Communication in Bargaining over Decision Rights*

Wooyoung Lim †
Department of Economics
University of Pittsburgh

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Abstract

This paper develops a model of bargaining over decision rights between an uninformed principal and an informed but self-interested agent in which the uninformed principal makes a price offer to the agent who then decides either to accept or to reject the offer. Contrary to the prediction Coase Theorem provides, actions induced in the unique perfect Bayesian equilibrium do not always satisfy *ex-post* efficiency. Once we introduce explicit communication into the model, however, there exists a truth-telling perfect Bayesian equilibrium, in which induced actions always satisfy *ex-post* efficiency. The truth-telling equilibrium is *always* neologism proof in the sense of Farrell (1993) and satisfies NITS (no incentive to separate) condition proposed by Chen, Kartik and Sobel (2008). Moreover, under some parameter value, it is the unique equilibrium satisfying either neologism proofness or NITS. The truth-telling equilibrium outcome is *ex-ante* Pareto superior to that of several dispute resolution schemes studied in the framework of Crawford and Sobel (1982) and Holmström (1977).

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1 Introduction

In many economic situations a party, such as a government or firm (principal), initially has full authority to make a decision but lacks information about the task or project at hand. There is often another, better-informed party (agent), but its interest may be so different from that of the principal that it may not be willing to share useful information with the uninformed principal.[1] This creates an incentive for the principal to delegate his or her decision rights to the agent in order to make full use of the agent's private information. When the principal delegates decision-making authority to the agent, it may beneficial for the principal to make some restriction on the set from which the agent can choose an action. The principal's optimal choice of the restricted set of actions is extensively studied in the literature of optimal delegation (Holmstrom [31, 32], Goltsman, Hörner, Pavlov, and Squintani [24], Alonso and Matouschek [3], Kováč Mylovanov [34] and Melumad and Shibano [43]).

It is remarkable that most of papers in the delegation literature focus on settings without monetary transfers.[2] Although there are many settings in which the use of monetary transfers is limited or ruled out, sometimes it is more natural to assume that nothing prevents parties from using financial incentives. In practice, the principal can and do use contracts or bargaining mechanisms that include financial incentives in order to transfer decision rights.[3] For example:

- Labor unions and managements typically negotiate the right and responsibility to choose how workers spend their time in workplace or how workers participate in the firm's managemental decision-making process. There are strong empirical evidences that show a positive relation between degree of delegation and wage levels, controlling for a variety of worker and firm characteristics (Caroli and Van Reenen [10], Black, Lynch and Krivelyova [9], Bauer and Brender [8]). Managements rarely have good information about the ease with which workers could increase their personal productivity, for example. In some settings, workers may also have superior information about changes in workplace organization, job descriptions, or work flows that would increase firm productivity. Management also may not have very good information about worker preferences, such as the

[1]See Crawford and Sobel [15]. For more general communication mechanisms, see Goltsman, Hörner, Pavlov, and Squintani [24].

[2]There are few exceptions in the literature on optimal delegation. See, for example, Krähmer [35]. Recently, Ambrus and Egorov [4] investigate the effect of money burning on the optimal delegation structure.

[3]In the framework of incomplete contracts (Grossman and Hart [26] and Hart and Moore [29]), Baker, Gibbons and Murphy [7] model the allocation of decision rights via contracts. They assume that decisions are not contractible ex post, the parties cannot negotiate over the decision after the state is revealed. Instead, the party in control simply takes her self-interested decision.

trade-offs workers would be willing to make between such matters as safety, work rates, wages, job security, and the like (Bainbridge [6]).

- When launching into a new business partnership, auto manufacturers and their dealers negotiate the right to determine the size and qualification of the sales force, or the right to set prices. Auto manufacturers may not have very good information about consumer preferences so that it gets some difficulties to determine price, advertising strategy and so on. Arruñada, Garicano, and Vasquez [5] empirically analyze the allocation of rights and monetary incentives in automobile franchise contracts. Similarly, when an international manufacturer enters a particular national market, it typically lacks relevant information about local market conditions and has difficulties making decisions on pricing, marketing, advertising, distribution and so on. As a result, it sells an exclusive distributorship to a domestic company who is better-informed but lacks authority to make such decisions. If a license agreement is reached through bargaining, the domestic company pays royalties in return for the exclusive right to make decisions about pricing, marketing, advertising, distribution, and so on in the domestic market.[4]

- It is typical that venture capitalists face substantial uncertainty when financing new ventures. (Kaplan and Strömberg [33] and Dessein [17]). Due to this uncertainty, biotechnology companies often *sells* its patent or the right to manufacture the final product to pharmaceutical firms who are better-informed through a license and development agreements.[5]

All these examples share the following commonalities: (i) there is a principal who has to make a decision but lacks decision-relevant information or knowledge; (ii) there is another party who is better-informed or more-experienced but it has its own agenda; (iii) these two

[4]For example, I.B.M., the world's largest computer maker in the 1990's, agreed to allow Mitsubishi to sell an I.B.M. mainframe computer under its own name in Japan in April, 1991. See Andrew Pollack, "IBM Model to Be Sold By Mitsubishi," *The New York Times* (April 29, 1991), 17. More recently, tobacco industry leader Philip Morris International announced an agreement with Chinese National Tobacco under which Chinese National Tobacco will manufacture Marlboro cigarettes for marketing in China. See Nicholas Zamiska and Juliet Ye, "Chinese Cigarettes to Go Global" *The Wall Street Journal*, (January 30, 2008) B4.

[5]For instance, *Animas Corporation*, an insulin infusion pump manufacturing company, set up a license and development agreements with the Swiss R&D company, *Debiotech*, for intellectual property related to next-generation insulin pumps and micro-needles. In return for the exclusive worldwide license to make, use, and sell products utilizing the intellectual property portfolio that includes over 70 issued patents, *Animas* paid $12 million in cash and issued 400,000 restricted shares of Animas common stock. See Rick Baron, "Animas acquires technology for disposable insulin micro-pumps and micro-neddles," http://www.bioalps.org/Bioalps/en/Internet/Documents/1996.pdf. Also see Lerner and Merges [38] and Higgins [30] for some empirical evidences.

parties negotiate the allocation of decision rights by using various monetary incentives schemes; (iv) the final decision made by the party in control determines both parties' welfare. In order to capture this situation, we follow the framework of Crawford and Sobel [15] and Holmstrom [31, 32]: there are two parties, uninformed principal (P) and informed but self-interested agent (A), with one dimensional decision to make that affects welfare of both under one dimensional uncertainty.

The novel feature of this model is as follows: we investigate reallocation of decision rights in settings with monetary transfers. In particular, we consider an uninformed principal's optimal choice of a price offer for decision rights when an informed agent decides either to accept or to reject the offer. If the price offer is accepted then the agent pays the principal the price for decision-rights and makes a decision. Otherwise, the principal retains decision-rights without making any monetary transfers. We call this game *bargaining over decision rights*.[6] Our main finding is as follows: it is optimal for the uninformed principal to use the price offer as a screening device. In equilibrium, the principal makes a price offer that is accepted by some agent types but not by all agent types. It means that the principal retains decision-rights with positive probability but still lacks precise information. As a result, actions taken by the principal without precise information may be inefficient *ex-post* for some realization of the state. That is, sometimes there exists an action that makes the principal better off without making the agent worse off or vice versa, once the true state of the world becomes public.

This result seems to be contrary to Coase [13] who asserts that if the market outcome is inefficient and there are no transaction costs, then the parties concerned will negotiate their way to efficiency. The main obstacle to the efficient bargaining seems to be bargaining costs due to incomplete or asymmetric information. Farrell [18] shows that in the presence of private or incomplete information, voluntary negotiation could not lead to the first-best outcome that maximizes joint surplus. The important issue is how to interpret "no transaction costs" in the presence of private information. In the basic model, we assume that bargaining is *tacit* in the sense that parties can communicate only by making a price offer that directly affects their payoffs. As pointed out by Crawford [14], real bargaining, by contrast, is usually *explicit*, in that parties can also communicate by sending non-binding messages with no direct effects on their payoffs. Thus, it is natural to interpret the absence of transaction costs in bargaining under asymmetric information as the absence of communication costs: people freely get together and communicate with each other without any costs. Therefore, it is impetuous to conclude that Coase's assertion is unwarranted in our environment without investigating

[6] A similar bargaining model is considered by Lim [39]. However, Lim [39] focuses on the situation where the informed agent has bargaining power so that he makes a take-it-or-leave-it price offer.

the impact of communication into the tacit bargaining carefully.

There are many theoretical evidences showing that such cheap talk messages play an important role in coordinating bargainers' expectations so that they can reach agreement and in determining how they share the resulting surplus (Farrell and Gibbons [22] and Matthews [41]). Farrell and Gibbons [22] study a two-stage bargaining game in which talk may be followed by the sealed-bid double auction studied by Chatterjee and Samuelson [11], a well-known model of bargaining under incomplete information. They show that talk can matter in the sense that the cheap talk equilibrium features bargaining outcomes that could not be an equilibrium behavior in the absence of talk. Matthews [41] considers a specific bargaining situation with a veto-threat and shows there exists an equilibrium in which an informed party (proposer) tells the other (chooser) which of two sets contains his type. This equilibrium behavior is not a part of equilibrium behavior in the absence of talk. These results intimate that communication may resolve inefficiency caused by the presence of incomplete or asymmetric information in our model.

How then does introducing talk into the tacit bargaining affect the behaviors of the parties? To answer this question, we devote the second half of our paper to bargaining over decision-making rights with explicit communication. Specifically, we assume the informed agent can send a cheap talk message before bargaining begins.[7] Once we allow parties to communicate via cheap talk before bargaining, there exists a truth-telling equilibrium. The existence of the truth-telling equilibrium is surprising because neither the tacit bargaining nor communication via cheap talk alone allows parties to make full use of the agent's private information to make a decision. Such an equilibrium is supported by the existence of a credible threat, an action that gives lower payoff to all agent types than the payoff from being identified. We show that there always exists such an action in our environment: the state space is bounded and the conflict of interest is type-independent.[8] The agent's equilibrium strategy is to report a true state in the cheap talk stage and accept a price offer only if taking his ideal action after accepting the offer gives at least the same payoff as the payoff from the principal's *ex-post* ideal action. The principal makes a message-independent price offer that any agent type reporting the true state is indifferent between accepting and rejecting. The principal thinks of rejection of the price offer as proof that the report from the agent is dishonest so that he takes the threat action to punish the agent whenever the price offer is rejected. This off-the-equilibrium threat action is rationalized by the belief that all agent types report the true state and accept

[7] However, our main result, the existence of the truth-telling equilibrium, does not depend on the exact timing of the game.

[8] For example, the threat action is the principal's ideal action when the true state is the lowest, if the conflict of interest between parties is constant and positive.

the principal's price offer. The threat action compels the agent to report the true state in the cheap talk stage and to accept the price offer from the principal in the bargaining stage. In this truth-telling equilibrium, induced actions always satisfy *ex-post* efficiency.

We apply two standard cheap-talk refinements, *neologism proofness* (Farrell [19]) and NITS (Chen, Kartik and Sobel [12]), and show that the existence of the truth-telling equilibrium is robust against those refinements: no matter how large the difference between parties' preferences, the equilibrium is neologism proof in Farrell [19]'s sense. Moreover, it is the unique neologism-proof equilibrium under some parameter value. Imposing NITS, the criterion proposed by Chen, Kartik and Sobel [12] to refine equilibria in cheap-talk games (Crawford and Sobel [15]) leads to the same result. That is, not only the truth-telling equilibrium *always* satisfies NITS, but also it is the unique equilibrium satisfying NITS under some parameter value.

We also show that the truth-telling equilibrium outcome of the explicit bargaining is *ex-ante* Pareto superior to that of several other protocols studied in the literature, such as communication (Crawford and Sobel [15]), optimal mediation (Goltsman, Hörner, Pavlov, and Squintani [24]), optimal delegation (Holmström [31][32], Alonso and Matouschek [3], Kováč Mylovanov [34] and Melumad and Shibano [43]) and optimal compensation contract (Krishna and Morgan [37]) if parties' interests are substantially misaligned. This might explain why bargaining over decision rights often takes place between two separately owned companies whose interests diverge widely.

The rest of the paper is organized as follows. The next section describes the environment. In section 3, we setup the basic model of bargaining over decision-making authority and show that there is no equilibrium in which an *ex-post* efficient action is taken for any realization of the state. Full characterization of equilibria is provided assuming the parties' priors are *uniform*. In section 4, we extend the basic model and allow parties to communicate before bargaining by sending cheap talk messages. We show that there exists a truth-telling perfect Bayesian equilibrium in which actions induced are efficient *ex-post*. The truth-telling equilibrium outcome always satisfies both neologism proofness and NITS condition. We devote Section 5 to welfare comparisons. We conclude in section 6.

2 Basic Model

2.1 Environment

There are two parties, a principal (P) and an agent (A). The principal who initially has decision-making authority has little information about the state of the world $\theta \in \Theta \equiv [0,1]$.

She has a prior distribution F over $[0,1]$ with an absolutely continuous density function $f > 0$. The agent who has different interests from the principal knows the true state of the world θ but does not have decision-making authority. The payoffs for a given allocation of authority depend on an action y taken by the party who has decision-making authority and the state of the world θ. The payoff functions of the parties are of the form $U^P(y,\theta) = -l(|y-\theta|)$ for the principal and $U^A(y,\theta,b) = -l(|y-(\theta+b)|)$ for the agent.[9] We refer to l as the loss function and assume that $l''(\cdot) > 0$, $l'(0) = 0$ and $l(0) = 0$. This means that the ideal action of the principal is $\overline{y}^P(\theta) = \theta$ and the ideal action of the agent is $\overline{y}^A(\theta,b) = \theta + b$ where $b > 0$ is a parameter that measures how nearly the agent's interest coincides with that of the principal. All of these are common knowledge between parties.

2.2 *Ex-post* Efficient Actions

Define an *ex-post* efficient action as follows. An action is said to be *efficient ex-post* if and only if there is no other feasible action that makes some individual better off without making other individuals worse off after the true state of the world θ is publicly known.

Definition 1. *An action $y \in \mathbb{R}$ is efficient ex-post at θ if there is no other action $z \in \mathbb{R}$ such that*

$$U^P(z,\theta) \geq U^P(y,\theta) \quad \textit{and} \quad U^A(z,\theta,b) \geq U^A(y,\theta,b) \tag{1}$$

with at least one strict inequality.

In our environment, an action y is efficient *ex-post* if and only if $y \in [\theta, \theta+b]$ when the realization of the state is θ, as one can see in Figure 1. Notice that most mechanisms considered in the literature on strategic information transmission (Crawford and Sobel [15]) and optimal delegation (Holmstrom [31][32]) lead to efficient actions for some states of the world but not all. The following example demonstrates *ex-post* inefficiency of actions in cheap talk and optimal delegation.

Example 1. Suppose that F is uniform and utilities are quadratic. Let $b = 1/5$ and the realized state of the world $\theta = 7/8$. As you can see in Figure 1, if an action y is not in $[\theta, \theta+b] = [7/8, 43/40]$, then there exists another action y' such that both parties strictly prefer y' to y. Suppose that parties communicate via cheap talk. In the most informative equilibrium, only two actions, $y_1 = \frac{1}{20}$ and $y_2 = \frac{11}{20}$, are induced.[10] Since $y_1 < \theta$ and $y_2 < \theta$, both actions

[9] A special case is a quadratic utility ($U^P(y,\theta) = -(y-\theta)^2$ and $U^A(y,\theta,b) = -(y-\theta-b)^2$) which we are assumed in most examples and applications. Similar utility functions are assumed in many other paper, for example, Dessein [16]. To see more papers assuming quadratic utilities, see Kováč and Mylovanov [34].

[10] See the leading example of Crawford and Sobel [15].

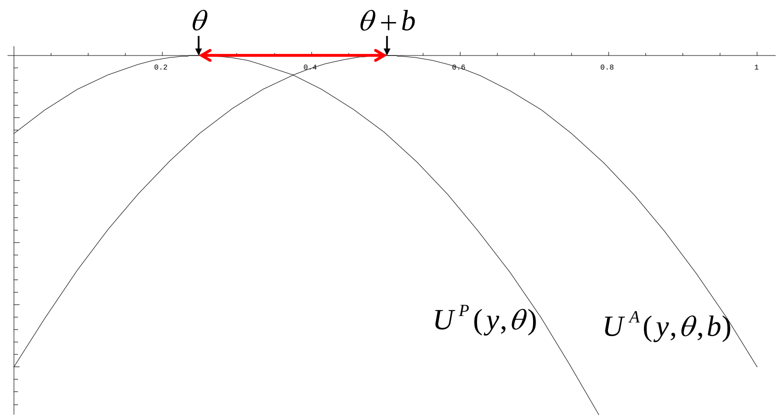


Figure 1: Ex-post Efficient Actions

are inefficient *ex-post*. Alternatively, suppose that the principal optimally proposes the set of admissible actions that the agent can take. In the optimal delegation, the proposed set is $[0, 1-b] = [0, 4/5]$.[11] As the result, the agent cannot take any action $y \in [7/8, 43/40]$.

3 Tacit Bargaining

Consider bargaining over decision-making authority between the informed agent and the uninformed principal. The timing of the game is as follows:

1. The agent privately observes the state of the world $\theta \in \Theta \equiv [0, 1]$.
2. The principal makes an offer $p \in \mathbb{R}$ for the authority to take an action.[12]
3. The agent decides whether to reject or accept the offer.
4. If the agent accepts the offer then he pays the price to the principal and takes an action, denoted by y^A. In this case, payoffs become $U^P(y^A, \theta) + p$ and $U^A(y^A, \theta, b) - p$ for the principal and the agent respectively. If the agent rejects the offer, however, the principal takes an action, denoted by y^P, without transferring the decision-making authority. Then payoffs are $U^P(y^P, \theta)$ and $U^A(y^P, \theta, b)$ for the principal and the agent, respectively.

The equilibrium concept we use is perfect Bayesian equilibrium. For the principal, a strategy consists of a price offer p^* and an action rule y^P. The action rule, denoted by $y^P : \mathbb{R} \to \mathbb{R}$ specifies the principal's action after the rejection of each price offer $p \in \mathbb{R}$ that the he might make. Since the utility function is strictly concave in y, the principal will never use mixed strategies in equilibrium. For the agent, a strategy consists of a decision

[11] See Holmström [31][32], Melumad and Shibano [43], Alonso and Matouschek [3] and Kováč and Mylovanov [34].

[12] We allow p to be negative, which means that the principal pays $|p|$ to the agent.

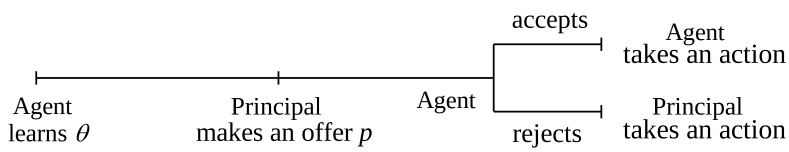


Figure 2: Timing of the game

rule and an action rule. The decision rule, denoted by $d^A : \Theta \times \mathbb{R} \to [0,1]$, specifies the probability of rejection for each price offer $p \in \mathbb{R}$ that the agent might receive. The action rule $y^A : \Theta \times \mathbb{R} \to \mathbb{R}$, specifies the agent's choice of action after he accepts the principal's price offer p. The strategy profile $\{(p^*, y^P), (d^A, y^A)\}$ forms a perfect Bayesian equilibrium if:
(**B1**) p^* solves

$$\max_{p \in \mathbb{R}} \int_0^1 \{d^A(\theta, p) U^P(y^P(p), \theta) + (1 - d^A(\theta, p))(p - l(b))\} f(\theta) d\theta$$

(**B2**) for each $p \in \mathbb{R}$ and each $\theta \in [0,1]$, $d^A(\theta, p)$ solves

$$\max_{d^A \in [0,1]} (1 - d^A)(-p) + d^A \cdot U^A(y^P(p), \theta, b)$$

(**B3**) for each $\theta \in [0,1]$ and $p \in \mathbb{R}$, $y^A(\theta, p) = \overline{y}^A(\theta) = \theta + b$
(**B4**) for each $p \in \mathbb{R}$, $y^P(p)$ solves

$$\max_{y \in \mathbb{R}} \int_0^1 U^P(y, \theta) \rho(\theta|p) d\theta$$

where $\rho(\theta|p)$ is the principal's updated belief after observing the agent's rejection of p, which is given by Bayes' rule whenever possible.

3.1 Equilibrium

3.1.1 Example: *uniform* distribution

In this section, we illustrate the main idea behind our analysis while assuming that f is *uniform* over $[0,1]$. This setting, together with quadratic utilities, is a leading example of Crawford and Sobel [15] and has been widely used in the literature on strategic information transmission and optimal delegation. We will extend our result to more general distributions in the next subsection. In what follows we first focus on the agent's decision whether to accept a given price offer or not. We will show that the agent's decision rule satisfies an interesting property called *monotonicity*. Next, with the full characterization of the agent's decision rule we show there exists a unique price offer that maximizes the principal's expected utility.

For an arbitrary $p \in \mathbb{R}$, define the set of agent types who accept p with probability one as

$$\Theta(p) = \{\theta \in [0,1] | d(\theta, p) = 0\}.$$

Define the set of agent types who reject the offer p with probability one as

$$\Theta^{-1}(p) = \{\theta \in [0,1] | d(\theta, p) = 1\}.$$

Lemma 1 (Monotonicity). *For any price offer, if there is an agent type θ who accepts the offer with positive probability then all agent types higher than θ have to accept it with probability one.*

Proof. See the appendix. □

To see the intuition of Lemma 1, consider the decision problem of agent type $\theta \in [0,1]$ who observes a price offer p. Define the agent type θ's willingness to pay as follows:

$$W(\theta, p, y^P(p)) = U^A(\overline{y}^A(\theta), \theta, b) - U^A(y^P(p), \theta, b) = l(|y^P(p) - (\theta + b)|), \tag{2}$$

where $y^P(p)$ is the action taken by the principal after the price offer p is rejected and $\overline{y}^A(\theta) = \theta + b$ is the agent type θ's optimal action. The agent type θ accepts the offer only if the gain of getting decision-making authority (or willingness to pay for authority) is at least as big as the loss of it, that is,

$$W(\theta, p, y^P(p)) \geq p.$$

It is not possible that $y^P(p)$ is on the right of θ, because otherwise, the quasi-cancavity of U^A implies that the set of agent types who reject the offer should be on the right of θ and the mid-point of the set should be $y^P(p) - b$ but not $y^P(p)$, which is contradicted by **(B4)**. It means that $y^P(p)$ is on the left of θ, and as a result, the agent type $\theta' > \theta$ whose most preferred action is higher than that of the agent type θ is willing to pay more to get authority to make a decision, that is,

$$\frac{\partial W(\theta, p, y^P(p))}{\partial \theta} \geq 0.$$

This means that agent type θ accepts any price offer which is accepted by agent type $\theta' < \theta$.

Lemma 1 implies that for any $p \in \mathbb{R}$, both $\Theta(p)$ and $\Theta^{-1}(p)$ are convex if they are non-empty. Further, $\Theta(p)$ cannot be to the left of $\Theta^{-1}(p)$. These guarantee that for any $p \in \mathbb{R}$ there is at most one agent type who is indifferent between accepting and rejecting the offer. Let $\theta_p \in [0,1]$ denote the agent type if it exists. Then we can write that $\Theta(p) = (\theta_p, 1]$ and $\Theta^{-1}(p) = [0, \theta_p)$. From the indifference condition at θ_p we have

$$p = l(|y^P(p) - \theta_p - b|), \tag{3}$$

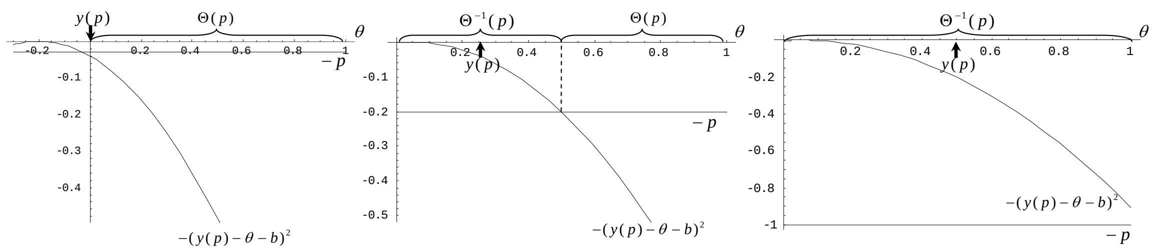
where $y^P(p) = arg\max_y \int_0^{\theta_p} -l(|y-\theta-b|)\cdot\frac{1}{\theta_p}d\theta = \frac{\theta_p}{2}$. Thus, we have

$$p = l(\frac{\theta_p}{2}+b) \quad or \quad \theta_p = 2(l^{-1}(p)-b). \tag{4}$$

Since $\theta_p \in [0,1]$, we have the following corollary.

Corollary 1.

$$\Theta(p) = \begin{cases} [0,1] & \textit{if } p < l(b), \\ (2(l^{-1}(p)-b),1] & \textit{if } l(b) \le p \le l(b+\frac{1}{2}), \\ \emptyset & \textit{if } p > l(b+\frac{1}{2}) \end{cases}$$



(*a*) low *p* (*b*) moderate *p* (*c*) high *p*

Figure 3: The agent's decision rule

In words, all agent types in $[0,1]$ accept a low price offer ($p < l(b)$) with probability one, and once the price offer becomes greater than $l(b)$ then low agent types start rejecting it. As p increases, the set $\Theta(p)$ becomes smaller and finally all agent types in $[0,1]$ reject a high price offer ($p > l(b+\frac{1}{2})$) with probability one.

In Figure 3, we see the clear trade-off between higher price and more rejections that the principal faces. Although a higher price offer gives a higher payoff to the principal if accepted, it does not seem to be optimal for the principal to make a very high offer because it cannot be accepted (Figure 3(a)). Similarly, making a price offer that could be accepted by all agent types does not seem to be optimal either because it is very low (Figure 3(c)). These suggest that the principal's optimal price offer should lie halfway between two extremes (Figure 3(b)). To confirm this idea, consider the principal's optimal price offer as a best response to the agent's strategy. The principal chooses p^* to solve

$$\begin{aligned} \max_{p\in\mathbb{R}} EU^P &= \int_0^{\theta_p} -l(|y^P(p)-\theta|)d\theta + (1-\theta_p)(p-l(b)) \\ &\text{s.t. } y^P(p) = \frac{\theta_p}{2} \text{ and } \theta_p = 2(l^{-1}(p)-b). \end{aligned} \tag{5}$$

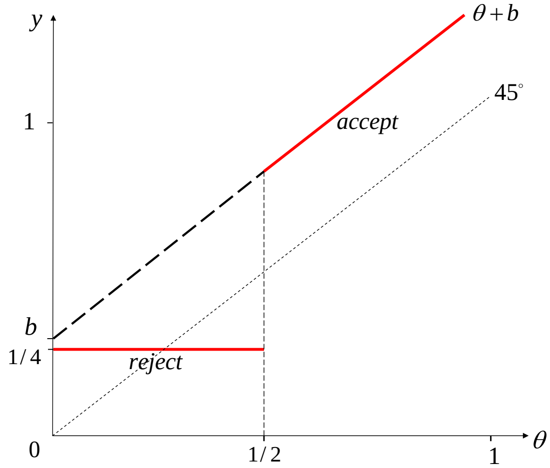


Figure 4: Equilibrium Outcome

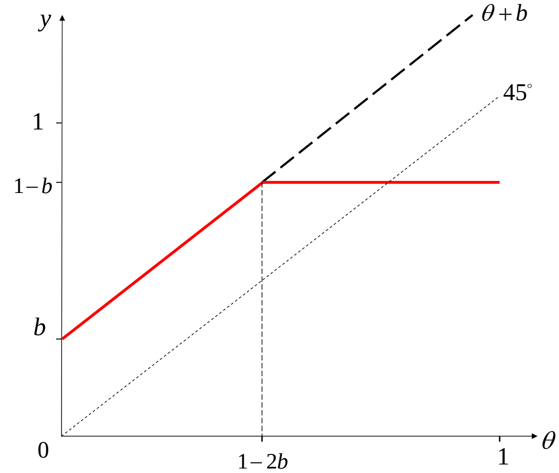


Figure 5: Optimal Delegation

Notice that there exists a unique interior solution of this maximization problem because of the strict concavity of EU^P in p. From the first order condition, we get

$$p^* = l(\frac{1}{4} + b) \quad and \quad \theta_{p^*} = \frac{1}{2}. \tag{6}$$

This implies that it is optimal for the principal to make the price offer that is acceptable for some agents of high type but not for the remaining agents of low type. This result is summarized in the following proposition.

Proposition 1. *In equilibrium, the principal makes a price offer* $p^* = l(\frac{1}{4}+b)$*. The agent type* $\theta \in [0, \frac{1}{2})$ *rejects the offer with probability one and* $\theta \in (\frac{1}{2}, 1]$ *accepts the offer with probability one. As a result, ex-post efficiency does not hold.*

It is interesting to compare this result with the outcome of optimal delegation studied by Holmström [31][32], Melumad and Shibano [43], Alonso and Matouschek [3], Goltsman *et al.* [24] and Kováč and Mylovanov [34]. They studied the uninformed principal's optimal choice of the set of admissible actions that the informed agent can take. According to the optimal delegation rule in the model with a uniform prior and quadratic utility functions, the informed agent can enforce any decision he likes, as long as it does not exceed $1 - b$ (see Figure 5). The intuition is as follows: since the informed party's most preferred action is always higher than that of the principal, it pays to impose an upper bound on the allowable actions. In case of the low state, on the other hand, the best way to make use of the informed agent's information is to grant complete freedom of choice of the action to the informed agent.

Although the outcome of the equilibrium in this model in which the agent obtains complete freedom of choice of the action only in case of the high state looks exactly opposite of that of optimal delegation, the underlying intuition is exactly the same as that of optimal delegation. Recall that the type θ agent's willingness to pay is strictly increasing in the distance between $y^P(p)$ and $(\theta + b)$ where $y^P(p)$ is determined by Bayes' rule. This means that the principal can maximize the willingness to pay by choosing $y^P(p)$ and the agent's most preferred action $(\theta + b)$ as distant as possible. Since $b > 0$, the principal can maximize this distance by making the price offer that the agent rejects in case of a low state and accepts in case of high state so that $y^P(p)$ is low and $(\theta + b)$ is high. Clearly, we should get exactly the opposite outcome in which the informed agent gets a complete freedom to choose the action in case of low state if the agent's most preferred action is always lower than that of the principal.

3.1.2 General Case

In this section, we extend the analysis in the previous section to more general distributions. Recall that in the previous section the monotonicity of the agent's decision rule allows us to have a unique optimal price offer for the principal. The following regularity assumption on the parties' prior belief f is necessary for us to have the same monotonicity of the agent's decision rule and as a result, ensures that all results we got in the previous section are preserved.

Assumption 1. *For a given value of $b > 0$,*

$$y(\underline{\theta}, \overline{\theta}) - b < \frac{\underline{\theta} + \overline{\theta}}{2} \tag{7}$$

for any $\underline{\theta}$ and $\overline{\theta}$ with $0 \leq \underline{\theta} \leq \overline{\theta} \leq 1$, where

$$y(\underline{\theta}, \overline{\theta}) = \begin{cases} argmax \int_{\underline{\theta}}^{\overline{\theta}} U^P(y, \theta) f(\theta) d\theta & \text{if } \underline{\theta} < \overline{\theta}, \\ \overline{\theta} & \text{if } \underline{\theta} = \overline{\theta}. \end{cases}$$

In words, this condition implies that for any interval subset of Θ, an action that maximizes the expected payoff for a principal who believes that agent type is in the interval is not lopsided too much toward the right of the interval. Any prior f satisfies this regularity condition if $b \geq 1/2$. Moreover, this condition holds for any $b > 0$ if f is non-increasing in θ. In particular, it is satisfied in the setting with *uniform* distribution considered in the previous subsection.

Under this assumption, the agent types' decision rule satisfies *monotonicity* that leads to the following result.

Proposition 2. *Under Assumption 1, there exists a unique perfect Bayesian equilibrium. In the equilibrium, the principal makes a price offer accepted by positive measure of agent types but not all.*

Proof. See the appendix. □

4 Explicit Bargaining

In this section, we explore how introducing explicit communication into the basic model affects its outcomes. The timing of the game is as follows:

1. The agent privately observes the state of the world $\theta \in \Theta \equiv [0, 1]$.
2. The agent sends a message $m \in M$ to the principal.
3. After observing the message from the agent, the principal makes a price offer $p \in \mathbb{R}$ for authority to take an action.
4. The agent decides whether to accept or reject the offer.
5. If the agent accepts the offer then he pays the price offered by the principal and takes an action, denoted by y^A. In this case, payoffs become $U^P(y^A, \theta) + p$ and $U^A(y^A, \theta, b) - p$ for the principal and the agent respectively. If the agent rejects the offer, however, the principal takes an action, denoted by y^P, without transferring the decision-making authority. Then payoffs are $U^P(y^P, \theta)$ and $U^A(y^P, \theta, b)$ for the principal and the agent, respectively.

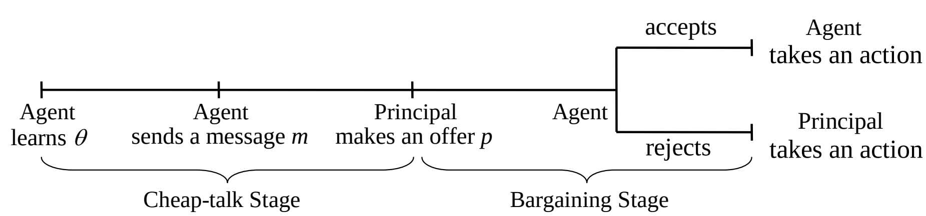


Figure 6: Communication before Bargaining

Again, the equilibrium concept we use is perfect Bayesian equilibrium. For the agent, a strategy consists of a message rule, a decision rule and an action rule. The message rule $\mu : \Theta \to \Delta(M)$ specifies the choice of message for each type $\theta \in \Theta$. The decision rule, denoted by $d : \Theta \times M \times \mathbb{R} \to [0, 1]$, specifies the probability of rejection for each price offer $p \in \mathbb{R}$ that the agent who sent the message m might receive. The action rule $y^A : \Theta \times M \times \mathbb{R} \to \mathbb{R}$, specifies the action taken by the agent type θ who sent a message m and accepted the principal's price offer p. For the principal, a strategy consists of a price rule and an action rule. The price rule $p^* : M \to \mathbb{R}$ specifies the principal's choice of price offer for each message $m \in M$ that the principal might receive. The action rule, denoted by $y^P : M \times \mathbb{R} \to \mathbb{R}$ specifies the action taken by the principal who observed a message m and her price offer p was rejected. The strategy profile $\{(\mu, d, y^A), (p^*, y^P)\}$ and the principal's posterior beliefs ρ_1 and ρ_2 form a perfect Bayesian equilibrium if:

(**CB1**) for each $\theta \in [0, 1]$, $\int_M \mu(m|\theta) dm = 1$ and if $m^* \in M$ is in the support of $\mu(\cdot|\theta)$

then m^* solves

$$\max_{m \in M} d(\theta, m, p^*(m))U^A(y^P(m, p^*(m)), \theta, b) - p^*(m)(1 - d(\theta, m, p^*(m)))$$

(**CB2**) for each $m \in M$, $p^*(m)$ solves

$$\max_{p \in \mathbb{R}} \int_0^1 \{d(\theta, m, p)U^P(y^P(m, p), \theta) + (1 - d(\theta, m, p))(p - l(b))\}\rho_1(\theta|m)d\theta$$

(**CB3**) for each $\theta \in [0, 1]$, $m \in M$, and $p \in \mathbb{R}$, $d(\theta, m, p)$ solves

$$\max_{d \in [0,1]} (1 - d)(-p) + d \cdot U^A(y^P(m, p), \theta, b)$$

(**CB4**) for each $\theta \in [0, 1]$, $m \in M$, and $p \in \mathbb{R}$, $y^A(\theta, m, p) = \theta + b$

(**CB5**) for each $m \in M$ and $p \in \mathbb{R}$, $y^P(m, p)$ solves

$$\max_{y \in \mathbb{R}} \int_0^1 U^P(y, \theta)\rho_2(\theta|m, p)d\theta$$

(**CB6**)

$$\rho_1(\theta|m) = \frac{\mu(m|\theta)}{\int_0^1 \mu(m|\theta')d\theta'} \qquad \text{and} \qquad \rho_2(\theta|m, p) = \frac{d(\theta, m, p)\rho_1(\theta|m)}{\int_0^1 d(\theta', m, p)\rho_1(\theta'|m)d\theta}$$

where $\rho_1(\theta|m)$ is the principal's updated belief after observing the message m from the agent and $\rho_2(\theta|m, p)$ is the updated belief of the principal receiving the message m and observing the rejection of the price offer p.

4.1 Truth-telling Equilibrium

Is it possible that communication before bargaining is informative and as a result, improves efficiency of bargaining? Surprisingly, there exists a truth-telling perfect Baysian equilibrium once we allow parties to communicate before bargaining.

Consider the following strategy profile: the principal makes a price offer $l(b)$ regardless of the message he observed and takes an action $y = \overline{y}^P(0) = 0$ if the offer is rejected. The agent fully reveals his private information by sending a truth-telling message in the cheap talk stage and accepts any offer less than or equal to $l(b)$ with probability one but rejects any other offer with probability one. It is easy to see that the agent types' strategy is a best response to the principal's strategy. First, no agent type has an incentive to deviate in cheap talk stage because the principal's price offer is message-independent. Second, no agent type has an incentive to reject the offer in the bargaining stage because for all $\theta \in [0, 1]$

$$\underbrace{-l(b)}_{\textit{from accepting } l(b)} \geq \underbrace{-l(|0 - \theta - b|)}_{\textit{from rejecting } l(b)} = -l(\theta + b).$$

Given the agent's strategy specified above, the principal's best response is to make an offer $l(b)$, the highest price offer accepted by agent types who tells the truth in the cheap talk stage. After the price offer $l(b)$ is rejected, the principal believes that the true state of the world is $\theta = 0$ with probability one. This is a reasonable belief in the sense that the agent with type $\theta = 0$ is the only type who is indifferent between accepting and rejecting the offer $l(b)$, and all other agent types strictly prefer accepting the offer.

Proposition 3 (Truth-telling equilibrium)**.** *For any $b > 0$, there exists a perfect Bayesian equilibrium in which the informed agent fully reveals his private information by sending truth-telling messages in cheap talk stage.*

Proof. See the appendix. □

In this truth-telling equilibrium, the informed agent accepts the equilibrium price offer $l(b)$ with probability one so that the final outcome is always efficient *ex-post*. This is surprising because neither the tacit bargaining nor communication via cheap talk alone allow parties to make full use of the agent's private information to make a decision. This result is similar to Farrell and Gibbons [20] in the sense that not only information conveyed by cheap talk in equilibrium, but the equilibrium outcomes differ from any that could occur in an equilibrium without talk.

Notice that there is no use of information by the principal in this equilibrium. Nonetheless, the role of communication is clear in this equilibrium. Recall that under the babbling strategy of the agent, the principal can make a price offer that screens the agent types. When the agent uses the truth-telling strategy, however, a price offer should be either accepted by all agent types ($p \leq l(b)$) or rejected by all agent types ($p > l(b)$). Therefore, the truth-telling strategy of the agent restrains the screening power of the principal's price offer. In other words, communication reduces the principal's bargaining power. Consequently, the principal's *ex-ante* payoff in this equilibrium is lower than that of the unique equilibrium of the tacit bargaining whereas the agent's *ex-ante* payoff in this equilibrium is higher than that of the unique equilibrium of the tacit bargaining.[13]

[13] In the tacit bargaining, the principal also can make a price offer $l(b)$ which is accepted by all agent types. However, making such an offer is not an optimal for the principal. Although all agent types in $[0, 1]$ are supposed to accept the offer with probability one, she may get some benefits from making a slightly higher offer that could be rejected by some agent types. In fact, without communication the principal's expected payoff from making the price offer $l(b + \frac{1}{4})$ that we derived in the previous section is

$$-\int_0^{\frac{1}{2}} l(|\frac{1}{4} - \theta|)d\theta + \frac{1}{2}\left(l(b + \frac{1}{4}) - l(b)\right) \tag{8}$$

which is greater than 0, the expected payoff from making the offer $l(b)$. This implies that the principal's *ex-ante*

It is remarkable to see that the existence of this equilibrium is robust against the exact timing of the game. To be more precise, consider the game in which bargaining comes first and communication comes next under the contingency that an agreement is not reached. Then there exists the following perfect Bayesian equilibrium in this game which is outcome equivalent to the truth-telling equilibrium in the original model. The construction of the equilibrium is almost the same as before: the principal makes a price offer $l(b)$ and takes an action $y = 0$ regardless of the message she received from the agent if the offer is rejected. All agent types in Θ always accept the offer $l(b)$ with probability one and fully reveal their private information by sending truth-telling messages off the equilibrium path (i.e. when any offer is rejected.) Since it is trivial to see that this strategy profile satisfies the mutual best response under some belief derived by Bayes' rule, I skip the detailed proof.

4.2 Only truth-telling and babbling equilibria exist

This model has multiple perfect Bayesian equilibria, which are common in signaling or cheap-talk games. Especially, it is well-known that babbling in the cheap talk stage can be a part of equilibrium. The outcome of the babbling equilibrium is the same as the unique perfect Bayesian equilibrium outcome of tacit bargaining. Is there an equilibrium other than babbling or truth-telling? In this section, we will show that it is impossible to have any equilibrium where information is revealed partially in cheap talk stage. That is, either truth-telling or babbling should be an equilibrium outcome.

One might wonder if there exist Crawford and Sobel [15] types of equilibria in this model, which are interval partitional: The agent's type space is divided into N convex intervals and all agent type in one interval use the same strategy in the cheap talk stage. In the following example, we will explain why there is no such partition equilibria by focusing on the 2-step partition strategy of the agent.

Example 2. Suppose that agent types in $[0, \theta^*)$ send a message m_1 and remaining agent types in $(\theta^*, 1]$ send a message m_2. Notice that the monotonicity of the agent type's decision rule still holds (replace $[0, 1]$ by either $[0, \theta^*)$ or $(\theta^*, 1]$ in the proof of Lemma 1). Then we have the principal's optimization problems which are similar to (5). By the strict concavity of the principal's expected utility in p, there exists a unique interior solution of each of these problems: It is optimal for the principal who observed the message m_1 to make a price offer p_1 which is rejected by $[0, \theta_{p_1})$ and accepted by (θ_{p_1}, θ^*) and for the principal who observed the message m_2 to make a price offer p_2 which is rejected by (θ^*, θ_{p_2}) and accepted by $(\theta_{p_2}, 1]$

payoff from the tacit bargaining is higher than that from the truth-telling outcome.

where $\theta_{p_1} = \frac{\theta^*}{2}$ and $\theta_{p_2} = \frac{\theta^*+1}{2}$. After the price offers p_1 and p_2 are rejected, the principal takes actions $y_1 = \frac{\theta_{p_1}}{2}$ and $y_2 = \frac{\theta^*+\theta_{p_2}}{2}$, respectively. From the indifference conditions at θ_{p_1} and θ_{p_2}, we have $p_i = l(|y_i - \theta_{p_i} - b|)$. After some rearrangement, we have

$$p_1 = l(\frac{\theta^*}{4} + b) \quad and \quad p_2 = l(\frac{1-\theta^*}{4} + b). \tag{9}$$

Observe that the agent type θ^* has to be indifferent between sending a message m_1 (and accepts it) and m_2 (and rejects it). From this indifference condition at θ^*, we have

$$l(\frac{\theta^*}{4} + b) = l\left(|\frac{\theta^* + \frac{\theta^*+1}{2}}{2} - \theta^* - b|\right) \quad or \quad \theta^* = \frac{1}{2} - 4b. \tag{10}$$

Plugging (10) into (9) gives

$$p_1 = l\left(\frac{1}{8}\right) < p_2 = l\left(\frac{1}{8} + 2b\right).$$

This implies that agent types in $(\theta_{p_2}, 1]$ have an incentive to deviate: sending the message m_1 and accepting the price offer p_1 is profitable. Therefore there is no 2-step partition equilibrium.

We can eliminate any equilibria which are interval partitional by using the same argument as in the example above: if the sets of agent types who use the same message rule are convex then it is optimal for the principal to make a price offer which is accepted only by high agent types but at the same time rejected by remaining low agent types. The indifference conditions at the boundary types ensure that the optimal price offers induced by different messages could not be the same with each other so that there always exists some agent type who has an incentive to deviate to the message that induces a lower price offer than his own. A similar argument still holds even if the set of agent types who use the same message rule is not convex.

Proposition 4. *Only babbling or truth-telling can be a cheap talk stage outcome in any equilibrium.*

Proof. See the appendix. □

4.3 Robustness of Truth-telling Equilibrium

In this section, we apply two equilibrium refinements for cheap-talk models- neologism proofness developed by Farrell [19] and NITS (no incentive to separate) developed by Chen, Kartik, and Sobel [12]. We show that the truth-telling equilibrium satisfies both neologism proofness and NITS condition for any $b > 0$ whereas the babbling equilibrium does not satisfy either of them for some parameter value of b.

4.3.1 Neologism proofness

There are several papers (see Gertner, Gibbons, and Scharfstein [23], Farrell and Gibbons [20][21], and Matthews [41]) that use neologism proofness, developed by Farrell [19] to refine equilibrium outcomes of cheap talk games, to refine their equilibrium outcomes. In what follows, we show that the truth-telling perfect Bayesian equilibrium is always neologism proof and for some parameter values, it is a unique neologism-proof equilibrium.

According to Farrell [19], assume that for every non-empty subset X of Θ, and for every perfect Bayesian equilibrium of the game, there exists a message $m(X)$ that is unused in the equilibrium and whose literal meaning is that $\theta \in X$. If the principal observes the message $m(X)$, then she hypothesizes that some members of specified subset X are responsible for the message and makes a price offer that is a best response under the posterior belief derived by Bayes' rule from her prior. For example, by Lemma 1 and the tacit bargaining analysis, for any convex $X \subseteq \Theta$ it is the principal's best response against getting the message $m(X)$ to make a price offer which is rejected by agent types in the low half of X and accepted by remaining agent types in X. The parties' behaviors in the remainder of the game satisfy sequential rationality and the final payoffs for the agent types from sending the message $m(X)$ are determined. Let $P(X)$ denote the set of all agent types that strictly prefer their payoffs from sending the message $m(X)$ to their equilibrium payoffs. We say that a subset X is *self-signaling* if $P(X) = X$. The neologism $m(X)$ is credible if X is self-signaling. If there is a credible neologism available in an equilibrium, we say that such an equilibrium is not *neologism proof*.

The notion of neologism proofness has a refining power in our model. To see this, suppose that parties' prior belief is *uniform* over $[0, 1]$ and utilities are quadratic. Notice that in the babbling equilibrium, it might be the case that some agent types prefer to reveal their types because either the unique action induced in equilibrium is too small ($\frac{1}{4}$) for them or the amount of money they should pay to the principal ($p = (\frac{1}{4} + b)^2$) is too high (See Figure 7). We therefore investigate if there is a self-signaling subset of the form $X = [\widetilde{\theta}, 1]$ with $\widetilde{\theta} > 0$. Suppose that $X = [\widetilde{\theta}, 1]$ send a neologism to the principal. Then, by Lemma 1 and analysis on the tacit bargaining, the principal's optimal response is to make a price offer, p', which is rejected by $[\widetilde{\theta}, \frac{\widetilde{\theta}+1}{2}]$ but accepted by $(\frac{\widetilde{\theta}+1}{2}, 1]$. From the indifference condition at $\frac{\widetilde{\theta}+1}{2}$, we have $p' = (\frac{1-\widetilde{\theta}}{4} + b)^2$. For X to be self-signaling, it is necessary and, for $\widetilde{\theta} \in (0, 1)$, sufficient that i) the agent type $\widetilde{\theta}$ is indifferent between sending the neologism inducing the action $\frac{3\widetilde{\theta}+1}{4}$ and sending his equilibrium message inducing the action $\frac{1}{4}$ and ii) the agent type 0 does not want

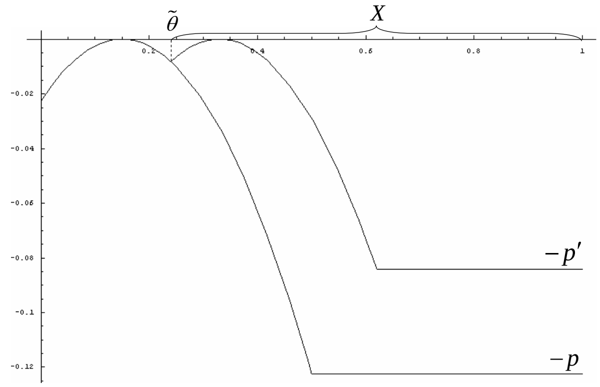


Figure 7: neologism proofness

to deviate to the neologism $m(X)$. This requires that

$$\frac{1}{4} - \widetilde{\theta} - b = -\frac{3\widetilde{\theta} + 1}{4} + \widetilde{\theta} + b \tag{11}$$

and

$$-(\frac{1}{4} - b)^2 \geq -p' = -(\frac{1 - \widetilde{\theta}}{4} + b)^2. \tag{12}$$

If the equation (11) gives a value of $\widetilde{\theta}$ in the range of $(0, 1)$ and the value of $\widetilde{\theta}$ satisfies the inequality (12), then we have constructed a self-signaling subset X. It is immediately clear that $\widetilde{\theta}$ satisfies both conditions if and only if $\frac{1}{24} \leq b < \frac{1}{4}$. Therefore, if $\frac{1}{24} \leq b < \frac{1}{4}$, then any babbling equilibrium is not neologism proof.

It is well-known that a neologism-proof equilibrium may select only a pooling equilibrium (Gertner, Gibbons, and Scharfstein [23]). Moreover, there might be no neologism-proof equilibrium in some models (Matthews [41]). However, truth-telling is always neologism proof in our model.

Proposition 5. *For any $b > 0$, the truth-telling perfect Bayesian equilibrium is neologism proof.*

Proof. See the appendix. □

The proof in the appendix shows that for any non-empty subset X of Θ there must be an agent type $\theta \in X$ such that sending the neologism $m(X)$ generates a payoff less than $-l(b)$, the payoff from the truth-telling equilibrium.

4.3.2 NITS (No Incentive To Separate)

Chen, Kartik, and Sobel [12] pose a criterion to select equilibria in Crawford and Sobel [15] cheap-talk games: NITS, for *no incentive to separate*. An equilibrium satisfies NITS if the agent of the lowest type weakly prefers the equilibrium outcome to credibly revealing his type. They show that equilibria satisfying NITS always exist in Crawford and Sobel [15], and the most informative equilibrium outcome is the unique equilibrium satisfying NITS under the monotonicity condition M in Crawford and Sobel [15]. In this section, we apply NITS to our model and show that the criterion is selective; under some value of b, the babbling equilibrium does not survive while the truth-telling equilibrium does survive for any $b > 0$.

Suppose that parties' prior belief is *uniform* over $[0, 1]$ and utilities are quadratic. Notice that in the babbling equilibrium, the agent of the lowest type gets $-(\frac{1}{4} - 0 - b)^2$. Thus, the babbling equilibrium does not satisfy NITS if and only if

$$-(\frac{1}{4} - b)^2 < -b^2,$$

which is equivalent to $b < \frac{1}{8}$.

It is straightforward that NITS holds in the truth-telling equilibrium, in which all agent types reveal their types fully.

Proposition 6. *For any $b > 0$, the truth-telling perfect Bayesian equilibrium satisfies NITS.*

One might be tempted to argue that the truth-telling equilibrium is not very reasonable because it does not satisfy "support restriction", the assumption used by several papers such as Grossman and Perry [25][27], Harrington [28], Kreps and Wilson [36] and Rubinstein [46]. This restriction requires that the support of beliefs at an information set should be contained in the supports of beliefs at preceding information sets. In our truth-telling equilibrium the principal has probability one beliefs after getting messages in the cheap-talk stage and switches away from these beliefs to the new belief that assigns probability one to the type $\theta = 0$ after observing "rejection" of the equilibrium price offer which takes place off-the-equilibrium path, and therefore the equilibrium violates the support restriction. It has been shown, however, that not only the support restriction may be based on a wrong interpretation of the concept of a belief in some games but also violations of the support restriction may represent a sensible reasoning process which supports interesting equilibrium behaviors by Madrigal, Tan and Werlang [40] and Nöldeke and van Damme [44]:

> ... violations of the support restriction may very well reflect the fact that once a deviation from equilibrium behavior has been observed, a reassement of all previous beliefs - which were based on the assumption that equilibrium strategies are

followed - is called for. In this light such "switching beliefs" is not an unfortunate problem, which cannot be avoided in some cases, but actually is a natural consequence of observing a deviation. (Nöldeke and van Damme [44], p. 9.)

5 Welfare Comparison

5.1 Comparisons to Other Schemes

In this section, we compare the truth-telling equilibrium outcome of our model to the equilibrium outcome of some dispute resolution schemes studied in the framework of Crawford and Sobel [15]: communication (Crawford and Sobel [15]), optimal mediation (Goltsman, Hörner, Pavlov, and Squintani [24]), optimal delegation (Holmström [31][32], Melumad and Shibano [43], Alonso and Matouschek [3] and Kováč and Mylovanov [34]) and optimal compensation contract (Krishna and Morgan [37]). For the comparison, we assume that f is *uniform* and utility functions are *quadratic* as follows:

$$U^P(y,\theta) = -(y-\theta)^2 \quad \textit{and} \quad U^A(y,\theta,b) = -(y-\theta-b)^2.$$

Crawford and Sobel [15] consider a strategic information transmission game in which the informed agent sends a cheap-talk message to the principal who then takes an action that determines payoffs of both. They show that there are multiple equilibrium outcomes in their model and with uniform quadratic assumption, the number of distinct equilibrium outcomes, denoted by $N_{CS}(b)$, is

$$N_{CS}(b) = \left\langle -\frac{1}{2} + \frac{1}{2}\sqrt{1+\frac{2}{b}}\right\rangle \tag{13}$$

where $\langle z \rangle$ denotes the smallest integer greater than or equal to z. Moreover, there is a Pareto ranking among $N_{CS}(b)$ equilibria so that, for any $b > 0$, the number of elements of the partition associated with the *Pareto dominant* equilibrium, which we will call the *best* equilibrium, is $N_{CS}(b)$. The expected payoff of the principal in this *best* equilibrium is

$$EU^P_{CS}(b) = -\frac{1}{12N_{CS}(b)^2} - \frac{b^2(N_{CS}(b)^2-1)}{3} \tag{14}$$

while the *ex-ante* expected payoff for the informed agent is

$$EU^A_{CS}(b) = EU^P_{CS}(b) - b^2. \tag{15}$$

Recently, Goltsman, Hörner, Pavlov, and Squintani [24] allow the parties to use any communication protocol, including the ones that call for a neutral trustworthy mediator. According to the optimal mediation rule, the parties' expected payoffs are

$$EU^P_{mediation}(b) = -\frac{b(1-b)}{3} \quad \textit{and} \quad EU^A_{mediation}(b) = EU^P_{mediation}(b) - b^2. \tag{16}$$

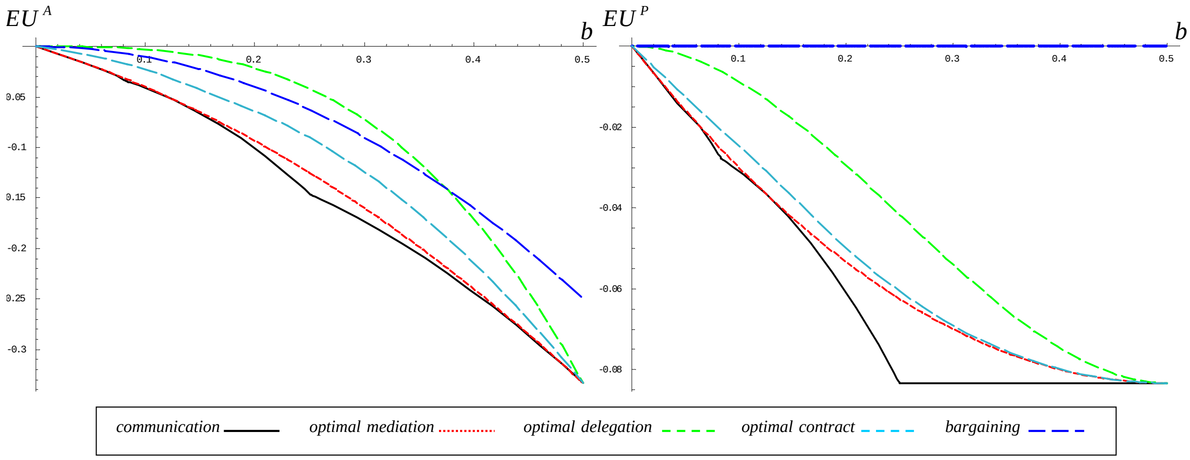


Figure 8: (a) Agent's expected payoff (b) Principal's expected payoff

Holmström [31][32], Melumad and Shibano [43], Alonso and Matouschek [3] and Kováč and Mylovanov [34] study the principal's optimal choice of the set of admissible actions that the agent can take and show that under the optimal delegation scheme, the principal restricts project choices of the agent to be from 0 up to a maximum of $1-b$. Under this scheme, the parties' expected payoffs are

$$EU^P_{delegation}(b) = -\frac{b^2(3-4b)}{3} \quad \textit{and} \quad EU^A_{delegation}(b) = -\frac{8b^3}{3}. \tag{17}$$

Krishna and Morgan [37] consider the situation in which the principal can commit to pay the agent for his advice but retains decision-making authority. They fully characterize the optimal compensation contract: the optimal compensation contract involves separation in low states and a finite number of pooling intervals in high state, and the principal never pays for imprecise information. In this optimal compensation contract, the expected payoffs for the principal and the agent are

$$EU^P_{contract}(b) = -\int_0^{a_0}(2b(a_0-\theta)+t_0)d\theta - \frac{1}{12}\sum_{i=1}^{K}\left(\frac{1}{K}-\frac{a_0}{K}-2b(K-2i+1)\right)^3 \tag{18}$$

and

$$EU^A_{contract}(b) = EU^P_{contract}(b) - b^2 + 2\int_0^{a_0}(2b(a_0-\theta)+t_0)d\theta \tag{19}$$

where

$$K = \left\langle -\frac{1}{2}+\frac{1}{2}\sqrt{1+\frac{3}{2b}}\right\rangle,$$

$$a_0 = \frac{3}{4}-\frac{1}{4}\sqrt{4+\frac{1}{3}(3-8bK(K-1))(8bK(K+1)-3)} \quad \textit{and}$$

$$t_0 = \frac{(1 - a_0 - 2K(K-1)b)(2bK(K+1) - (1-a_0))}{4K^2}.$$

Figure 8 illustrates the comparison. As the figure shows, the truth-telling equilibrium outcome of explicit bargaining is *ex-ante* Pareto superior to communication, optimal mediation rule and optimal contract for any $b > 0$. Furthermore, it is *ex-ante* Pareto superior to all other schemes (including optimal delegation) when $b > .375$. This might explain why bargaining over decision rights often takes place between two separately owned companies whose interests diverge widely.

5.2 Comparisons to Bargaining with Agents Making Offers

Lim [39] considers bargaining over decision-making authority in which the informed agent makes a price offer (*A-offer Bargaining*) and shows that there are continuum of perfect Bayesian equilibria, each of which yields an *ex-post* efficient outcome. Although there is no general Pareto ranking among equilibria, Lim [39] shows that there exists the principal optimal equilibrium and the agent optimal equilibrium. Moreover, the principal optimal equilibrium gives the lowest payoff to the agent among all equilibria of the model and vice versa. By using the refinement of perfect sequential equilibrium (Grossman and Perry [25]), Lim [39] gets a unique equilibrium outcome, which coincides with the agent optimal equilibrium.

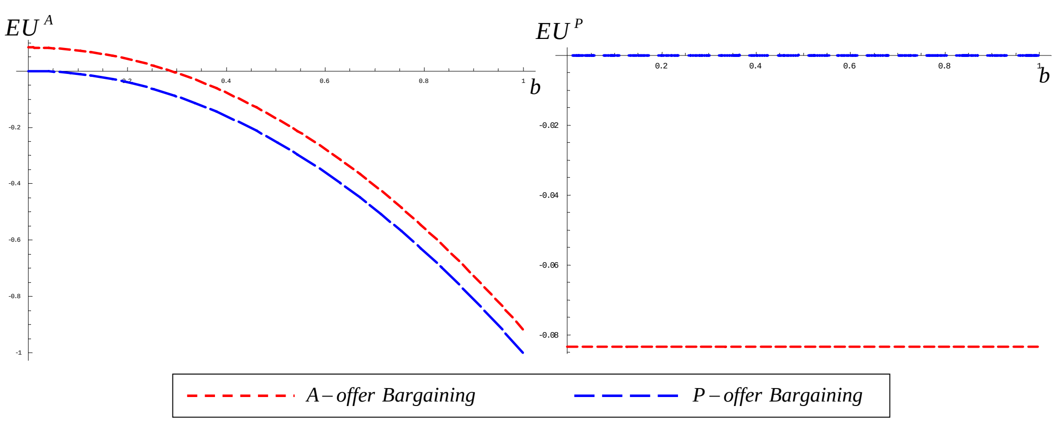


Figure 9: (a) Agent's expected payoff (b) Principal's expected payoff

Since the uninformed principal makes a price offer in our model (*P-offer Bargaining*), the equilibrium outcomes are quite different from those of *A-offer Bargaining*. Interestingly, the truth-telling equilibrium outcome of *P-offer Bargaining* coincides with the outcome of the agent optimal equilibrium of *A-offer Bargaining*. Figure 9 illustrates this result. It tells us that although bargaining over decision-rights can lead to a Pareto-efficient outcome regardless of who has bargaining power, allocation of initial bargaining power plays an important role in determining how they share the resulting surplus.

6 Conclusion

This paper studies bargaining over decision-making rights between an informed but self-interested agent and an uninformed principal in which the uninformed principal makes a price offer to the agent who then decides either to accept or to reject it. We show that the unique perfect Bayesian equilibrium outcome does not satisfy *ex-post* efficiency. Once we introduce explicit communication into the model, however, there exists a truth-telling perfect Bayesian equilibrium, which is not only efficient *ex-post* but also neologism proof. Moreover, it is the unique neologism-proof equilibrium if parties' preferences are sufficiently similar.

We compare the equilibrium outcome of our model to that of some dispute resolution schemes studied in the framework of Crawford and Sobel [15] and and Holmström [31] and show that it is *ex-ante* Pareto superior to all other schemes when the parties' interests diverge substantially. This might explain why bargaining over decision rights often takes place between two separately owned companies whose interests diverge widely. Although bargaining over decision-rights can lead to a Pareto-efficient outcome regardless of who has bargaining power, allocation of initial bargaining power plays an important role in determining how they share the resulting surplus.

A Appendix. Proofs

Proof of Lemma 1. First, any price offer $p < 0$ is accepted by all agent types because for any $\theta \in [0,1]$, $U^A(y,\theta,b) < -p$ for any action $y \in \mathbb{R}$. Thus, in the remainder of the proof, take $p \geq 0$. Let $\overline{y}$ denote the principal's action induced by the offer p. Suppose that an agent type $\overline{\theta} \in [0,1]$ accepts the price offer p with positive probability in equilibrium. Then we have $U^A(\overline{y},\overline{\theta},b) \leq -p$. By continuity, there exists $\theta_p \in [0,1]$ such that $U^A(\overline{y},\theta_p,b) = -p$. (Otherwise, we have $U^A(\overline{y},\theta,b) < -p$ for any $\theta \in [0,1]$ so that all agent types accept the offer, which means the proof is done.) Now, suppose that $\theta_p > \overline{\theta}$. Then by quasi-concavity of U^A, the set of agent types who reject p with probability one is $(\theta_p, \theta']$ with $\theta_p < \theta' \leq 1$. Since the agent type θ' rejects the offer, we have $U^A(\overline{y},\theta',b) \geq -p$. However, by **(B4)** and Bayes' rule, we have $\overline{y} = y(\theta_p,\theta')$ and by Assumption 1, $U^A(\overline{y},\theta',b) < U^A(\overline{y},\theta_p,b) = -p$, which leads to a contradiction. Thus, we have $\theta_p \leq \overline{\theta}$. Then, by the strict-concavity of U^A, we get $U^A(\overline{y},\theta,b) < -p$ for all $\theta > \theta_p$. This completes the proof.

Proof of Proposition 2. Lemma 1 implies that for any $p \in \mathbb{R}$, both $\Theta(p)$ and $\Theta^{-1}(p)$ are convex if they are non-empty. Further, $\Theta(p)$ cannot be to the left of $\Theta^{-1}(p)$. These guarantee that for any $p \in \mathbb{R}$ there is at most one agent type who is indifferent between accepting and rejecting the offer. Let $\theta_p \in [0,1]$ denote the agent type if it exists. Then we can write that $\Theta(p) = (\theta_p, 1]$ and $\Theta^{-1}(p) = [0, \theta_p)$. From the indifference condition at θ_p we have

$$p = l(|y^P(p) - \theta_p - b|), \tag{20}$$

where

$$y^P(p) = arg\max_y \int_0^{\theta_p} -l(|y - \theta - b|) \cdot \frac{f(\theta)}{\theta_p} d\theta = y(0, \theta_p). \tag{21}$$

Notice that $y(0,\theta_p) < \theta_p$. Then from (20), we have

$$\theta_p = y(0,\theta_p) + l^{-1}(p) - b. \tag{22}$$

Then the principal chooses p^* to solve

$$\begin{aligned} \max_{p \in \mathbb{R}} EU^P \quad &= \int_0^{\theta_p} -l(|y^P(p) - \theta|) d\theta + (1 - \theta_p)(p - l(b)) \\ &\text{s.t. } (22). \end{aligned} \tag{23}$$

Since, from (21), $\frac{\partial y^P(p)}{\partial \theta_p} = \frac{\partial y(0,\theta_p)}{\partial \theta_p}$ and f has a full support, $0 < \frac{\partial y^P(p)}{\partial \theta_p} < 1$. From (22), we have

$$\frac{\partial \theta_p}{\partial p} = \frac{\partial y^P(p)}{\partial \theta_p} \cdot \frac{\partial \theta_p}{\partial p} + \frac{\partial l^{-1}(p)}{\partial p}.$$

After some rearrangement, we get

$$\frac{\partial \theta_p}{\partial p} = \frac{1}{1 - \frac{\partial y^P(p)}{\partial \theta_p}} \cdot \frac{\partial l^{-1}(p)}{\partial p}.$$

Since $\frac{\partial l^{-1}(p)}{\partial p} \geq 0$, we have $\frac{\partial \theta_p}{\partial p} \geq 0$. This, together with $0 < \frac{\partial y^P(p)}{\partial \theta_p} < 1$, implies that $\frac{\partial y^P(p)}{\partial p} > 0$. Taking a derivative in (23) w.r.t. p yields

$$\frac{\partial EU^P}{\partial p} = \frac{\partial \theta_p}{\partial p} \cdot (-l(|y(0,\theta_p) - \theta_p|) - p + l(b)) + (1 - \theta_p). \tag{24}$$

At $\theta_p = 0$, we have

$$\frac{\partial EU^P}{\partial p}\Big|_{\theta_p=0} = \frac{\partial \theta_p}{\partial p}\Big|_{\theta_p=0} \cdot (l(b) - l(b)) + (1 - 0) = 1 > 0. \tag{25}$$

At $\theta_p = 1$, we have

$$\frac{\partial EU^P}{\partial p}\Big|_{\theta_p=1} = \frac{\partial \theta_p}{\partial p}\Big|_{\theta_p=1} \cdot (-l(|y(0,1) - 1|) - l(|1 - y(0,1) + b|) + l(b)) < 0. \tag{26}$$

Taking a derivative in (24) w.r.t. p yields

$$\begin{aligned} \frac{\partial^2 EU^P}{\partial p^2} &= \frac{\partial^2 \theta_p}{\partial p^2} \cdot (-l(|y(0,\theta_p) - \theta_p|) - p + l(b)) \\ &\quad + \frac{\partial \theta_p}{\partial p} \cdot (-l'(|y(0,\theta_p) - \theta_p|) \cdot (-\frac{\partial y(0,\theta_p)}{\partial p} + \frac{\partial \theta_p}{\partial p}) - 1) - \frac{\partial \theta_p}{\partial p}. \end{aligned} \tag{27}$$

It is routine to verify that

$$\frac{\partial^2 EU^P}{\partial p^2} < 0 \quad \textit{if } \theta_p \in [0,1].$$

Therefore, by continuity, the principal's optimal price offer p^* is unique and $\theta_{p^*} \in [0,1]$. This completes our proof.

Proof of Proposition 3. The proof is constructive. Consider the following strategies and belief:

i) The agent type θ fully reveals his private information by sending a message θ.

ii) For any $m \in M$, the principal makes the price offer $l(b)$.

iii) For any $\theta \in [0,1]$, the agent accepts the offer p with probability one if $p \leq l(b)$ but rejects p with probability one if $p > l(b)$, regardless of the message he sent.

iv) If a price offer $p \leq l(b)$ is rejected then the principal takes an action $y = 0$ regardless of the message she received. If a price offer $p > l(b)$ is rejected then the principal who received a message m takes an action $y = m$.

v) For any $m \in M$, $\rho_1(\theta|m) = \begin{cases} 0 & \forall \theta \in [0,1] \setminus m, \\ 1 & \textit{if } \theta = m. \end{cases}$

vi) For any $m \in M$ and any $p \leq l(b)$, $\rho_2(\theta|m,p) = \begin{cases} 0 & \forall\theta \in (0,1], \\ 1 & \textit{if}\ \theta = 0. \end{cases}$

vii) For any $m \in M$ and any $p > l(b)$, $\rho_2(\theta|m,p) = \begin{cases} 0 & \forall\theta \in [0,1] \setminus m, \\ 1 & \textit{if}\ \theta = m. \end{cases}$

First, consider the agent's incentive. Under the principal's strategy and beliefs above, the agent has no incentive to deviate in his message rule because the principal makes the message-independent price offer $l(b)$. For any $m \in M$, any agent type $\theta \in [0,1]$ accepts an offer p with probability one if $p \leq l(b)$ since he gets $-p$ which is greater than or equal to $-l(b)$ from accepting the offer, but the expected payoff of the agent type θ from rejecting the offer is

$$-l(|0-\theta-b|) = -l(\theta+b) \leq -l(b), \quad \forall\theta \in [0,1].$$

Any agent type $\theta \in [0,1]$ who reveals his private information fully rejects an offer p with probability one if $p > l(b)$ since he gets $-p$ which is less than $-l(b)$ from accepting the offer, but the expected payoff of the agent type θ from rejecting the offer is $-l(b)$.

Second, consider the principal's incentive. Under the agent's strategy and beliefs above, the principal's optimal behavior after observing truth-telling (or a message θ) is to make the price offer $l(b)$, because any offer less than $l(b)$ will be accepted by all types of agent with probability one and give her the expected payoff strictly less than 0, the principal's expected payoff from making the offer $l(b)$ and any offer greater than $l(b)$ will be rejected with probability one and induces the principal's action θ which gives the principal the expected payoff 0.

By the construction, no price offer is rejected with positive probability on the equilibrium path so that we cannot use Bayes' rule to determine beliefs that the principal has after price offers are rejected. The principal's action rule specified above is sequentially rational under the beliefs we take. This completes our proof.

Proof of Proposition 4. Before we prove this proposition, we need some preliminaries.

Take an arbitrary $\theta \in \Theta$ and define the set of agent types who use the same message rule as the agent type θ as

$$\Theta(\theta) = \{\theta' \in \Theta \mid \mu(m|\theta') = \mu(m|\theta)\ \textit{for}\ \forall m \in M\}.$$

Notice that arbitrary given m and p the monotonicity of $d(\theta, m, p)$ in θ still holds.

Lemma 2 (Monotonicity)**.** *For any $\Theta(\theta)$ and any price offer p, if there is an agent type $\theta \in \Theta(\theta)$ who accepts the offer p with positive probability then all agent types $\theta' \in \Theta(\theta)$ with $\theta' > \theta$ have to accept p with probability one.*

Proof. Replace Θ by $C(\Theta(\theta))$, a convex hull of $\Theta(\theta)$, in the proof of Lemma 1. □

By the monotonicity, we again have three types of price offers. If a price offer is low enough then it is accepted by all agent types in $\Theta(\theta)$. If a price offer is high enough then it is rejected by all agent types in $\Theta(\theta)$. Any price offer in between these two extremes is accepted by some high agent types in $\Theta(\theta)$ but rejected by remaining agent types in $\Theta(\theta)$. Given the decision rule, the principal makes a price offer to maximize her expected utility. By the strict concavity of the principal's expected utility in p, there exists a unique interior solution of this maximization problem. This implies that given the message the principal observes and associated belief, it is optimal for the principal to make a price offer which is accepted by some agent types who send the message but also rejected by remaining agent types who send the message.

Lemma 3. *For any θ and associated $\Theta(\theta)$, if $\Theta(\theta)$ is not a singleton then there exists $\theta_1 \in \Theta(\theta)$ such that $d(\theta_1, m, p^*(m)) = 1$ for any $m \in M$ with $\mu(m|\theta) > 0$. Moreover, $p^* > b^2$.*

Proof. Given a price offer p there is at most one agent type in $C(\Theta(\theta))$, the convex hull of $\Theta(\theta)$, who is indifferent between accepting and rejecting the offer. Let $\theta_p \in C(\Theta(\theta))$ denote the agent type if exists. Let $\Theta_p = \{\theta \in \Theta(\theta) | \theta \leq \theta_p\}$. From Lemma 2 and the indifference condition at θ_p we have

$$p = (y^P(m,p) - \theta_p - b)^2, \tag{28}$$

where

$$y^P(m,p) = arg \max_y \int_{\Theta_p} -(y-\theta)^2 \cdot \frac{\mu(m|\theta)}{\int_{\Theta_p} \mu(m|\theta')d\theta'} d\theta. \tag{29}$$

Since $y^P(m,p) \leq \theta_p$, $p \geq b^2$. The principal chooses $p^*(m)$ to solve

$$\begin{aligned} \max_{p\in\mathbb{R}} EU^P &= \int_{\Theta_p} -(y^P(m,p)-\theta')^2 \frac{\mu(m|\theta')}{\int_{\Theta_p} \mu(m|\theta'')d\theta''} d\theta' + \int_{\Theta(\theta)\setminus\Theta_p} (p-b^2) \frac{\mu(m|\theta')}{\int_{\Theta(\theta)\setminus\Theta_p} \mu(m|\theta'')d\theta''} d\theta' \\ & \text{s.t. (28) and (29).} \end{aligned}$$

It is routine to verify that

$$\frac{\partial EU^P}{\partial p}\Big|_{p=b^2} > 0.$$

This implies that it is not optimal for the principal to make the price offer b^2 which is accepted by all agent type $\Theta(\theta)$. Therefore we have $p^*(m) > b^2$. This completes our proof. □

Let $\overline{M}(p) \equiv \{m \in M \mid p^*(m) = p\}$. We say that a price offer p is induced in equilibrium if there exists some $\theta \in [0,1]$ such that $\int_{\overline{M}(p)} \mu(n|\theta)dn > 0$. Define the set of agent types who induce a price offer p as $\Theta(p) = \{\theta \in \Theta \mid \int_{\overline{M}(p)} \mu(n|\theta)dn > 0\}$. We say that a price offer p induced by the agent type θ in equilibrium is acceptable for that agent type if there exists some $m \in \overline{M}(p)$ such that $d(\theta, m, p) = 0$. Similarly, we can say that a price offer p

induced in equilibrium is unacceptable for the agent type θ if there is no $m \in \overline{M}(p)$ such that $d(\theta, m, p) = 0$. A price offer p is unacceptable if it is unacceptable for all agent types.

Lemma 4. *There is a unique price offer induced in equilibrium. Moreover, it is acceptable.*

Proof. By Lemma 3, an unacceptable price offer cannot be induced in equilibrium. Suppose that two different acceptable price offers p_1 and p_2 are induced in equilibrium. Without loss of generality, assume that $p_1 > p_2$. Then the agent type who induces and accepts p_1 has an incentive to induce p_2 and to accept it. □

This lemma shows that in any equilibrium all agent types either send a common message or send some messages that induce the same price offer which is acceptable. However, this does not mean that a unique action has to be taken by the principal after the induced price offer is rejected. Especially in the case that agent types send several different messages, the principal's action that she wants to take after rejecting the offer should be contingent on both price offer she made and the message she observed. Thus, in equilibrium it might be possible for the set of the actions taken by the principal not to be a singleton. However, the next result tells us that the set has to be a singleton.

Lemma 5. *There is at most one principal's action induced in equilibrium.*

Proof. Let Y_0 be the set of all principal's actions induced in equilibrium. To get a contradiction, suppose that Y_0 is neither empty nor singleton. Let $\Theta(y)$ be the set of agent types who induces the principal's action y.

Claim 1. *For any $y_0 \in Y_0$, $\Theta(y_0)$ is convex.*

Proof. Suppose that agent types θ and θ' with $\theta < \theta'$ are in $\Theta(y_0)$. Then agent type $\theta'' \in (\theta, \theta')$ never induce a principal's action $y_1 > y_0$, because otherwise, since $U^A_{12}(y, \theta, b) > 0$, agent type θ' would strictly prefer y_1 to y_0. Similarly, agent type $\theta'' \in (\theta, \theta')$ never induce a principal's action $y_2 < y_0$. Let $\widehat{p}$ denote the unique acceptable price offer. The agent type $\theta'' \in (\theta, \theta')$ never induce the acceptable price offer $\widehat{p}$, because $U^A(y_0, \theta, b) \geq -\widehat{p}$, $U^A(y_0, \theta', b) \geq -\widehat{p}$ and strict concavity of $U^A(y_0, \theta, b)$ in θ imply that $U^A(y_0, \theta'', b) > -\widehat{p}$, which completes our proof. □

Pick two adjacent actions $y_1, y_2 \in Y_0$ with $y_1 < y_2$. By Claim 1, we have $\Theta(y_1) \equiv [\underline{\theta}_1, \overline{\theta}_1]$ and $\Theta(y_2) \equiv [\underline{\theta}_2, \overline{\theta}_2]$. Then $y_1 = \frac{\underline{\theta}_1 + \overline{\theta}_1}{2}$ and $y_2 = \frac{\underline{\theta}_2 + \overline{\theta}_2}{2}$. Notice that $-(y_2 - \underline{\theta}_2 - b)^2 > -\widehat{p}$. This means that $\overline{\theta}_1 = \underline{\theta}_2$, because otherwise, there exists an agent type $\underline{\theta}_2 - \varepsilon$ with arbitrary small $\varepsilon > 0$ in $(\overline{\theta}_1, \underline{\theta}_2)$ who accepts $\widehat{p}$ but this agent type gets strictly higher payoff from inducing the action y_2 by rejecting the offer. Then for any $\theta \in \Theta(y_1)$, $-(y_1 - \theta - b)^2 > -\widehat{p}$. Let $\theta_1^* > \overline{\theta}_1$ be such that $-(y_1 - \theta_1^* - b)^2 = -\widehat{p}$. Since $\theta_1^* > \overline{\theta}_1$ and by the strict concavity of U^A in θ,

$-(y_2 - \theta_1^* - b)^2 > -\widehat{p}$. This implies that for any agent type θ in $\Theta(\theta')$ with $\theta' \in \Theta(y_1)$ who accepts $\widehat{p}$, $-(y_1 - \theta - b)^2 < -\widehat{p}$. Then the principal can make an offer $\widehat{p} + \varepsilon$ with an arbitrary small $\varepsilon > 0$ that any agent type in $\Theta(y_1)$ still rejects and any agent type in $\Theta(\theta') \setminus \Theta(y_1)$ still accepts. Since the set $\Theta(\theta') \setminus \Theta(y_1)$ should have positive measure, the price offer $\widehat{p} + \varepsilon$ is profitable for the principal. □

Now, we are ready to state and prove the main result.

Proposition 4. *Only babbling or truth-telling can be a cheap talk stage outcome in any equilibrium.*

Proof. To get a contradiction, suppose that there exists an equilibrium other than babbling or truth-telling in the cheap talk stage. Then there exist $\Theta(\theta_1)$ and $\Theta(\theta_2)$, two non-empty, subsets of Θ. Without loss of generality, we assume that $\Theta(\theta_1)$ is a non-singleton. Let p_1 denote the unique price offer induced in equilibrium. Suppose that $\Theta(\theta_2)$ is a singleton. Then the agent type θ_2 is indifferent between accepting and rejecting p_1 for any $m \in M$ with $\mu(m|\theta_2) > 0$. From this indifference condition we get $p_1 = b^2$. However, by Lemma 3, $p_1 > b^2$, which leads to a contradiction. Thus $\Theta(\theta_2)$ is a non-singleton. Then by Lemma 3 there exists an agent type $\theta' \in \Theta(\theta_1)$ such that $d(\theta', m, p^*(m)) = 1$ for any m such that $\mu(m|\theta') > 0$ and $\theta'' \in \Theta(\theta_2)$ such that $d(\theta'', m, p^*(m)) = 1$ for any m such that $\mu(m|\theta'') > 0$. Since the set of agent types who induce a principal's action is convex (by Claim 1), these rejections should induce two different principal's actions. This is contradicted by Lemma 5. □

Proof of Proposition 5. Note that for any $\theta \in \Theta$, the agent's payoff in the truth-telling equilibrium is $-l(b)$. Any singleton subset of Θ could not be self-signaling because sending a neologism message by himself reveals his true type to the principal so that the agent type in the set could not get more than $-l(b)$. Thus, suppose that an arbitrary non-singleton subset $\widehat{\Theta}$ of Θ sends a neologism message $\widehat{m}$ to the principal. Let $\widehat{p}$ denote the price offer induced by $\widehat{\Theta}$. Then $\widehat{p} \geq l(b)$ because, otherwise, all agent types in Θ would be strictly better off by accepting the offer $\widehat{p}$ which implies $\widehat{\Theta} = \Theta$. However, by Lemma 1, making the price offer $\widehat{p} < l(b)$ is never optimal for the principal who believes that $\widehat{\Theta} = \Theta$. Thus, the price offer induced by $\widehat{\Theta}$ is greater than or equal to $l(b)$. In order for the neologism $\widehat{m}$ to be credible, all agent types in $\widehat{\Theta}$ should reject $\widehat{p}$ since accepting $\widehat{p}$ gives them at most $-l(b)$. However, rejecting $\widehat{p}$ cannot give all agent types in $\widehat{\Theta}$ higher payoff than $-l(b)$ either because the principal's action induced by $\widehat{\Theta}$, denoted by $y^P(\widehat{p})$, is always in the interior of $C(\widehat{\Theta})$, convex hull of $\widehat{\Theta}$, and as a result, there always exist some agent types to the right of $y^P(\widehat{p})$ who get strictly less payoff than $-l(b)$. Therefore, $\widehat{m}$ cannot be a credible neologism.

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