the seemingly strict dominance of information disclosure in comparison to cheap talk. Our paper fills this gap proving that indeed cheap talk may be superior to disclosure, even in the absence of such costs.

We also contribute to the literature on buyer-seller communication with asymmetric information. The case where the seller has more information and makes recommendations to a buyer has been analyzed in a cheap talk environment (Inderst and Ottaviani, 2013) and in a persuasion and disclosure setup (Milgrom, 2008; Kamenica and Gentzkow, 2011). We focus here on the case where the buyer has superior information about his own preferences and the seller has the bargaining power.[6] In this sense our article is closer to Sher and Vohra (2015) which address the communication problem in our setup. In their interesting paper, the buyer may have constraints on the verifiable information set and the seller uses rounds of cheap talk communication (from buyer to seller) as a price discrimination device. However, they do not compare alternative communication structures and we do not impose any constraint on the set of verifiable signals. We contribute to the literature by analyzing the optimality of alternative communication structure in a buyer-seller interaction.

Finally, our framework can also be used to model alternative interactions. For instance, the

[4]Disclosure a la Milgrom assumes that agents with different vertically differentiated types have access to different set of verifiable signals. Consequently the disclosure procedure relies on the unraveling argument that generates the following fulfilled beliefs: the type who does not disclose itself is assumed to be the lowest type. This argument, however, does not apply in our model as we consider a horizontally differentiated model.

[5]See Sobel (2010) for a survey with applications on cheap talk and strategic disclosure.

[6]Our results also hold in those situations where communication may disclose information, even when neither the buyer nor the seller know buyer's preferences. For instance, an architect may learn buyer's preferences asking questions about buyer's habits even if the buyer does not really know his preferences about designs until he sees it but he is aware of the role of communication on seller's strategy.

literature on authority versus communication in organizational design (Dessein, 2002; Alonso and Matouschek, 2008; Goltsman, Hörner, Pavlov, and Squintani, 2009) analyzes situations where an agent is better informed about the state of world and a principal has the bargaining power to choose between delegating the decision right to the agent and communicating with the agent to make a decision herself. This literature assumes cheap talk as the communication device since it focuses on those organizational interactions where decision making and communication take place in a complex, fast, and dynamic environment. Thus, cheap talk provides a good fit to represent them, specially for interactions within lower levels in the organization. However, when important strategic decisions in higher levels are involved, the CEO may require hard information to base an important strategic decision (e.g., studies of market demand, consultancy, etc.). In such a case the CEO may choose between strategic disclosure as an alternative to cheap talk. We have shown that this cheap talk scenario results to be optimal in such environments, providing foundations to its assumption, but further research can be encouraged to analyze the optimal communication structure when defining the best organizational design.

The rest of the paper is organized as follows: section 2 presents a simple example that summarizes the paper. Section 3 introduces the main model. The model is solved in sections 4, for cheap talk, and 5, for information disclosure; and welfare is calculated in section 6. Section 7 discusses the option of delegation. Section 8 concludes.

## 2 A simple example

Let us continue with the motivational example in the introduction where Bob is a consumer with unitary demand for a poker-card. He has an ideal suit $x \in X := \{\heartsuit, \diamondsuit, \clubsuit, \spadesuit\}$. There is a uniform prior, i.e., $Pr(x = x^*) = \frac{1}{4}$. Bob's willingness to pay for a card with his ideal suit is \$20, for a card that has the same color of his ideal suit is \$12, and for a card with different color is \$9. E.g., if his best suit is $\heartsuit$, then $v(\heartsuit, \diamondsuit, \clubsuit, \spadesuit) = (20, 12, 9, 9)$.

Ann, the seller, with no cost, makes a TIOLI offer (take-it-or-leave-it offer) comprising a suit $x \in X$ and a price $p \in \Re_+$. If the offer is rejected both individuals get zero. Ann can also allow for some communication round before making the TIOLI offer. This communication round is strategic and is one of two types: "cheap talk" or "information disclosure".

If Ann knows the preferences of Bob, it is clear that she will make an offer comprising Bob's ideal card at a price of \$20. With no communication Ann will offer any suit (randomly) at a price of \$9. As Bob is better off in the latter case ($EU = 3.5$ vs $EU = 0$), Bob will never have incentives to voluntarily reveal the suit of his ideal card. However, he may be willing to reveal some information.

Suppose Ann asks Bob the color of his best suit, has Bob the incentives to reveal it truthfully? The answer is yes! To see this notice that answering this question truthfully will lead Ann to offer a card with Bob's preferred color and random suit at a price of \$12. In this case, Bob will definitely accept the offer, receiving a card with his best suit with probability 0.5, enjoying an expected utility $EU = 4$. Total welfare is \$16. This case represents a cheap-talk communication game as in Crawford and Sobel (1982). Notice that Bob will never reveal the suit of his ideal card, but just its color.

Another possible communication setup is to allow Bob to provide a verifiable signal of his own preferences. We define this case as "information disclosure" setup. In this case Bob is free to disclose any information selectively trying to manipulate Ann's posteriors. For instance, Bob can propose a sample deck with 15 cards: 9 of his best suit and 6 of his best color but different suit (e.g., 9 ♡ and 6 ♢ when his best suit is ♡); but Ann picks and observes only one of them at random. In this case, Ann's offer will comprise a card with the suit of the card observed at a price of \$12. Consequently, Bob's expected utility is $EU = 4.8$ and total welfare is \$16.8.[7] This particular example shows that information disclosure (verifiable signals) can overcome the outcome under a cheap talk setup.

Allowing Bob to provide verifiable information, however, may not be a good idea for Ann. Bob may, instead, offer another sample deck with 20 cards: 9 of his best suit, 6 of his best color but different suit, and 5 of different color (e.g., 9 ♡, 6 ♢, 3 ♣, and 2 ♠ when his best suit is ♡); but, again, Ann picks and observes only one of them at random.[8] In this case, Ann's offer will be a card with the suit of the card observed at a price of \$9; then, Bob's expected utility is $EU = 5.85$ and total welfare is \$14.85. Consequently, this simple example captures the main contribution of this paper. Ann may prefer a cheap talk setup because verifiable signals provide too much degree of freedom to Bob. Even when there are verifiable information signals that are pareto optimal compared to the cheap talk outcome, Bob is tempted to persuade a lower price. Notice that welfare is greater with a cheap talk than with ID. Of course, ID would be optimal if Ann can impose some constraints on the set of verifiable signals Bob can show.

# 3 Model

A buyer would like to acquire a unit of a good that comes in different varieties. He has private information about his ideal variety $\theta$ and there is a common prior that $\theta \sim U[0,2]$. The utility derived from consuming a product with variety $x \in [0,2]$ and price $p \in \mathbb{R}_+$ is

$$U(p, x; \theta) := 1 - \|x, \theta\| - p, \tag{1}$$

where $\|x, \theta\| := \min\{|x - \theta|, 2 - |x - \theta|\} \leq 1$ represents a linear transportation cost.[9] Notice that, for a given price, a product with variety $x = 2$ provides the same utility to the buyer than

[7]Ann profits is 12 as in the cheap talk game. In the setup presented in section 3 there are verifiable signals where both agents are better off compared to a cheap talk communication setup.

[8]This is the best verifiable information signal according to Bob's preferences satisfying the bayesian plausible condition defined in Kamenica and Gentzkow (2011).

[9]The results trivially extend for the case where $\tilde{U}(p, x; \theta) := v\big(1 - \|x, \theta\|\big) - p$ for any $v \in \mathbb{R}_{++}$.

a product with variety $x = 0$. Consequently, our setup represents a circular model as in Salop (1979).[10] On the supply side, a seller with zero production and location costs is entitled to make a take-it-or-leave-it offer comprising a price and a product location, i.e., $(p, x)$. If the offer $(p, x)$ is accepted, seller payoff is $\Pi = p$. Both the seller and the buyer are risk neutral and have zero outside options.

We allow the buyer to communicate with the seller providing a signal $s$. The message space equals the location space, i.e., $s \in [0, 2]$. We compare two possible ways of costless communication: 1) strategic information transmission (or *cheap talk*, CT) where any non-verifiable and non-contractible signal can be sent as in Crawford and Sobel (1982); and 2) strategic information disclosure (ID) where the buyer announces and commits to a verifiable but non-contractible signal distribution $F$ as in Kamenica and Gentzkow (2011).

The timing in each communication structure is as follows: The buyer privately observes $\theta$ and sends a signal $s$ drawn from a distribution $F : [0, 2] \to [0, 1]$.[11] After observing $s$, the seller makes a take-it-or-leave-it offer $(p, x)$. Finally, the buyer accepts or rejects. The equilibrium concept is the Perfect Bayesian Nash equilibrium. Without loss of generality, we assume the buyer accepts any offer that yields positive utility.

# 4 Strategic Information Transmission (CT)

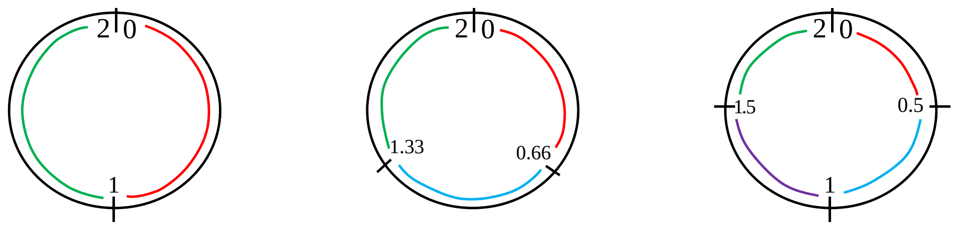
We first show that our model fits into the strategic information transmission (CT) environment (Crawford and Sobel, 1982). The seller's offer comprises a product location $x$, defining the welfare loss $\|\theta, x\|$, and a price $p$, defining how to share the surplus when there is trade. If the buyer perfectly communicates $\theta$, the seller will offer $(p, x) = (1, \theta)$, guaranteeing trade and fully appropriating the (maximum) welfare. If the buyer communicates nothing about $\theta$, the seller offers, for instance, $(p, x) = (0.5, 1)$; then there is a probability of no trade equal to $1/2$, reducing welfare, but allowing the buyer to enjoy positive expected surplus equal to $1/8$. As no trade makes both the buyer and the seller strictly worse off, the objective functions are partially aligned.[12] Thus, some (but probably not all) information can be transmitted through *cheap talk* (CT).

We now follow the literature on CT proving that there exists a partition of $[0, 2]$ that forms an equilibrium of the communication game. Figure 1 shows examples of equilibria with partitions of $n = 2, 3, 4$. Actually, Proposition 1 shows that any partition of the set $[0, 2]$ in connected intervals of equal length can be a part of an equilibrium.

[10] The Salop circular model facilitates the algebra to find the equilibrium under information disclosure.

[11] Under ID, the buyer chooses a cumulative distribution $F$, but under CT the cumulative distribution $F$ arises from players' beliefs in the equilibrium.

[12] In the introductory example, cheap talk allows a better deal for both agents than in the case with no communication; communication increases the probability of having a high valuation product with a little increase in price.




(a) $n = 2$ partition (b) $n = 3$ partition (c) $n = 4$ partition

Figure 1: Examples of equilibria for different partitions.

**Proposition 1.** *For any $n \in \mathbf{N}$, there exists an equilibrium with $n$-partition subsets of equal length of $[0, 2]$ of the form $\left[(j-1)\frac{2}{n}, j\frac{2}{n}\right)$ for each $j = 1, \ldots, n$ (last interval is closed) where,*

1. *The buyer's signaling rule is defined by,*

$$F\left(s \,\middle|\, \theta \in \left[(j-1)\frac{2}{n}, j\frac{2}{n}\right)\right) = \begin{cases} 0 & \text{if } s < (j-1)\frac{2}{n}, \\ \frac{n}{2}\left(s - (j-1)\frac{2}{n}\right) & \text{if } s \in \left[(j-1)\frac{2}{n}, j\frac{2}{n}\right), \\ 1 & \text{if } s \geq j\frac{2}{n}. \end{cases}$$

2. *The seller's beliefs are defined by*

$$H\left(\theta \,\middle|\, s \in \left[(j-1)\frac{2}{n}, j\frac{2}{n}\right)\right) = \begin{cases} 0 & \text{if } \theta < (j-1)\frac{2}{n}, \\ \frac{n}{2}\left(\theta - (j-1)\frac{2}{n}\right) & \text{if } \theta \in \left[(j-1)\frac{2}{n}, j\frac{2}{n}\right), \\ 1 & \text{if } \theta \geq j\frac{2}{n}. \end{cases}$$

3. *Price and location are defined by $p(s) = 1 - \frac{1}{n}$ and $x(s) = 0.5\big((j-1)\frac{2}{n} + j\frac{2}{n}\big) = \frac{2j-1}{n}$ given that $s$ belongs the $j$-th subset.*

Hence there are infinitely many equilibria.[13] Our comparison between CT and ID holds for all informative equilibria, i.e., except the pure babbling equilibrium. However, in order to make a clean comparison, we concentrate in the equilibria that satisfy two conditions: 1) be Pareto optimal; 2) be Pareto superior than the no communication case. Then, we eliminate those equilibria that are Pareto inferior or that are dominated by saying nothing for at least one of the players (or not showing up and sending a mute or uninformed intermediary).

**Lemma 2.** *The cheap talk equilibria that are Pareto optimal and that are better off for both player compared to the no communication case are those equilibria with partitions of $n = 2, 3, 4$ which actions and beliefs are defined according to Proposition 1.*

[13]Even with exactly the same number of $n$-partition there are infinite equilibria. Notice that a 2-partition for an equilibrium can be either $\{[0, 1), [1, 2)\}$ or $\{[0.5, 1.5), [0, 0.5)U[1.5, 2]\}$, or any partition of this kind.

A babbling equilibrium does not satisfy this refinement. The difference among these equilibria is the total surplus generated and how it is shared between the seller and the buyer. Table 1 shows the values of the price, profits, buyer surplus, welfare, and probability of trade for each $n$-partition with $n = 1, 2, 3, 4, 5$. A simple comparison shows that $E[U](n)$ decreases in $n > 2$ and that $E[U](1) > E[U](n)$ for $n \geq 5$.

On the other hand, there is a trade-off between generation and appropriation when comparing equilibria with partitions $n = 2,\ 3,$ and $4$. Having more partitions increases welfare and the seller's ability to appropriate it. The seller appropriates the welfare increased and, additionally, part of the buyer surplus when increasing the number of partitions. Consequently, objective functions for equilibria with $n = 2, 3, 4$ partitions are perfectly misaligned and, ex-ante, there is no unique criteria to select among them. So our comparison will have these three types of equilibria as a benchmark.

Table 1: Price, profits, buyer surplus, welfare, and probability of trade for cheap talk equilibria for a $n$-partition equilibria.

| partition $n$ | price $p$ | profits $E[\Pi]$ | buyer surplus $E[U]$ | welfare $E[W]$ | prob. of trade $Pr(v \geq p)$ |
|---|---|---|---|---|---|
| 1 | 0.500 | 0.250 | 0.125 | 0.375 | 0.5 |
| 2 | 0.500 | 0.500 | 0.250 | 0.750 | 1 |
| 3 | 0.666 | 0.666 | 0.166 | 0.833 | 1 |
| 4 | 0.750 | 0.750 | 0.125 | 0.875 | 1 |
| 5 | 0.800 | 0.800 | 0.100 | 0.900 | 1 |

# 5 Strategic Information Disclosure (ID)

Under information disclosure (ID), the buyer announces and commits to a signal $s$ of the form $F(s|\theta) : [0, 2] \to [0, 1]$, where $F$ may change with $\theta$. Note that, using this signal technology, the buyer can trivially replicate the distribution corresponding to any CT equilibrium. Consequently, the buyer must be better off under ID. Additionally, it is straightforward to see that there are signal structures under ID that Pareto dominate those under CT.[14] It is not clear, however, that, in effect, the buyer chooses among these pareto superior signals, increasing welfare and/or seller payoffs.

[14] Comparing with a cheap talk equilibrium with $n = 3$ (see Table 1), the verifiable signal $s := (\theta - 0.3, \theta - 0.15, \theta, \theta + 0.15, \theta + 0.3)$ with probabilities $q := (0.1, 0.08, 0.64, 0.08, 0.1)$ and a seller's strategy $(x, p) = (s, 0.7)$ would generate a buyer surplus of $0.216$, a seller's profit of $0.7$, and, thus, a welfare of $0.916$.

**Definition 3.** *An equilibrium in the ID game is characterized by a signal structure $F$, seller's posterior $H$ (beliefs) about $\theta$, and offers $(p(H), x(H))$ such that: 1) $H$ is derived by Bayes' Rule whenever possible; 2) Each $(p(H), x(H))$ maximize seller profit $E[\Pi](H)$; and 3) $F$ maximizes buyer surplus conditioning on seller's best reply $(p(H), x(H))$.*

Following Kamenica and Gentzkow (2011), the buyer can manipulate seller's posterior $H$ about $\theta$ as long as it is *Bayes Plausible*. As stated in Definition 3, the buyer's problem is to find a signal structure $F$ to maximize his expected surplus conditioning on seller's best response. After receiving a realization $s$ from $F$, the seller calculates the posterior $H$ about buyer's type $\theta$. Our setup facilitates the solution of the problem, as we can calculate the optimal posterior $H$ and then design a signal distribution $F$ to replicate the posterior $H$ using Bayes rule.

We solve buyer's problem of maximizing his expected surplus choosing $H$ anticipating seller's best reply $(p(H), x(H))$, and then we show how to implement this optimal $H$ (being Bayes Plausible). Seller's best reply is defined by

$$\Big(p(H), x(H)\Big) \in \arg\max_{(p,x)} \int_0^2 p\, I(\theta, p, x)\, \mathrm{d}H(\,\theta\,), \tag{2}$$

where $I(\theta, p, x) = 1$ if $1 - \|\theta, x\| - p \geq 0$ and $0$ otherwise. That is, the seller profit is $p$ if there is trade, i.e., if $I(\theta, p, x) = 1$.

Conditioning on seller's best replies $(p(H), x(H))$ from Condition (2), the buyer chooses $H$ to maximize his expected surplus

$$\max_H \int_0^2 \max\Big\{\,0\,, 1 - \|\theta, x(H)\| - p(H)\Big\}\mathrm{d}H(\,\theta\,). \tag{3}$$

The buyer enjoys utility $U(p, x; \theta) = 1 - \|\theta, x\| - p$ if there is trade and zero otherwise.

Assuming that a solution exists (which is then confirmed) this problem can be simplified. Suppose $(p_0, x_0)$ is the best response to $H$, then there is trade for every buyer type $\theta \in [x_0 - (1 - p_0), x_0 + (1 - p_0)]$. Assuming, wlog, $[x_0 - (1 - p_0), x_0 + (1 - p_0)] \subset [0, 2]$,[15] the buyer's problem can be written as

$$\begin{aligned}
\max_H E[U] \;&=\; (1 - p_0)\Big[H\Big(x_0 + (1 - p_0)\Big) - H\Big(x_0 - (1 - p_0)\Big)\Big], \\
&\quad - \int_{x_0-(1-p_0)}^{x_0} (x_0 - \theta)\mathrm{d}H - \int_{x_0}^{x_0+(1-p_0)} (\theta - x_0)\mathrm{d}H, \qquad (4) \\
\text{s.t. } \Big(p_0, x_0\Big) \;&\in\; \arg\max_{(p,x)} p\Big[H\Big(x + (1 - p)\Big) - H\Big(x - (1 - p)\Big)\Big].
\end{aligned}$$

The first term in $E[U]$ represents the maximum buyer surplus of buying a product at a price $p_0$. The second and third terms represent the loss incurred when the buyer buys a product which

[15] We can always redefine the domain from a point $x_0$ as $\theta \in [x_0 - 1, x_0 + 1]$.

does not fit with his ideal one. The seller payoff is the price multiplied by the probability of trade. Given this representation, the next result is direct.

**Lemma 4.** *If $H$ with the best response $(p_0, x_0)$ solves Problem 4, then there is trade with probability one.*

Lemma 4 proves that situations with no trade decreases both players payoff. The buyer can manipulate $H$ to avoid those cases and increase both players payoff. We now define the posterior that maximizes buyer surplus when implementing a best reply $(p_0, x_0)$.

**Proposition 5.** *If the buyer wants to implement $(p_0, x_0)$ as seller's best response, then the posterior $H$ that maximizes his surplus $E[U]$ is,*

$$H^*(\,\theta\,) = \begin{cases} 0 & \text{if } \theta \in [x_0 - 1\,,\, x_0 - (1-p_0)), \\ \frac{1-p_0+\theta-x_0}{1+p_0+\theta-x_0} & \text{if } \theta \in [x_0 - (1-p_0)\,,\, x_0\,), \\ \frac{2p_0}{1+p_0-\theta+x_0} & \text{if } \theta \in [\,x_0\,,\, x_0 + (1-p_0)\,],\ \text{and} \\ 1 & \text{if } \theta \in [x_0 + (1-p_0)\,,\, x_0 + 1]. \end{cases} \tag{5}$$

Having the optimal $H^*$ to implement $(p_0, x_0)$, the buyer's problem is easy to solve. Using $H^*$, the buyer surplus can be represented as a function only of $p_0$ as follows

$$E[U](p_0) = -(1-p_0) + 4p_0 \ln\Big(\frac{1+p_0}{2p_0}\Big), \tag{6}$$

which is a continuous, differentiable, and concave function for $p_0 \in (0,1)$. From the first order condition we get $4\ln\big(\frac{1+p_0}{2p_0}\big) = \frac{3-p_0}{1+p_0}$, which is uniquely solved by $p_0 \cong 0.487657$. Consequently, replacing $p_0$ in Equation (6) we calculate buyer surplus $E[U] \cong 0.311$.

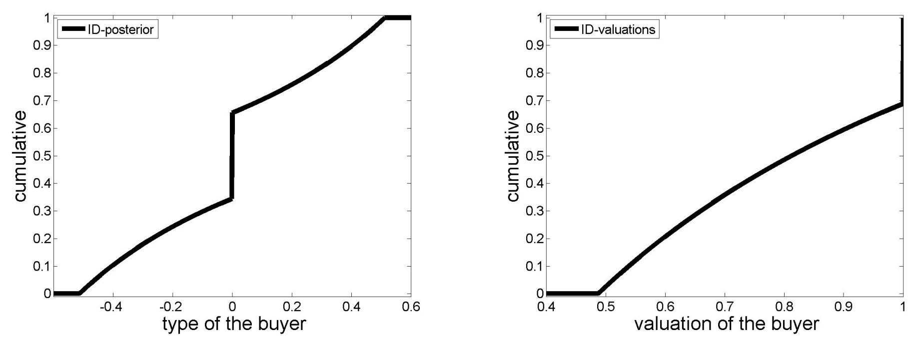
Next, we characterize the signal distribution $F$ that implements $H^*$

**Proposition 6.** *To implement the posterior $H^*$ the buyer sends a signal $s$ distributed according to,*

$$F^*(\,s\,|\,\theta\,) = \begin{cases} 0 & \text{if } s \in [\theta - 1\,,\, \theta - (1-p_0)), \\ \frac{1-p_0+s-\theta}{1+p_0+s-\theta} & \text{if } s \in [\theta - (1-p_0)\,,\, \theta\,), \\ \frac{2p_0}{1+p_0-s+\theta} & \text{if } s \in [\,\theta\,,\, \theta + (1-p_0)\,],\ \text{and} \\ 1 & \text{if } s \in [\theta + (1-p_0)\,,\, \theta + 1], \end{cases} \tag{7}$$

*A realization $s$ of $F^*$ generates the posterior $H^*(\theta|s, F^*)$ according to Equation 5 where $x_0 = s$. The seller's best reply is defined by a price $p(H^*) \cong 0.487657$ and a product location $x(H^*) = s$. Notice that the signal can be represented by $s = \theta + \varepsilon$ where $\varepsilon$ represents the signal deviation respect to buyer's type, independently of his realization.*

Figure 2.a represents the posterior $H$ (normalizing $x_0 = 0$) or the signal distribution $F$ (normalizing $\theta = 0$). Figure 2.b shows the distribution of valuations $v := 1 - \|\theta, x_0\|$ in the solution $x_0 = s$. The cumulative distribution of the signal is antisymmetric at $1/2$ around $\theta$ (i.e., the mass is symmetrically distributed around $\theta$), continuous except in the true $\theta$ where there is a jump, and its slope increases for values that are more distant to $\theta$. The signal reveals the true location with high probability (mass-point). However, when the signal is wrong, it is more likely that the signal is closer to the limits of the domain (closer to $\theta - (1 - p_0)$ or $\theta + (1 - p_0)$) than closer to $\theta$. The buyer uses this signal shape to persuade the seller to reduce the price at the (likely) cost of reducing product attractiveness.




(a) Posterior $H$ (b) Valuations $G$ given $x_0$

Figure 2: Cumulative distribution under ID normalizing $x_0 = 0$.

A simple comparison between buyer's surplus under ID, $E[U] \cong 0.311$, with respect to any CT, $E[U] = \{0.25, 0.166, 0.125\}$, explains why the buyer prefers ID to CT. Additionally, the seller profits show the opposite result, as she enjoys higher profits under any CT, $\{0.50, 0.66, 0.75\}$, than under ID $0.487$. We have pointed out situations where the receiver (the seller) chooses the communication environment. A more general result indicates that depending which of them chooses the communication setup we will have one environment or the other.

Finally, as pointed out at the beginning of this section, there always exists an ID communication that dominates a CT equilibrium. Consequently, a next step would be to study whether incorporating restrictions to the ID signals makes this environment superior to CT. Research on this ground is welcome.

# 6 Welfare

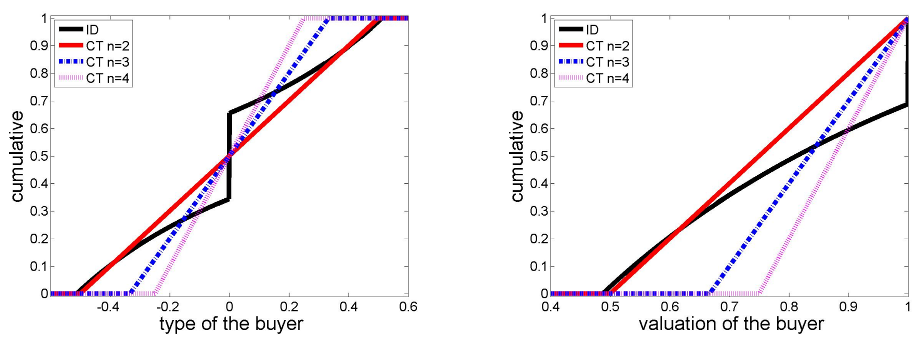
To make a comparison we define the welfare function. Independent of the distribution that generates the posterior, the welfare $E[W] = E[U] + E[\Pi]$ as a function of posterior $H$ and best reply $(p_0, x_0)$ is defined by[16]

$$E[W](p_0, x_0, H) := 1 - \int_{x_0-(1-p_0)}^{x_0} H(\theta)\,\mathrm{d}\theta - \int_{x_0}^{x_0+(1-p_0)} [1 - H(\theta)]\,\mathrm{d}\theta. \tag{8}$$

If we define buyer valuation $v := 1 - \|\theta, x_0\|$ where $v \sim G$ ($G$ depends on $H$ and $x_0$), then the welfare function is defined by

$$E[W](p_0, G) := 1 - \int_{p_0}^{1} G(v)\,\mathrm{d}v. \tag{9}$$

A graphical comparison between CT equilibria and ID equilibria with cumulatives $H$ and $G$ is represented in Figures 3.a and 3.b, respectively. Recall that $p_0$ (and profits) are equal to $0.500$, $0.666$, and $0.750$ for CT with $n = 2, 3,$ and $4$ partitions, respectively, and $0.487657$ for ID.




(a) $H^*$ with $CT(n = 2, 3, 4)$ and $ID$ (b) $G^*$ with $CT(n = 2, 3, 4)$ and $ID$

Figure 3: Cumulatives of posterior ($H^*$) and valuations ($G^*$), normalizing $x_0 = 0$.

The values calculated are $E[W] \cong 0.798867$ for ID and $E[W] = \{0.75, 0.833, 0.875\}$ for CT of $n = 2, 3, 4$, respectively. In two out of three cases the CT overcomes ID in terms of welfare. CT will prove to be even more preferable if, eventually, ID requires additional costs.

# 7 Delegation

In this paper we focus on comparing alternative strategic communication structures. One could argue that, in our simple setup, the Seller is better off delegating the decision choice to the Buyer, implementing a simple price independently of Buyer's choice, getting rid of strategic

[16]This representation is feasible if $H$ has finitely many jumps (Cramer, 1946).

communication (e.g., a price of $p = 20$). However, consider an extension where additional products with inferior mark-ups are available and cannot be banned by the Seller when delegating the product choice. In this scenario delegation may not be optimal and strategic communication does play a significant role in defining the product to trade.

For instance, suppose a Seller must choose one of the products $x \in X := \{\heartsuit, \diamondsuit, \clubsuit, \spadesuit, \Omega\}$, where $\Omega$ is the new introduction. The Seller knows that products $x \in X - \{\Omega\}$ implies no cost but there is uncertainty with respect to Buyer's valuation. The best product has a valuation of \$20, another of \$12, and the rest of \$9. The prior is that any of them has the same probability of being the product with highest valuation (so far, identically than in our motivating example in section 2). Additionally, there always is available a product $\Omega$ with a cost of \$20 and valuation of \$26 (lower markup). While this choice cannot be banned by Seller, delegation is not optimal. To see this notice that by delegating the product choice at a price of $p \leq 20$, the Buyer has incentives to choose the product $\Omega$ ($EU(p \leq 20, \Omega) = 26 - p \geq 0$), generating profits of $\Pi = p - 20 \leq 6$. On the contrary, any product $x \in X - \{\Omega\}$ at a price of $p = 9$ generates profits of $\Pi = 9$.

Finally, it is not clear that with delegation the seller remains with same the bargaining power (e.g. she may loss power in charging the price). In alternative applications of this model, there may be other reasons making suboptimal to delegate the location choice (product/project). Consider the agency problem of a CEO and a local manager with private information and empire building preferences. Delegation may imply additional costs related with loss of formal authority, loss of bargaining power in the capital budgeting process (i.e., the budget is now bilaterally bargained), or loss of control over expenses (which jeopardizes the empire building goals of the CEO).

# 8 Conclusion

We have shown several results. First, the buyer trivially prefers information disclosure over cheap talk. Second, there is trade with probability 1 in any informative equilibria and a welfare loss arises when actual product's design does not fit the buyer's ideal one. Third, the seller's payoff is higher with cheap talk than with information disclosure (i.e., $\{0.5, 0.66, 0.75\} > 0.487$). Finally, and more important, the disclosure reduces total welfare in two out of three cases (i.e., $0.750 < 0.799 < \{0.833, 0.875\}$).

This analysis reveals that cheap talk can result as the optimal communication structure when there are incomplete contracts but leaves the door open for further research. Empirical evidence in the use of cheap talk and information disclosure (like certifications) is mixed. For instance, different lenders have relied in different type of communication environments (Petersen and Rajan, 2002). Then, before offering a financial contract, a lender (seller) may require a borrower (buyer) to certify his financial records or they may initiate conversations in order to show financial responsibility. This evidence suggests that, under some constraints over signals, certifications are used as a way to disclose information. Consequently, more research is needed to understand the constraints required over the set of strategic disclosure signals to be superior to cheap talk.

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# A Appendix: Main Results

*Proof of Proposition 1.* This proof is direct from Crawford and Sobel (1982). □

*Proof of Lemma 2.* $E[U](1) = \frac{1}{8}$ and $E[U](n) = \frac{1}{2n}$ for $n \geq 2$. Then $E[U](n) \geq E[U](1)$, if $n \leq 4$. □

*Proof of Lemma 4.* Suppose there is not trade with probability one, then there exists another $\hat{H}$ with the same best response $(p_0, x_0)$ such that guarantees trade with probability one (relaxing the constraint) and increases $E[U]$. Thus, $H$ could not be a solution. □

*Proof of Proposition 5.* If the buyer wants to implement $(p_0, x_0)$, then $H$ must provide the maximum buyer surplus and it must survive to any deviation $(\hat{p}, \hat{x})$. In particular we first check deviations $(\hat{p}_0, \hat{x}_0) = (p_0 + |a|, x_0 + a)$ for $a \in [-\frac{1-p_0}{2}, \frac{1-p_0}{2}]$, and then we prove that these deviations are the relevant ones.

Given, for instance, a deviation $(\hat{p}_0, \hat{x}_0) = (p_0 + a, x_0 + a)$ with $a > 0$, all buyer types $\in [x_0 - (1 - p_0) + 2a, x_0 + (1 - p_0)]$ buy the product. As the profit with no deviation is $E[\Pi] = p_0$ (there is trade with probability one), a deviation $(p_0 + a, x_0 + a)$ with $a > 0$ does not survive if

$$p_0 \geq (p_0 + a)[1 - H^-(x_0 + 2a - (1 - p_0))], \text{ or}$$
$$H^-(\theta = x_0 + 2a - (1 - p_0)) \geq \frac{a}{a + p_0}.$$

Where $H^-$ represents the limit from the left.[17] Consequently, we define the shape of the minimum $H$ for $\theta = x_0 + 2a - (1 - p_0) \in [x_0 - (1 - p_0), x_0)$ given $a \in (0, \frac{1-p_0}{2}]$. Replacing $a = \frac{1-p_0+\theta-x_0}{2}$ half of the $H^*$ is defined.

For the other part, deviations $(p_0 + |a|, x_0 + a)$ with $a < 0$ does not survive if

$$
\begin{aligned}
p_0 &\geq (p_0 - a)H(x_0 + 2a + (1 - p_0)), \text{ or} \\
H(\theta = x_0 + 2a + (1 - p_0)) &\leq \frac{p_0}{p_0 - a}.
\end{aligned}
$$

Replacing $a = \frac{-1+p_0+\theta-x_0}{2}$ the other half of $H^*$ is defined.

We did not check all deviations $(\hat{p}, \hat{x})$. However, it is easy to verify that given $H^*$ and a deviation $x_0 + a$, the seller maximizes profit at $p = p_0 + |a|$. For instance, for $a > 0$ deviations in price $p$ has 3 relevant segments: 1) $p > 1 - a$; 2) $1 - a \geq p \geq p_0 + a$; and 3) $p_0 + a > p$. Calculating the profit function, the reader can verify that $\frac{\partial \Pi}{\partial p}(p < p_0 + a) > 0$ and $\frac{\partial \Pi}{\partial p}(p > p_0 + a) < 0$, then $p = p_0 + a$ is the price given $H^*$ and $x_0 + a$; consequently $(\hat{p}, \hat{x}) = (p_0 + |a|, x_0 + a)$ is the best deviation to be considered. □

*Proof of Proposition 6.* It is direct. □

[17] Cumulative distributions are, by definition, continuous from the right. But intuitively, a buyer with type $\theta = x_0 + 2a - (1 - p_0) < x_0$ (who is indifferent between buying or not) should buy. We use the limit from the left to represent this situation when $H$ has a jump at $\theta = x_0 + 2a - (1 - p_0)$. Note that this is not a problem for rightward deviations (when $a < 0$).