Communicating Bias with two senders*

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April 18, 2026

Abstract

We consider a cheap talk model with two senders whose biases are privately known. Before the senders learn the state, they send a cheap talk message about their bias to the receiver. Subsequently, the receiver hires one sender to get state-relevant advice from. In our sister paper Bhattacharjee et al. (2026), we find that with one sender, there is no bias revealing equilibrium. However, in this paper, with two senders, there exists a bias revealing equilibrium due to competition and strategic uncertainty. The receiver may prefer the bias revealing equilibrium to equilibria where biases are not revealed.

JEL codes: D82, D83, C72

*For helpful comments and suggestions, we thank Sourav Bhattacharya, Bhaskar Dutta, Parikshit Ghosh, Anirban Kar, Navin Kartik, Kristóf Madarász, Debraj Ray, Arunava Sen, and the conference participants at the European meetings of the Econometric society 2024, Winter School 2023 held at the Delhi School of Economics, at the 19th Annual Conference on Economic Growth and Development seminar held at ISI, New Delhi in 2024, Society of Economic Research in India (SERI) in 2025, seminar participants at Delhi School of Economics, ISI Delhi, Shiv Nadar University, and seminar participants at Ashoka University. All the remaining errors are ours. In previous versions, this analysis was contained in our sister paper - *Communicating bias*.

Disclosure statement: The authors declare that we have no relevant or material financial interests related to the research described in this paper.

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Keywords - Cheap talk, uncertain bias, multiple senders, bias revelation

1 Introduction

Consider a strategic communication problem between a decision-maker (the receiver), and an informed expert (the sender). The sender provides costless advice to the receiver regarding an uncertain, payoff-relevant state. However, the preferences of the two are not perfectly aligned, i.e., the sender is *biased*. Often, a challenge in this environment arises from the fact that the sender's underlying bias is not observed before communication regarding the state takes place. For instance, an investor shopping for a financial planner typically does not know the planners' risk appetites before selecting one for portfolio advice. Similarly, a defendant who plans to hire a lawyer cannot observe how misaligned the lawyers' preferences are regarding optimal trial lengths. A political candidate lacks information about potential advisers' ideological leanings before hiring one of the candidates. In each case, strategic communication is complicated by asymmetric information not just about the state of the world, but also about the sender's preferences.

In such contexts, one might imagine that it would be helpful if the receiver could learn about the sender's bias before obtaining payoff-relevant advice. Indeed, in several environments, before the sender gets access to state information, the receiver attempts to understand the sender's bias, and only then makes a hiring decision. For this purpose, the sender and the receiver engage in a non-binding and costless interaction, before the true state is observed. For example, an investor can interview multiple financial advisors to assess their attitudes toward risk and, only after hiring, reveal portfolio details that would determine the relevant advice. Similarly, a defendant can interact with several lawyers before making a hiring decision, and a political candidate may use informal chats to gauge the ideological alignment of prospective advisors. In this paper, we add this bias communication stage to investigate whether bias revelation can emerge endogenously, and if bias revelation does happen, whether the receiver benefits from being able to screen the experts by knowing their bias.

We consider a cheap talk game with one receiver (he) and two senders (she), where the bias of each sender is her private information. The bias of each sender is drawn independently from a commonly known distribution. The set of possible biases can be finite or infinite. Before any player (sender or receiver) gets information about the payoff relevant state, we add a bias communication stage (stage 1). At this stage, the senders simultaneously send cheap talk messages about their bias type, after which the receiver hires only one sender. The sender who is not hired collects her outside option. The next stage (stage 2) is a cheap talk game in which the chosen sender perfectly observes the true state and sends a cheap talk message about the state to the receiver. The receiver chooses an action, and all players get paid. Our focus will be on informative equilibria, that is, where the receiver can update his belief about the state in stage 2[1].

Our paper makes three main contributions. First, we investigate whether there is an equilibrium in which the sender(s) reveal their bias in stage 1. In a companion paper Bhattacharjee et al. (2026), we show that with only one sender, a bias revelation equilibrium does not exist. With two senders, we show that a bias revelation equilibrium does not exist if there are an infinite number of bias types. However, when there are only two (or finite) bias types, a revelation equilibrium can exist in the two sender world. This highlights the idea that, without additional forces, such as sender competition, private expert bias is difficult to learn endogenously. Second, we ask whether the receiver prefers a bias-revelation equilibrium. We characterize conditions under which the receiver can, and cannot, improve her welfare with bias revelation. Third, this paper also contributes to the literature on static cheap talk with uncertain biases by characterizing closed-form expressions for equilibria and all equilibrium payoffs in a cheap talk game with quadratic loss utility functions.

In a two-sender framework, the receiver hires one of the senders after the bias communication cheap-talk stage. Compared to the one sender benchmark, in this environment, two new strategic forces appear. First, since the receiver hires only one sender, the senders *compete* to get hired. Competition is a powerful force owing to our assumption that the sender who is not hired receives an outside option that is strictly worse than the lowest equilibrium payoff from being hired. The incentive to compete is further amplified by our assumption of differential outside options across types: a higher bias sender faces a strictly lower outside payoff[2] than a lower bias sender. This asymmetry sharpens the stakes for the higher bias sender types and can facilitate truthful bias reporting. Second, since the probability of being hired depends on every sender's bias message and

[1]Babbling equilibrium in stage 2 (where the receiver ignores the sender's advice and the sender sends an uninformative message) will induce bias revelation in stage 1. However, since this gives the receiver the same payoff as she would get without hiring any sender at all, we ignore this case.

[2]Note that a strictly worse outside option for a higher bias type is a necessary condition for the existence of bias revealing equilibrium.

the senders are uncertain about their rival's bias, there is *strategic uncertainty*, which is not present in the one-sender case.

When there are infinitely many bias types that are arbitrarily close to each other, we find that all of their incentive compatibility constraints cannot be simultaneously satisfied even with competition incentives and strategic uncertainty. However, we show that when there are only two bias types[3] which are sufficiently different, we can sustain a revelation equilibrium by appropriately choosing the outside options and hiring probabilities. In this case, the announcement of high bias is rewarded with a higher hiring probability, whereas the biases being sufficiently far apart makes it less lucrative for the lower bias type to mimic the high bias type[4]. Further, to ensure that the different bias types do not deviate, we need the outside option of the higher bias type to be sufficiently low while that of the lower bias type is not so bad. This incentivizes the high bias type to choose messages which increase her probability of being hired, while at the same time, the low bias sender is not punished too much for her lower probability of being hired.

Finally, we ask whether the bias revelation is worthwhile for the receiver. Does the revelation equilibrium give the receiver a higher payoff than the equilibria that can be achieved in environments without a bias revealing stage? For a large range of parameters, the revelation equilibrium does not exist at all. However, we find that when the revelation equilibrium exists, it can generate higher payoff for the receiver compared to equilibria without any bias revelation.

To understand the intuition behind this result, remember that 1) the receiver with a quadratic loss utility function prefers a more precise (more partitions) and a more balanced (lower ex-ante variance in payoff) partition, and 2) the revelation equilibrium exists when there are finite number of bias types. For simplicity, we consider an environment where the bias is either high or low. The maximum precision possible without a bias-revelation stage always lies between the maximum precision possible after hiring a high bias sender and the maximum precision possible after hiring a low bias sender in stage 1[5]. In a revelation equilibrium, the receiver either hires the low bias sender and subsequently obtains a high payoff in stage 2, or hires a high bias sender, which leads to a low stage 2 payoff. Thus, a revelation equilibrium yields a high variance in payoffs for the

[3] The argument can be extended for finitely many types.

[4] Since then the low bias sender would get a highly unbalanced partition if she deviates.

[5] As the fraction of high bias senders in the society goes from zero to one, the maximum number of partitions spans the range.

receiver. For this reason, if the precision obtained in the non-revelation equilibrium is the same as the maximum precision possible with the low bias sender, then the revelation equilibrium leads to lower ex-ante expected payoff for the receiver compared to the non-revealing equilibrium. Thus, in order to make the revelation equilibrium better, it must be the case that the non-revelation equilibrium offers strictly lower precision than that with a low bias sender. This requires the fraction of high types to be large enough in the population. Additionally, since we need to reward the high bias sender for truthfully revealing her bias by hiring her with a higher probability, to ensure that low type sender does not deviate, we require the fraction of higher bias senders has to be low enough in the population. Thus, the fraction of higher bias senders has to be within an interval. Our results identify a novel channel through which sender competition enhances communication: not by directly improving information transmission regarding the true state, but by endogenously enabling bias revelation that is otherwise unattainable.

We further demonstrate in an extension (appendix section C) that if the players have access to a commitment device, such as a public randomization device, then mixed strategies can be supported in equilibrium. This additional commitment expands the set of implementable strategies and facilitates endogenous bias revelation in the two-sender setting. In the two sender case, for any value of the high bias, we find that bias revelation occurs and can be strictly preferred by the receiver to all equilibria without any bias revelation. However, as we show in Bhattacharjee et al. (2026), in the one-sender environment, the introduction of a public randomization device does not suffice to sustain an informative bias-revealing equilibrium. The absence of sender competition remains a fundamental obstacle to endogenous bias disclosure.

Literature Review

We contribute to the literature on cheap talk games with uncertain sender bias. The paper closest to ours is Li and Madarász (2008), which discusses a static cheap talk game with one sender of unknown bias. They compare two regimes - one where the sender must announce her true bias before communicating about the state (disclosure regime), and another where the sender has no possibility of revealing any information about her bias before sending state relevant information to the receiver (non-disclosure regime). They find that if the utility function of the receiver is concave enough, then he may prefer the regime where the sender's bias is not revealed. Our paper differs from Li and Madarász (2008) in the following ways. One, we consider *endogenous* bias revelation by adding a pre-play bias communication stage before any sender gets to observe the true state. While Li and Madarász (2008) consider the endogenous revelation of bias that can occur in equilibrium in the non-disclosure environment, in their model, only the bias of the low bias type can be revealed and that too only for some states. In contrast, we ask when the bias of all senders can be revealed for all states. Since a sender's bias is her private information, we believe that in many environments, it would be very difficult to explain how an exogenous truthful bias revelation can be enforced. This assumption becomes even more difficult to justify because we show that in the one sender case, endogenous bias revelation is not possible. Finally, unlike Li and Madarász (2008), we allow for more than one sender. We show that while endogenous bias revelation is not possible with one sender, bias-revealing equilibria exist with two senders.

Quement (2016) considers a model with unknown sender bias in which there are two senders and the receiver gets messages from both senders sequentially. In our model, the receiver can only get message from one sender, and the sender has the option to reveal her bias before learning state-relevant information. Similarly, Gülen (2022) finds that with two senders with uncertain biases, consulting only one sender can be welfare improving. In contrast, we include the first stage to incentivize bias revelation, and ask if the revelation of bias can improve the receiver's welfare. Other papers with uncertain sender bias include Antić and Persico (2020) in which the bias is endogenously determined, and Atakan et al. (2020) which looks at a repeated game environment to determine the optimal path of the stakes involved in the relationship between a sender and a receiver.

The second strand of literature we connect to is the one on cheap talk models with multiple senders. Li (2010) considers a model with multiple senders and privately known bias with different learning protocols. They find that competition improves welfare. In contrast, we introduce sender competition in a different way: only one sender is hired after the pre-play bias communication stage, so the senders compete to get hired, without knowing the state. Li et al. (2016) considers a model of cheap talk with multiple senders, where each sender gets a private signal about their own project. In contrast, in our model, there is only one payoff relevant state; and once hired, the sender learns the state perfectly[6].

[6]Schmidbauer (2017) considers a multi-period version of Li et al. (2016) and shows more competition harms the

Our paper also relates to multi dimensional cheap talk literature, since there are two dimensions (sender bias and state of the world) which are privately observed by the sender. Multi-dimensionality of the state of the world in itself generates an additional benefit of sender competition, as documented in Battaglini (2002). In our paper, we highlight a novel consequence of competition - it allows bias revealing equilibrium to exist. Chakraborty and Harbaugh (2007), Chakraborty and Harbaugh (2010) consider multi-dimenisonal cheap talk environments and show how using comparative ranking we can get full information revelation. In our paper, the two dimensions are independent of each other and hence can not be comparatively ranked. Our focus is not on full information revelation across both dimensions, we are interested in examining the bias-revealing equilibria and their welfare properties.

Finally, we contribute to the growing literature on papers which use mechanism design in cheap talk games. We allow the receiver to design a mechanism (without transfers) where she can only reward bias announcements with an equilibrium choice in stage 2 to elicit the true bias of the sender. This is different from mechanism design with transfers as has been studied before by Krishna and Morgan (2008) and Ottaviani et al. (2000) where the receiver can commit to message-contingent transfers to make the sender reveal the state truthfully. Further, in our paper, the message on which the transfer is based is about the senders' bias as opposed to the state-relevant message. For the same reasons, and because we have a static model, we differ from papers like Kolotilin and Li (2021) which looks at a repeated communication framework with transfers, and papers which study relational contracts in a repeated communication framework like Golosov et al. (2014) and Kuvalekar et al. (2022).

2 Model

Primitives

We consider a strategic communication game with one receiver (he) and two senders (she). It is common knowledge that the state of the world, θ, is uniformly distributed on the unit interval $[0,1]$. The receiver is required to hire exactly one sender, who, upon hiring, learns the state perfectly and sends a cheap talk message to the receiver. Subsequently, the receiver takes an action.

information transmission and reduces payoffs.

If the true state is θ, the hired sender is sender i, and the receiver takes the action y, then the payoffs are as follows:

$$\begin{aligned}\text{Payoff receiver: } U_R(\theta, y) &= -(y-\theta)^2 \\ \text{Payoff hired sender: } U_i(\theta, y, b_i) &= -(y-\theta-b_i)^2 \\ \text{Payoff not hired sender: } U_{j\neq i} &= -A_{b_j}\end{aligned}$$

where b_i is the bias of sender i, and the sender who is not hired gets a reservation payoff of $-A_{b_j}$. A sender k's bias b_k is her private information, but it is common knowledge that biases are drawn IID from a distribution F with support on set $K \subseteq \mathbb{R}$, where $\mathbb{R}$ denotes the real line. We assume that the biases are low enough to ensure that there exists at least one informative cheap talk equilibrium when the hired sender's bias is known. From Crawford and Sobel (1982), this means that $|b_k| < \frac{1}{4}\ \forall\, k \in K$. Thus, without loss of generality(WLOG), we assume $K \subseteq (\frac{-1}{4}, \frac{1}{4})$. Note that K could be a finite set or an infinite set.

Given two biases, b_l and b_h where $|b_h| > |b_l|$, we assume that the outside option of the higher bias sender, i.e., the outside option for b_h is worse than the outside option of the lower bias sender, i.e., b_l[7]. To ensure that all types of senders want to be hired, we assume that their reservation payoff is weakly worse than the lowest possible equilibrium payoff obtained by any sender from being hired, that is, worse than the payoff from a babbling equilibrium[8].

Two stage game

We consider a two-stage game. In the first stage, senders do not have additional information about the state of the world, but they can send cheap talk messages that could reveal information about their type, that is, their bias[9]. Following this, the receiver decides to hire a sender, who then learns the state perfectly. In the second stage, the hired sender can send a cheap talk message to the receiver about the state of the world. Subsequently, the receiver takes an action. In an equilibrium, when the

[7] One possible reason could be that, in the external job market, employers might be better informed and more certain about the senders' bias. As a result, a sender with a higher bias would have fewer job opportunities outside our model, making their outside option less attractive.

[8] In such an equilibrium, the hired sender sends uninformative messages, and the receiver ignores these messages and chooses his ex-ante payoff maximizing action.

[9] Note that a sender learns the state only after being hired.

first stage results in full bias revelation[10], we call this a revelation equilibrium.

To evaluate the importance of bias revelation, we compare equilibria where biases can be explicitly revealed (as in our first stage) to those in settings where such disclosure is not possible, specifically, where the first stage of our game is absent. This resembles the non-disclosure environment considered in Li and Madarász (2008). We refer to this game as the *LM* game. If in the *LM* game the bias of the sender(s) is not revealed for any $\theta \in [0,1]$, we call such an equilibrium a conflict hiding (*CH*) equilibrium following Li and Madarász (2008).

The timing of the game is as follows. At the beginning of the game in stage 1, each sender j privately learns her own type (bias) $b_j \in K$ and then simultaneously sends a costless message $\mu_j(b_j) \in \mathscr{M}_b$ to the receiver that potentially conveys information about their own bias. Without loss of generality, we focus on direct mechanisms, so $\mathscr{M}_b = K$. Upon receiving the bias message vector $(\mu_1(b_1), \mu_2(b_2))$ from the two senders, the receiver updates his belief about the type (bias) of the senders using Baye's rule, and then chooses to hire one sender according to a hiring rule $h(\mu_1(b_1), \mu_2(b_2))$ that depends on the observed message vector sent by both senders. Let $h_j(\mu_1(b_1), \mu_2(b_2))$ denote the probability of hiring sender j.

In stage 2, the hired sender i (with bias b_i) learns the true state θ perfectly and sends another message $\mu_{b_i}(\theta) \in \mathscr{M}$ to the receiver, possibly conveying some information about the state. Focussing on direct mechanisms, we assume $\mathscr{M} = [0,1]$. Upon observing $\mu_{b_i}(\theta)$, the receiver updates his belief about the true state θ using Bayes rule and takes action $y(\mu_{b_i}(\theta)) \in [0,1]$. Note that the subgame in stage 2 is identical to the game in Crawford and Sobel (1982) if the bias of the chosen sender is fully revealed in stage 1. If the bias of the hired sender is not revealed in stage 1, then stage 2 is akin to the non-disclosure game of Li and Madarász (2008).

Perfect Bayesian Equilibrium

A Perfect Bayesian equilibrium consists of a profile of strategies for the receiver and all senders, and belief vectors such that:

(a) Given the strategies of all players, the beliefs are derived using Bayes' rule whenever possible.

[10]Throughout the paper, we only consider the fully separating equilibrium. However, it is possible for a partially pooling equilibrium to exist as well. Deriving such an equilibrium is beyond the scope of this paper.

(b) The receiver's hiring rule h and the action function y, maximize his ex-ante expected utility given his belief and the equilibrium strategy of all senders.

(c) For each type of sender, their messaging strategy should maximize their expected payoff given the strategies of all the other senders and the receiver[11].

Notation

For ease of exposition, we use E_{RE} for a bias revelation equilibrium and E_{CH} for a conflict hiding equilibrium. Following this notation, let a $n(b_j)$ partition bias revelation equilibrium when the bias of the sender is known to be b_j be denoted by $E_{RE}(b_j, n(b_j))$, and let N_{b_j} denote the maximum number of partitions possible in such an equilibrium.

Furthermore, we denote $CS^{b_j}_{b_{j'}}(k)$ as the payoff for a b_j type sender in a k partition equilibrium when the sender's bias is thought to be $b_{j'}$ with probability 1 ($b_j, b'_j \in K$). Thus, from Crawford and Sobel (1982), we get:

$$CS^{b_i}_{b_i}(k) = -\frac{1}{12k^2} - \frac{b_i^2(k^2+2)}{3}; \tag{1}$$

We denote $CS^{b_i}_{b_i}(k,R)$ as the corresponding receiver's payoff, i.e,,

$$CS^{b_i}_{b_i}(k,R) = -\frac{1}{12k^2} - \frac{b_i^2(k^2-1)}{3}; \tag{2}$$

When a sender of type b_i announces her type as b_j, we denote the corresponding expressions for the sender's payoffs as $CS^{b_i}_{b_j}(k)$. The expression for this is derived in the appendix A.2.

3 Analysis

We start with our benchmark case of one sender. Is truthful bias revelation possible in equilibrium? In our sister paper Bhattacharjee et al. (2026), we show that there is no bias revelation equilibrium with one sender. In this paper, we consider a two-sender environment and show that a bias revealing equilibrium can exist in the two-sender world. Then, we investigate whether the receiver prefers a

[11]The formal definition of PBE is in the Appendix A.1.

bias revealing equilibrium to those without any bias revelation.

3.1 Two Sender Problem

Can sender competition permit the existence of a revelation equilibrium? If so, is such an equilibrium preferred by the receiver to any conflict hiding equilibrium? The sender who is not hired after stage 1 receives an outside option $-A_{b_j}$ where b_j is the bias of that sender. We assume that $-A_{b_j} < CS_{b_j}^{b_j}(1)$, i.e., not being hired yields a payoff worse than the lowest equilibrium payoff if hired (from a babbling equilibrium). This ensures that all senders prefer to be hired in equilibrium.

3.1.1 Revelation equilibrium

In any equilibrium of the two-stage game, if the bias is revealed in the first stage, a partition equilibrium a la Crawford and Sobel (1982) is played in the second stage. We focus our attention only on the ex-post most informative revelation equilibrium (involving the highest partition cheap talk equilibrium possible with the chosen sender in stage 2). The reason for this is that such an equilibrium gives the bias revelation equilibrium the highest probability of being welfare improving for the receiver (over conflict hiding equilibria). This assumption helps us show that, when the revelation equilibrium exists, it can indeed generate a higher receiver's payoff compared to conflict-hiding equilibria. For brevity, henceforth, we will refer to the most informative revelation equilibrium as 'the most informative equilibrium'.

We use the notation $S_{RE,v_{b_i b_j}}$ to refer to the highest partition revelation strategies where the senders announce b_i and b_j as their biases where $b_i \neq b_j$ [12] and whoever announces the higher type is chosen with probability $v_{b_i b_j}$.The corresponding revelation equilibrium (if it exists) is denoted by $E_{RE,v_{b_i b_j}}$. The utility of the receiver from this equilibrium is given by $U_R(RE, v_{b_i b_j})$. Below, we describe the strategy profile $S_{RE,v_{b_i b_j}}$.

Definition 1. *The highest partition revelation strategy profile* $S_{RE,v_{b_i b_j}} = (\mu_i(b_i), h(b_i, b_j), \mu_j, y)$ *is*

[12] When both senders announce the same bias, the receiver is indifferent between picking any of the senders to get advice from, and hence pick either with probability 0.5.

defined as:

$$
\begin{aligned}
&\textit{Stage } 1\\
&\mu_i(b_i) = b_i \ \forall\ b_i \in K\\
&h(b_i,b_j) = \left(\frac{1}{2},\frac{1}{2}\right) \quad if \quad |b_i| = |b_j|\\
&h(b_i,b_j) = (1-v_{b_ib_j}, v_{b_ib_j}), \quad if \quad |b_i| < |b_j|\\
&h(b_i,b_j) = (v_{b_ib_j}, 1-v_{b_ib_j}), \quad if \quad |b_i| > |b_j|; \quad v_{b_ib_j} \in [0,1]\\
&\textit{Stage } 2\\
&\textit{For any reports where the sender who announced } b_k \textit{ is hired:}\\
&\textit{Play } E_{CS}(b_k,N_{b_k}) \textit{ equilibrium in period 2}\\
&\textit{Deviation by hired sender in stage 2: take the lowest equilibrium action in } E_{CS}(b_k,N_{b_k})\\
&\textit{Deviation by the receiver in hiring in stage 1: Play a babbling equilibrium with the hired sender}
\end{aligned}
\tag{3}
$$

This strategy profile involves both the senders truthfully announcing their bias in stage one of the game. If both senders announce the same level of bias, then the receiver randomly hires one of them, and the hired sender and the receiver play the highest partition CS equilibrium in stage 2. If the senders announce two different biases b_h and b_l where $|b_h| > |b_l|$, then with probability $v_{b_hb_l}$ the receiver hires the sender who announces the higher bias and subsequently they play the highest partition CS equilibrium $E_{CS}(b_h,N(b_h))$ in stage 2, and with probability $(1-v_{b_hb_l})$ the receiver hires the sender who announces the lower bias and subsequently, they play the corresponding highest partition CS equilibrium $E_{CS}(b_l,N(b_l))$ in stage 2. Formally, the most informative revelation equilibrium is defined as follows:

Definition 2. *The ex-post most informative revelation equilibrium $E_{RE,v_{b_ib_j}}$ is the PBE generated by the highest partition strategy profile $S_{RE,v_{b_ib_j}}$.*

Now, we identify parameter values under which 3 can generate an equilibrium. First, we argue that if $v_{b_ib_j} \in [0,1)$ for any biases $b_i, b_j \in K$, then the highest partition revelation strategy profile does not generate an equilibrium.

Lemma 1. *If there exists $b_i, b_j \in K$ such that $|b_i| > |b_j|$ or $b_i = -b_j$, and $v_{b_i b_j} \in [0,1)$, then $S_{RE, v_{b_i b_j}}$ does not generate a Perfect Bayesian equilibrium.*

The proof of the lemma is given in the Appendix (refer Appendix B.1). The intuition is as follows. If $v_{b_h b_l} \in (0,1)$, then the receiver always finds it optimal to deviate and hire the lower bias type. Since such a deviation cannot be detected, the receiver cannot be punished for this deviation, and therefore $v_{b_h b_l} \in (0,1)$ cannot be sustained in this equilibrium. For $v_{b_h b_l} = 0$, the higher bias type always finds it optimal to deviate and pretend to be the lower bias type. This way, she gets hired with a higher probability and gets a better payoff in stage 2. Thus, in the most informative revelation equilibrium, for every pair of biases $b_i, b_j \in K$, $v_{b_i b_j} = 1$. Since $v_{b_i b_j}$ is independent of the announced biases in any equilibrium, for the remainder of the paper, we denote $v_{b_i b_j} = v$. We will use $S_{RE,v}$ and $E_{RE,v}$ as the corresponding strategy and equilibrium.

Next, we consider the case where the set of possible biases is infinite and $v = 1$. We show that, in this case, the most informative revelation equilibrium does not exist.

Proposition 1. *If $||K|| = \infty$, the highest partition revelation strategy profile $S_{RE,v}$ cannot be sustained in any equilibrium.*

The proof of the proposition is given in the Appendix (refer to Appendix B.2). The intuition behind the proof is as follows: since a higher bias type is hired with a higher probability (because $v = 1$), to ensure that no bias type wants to deviate to a lower bias and no lower bias type want to deviate to a higher type, we need the difference between the outside options to be sufficiently large for each pair of bias types. Moreover, as the difference in the level of biases increases, the required difference between the outside option also increases. Thus, if the type set K contains infinitely many points, then to ensure that the IC for all of them is satisfied, the maximum difference between outside options goes to infinity. But this implies the incentive constraint for some type will be violated.

Proposition 1 implies that the only type set K that can allow the most informative revelation equilibrium to exist is a set of finitely many points and with $v = 1$. We focus our attention on the case where K contains only two points. Note that since a necessary condition for the existence of a revelation equilibrium is that the difference between the outside options of any two types of biases is sufficiently high, it would be easiest for the revelation equilibrium to exist if $|K| = 2$. If the revelation equilibrium does not exist when $|K| = 2$, it cannot exist for any $2 < |K| < \infty$. For the rest of the analysis, we assume $K = \{b_l, b_h\}$ where (WLOG) let $b_h > 0$, $b_h \neq b_l$, and $b_h \geq |b_l|$. Thus, we will denote b_h as the higher bias type and b_l as the lower bias type. We will identify the parametric conditions required for the existence of the most informative revelation equilibrium $E_{RE,v}$.

Since the low bias type sender is typically able to sustain cheap talk equilibria with higher partition and higher balance, the high bias sender is more inclined to deviate. In our setting, three key mechanisms help achieve this: first, the hiring rule (parameterized by the hiring probability v). The high-bias sender can be motivated to truthfully reveal her bias if she is rewarded with a higher probability of being hired following a mixed message in stage 1. Second, the differential outside option [13] helps to meet the incentive constraints (owing to $A_{b_h} > A_{b_l}$, the high-bias type loses more from not being hired than the low bias type) [14]. Finally, there is strategic uncertainty. A sender's payoff depends upon the announcement of the other sender as well[15]. Thus, in this two-sender framework, competition facilitates truthful revelation through these channels. The following proposition shows conditions under which the most informative revelation equilibrium may exist.

Proposition 2. *Suppose $v = 1$ and $K = \{b_l, b_h\}$ with $b_h > 0$, $b_h \neq b_l$, and $b_h \geq |b_l|$*

1. *If $b_h \leq \frac{1}{\sqrt{24}}$, $E_{RE,v=1}$ cannot exist.*
2. *For $b_h \in (\frac{1}{\sqrt{24}}, \frac{1}{4})$, there exists $\underline{b}, \overline{b}$ where $-b_h < \underline{b} < 0$ and $b_h > \overline{b} > 0$, such that if $b_l \in [\underline{b}, \overline{b}]$ a revelation equilibrium can exist.*

While the proof is in the appendix (refer to Appendix B.3), we explain the result intuitively here. When $v = 1$, the high bias sender is always hired following a mixed message vector. This helps make it incentive compatible for the high bias sender to reveal her type, when her outside option is sufficiently low[16]. However, here it is difficult to incentivize the low bias sender to reveal her true type. The low bias type's IC holds only when the payoff from deviating and announcing to be a high bias type is not very high. This happens when the level of high bias, b_h, is sufficiently high. Thus, the revelation equilibrium doesn't exist when b_h is lower than $\frac{1}{\sqrt{24}}$. Even when b_h is

[13]The outside option for the lower bias type is A_{b_l} and the same for the higher bias type is A_{b_h}.

[14]As we show in proof of proposition 2 if $A_{b_h} = A_{b_l}$, $E_{RE,v_{b_h b_l}=1}$ does not exist for any parameters of the model

[15]This plays an important role. To illustrate this, suppose that the senders know the type of all senders, and that the two senders have different types i.e. one high bias sender and one low bias sender. If we try to incentivize the high bias sender to reveal their type by offering to hire them in case of mixed messages, a low bias sender would always deviate and announce her type to be high bias.

[16]Since the high bias sender has a bad outside option, she gains more from being hired than the low bias sender.

higher than this threshold, the difference between b_h and b_l needs to be sufficiently high to ensure the IC for b_l is satisfied.

The above equilibrium $E_{RE,v=1}$ requires that ex-post, once the types are revealed, the receiver takes a suboptimal action, specifically, choosing the high-bias sender[17] after the types have been revealed. In the next section, we ask if this cost is worth it. Does the receiver prefer the best bias revealing equilibrium to equilibria which are possible without any bias revelation?

3.1.2 Welfare

In this section, we compare the expected utility of the receiver in the revelation equilibrium $E_{RE,v=1}$ and the most informative equilibrium where biases are not revealed for any state - a conflict hiding equilibrium with the highest feasible number of partitions. Since a revelation equilibrium only exists when K has finitely many points, for simplicity and ease of illustration, we continue with the assumption that $K = \{b_l, b_h\}$ with $b_h > 0$, $b_h \neq b_l$, and $b_h \geq |b_l|$. Let a k partition conflict hiding equilibrium be denoted by $E_{CH}(p,k)$ where p denotes the probability that the sender is of high bias type. Given p, let N_p denote the maximum number of partitions possible in a conflict hiding equilibrium. By definition, the maximum number of partitions possible in the conflict hiding equilibrium is bounded by N_{b_l} and N_{b_h} for any $p \in (0,1)$, i.e., $N_{b_h} \leq N_p \leq N_{b_l}$.

To compare the two equilibria, in appendix A.3, we first derive the closed-form expression for the receiver's payoff in the conflict hiding equilibrium. The receiver's payoff in a conflict hiding equilibrium with k partition and expected bias $b = pb_h + (1-p)b_l$ is given by,

$$U_R(CH,p,k) = -\frac{1}{12k^2} - \frac{b^2}{3}\left(k^2-1\right) - (b_h - b_l)^2 p\,(1-p)\,\frac{k-1}{k}$$

Notice that as $p \to 0$, this converges to the payoff expression in Crawford and Sobel (1982) with only low bias type, and as $p \to 1$, it converges to the equilibrium payoff expression in Crawford and Sobel (1982) with only high bias type for $N_h = m \geq k$.

When comparing the two equilibria, we find that, for the receiver, the payoff advantage of the revelation equilibrium lies in the ability to identify and hire a low-bias sender. This leads to a (weakly) more informative and more balanced partition. On the other hand, the advantage of the

[17] Whenever this type exists.

conflict-hiding equilibrium lies in reducing the ex-ante variance in payoff for the receiver (across the two types of biased senders). Since the receiver is risk averse, reduced variance in payoff improves her expected utility.

Thus, to compare the two types of equilibria, we first consider the case where $k = N_p = N_{b_l} = n$. Here, the revelation equilibria provide a more balanced partition when a low-bias type sender is hired, but a (weakly) coarser and less balanced partition when a high bias type sender is hired. We show that under our quadratic utility specification, the net gain in the revelation equilibrium is dominated by the gain from the reduction in variance under the conflict hiding equilibrium. The following lemma formalizes this result.

Lemma 2. *Suppose $E_{RE,v=1}$ exists with the strategy profile $S_{RE,v=1}$. Suppose the number of partitions in the most informative conflict hiding equilibrium $E_{CH}(p,N_p)$ is $N_p = N_{b_l}$. In that case, the $E_{CH}(p,N_p)$ is preferred to the revelation equilibrium $E_{RE,v=1}$ by the receiver.*

For the proof, please refer to appendix B.4. Next, we consider the case where $k = N_p < N_{b_l} = n$. Note that the condition $k < n$ imposes a lower bound on p, the probability of high bias type biases in the population. If p is sufficiently small, then the most informative conflict-hiding equilibrium resembles the second-stage n partition revelation equilibrium with low-bias type, and thus k cannot be strictly lower than n. With $k < n$, we find that the revelation equilibrium can outperform the conflict hiding equilibrium. Intuitively, the revelation equilibrium benefits the receiver if it leads to hiring a low bias sender (with a finer and more balanced partition equilibrium in stage 2), and leads to a loss when he hires the high bias sender (lower precision and lower balance). So, while comparing RE and LM equilibria, two key parameters are: (a) the bias magnitude b_h, and consequently the bias difference $b_h - b_l$ (this affects the incentive compatibility constraints required for bias revelation); and (b) the probability of high bias: p (which affects both the incentive compatibility constraints and influences the precision of the conflict hiding equilibrium).

As shown in proposition 2, if b_h is sufficiently low,i.e., below $\frac{1}{\sqrt{24}}$, IC for the b_l type cannot be satisfied. If b_h is sufficiently high, two forces are at play: first, the IC for b_l is satisfied when $|b_l|$ is sufficiently low, and second, the net gain from knowing the types can dominate in the second stage. This makes the revelation equilibrium perform better. This result is formalized in the following proposition.

Proposition 3. *For any $b_h \in (\frac{1}{\sqrt{24}}, \frac{1}{4})$ there exists $\underline{n} > 3$, such that if $n > \underline{n}$ and $b_l \to \frac{1}{2n(n-1)}$, there exists an interval $I \subset (0,1)$ such that for all $p \in I$, the revelation equilibrium $E_{RE,v=1}$ exists and the receiver prefers $E_{RE,v=1}$ equilibrium over all possible conflict hiding equilibrium.*

The proof of the proposition is given in the appendix (refer Appendix B.5). From proposition 2, we need a sufficiently high b_h to ensure that the incentive compatibility constraint for the b_l type sender is satisfied. A high b_h along with a high n ensures that the difference term $b_h - |b_l|$ is sufficiently high, making revelation a lucrative outcome for the receiver. Following lemma 2, we need to take $b_l \to \frac{1}{2n(n-1)}$. This ensures $k < n$ for almost all values of p (since even a b_l type sender would not be able to sustain an n partition equilibrium if b_l were just a little larger). A low p in this case implies that revelation and conflict hiding aren't much different from one another. Thus, we need an intermediate range of p where IC for b_l is satisfied and the gain from obtaining a more precise and more balanced (k vs n) partition is sufficiently large to make the revelation equilibrium better.

The following example illustrates the existence of a revealing equilibrium that benefits the receiver more than the most informative conflict hiding equilibrium.

Example 1. *Suppose $b_h = 0.24$, $n = 4$ and $b_l \to 0.41667$, then for all $p \in (0.236, 0.2436)$ $E_{RE,v=1}$ performs better $E_{CH}(p,3)$.*

4 Discussion and Conclusion

Here, we discuss some other extensions and their possible impact on our results.

4.1 Renegotiation

The revelation equilibrium we obtain in Propositions 3 and 4 is ex ante better for the receiver than all equilibria without any bias revelation. However, we support this with strategies that are ex-post not optimal. For example, if the receiver is supposed to pick the sender who announced the high bias but instead deviates and picks the sender who announced the low bias, the hired sender and receiver are required to play the babbling equilibrium in stage 2 on this off-equilibrium path. As babbling is an equilibrium, no player deviates in stage 2. However, if renegotiation were permitted, then the hired lower bias sender and receiver could play the most informative equilibrium in stage 2. Allowing for renegotiation makes it impossible for a revelation equilibrium to exist since the receiver will always pick the lower bias sender[18].

4.2 Other Equilibria

We have focused on the case where once the sender's type is revealed in stage 1, the most informative equilibrium will be played in stage 2. Other revelation equilibria are, of course, possible. The simplest such equilibria entail the receiver playing a babbling equilibrium with the hired sender. For such a stage 2 outcome, no type of sender will want to deviate from truth-telling. While this is a revelation equilibrium, it provides the receiver with low utility due to the suboptimal equilibrium being played in stage 2. Thus, it is obvious that welfare comparisons will always favor the conflict hiding equilibria in this case, making such revelation equilibria less interesting.

4.3 Endogenous Revelation equilibrium

In this paper, to understand welfare implications, we have compared the best revealing equilibrium with the conflict hiding equilibria. We found that, for a wide range of parameters, the conflict hiding equilibrium is preferred by the receiver. Li and Madarász (2008) posit the existence of another type of equilibria that is possible in the game without the first stage for bias revelation: the "partial revelation" equilibria. In such partial revelation equilibria, the receiver can infer the bias from the state message. They show that (a) only the low bias type can endogenously reveal her bias, and (b) only in some states of the world (when $\theta \in [0,s]$ where $s \leq d = b_h - b_l$). For the sake of completeness, here we discuss how our endogenous revealing equilibrium compares with this partial revelation equilibrium. [19].

The major difference between the revelation equilibrium described in this paper and the partial revelation equilibrium described in Li and Madarász (2008) is that, in this paper, biases can be revealed before any sender observes the true state θ, whereas in their framework, the sender knows the state from the beginning, and the bias can be inferred from the state relevant message. Moreover,

[18] The result follows from the case of $v = 0$ in proposition 2.

[19] Theorem 12 from Li and Madarász (2008)]: For all distributions of the conflict, no equilibrium reveals the conflict of the high type, and no equilibrium reveals the conflict of the low type for true state higher than $b_h - b_l$.

in Li and Madarász (2008)'s partial revelation equilibrium, biases can only be revealed by the low bias type and only for some states of the world. In contrast, we are interested in the revelation of biases by both types before they learn the state. Thus, both biases are revealed in all states in our revelation equilibrium. Finally, for $b_h > \frac{1}{\sqrt{24}}$, the best partial revelation equilibrium, whenever it exists, performs better than the best revelation equilibrium.

4.4 Conclusion

We consider a model of costless strategic information transmission in which senders privately know their biases and may endogenously choose to disclose these biases prior to communicating state-relevant information. In the canonical setting with a single sender, Bhattacharjee et al. (2026) find that no informative equilibrium exists in which bias revelation is sustained. To investigate the implications of sender competition, we extend the framework to a two-sender environment and examine whether (a) bias revelation can be sustained in equilibrium and (b) such revelation is welfare-improving for the receiver. In the two-sender setting, we show that an informative bias-revealing equilibrium can emerge through the interaction of two key forces: sender competition and strategic uncertainty. We compare this equilibrium to conflict-hiding equilibria that arise in games without a bias-revelation stage. We derive closed-form expressions for the payoffs in conflict-hiding equilibria. Our analysis reveals that a bias-revealing equilibrium can be welfare improving for the receiver when the sender types are sufficiently different. This demonstrates a novel indirect channel through which sender competition can benefit the receiver.

A Notations and Derivations

A.1 Definition of Perfect Bayesian Equilibrium

A Perfect Bayesian equilibrium consists of 1. strategy for the receiver (hiring rule $h(\mu_1(b_1),\mu_2(b_2))$, and stage two action $y(P_b(\mu_1,\mu_2,p,h),\mu_{b_i}(\theta,h))$ (where P_b is the posterior belief about the bias of the hired sender)), 2. strategy for each sender (for each, the stage one bias message $\mu_i(b_i)$ and stage two message about the state upon being hired $\mu_{b_i}(\theta,h)$), and 3.belief vectors P,P_b (on state and bias, respectively) such that: given the strategies of all players, the beliefs are derived using Bayes' rule whenever possible. The receiver's hiring rule h and the action function y maximize his ex-ante expected utility given his belief P, P_b and the strategy of all experts. We can write the receiver's problem as

$$\max_{y,h} U_R(P(P_b(\mu_1,\mu_2,p,h),\mu_{b_i}(\theta,h)),y(P_b(\mu_1,\mu_2,p,h),\mu_{b_i}(\theta,h)))$$

For each type of sender, their strategy should maximize their expected payoff given the strategies of all the other experts and the receiver. We can write sender i's problem as

$$\max_{\mu_i(b_i),\mu_{b_i}(\theta,h)} U_i(P(P_b(\mu_1,\mu_2,p,h),\mu_{b_i}(\theta,h)),y(P_b(\mu_1,\mu_2,p,h),\mu_{b_i}(\theta,h)),b_i)$$

A.2 Derivation of Deviation Payoffs in Revelation Equilibrium

Suppose a revelation equilibrium is to be played, and the b_j type sender deviates and pretends to be b_{-j} type sender. What would be her payoff? Consider a b_l type sender who announces her type to be b_h. Suppose that the receiver and sender were supposed to play a Crawford-Sobel type k partition equilibrium after the sender announced her type to be b_h. In this equilibrium, the receiver chooses actions,

$$y_i^h = \frac{2i-1}{2k} + b_h(2i^2-(k+1)(2i-1))$$

in the i^{th} interval $[a_{i-1}^h, a_i^h]$ for all $i = 1,\dots k$. Given y_i^h, low bias type chooses cutoffs $\alpha_1,\dots\alpha_k$ such that, she is indifferent between y_i^h and y_{i+1}^h at α_i, i.e,

$$\begin{aligned} y_i^h - \alpha_i - b_l &= -(y_{i+1}^h - \alpha_i - b_l) \\ \Rightarrow \alpha_i &= \frac{i}{k} - b_h(2i(k-i)-1) - b_l \end{aligned}$$

Thus, the deviation payoff would be,

$$CS_{b_h}^{b_l}(k) = \sum_{i=1}^{k} \int_{\alpha_{i-1}}^{\alpha_i} -(y_{ih} - \alpha_i - b_l)^2 d\alpha$$

Plugging in the value of α_i and y_{ih} we get,

$$CS_{b_h}^{b_l}(k) = -\frac{1}{12k^2} + \frac{b_h^2}{3}(4 - \frac{3}{k} - k^2) - 2b_h b_l \frac{k-1}{k} - \frac{b_l^2}{k}. \tag{4}$$

Similarly, if we consider a b_h type sender who hides in a j partition equilibrium offered to b_l type.

$$CS_{b_l}^{b_h}(j) = -\frac{1}{12j^2} + \frac{b_l^2}{3}(4 - \frac{3}{j} - j^2) - 2b_h b_l \frac{j-1}{j} - \frac{b_h^2}{j} \tag{5}$$

Moreover, by taking the difference between the payoff of any player from truth-telling and the payoff of the other player from hiding in the same partition and rearranging terms, we can write,

$$CS_{b_l}^{b_l}(j) - CS_{b_l}^{b_h}(j) = (b_h - b_l)(b_h \frac{1}{j} + b_l(2 - \frac{1}{j})) \tag{6}$$

$$CS_{b_h}^{b_l}(k) - CS_{b_h}^{b_h}(k) = (b_h - b_l)(b_h(2 - \frac{1}{k}) + b_l \frac{1}{k}) \tag{7}$$

We use these two expressions in the following proofs.

A.3 General Expression for k-partition Conflict Hiding Equilibrium

In this section, we derive the expression for the conflict-hiding equilibrium with only two types of biases. Suppose there are two bias types, b_h and b_l, where $b_h > 0$, and $b_h > |b_l|$, where p denote the probability of b_h type. Here we derive the expressions for the equilibrium $E_{CH}(p,k)$, which we use for welfare comparison. In a k-partition conflict hiding equilibrium, denote the equilibrium partition structure chosen by a b_j type sender to be: $[a_0^j = 0, a_1^j, a_2^j, ..., a_{k-1}^j, a_k^j = 1]$. Then, the action chosen by the receiver after receiving the i^{th} message is:

$$y_i = p\frac{a_{i-1}^h + a_i^h}{2} + (1-p)\frac{a_{i-1}^l + a_i^l}{2}$$

Now, since

$$a_1^h = \frac{y_1 + y_2}{2} - b_h; \quad a_1^l = \frac{y_1 + y_2}{2} - b_l$$

we get

$$y_1 = p\frac{\frac{y_1+y_2}{2} - b_h}{2} + (1-p)\frac{\frac{y_1+y_2}{2} - b_l}{2} = \frac{y_1+y_2}{4} - \frac{b}{2}$$

where $b = pb_h + (1-p)\,b_l$ =expected bias. Similarly, we get for all $2 \leq i \leq k-1$:

$$\begin{aligned}
y_i &= p\frac{\frac{y_{i-1}+y_i}{2} - b_h + \frac{y_{i+1}+y_i}{2} - b_h}{2} + (1-p)\frac{\frac{y_{i-1}+y_i}{2} + \frac{y_{i+1}+y_i}{2} - 2b_l}{2} \\
&= \frac{y_{i-1}+2y_i+y_{i+1}}{4} - b \\
2y_i &= y_{i-1} + y_{i+1} - 4b \\
(y_{i+1}-y_i) &- (y_i - y_{i-1}) = 4b
\end{aligned} \tag{8}$$

Iterating equation 8 we get,

$$\begin{aligned}
y_2 - y_1 &= 2y_1 + 2b \\
y_i - y_{i-1} &= y_{i-1} - y_{i-2} + 4b = 2y_1 + 2b + (i-2)4b \\
y_k - y_{k-1} &= 2y_1 + 2b + (n-2)\,4b
\end{aligned} \tag{9}$$

This implies

$$\begin{aligned}
y_2 &= y_1 + 2y_1 + 2b = 3y_1 + 2b \\
y_i &= (2i-1)\,y_1 + 2\,(i-1)^2\,b \\
y_k &= (2k-1)\,y_1 + 2\,(k-1)^2\,b
\end{aligned} \tag{10}$$

Also, using:

$$\begin{aligned}
y_k &= \frac{p}{2}\left(\frac{y_{k-1}+y_k}{2} + 1 - b_h\right) + \frac{1-p}{2}\left(\frac{y_{k-1}+y_k}{2} + 1 - b_l\right) \\
&= \frac{y_{k-1}+y_k}{4} - \frac{1}{2} - \frac{b}{2} \\
y_k &= 1 - y_1 - 2\,(k-1)\,b
\end{aligned} \tag{11}$$

Equating the two expressions for y_k, we solve for the equilibrium actions

$$\begin{aligned}
(2k-1)\,y_1 + 2\,(k-1)^2\,b &= 1 - y_1 - 2\,(k-1)\,b \\
y_1 &= \frac{1}{2k} - b\,(k-1) \qquad (12)
\end{aligned}$$

For this to be valid, we need:

$$y_1 \geq 0 \iff \frac{1}{2k} - b\,(k-1) \geq 0 \iff b \leq \frac{1}{2k\,(k-1)} \qquad (13)$$

Since $b = pb_h + (1-p)b_l$, rewriting eq 13 we get the following necessary condition for a k partition CH equilibrium,

$$\begin{aligned}
b \equiv pb_h + (1-p)b_l &< \frac{1}{2k(k-1)} \\
\Rightarrow p &< \frac{\frac{1}{2k(k-1)} - b_l}{d}; \qquad (14)
\end{aligned}$$

where $d = b_h - b_l > 0$.

Plugging equation 12 in equation 10, we get,

$$y_i = \frac{(2i-1)}{2k} + b\left[2i^2 - (2i-1)\,(k+1)\right] \qquad (15)$$

Receiver's Payoff: Using the values of y_i we can find the Receiver's payoff from this equilibrium $E_{CH}(p,k)$ as:

$$U_R(CH,p,k) = pU_R^h(CH,p,k) + (1-p)\,U_R^l(CH,p,k) \qquad (16)$$

where U_R^b = receiver's payoff if the hired sender's type is $b \in \{b_h, b_l\}$.

Calculating $U_R^h(CH,p,k)$ separately we get:

$$
\begin{aligned}
U_R^h(CH,p,k) &= \int_0^{a_1^h} -(y_1-\theta)^2 d\theta + \int_{a_1^h}^{a_2^h} -(y_2-\theta)^2 d\theta + \cdots + \int_{a_{k-1}^h}^{a_k^h} -(y_k-\theta)^2 d\theta \\
&= \frac{1}{3}\left[\left[(y_1-\theta)^3\right]_0^{a_1^h} + \left[(y_2-\theta)^3\right]_{a_1^h}^{a_2^h} + .. + \left[(y_k-\theta)^3\right]_{a_{k-1}^h}^{1}\right] \\
&= \frac{1}{3}\left[-(1-y_k)^3 - y_1^3 + \sum_{j=1}^{k-1}\left(\left(y_j-a_j^h\right)^3 - \left(y_{j+1}-a_j^h\right)^3\right)\right] \qquad (17)
\end{aligned}
$$

Now, we know that:

$$
\begin{aligned}
y_j - a_j^h &= -\frac{1}{2k} + b\,[k-2j] + b_h; \\
y_{j+1} - a_j^h &= \frac{1}{2k} + b\,[2j-k] + b_h
\end{aligned}
$$

So,

$$
\left(y_j-a_j^h\right)^3 - \left(y_{j+1}-a_j^h\right)^3 = -2\left(\frac{1}{2k} + b\,[2j-k]\right)^3 - 6b_h^2\left(\frac{1}{2k} + b\,[2j-k]\right)
$$

since $(a-b)^3 - (a+b)^3 = -2b^3 - 6a^2 b$ Thus,

$$
\sum_{j=1}^{k-1}\left(\left(y_j-a_j^h\right)^3 - \left(y_{j+1}-a_j^h\right)^3\right) = -\left[\frac{k-1}{4k^3} + b^2\,(k-1)\,(k-2) + 3b_h^2\frac{k-1}{k}\right]
$$

Using this, we get

$$
\begin{aligned}
U_R^h(CH,p,k) &= -\frac{1}{3}\left[\frac{k-1}{4k^3} + b^2\,(k-1)\,(k-2) + 3b_h^2\frac{k-1}{k} + \left(\frac{1}{2k} + b\,(k-1)\right)^3 + \left(\frac{1}{2k} - b\,(k-1)\right)^3\right] \\
&= -\frac{1}{12k^2} - \frac{b^2}{3}\,(k-1)\left(k+1-\frac{3}{k}\right) - b_h^2\frac{k-1}{k} \qquad (18)
\end{aligned}
$$

Similarly, we can calculate:

$$
U_R^l(CH,p,k) = -\frac{1}{12k^2} - \frac{b^2}{3}\,(k-1)\left(k+1-\frac{3}{k}\right) - b_l^2\frac{k-1}{k} \qquad (19)
$$

This gives us the final expression for the receiver's payoff in the equilibrium $E_{CH}(p,k)$:

$$\begin{aligned} U_R(CH,p,k) &= pU_R^h + (1-p)\,U_R^l \\ &= -\frac{1}{12k^2} - \frac{b^2}{3}\left(k^2-1\right) - d^2 p\,(1-p)\,\frac{k-1}{k} \end{aligned} \tag{20}$$

Comparison of Payoffs: Using $U_R(CH,p,k)$, we want to compare the payoff from the most informative revelation equilibrium with the conflict hiding equilibrium. Now, the receiver's payoff from the most informative revelation equilibrium for any $0 \leq v \leq 1$ is (from 3). Suppose that $N_{b_l} = n$ and $N_{b_h} = m$.

$$U_R(RE,v) = \left(p^2 + 2vp\,(1-p)\right) CS_{b_h}^{b_h}(m) + \left((1-p)^2 + 2\,(1-v)\,p\,(1-p)\right) CS_{b_l}^{b_l}(n) \tag{21}$$

Simplifying, we get the difference between these two payoffs:

$$\begin{aligned} \Delta(p) \equiv U_R(RE,v)) - U_R(LM,p,k)) = p^2 &\left((1-2v)\left(CS_{b_h}^{b_h}(m,R) - CS_{b_l}^{b_l}(n,R)\right) + \frac{k^2-1}{3}d^2 - \frac{k-1}{k}d^2 \right) \\ &+ p\left(2v\left(CS_{b_h}^{b_h}(m,R) - CS_{b_l}^{b_l}(n,R)\right) + \frac{k^2-1}{3}2b_l d + \frac{k-1}{k}d^2\right) \\ &+ \left(CS_{b_l}^{b_l}(n,R) + \frac{1}{12k^2} + \frac{k^2-1}{3}b_l^2\right) \end{aligned} \tag{22}$$

We use this expression for the proof of Propositions 3 and 4.

B Proofs

B.1 Proof of Lemma 1

Proof. We will prove the lemma in two steps. First, we will consider the most informative revelation equilibrium with different level of biases and $v_{b_i b_j} \in (0,1)$, which will not be IC for the receiver. Next, we will consider $v_{b_i b_j} = 0$ and the case of $v_{b_i b_j} = \frac{1}{2}$ and $b_i = -b_j$ $(b_j > 0)$, and show that it is not IC for the higher bias type.

If $v_{b_i b_j} \in (0,1)$, the receiver will deviate when two different bias levels are announced in stage 1. Since $v_{b_i b_j}$ is strictly between zero and one, the strategy profile in 3 requires the receiver to sometimes hire the lower bias sender and sometimes the higher bias sender, and subsequently play the most informative equilibrium with them. However, since the receiver is always better off with a lower bias sender in the most informative equilibrium, the receiver will deviate from mixing and always choose the lower bias sender. Given that this deviation cannot be observed by the senders, it cannot be punished, and therefore $v_{b_ib_j} \in (0,1)$ cannot be sustained in any equilibrium.

Next, consider the following cases: 1) there are two biases, b_l, b_h where b_h is the higher level of bias, and $v_{b_lb_h} = 0$, 2) $v_{b_ib_j} = \frac{1}{2}$ and $b_i = -b_j$ $(b_j > 0)$. Suppose $N_{b_h} = j, N_{b_l} = k$. The high bias sender will not deviate from truth telling if:

$$P(b_h)CS_{b_h}^{b_h}(j) + (1 - P(b_h))(-A_{b_h}) > P(b_l)CS_{b_l}^{b_h}(k) + (1 - P(b_l))(-A_{b_h})$$
$$P(b_h)(CS_{b_h}^{b_h}(j) + A_{b_h}) > P(b_l)(CS_{b_l}^{b_h}(k) + A_{b_h})$$

where the probability of being hired $P(b_h)$ and $P(b_l)$ are given by,

$$P(b_h) = 1 - F(b_h) + F(-b_h) + \frac{1}{2}f(b_h) - \frac{1}{2}f(-b_h);$$
$$P(b_l) = 1 - F(b_l) + F(-b_l) + \frac{1}{2}f(b_l) - \frac{1}{2}f(-b_l)$$

$$\begin{aligned} P(b_l) - P(b_h) &= F(b_h) - F(b_l) + F(-b_l) - F(-b_h) + \frac{1}{2}(f(b_l) - f(b_h)) + \frac{1}{2}(f(-b_h) - f(-b_l)) \\ &= \frac{1}{2}(f(b_h) + f(b_l) + f(-b_h) + f(b_l)) + F(b_h-) - F(b_l) + F(-b_l-) - F(-b_h) > 0 \end{aligned}$$

where $F(x) = \int_{-\infty}^{x} f(x)dx$; $F(x-) = F(x) - f(x)$. Thus IC for b_h would be satisfied if

$$\frac{P(b_h)}{P(b_l)} > \frac{CS_{b_l}^{b_h}(k) + A_{b_h}}{CS_{b_h}^{b_h}(j) + A_{b_h}} \tag{23}$$

We would show that the RHS of equation 23 is greater than 1, thereby creating a contradiction.

Case 1: $j = k$ Comparing $CS^{b_h}_{b_l}(j)$ and $CS^{b_h}_{b_h}(j)$ we get,

$$\begin{aligned} CS^{b_h}_{b_l}(j) - CS^{b_h}_{b_h}(j) &= -\frac{1}{12j^2} + \frac{b_l^2}{3}(4 - \frac{3}{j} - j^2) - 2b_h b_l \frac{j-1}{j} - \frac{b_h^2}{j} + \frac{1}{12j^2} + b_h^2 \frac{j^2+2}{3} \\ &= \frac{j^2-1}{3}(b_h^2 - b_l^2) + \frac{j-1}{j}(b_h - b_l)^2 > 0 \end{aligned}$$

Case 2: $j < k$ Let us compare $CS^{b_h}_{b_l}(k)$ and $CS^{b_h}_{b_l}(j)$ as follows,

$$\begin{aligned} CS^{b_h}_{b_l}(k) - CS^{b_h}_{b_l}(j) &= -\frac{1}{12k^2} + \frac{b_l^2}{3}(4 - \frac{3}{k} - k^2) - 2b_h b_l \frac{k-1}{k} - \frac{b_h^2}{k} \\ &\quad + \frac{1}{12j^2} - \frac{b_l^2}{3}(4 - \frac{3}{j} - j^2) + 2b_h b_l \frac{j-1}{j} + \frac{b_h^2}{j} \\ &= (k^2 - j^2)(\frac{1}{12j^2k^2} - \frac{b_l^2}{3}) + \frac{k-j}{jk}(b_h - b_l)^2 > 0 \end{aligned}$$

since $b_l^2 \leq \frac{1}{4k^2(k-1)^2} \leq \frac{1}{4j^2k^2}$. Thus, $CS^{b_h}_{b_l}(k) > CS^{b_h}_{b_h}(j)$. Thus,

$$\frac{CS^{b_h}_{b_l}(k) + A_{b_h}}{CS^{b_h}_{b_h}(j) + A_{b_h}} > 1 > \frac{P(b_h)}{P(b_l)}$$

This implies the IC for the higher bias type can never be satisfied. Hence, proved. □

B.2 Proof of Proposition 1

Proof. Since $K = \infty$, there exists at least one bias type b_l such that there exist infinitely many bias types b_h's where $|b_h| > |b_l|$. Let us consider the IC for any such pair of b_h and b_l. Suppose b_l obtains a k partition by revealing her type is stage 1, and b_h obtains a j partition CS equilibrium by announcing b_h as her type in stage 1. Hence the IC constraint for low type is given by,

$$\begin{aligned} P(b_l)CS^{b_l}_{b_l}(k) + (1 - P(b_l))(-A_{b_l}) &\geq P(b_h)CS^{b_l}_{b_h}(j) + (1 - P(b_h))(-A_{b_l}) \\ \Rightarrow \frac{P(b_l)}{P(b_h)} &\geq \frac{CS^{b_l}_{b_h}(j) + A_{b_l}}{CS^{b_l}_{b_l}(k) + A_{b_l}} \end{aligned}$$

where,

$$
\begin{aligned}
P(b_l) &= F(b_l) - F(-b_l) + \frac{1}{2}(f(-b_l) - f(b_l)) \\
P(b_h) &= F(b_h) - F(-b_h) + \frac{1}{2}(f(-b_h) - f(b_h)) \\
P(b_h) - P(b_l) &= F(b_h) - F(b_l) + F(-b_l) - F(-b_h) + \frac{1}{2}(f(-b_h) + f(b_l) - f(-b_l) - f(b_h)) \\
&= \frac{1}{2}(f(b_h) + f(b_l) + f(-b_h) + f(b_l)) + F(b_h-) - F(b_l) + F(-b_l-)F(-b_h) > 0
\end{aligned}
$$

and the IC constraint for any type b_h, such that $|b_h| > |b_l|$ would be,

$$
\begin{aligned}
P(b_h)CS^{b_h}_{b_h}(j) + (1 - P(b_h))(-A_{b_h}) &\geq P(b_l)CS^{b_h}_{b_l}(k) + (1 - P(b_l))(-A_{b_h}) \\
\Rightarrow \frac{P(b_l)}{P(b_h)} &\leq \frac{CS^{b_h}_{b_h}(j) + A_{b_h}}{CS^{b_h}_{b_l}(k) + A_{b_h}}
\end{aligned}
$$

Both ICs can hold simultaneously if,

$$
\begin{aligned}
\frac{CS^{b_h}_{b_h}(j) + A_{b_h}}{CS^{b_h}_{b_l}(k) + A_{b_h}} &> \frac{CS^{b_l}_{b_h}(j) + A_{b_l}}{CS^{b_l}_{b_l}(k) + A_{b_l}} \\
\Rightarrow \frac{CS^{b_l}_{b_l}(k) - CS^{b_l}_{b_h}(j)}{CS^{b_l}_{b_l}(k) + A_{b_l}} &> \frac{CS^{b_h}_{b_l}(k) - CS^{b_h}_{b_h}(j)}{CS^{b_h}_{b_l}(k) + A_{b_h}}
\end{aligned}
\tag{24}
$$

Note that, if we compare the numerators, we get,

$$
CS^{b_l}_{b_l}(k) - CS^{b_l}_{b_h}(j) > CS^{b_h}_{b_l}(k) - CS^{b_h}_{b_h}(j)
$$

Plugging in the values from equations 4 and 5, we get

$$
(b_h - b_l)(b_h\frac{1}{k} + b_l(2 - \frac{1}{k})) > (b_h - b_l)(b_h(2 - \frac{1}{j}) + b_l\frac{1}{j})
$$

which for $b_h > b_l$ would be,

$$
b_l(2 - \frac{1}{k} - \frac{1}{j}) > b_h(2 - \frac{1}{k} - \frac{1}{j})
$$

and for $b_h < b_l$ would be,

$$b_l(2-\frac{1}{k}-\frac{1}{j}) < b_h(2-\frac{1}{k}-\frac{1}{j})$$

Neither of which can be true unless $j=k=1$. Thus, a necessary condition for the existence of such an equilibrium is that the denominator of LHS in 24 is lower than denominator of RHS

$$\begin{aligned}
CS_{b_l}^{b_h}(k)+A_{b_h} &> CS_{b_l}^{b_l}(k)+A_{b_l} \\
A_{b_h}-A_{b_l} &> CS_{b_l}^{b_l}(k)-CS_{b_l}^{b_h}(k) \\
A_{b_h}-A_{b_l} &> (b_h-b_l)(b_h\frac{1}{k}+b_l(2-\frac{1}{k}))
\end{aligned}$$

Consider any three levels of biases, such that $b_1 > b_2 > b_3$ then we get, the necessary condition for all three of them will be satisfied, only if,

$$\begin{aligned}
A_{b_1}-A_{b_2} &> (b_1-b_2)(b_1\frac{1}{k}+b_2(2-\frac{1}{k})) \\
A_{b_2}-A_{b_3} &> (b_2-b_3)(b_2\frac{1}{k}+b_3(2-\frac{1}{k})) \\
&\ldots so\ on
\end{aligned}$$

Note that $A_{b_3}-A_{b_1}$ needs to be greater than the sum of the RHS of the first two inequalities. Similarly, $A_{b_4}-A_{b_1}$ needs to be greater than the sum of the RHS of the first three inequalities. As we go to higher and higher biases, the difference $A_{b_n}-A_{b_1}$ needs to be greater than the sum of n numbers, each of which is bounded away from zero. Thus, for infinitely many points in K, to ensure that the ICs for all of them are satisfied, we would need $\max_K A_{b_i}-A_{b_j}=\infty$. However, this implies that the constraint cannot be satisfied for at least one type. Hence, such an equilibrium cannot exist. □

B.3 Proof of Proposition 2

Proof. In this proof, we consider only two types of biases, b_h and b_l, where $b_h > 0$ and $b_h > |b_l|$. Let $n = N_{b_l}$ and $m = N_{b_h}$, i.e., n and m denote the maximum number of partitions sustained by b_l and b_h type respectively (when their types are known i.e. in a Crawford Sobel world). For notational simplicity, let $A = A_{b_l}$ and $A + c = A_{b_h}$ where $c > 0$ (since we assume that the high bias type has a worse outside option). For $v = 1$, let us write the IC for both the b_h and b_l type senders. The IC for b_h is given by,

$$\left(1-\frac{p}{2}\right)CS^{b_h}_{b_h}(m)+\frac{p}{2}(-A_{b_h}) \geq \frac{1}{2}(1-p)CS^{b_h}_{b_l}(n)+\frac{1}{2}(1+p)(-A_{b_h})$$

Rearranging, we get,

$$p \geq p_h \equiv \frac{CS^{b_h}_{b_h}(m)+\frac{1}{2}(A+c)-\frac{1}{2}CS^{b_h}_{b_l}(n)}{\frac{1}{2}(CS^{b_h}_{b_h}(m)-CS^{b_h}_{b_l}(n))} = \frac{(CS^{b_h}_{b_l}(n)-CS^{b_h}_{b_h}(m))-(CS^{b_h}_{b_h}(m)+(A+c))}{(CS^{b_h}_{b_l}(n)-CS^{b_h}_{b_h}(m))} \tag{25}$$

Let us define $c'(b_h) = CS^{b_h}_{b_l}(n) - 2CS^{b_h}_{b_h}(m) - A$, Thus, given any b_l, b_h, the above cut off is pushed down to zero, i.e. $p_h = 0$ at $c = c'$.

The IC for b_l is given by,

$$\frac{1}{2}(1-p)CS^{b_l}_{b_l}(n)+\frac{1}{2}(1+p)(-A_{b_l}) \geq (1-\frac{p}{2})CS^{b_l}_{b_h}(m)+\frac{p}{2}(-A_{b_l})$$

Rearranging we get,

$$p \leq \overline{p} \equiv \frac{(\frac{1}{2}CS^{b_l}_{b_l}(n)-CS^{b_l}_{b_h}(m)-\frac{1}{2}A_{b_l})}{\frac{1}{2}(CS^{b_l}_{b_l}(n)-CS^{b_l}_{b_h}(m))} = \frac{(CS^{b_l}_{b_l}(n)-CS^{b_l}_{b_h}(m))-(CS^{b_l}_{b_h}(m)+A)}{(CS^{b_l}_{b_l}(n)-CS^{b_l}_{b_h}(m))} \tag{26}$$

This IC can hold only if $\overline{p} \geq 0$ i.e.

$$CS^{b_l}_{b_l}(n)-CS^{b_l}_{b_h}(m) \geq CS^{b_l}_{b_h}(m)+A \tag{27}$$

Note that, given b_l, if we consider how $CS^{b_l}_{b_h}(m)$ changes as b_h changes we find,

$$\frac{\partial CS^{b_l}_{b_h}(m)}{\partial b_h} = \begin{cases} -2b_h\frac{m^2-4}{3}-\frac{2(b_h-b_l)}{m}-2b_l & \text{if} \quad \frac{1}{2m(m+1)} \leq b_h < \frac{1}{2m(m-1)} \\ CS^{bl}_{b_h}(m-1)-CS^{bl}_{b_h}(m) & \text{otherwise} \end{cases}$$

Thus for any $m \geq 2$, and $b_h > |b_l|$, $\frac{\partial CS^{b_l}_{b_h}(m)}{\partial b_h} < 0$. This implies that as b_h increases, the LHS of 27 increases and the RHS decreases, thus a higher b_h makes the IC for b_l easier to hold.

27 can be written as $(CS_{b_l}^{b_l}(n) - 2CS_{b_h}^{b_l}(m) - A) > 0$

$$\frac{\partial (CS_{b_l}^{b_l}(n) - 2CS_{b_h}^{b_l}(m) - A)}{\partial b_l} = \begin{cases} -\frac{2}{3}b_l(n^2+2) & \text{if} \quad \frac{1}{2n(n+1)} \leq |b_l| < \frac{1}{2n(n-1)} \\ CS_{b_l}^{b_l}(n-1) - CS_{b_l}^{b_l}(n) & \text{if} \quad b_l = \frac{1}{2n(n-1)} \\ CS_{b_l}^{b_l}(n) - CS_{b_l}^{b_l}(n-1) & \text{if} \quad -b_l = \frac{1}{2n(n-1)} \end{cases}$$

Thus, $\frac{\partial (CS_{b_l}^{b_l}(n) - 2CS_{b_h}^{b_l}(m) - A)}{\partial b_l}$ is positive for $b_l < 0$ and negative for $b_l > 0$. It achieves its highest point at $b_l = 0$, and hence, the IC for b_l is easiest to hold at $b_l = 0$.

Furthermore, as $b_h \to \frac{1}{4}$, we get,

$$CS_{b_l}^{b_l}(n) - 2CS_{b_h}^{b_l}(m) - A = \frac{1}{48} - \frac{1}{12n^2} + \frac{b_l}{2} - \frac{b_l^2(n^2+2)}{3} \geq 0 \quad \forall n \geq 2$$

However, if $m = 3$, we get,

$$CS_{b_l}^{b_l}(n) - 2CS_{b_h}^{b_l}(3) - A = -\frac{7}{108} - \frac{1}{12n^2} - \frac{1}{3}b_l^2(n^2+3) + 4b_h^2 + \frac{8}{3}b_h b_l$$

At $b_l = 0$, this becomes,

$$CS_{b_l}^{b_l}(n) - 2CS_{b_h}^{b_l}(3) - A = -\frac{7}{108} + 4b_{h^2} < -\frac{7}{108} + \frac{1}{36} < 0$$

where the second inequality is derived using $b_h < \frac{1}{12}$ for $m = 3$. Thus $R_{RE,v=1}$ can only exists if $m = 2$. Plugging $m = 2$ in the IC for b_l we get,

$$CS_{b_l}^{b_l}(n) - 2CS_{b_h}^{b_l}(2) - A = -\frac{1}{24} - \frac{1}{12n^2} - \frac{1}{3}b_l^2(n^2+2) + b_h^2 + 2b_h b_l$$

at $b_l = 0$, this becomes,

$$CS_{b_l}^{b_l}(n) - 2CS_{b_h}^{b_l}(2) - A = -\frac{1}{24} + b_h^2$$

Thus IC for b_l can only be satisfied if $CS_{b_l}^{b_l}(n) - 2CS_{b_h}^{b_l}(2) - A > 0$ i.e. $-\frac{1}{24} + b_h^2 > 0 \Rightarrow b_h \in (\frac{1}{\sqrt{24}}, \frac{1}{4})$.

Moreover, if $b_h = |b_l|$, the IC for b_l becomes,

$$CS^{b_l}_{b_l}(2) - 2CS^{b_l}_{b_h}(2) - A = -\frac{1}{24} - \frac{1}{48} - 2b_l^2 + b_h^2 + 2b_h b_l = b_h^2 - \frac{1}{16} < 0$$

since $b_h < \frac{1}{4}$.

This implies that b_l cannot be equal to $-b_h$. There exist $\underline{b}, \overline{b}$ such that $-b_h < \underline{b} < 0$ and $b_h > \overline{b} > 0$ and if $b_l \in [\underline{b}, \overline{b}]$, $b_h \in (\frac{1}{\sqrt{24}}, \frac{1}{4})$ and $c > c'(b_h)$, for all $p < \overline{p}$ both the ICs hold simultaneously. Given any b_l we can write $c'(b_h)$ as

$$c'(b_h) = \underbrace{CS^{b_h}_{b_l}(n) - CS^{b_h}_{b_h}(m)}_{b_h\text{'s payoff gain by deviating}} - \underbrace{CS^{b_h}_{b_h}(m)}_{b_h\text{'s payoff from truth-telling}} - A,$$

where both the first and second terms are increasing in b_h. For any b_l, let us define $c' = \lim_{b_h \to \frac{1}{4}} c'(b_h)$. Thus both the ICs are satisfied for $p < \overline{p}$, $c > c^{'}$ and $b_h \geq \bar{b} (> b_l)$.

Next, we show that c' needs to be strictly positive. We highlight this point because it shows that the outside options for the two types cannot be the same for a revelation equilibrium to exist. We show this by contradiction. Suppose at $c = 0$, the IC for b_h and b_l holds simultaneously, this implies:

$$\begin{aligned} p_h &\leq \overline{p} \\ \frac{(CS^{b_h}_{b_l}(n) - CS^{b_h}_{b_h}(m)) - (CS^{b_h}_{b_h}(m) + A)}{(CS^{b_h}_{b_l}(n) - CS^{b_h}_{b_h}(m))} &\leq \frac{(CS^{b_l}_{b_l}(n) - CS^{b_l}_{b_h}(m)) - (CS^{b_l}_{b_h}(m) + A)}{(CS^{b_l}_{b_l}(n) - CS^{b_l}_{b_h}(m))} \\ \frac{CS^{b_l}_{b_h}(m) + A}{(CS^{b_l}_{b_l}(n) - CS^{b_l}_{b_h}(m))} &\leq \frac{CS^{b_h}_{b_h}(m) + A}{(CS^{b_h}_{b_l}(n) - CS^{b_h}_{b_h}(m))} \end{aligned} \tag{28}$$

Comparing the denominators, inequality 28 holds if,

$$\begin{aligned} CS^{b_l}_{b_l}(n) - CS^{b_l}_{b_h}(m) &\geq CS^{b_h}_{b_l}(n) - CS^{b_h}_{b_h}(m) \\ CS^{b_l}_{b_l}(n) - CS^{b_h}_{b_l}(n) &\geq CS^{b_l}_{b_h}(m) - CS^{b_h}_{b_h}(m) \end{aligned}$$

Plugging in the differences from equations 6 and 7 we get,

$$(b_h - b_l)(b_h\frac{1}{n} + b_l(2 - \frac{1}{n})) \geq (b_h - b_l)(b_h(2 - \frac{1}{m}) + b_l\frac{1}{m}))$$
$$b_h(\frac{1}{n} + \frac{1}{m} - 2) \geq b_l(\frac{1}{n} + \frac{1}{m} - 2)$$

which can never hold unless $n = m = 1$. Furthermore, comparing the numerators using equation 7 we get,

$$CS_{b_h}^{b_h}(m) \geq CS_{b_h}^{b_l}(m)$$
$$(b_h - b_l)\left(b_h\left(2 - \frac{1}{m}\right) + b_l\frac{1}{m}\right) \leq 0$$

which cannot happen unless $b_h = b_l$. Thus for all $b_h > b_l$ and $n \geq m > 1$ we get $p_h > \overline{p}$ for $c = 0$. This implies $c' > 0$. □

B.4 Proof for lemma 2

Proof. In this proof, we consider only two types of biases, b_h and b_l, where $b_h > 0$ and $b_h > |b_l|$. Let $n = N_{b_l}$ and $m = N_{b_h}$, i.e., n and m denote the maximum number of partitions sustained by b_l and b_h type respectively (when their types are known i.e. in a Crawford Sobel world). For notational simplicity, let $A = A_{b_l}$ and $A + c = A_{b_h}$ where $c > 0$ (since we assume that the high bias type has a worse outside option). Let us define, $d = b_h - b_l$, from equation 22 we find the difference in the revelation payoff and the n partition CH equilibrium is given by,

$$U_R(RE,1)) - U_R(LM,p,n)) = p^2\left(CS_{b_l}^{b_l}(n) - CS_{b_h}^{b_h}(m) + \frac{n^2-1}{3}d^2 - \frac{n-1}{n}d^2\right)$$
$$+ p\left(2\left(CS_{b_h}^{b_h}(m) - CS_{b_l}^{b_l}(n)\right) + \frac{n^2-1}{3}2b_l d + \frac{n-1}{n}d^2\right)$$

Given equation 13 in appendix A.3, if the maximum number of partitions of $E_{CH}(p,n)$ is the same as the maximum number of partitions sustained with a b_l sender in a revelation equilibrium, it must be that when we plug in the value of $CS_{b_h}^{b_h}(m)$ and $CS_{b_l}^{b_l}(n)$, we get $U_R(RE,1) < U_R(LM,p,n)$ if,

$$\frac{(1-p)^2}{12n^2} - \frac{1}{12n^2} - p^2\frac{b_h^2\left(n^2-1\right)}{3} - 2p\left(1-p\right)b_hb_l\frac{\left(n^2-1\right)}{3} - \frac{n-1}{n}d^2p\left(1-p\right)$$
$$> \left[p^2+2p\left(1-p\right)\right]\left(-\frac{1}{12m^2} - b_h^2\frac{m^2-1}{3}\right)$$

Since $n > m$, and $p < 2$, it suffices to show:

$$2p\frac{b_h^2\left(n^2-1\right)}{3} - 2p^2\frac{b_h^2\left(n^2-1\right)}{3} - 2p\left(1-p\right)b_hb_l\frac{n^2-1}{3} - d^2p\left(1-p\right)\frac{n-1}{n} > 0$$
$$\Longleftrightarrow 2p\left(1-p\right)\left[\frac{b_h\left(n^2-1\right)}{3}\right]\left(b_h-b_l\right) > \left(b_h-b_l\right)^2p\left(1-p\right)\frac{n-1}{n}$$
$$\Longleftrightarrow 2n\left(\frac{n+1}{3}\right)b_h > \left(b_h-b_l\right)$$

Since $n > m \geq 2$, this implies that $n \geq 3$. In this case, the LHS is at least $8b_h$ whereas the maximum value of the RHS is $2b_h$. Thus, the above holds and $U_R(RE,1) < U_R(LM,p,n)$. □

B.5 Proof of proposition 3

Proof. In this proof, we consider only two types of biases, b_h and b_l, where $b_h > 0$ and $b_h > |b_l|$. Let $n = N_{b_l}$ and $m = N_{b_h}$, i.e., n and m denote the maximum number of partitions sustained by b_l and b_h type respectively (when their types are known i.e. in a Crawford Sobel world). For notational simplicity, let $A = A_{b_l}$ and $A + c = A_{b_h}$ where $c > 0$ (since we assume that the high bias type has a worse outside option).

To prove this proposition, we show that for any $b_h \in (\frac{1}{\sqrt{24}}, \frac{1}{4})$, there exists a value of $n > 3$ such that if $b_l \to \frac{1}{2n(n-1)}$, then there exists an interval $(\tilde{p}, \overline{p}]$ in which $E_{RE,v=1}$ exists and the receiver strictly prefers it over the most informative (and hence all) conflict hiding equilibrium.

The roadmap for the proof is as follows:

First, we find the necessary conditions such that $E_{RE,v=1}$ exists and it is better than conflict hiding equilibrium, $E_{CH}(p, N_p = n-1)$.

Second, for $b_h \in (\frac{1}{\sqrt{24}}, \frac{1}{4})$, we compare the payoff from the most informative revelation and conflict hiding equilibrium and show that the revelation equilibrium can be better than all conflict hiding equilibria when $n \geq 4$.

Necessary Condition: The necessary condition involves two conditions holding simultaneously. The first condition ensures the IC for b_l is satisfied (as shown in proposition 2, the IC for b_h can be satisfied for all $p \in [0,1]$ by choosing c appropriately.), the second condition ensures that $N_p < N_l$ (if not, by lemma 2 $E_{CH}(p, N_p = n)$ would be strictly better than the $E_{RE,v=1}$.) From proposition 2, $E_{RE,v=1}$ exists when:

$$p \leq \overline{p} = \frac{(CS_{b_l}^{b_l}(n) - CS_{b_h}^{b_l}(m)) - (CS_{b_h}^{b_l}(m) + A)}{(CS_{b_l}^{b_l}(n) - CS_{b_h}^{b_l}(m))} \tag{29}$$

From Lemma 2, we know that $E_{CH}(p,k)$ can generate lower welfare compared to $E_{RE,v=1}$, only when it can sustain at most $n-1$ partitions. The condition which guarantees this comes from equation 14 in appendix A.3:

$$p \geq \underline{p} = \frac{\frac{1}{2n(n-1)} - b_l}{b_h - b_l} \tag{30}$$

Thus, the necessary condition that $E_{RE,v=1}$ exists and performs better than $E_{CH}(p, N_p)$ is $\underline{p} \leq \overline{p}$, i.e., conditions 29 and 30 holds together.

This implies if $b_l \to \frac{1}{2n(n-1)}$, $\underline{p} \to 0$ and by proposition 2, $\overline{p} > 0$ for $b_h \in (\frac{1}{\sqrt{24}}, \frac{1}{4})$.

Next, we identify conditions under which the revelation equilibrium provides the receiver with higher utility than any conflict hiding equilibrium.

Payoff Comparison: Using equation 22 in Appendix A.3, at $v = 1$ the difference between the payoff from $E_{RE,v=1}$ and $E_{CH}(p, N_p = n-1)$ is given by,

$$\Delta(p)_{v=1} \equiv U_R(RE, v=1)) - U_R(LM, p, n-1)) \tag{31}$$

$$\begin{aligned} =&p^2\left(\left(CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R)\right) + \frac{(n-1)^2-1}{3}d^2 - \frac{n-2}{n-1}d^2\right) \\ &+ p\left(2\left(CS_{b_h}^{b_h}(m,R) - CS_{b_l}^{b_l}(n,R)\right) + \frac{(n-1)^2-1}{3}2b_l d + \frac{n-2}{n-1}d^2\right) \\ &+ \left(CS_{b_l}^{b_l}(n,R) + \frac{1}{12(n-1)^2} + \frac{(n-1)^2-1}{3}b_l^2\right) \end{aligned} \tag{32}$$

For $b_l \to \frac{1}{2n(n-1)}$, the constant term in the equation becomes,

$$\lim_{b_l \to \frac{1}{2n(n-1)}} CS^{b_l}_{b_l}(n,R) + \frac{1}{12(n-1)^2} + \frac{(n-1)^2-1}{3} b_l^2 = \frac{2n-1}{3}\left(\frac{1}{4n^2(n-1)^2} - b_l^2\right) = 0$$

Thus, for $N_p = n-1$, one root of the quadratic expression $\Delta(p)_{v=1}$ goes to zero as $b_l \to \frac{1}{2n(n-1)}$. We further show that the other root of the quadratic equation, denoted by $\tilde{p}$, lies below $\overline{p}$. Since the coefficient of the quadratic term is positive for all $n \geq 3$, and $\underline{p}$ goes to zero when $b_l \to \frac{1}{2n(n-1)}$, this implies that if p in $(\tilde{p}, \overline{p}]$, then the conflict hiding equilibria can support a maximum of $n-1$ partitions, and $\Delta(p)_{v=1} > 0$. To show that $\tilde{p} < \overline{p}$, we check if $\Delta(p)_{v=1} > 0$ at $\overline{p}$ when $b_l \to \frac{1}{2n(n-1)}$, substituting the values we get,

$$\begin{aligned}
&\frac{6(2b_hn(n-1)+1)^2 - (n^2+2)(n-1)^2 - 2(n^2+5)}{6(2b_hn(n-1)+1)^2 + (n^2-4)(n-1)^2 - 4(n^2+2)} \\
&> \frac{A - 6(n-2)(2b_hn(n-1)-1)^2 - 4n(n-1)(n-2)(2b_hn(n-1)-1)}{A - 12(n-2)(2b_hn(n-1)-1)^2 - 4n(n-1)(n-2)(2b_hn(n-1)-1)^2} \\
&\text{where } A = (n^2-4)(n-1)^3 - 4(n^2-1)(n-1) + 48b_h^2n^2(n-1)^3
\end{aligned}$$

Simplifying we get,

$$\begin{aligned}
&6(2b_hn(n-1)-1)(2b_hn(n-1)+1)^2((2n^2-2n-3)2b_hn(n-1)+3) \\
&+9(2b_hn(n-1)-1)^2(n^2(n-1)^2+4) - n(n-1)^2(n^2-1)((n^2-4)(n-1) - 4(n+1) + 48b_h^2n^2(n-1)) \\
&-2n(n-1)^2\left(2b_hn(n-1)-1)((n-1)^2(n^2+2)2b_hn - 2(n+1)(n-1)^2 + 4(n^2+5)b_hn + 2(n+1)\right) \geq 0
\end{aligned}$$

The leading term of the polynomial (in n) is given by $(192b_h^4 - 8b_h^2)n^{10}$. Thus, for $b_h > \frac{1}{\sqrt{24}}$, since the leading term of $\Delta(p)_{v=1} > 0$, there exists an n sufficiently large, say $\overline{n}$ such that $D(p)_{v=1} > 0$ for all $n \geq \overline{n}$. This completes the proof.

□

C Extension - Public Randomization Device

In the most informative revelation equilibrium, $E_{RE,v=1}$ (see proposition 2), the receiver must hire the high-bias sender whenever the two bias reports differ. This hiring rule is ex-post inefficient and diminishes the receiver's payoff. Allowing a positive probability of hiring the low-bias sender after mixed messages in stage 1 would boost the receiver's payoff. But, as noted, this mixed strategy isn't incentive-compatible: upon seeing a mixed message in Stage 1, the receiver would always rather pick the low-bias sender than randomize (for any $v \in (0,1)$). Since the receiver's deviation from the prescribed mixing cannot be observed or enforced, such an equilibrium cannot be sustained. By granting the receiver access to a public randomization device[20] (PRD) , we resolve the receiver's commitment problem and expand the strategy set by including mixed strategies for the receiver. While the result from the one sender case remains unchanged (see Bhattacharjee et al. (2026)), with two senders, the commitment helps in generating higher welfare in the revealing equilibrium because now receiver can choose to hire a low bias type with a high enough probability. We consider the most general case for biases i.e. one in which $K \subset (\frac{-1}{4}, \frac{1}{4})$, and K could be a finite set or an infinite set.

C.1 Two sender Problem with PRD

In contrast, with two senders, the public randomization device permits not only mixed strategies employed in Stage 2, but also mixed hiring rules in Stage 1. We first show that even with PRD no revelation equilibrium can exist with $v_{b_l b_j} < \frac{1}{2}$ where $|b_i| > |b_j|$ (corollary 1). Also, with infinitely many bias types, no equilibrium exists for any $v > \frac{1}{2}$ even with the PRD (Corollary 2). But with $N = 2$, expanding the strategy set enhances the receiver's welfare. As a result, for a wider range of parameter values, a bias-revealing equilibrium $E_{RE,v}$ exists and yields strictly higher welfare for the receiver (Proposition 4).

The following two corollaries are derived from Lemma 1 and Proposition 1, respectively. The formal proofs are in appendix section C.2.1 and C.2.2.

Corollary 1. *If there exists $b_i, b_j \in K$ such that $|b_i| > |b_j|$ and $v_{b_i b_j} \in [0, \frac{1}{2})$, then $S_{RE,v}$ does not generate a Perfect Bayesian equilibrium with PRD.*

Corollary 2. *If $|K| = \infty$, the highest partition revelation strategy profile $S_{RE,v}$ cannot be sustained*

[20] Suppose we wish to sustain an equilibrium where the high bias sender is hired with probability v ($\in (0,1)$) when the senders announce different biases in stage 1. Then a public randomization device (henceforth PRD) can be thought of as a biased coin that takes heads with probability v. The coin is tossed, and if the outcome (publicly observed) is heads, then the receiver is supposed to pick the high bias sender, and if it is tails, then the receiver is supposed to pick the low bias sender.

in any equilibrium with PRD.

Next, we consider the case where there are only two types of biases, say b_h and b_l, where WLOG $b_h > |b_l|$. We show that allowing for a public randomization device significantly affects the welfare of the receiver in this case. As $v \to \frac{1}{2}$, the receiver can choose to hire the low bias type with a high enough probability and increase his expected payoff from the second stage game. This implies that for any b_h, by choosing v appropriately small, we can ensure that the revelation equilibrium exists and generates a higher expected payoff for the receiver compared to the most informative conflict hiding equilibrium $E_{CH}(p, N_p)$. The following proposition formalizes this.

Proposition 4. *Given any $b_h \in (0, \frac{1}{4})$ and $n > m$ there exists $\overline{v}(h) \in (\frac{1}{2}, 1)$, such that if $v \in (\frac{1}{2}, \overline{v}(h))$ and $b_l \to \frac{1}{2n(n-1)}$, then for all $p \leq \overline{p}(v)$ and $c > c'(v)$, the most informative revelation equilibrium $E_{RE,v}$ exists and generates a higher expected utility for the receiver compared to the any conflict hiding equilibrium $E_{CH}(p,k)$.*

The formal proof of the proposition is given in Appendix C.2.3. The intuition of the proof is similar to the logic to proposition 2 (for existence) and Proposition 3 (for welfare comparison).

To show existence, we choose the difference between the outside options for the two bias types to be sufficiently high such that the incentive compatibility constraint for b_h is satisfied. Since we allow for $v < 1$, it reduces the incentive to deviate for low bias type compared to the $v = 1$ case. Thus, a revelation equilibrium can exist for a larger range of parameters.

For welfare comparison, we find conditions on p such that the maximum number of possible partitions under the conflict hiding equilibrium is strictly lower than that of the low bias most informative equilibrium. This creates the possibility of finding conditions under which the revelation equilibrium can beat the best conflict hiding one. We show that for any b_h if $v \to \frac{1}{2}$, a revelation equilibrium exists and generates higher welfare than all conflict hiding equilibria. Thus, choosing a sufficiently low v allows the revelation equilibrium to exist and be welfare-improving. The example below assumes a value of $b_h < \frac{1}{\sqrt{24}}$ and shows that revelation equilibrium can be better for such a low b_h,

Example 2. *Suppose $b_h = 0.046, b_l = 0.022$, which implies $N_{b_h} = 3$ and $N_{b_l} = 5$ and the receiver chooses the high bias type with probability $v = 0.75$. Furthermore, suppose $p <= 0.125$ i.e., $N_p < 5$.*

Then, assuming $N_p = 4$, from 22 derived in Appendix A, the payoff difference is given by:

$$U_R(RE, v = 0.75) - U_R(LM, p, N_{b_l} - 1) = p^2(0.5 * 0.0076 + 4.25 * 0.02387^2) \\ + p(-1.5 * 0.0076 + 10 * 0.022 * 0.02387 + 0.75 * 0.02387^2) + 0.0004$$

For all $p < 0.0762345$ (note that this satisfies the earlier constraint on $p < 0.125$), we get $U_R(RE, v = 0.75) > U_R(LM, p, N_{b_l} - 1)$.

C.2 Proofs of Extension: Public Randomization Device

C.2.1 Proof of corollary 1

Proof. This corollary is derived from Lemma 1. Using a similar logic suppose for any two type b_h and b_l where $|b_h| > |b_l|$ and b_h being chosen with probability $v_{b_h b_l}$ the IC for b_h is given by,

$$P(b_h)CS_{b_h}^{b_h}(j) + (1 - P(b_h))(-A_{b_h}) > P(b_l)CS_{b_l}^{b_h}(k) + (1 - P(b_l))(-A_{b_h}) \\ P(b_h)(CS_{b_h}^{b_h}(j) + A_{b_h}) > P(b_l)(CS_{b_l}^{b_h}(k) + A_{b_h})$$

where $P(b_h)$ and $P(b_l)$ are given by,

$$P(b_h) = v_{b_h b_l}[F(b_h) + 1 - F(-b_h)] + (1 - v_{b_h b_l})[1 - F(b_h) + F(-b_h)] \\ + (\frac{1}{2} - v)(f(b_h) - f(-b_h)); \\ P(b_l) = v_{b_h b_l}[F(b_l) + 1 - F(-b_l))] + (1 - v_{b_h b_l})[1 - F(b_l) + F(-b_l)] \\ + (\frac{1}{2} - v)(f(b_l) - f(-b_l))$$

Thus, if $v \leq \frac{1}{2}$ the difference between the two probabilities would be,

$$P(b_l) - P(b_h) = (1 - 2v)(F(b_h-) - F(b_l) + F(-b_l) - F(-b_h)) \\ +(\frac{1}{2} - v)(f(b_h) + f(-b_h) + f(b_l) - f(-b_l)) \geq 0$$

Thus by lemma 1 no revelation equilibrium can exist for $v \leq \frac{1}{2}$. □

C.2.2 Proof of Corollary 2

Proof. This corollary is derived from proposition 1. Using a similar argument, for any two types b_h and b_l such that $|b_h| > |b_l|$, the IC for b_l is given by,

$$P(b_l)CS_{b_l}^{b_l}(k) + (1-P(b_l))(-A_{b_l}) \geq P(b_h)CS_{b_h}^{b_l}(j) + (1-P(b_h))(-A_{b_l})$$
$$\Rightarrow \frac{P(b_l)}{P(b_h)} \geq \frac{CS_{b_h}^{b_l}(j) + A_{b_l}}{CS_{b_l}^{b_l}(k) + A_{b_l}}$$

where for $v > \frac{1}{2}$, the probabilities are given by,

$$P(b_l) = v_{b_h b_l}[F(b_l) + 1 - F(-b_l))] + (1 - v_{b_h b_l})[1 - F(b_l) + F(-b_l)]$$
$$+ (\frac{1}{2} - v)(f(b_l) - f(-b_l))$$
$$P(b_h) = v_{b_h b_l}[F(b_h) + 1 - F(-b_h))] + (1 - v_{b_h b_l})[1 - F(b_h) + F(-b_h)]$$
$$+ (\frac{1}{2} - v)(f(b_h) - f(-b_h))$$

and the IC for b_h is given by,

$$P(b_h)CS_{b_h}^{b_h}(j) + (1-P(b_h))(-A_{b_h}) \geq P(b_l)CS_{b_l}^{b_h}(k) + (1-P(b_l))(-A_{b_h})$$
$$\Rightarrow \frac{P(b_l)}{P(b_h)} \leq \frac{CS_{b_h}^{b_h}(j) + A_{b_h}}{CS_{b_l}^{b_h}(k) + A_{b_h}}$$

Both ICs can hold simultaneously if,

$$\frac{CS_{b_h}^{b_h}(j) + A_{b_h}}{CS_{b_l}^{b_h}(k) + A_{b_h}} > \frac{CS_{b_h}^{b_l}(j) + A_{b_l}}{CS_{b_l}^{b_l}(k) + A_{b_l}}$$
$$\Rightarrow \frac{CS_{b_l}^{b_l}(k) - CS_{b_h}^{b_l}(j)}{CS_{b_l}^{b_l}(k) + A_{b_l}} > \frac{CS_{b_l}^{b_h}(k) - CS_{b_h}^{b_h}(j)}{CS_{b_l}^{b_h}(k) + A_{b_h}}$$

Thus, by Proposition 1, such a revelation equilibrium cannot exist. □

C.2.3 Proof of proposition 4

Proof. In this proof, we consider only two types of biases, b_h and b_l, where $b_h > 0$ and $b_h > |b_l|$. Let $n = N_{b_l}$ and $m = N_{b_h}$, i.e., n and m denote the maximum number of partitions sustained by b_l and b_h type respectively (when their types are known i.e. in a Crawford Sobel world). For notational simplicity, let $A = A_{b_l}$ and $A + c = A_{b_h}$ where $c > 0$ (since we assume that the high bias type has a worse outside option).

The road map for the proof is as follows: First, we show with $v \in (\frac{1}{2}, 1)$, although the IC for b_h is harder to satisfy compared to $v = 1$, with a sufficient difference in outside option, it can be satisfied. Moreover, for $v \in (\frac{1}{2}, 1)$ the IC for b_l becomes easier to satisfy, and as $v \to \frac{1}{2}$ the IC for b_l can be sustained for any b_h. Third, we outline the necessary condition for RE to generate higher welfare than the conflict hiding equilibrium. Finally, by comparing payoffs, we show that RE can generate higher welfare compared to any conflict hiding equilibrium.

First, we show that if $v \geq \frac{1}{2}$, the IC for b_h can be written as,

$$p > \frac{\frac{1}{2}\left(CS^{b_h}_{b_l}(n) - CS^{b_h}_{b_h}(m)\right) + \left(\frac{1}{2} - v\right)\left(CS^{b_h}_{b_h}(m) + A + c\right)}{\left(v - \frac{1}{2}\right)\left(CS^{b_h}_{b_l}(n) - CS^{b_h}_{b_h}(m)\right)} = p_h(v) \tag{33}$$

We need the RHS to be less than 1 to get a feasible region for p. We know that the denominator is positive, since $CS^{b_h}_{b_l}(n) \geq CS^{b_h}_{b_h}(m)$ as shown in lemma 1. In the numerator, since $CS^{b_h}_{b_l}(n) \geq CS^{b_h}_{b_h}(m)$, and $CS^{b_h}_{b_h}(m) > -(A+c)$, the first expression is positive while the second expression is negative. Then, for every $v \in (\frac{1}{2}, 1]$, $\exists c'(v, b_h)$ such that $\forall c > c'(v, b_h)$ we get $p_h = 0$.

Next, we write the IC for b_l when $v > \frac{1}{2}$, as below,

$$p < \frac{\frac{1}{2}\left(CS^{b_l}_{b_l}(n) - CS^{b_l}_{b_h}(m)\right) + \left(\frac{1}{2} - v\right)\left(CS^{b_l}_{b_h}(m) + A\right)}{\left(v - \frac{1}{2}\right)\left(CS^{b_l}_{b_l}(n) - CS^{b_l}_{b_h}(m)\right)} \equiv \overline{p}(v) \tag{34}$$

Note that $\frac{\partial \overline{p}(v)}{\partial v} = -\frac{2}{(2v-1)^2} < 0$. Intuitively, this is because as v increases, i.e. in case of a mixed message, the high bias sender is chosen with a higher probability, a low bias sender needs to be even more sure that the other sender is not high bias to not deviate. Thus if $\overline{p}(v) > 0$, for $v = 1$ and $b_h > \frac{1}{\sqrt{24}}$, it will be true for some $b_h > \overline{b}_h(v)$ for all $v \in (\frac{1}{2}, 1)$, where $b_h(v)$ is increasing in v. Since $\lim_{v \to \frac{1}{2}} \overline{p}(v) = \infty$, we can always ensure that $\underline{p} \leq \overline{p}(v)$ is satisfied for any b_h by choosing a v

sufficiently close to $\frac{1}{2}$ from above.

Next, using equation 14, we know the most informative conflict hiding equilibrium can sustain at most $k = n-1$ partitions if,

$$p > \frac{\frac{1}{2n(n-1)} - b_l}{b_h - b_l} = \underline{p} \tag{35}$$

From equation 34, we know that we need $p < \overline{p(v)}$ for the incentive compatibility constraint of b_l type sender[21] to hold in a revealing equilibrium. Thus, both conditions can be upheld simultaneously if $\underline{p} \leq \overline{p}(v)$. Since $\lim_{v \to \frac{1}{2}} \overline{p}(v) = \infty$, we can always ensure that $\underline{p} \leq \overline{p}(v)$ is satisfied for any b_h by choosing a v sufficiently close to $\frac{1}{2}$ from above.

Following the same logic as proposition 3, we consider the payoff difference between the revelation equilibrium and the conflict hiding equilibria with $k = n-1$ and $b_l \to \frac{1}{2n(n-1)}$ at $p = \min\{\overline{p}(v), 1\}$. For all $v \leq 1$ where $\overline{p}(v) < 1$[22] (we will consider the case of $\overline{p}(v) > 1$ later in the proof) let us consider the conditions under which the payoff difference between revealing equilibrium and conflict hiding with $n-1$ partitions is positive at $\overline{p}$ for $b_l \to \frac{1}{2n(n-1)}$ as,

$$\Delta(\overline{p}(v))_v \equiv U_R(RE, v)) - U_R(LM, \overline{p}(v), n-1)) > 0 \tag{36}$$

$$\begin{aligned} =&\overline{p}(v)\left((2v-1)\left(CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R)\right) + \frac{(n-1)^2-1}{3}d^2 - \frac{n-2}{n-1}d^2\right) \\ &+ 2v\left(CS_{b_h}^{b_h}(m,R) - CS_{b_l}^{b_l}(n,R)\right) + \frac{(n-1)^2-1}{3}2b_l d + \frac{n-2}{n-1}d^2 > 0 \end{aligned} \tag{37}$$

Simplifying we get,

$$\overline{p}(v) \geq \frac{2v\left(CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R)\right) - \frac{(n-1)^2-1}{3}2b_l d - \frac{n-2}{n-1}d^2}{(2v-1)\left(CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R)\right) + \frac{(n-1)^2-1}{3}d^2 - \frac{n-2}{n-1}d^2} \tag{38}$$

[21] As before, the IC of the b_l type is the binding constraint for revelation eq to exist.

[22] Such a v exists because $\overline{p}(v)$ is continuous and decreasing in v, with $\overline{p}(v = \frac{1}{2}) = \infty$ and $\overline{p}(v = 1) = 1 - \frac{CS_{b_h}^{b_l}(m)+A}{CS_{b_l}^{b_l}(n)-CS_{b_l}^{b_h}(m)} = 1 - \frac{CS_{b_h}^{b_l}(m)-CS_{b_l}^{b_l}(1)}{CS_{b_l}^{b_l}(n)-CS_{b_l}^{b_h}(m)}$. Both the numerator and the denominator are positive in $\frac{CS_{b_h}^{b_l}(m)-CS_{b_l}^{b_l}(1)}{CS_{b_l}^{b_l}(n)-CS_{b_l}^{b_h}(m)}$, and therefore $\overline{p}(v = 1) < 1$

Note that the derivative of $\overline{p}(v)$ is negative for all $v \in (\frac{1}{2}, 1]$. The derivative of RHS is given by,

$$\frac{\partial RHS}{\partial v} = \frac{2(\left(CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R)\right))D - 2(\left(CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R)\right))N}{D^2}$$

where $D = (2v-1)\left(CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R)\right) + \frac{(n-1)^2-1}{3}d^2 - \frac{n-2}{n-1}d^2$ denotes the denominator of the RHS and $N = 2v\left(CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R)\right) - \frac{(n-1)^2-1}{3}2b_l d - \frac{n-2}{n-1}d^2$ denotes the numerator of RHS. This implies $\frac{\partial RHS}{\partial v} > 0$ if $N < D$, i.e.,

$$\begin{aligned} 2v\left(CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R)\right) - \frac{(n-1)^2-1}{3}2b_l d - \frac{n-2}{n-1}d^2 \\ < (2v-1)\left(CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R)\right) + \frac{(n-1)^2-1}{3}d^2 - \frac{n-2}{n-1}d^2 \\ \frac{(n-1)^2-1}{3}d(b_h+b_l) > CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R) \\ \frac{(n-1)^2}{3}(b_h^2 - b_l^2) > \frac{n^2-m^2}{12m^2n^2} + \frac{b_h^2m^2 - b_l^2n^2}{3} \end{aligned}$$

Simplifying we get,

$$4n^2m^2(n-1)^2((n-1)^2 - m^2) - (n^2-m^2)(n-1)^2 - m^2((n-1)^2-1) > 0,$$

which holds for n sufficiently large[23]. Thus, as $v\downarrow$, for n sufficiently large, the RHS of the inequality 38 decreases and the LHS of the inequality 38 increases. This implies that, since the condition holds for $v = 1$, it would hold true for all lower values of v where $\overline{p}(v) < 1$.

Next, we consider the case for $\overline{p}(v) \geq 1$. Note that at $p = 1$, the difference of the payoff term is given by,

$$\begin{aligned} \Delta(p=1)_v = \left((2v-1)\left(CS_{b_l}^{b_l}(n,R) - CS_{b_h}^{b_h}(m,R)\right) + \frac{(n-1)^2-1}{3}d^2 - \frac{n-2}{n-1}d^2\right) \\ +2v\left(CS_{b_h}^{b_h}(m,R) - CS_{b_l}^{b_l}(n,R)\right) + \frac{(n-1)^2-1}{3}2b_l d + \frac{n-2}{n-1}d^2 > 0 \end{aligned}$$

Since at $p = 1$, there are only high bias type senders, we get,

$$\Delta(p=1)_v = \frac{m^2-1}{3}(d^2 + 2db_l) > 0.$$

[23]Since the coefficient of the highest power n term is positive.

By continuity, this implies for all v such that $\overline{p}(v) > 1$, there exists an interval I such that if $p \in I$ then the difference term is strictly positive.

$\square$

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